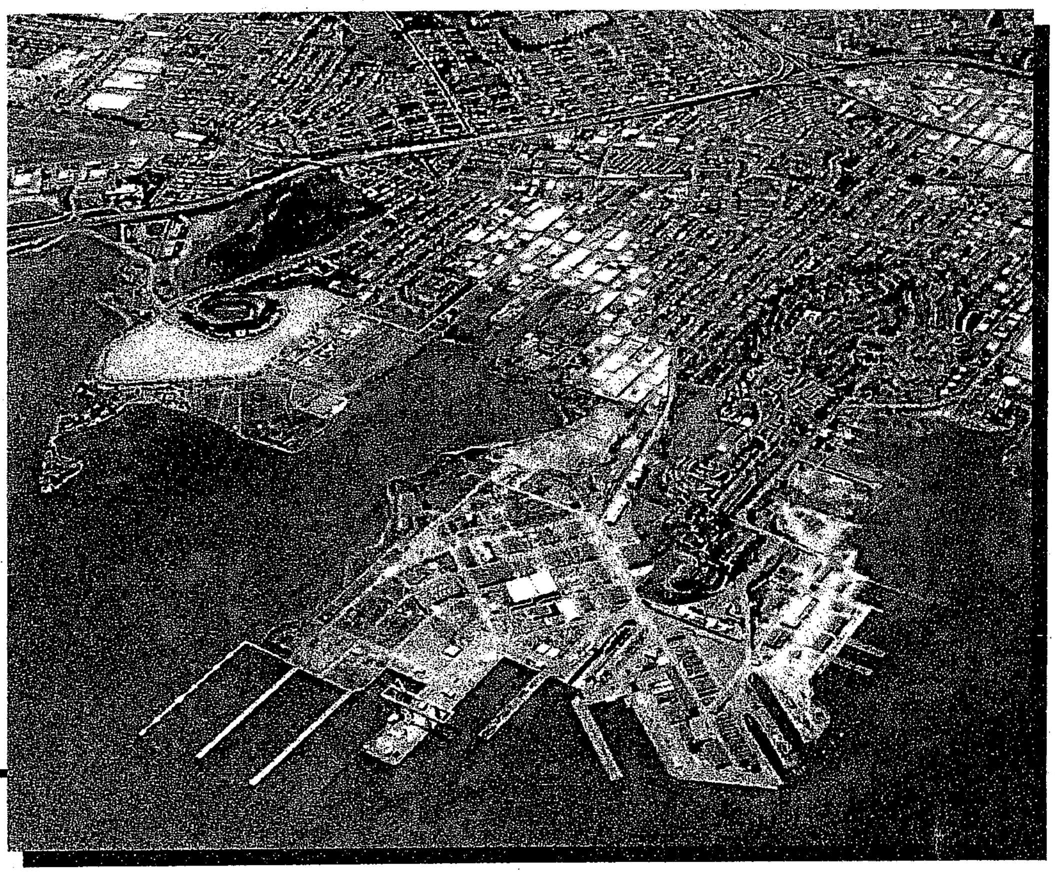
Draft Report

Sediment Investigation at Yosemite Creek



May 5, 2004

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Sediment Investigation at Yosemite Creek
October 1998 – May 2000

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EXECUTIVE SUMMARY

Pending completion of the Ecological Risk Assessment (will be inserted as Section 7).

1.0 INTRODUCTION AND SITE HISTORY

This report presents the results, interpretation and conclusions of a comprehensive sediment investigation conducted in San Francisco Bay at Yosemite Creek on behalf of the City and County of San Francisco, Public Utilities Commission (SFPUC). Two of the field surveys were conducted during wet weather in October 1998 and April 2000. A single dry weather survey was conducted in October 1999.

The San Francisco Bay Regional Water Quality Board (Regional Board) identified Yosemite Creek and the adjacent South Basin as "sites of concern", citing the presence of elevated pollutants in sediments (RWQCB 1998). A comprehensive sampling program was initiated by SFPUC in 1998 in response to Regional Board concerns regarding contaminant levels and aquatic toxicity in the creek. Toxicity and chemistry tests were conducted on surface sediments to document the horizontal extent of impacts; and subsurface cores were analyzed to estimate the vertical extent of contamination. Bioaccumulation of selected chemicals of concern (COCs) was examined in May 2000 only, using clam tissue exposed to creek sediments in standard laboratory tests. The analytical results provide an appropriate basis for interaction with the Regional Board to evaluate the need for further studies and/or possible remedial or preventative measures, if warranted.

The spatial extent of sediment chemical contamination and toxicity in the creek was examined relative to clean in-bay reference sites. Sediment samples were collected throughout the creek to estimate relative contributions from City-operated combined sewer overflows (CSOs) and other possible geographic sources. The scope of the investigations followed the Sampling and Analysis Plan (SAP) first submitted to the Regional Board in October 1998 (ADL 1998), and revised for the October 1999 and May 2000 investigations (ADL 1999). The SAPs were responsive to the Regional Board's Section 13267 letter of June 1998. The field and laboratory studies were performed by Arthur D. Little, Inc. (ADL) and SFPUC, with field support from Olivia Chen Consultants (OCC) and SCA Environmental (SCA). Results of these studies were submitted to the Regional Board after each investigation; except for a draft report issued in 1999 (ADL 1999), no other formal reports were issued. This report was prepared by Battelle Memorial Institute (Battelle) in response to a Regional Board request to report the horizontal and vertical extent of chemical distributions in Yosemite Creek.

1.1 Purpose of Report

The primary objectives of this report are to determine the environmental condition of creek sediments based on data collected over a two year period from 1998 to 2000. Information from this report will be used to support an ecological risk assessment, to establish potential risk-based remedial goals for creek sediments. Data are evaluated for appropriateness, completeness, and quality to determine if they can support an ecological risk assessment of Yosemite Creek, since that was not their original intended use.

Specific objectives of this investigation are:

1. to define the horizontal extent of contamination and toxicity under both wet and dry weather conditions in creek sediments;
2. to define the vertical extent of contamination in Yosemite Creek;

3. to identify chemicals of concern, and;
4. to determine if existing data are of sufficient quality, quantity and type to conduct a screening ecological risk assessment for creek sediments.

1.2 Report Organization

The main body of this report consists of eight sections described below. Appendices A and B present laboratory data and report graphics, respectively. Detailed descriptions of laboratory, data analysis and quality control methods used in support of these investigations are presented in separate documents (ADL 1998 & 1999) that are included on the CD-ROM (*Sediment Investigations at Yosemite Creek*), accompanying this report.

Section 1 – Introduction and Site History presents the purpose and objectives of the study, citing regulatory requirements and background. An abbreviated site history presents the location, geological setting, and cites available documents with detailed environmental information from previous investigations at and around the creek. Document references for previous and ongoing investigations at nearby sites are listed.

Section 2 – Study Design and Methods presents the sampling design and data interpretation methods used to determine the extent of environmental impact at the creek. An overview of the study design along with the sampling inventory and corresponding minor modifications made between sampling events are presented in Section 2.2. Brief discussions of field, laboratory and data analysis procedures are provided in Section 2.3. Detailed methods are presented in the project SAPs included on the CD-ROM accompanying this report.

Section 3 – Sediment Physical Characteristics presents results for grain size and total organic carbon in creek and reference area sediments. Effects of sediment physical characteristics on chemical and biological parameters are emphasized.

Section 4 – Sediment Toxicity presents results for standard 10-day acute laboratory tests, using the amphipod *Eohaustorius estuarius*. Results for creek and reference areas are described by presenting central tendencies, range and variation. Comparisons of survival between creek and reference areas are presented.

Section 5 – Sediment Chemistry presents results for organic and metal chemicals measured in the creek, defining vertical and horizontal patterns of distribution. Results are described by presenting central tendencies, range and variation between and across surveys. Results for statistical comparisons between creek and reference area surface sediments also are presented, and are used to identify chemicals of concern (COCs) for the creek.

Section 6 – Bioaccumulation in Clams presents results for selected COCs measured in organisms exposed to sediments in standard 28-day laboratory tests in April 2000. Results are described by presenting central tendencies, range and variation. Bioaccumulation factors calculated for each creek station are compared to results from clams exposed to in-bay reference stations to evaluate bioaccumulation potential through the local food web.

Section 7 – Summary and Conclusions are presented in this section. Final chemicals of concern for Yosemite Creek are identified in this section, synthesizing toxicity, sediment chemistry and bioaccumulation results. Data are re-examined to determine if they are of sufficient quantity and type to meet the study objectives identified in Section 1.

Section 8 - Cited literature is listed here.

1.3 Abbreviated Site History

1.3.1 Geographical Setting

The Yosemite Creek drainage basin encompasses approximately 1469 acres of the southeast portion of San Francisco (Figures 1-1 and 1-2). The present creek channel extends inland only 500 m from its mouth, trending northwest and terminating at the combined sewer and stormwater CSO 41 weir that was constructed in 1987. The current creek is actually a channel that receives combined sewage/storm water overflows and storm water runoff, but is otherwise separated from its original freshwater origins. The creek opens into the South Basin, which adjoins the southern shoreline of the Hunters Point Shipyard.

Prior to the turn of the century, areas surrounding Yosemite Creek were mainly marshland, wetland or submerged below mean tide level. Most of this area was land-filled between 1940 and 1970. The fill material was undocumented, but likely included crushed bedrock and construction debris from the Navy Shipyard property (Figure 1-2), which began ship repair operations in 1941. By 1950, areas surrounding the creek were heavily utilized for residences, commercial business, and small industry. The Navy port was an active center of secondary manufacturing for the shipyard from the 1940s to 1974. Within the last 15 years, industrial activities have primarily characterized the area surrounding the creek.

Potential contaminant pathways into Yosemite Creek include groundwater, surface runoff, eroded sediment, and combined sewer overflows. Present and past land use activities surrounding the creek include: an industrial landfill, chemical drum recycling facilities, auto wrecking yards, a junk yard, a lumber yard, tanneries, greenhouses, and several petroleum underground storage tank (UST) sites. Potential sources of historical chemicals into the Yosemite Creek Basin watershed include the following:

1. Pesticides that were used through the 1950's from greenhouse operations located west of Freeway 101. This area is of considerable distance from the creek, and although it may have been a historical source of persistent compounds such as DDT, it is probably not a significant current source to creek sediments.
2. Pesticides, metals and PCBs that were used in business and industrial operations from the drainage area east of Highway 101 (Figure 1-1). Major historical sources, based upon inventories of underground storage tanks, chemical releases, and hazardous waste generation included the properties of Bay Area Drum, Buckeye Properties and Gonzalez Bucket and Drum.
3. An industrial landfill operation located on the northern shoreline near the creek mouth was used to dispose solid and industrial wastes from the Navy shipyard at Hunters Point from 1958 through 1974. Disposed waste contained heavy metals, PCBs and petroleum hydrocarbons.

Due to wide ranging sources and disposal practices, elevated concentrations of metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and petroleum hydrocarbons appeared in creek sediments, and were detected in surrounding soil and groundwater samples. Surrounding areas likely presented numerous pathways for historical contaminants into the creek area, including CSO discharge, groundwater seepage, non-CSO stormwater runoff, and wind-borne particulates.

General Land Use. Historically, the area west of present-day Highway 101 was residential. This area was largely undeveloped in the late 1800s but, between 1900 and 1950, residential neighborhoods began to develop. Several large greenhouses and nurseries and a few small industrial businesses (e.g., auto repair shops, steel mill supply) were also located in this area during that time. Since the 1950s, the area has been mainly residential and commercial.

In the late 1800s and early 1900s, the land east of present-day Highway 101 was undeveloped or residential. By the 1950s, the area was a mix of residential, commercial, and small industrial businesses. The eastern portion of South Basin is located directly adjacent to the Shipyard, it served as a gateway for port activity and supported secondary manufacturing for the Shipyard from the 1940s to 1974.

