South East Bay Plain Basin

GROUNDWATER MANAGEMENT PLAN

March 2013

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APPENDICES

REFERENCES

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ACRONYMS

ACWD	Alameda County Water District
ABAG	Association of Bay Area Governments
AFY	acre-ft per year
AHGW	Arc Hydro Groundwater
ASR	Aquifer Storage and Recovery
CSM	Conceptual Site Model
DEIR	Draft Environmental Impact Report
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
FEMA	Federal Emergency Management Agency
ftp	File Transfer Protocol
GIS	Geographic Information System
gpd/ft	gallons per day per foot
GMP	Groundwater Management Plan
IGSM	Integrated Groundwater and Surface Water Model
LSCE	Luhdorff & Scalmanini Consulting Engineers
msl	mean sea level
NWIS	National Water Information System
NCGB	Niles Cone Groundwater Basin
NEBIGSM	Niles Cone and South East Bay Plain Integrated Groundwater and Surface Water Model
OLSD	Oro Loma Sanitary District
SB	Senate Bill
SEBP Basin	South East Bay Plain Basin
SSM	Soil Survey Manual
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
USGS	U.S. Geological Survey
West Yost	West Yost Associates
WRIME	Water Resources & Information Management Engineering Inc.

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PREFACE

What Is The Intent of Preparing A Groundwater Management Plan (GMP)?

Water is a finite resource with increasing demand for water exploration and reliance on local groundwater supplies has increased. Preserving this valuable natural resource is essential. Various state and local stakeholders recognize that proper management of groundwater resources is necessary.

Recognizing the importance of managing groundwater resources, in 1992, the California Legislature passed Assembly Bill 3030 (AB 3030) which provided local public agencies increased management authority via the development of GMPs. In September 2002, Senate Bill 1938 expanded AB 3030 by requiring GMPs to include specific components in order to be eligible for grant funding for various types of groundwater related projects. A GMP provides the framework for coordinating groundwater management activities among stakeholders. In general, GMP documents are prepared to identify basin management goals and objectives. They also are used to guide future efforts that could be undertaken to effectively monitor and manage a groundwater basin.

With that understanding, the Board of Directors of East Bay Municipal Utility District unanimously adopted a resolution of intent to prepare a GMP for the South East Bay Plain Basin on May 24, 2011. EBMUD, together with other basin stakeholders, has prepared this GMP as a means to assure basin sustainability for generations to come.

The South East Bay Plain Basin's Groundwater Management Plan Satisfies Multiple Stakeholder Needs and Objectives

What Is A GMP?

A Groundwater Management Plan (GMP) is a planning tool that assists overlying water providers in maintaining a safe, sustainable and high quality groundwater resource within a given groundwater basin. GMPs are intended to be "living documents" that can be readily updated and refined over time to reflect progress made in achieving the GMP's objectives. Because many agencies are new to groundwater planning, state law (SB 1938) outlines a series of actions that will promote ongoing GMP development.

In addition, GMPs have become a required "baseline" document for agencies seeking grant funds available from the State of California. Like other planning documents required by the State, an approved GMP is a minimum requirement for agencies seeking competitively awarded grant funds.

What Is Required In A GMP?

SB 1938 describes the preparation of GMPs and contains numerous requirements and provisions which are briefly summarized as follows:

- A GMP contains an inventory of water supplies and describes water uses within a given region.
- A GMP establishes groundwater Basin Management Objectives (BMOs) that are designed to protect and enhance the groundwater basin.

- A GMP identifies monitoring and management programs that ensure the BMOs are being met.
- A GMP outlines a stakeholder involvement and public information plan for the ground water basin.

Why Was The SEBP GMP Prepared?

The South East Bay Plain (SEBP) Basin GMP has been prepared primarily to document ongoing groundwater management activities, coordinate among basin stakeholders, and prepare for future activities:

- A GMP is a prerequisite for state grant funding opportunities.
- The GMP develops a framework or baseline on which to build future planning efforts.
- Preparing a GMP is good planning procedure.
- The SEBP Basin GMP satisfies multiple stakeholder needs and objectives.

Stakeholder Involvement

To address the needs of all affected stakeholders, several meetings and workshops were held that included a discussion of the means of achieving broader involvement in the management of the Basin. Activities have included:

- Stakeholder planning meetings
- Coordinating with other local agencies and interests adjacent to the SEBP basin area
- Soliciting input from stakeholders during the development and public comment process for approving the GMP
- Developing and fostering relationships with state and federal regulatory agencies
- Incorporating comments received from stakeholders into the GMP

Future Action Items and Recommendations

The intended approval date of the SEBP Basin GMP is March 26, 2013. Following approval, Stakeholders will meet periodically to share basin information and to consider potential refinements to the GMP, adding the next increment of details as and when appropriate.

In addition, the following recommendations will move forward:

- Encourage local stakeholder agencies to adopt the GMP
- Encourage Alameda County Board of Supervisors to adopt more stringent policies regarding well standards
- Future grant funding should be used when available to:
  - Better understand the connectivity between the SEBP Basin and the Niles Cone Groundwater Basin
  - Establish survey control within the Basin
  - Expand the groundwater model (to include water quality data evaluation, additional geologic data as collected, etc.)
  - Improve basin understanding

- Coordinate among stakeholders; and
- Support beneficial uses of the SEBP basin

DWR Bulletin 118 delineates the boundaries of the East Bay Plain Basin ranging from the Carquinez strait in the north to the City of Hayward area in the south. It is bound by the Hayward fault zone in the east and San Francisco Bay in the west. Only the southern portion of East Bay Plain Basin has significant storage capacity and has seen significant municipal, industrial, and irrigation well production.

As such, for all practical purposes, the management of groundwater resources focuses the southern portion of the Basin.