Since the early 1980s, land use near Yosemite Creek is mostly industrial or undeveloped. Between the industrial area along the southern shoreline and Third Street, is a mix of residential, industrial and commercial uses. Third Street consists primarily of commercial businesses, while land west of Third Street is a mix of commercial and residential.

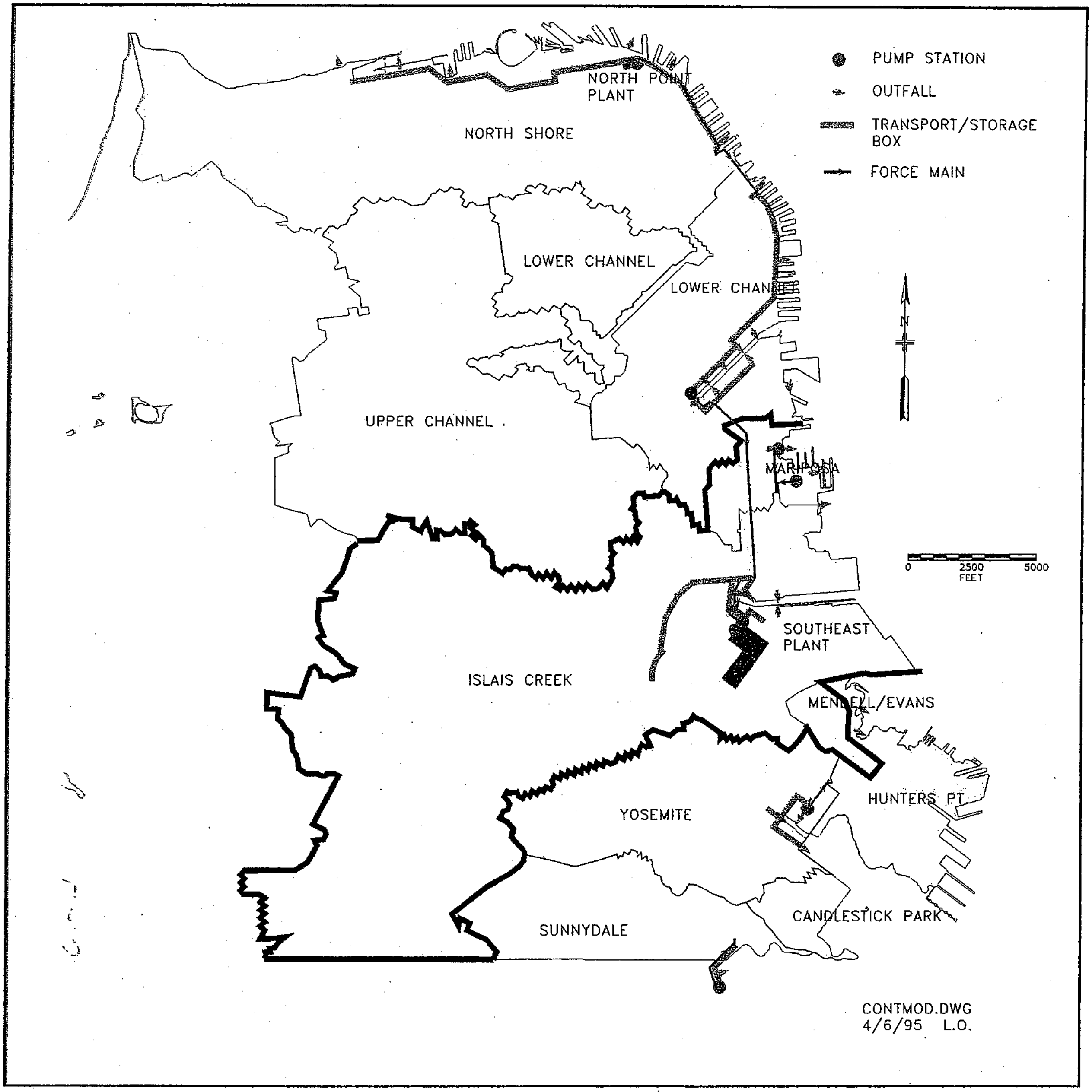

Figure 1-1. Major drainage basins surrounding Yosemite Creek.

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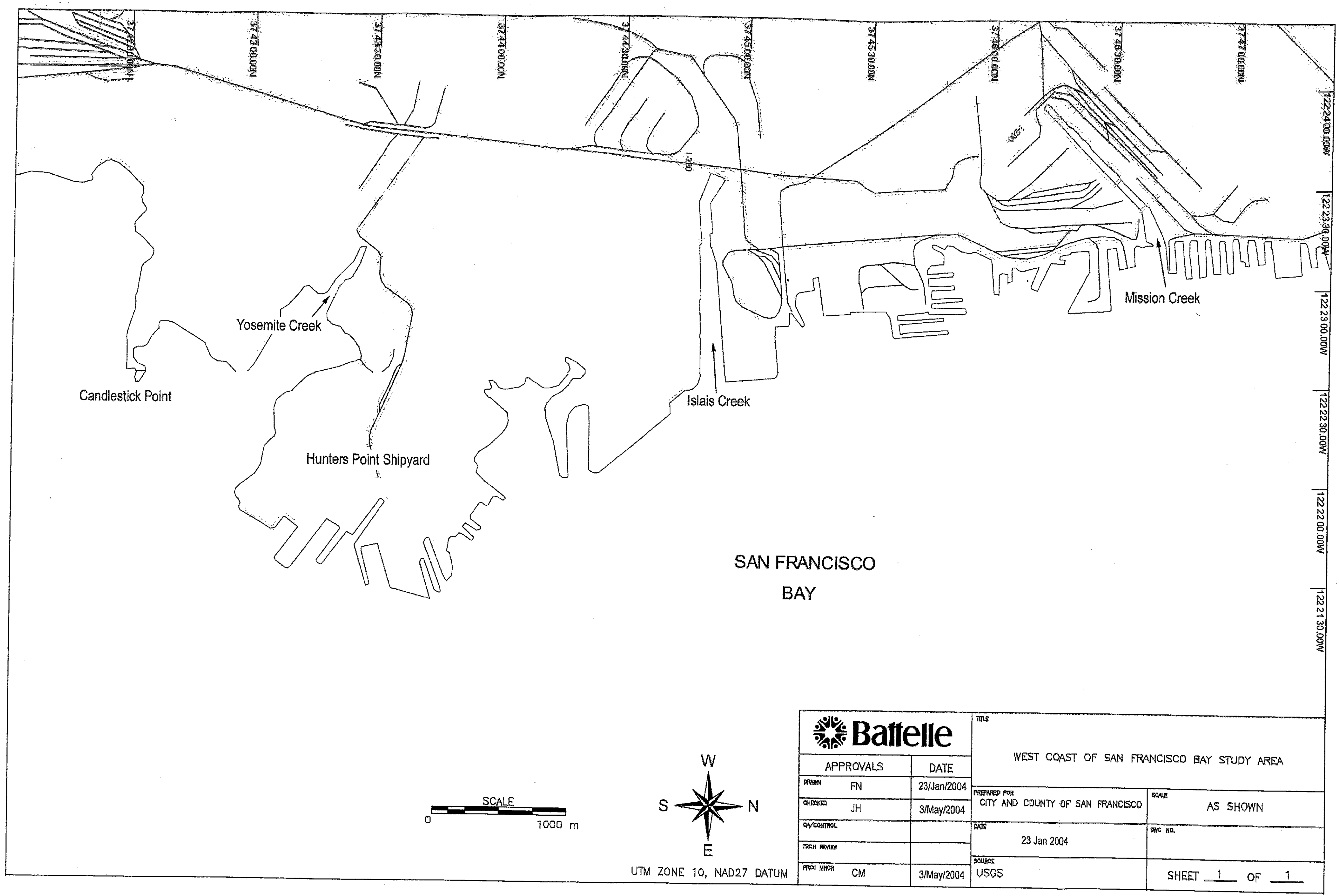


Figure 1-2. Yosemite Creek Study Area.

1.3.2 Stormwater and Sewer System

Since World War II, sewerage in Yosemite Creek Basin has operated under a number of different hydraulic configurations. Until 1958, the Yosemite Basin was isolated hydraulically, with combined sewer and stormwater flows discharging at three outfalls. Outfall 41, located at the head of Yosemite Creek, discharged the greatest volume from the basin, including most of the area east of Highway 101. The first of two smaller drainage sub-basins, including an area of approximately 200 acres north of Yosemite Creek, discharged to outfall 40, located near Griffith Street at the north side of Yosemite Creek. This area included such operations as Bay Area Drum and Legalett Tannery, as well as sanitary and stormwater discharges from the U.S. Navy Shipyard at Hunters Point. A second sub-basin discharged at outfall 42 located near Fitch Street, close to the Yosemite Creek mouth on the southern shoreline. Discharges from this outfall included flows from industrial properties located along the southern edge of Yosemite Creek, as well as the Candlestick Park area.

In 1959, the Yosemite pump station began operation and all dry-weather flows were thereafter transported and treated at the Southeast Wastewater Pollution Control Plant (SEWPCP) and later discharged at a depth of 12 m (40 feet) into San Francisco Bay from the Southeast Outfall. Combined wet-weather flows were discharged from three primary CSOs shown in Figure 2-1 (Section 2).

In 1965, the three Yosemite Basin overflow structures were consolidated into a single system. As a result of mandates promulgated under the 1972 Clean Water Act, San Francisco upgraded its sewage collection and treatment facilities, leading to significant reductions in pollutant loadings by the mid 1980s. In order to minimize the number and magnitude of wet weather overflows throughout the city, large storage and treatment boxes were built to contain combined flows during wet weather events. A transport/storage box designed to contain wet weather flows from Yosemite Basin went into operation in 1990, followed in 1991 by an additional transport/storage box for the adjacent Sunnydale Basin. The wet weather overflow located at the end of Yosemite Street was replaced by an overflow weir, located near the creek end (Figure 2-1, Section 2). By 1991, the combined sewer collection system had reached its current configuration.

These infrastructure improvements have reduced total suspended solids into the creek, and the number of overflows into Yosemite Creek have dropped from 46 to an average of one per year (Table 1-1) (CSPFS 2003).

Table 1-1. Number of CSO stormwater discharges into Yosemite Creek from 1996-2002 (from CSPFS 2003).

Winter Season	Number of CSO Discharges
2001-2002	1
2000-2001	0
1999-2000	0
1998-1999	5
1997-1998	3
1996-1997	1

1.3.3 South Basin Environmental Studies

Intensive environmental investigations have recently been conducted throughout the South Basin, including Yosemite Creek, its receiving waters, and the surrounding shoreline. Various remedial investigations and feasibility studies are being conducted under the U.S. Navy's Base Realignment and Closure Program of the Hunters Point Shipyard.

<u>**Ongoing Studies.**</u> Most recently, the Navy conducted an extensive data gaps investigation of subtidal sediments in the South Basin. In addition, the California State Parks Foundation is currently conducting ground water, soil, and sediment contaminant investigations on 35 acres encompassing Yosemite Creek that is designated for wetland creation (ref). These combined studies will produce extensive environmental information on the South Basin and surrounding shoreline. Existing information is available in the following reports and/or study plans, and is not detailed here.

US Navy Studies:

Parcel F Phase IB Ecological Risk Assessment conducted by PRC in 1996 (PRC 1996)

Parcel E Remedial Investigation conducted by Tetra Tech, Uribe and Associates, and Levine-Fricke Recon (Tetra Tech et al. 1997)

Parcel E Ecological Risk Assessment conducted by Tetra Tech in 1997 (Tetra Tech 1997)

Parcel E Ecological Risk Assessment Validation Study conducted by Tetra Tech and LFR in 2000 (Tetra Tech and LFR 2000)

Parcel F Validation Study conducted by Battelle, Entrix, and Neptune and Co. in 2002 (Battelle et al. 2002)

California State Parks Foundation Studies:

Draft Yosemite Slough Wetlands Restoration, Phase II Environmental Site Assessment Sampling Plan, Northgate Environmental Management, Inc., December, 2003

Past Studies. In addition to ongoing Navy and State Parks studies, other environmental investigations have been conducted in the area. These past studies are summarized below.

Bay Area Drum:

The Bay Area Drum site is located at 1212 Thomas Avenue (at the intersection of Thomas Avenue and Hawes Street) and occupies approximately 30,000 square feet. Drum reconditioning operations took place at the site from the 1940s until 1987. Typical drum suppliers included petroleum companies; paint, solvent, and thinner manufacturers; and solvent recyclers. Drums were sorted by type and quality and stacked in the yard; their number at any given time ranging from a few hundred to several thousand.

In 1963, pretreatment consisted of a trench with a large-mesh screen that allowed most of the solids to enter the sewer. By 1974, a system was built to contain, reuse, and recycle the caustic solution used to wash drums. Following a City request, a system to catch and reuse washing water, remove solids from the catch basin, and adjust pH prior to discharge into the sewer was installed in 1975. A Cease and Desist Order was issued by the City in 1986 requiring full compliance with applicable regulations and City discharge requirements. A February 1987 letter from the City to the DTSC indicates that the facility was in compliance as of December 1986. The facility was closed by March 1987.

Several soil and groundwater remedial investigations have been conducted at and near the facility since 1986. Sampling results indicated elevated concentrations of metals, PCBs, pesticides, VOCs, and SVOCs in soil and/or groundwater beneath the site and in the vicinity. Soil sampling results indicated PCBs at concentrations as high as 2600 $\mu g \cdot g^{-1}$, lead concentrations up to 52,000 $\mu g \cdot g^{-1}$, and pesticide concentrations up to 2200 $\mu g \cdot g^{-1}$ (Erler & Kalinowski 1996). An earlier study (CH2M Hill 1986) indicated that potentially contaminated surface runoff could enter the storm drains at the intersection of Thomas Avenue and Hawes Street and reach the Bay during heavy rainfall events. PCBs were detected in liquid/solid gutter samples at 2.9 and 7.3 $\mu g \cdot g^{-1}$ (CH2M Hill 1986). In 2001, approximately 6,000 cubic yards of contaminated soil were excavated from the site and backfilled with clean soil to residential cleanup standards. In 2002, an oxygen-releasing compound was injected into the groundwater to enhance the natural breakdown of VOCs. Samples collected at the site showed that contaminants in the groundwater were below the cleanup standards set for the site. The site was certified clean by DTSC in July 2003. Based on this information, past activities may have contributed contaminants to the creek, especially in the deeper sediments. Following cleanup and certification, however, this site should no longer pose a threat to Yosemite Creek.

Buckeye Properties:

Buckeye Properties is located at 1296 Armstrong Avenue adjacent to Yosemite Creek. This site occupies approximately 5 acres and is situated on tidal land reclaimed from San Francisco Bay between about 1943 and 1955. The Buckeye site was used for lumber storage from 1955 to 1986.

City Debris began operation at this site in 1990, but was ordered to stop receiving new material in 1995 because it did not have a Solid Waste Facility Permit. Mobile Debris Box began operation in 1996 or 1997, and apparently used the site to dump waste collected in debris boxes, resulting in two waste stockpiles on the site.

Based on the information reviewed, former operations at the Buckeye property do not appear to present a significant source of PCBs or pesticides; metal concentrations in the fill material or waste piles may present a potential source of contamination to Yosemite Creek.

In 1986, during sampling associated with construction of the Yosemite-Fitch sewer outfall, site soil was found to contain elevated concentrations of lead (230 $\mu g \cdot g^{-1}$) (Ecology & Environment 1993). Such levels, however, are typical of other San Francisco Bay fill sites and are not necessarily associated with former activities at the Buckeye site. Copper, mercury and zinc concentrations were found elevated in Buckeye property soils, along the back two-thirds of the south shore of the creek. PCBs were relatively low (250 $ng \cdot g^{-1}$). Groundwater beneath the site contained elevated concentrations of benzene (800 $ng \cdot g^{-1}$) and xylenes (1200 $ng \cdot g^{-1}$; French, 1989). Under CERCLA, the site did not require further remedial investigation.

City Debris began operation at this site in 1990, but was ordered to stop receiving new material in 1995 because it did not have a Solid Waste Facility Permit. Mobile Debris Box began operation in 1996 or 1997, and apparently used the site to dump waste collected in debris boxes, resulting in two waste stockpiles on the site. Sampling of the waste stockpiles indicated high levels of friable asbestos. Lead was detected at 7200 $\mu g \cdot g^{-1}$ (DTSC files, date unknown). The City took legal action and had the waste piles removed. There is no information, however, on any sampling following the waste removal (SFPUC 2003).

Based on the information reviewed, former operations at the Buckeye property do not appear to present a significant source of PCBs or pesticides; metal concentrations in the fill material or waste piles may present a potential source of contamination to Yosemite Creek.

Gonzales Bucket and Drum (GB&D):

GB&D is a drum reconditioning facility located at 1324 Fitzgerald Avenue. The facility has been in operation since 1977, and has been permitted and routinely inspected by City staff since 1979. Review of City pretreatment inspections did not indicate use of PCBs, though the waste inventory did include heavy metals and solvents. Prior to reconditioning, residuals in drums were removed using commercial adsorbent. Drums were reconditioned using a thermal treatment and a shot blasting process, or by soaking in a caustic bath, then rinsing to remove any residual from inside the drum and any paint from the exterior. Waste streams generated included spent adsorbent, bag house residue from the shot blasting process, sludge from the drum burner sump generated during the thermal treatment, and rinsewater. In response to an administrative order from the City, GB&D installed a pretreatment system in 1982 to neutralize the pH and remove metals from wastewater prior to discharging to the sewer. Following a second administrative order, a new pretreatment system incorporating an incineration process was installed in 1989. Since 1989, GB&D has maintained compliance with its City permit.

A 1989 DTSC inspection report indicates that the facility discharged liquid hazardous waste (based on pH) into the sewer without a permit. A 1991 DTSC inspection found baghouse dust on the floor, hazardous waste from the burner sump not stored in proper containers, and sludge spilled on the floor. The facility does not appear to be a significant source of metals, PCBs, or pesticides to Yosemite Creek.

Bay Protection and Toxic Cleanup Program (BPTCP):

The Regional Board (RWQCB 1998) identified Yosemite Creek and the adjacent South Basin as "sites of concern", citing the presence of pollutants in sediments, including PCBs, PAHs, DDT, Chlordane, Dieldrin, Endrin, tributyl-tin and metals. BPTCP analyses of sediment chemistry and toxicity were conducted in December 1995. Results are presented in Hunt et al. (1998a). Sediments were collected from a site approximately one-third the distance from the creek origin to the mouth, near SFPUC stations 2N and 2S (Figure 2-1, Section 2). Sediments had an 86% silt-clay fraction and total organic carbon (TOC) concentration of 2.3%. Amphipod tests (85% survival) showed no significant toxicity in comparison with the bay reference envelope guideline value (69.5% of control survival). Urchin larval development tests indicated significant toxicity. Hydrogen sulfide and un-ionized ammonia levels were not elevated. Mercury and PCB concentrations were cited as exceeding effects-range-median (ERM) guidelines (Long and Morgan 1991; Long et al. 1995). Chlordane was not analyzed.

U.S. Navy Studies:

A remedial investigation and feasibility study (RI/FS) of Parcel F, encompassing the Hunters Point South Basin shoreline and adjacent sediments was performed by PRC (1996) under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This study pointed to Navy sources of contamination to South Basin, but also introduced the possibility of other potential regional contaminant sources, including Yosemite Creek. Sediment analyses showed elevated concentrations of mercury, total PCBs, total DDT, and Chlordane. Sampling locations in Yosemite Creek from the 1996 PRC investigation are shown in Figure 2-1 (Section 2).

Since 1996, the Navy has conducted numerous studies in and around South Basin. Many of the associated reports (cited above) are still in draft form or are currently being prepared, and are not summarized here.

1.4 Summary

The evidence of contaminated sediments in Yosemite Creek prompted the Regional Board to require a site investigation to delineate the horizontal and vertical extent of creek contamination. SFPUC investigated sediment quality in Yosemite Creek in October 1998 to compare with historical data, which indicated high PCB and mercury concentrations in creek sediments. Additional studies of the creek followed in October 1999 and April 2000 to examine conditions over time and determine potential differences between wet and dry seasons. These studies were responsive to the Board's requirement for site investigations, and were designed to provide data necessary to document the type and extent of contamination in Yosemite Creek sediments. The sampling design, methods, analytical results, data interpretation and conclusions for the investigations are presented in the report sections that follow, herein.

2.0 STUDY DESIGN AND METHODS

This section presents the study design and methods used to collect, analyze and interpret sediment data in Yosemite Creek. The study design describes data type and sampling location used to report the spatial extent of environmental impact to sediments that have received and continue to receive combined effluent and stormwater discharges from City-operated CSOs (study objectives 1 and 2, Section 1.1). In addition, the study design describes the criteria used to identify chemicals of concern (COCs) for Yosemite Creek sediments.

The analytical chemistry program featured ultra-trace measurements of organic and inorganic compounds consistent with methods and analyte lists used in the San Francisco Bay Regional Monitoring Program (RMP) and the Bay Protection and Toxic Cleanup Program (BPTCP). Detailed method descriptions of field activities, laboratory and data analyses, including quality control procedures and criteria, are presented in the Sampling and Analysis Plans are included on the CD-ROM accompanying this report.

2.1 STUDY DESIGN

Sediment sampling locations were chosen to measure the vertical and horizontal distribution of sediment chemical contaminants throughout the creek, and toxicity in corresponding surface samples. Stations extended the creek length and were placed near active and historical CSOs (Figure 2-1). COCs were identified by comparing creek results for each station to a threshold limit calculated using reference station results for the same survey.

Surface sediment chemistry and toxicity were measured in October 1998, October 1999, and April 2000 in the creek and at selected in-bay reference locations (Figure 2-1). Subsurface sediment cores were collected in December 1998 to a target depth of 4 feet below the sediment surface and analyzed for bulk chemistry in 1-ft intervals. Bioaccumulation tests using the clam, *Macoma nasuta* were conducted in April 2000 only. Tissues were analyzed for COCs (identified in Section 5) known to biomagnify in the marine food web.

Sediments in all surveys were analyzed for 20 trace level polychlorinated biphenyl congeners (PCBs), 17 chlorinated pesticides, 41 polynuclear aromatic hydrocarbons (PAHs) - including alkylated homologs and 12 metals. April 2000 tissue samples were analyzed for mercury, PCBs and chlorinated pesticides. Surface sediments collected in October 1998 also were analyzed for total and resolved saturated hydrocarbons (SHC), linear alkylbenzenes (LABs) and PCB Aroclors. Linear alkylbenzenes were measured as indicators of sewage-related contamination. Saturated hydrocarbons were measured to help determine potential petroleum-related sources of co-occurring PAH. Aroclors were measured for comparison with historical data. These analytes were used as ancillary data to identify potential sources of coexisting contaminants, and were not treated as potential COCs. In addition, surface sediment grain size and total organic carbon (TOC) were measured to support interpretation of chemistry and toxicity data.

Acute toxicity was measured in surface sediments using the amphipod crustacean *Eohaustorius estuarius* exposed for 10-days in all three sampling events. Toxicity tests in 1998 were invalid due to probable predation of test organisms from resident polychaetes that were not removed prior to testing in order to comply with Regional Board protocols. A modified method based on protocols from the American Society for Testing and Materials (ASTM), the U.S. EPA and the Army Corps of Engineers (see Table 2-6) was used for toxicity testing in 1999 and 2000. SFPUC conducted all toxicity tests at their Oceanside Biology Laboratory. Conventional sediment parameters were assessed in each test to determine whether observed toxicity was attributable to natural products of organic degradation, such as ammonia and dissolved sulfides. Modified toxicity tests made use of 1) exchanges of overlying water both before and during (one per day) the test to reduce ammonia, and 2) press sieving of sediments prior to test initiation to remove potential resident predators.