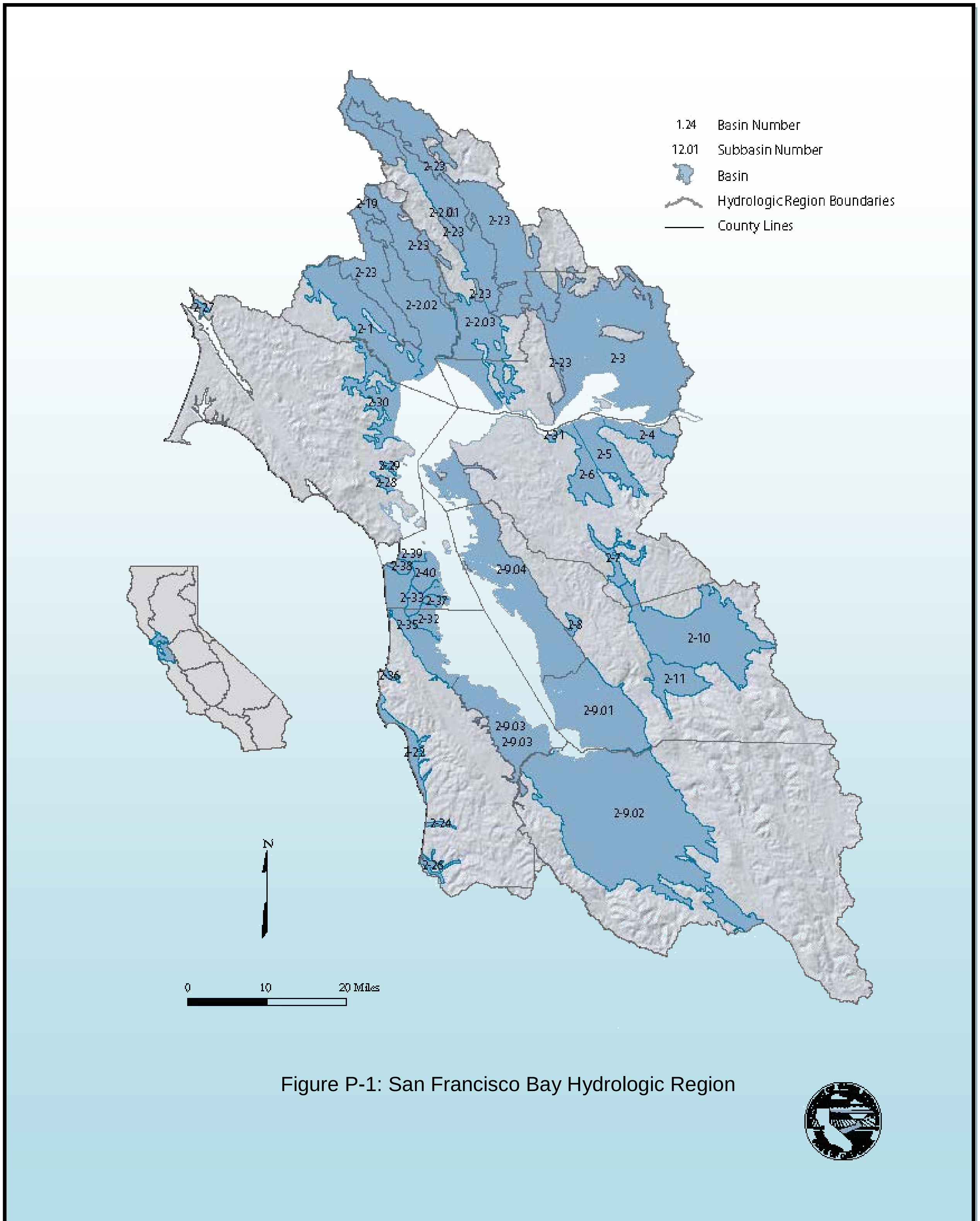

Figure P-1: San Francisco Bay Hydrologic Region

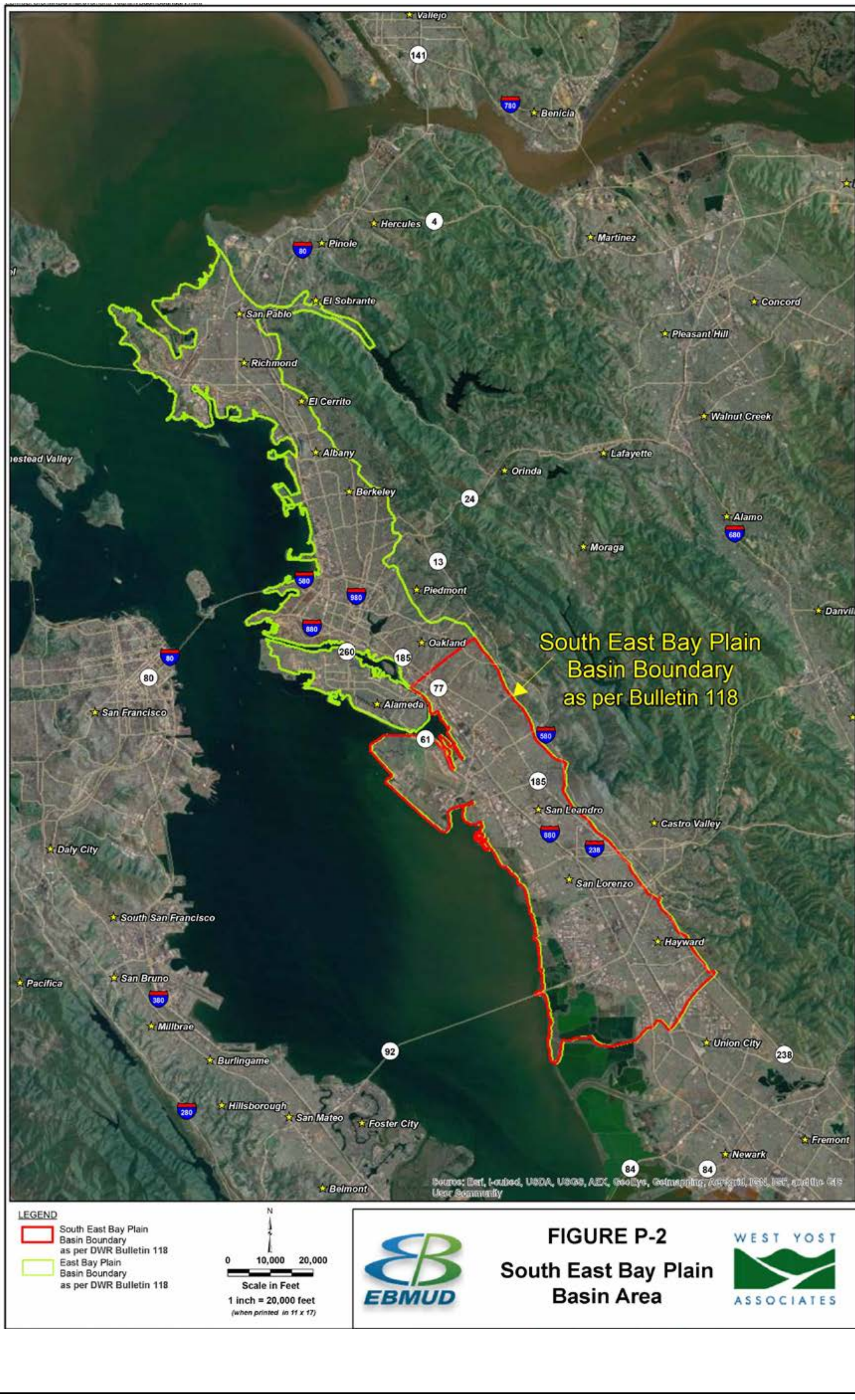

FIGURE P-2
South East Bay Plain Basin Area

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SECTION 1.0 INTRODUCTION

1.1 BACKGROUND

In 1992, the California Legislature passed Assembly Bill (AB) 3030 which provided local public agencies increased management authority over their groundwater resources by enabling them to develop Groundwater Management Plans (GMPs). In September 2002, Senate Bill 1938 expanded AB 3030 by requiring GMPs to include specific components in order for Basin agencies to be eligible for grant funding for various types of groundwater related projects. A GMP provides the framework for coordinating groundwater management activities among stakeholders. In general, the documents are fashioned to identify basin management goals and objectives, along with guiding further efforts that will be undertaken to effectively monitor and manage a groundwater basin.

In recent years, due primarily to local interest in the southern portion of the East Bay Plain Groundwater Basin (the South East Bay Plain Basin or SEBP Basin), the interest in crafting a GMP for the SEBP Basin has grown. East Bay Municipal Utility District (EBMUD), as the largest water provider overlying the East Bay Plain Basin, has taken the lead to guide the GMP development process.

1.2 STAKEHOLDER INTEREST AND PLAN FORMAT

With the completion of Bayside Groundwater Project Bayside Phase 1 in March of 2010 and the potential future development of Bayside Phase 2, East Bay Municipal Utility District (EBMUD) recognized that local groundwater resources were now a key component of the District's future supplemental supply. Other stakeholder agencies, such as the City of Hayward, have reached similar conclusions. A list of stakeholders is provided in the Table below.

Table 1-1: List of Key Stakeholders

PARTICIPATING KEY STAKEHOLDERS	AGENCY REPRESENTATIVE
Alameda County Environmental Health	Donna Drogos
Alameda County Public Works	James Yoo
Alameda County Water District (ACWD)	Steven Inn
City of Alameda	Laurie Kozisek
City of Hayward	Marilyn Mosher
City of Oakland	Craig Pon
City of San Leandro	Keith Cooke
Hayward Area Recreation District	Edwin Little
Port of Oakland	Liem Nguyen
San Francisco Bay Regional Water Quality Control Board	Barbara Baginska
San Lorenzo Unified School District	Prachi Amin

All of the above stakeholders have an interest in protecting or managing the SEBP basin (see Figure P-2 for a graphical depiction of the Basin boundary). Preparation of a GMP is an effective step to assure basin sustainability. For EBMUD, preparation of a GMP is consistent with commitments made in the Phase 1 EIR for the Bayside Groundwater Project. A GMP provides a mechanism for EBMUD to monitor, manage, and protect water quality and quantity in the SEBP Basin for potable uses. For the Alameda County Public Works Department, the GMP discusses their interest in modifying existing well installation and decommissioning standards. The City of Hayward, like EBMUD, has an interest in exploring the potential for the Basin to address a portion of their water supply. All stakeholders understand that working together through the GMP process safeguards their interests and provides a mechanism for a collaborative basin management approach.

Emergency Water Supply Wells (City of Hayward):

The City of Hayward (City) provides water services for residential, commercial, industrial, governmental, and fire suppression uses. Originally, groundwater wells were used as the primary source of water supply. During the 1940s and 1950s, the well water was supplemented by water purchased from San Francisco's Hetch Hetchy system, owned and operated by the San Francisco Public Utilities Commission (SFPUC). In 1962, Hayward entered into an agreement with SFPUC to purchase water from SFPUC and ceased providing well water in 1963. However, to secure a reliable source of potable water for use in the event of an interruption in delivery from the regional Hetch Hetchy Water System, the City designed and constructed five emergency wells, beginning in the mid-1990s and completed in 2001. Although the City does not currently operate these groundwater wells to meet any portion of its day-to-day normal water demand, these emergency wells, which are located within the City and use the local groundwater basins, can theoretically provide up to a total of 13.6 million gallons per day of potable water. These wells are currently certified by the California Department of Health Services for short duration emergency use only.

Emergency Well Capacities

Well Identification	Capacity
Well A	1.7 mgd
Well B	2.9 mgd
Well C	4.6 mgd
Well D	1.4 mgd
Well E	3.0 mgd

1.3 OBJECTIVES OF GMP

The overarching goal of the South East Bay Plain Basin GMP is to preserve the local groundwater basin as a reliable and sustainable water supply for current and future beneficial uses. To accomplish this goal, the objectives of the GMP together with accompanying plan elements are listed below.

The SEBP Basin GMP Objectives are to:

- Preserve basin storage by maintaining groundwater elevations in the GMP area to ensure sustainable use of the basin;
- Maintain or improve groundwater quality in the GMP area to ensure sustainable use of the basin; and
- Manage potential inelastic land surface subsidence from groundwater pumping

The following plan components are structured to achieve these objectives:

- Stakeholder and Public Involvement
- Monitoring Program
- Data Management and Analysis
- Groundwater Resource Protection
- Groundwater Sustainability

Each component includes specific management actions. Figure 1-1 graphically depicts the means by which objectives are folded into plan components that in turn address goals for basin management.

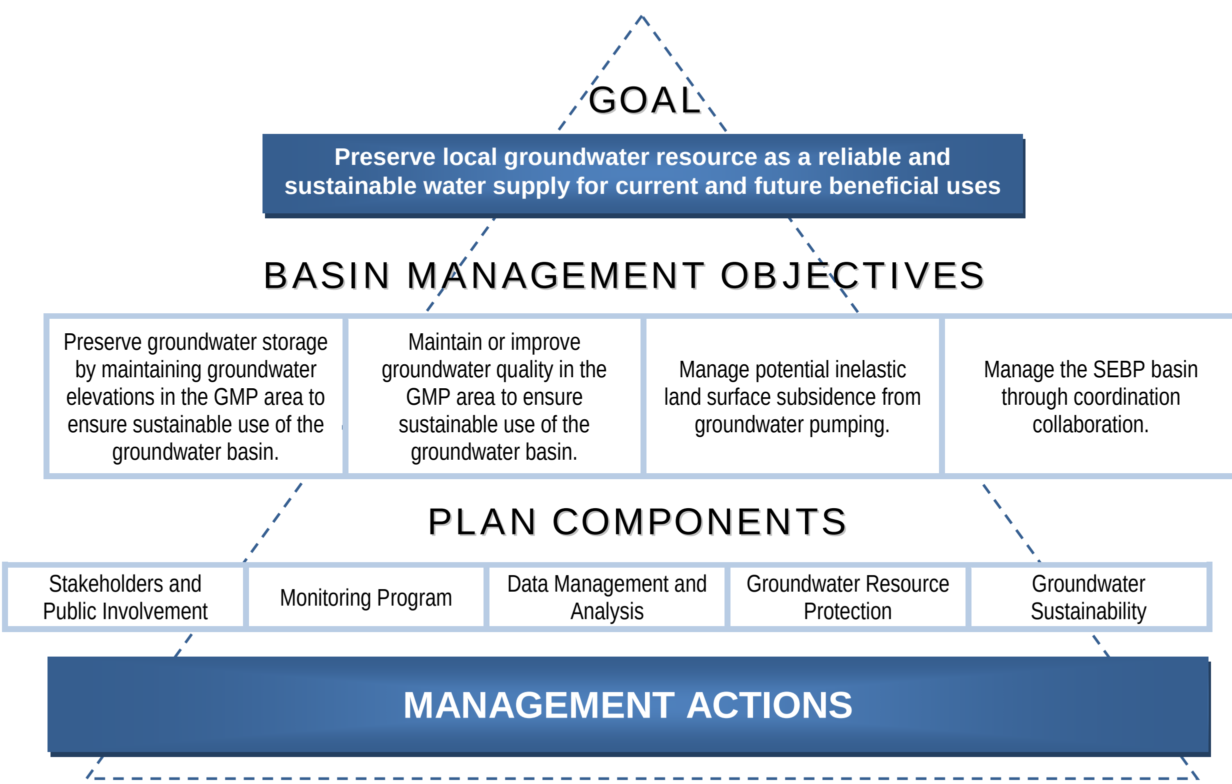


Figure 1-1: Basin Management Objectives

The SEBP Basin GMP accomplishes the following objectives:

- Provides statutory authority for stakeholders to manage the groundwater basin;
- Supports basin sustainability;
- Maintains local control of groundwater;
- Supports the rights and beneficial uses of groundwater for basin users;
- Fosters collaboration and prevents legal disputes among stakeholders; and
- Increases opportunities for future grant funding.

1.4 GMP TIMELINE AND DEVELOPMENT PROCESS

Preparation of the SEBP Basin GMP has taken approximately two years. The effort began with EBMUD's Board adoption of a resolution of intent on May 9, 2010. Significant milestones in the GMP development process since that date are summarized in Table 1-3 below.

Table 1-3: Significant Milestones/Development Process

Milestones	Date
Public Notice to adopt the Resolution of Intent	5/7/2011
EBMUD Board Adoption of the Resolution of Intent	5/24/2011
Stakeholder Liaison Group Meeting	8/9/2011
Technical Consultant Contract Award	11/8/2011
Stakeholder Liaison Group Meeting	3/29/2012
Stakeholder Well Standard Development Subgroup Meeting	10/16/2012
Stakeholder Salts and Nutrients Management Subgroup Meeting	10/16/2012
Stakeholder Land Subsidence Management Subgroup Meeting	10/23/2012
Completion of Draft Technical Study Report	1/23/2013
Completion of Draft GMP document	1/31/2013
Completion of Final Technical Study Report	2/28/2013
Completion of Final GMP document	3/21/2013
Planned Public Notice to Adopt the GMP	3/12/2013
Planned EBMUD Board Adoption of the GMP	3/26/2013

1.5 ELEMENTS OF THE SEBP BASIN GMP

Elements of the SEBP Basin GMP include basin delineation and characterization, the establishment of basin objectives, a description of monitoring activities, and identification of management activities. Stakeholder participation is also detailed.

1.6 DOCUMENT DEVELOPMENT

The GMP was prepared by EBMUD staff with significant assistance provided by stakeholder organizations. The engineering firm of West Yost, Inc. was contracted to prepare a hydrologic study as well as develop a new groundwater model of the basin. EBMUD staff supervised their efforts. Table 1-4 denotes participation in document development by stakeholder/consultant support.