Parameters measured and corresponding laboratories used throughout the program are presented in Table 2-1. Individual analytes and detection limits for each test are presented in Appendix A. Detailed method descriptions are presented in the Project Sampling and Analysis Plan on the accompanying CD-ROM.

Surface sediment sampling inventories for each survey, detailing number of stations sampled and tests performed, are presented in Table 2-2. Corresponding reference station information is shown in Table 2-3. Reference station location coordinates are shown in Table 2-4. Location coordinates for all samples collected are included in the project database (provided in Excel project database on the accompanying CD-ROM). Subsurface core descriptions are presented in Table 2-5. A description of the sampling design used to collect surface sediment follows.

Table 2-1. Summary of analytical methods and laboratories used in each survey.

Parameter	Year Studied[1]	Laboratory	Analytical Method
		Sediment Chemistry	
PAHs	1998-2000	ADL	EPA SW-846 8270 modified using SIM
PCB congeners & Pesticides[2]	1998-2000	ADL	EPA SW-846 8082 modified
Saturated Hydrocarbons (SHC)	1998	ADL	EPA SW-846 8015 modified
LAB	1998	ADL	EPA SW-846 8270 modified using SIM
Metals	1998-2000	SFPUC	EPA SW-846 6010 and 7000 series
Total Organic Carbon (TOC)	1998-2000	SFPUC	EPA SW-846 Method 9060
Grain Size	1998-2000	SFPUC	Plumb et al. 1981
		Bioassays	
10-day solid phase amphipod[3]	1998-2000	SFPUC	ASTM E1367-92 modified using EPA/USACE 1999 (PN 99-3)
28-day clam bioaccumulation	2000	EVS	EPA/USACE 1991
		Bioaccumulation in Clam Tissue	
PCB congeners & Pesticides	2000	ADL	EPA SW-846 8082 modified
Mercury	2000	SFPUC	EPA SW-846 7460

[1]1998-2000 = October 1998, October 1999 & April 2000; [2]Aroclors also measured in 1998; [3] Bioassays not valid in 1998

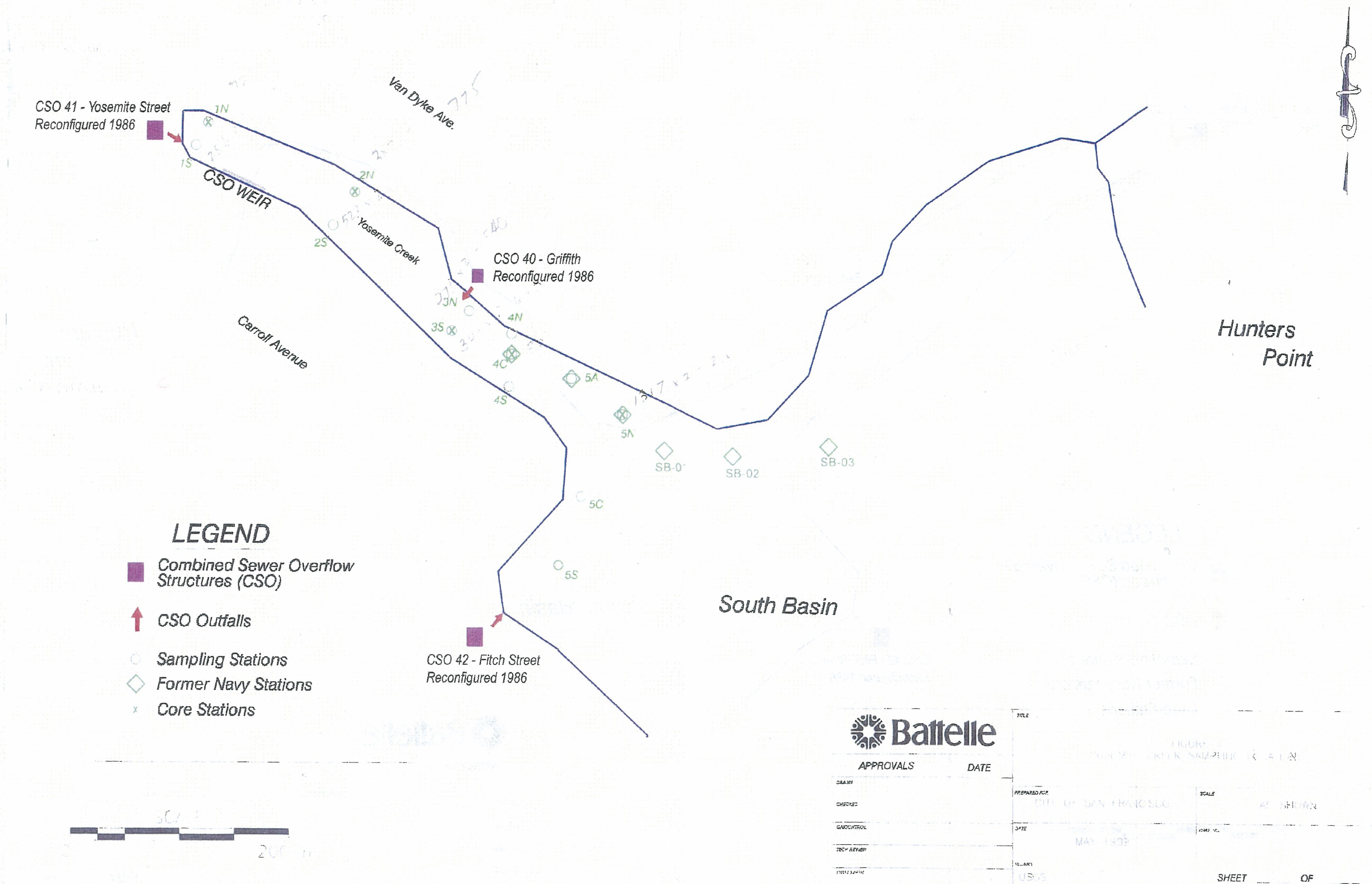


Figure 2-1. Yosemite Creek sampling locations.

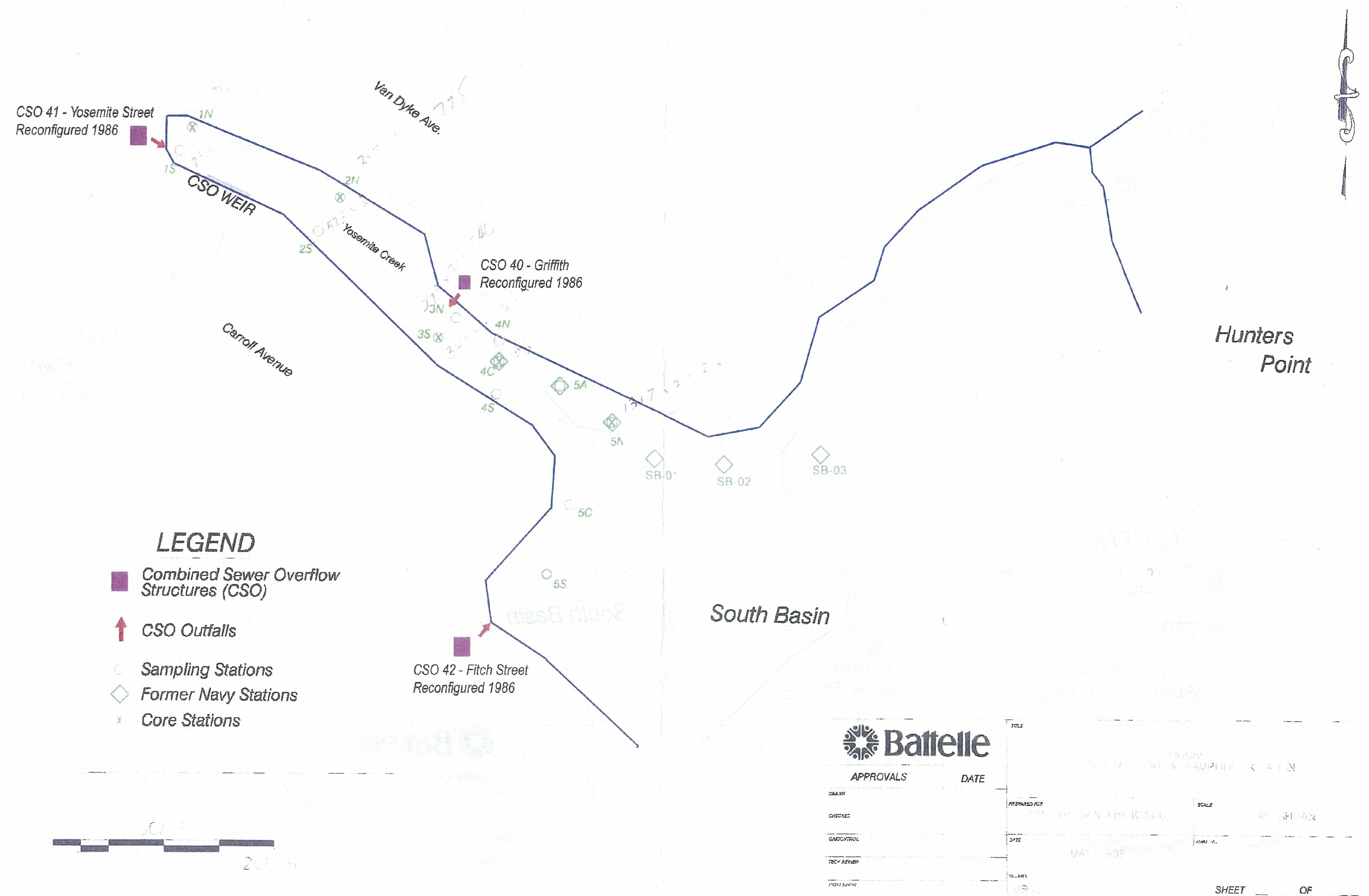


Figure 2-1. Yosemite Creek sampling locations.

2.1.1 Yosemite Creek – Surface Sediments

Thirteen Yosemite Creek surface sediment stations were sampled in 1998 (Figure 2-1). Eight of these stations were re-sampled in 1999 and 2000. Stations extended from the creek end near the historic CSO to the north shore of the creek mouth; however, not all stations were sampled each year. Results for three sediment stations sampled in May 2001 just outside of the creek mouth by the U.S. Navy (Battelle et al. 2002) were included in the SFPUC April 2000 data set, following a request from the Regional Board. Results for common tests and methods used between SFPUC and Navy studies are presented in this report. Results for US Navy stations SB-01, SB-02, and SB-03 are presented in Appendix A1.

Sampling parameters are shown for each creek station by year in Table 2-2. Corresponding information for reference stations and subsurface cores is shown in Tables 2-3 and 2-4, respectively. Subsurface cores were targeted to a depth of 4 feet in 1998 at five of the corresponding Yosemite Creek surface sediment stations, with only two stations sampled to the target depth (Table 2-5) due to refusal.

Table 2-2. Sample inventory for surface sediments collected at Yosemite Creek.

Station	Metals	PAH	PCBs & Pesticides	LAB, SHC & Aroclors	Grain Size/TOC	Toxicity
			October 1998			
1N	1	1	1	1	1	
1S	1	1	1	1	1	1
2N	3	3	3	3	3	
2S	1	1	1	1	1	1
3N	1	1	1	1	1	1
3S	1	1	1	1	1	
4C	1	1	1	1	1	1
4N	1	1	1	1	1	
4S	1	1	1	1	1	
5A	1	1	1	1	1	
5C	3	3	3	3	3	
5N	1	1	1	1	1	1
5S	1	1	1	1	1	
Total Samples	17	17	20	20	20	5
Total Stations	13	13	13	13	13	5
			SFPUC October 1999 and April 2000[1]			
1N	1	1	1		1	1
1S	1	1	1		1	1
2N	1	1	1		1	1
2S	1	1	1		1	1
3N	1	1	1		1	1
3S	1	1	1		1	1
4C	1	1	1		1	1
5N	1	1	1		1	1
Total Samples	8	8	8		8	8
Total Stations	8	8	8		8	8
			US Navy May 2001 (included in this report)			
SB-01	1	1	1		1	
SB-02	1	1	1		1	
SB-03	1	1	1		1	
Total Samples	3	3	3		3	
Total Stations	3	3	3		3	

[1]=PCBs, pesticides and mercury were also measured in clam tissue at each station in April 2000

2.1.2 Reference Area

A total of six reference stations were sampled throughout the program, although not all stations were sampled each year (see Tables 2-3 & 2-4). These locations, shown in Figure 2-2, extending from the south to north end of San Francisco Bay, consisted primarily of fine-grained sediments (i.e., >80%) with moderate organic carbon content (ca. 1%). Five of the sites have been sampled previously in the RMP and/or BPTCP, and were used to define the toxicity reference envelope (Hunt et al. 1998a). In the 1999 SFPUC survey, an additional reference station at Tomales Bay, located approximately 20 kilometers northwest of San Francisco Bay was included. This site was evaluated in the BPTCP but not used in the development of toxicity tolerance limits. It was sampled as a potential "fine-grained" reference site that had consistently produced high amphipod survival and low chemical concentrations in numerous dredge material disposal studies. It was not resampled in 2000, as the other in-bay reference stations adequately addressed fine-grained sediment conditions.

The 1998 SFPUC survey, in contrast to following years, used only one reference station, Paradise Cove. A single reference location was considered adequate to address the initial study objective established in 1998, which was to "confirm or refute Regional Board findings." Reference sites were expanded in 1999 and 2000 to provide background data sufficient to calculate corresponding reference envelopes relevant to each survey. This was considered necessary after reduced survival was observed in toxicity tests performed at Paradise Cove in 1998, in the absence of elevated chemical contaminants.

Although unimpacted, in-bay reference stations are not well matched with the environmental conditions of the creek sediments, due to differences in grain size/mineralogy, total organic carbon, hydrodynamics and other conditions (e.g., temperature, depth, salinity). Any of these factors can affect the environmental parameters of interest, potentially confounding interpretation of results. These stations were used because of their established history within the RMP, and the lack of other suitable reference locations that may have better represented creek conditions. Since creek and reference sediments were not well-matched, chemistry results were normalized to minimize effects that may have been caused by sediment physical characteristics. This is a common approach that is used to correct disparities between test and reference areas that are independent of contaminant inputs. Chemical results were normalized using total organic carbon, since it is known to have a significant influence on sediment contaminant concentrations and associated toxicity (Di Toro 1991; Schwartz et al. 1984).

Table 2-3. Sample inventory for Reference Area surface sediments.

Station	Metals	PAH	PCBs & Pesticides	LAB, SHC & Aroclors	Grain Size/TOC	Toxicity
			October 1998			
Paradise	1	1	1	1	1	1
Total Stations	1	1	1	1	1	1
			October 1999			
Island#1	1	1	1		1	1
Marconi Cove	1	1	1		1	1
North Site	1	1	1		1	1
Paradise	1	1	1		1	1
South Site	1	1	1		1	1
Tubbs Island	1	1	1		1	1
Total Stations	6	6	6	0	6	6
			April 2000[1]			
Island#1	1	1	1		1	1
North Site	1	1	1		1	1
Paradise	1	1	1		1	1
South Site	1	1	1		1	1
Tubbs Island	1	1	1		1	1
Total Stations	5	5	5	0	5	5

[1] PCBs, pesticides and mercury were measured in clam tissue in April 2000

Table 2-4. Reference Area surface sediment sampling locations.

Location	BPTCP Station ID	Latitude (N)[1]	Longitude (W)[1]	Location Description
Paradise Cove	20005	37° 53' 57.00"	122° 27' 51.60"	Central San Francisco Bay
Tubbs Island	20006	38° 06' 52.20"	122° 25' 09.60"	San Pablo Bay
Island #1	20007	37° 06' 43.20"	122° 19' 42.60"	San Pablo Bay
North Site	20013	37° 34' 13.80"	122° 08' 58.50"	South San Francisco Bay
South Site	20014	37° 32' 10.80"	122° 07' 09.60"	South San Francisco Bay
Marconi Cove	20009	38° 08' 21.60"	122° 52' 27.60"	Tomales Bay

[1]Station coordinates shown in NAD 83 datum

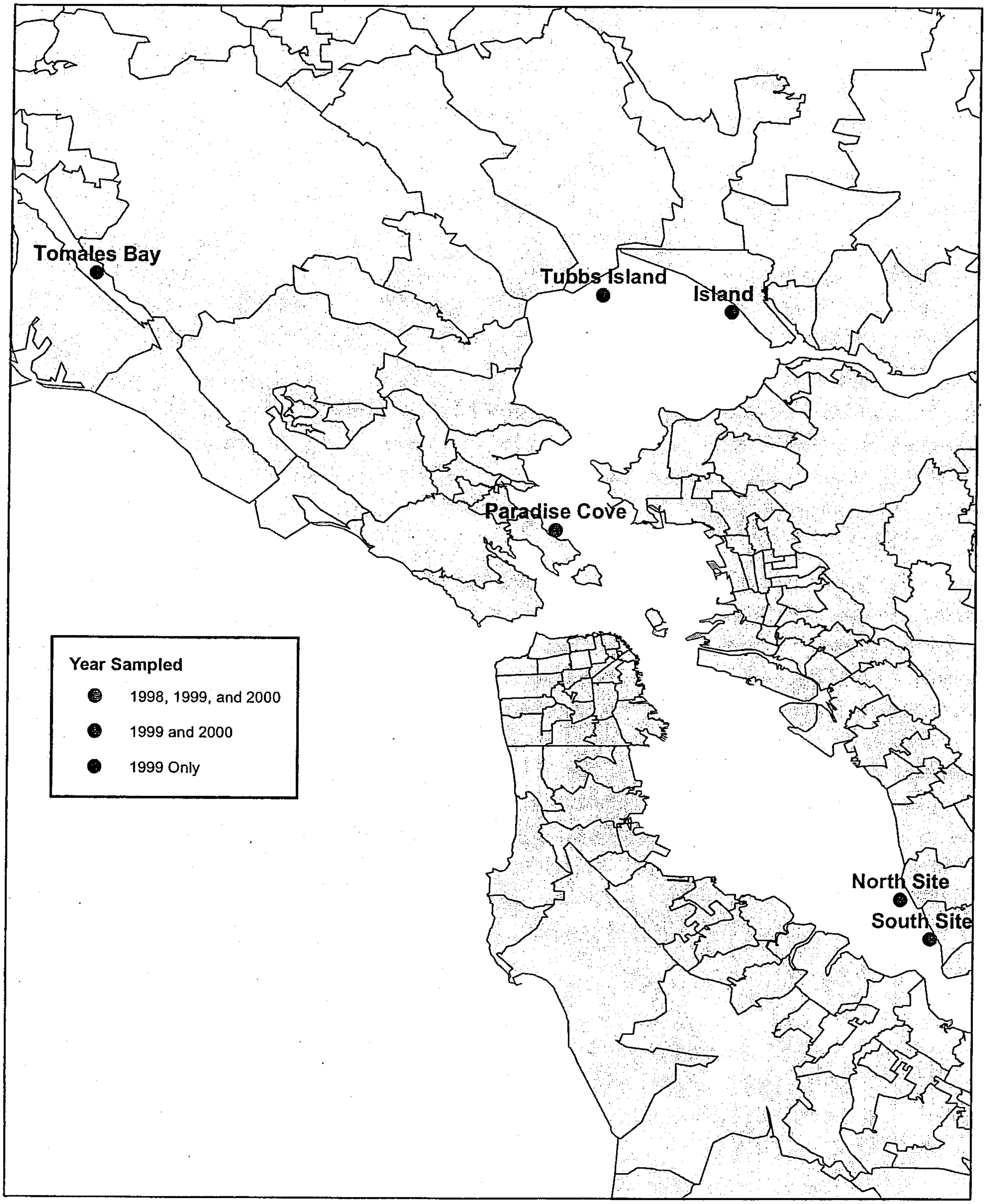


Figure 2-2. **San Francisco Bay reference sites.**

2.1.3 Subsurface Sediments

Five subsurface cores were collected from the creek in October 1998, penetrating a maximum depth of 4 feet. The top two 1-ft core intervals (i.e., 0-1 and 1-2 ft) were analyzed for bulk chemistry, grain size and total organic carbon. The remaining core intervals (i.e., 2-3 ft and 3-4 ft) were stored frozen until they were analyzed in 1999 for bulk chemistry only. Core locations, which corresponded with selected surface sediment stations, are shown in Figure 2-1. Cores were not collected at any of the in-bay reference stations. Subsurface data were collected to determine whether significant vertical contaminant gradients existed in the creek, and if possible to bound the vertical extent of contamination.

2.1.4 Summary of statistical comparisons between creek and reference stations

Individual comparisons are made for each station within each creek and year sampled using a group tolerance limit, to produce a "reference envelop" for each parameter evaluated. Group tolerance limits were calculated using two reference seasonal data sets: 1) 1999 (dry season); and 2) 1998 and 2000 (wet season). Reference data for the 1998 and 2000 surveys were combined, since only one station was sampled in 1998.

A 95^{th} percent one-sided predictive limit (a=0.05 for one-sided test) was calculated for chemical parameters measured in reference surface sediments. The predictive interval is a modification of the confidence interval and is used when comparing individual results to grouped data (Steel and Torrie 1960). Nonparametric tolerance interval bounds were used (Hahn and Meeker 1991) for chemical data that failed test assumptions for the predicative limit (e.g., non-normally distributed data). A lower tolerance limit was calculated for reference survival (to identify stations more toxic than reference); and an upper predictive limit was calculated for reference chemistry (to identify stations more contaminated than reference). Yosemite Creek data were compared on a station-by-station basis to the corresponding upper 95^{th}-predictive limit for wet and dry sampling seasons.

Table 2-5. Sample inventory for subsurface sediments collected in December 1998.

Station	Core Intervals[1]	Analyses[2]	Comments
1N	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
2N	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	2-3 & 3-4 ft core not collected due to refusal
3S	1, 2	Grain size, PCB, pesticides, PAH, metals, TOC	2-3 & 3-4 ft core not collected due to refusal
4C	1, 2, 3, 4	Grain size, PCB, pesticides, PAH, metals, TOC	
5N	1, 2, 3	Grain size, PCB, pesticides, PAH, metals, TOC	3-4 ft core not collected due to refusal

[1]=core interval 1 = 0-1 ft, 2 = 1-2 ft, 3 = 2-3 ft, 4 = 3-4 ft; [2]=Grain size & TOC - measured intervals 1 & 2 only

2.2 Methods Summary

Abbreviated field and analytical methods follow. Detailed method descriptions for sample collection, handling, laboratory, data analysis and quality control are presented in the Sampling and Analysis Plan included on the CD-ROM accompanying this report.

2.2.1 Field Methods

Surface sediments were collected with a 0.05-m^2 Ponar grab sampler, constructed of stainless steel and coated with Halar to reduce cross-contamination. A sufficient number of grabs (4-5) were collected at each station to ensure adequate sediment for testing. Surface sediment was subsampled from the top 5 cm of each grab and homogenized in a Halar-coated bucket. Subsurface cores were collected several months after surface sediments in 1998, due to extremely low tidal conditions encountered during surface sampling. Subsurface sediments were sampled in December 1998 using a gravity corer with a butyrate liner. The liners were capped and sediments were sub-sectioned into 1-ft intervals and homogenized in SFPUC's Oceanside Laboratory prior to subsampling. Organic chemistry samples were placed in borosilicate glass jars; metal samples were placed in polycarbonate jars and TOC and grain size samples were stored in plastic bags. All samples were stored on ice and transferred within 48 hours from the vessel to SFPUC's Oceanside Laboratory for subsequent shipment or analysis.