Table 1-4 : GMP Document Development Contributors

GMP Development Lead Agency	EBMUD Board
Technical Consultant for the SEBP Basin Characterization Study	West Yost Associates
Public Outreach	EBMUD staff
Well Standard Development Subgroup	Lead: James Yoo (ACPWA) Members: • Marilyn Mosher (COH) • Prachi Amin (SLUSD) • Ken Minn (EBMUD)
Salts and Nutrients Management Subgroup	Lead: Alec Naugle (SFRWQCB) Members: • Donna Drogos (ACEH) • James Yoo (ACPWA) • Laurie Kozisek (COA) • Marilyn Mosher (COH) • Prachi Amin (SLUSD) • Ken Minn (EBMUD)
Land Subsidence Management Subgroup	Lead: Tom Francis (EBMUD) Members: • James Yoo (ACPWA) • Laurie Kozisek (COA) • Marilyn Mosher (COH) • Ken Minn (EBM UD) • Steve Martin (EBMUD)
Technical Data and Research Contributors	Mike Halliwell (ACWD) John Izbicki (USGS) Ken Minn (EBMUD)
Technical Reviewers	Mike Halliwell (ACWD) Marilyn Mosher (COH) Ken Minn (EBMUD)
DWR Liaison	Mark Nordberg

1.7 AUTHORITY TO PREPARE AND IMPLEMENT A GMP

The authority to manage the groundwater basin is provided through the Act and Water Code Division 6, part 2.75 (§ 10750 et seq.). The state groundwater management law (Water Code Division 6, part 2.75, commencing with section 10750) prohibits the District from managing groundwater within the service area of another local water district, public utility or mutual water company, without the agreement of that other entity. (Section 10750.9 (b)). State law also encourages local water agencies to coordinate on groundwater management plans. (See Water Code §§ 10755.2-10755.4.)

This GMP is prepared to cover the southern portion of East Bay Plain basin as per DWR Bulletin 118. In accordance with Water Code section 10750, EBMUD will be authorized to manage the basin within its service area. Similarly, City of Hayward will be authorized to manage the portion the basin under its groundwater service area. This GMP does not cover areas currently under the management of ACWD.

This plan and implementation of the plan shall comply with these and other applicable limitations of state law. On May 24, 2011, EBMUD Board of Directors formally adopted the Resolution of Intent to prepare the GMP for the South East Bay Plain Basin. The Resolution is included in Appendix A.

1.8 GROUNDWATER MANAGEMENT PLAN COMPONENTS

The South East Bay Plain Basin GMP includes the required and recommended components and applicable voluntary components per CWC § 10750 et seq. as described in DWR's Bulletin 118, California Groundwater – Update 2003 (DWR, 2003).

Seven mandatory components of CWC § 10750 et seq. CWC § 10750 *et seq.* requires GWMPs to include seven mandatory components and twelve voluntary components to be eligible for award of funding administered by DWR for the construction of groundwater projects or groundwater quality projects. These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003. The amendments apply to funding authorized or appropriated after September 1, 2003.

CWC § 10750 *et seq.*, Mandatory Components:

- Documentation of public involvement statement 1.2, 1.4, 1.6, and 3.3.1
- Establish basin management objectives 1.3
- Monitor and manage groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping 3.3
- Plan to involve other agencies located within groundwater basin 1.7
- Adoption of monitoring protocols by basin stakeholders 3.3.2
- Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118 (Figure 2-1)
- For agencies not overlying groundwater basins, prepare GMP using appropriate geologic and hydrogeologic principles.

Twelve voluntary components of CWC § 10750 et seq. includes twelve specific technical issues that could be addressed in GMPs to manage the basin optimally and protect against adverse conditions. In addition, DWR Bulletin 118-223 recommends seven components to include in a GMP. The mandatory, voluntary and recommended components are listed below:

- Control of saline water intrusion. 3.3.5.1
- Identification and management of wellhead protection areas and recharge areas. 3.3.5.1 and 3.3.4.3
- Regulation of the migration of contaminated groundwater. 3.3.5.1
- Administration of well abandonment and well destruction program. 3.3.5.1
- Mitigation of conditions of overdraft. 3.3.5.1
- Replenishment of groundwater extracted by water producers. 3.3.5.1
- Monitoring of groundwater levels and storage. 3.3.2
- Facilitating conjunctive use operations.
- Identification of well construction policies. 3.3.4.1
- Construction and operation by local agency of groundwater contamination clean up, recharge, storage, conservation, water recycling, and extraction projects. 3.3.4.4 and 3.3.5.2
- Development of relationships with state and federal regulatory agencies. 3.3.1.3
- Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination.

DWR Bulletin 118 Suggested Components:

- Manage with guidance of advisory committee.
- Describe area to be managed under GWMP
- Create link between BMOs and goals and actions of GWMP 1.3
- Describe GWMP monitoring program 3.3.2
- Describe integrated water management planning efforts 3.3.5.1 and 4.4
- Report on implementation of GWMP 4.1
- Evaluate GWMP periodically 4.2

1.9 SEBP GROUNDWATER MANAGEMENT PLAN STRUCTURE

This GMP is structured as follows:

- **Section 1.0 - Introduction:** Provides the executive summary and introductory information.
- **Section 2.0 - Water Resources Setting:** Provides an overview of existing physical conditions that should be understood and considered when developing and implementing groundwater management activities. This section includes information on topics such as precipitation, hydrology, geology, groundwater levels, groundwater quality, existing well infrastructure, and water demand and supply. The understanding of existing physical conditions helps define groundwater management needs, objectives, and actions.
- **Section 3.0 - Plan Implementation:** Discusses the major plan components. The five groundwater management components included in the plan are stakeholders and public involvement, monitoring program, data management and analysis, groundwater protection and groundwater sustainability.

- **Section 4.0 - Plan Implementation and Integration:** Successful management of the basin directly correlates with successful implementation of plan components and associated actions. As the basin is the local resource for multiple stakeholders with various stakes, successful implementation is, in turn, contingent upon effective collaboration and available resources. Also, the basin management is a perpetual task concerning all stakeholders. Leading a group of stakeholders with common interest, EBMUD will foster collaborative efforts in seeking state and federal funding as well as developing mutually beneficial projects in the basin.

Bayside Groundwater Project (EBMUD):

The Bayside Groundwater Project is one of several future water supply projects that will help protect EBMUD's 1.3 million customers against severe water rationing in the event of a prolonged drought. In wet years, water would be stored in a deep aquifer; then extracted, treated and distributed to customers during drought.

The aquifers far beneath San Leandro and San Lorenzo were chosen as project sites after much exploration. The Bayside Groundwater Project's planning began in 2001, the Environmental Impact Report was approved by the EBMUD Board of Directors in November 2005 and the project's construction was completed in 2009.

After successfully operating the project for some time, EBMUD will consider a larger project in the area that would have a storage capacity of 2 to 10 mgd, providing even greater drought protection. The larger project would first be subjected to the same environmental and public review as the first project, and EBMUD will review results of the groundwater monitoring system and extensometer, which measures minute changes in ground surface elevation.

SECTION 2.0 WATER RESOURCES SETTING

2.1 OVERVIEW OF SEBP GROUNDWATER BASIN

The study area covers a large area of the East Bay Plain underlying a portion of the City of Oakland, Alameda, San Lorenzo, and the City of Hayward (see Figure 2-1). The study area is approximately four miles wide and twelve miles long. It extends from the San Francisco Bay on the west to the edge of the alluvial basin at the base of the Oakland hills on the east, and runs from 35th Avenue in Oakland on the north near the City of Hayward's southern boundary. The area is densely populated and highly urbanized and is characterized by industrial, commercial, and residential land uses. Although agriculture was important in the past, there is little agricultural land use in the study area at the present time. More information on the hydrology and hydrogeology of the study area is provided in later sections of this report.

2.2 HISTORICAL GROUNDWATER USE IN THE EAST BAY AREA

Groundwater was a major part of water supply to the East Bay area from the 1860s to 1930. During that time there was a continuous struggle to locate and develop both ground and surface waters to serve the growing population. By the early 1920s, it was recognized that local groundwater and surface water supplies had reached their limits, and water would have to be brought in from outside the Bay Area. After years of planning and construction, Sierran water entered the area in the spring of 1930. However, instead of continuing to be part of the water supply, municipal well fields were shut down and forgotten.

In their 1998 study of groundwater and water supply history of the East Bay Plain, Norfleet Consultants estimated that in the range of 15,000 wells were drilled in the Basin between 1860 and 1950. The majority of these were shallow (less than 100 feet deep), but some were up to 1,000 feet deep. Few of these wells were properly destroyed. EBMUD's historical review indicates that there were only three sites in the East Bay Plain that historically supported municipal well fields: the Alvarado, San Pablo, and southern Oakland areas. The Alvarado Well Field was located south of the SEBP Basin in the Niles Cone. This site had the most prolific wells and supplied about one half of the groundwater to the East Bay Area. There were 8 to 10 individual well fields in the southern Oakland trend. The first well field in the SEBP area was drilled on Alameda Island (the High Street Field) in the 1880s. Within 10 years, the field was shut down because of water quality problems and casing failures. Additional well fields were drilled to the west (Fitchburg, 98th Street, etc.), following the trend of the aquifer. In 1916, the East Bay Water Company, predecessor of EBMUD, drew about 10 million gallons a day from 117 wells including Robert's Landing well filed located in San Lorenzo area. These fields were an integral part of the water supply system until they were shut down in 1930. There were three well fields in San Pablo. They were drilled in the late 1900s to supply water to the rapidly growing Richmond area. Overpumping and intrusion of brackish water caused those fields to be shut down by 1920.

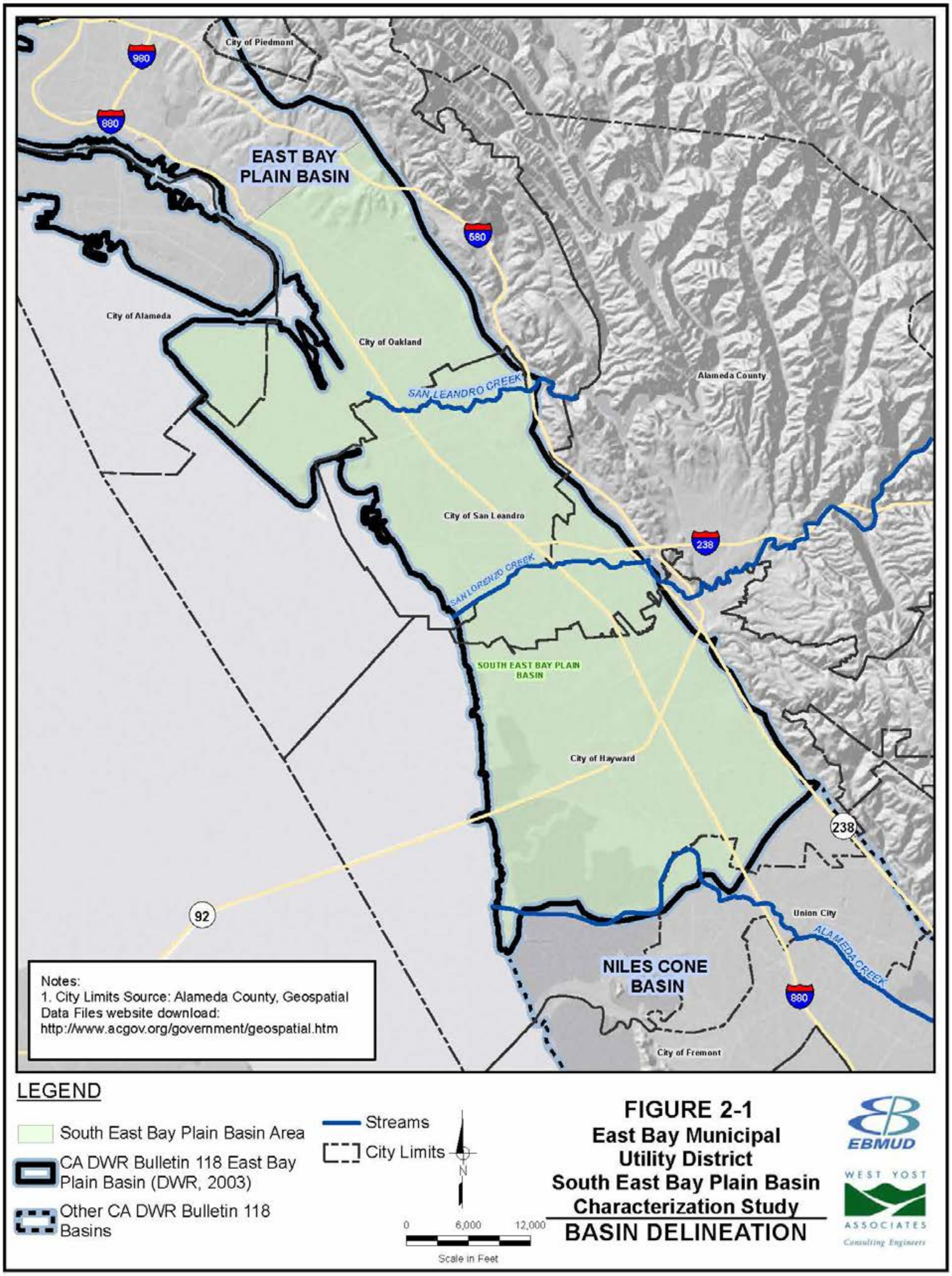
There is little specific information about historic groundwater quality, but the existing information indicates that groundwater had a relatively similar quality throughout the East Bay Plain. Total dissolved solids (TDS) varied between 500 and 1,000 ppm. Salt/brackish water intrusion occurred along the eastern end of Alameda Island (early 1890s), in the Fitchburg Well Field (late 1920s), and in San Pablo (late 1910s). Existing information indicates that the intrusion was restricted to the upper aquifer (above the Yerba Buena Mud) and was caused by overpumping. All of these fields were shut down by 1930. Overpumping continued to occur in the Niles Cone for the next 30 years. This resulted in intrusion of the deeper aquifers by the 1950s.

2.3 GROUNDWATER BASIN DELINEATION

California Water Code Section 10750 et seq., commonly referred to as AB 3030, stipulates certain procedures that must be followed in adopting a GMP under this section. Amendments to Section 10750 et seq. added the requirement that new GMPs being prepared under Section 10750 et seq. must include additional components in order to be eligible for state grants administered through DWR (SB1938 (Stats 2002, Ch 603)). One of the required components is a map showing the area of the groundwater basin, as defined by DWR Bulletin 118, with the area of the local agency subject to the plan as well as the boundaries of other local agencies that overlie the basin.

The SEBP Basin GMP study area is located within the East Bay Plain Subbasin[1] (Figure P-2). DWR describes the East Bay Plain Subbasin as a northwest trending alluvial plain bounded on the north by San Pablo Bay, on the east by the contact with Franciscan Basement rock, and on the south by the Niles Cone Groundwater Basin (NCGB). The East Bay Plain Basin extends beneath San Francisco Bay to the west (DWR, 2003). The study area (shown in light green in Figure 2-1) is bounded on the east, west and south by the groundwater basin boundary as delineated by the DWR in Bulletin 118 (2003) and shown in Figure P-1. The SEBP basin deep aquifer thins to the north and becomes an insignificant source of groundwater near Berkeley (CH2MHill, 2000). For the purpose of this study, the northern boundary of the SEBP Basin GMP area was drawn in Oakland at a location where the depth to basement is relatively shallow and the deep aquifer is relatively thin (CH2MHill, 2004). The southern boundary extends near the southern boundary of the City of Hayward in the transition zone with the Niles Cone Subbasin to the south.

[1] The southern boundary of the basin in DWR Bulletin 118 may be subject to modification in a future edition of the Bulletin 118 as per ongoing discussions between DWR and ACWD.


City of Piedmont
980
880
EAST BAY
PLAIN BASIN
580
City of Alameda
City of Oakland
SAN LEANDRO CREEK
Alameda County
City of San Leandro
238
SAN LORENZO CREEK
SOUTH EAST BAY PLAIN
BASIN
City of Hayward
238
92
Union City
ALAMEDA CREEK
NILES CONE
BASIN
880
City of Fremont
Notes:
1. City Limits Source: Alameda County, Geospatial
Data Files website download:
http://www.acgov.org/government/geospatial.htm
LEGEND
South East Bay Plain Basin Area
CA DWR Bulletin 118 East Bay
Plain Basin (DWR, 2003)
Other CA DWR Bulletin 118
Basins
Streams
City Limits
N
0
6,000
12,000
Scale in Feet
FIGURE 2-1
East Bay Municipal
Utility District
South East Bay Plain Basin
Characterization Study
BASIN DELINEATION
EBMUD
WEST YOST
ASSOCIATES
Consulting Engineers

2.4 TOPOGRAPHY AND GEOMORPHIC FEATURES

The GMP study area includes Oakland, Alameda, San Leandro, San Lorenzo and Hayward, covering an area of about 115 square miles. The study area consists primarily of flat alleviated lowlands and bay tidal marshes. The topography generally slopes downward toward the San Francisco Bay to the west, ranging in elevation from about 400 feet above mean sea level (msl) in the east to 0 feet msl to the west where the plain meets the San Francisco Bay. This information is relevant to this groundwater study, because groundwater direction and gradient typically correlate well with surface topography on a regional level. Local variations result from groundwater pumping patterns, and geomorphic and structural features such as fault zones.

2.5 SOILS

Soils information was compiled and evaluated from field data collected by the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service as well as data collected by the U.S. Geological Survey (USGS). This information is key to developing an understanding of groundwater recharge within the GMP study area. These studies utilized soil information for the East Bay Plain obtained by ACWD during the development of the Niles Cone and South East Bay Plain Integrated Groundwater and Surface Water Model (NEBIGSM) (WRIME, 2005), which included the entire East Bay Plain. The model subregions used for depicting soil information extend beyond the boundaries of the GMP study area.

Soils types for the entire East Bay Plain are shown on Figure 2-2. The Soil Survey Manual (SSM) (U.S. Department of Agriculture, 1993), prepared by the USDA Soil Survey Division was used as a guideline for soil classification. The soil data for the study area were categorized into four classifications established from the Natural Drainage Classes and Hydrologic Soil Groups published in the SSM. The categories are briefly described below.

2.5.1 Type A Soils

Type A soils, defined as excessively drained to somewhat excessively drained soils, are so termed because water moves rapidly through them. Soils are typically coarse-textured and have high hydraulic conductivity in the upper half of the horizon. Examples of type A soils include coarse sands, tailings, and alluvial deposits, which typically occur along major stream channels.

2.5.2 Type B Soils

Type B soils are well drained soils, meaning that water is removed from the soil readily, not rapidly. Soils in the upper one meter of this horizon typically have higher conductivity in the lower half and moderately high hydraulic conductivity in the upper half of the one-meter interval. A representative type B soil is sandy loam.

2.5.3 Type C Soils

Type C soils are moderately well drained soils, meaning that water is removed from the soil slowly during portions of the year. Soils typically have moderately high hydraulic conductivity in the upper half of the horizon and moderately low hydraulic conductivity in the lower half. Examples of type C soils include silty sands, silty loam, and clayey sands.

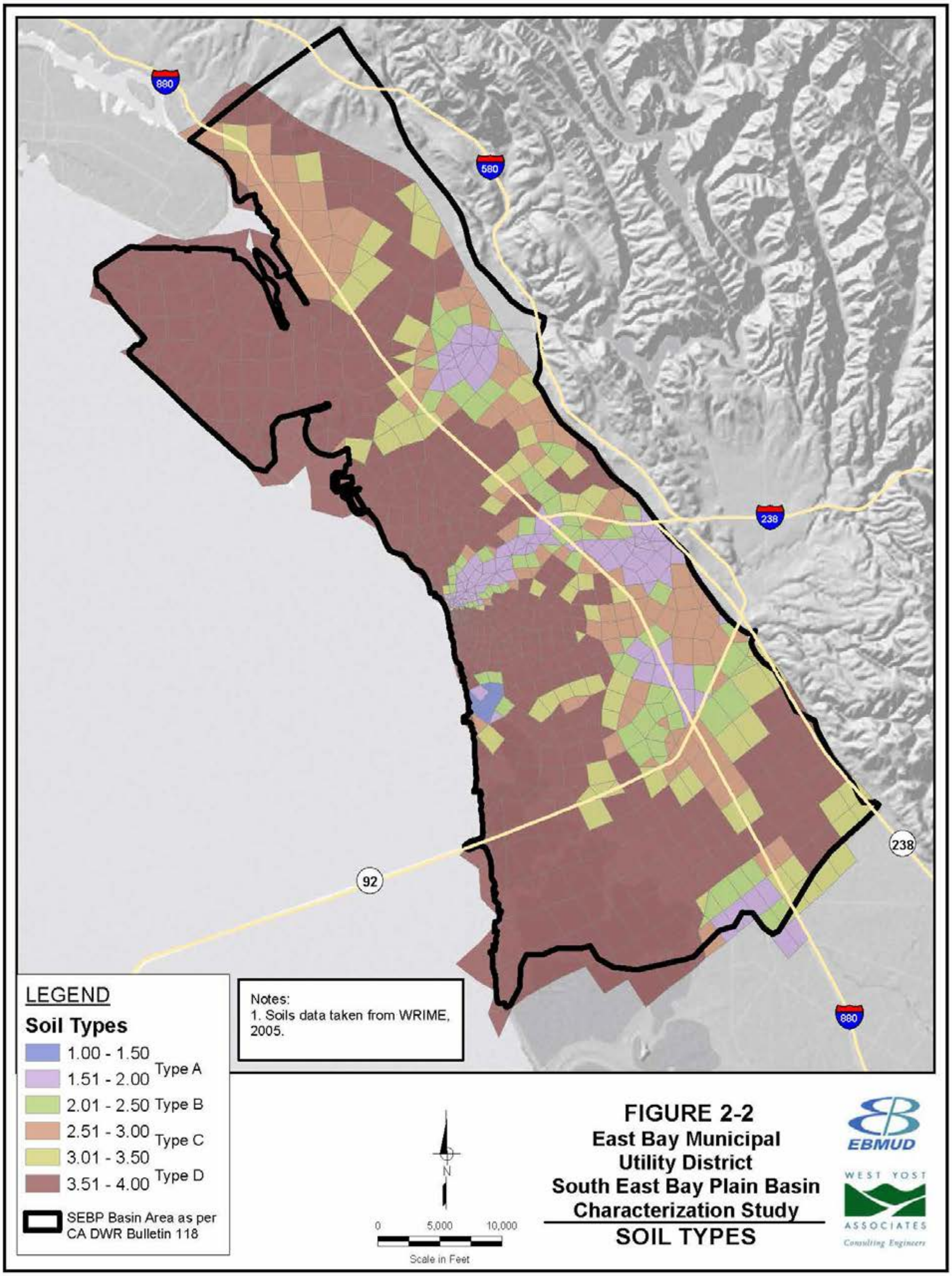


FIGURE 2-2
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
SOIL TYPES

2.5.4 Type D Soils

Type D soils are poorly drained to very poorly drained soils, meaning that water is removed very slowly and free water typically is present at shallow depths or at the surface. These soils typically have low hydraulic conductivity. Examples of type D soils include clays, hardpan, and floodplain deposits.