2.2.2 Laboratory Methods

All samples were analyzed using standard analytical methods referenced in individual laboratory standard operating procedures (SOPs). Quality control samples for laboratory and field samples were analyzed. Laboratory quality control samples consisted of calibration standards, matrix spikes, duplicate samples, standard reference materials, surrogates, and laboratory blanks where appropriate. Table 2-6 lists chemistry, toxicity and physical tests, and analytical laboratories for the program.

Table 2-6. Summary of sediment analytical methods and laboratories.

Parameter	Laboratory	Analytical Method
Chemistry		
Polynuclear Aromatic Hydrocarbons (PAH)	ADL	EPA SW-846 8270 modified using SIM
Polychlorinated Biphenyl Congeners (PCBs) & Chlorinated Pesticides	ADL	EPA SW-846 8082 modified for congener analysis
Metals	SFPUC	EPA SW-846 6010 and 7000 series
Total Organic Carbon (TOC)	SFPUC	EPA SW-846 Method 9060
Grain Size	SFPUC	Plumb et al. 1981
Toxicity		
10-day solid phase amphipod	SFPUC	ASTM E1367-92 modified using EPA/USACE 1999 (PN 99-3)

Physical Laboratory Methods. Sediment grain size was analyzed using a sieve and pipette method by SFPUC, which produced results for four grain size classes (gravel, sand, silt and clay). Results reported for 1998 samples only, included mean diameter, percent sediment contribution for each of 16 size classes, Phi sorting coefficient, skewness and kurtosis. Percent gravel, sand, silt and clay only were reported for 1999 and 2000 data. Total organic carbon (TOC) was analyzed by SFPUC using EPA Method SW-846 9060, combustion followed by infrared detection of carbon dioxide, and reported as a percentage of total sediment dry weight.

Chemical Laboratory Methods. Sediment hydrocarbon analyses consisting of polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl (PCB) congeners, and chlorinated pesticides were analyzed by ADL's Environmental Laboratory in Cambridge, MA. Additionally, saturated hydrocarbons (SHC) and linear alkylbenzenes were analyzed for source identification purposes in the 1998 survey only. A total of 41 PAH compounds were measured using gas chromatography with mass spectrometer selected ion monitoring (SIM). PCBs were measured as 22 congeners in all surveys and additionally as Aroclors in 1998 only. Dry weight detection limits for organic analytes were all in the sub-part-per-billion range, ranging from 0.01 $ng \cdot g^{-1}$ for pesticides and PCBs to 0.1 $ng \cdot g^{-1}$ for PAHs.

Table 2-7 shows detection limits and corresponding methods for the 12 heavy or trace metals measured throughout the investigation. Sediment metals were analyzed by SFPUC using nitric acid and hydrochloric acid digestion followed by inductively coupled plasma spectroscopy (ICP), or atomic absorption with either a flame or graphite furnace detector, except mercury, which was analyzed using atomic absorption following cold vapor extraction.

Table 2-7. Methods and detection limits for metals (µg·g⁻¹ dry weight).

Metal	Minimum Detection Limit	Analytical Method*
Aluminum (Al)	0.2/0.01	ICP/AAGF
Arsenic (As)	0.5	ICP
Cadmium (Cd)	1.0/0.025	ICP/AAH
Chromium (Cr)	0.1/0.01	ICP/AAGF
Copper (Cu)	0.2	ICP
Iron (Fe)	0.2	ICP
Mercury (Hg)	0.3	ICP
Nickel (Ni)	0.0005	CVAA
Lead (Pb)	0.2	ICP
Selenium (Se)	1.0/0.07	ICP/AAGF
Silver (Ag)	0.025	AAH
Zinc (Zn)	0.1	ICP

AAH = Atomic absorption hydride; ICP= Inductively coupled plasma emission spectroscopy; AAGF= Atomic absorption with graphite furnace; CVAA = Cold vapor atomic absorption

Toxicity Laboratory Methods. The acute 10-day amphipod test was performed by SFPUC following ASTM E1367-92 modified following EPA/USACE guidelines in Public Notice 99-3 to remove potential confounding toxicity from elevated levels of ammonia and/or hydrogen sulfide. All test sediments were press-sieved (through 0.5 mm mesh stainless steel screens) and picked to remove possible amphipod predators and native amphipods prior to test initiation. Eighty percent (80%) of overlying water was exchanged and allowed to equilibrate for 24-hours for all sediment samples with ammonia porewater values greater than 20 $mg{\cdot}L^{-1}$ prior to test initiation. Dissolved oxygen, pH, salinity and temperature were measured and recorded daily. After 10-days of exposure, amphipods were carefully removed by wet-sieving, counted, placed on clean sediment and permitted to rebury. Percent survival and percent reburial were reported for each of the five laboratory replicates run for each sample. The test was considered valid if after ten days of exposure the average control survival was ≥90% and each control replicate had at least 80% survival.

Bioaccumulation Laboratory Methods. A 28-day clam bioaccumulation test was undertaken to evaluate the potential for chemical uptake and subsequent food chain transfer. Bioaccumulation of certain organic chemicals and metals is known to occur across trophic levels. The test animal, *Macoma nasuta* is widely distributed and native to San Francisco Bay, commonly used in dredged sediment studies, known to actively ingest surface sediments, and provides enough tissue for trace level tissue analysis. Laboratory bioaccumulation was performed following the EPA/USACE (1991) "Greenbook" protocol, modified to use one laboratory "replicate" instead of five used in standard dredged material testing programs. One composite sample of 25 clams was analyzed for chemistry at all stations. The reduced number of laboratory replicates (i.e., n=1 instead of n=5 in EPA/USACE [1991]) was reasonable due to the high sample density (e.g., field replication) used in the creek. Laboratory control samples (e.g., zero time) were analyzed for quality control purposes. Dry weight chemical results in tissue are presented in Appendix A3.

3.0 PHYSICAL CHARACTERISTICS OF SEDIMENT

Grain size and total organic carbon (TOC) results for surface and subsurface sediments are presented in this section. These physical parameters are known to influence contaminant distribution and amphipod toxicity in sediment, and are therefore important in the interpretation of data. Grain size categories are summarized in Table 3-1. Interpretation of results focuses primarily on surface and near-surface sediments due to their influence on resident biota and contaminant bioavailability. For this reason, physical parameters were measured only at the surface and in the top two core intervals (i.e., 0-1 and 1-2 ft). Surface sediment results for Yosemite Creek and the reference areas are summarized in Tables 3-2 through 3-3. Surface distributions of percent fines (silt + clay fractions) and TOC are shown in Figures 3-1 and 3-2. Surface sediment results are presented in Appendix A1 for each station. Results for subsurface core intervals are presented in Appendix A2.

Sediment grain size characteristics are emphasized for their controlling influence upon benthic community dynamics, and because they correlate with biologically meaningful variables such as sediment porosity, compaction, oxygen tension, water content and retention of organic matter. Grain size characteristics are equally important in controlling sediment chemical concentrations due to an increase in adsorptive capacity with finer-grained particles. Total organic carbon concentrations provide an indication of the amount of organic matter present in sediment. High organic content is typical of fine-grained sediments from low-energy depositional areas and areas impacted by anthropogenic activities, including discharges from sewage outfalls and storm drains. High levels of organic carbon also occur naturally in sediments from terrestrial and aquatic humic plant material.

Most studies of marine and brackish sediments show a high positive correlation between fine-grained particles and organic carbon. Deposition, resuspension and sorting processes influenced by the nearshore wave and current regime normally create a gradient of diminishing grain size proceeding offshore. As they are introduced into the coastal system, the smallest particles remain in suspension for longer periods and, following deposition, are more readily re-suspended from the seafloor by waves, currents and turbidity flows.

Since contaminants are strongly bound to organic particles that are complexed with fine mineral particles, there is a high potential for contaminant accumulation in habitats where settlement of finer-grained, organically enriched sediment occurs. It is this binding process that usually results in far lower soluble threshold limit concentrations (STLC) than those expected based on corresponding bulk chemical concentrations in sediments.

3.1 Overview

Creek sediments consisted mainly of fine-grained material (=80% fines), located at water depths of 2 m and less (Figure 3-1). In general, percent fines decreased with distance from the creek end, except for persistent fine material observed on the southern creek shoreline (Stations 3S and 4S in Figure 3-1).

A full suite of grain size parameters including mean grain size for 12 classes, Phi sorting coefficient and percent gravel, sand, and fines (silt + clay) were measured for 1998 surface sediment data only. Percent fines and sand were the only grain size metrics reported in 1999 and 2000.

Table 3-1. Sediment grain size classes (adapted from Folk 1968).

Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class
64	Pebble	0.50	Medium sand	0.031	Medium silt
16		0.42		0.0156	Fine silt
		0.35		0.0078	Very fine silt
		0.30			
4	Granule	0.25	Fine sand	0.0039	Clay
3.36		0.210		0.0020	
2.83		0.177		0.00098	
2.38		0.149		0.00049	
2.00	Very coarse sand	0.125	Very fine sand	0.00024	
1.68		0.105		0.00012	
1.41		0.088		0.00006	
1.19		0.074			
1.00	Coarse sand	0.0625	Coarse silt		
0.84		0.053			
0.71		0.044			
0.59		0.037			

— denotes criterion (i.e., < 0.0625 mm) for fines (silt + clay)

Percent fines and TOC were significantly, but very weakly correlated (r^2=0.17, p=0.03). The strong correlation typically observed in marine sediments was undermined primarily because of the sandier material associated with relatively high concentrations of TOC at several of the mid-creek stations.

3.2 Reference Area

Most reference area samples had greater than 90% fines (mean=79.2%), consistent across surveys, except for North Site sediments (Figure 2-2, Section 2), which were sandy in 2000 (26.3% fines) yet fine-grained in 1999. South Site sediments were consistently coarser with less than 60% fines in two consecutive samplings. In general, reference site sediments had similar grain size distributions compared to most creek sediments. Only a few sediment samples collected at Yosemite Creek, most notably 3N, were consistently coarser-grained than reference area samples. Concentrations of total organic carbon in reference sediments ranged from 0.4 to 1.8% (mean=0.9%) for all three sampling events. These concentrations were generally lower than TOC concentrations measured in most creek sediments, especially those measured during the 1998 wet-weather survey where all stations had TOCs greater than 2%. Reference surface sediment results are summarized in Table 3-2. There were no subsurface cores collected at the reference sites.

Sediment physical attributes can affect test results, including toxicity and chemistry, as discussed in Sections 4 and 5, respectively. In particular, grain size and organic carbon affect adsorption and retention of sediment contaminants and their subsequent bioavailability. Many creek sediments had significantly higher concentrations of TOC compared to reference area sediments (see Table 3-2).

3.3 Yosemite Creek

With the exception of sandy sediments that characterized the mid-southern section of the creek (Figure 3-1), both surface and subsurface sediments along the creek length were characterized by fine-grained fractions exceeding 80% of sediment dry weight. Percent fines were highly variable in creek surface sediments, ranging from 5.1 to 99.4% (mean=86.2%); however, distribution patterns were similar between surveys (Figure 3-1, Appendix A1). Sediments located at the end of the creek were finer-grained than sediments closer to the reconfigured CSO, suggesting greater hydrodynamic activity (scouring) near the active CSO. Percent fines at Station 3N (located closest to the reconfigured CSO) ranged from 5.1 to 81.7% fines across sampling events, with the lowest value measured during the 2000 wet weather survey. Subsurface samples, with the exception of Station 5N collected only in 1998, had higher percent fines in the 0-1 ft interval when compared to the lower 1-2 ft segment. Core Station 5N, located farthest from the creek end, was atypical of the five core samples with courser sediments (66.1% fines) overlying much finer material (88.1% fines). The mean and range of percent fines in creek and reference area surface sediments are shown in Table 3-2 for each survey.