2.6 SURFACE WATER FEATURES

San Leandro and San Lorenzo Creeks are the principal streams in the study area. These streams originate in the Diablo Range and flow westward into San Francisco Bay. The upland area drained by these streams (43 and 44 square miles, respectively) contains two large reservoirs. With the exception of the Castro Valley area, the drainage basins are not extensively developed. These streams may have been important sources of pre-development groundwater recharge. Muir (1996) estimated that annual recharge from infiltration of stream-flow and direct infiltration of precipitation in the San Leandro and San Lorenzo areas was about 3,500 and 800 acre-ft, respectively.

Channeling of these streams due to urbanization has reduced the amount of surface water available for groundwater recharge along the mountain front (Izbicki, 2003). The results of a USGS study completed in 2003 show that recharge of San Leandro and San Lorenzo Creeks occurs as infiltration of stream flow during winter months. Most recent recharge is restricted to the upper aquifer system in areas near the mountain front. Recently recharged water was not present in the lower aquifer system, probably because of the presence of clay layers that separate the upper and lower aquifer systems. The time to recharge based on Carbon-14 dating of deep groundwater ranged from 500 to greater than 20,000 years. Older groundwater ages suggest that the lower aquifer system is isolated from surface sources or recharge (Izbicki, 2003).

2.6.1 San Leandro Creek

San Leandro Creek stream flow data were not available. Because it is a lined channel having little or no interaction with groundwater, no effort was made to estimate the missing data for San Leandro Creek during construction and calibration of the NEBIGSM (WRIME, 2005).

2.6.2 San Lorenzo Creek

San Lorenzo Creek stream flow data, compiled by WRIME in preparation of the NEBIGSM, covers the period 1964 to 2000 and more recent (2008 to 2012) data retrieved from the USGS for the Hayward Gage (see Appendix B). The steam flows year round with highest flows in the winter months. Flows rarely exceed 2,000 cubic feet per second.

2.7 PRECIPITATION

Although the area is heavily urbanized, precipitation does contribute to recharge in the study area. Rainfall data were compiled and analyzed from two rainfall gages in the study area during development of the NEBIGSM for the period 1922 to 1998. During this period, average rainfall was 19.36 inches per year at the Oakland Museum Station (northern study area) and 17.87 inches per year at the Niles Station (southern study area). Recent precipitation data at the Oakland Museum Station is plotted on Figure 2-3 and shows that average annual precipitation for the period 1971 to 2011 was 22 inches.

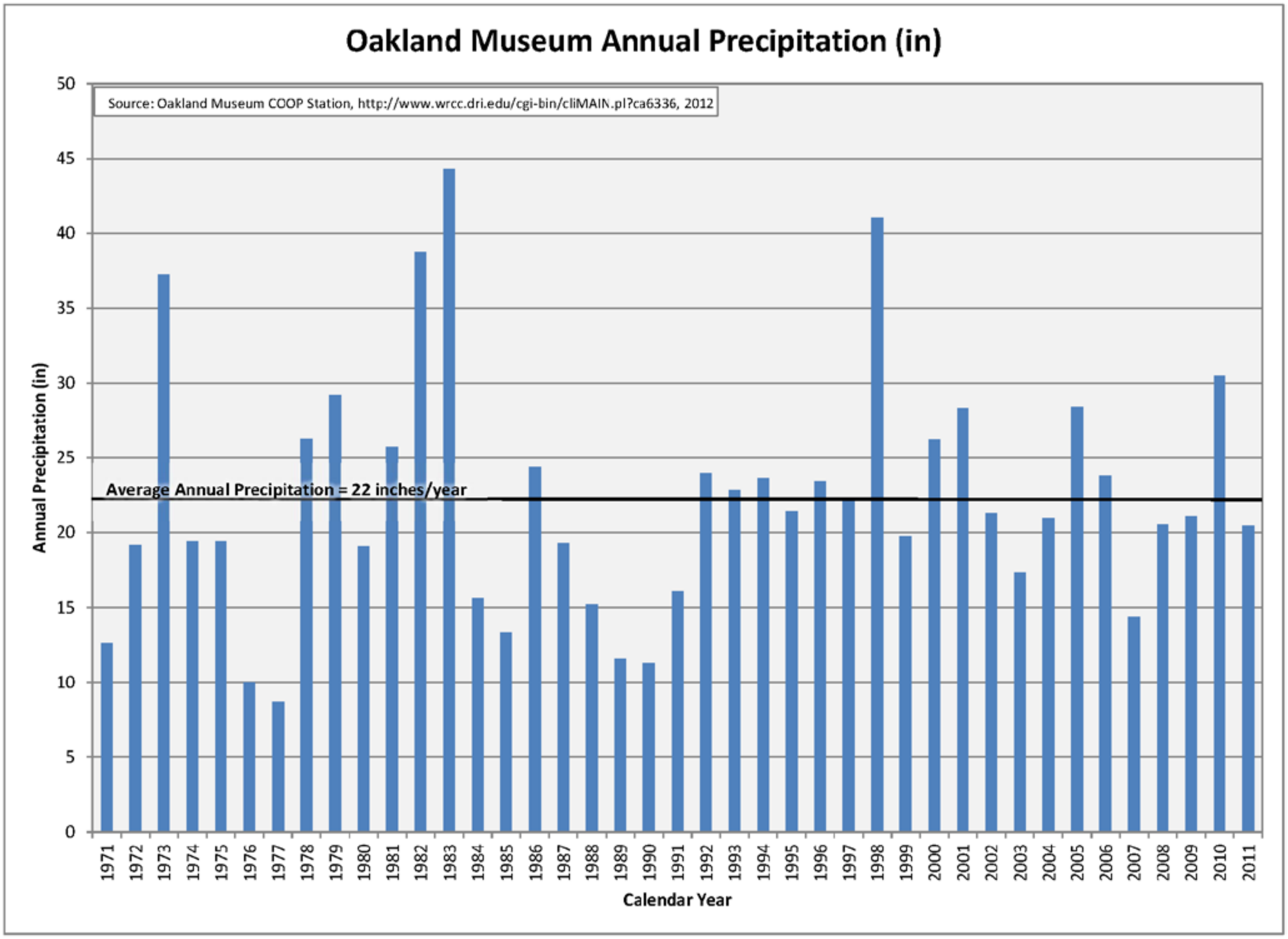
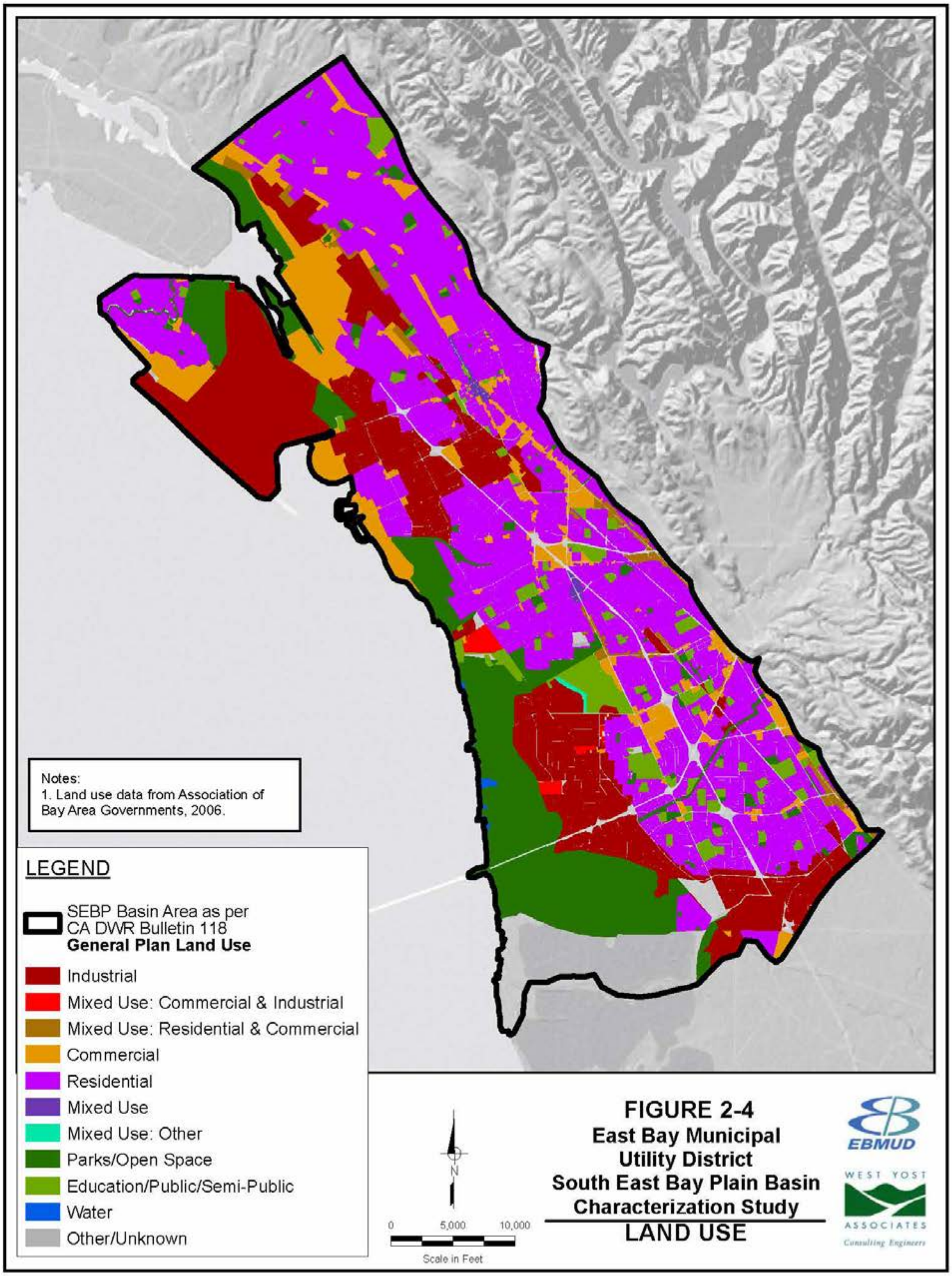


Figure 2-3

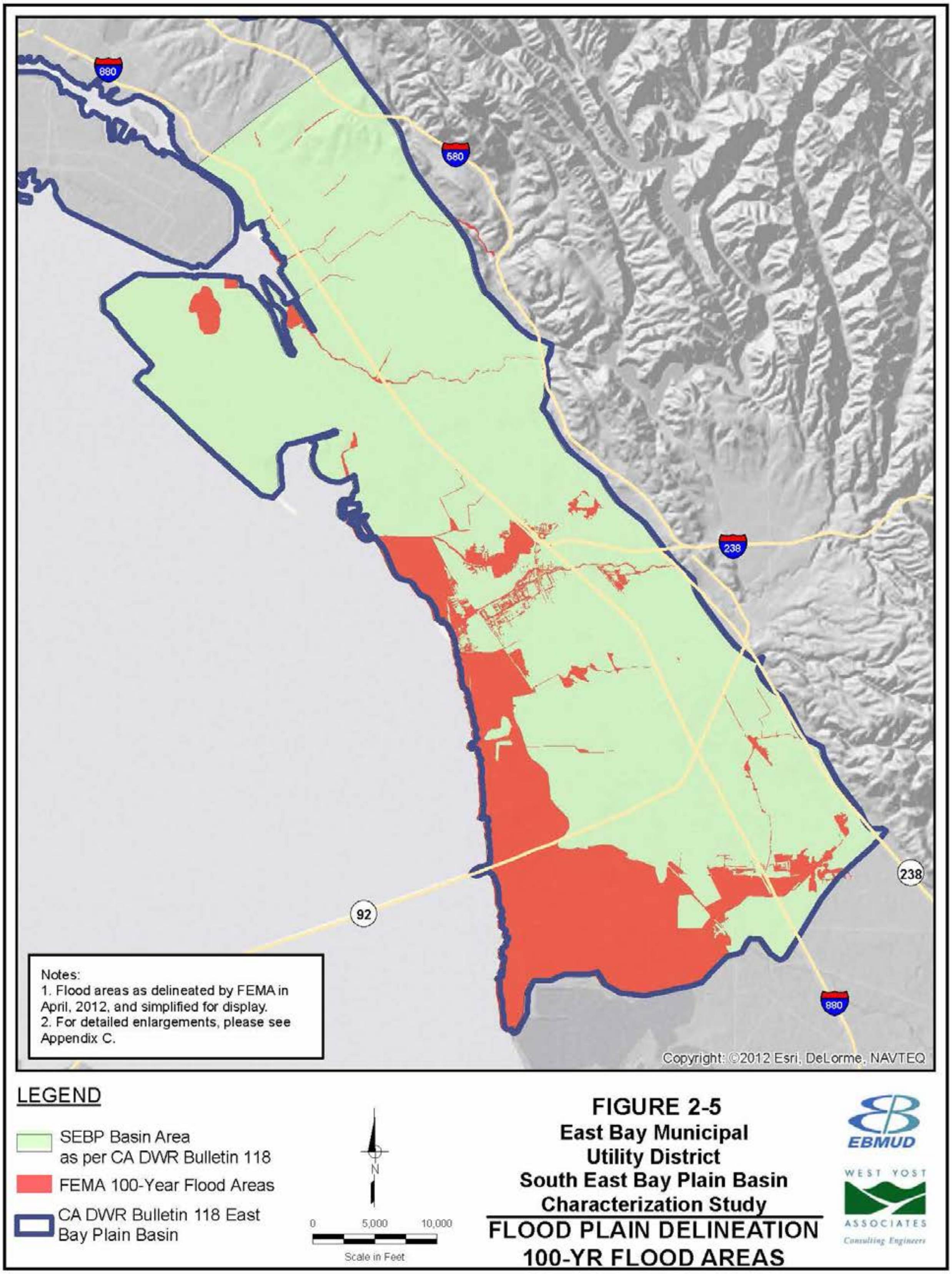
2.8 LAND USE

Land use information is another factor considered in developing a recharge area/net percolation map for the study area. Figure 2-4 shows the mix of land uses across the SEBP Basin, including the study area. Principal land uses within the study area include residential, industrial, parks and open space. The land use classification information was developed from the 2006 Planned Land Use GIS data file available from the Association of Bay Area Governments (ABAG) GIS Data Catalog. The 2006 Planned Land Use data file contains geospatial information relating to land uses found in the general plans of the cities and counties of the nine-county San Francisco Bay Area.


Notes:
1. Land use data from Association of Bay Area Governments, 2006.
LEGEND
SEBP Basin Area as per CA DWR Bulletin 118
General Plan Land Use
Industrial
Mixed Use: Commercial & Industrial
Mixed Use: Residential & Commercial
Commercial
Residential
Mixed Use
Mixed Use: Other
Parks/Open Space
Education/Public/Semi-Public
Water
Other/Unknown
N
0
5,000
10,000
Scale in Feet
FIGURE 2-4
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
LAND USE
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers

2.9 FLOOD PLAIN DELINEATION

Figure 2-5 shows the Federal Emergency Management Agency (FEMA) flood plain delineation mapping for the study area dated April 2012. The flood plain delineation was derived from 100-year flood maps available directly from FEMA and digitized into GIS Data. The total area included in FEMA's 100-year flood plains is approximately 8,400 acres, or 21 percent of the 39,900-acre GMP area. Because Figure 2-5 is scaled to show the entire GMP area, inset maps were created at ten times the size to show better detail. Inset maps are included in Appendix C showing more detail along creeks and streams within the study area.


880
680
238
92
238
880
Notes:
1. Flood areas as delineated by FEMA in April, 2012, and simplified for display.
2. For detailed enlargements, please see Appendix C.
Copyright: ©2012 Esri, DeLorme, NAVTEQ
LEGEND
SEBP Basin Area as per CA DWR Bulletin 118
FEMA 100-Year Flood Areas
CA DWR Bulletin 118 East Bay Plain Basin
N
0
5,000
10,000
Scale in Feet
FIGURE 2-5
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
FLOOD PLAIN DELINEATION 100-YR FLOOD AREAS
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers

2.10 HYDROGEOLOGIC SETTING

The purpose of this chapter is to provide sufficient detail on the geologic history and setting to improve understanding of the geologic framework that defines the groundwater basin, including freshwater aquifers. This also includes understanding of the bedrock geometry which defines the boundaries of the basin, aspects of the bedrock geology that could influence groundwater quantity and quality, and the sequence of sedimentation within the bedrock basin that resulted in the SEBP Basin aquifers. The description of the sedimentary sequence is intended to provide a framework for interpreting site-specific geologic information obtained from drilling and logging and to plan future investigative efforts within the SEBP Basin.

The sediments comprising the aquifers of the SEBP Basin, as delineated in this report, are primarily composed of relatively young alluvial deposits formed in approximately the last few hundred thousand years by streams, such as San Leandro, San Lorenzo and Alameda Creeks, emanating from the East Bay Hills. Productive groundwater zones, likely former stream channels, are found in discontinuous sand and gravel deposits. These sand and gravel zones are enclosed in fine grained deposits formed in alluvial systems during flood events that overtopped stream channels. Near San Francisco Bay, the alluvial deposits interfinger with estuarine deposits and localized wind-blown sand deposits of approximately the same age. The fine grained alluvial and estuarine deposits have low permeability and create confined (pressurized) conditions for most of the SEBP Basin groundwater production zones.

The characteristics of the SEBP Basin aquifers are significantly affected by fault motion. Earth movements not only created the groundwater basin and the depositional environments resulting in the aquifer sediments, but also displaced the aquifer sediments once deposited. Even the youngest deposits forming the SEBP Basin aquifer system are affected, because fault motion is ongoing. However, the somewhat older alluvial deposits, possibly including the productive zones in the SEBP Basin Deep Aquifer, have undergone greater northwesterly translation from their original sites of deposition. Also, Alameda Creek is the only antecedent stream in the region, suggesting that it predates the geologically recent deformation and uplift of the East Bay Hills. The geomorphic characteristics of San Leandro and San Lorenzo Creeks suggest that they are young relative to geologically recent deformation and uplift, introducing the possibility that some deeper alluvial deposits may have been formed by Alameda Creek or other local streams that no longer exist.

The alluvial sediments comprising the main freshwater-bearing zones and underlying the SEBP Basin, probably rest upon and are juxtaposed across faults with older fluvial deposits formed in the early stages of the San Francisco Bay lowland's development. Although the permeability of the coarse-grained fluvial sediments is probably less than the permeability of the coarse-grained alluvial sediments due to greater compaction and cementation, the fluvial sediments are significant to the freshwater aquifer system because they are relatively widespread in the southern San Francisco Bay region.

The alluvial, fluvial and estuarine sediments comprising the freshwater aquifer system in the vicinity of the SEBP Basin are underlain by bedrock consisting of very old Franciscan Complex rocks and deformed marine sedimentary rocks, predating the most geologically recent Coast Range uplift. These older rocks are significant because their structural configuration defines the geometry of the groundwater basin and aspects of their mineralogy may influence groundwater quality in the SEBP Basin.

The following sections of this chapter provide summaries of the geologic history and structural features that make up the geologic framework of the SEBP Basin.

2.10.1 Geologic History

A conceptual geologic column shown in Figure 2-6, illustrates the geologic history of the SEBP Basin within the oldest geologic formation at the base and youngest formation at the top. The geologic column is a graphical representation of the geometrical and temporal relationships between the geologic units that define the SEBP Basin's geometry and hydraulic properties and influence its water quality. Figure 2-7 is a surficial geologic map of the area.

The thickness and extent of the SEBP Basin freshwater aquifer system is delimited by the extent and depth to the top of basement rocks comprised of the Franciscan Complex and the overlying marine sedimentary rocks shown near the bottom of Figure 2-6.

Fluvial sediments located at, or near the base of, the freshwater aquifer system may extend the depth and extent of the system beyond the limits indicated by mapped alluvial deposits in the SEBP Basin.

The primary aquifers of the SEBP Basin are comprised of the Late Pleistocene through Holocene alluvial and estuarine deposits (shown on the upper part of the geologic column).

2.10.2 Mesozoic Through Early Cenozoic Basement Rocks Formed During Subduction of the Farallon Plate

The oldest rocks in the vicinity of the SEBP Basin are late Jurassic through early Tertiary age rocks of the Franciscan Complex and Great Valley Sequence. These rocks provide a record of approximately 140 million years of compressive tectonics, oceanic plate subduction and continental accretion, which ended approximately 28 million years ago when the Farallon Plate was subducted beneath the North American Plate, and right-lateral strike-slip motion was initiated along the San Andreas Fault system (Wakabayashi, 1992).

Rocks of the Franciscan Complex are dominated by detrital sediments (greywacke and shale), with lesser amounts of pillow basalts, chert and minor limestone. As originally formed, these rock units present a record of the formation of new oceanic crust (pillow basalts) at oceanic ridges. Chert deposits formed in deep water over the pillow basalts as the oceanic crust moved away from spreading centers and toward the subduction zone on the western margin of North America. Limestone formed in shallow water over oceanic crust at equatorial latitudes. Greywacke and shale were formed by deposition of continentally-derived sediments by turbidity currents at the subduction zone. The entire assemblage was extensively disrupted by folding and faulting in the oceanic trench near the western margin of North America during subduction of the oceanic Farallon Plate. Tectonic disruptions in the subduction zone resulted in metamorphosis of some Franciscan rocks, which are often identified based on metamorphic petrology resulting from high pressure-low temperature conditions brought about by rapid burial and exhumation in the subduction zone. Serpentinite is a characteristic metamorphic rock type of the Franciscan Complex resulting from the metamorphosis of mantle rocks underlying oceanic crust. Intense shearing resulted in mélange, another characteristic part of the Franciscan Complex. Mélange consists of crushed soft rocks, such