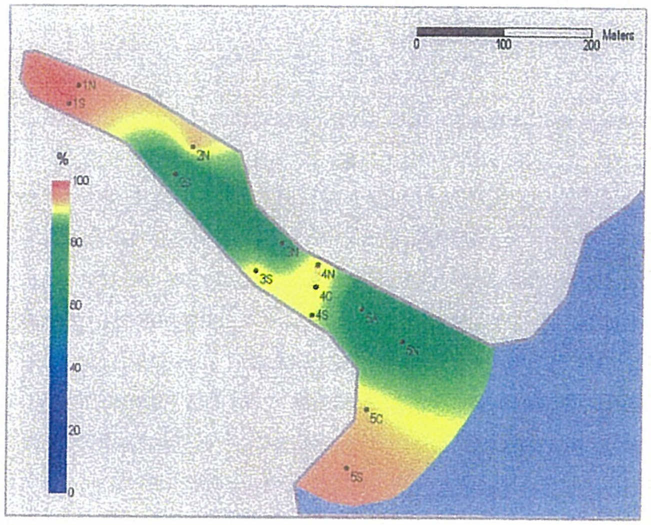
Table 3-2. Yosemite Creek - percent fines and TOC in surface sediments.

Survey Year	Area Sampled	No. of Stations	Mean % Fines	Range % Fines	Mean % TOC	Range % TOC
1998	Yosemite Creek	13	89.3	75.4 - 97.5	2.0	1.5 – 2.7
	Reference Sites	1	90.3	90.3 - 90.3	1.2	1.2 - 1.2
1999	Yosemite Creek	8	87.8	74.2 - 99.4	1.4	0.8 – 1.8
	Reference Sites	6	80.9	30.7 - 99.7	0.9	0.4 - 1.8
2000	Yosemite Creek	8	79.4	5.1 - 98.0	1.4	0.7 – 1.9
	Reference Sites	5	74.8	26.3 - 97.9	0.9	0.5 - 1.2
All	Yosemite Creek	29	86.2	5.1 - 99.4	1.7	0.7 – 2.7
	Reference Sites	12	79.2	26.3 - 99.7	0.9	0.4 - 1.8

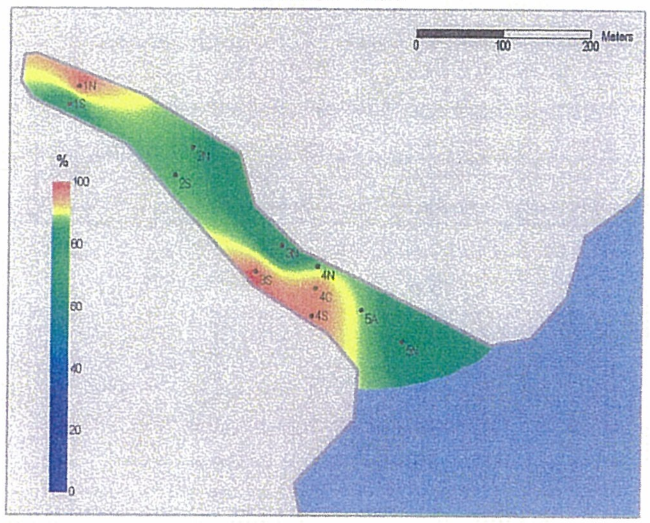
*Fines = silt+clay, < 0.0625 mm diameter

Total organic carbon results are summarized in Table 3-2 for creek and reference area surface sediments. Although chemical exchange processes in Yosemite Creek sediments have not been investigated, high organic content combined with low overlying oxygen levels from limited water circulation may present a reducing environment in creek sediments. Dark sediments collected at the creek end suggest low oxygen retention that may have contributed to an impoverished benthic infaunal community observed in previous studies (Hunt et al. 1998a).

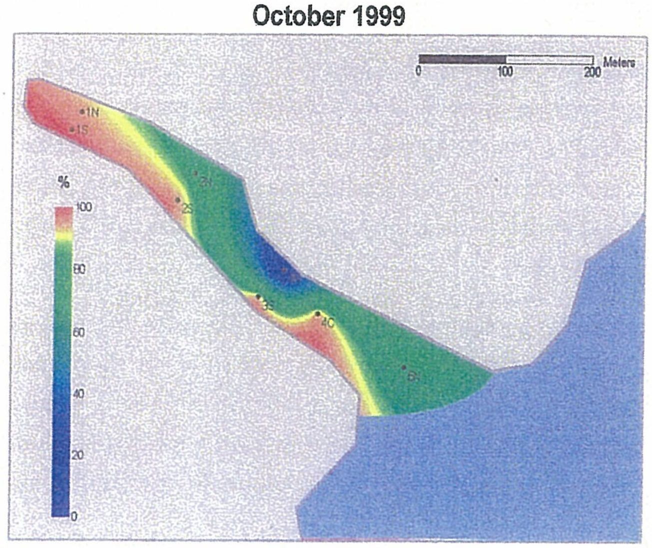
Concentrations of total organic carbon ranged from 0.7 to 2.7% (mean=1.7%) in creek surface sediments, and from 0.4 to 1.8% (mean=0.9%) in reference sediments for all three surveys. The distribution of sediment TOC shifted dramatically between 1998 and 1999/2000, and is visually depicted in Figure 3-1. Differences in the spatial distribution pattern of TOC between surveys, suggests that overflows from the reconfigured CSO were strong enough to wash away much of the light, organically enriched surface layer observed in 1998, which was characterized by heavy rainfall.



October 1998



October 1999



April 2000

Figure 3-1. Percent fines (silt + clay) in Yosemite Creek.

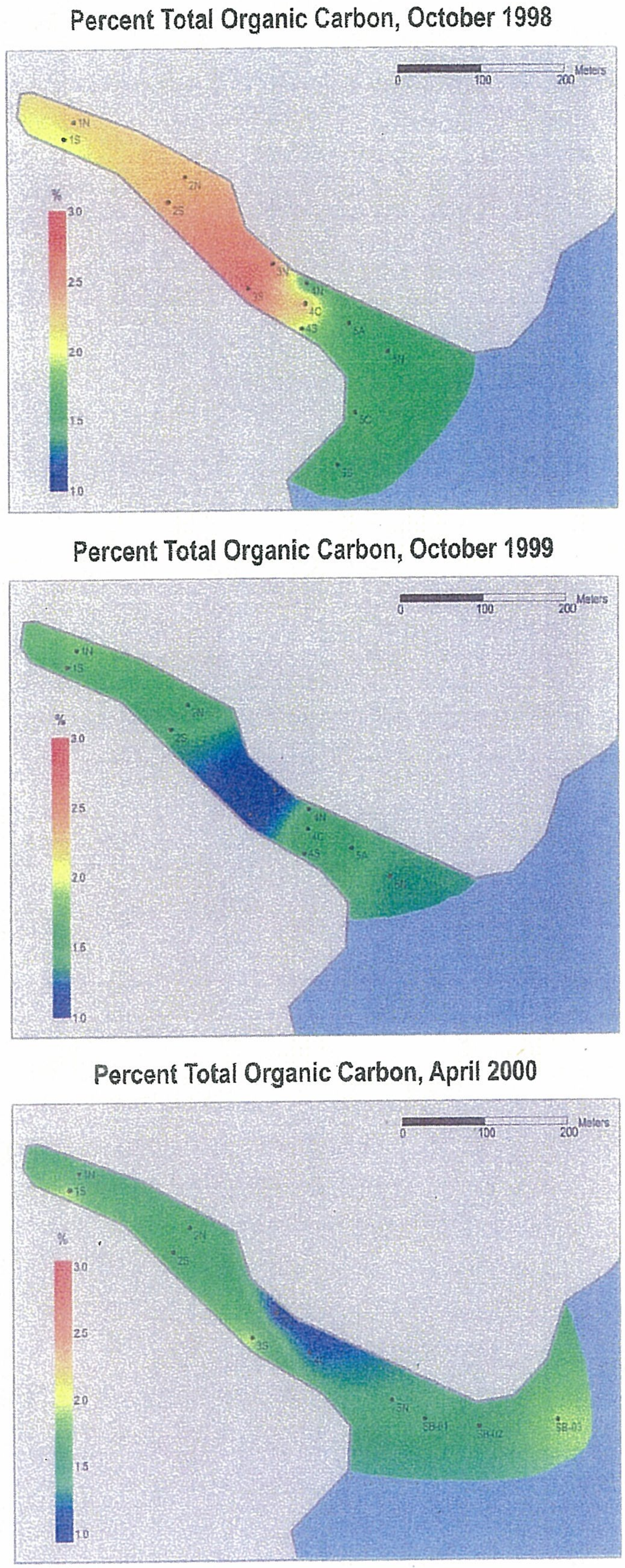


Figure 3-2. Percent total organic carbon (TOC) in Yosemite Creek.

4.0 SEDIMENT TOXICITY

Toxicity results for surface sediments are presented in this section. *Eohaustorius estuarius*, an estuarine amphipod of the family Haustoriidae, common in the evaluation of marine sediments, was used in a 10-day acute test. Percent survival, based on the average of five laboratory replicates, is summarized for reference and creek stations in Tables 4-1 and 4-2. Test results are compared to a reference envelope tolerance limit based on survey-specific data. Complete results are presented in Appendix A1.

October 1998 toxicity data were generated using test protocols from the Regional Board administered Bay Protection and Toxic Hot Spot Program (BPTCP), since data were originally collected to "confirm or refute" BPTCP findings (Battelle 2003). These protocols did not include steps to reduce high levels of ammonia or hydrogen sulfide, nor did they allow sieving before testing to remove potential predator species. These confounding factors contributed to the abnormally low survival results for both creek and reference data, and were subsequently invalidated by the performing laboratory. Testing protocols were replaced with standard EPA and ASTM procedures in the 1999 and 2000 surveys, which included modifications to amend these conditions. Toxicity data collected in October 1999 and April 2000 are presented here, representing dry and wet seasons, respectively.

A total of 16 sediment stations were sampled and tested for acute toxicity to examine potential differences between dry and wet seasons. October 1999 samples were collected after a prolonged dry season; April 2000 samples were collected in the wet season, with many samples collected during rainfall. These studies were responsive to the Regional Board's requirement for site investigations, and were designed to address and/or reduce confounding factors apparent in previous testing programs (Hunt et al. 1998). Toxicity tests consistent with EPA and ASTM protocols were used to ameliorate five potential confounding factors: 1) high ambient levels of ammonia; 2) high ambient levels of hydrogen sulfide; 3) low levels of dissolved oxygen; 4) *in situ* predators of test organisms; and 5) experimentally induced organism sensitivity. Elevated levels of ammonia and hydrogen sulfide were reduced through careful replacement of overlying water, following a 24-hour equilibration period for each test chamber (see Section 2.2.2.3). This procedure has the potential for removing, not only unwanted confounding factors, but also soluble chemical contaminants. Considering the fact that contaminant chemicals sequestered in tested sediments have been subjected to continuous natural water exchange, it is believed that the benefits derived from reducing confounding factors far outweigh the potential minimal reduction of these chemicals. The renewal process, combined with the increased water aeration effectively eliminated low dissolved oxygen levels. Experimentally induced test organism sensitivity was addressed through close interaction with the *Eohaustorius* supplier (Northwest Aquatic Sciences [NWAS], also used in the BPTCP). The salinity acclimation process for *Eohaustorius* was begun by NWAS prior to shipping the amphipods, and continued at SFPUC's Oceanside Biology Laboratory.