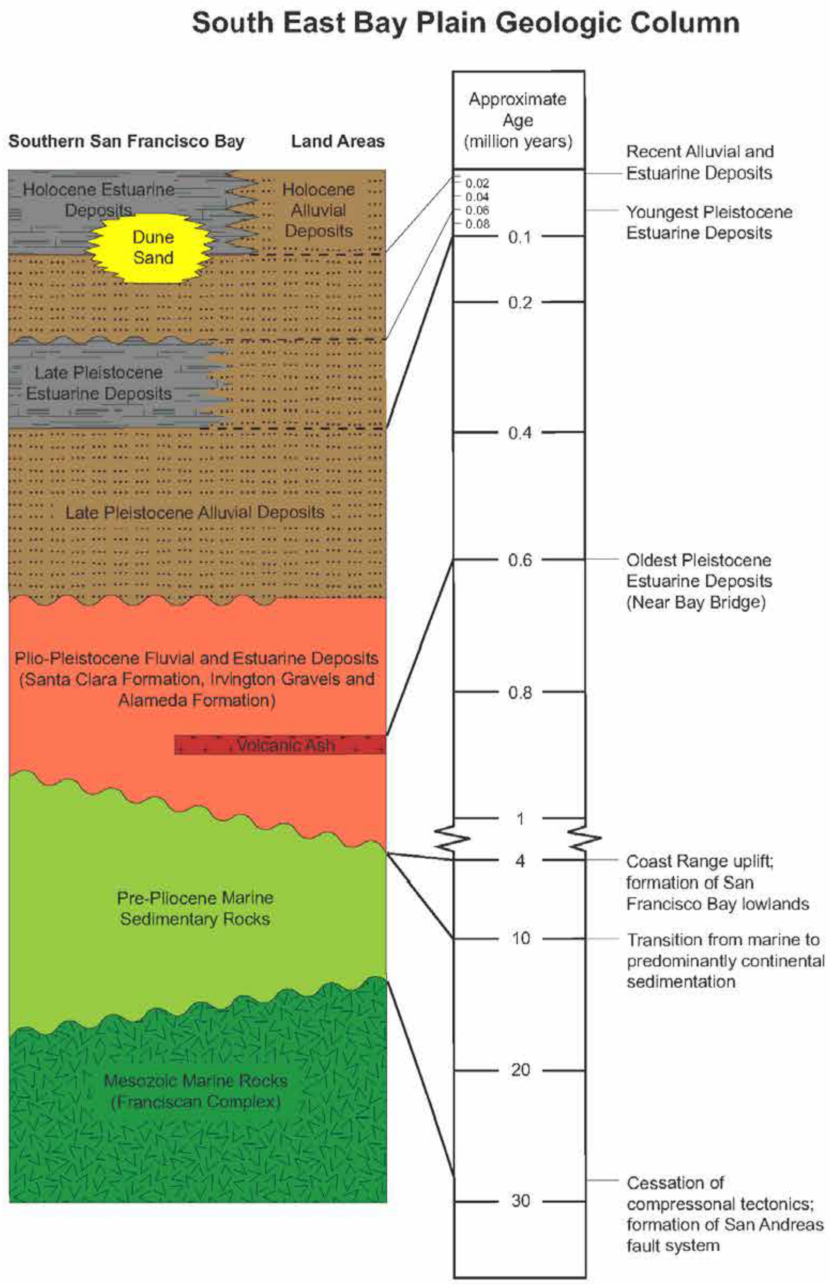


FIGURE 2-6

East Bay Municipal Utility District
South East Bay Plain
Characterization Report

SOUTH EAST BAY PLAIN GEOLOGIC COLUMN

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Consulting Engineers

as shale or serpentinite, containing floating blocks of other more resistant rock types ranging in size from a few square feet to a few square miles (Sloan, 2006). Up to nine different Franciscan Complex terrains have been identified in the San Francisco Bay area (Wahrhaftig and Sloan, 1989; Wakabayashi, 1992).

The Great Valley Sequence formed contemporaneously with the Franciscan Complex in a marine sedimentary basin, known as a forearc basin, located between the Franciscan Complex subduction zone and the Sierran volcanic arc forming the western edge of the continent. The Sierra volcanic arc was the result of melting of the subducted oceanic plate. Buoyant forces drove the melts upwards into the continental crust and to the land surface creating the predominant rock types of the Sierra Nevada. The Great Valley Sequence consists mostly of shale, sandstone and conglomerate.

The Coast Range ophiolite is located at the base of the Great Valley Sequence. The ophiolite is a sequence of dense, igneous rocks of the upper mantle and overlying oceanic crust, which was accreted to the North American continent at the subduction zone. The Mesozoic Coast Range fault system separates the Coast Range ophiolite and overlying Coast Range Sequence on the east from the Franciscan Complex on the west. The Coast Range fault may have been the original demarcation between the Mesozoic rocks undergoing subduction (Franciscan Complex) and those accumulating on the North American continent (Great Valley Sequence).

Figure 2-7 shows the extent of the Franciscan Complex and Great Valley Sequence outcrops mapped in the vicinity of the SEBP Basin. The Hayward fault separates the two units, with virtually all mapped occurrences of the Franciscan Complex occurring west of the Hayward fault. These outcrops consist of marine sedimentary rocks of the central terrain east of Oakland, and mélange and chert of the Marin Headlands terrain at Coyote Hills (Wahrhaftig and Sloan, 1989). Likewise, all mapped occurrences of the Great Valley Sequence are east of the Hayward fault. In the areas nearest the SEBP Basin, the Panoche Formation, a sequence of marine sandstones and shales, is the predominant rock type representing the Great Valley Sequence. The watersheds of San Leandro Creek and San Lorenzo Creek, the two main streams entering the SEBP Basin, are underlain by the Panoche Formation. Runoff characteristics of the streams may be influenced to some degree by the geochemical and hydraulic characteristics of the Panoche Formation.

The Hayward fault is closely associated with the Coast Range ophiolite near the SEBP Basin, which in this area includes the San Leandro Gabbro and other serpentinized rocks (Figure 2-7). Geophysical data show that the Hayward fault in the vicinity of the SEBP Basin is located on the west edge of a 75 to 80 degree easterly dipping mass of San Leandro Gabbro extending to a depth of approximately four to five miles. This indicates that the location of the Hayward fault in this area is controlled by the Mesozoic Coast Range fault because the Coast Range fault separates the Franciscan Complex from the Coast Range ophiolite and the overlying Great Valley Sequence (Ponce, et. al., 2003). This association may be significant to the SEBP Basin groundwater basin, because the mineral chromite is concentrated in ophiolite sequences, including serpentinized derivatives. Sediments eroded from these rocks, including chromite and other chromium compounds, could be present in the SEBP Basin aquifer sediments, because streams such as San Leandro and San Lorenzo Creeks cross the ophiolite belt. These streams contribute alluvial deposits that comprise the SEBP Basin groundwater basin.

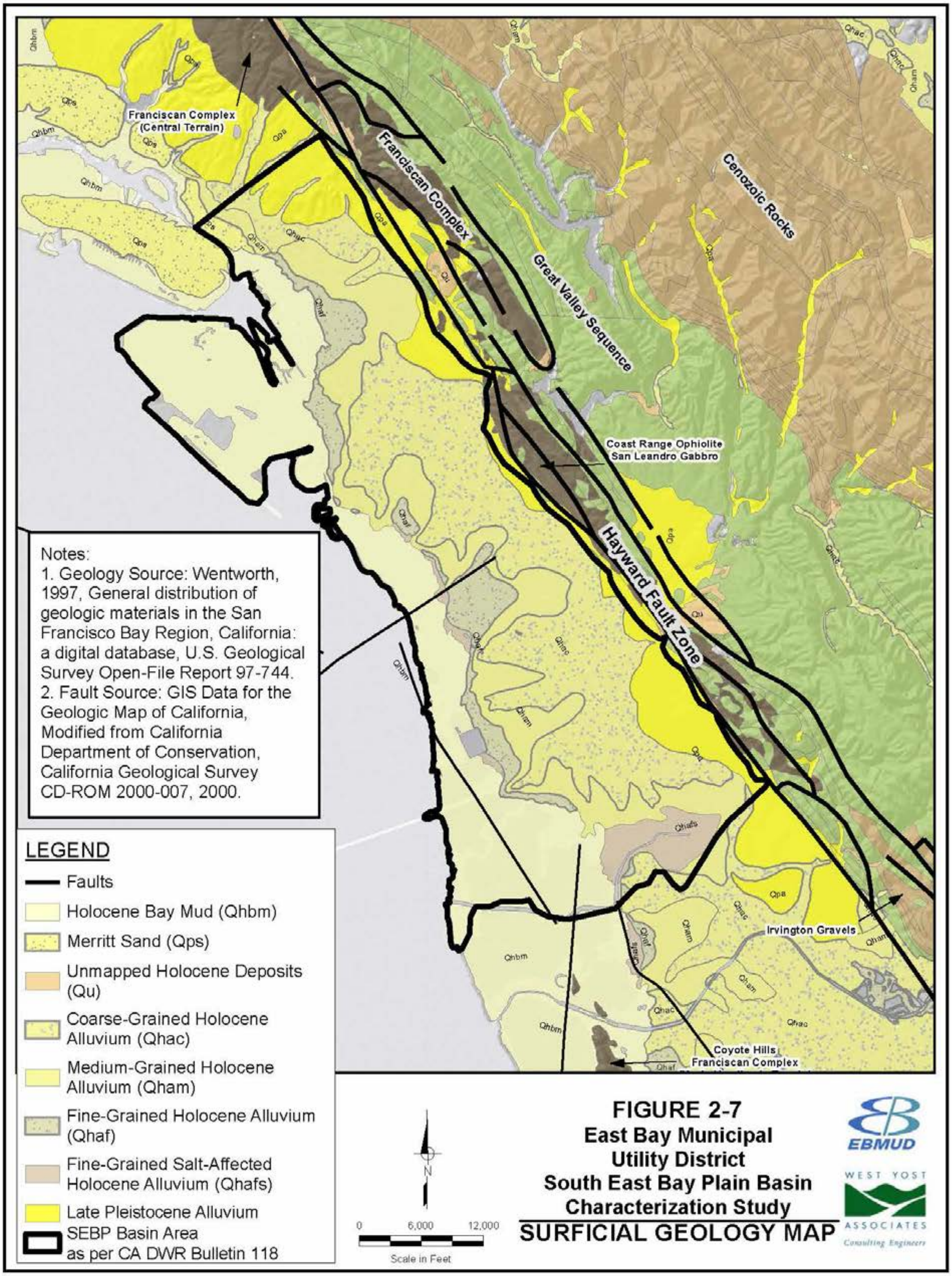

FIGURE 2-7
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
SURFICIAL GEOLOGY MAP

2.10.3 Mid-Cenozoic Rocks Formed Prior to the Existence of the San Francisco Bay Lowlands

Transverse movement on the San Andreas fault system began in Southern California approximately 28 million years ago (Wakabayashi, 1992). Transverse movement progressed northwestward over time, and the Hayward fault began to develop approximately 5 to 12 million years ago. Prior to development of the Hayward fault and extending to about 11 to 12 million years ago, marine conditions prevailed in the vicinity of the SEBP, resulting in the marine sedimentary rocks deposited on Mesozoic basement rocks. These mid-Cenozoic rocks are mapped in the East Bay hills (Figure 2-7). The oldest rocks of this period, typified by the Claremont Formation, were formed in deep water environments while younger rocks, typified by the Briones Formation, were formed in shallow marine environments, demonstrating a general progression from deep to shallow marine conditions. No rocks of this age are mapped near the SEBP Basin, but they are present in the subsurface beneath South San Francisco Bay adjacent to the SEBP Basin (Marlow et al, 1999).

Approximately 10 million years ago, continued uplift resulted in deposition of non-marine sedimentary rocks. Rocks of this age in the vicinity of the SEBP Basin are represented by the Orinda Formation, which outcrops to the northeast near the Caldecott Tunnel. Sediments in the Orinda Formation indicate deposition on an alluvial plain sloping to the east away from the present day San Francisco Bay Peninsula.

2.10.4 Plio-Pleistocene Fluvial Deposits Formed After Creation of the San Francisco Bay Lowlands

Formation of the San Francisco Bay lowlands began approximately four million years ago with uplift of the Coast Range. Fluvial deposits accumulated in localized depositional basins during this time are represented by the Livermore Gravels, the Santa Clara Formation, and in the vicinity of the SEBP Basin, the Irvington gravels (Figures 2-6 and 2-7). The Irvington gravels outcrop intermittently in a narrow band near the Hayward fault extending from the Irvington District of Fremont south towards Coyote Valley. These formations consist predominately of poorly consolidated conglomerate, sandstone, siltstone and clay. They range from approximately 0.5 to 4 million years in age (Page, 1992). They are folded and faulted, consistent with their genetic association with uplift of the Coast Ranges during the same period.

2.10.5 Late Pleistocene Through Holocene Alluvial, Estuarine and Eolian Deposits

Approximately 0.6 million years ago, the Sacramento-San Joaquin River flowed through the San Francisco Bay lowlands to the Pacific Ocean, and the first known estuarine deposits were formed (Trask and Rolston, 1951; Hall, 1966; Sarna-Wojcicki, 1976; Atwater, 1977; Sarna-Wojcicki et al., 1985; Lanphere, et al., 1999)[2].