4.1 Overview

Sediment toxicity is evaluated using a survey-specific reference tolerance envelope following the methods outlined in Hunt et al. (1998a). Tolerance limits were calculated for the October 1999 and April 2000 surveys using amphipod survival measured at six and five San Francisco Bay reference stations, respectively. All reference sites, except for Tomales Bay (measured in 1999 only), are established Regional Monitoring Program reference sites (SFEI 2003). The resulting survey-specific tolerance limits were calculated using the same method used to calculate the BPTCP tolerance limit of 69.5%, currently used as a toxicity threshold by the Regional Board. The use of survey (time) specific tolerance limits is critical to account for potential changes in bay-wide conditions or test organism sensitivity that can impact reference sediment toxicity results. For example, storm events at the time of testing can negatively impact reference site survival, through salinity changes and/or mixing of surface sediments, which changes pore-water chemistry. A large storm occurred just before sediment collection at Paradise Cove, the only 1998 reference station, which produced an abnormally low amphipod survival of 60% even though no other confounding factors (e.g., high ammonia, low oxygen) were observed.

The resulting SFPUC tolerance limits are 65.3 and 56.6% for October 1999 and April 2000 data, respectively. Both the SFPUC and historic BPTCP tolerance limit (i.e., 69.5%) are adjusted to account for control survival (i.e., 69.5% x fractional control survival) as recommended by Hunt et al. (1998a).

4.2 Reference Areas

Toxicity results for reference area stations are shown in Table 4-1. Survival results for the six stations sampled in October 1999 ranged from 59.0 to 99.0%, averaging 81.3%. One reference station, Island #1, fell below the BPTCP tolerance limit indicating toxicity by this standard. All other reference site survivals exceeded the BPTCP criterion of 68.8% (i.e., 69% of 1999 control survival). All 1999 stations, except Tomales Bay, were resampled in April 2000. In general, lower survivals were observed in 2000 under wet-weather conditions, compared with October 1999, which was dry. Only Island #1 had a substantially higher survival value in 2000. North Site survival values of 83 and 89% were commensurate.

Table 4-1. Reference area toxicity results for the 10-day amphipod test with *Eohaustorius estuarius* and calculated reference area tolerance limits.

Station	October 1999	April 2000
Island #1	59.0	68.0
Marconi Cove (Tomales Bay)	83.0	NS
North Site	83.0	89.0
Paradise Cove	94.0	65.0
South Site	99.0	80.0
Tubbs Island	70.0	59.0
Home Sediment Control	99.0	95.5
Tolerance Limit	**65.3**	**56.6**

NS=not sampled

4.3 Yosemite Creek

The rejection of all 1998 toxicity data, was largely due to unacceptably high laboratory replicate variability. Within station replicate test results varied from 65% to 90%, which is highly unusual for this test. Large, potentially predacious, polychaete worms were observed in many of the replicate test chambers at the conclusion of the 10-day exposure period by SFPUC technicians. These worms may have significantly contributed to the laboratory replicate variability by consuming test organisms. ASTM (1993) testing protocol permits the dry sieving of sediments prior to testing for the expressed purpose of predator removal; however, pre-sieving of test sediments was not done in order to conform with BPTCP protocols during the 1998 exposures. It should be noted that the acute toxicity testing protocol followed in 1999 and 2000 included the pre-screening of test sediments to remove predacious organisms.

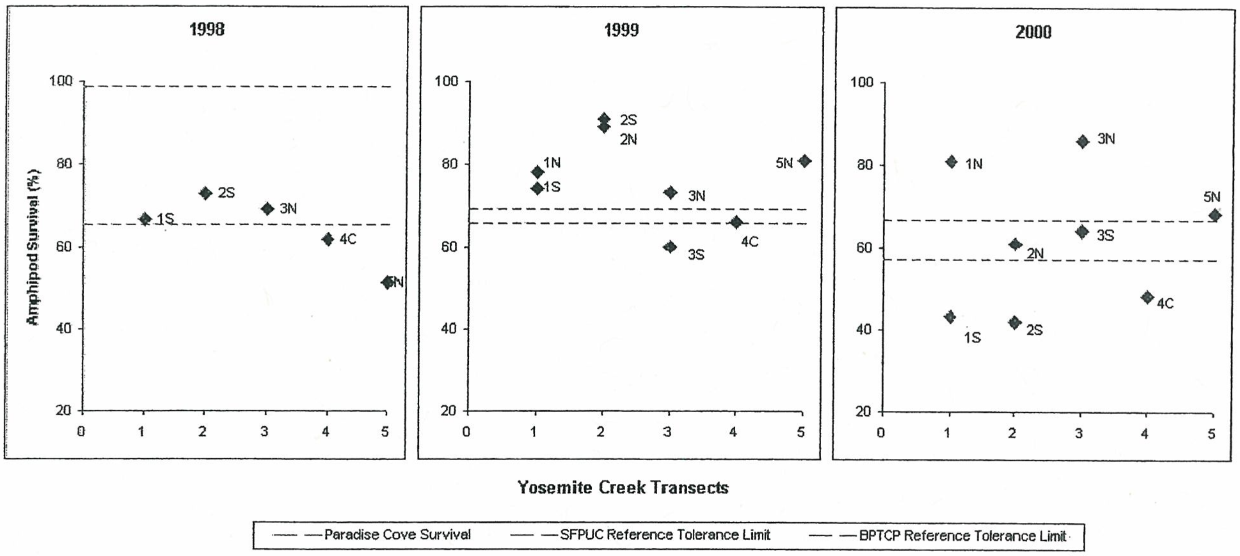


Figure 4-1. Yosemite Creek toxicity results (corrected to control survival) and corresponding BPTCP and SFPUC survey-specific tolerance limits.

Average amphipod survival in October 1999 was 76.5%, ranging from 60.0 to 91.0% for a total of eight stations sampled from the creek end to the mouth. Survival at Station 3S (60.0%) and 4C (66.0%) were slightly below both the SFPUC and the BPTCP control-adjusted tolerance limit of 65.3 and 68.8%, respectively. All other stations were comparable to reference station results

April 2000 sampling, conducted during wet weather, re-examined all October 1999 stations. Average survival was 61.6%, ranging from 42.0 to 86.0%. Five of the eight stations sampled (1S, 2N, 2S, 3S, 4C) fell below the BPTCP reference threshold of 66.4% (69.5% of 2000 control survival) and three (1S, 2S, 4C) were below the study-specific tolerance limit of 56.6%.

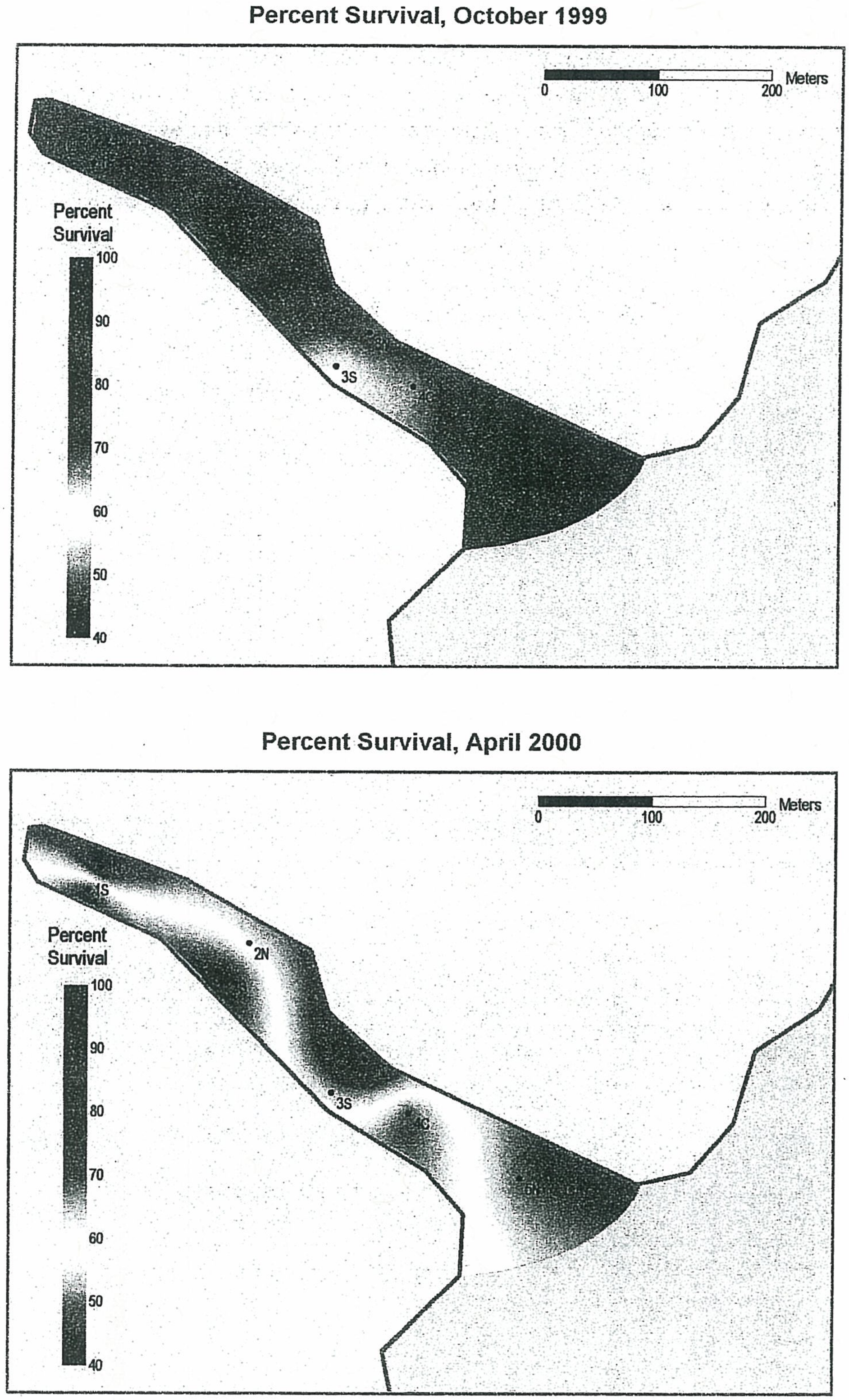


Figure 4-2. Yosemite Creek toxicity results for 1999 and 2000.

Table 4-2 compares amphipod survival at the 1999 and 2000 to tolerance limits for the BPTCP (69.5% of control survival) and the SFPUC surveys. Amphipod survival, observed at Stations 1S, 2S and 3S, indicated recurrent sediment toxicity located on the south side of the creek and east of the end of the reconfigured CSO for both tolerance limits. The extent of toxicity appears to be confined to this immediate area. General toxicity also appears to be influenced by seasonal rainfall. Bay-wide conditions appear stressed during the April 2000 sampling period (wet weather) as reflected in lower overall survival rates measured at both creek and reference stations.

Table 4-2. Yosemite Creek amphipod survival for each station and survey year.

Station	Survey Year*	Percent Survival	SFPUC Tolerance Limit	BPTCP Tolerance Limit (69.5% of control)
1N	1999	78.0	65.3	68.8
1N	2000	81.0	56.6	66.4
1S	1999	74.0	65.3	68.8
1S	2000	43.0	56.6	66.4
2N	1999	89.0	65.3	68.8
2N	2000	61.0	56.6	66.4
2S	1999	91.0	65.3	68.8
2S	2000	42.0	56.6	66.4
3N	1999	73.0	65.3	68.8
3N	2000	86.0	56.6	66.4
3S	1999	60.0	65.3	68.8
3S	2000	64.0	56.6	66.4
4C	1999	66.0	65.3	68.5
4C	2000	48.0	56.6	66.4
5N	1999	81.0	65.3	68.8
5N	2000	68.0	56.6	66.4

Red=corresponding creek station below tolerance limit; Blue=wet weather event