[2] Data supporting these statements were first reported in an engineering geology study conducted to assess alternative crossings near the San Francisco Bay - Oakland Bay Bridge (Trask and Rolston, 1951). Trask and Rolston, page 1083 (1951) reported encountering a volcanic ash deposit at a depth of 280 feet in the deepest of the five members of the Alameda formation defined in their report. The boring was located on the west side of the Bay Bridge near San Francisco (Figure 4-3). Hall (1966) concluded, based on mineralogical analysis, that Great Valley drainage had been established by the time a similar tuff had been deposited in marine sandstone of the Merced Formation outcropping slightly south of San Francisco (Figure 4-2). Sarna-Wojcicki (1976) correlated the ash documented in Trask and Rolston (1951), and equivalent ashes in the Merced and Santa Clara Formations, with the Rockland Ash of the southern Cascade Range and documented an age of approximately one million years, based on the available radiometric age dating of the time. Atwater (1977) apparently interpreted the deepest member of Trask and Rolston's (1951) Alameda Formation, a stiff greenish gray clay, as an estuarine deposit, and concluded that it was the oldest identified estuarine deposit. Sarna-Wojcicki et al. (1985) documented a revised age of approximately 0.4 million years for the Rockland Ash based on fission track methods. Lanphere, et al. (1999) revised the age upwards to approximately 0.6 million years using radiometric methods.

Sediments deposited during this period consist of estuarine deposits within the footprint of the current San Francisco Bay, alluvial deposits on the flanks of the East Bay Hills extending into the area currently occupied by San Francisco Bay, and eolian (wind-born) sands (Figure 2-6).

The detailed stratigraphy of the deposits underlying the San Francisco Bay was developed by Trask and Rolston (1951). Figure 2-8 shows the five stratigraphic units identified by Trask and Rolston (1951) based on drilling near the Bay Bridge. These stratigraphic units from shallowest to deepest are:

- Bay Mud
- Merritt Sand
- Posey Formation
- San Antonio Formation
- Alameda Formation

As described in footnote 1, the lower part of the Alameda Formation contains the oldest known estuarine deposits identified in the bay. The Alameda Formation rests directly on Franciscan bedrock on the west edge of the bay, but the full thickness of the Alameda Formation was not penetrated by borings elsewhere (Figure 2-7). Researchers concluded that the Alameda Formation may overlay the Santa Clara Formation or the marine Merced Formation in other areas (see footnote 1). This conclusion is reasonable based on the geologic setting described above, noting especially that the ages of the Santa Clara Formation and other similar fluvial deposits, including the Irvington Gravels, predate and overlap the age of the lowest Alameda Formation estuarine deposits (Figure 2-6).

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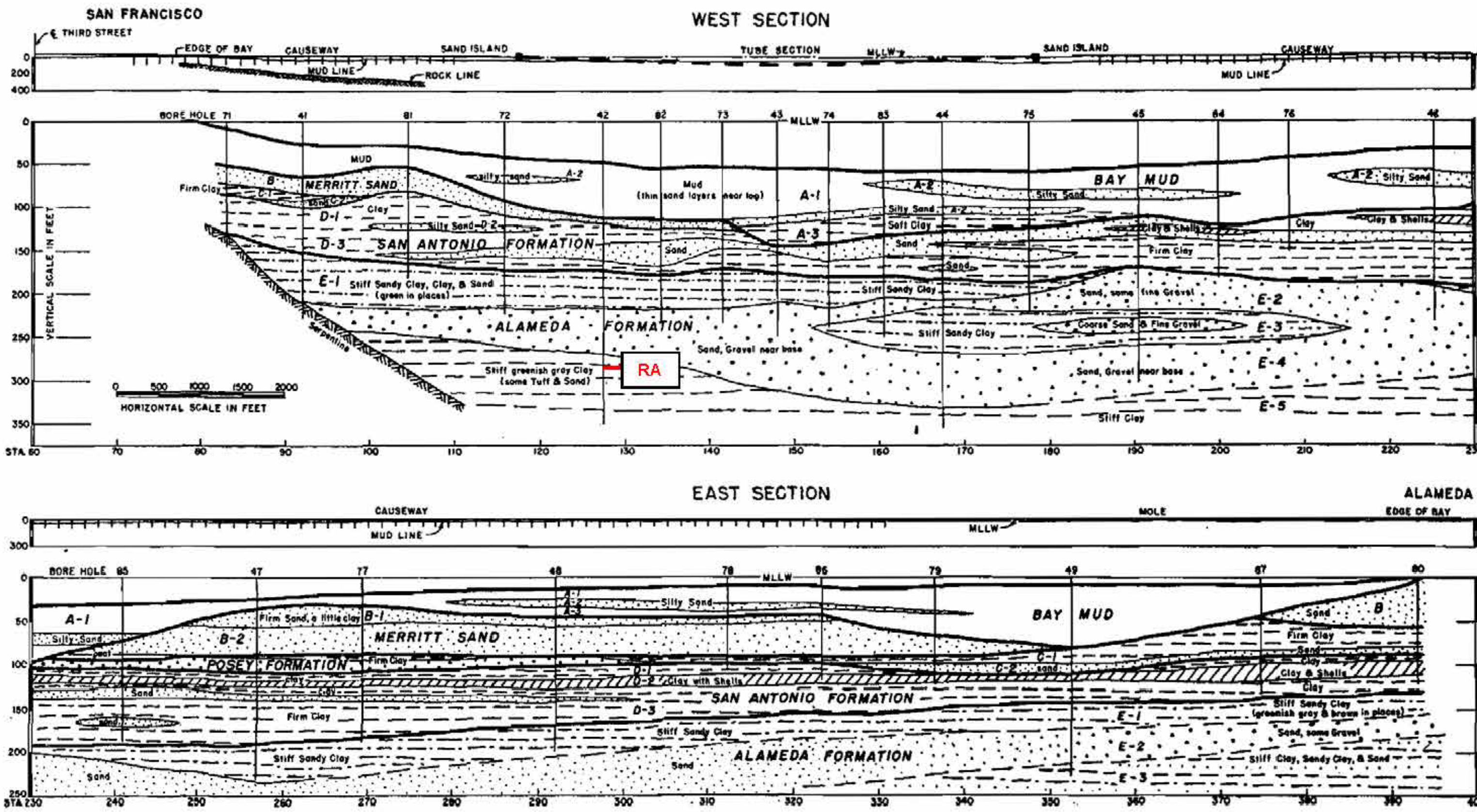

FIGURE 3.—PROFILE OF SEDIMENTS, SOUTHERN CROSSING, SAN FRANCISCO BAY

Note: RA designates location of volcanic ash encountered at a depth of approximately 280 feet. The volcanic ash is correlated with the Rockland Ash (Sarna - Wojcicki, 1976) and has a radiometric age of approximately 600,000 years (Lanphere, et al, 1999). Atwater (1976) interpreted the surrounding clay deposits as representing the oldest known estuarine sediments in San Francisco Bay.

FIGURE 2-8

East Bay Municipal Utility District
South East Bay Plain Basin Characterization Report

CROSS SECTION SHOWING OLDEST IDENTIFIED ESTUARINE DEPOSITS

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The stratigraphic relationship between the age equivalents of the lower Alameda Formation and adjacent strata is unclear farther south, including adjacent to the SEBP Basin. It is possible that estuarine deposits of lower Alameda Formation age extend as far south as the SEBP Basin, or interfinger with fluvial sediments, because the Santa Clara Formation contains a volcanic ash of the same age as the volcanic ash found in the lower Alameda Formation (Atwater, 1977). Mid-Cenozoic marine rocks formed prior to the existence of the San Francisco Bay lowlands underlie lower Alameda age sediments west of San Leandro (Marlow, 1999).

Atwater (1977) reinterpreted the stratigraphic sequence used by Trask and Rolston (1951) based on microfossil and other evidence collected in the south bay. Atwater (1977) concluded, based on the lack of marine microfossils and estuarine mollusks and other evidence, that the Posey Formation in the south bay is alluvial rather than estuarine. Atwater (1977) also identified the San Antonio Formation as the youngest Pleistocene age estuarine deposit in the south bay, with an age of 60,000 to 100,000 years. The late-Pleistocene estuarine sequence has approximately the same lateral extent as the recent estuarine deposits (Atwater 1977).

Based on this information, the depositional sequence in the south bay is from youngest to oldest (Figure 2-6):

- Estuarine deposits (Bay Mud, Holocene)
- Isolated eolian sand deposits (late-Pleistocene-Holocene)
- Alluvium (late-Pleistocene, <60,000 years)
- Estuarine deposits equivalent to the San Antonio Formation (late Pleistocene, approximately 60,000-100,000 years)
- Alluvium (late-Pleistocene, >100,000 years)
- Fluvial and estuarine deposits with undefined stratigraphic relationships. Plio-Pleistocene, 4 million to 500,000 years; oldest identified estuarine deposit (600,000 years) identified near Bay Bridge

In summary, the significance of this stratigraphic sequence is that thick alluvial and fluvial sequences capped by two major estuarine sequences underlie the bay to the west of the SEBP Basin. If sufficiently permeable, these alluvial and fluvial sequences should have hydraulic continuity with the alluvial and fluvial sediments underlying the SEBP Basin and form a continuous confined aquifer system extending to the west beneath the bay.

Holocene to late-Pleistocene alluvial deposits formed by streams emanating from the East Bay hills are the youngest deposits in the SEBP Basin (Figure 2-6 and 2-7). The SEBP Basin is underlain by the coalesced alluvial fans of San Leandro Creek, San Lorenzo Creek and Alameda Creek. Although Alameda Creek is located south of the SEBP Basin, it has significance to the SEBP Basin geology, because of its size and age. San Leandro Creek and San Lorenzo Creek have small drainages in comparison to Alameda Creek, and, of the three streams, only Alameda Creek is an antecedent stream, predating the most recent Coast Range uplift. Assuming a long-term slip rate of approximately one centimeter per year on the Hayward Fault over 500,000 years, sediments deposited by Alameda Creek west of the Hayward fault could have been displaced approximately three miles to the northwest. Coincidently, this is approximately the distance to the dissected older alluvial deposits mapped on the west side of the Hayward fault in the SEBP Basin (Figure 2-7). Extensive older alluvial deposit are also mapped in the SEBP Basin farther north in the Oakland area. Older alluvial deposits may have been formed by ancestral streams not associated with existing drainages, because the most recent episode of Coast Range uplift has been underway for approximately the past four million years. This uplift has significantly modified the topography of the area.

Regardless of the origin of the oldest late-Pleistocene alluvial deposits in the SEBP Basin, they are likely to be widespread in the subsurface based on the depositional environment. However, estimation of the spatial distribution of coarse versus fine textures in these deposits based on geologic principles is hindered by the unknown nature of ancestral streams forming the deposits and the unknown displacement history of the Hayward fault and possibly other faults hidden in the subsurface.

2.11 GEOLOGIC STRUCTURE

The San Francisco Bay lowlands occupy a down-dropped fault block between the Santa Cruz Mountains and the East Bay hills of the Diablo Range. The block is bounded by major, active strands of the San Andreas fault on the west and the Hayward fault on the east (Figure 2-7). The block is disrupted by other active and inactive faults as evidenced by the seismicity away from the active strands of the San Andreas and Hayward faults, and the bedrock relief, which locally brings Franciscan Complex rocks above the elevation of basin filling sediments.

A map of isostatic residual gravity contours of the SEBP Basin and vicinity is represented in Figure 2-9. Gravity data was evaluated to understand the shape of the bedrock surface underlying the more recent sedimentary deposits, including the freshwater aquifer. Isostatic residual gravity measurements have been corrected to compensate for lateral variation in the density or thickness of large crustal blocks. The SEBP Basin is situated on the eastern edge of one of two major areas of anomalously low gravity measurements (Roberts and Jachens, 1993). The other anomaly is located in eastern San Pablo Bay and is caused by a young pull-apart basin where the Hayward fault steps over to the east to the Rodgers Creek fault (Ponce et. al, 2003). The geologic structure causing the gravity anomaly at the SEBP Basin is an older structure known as the San Leandro synform (Marlow, et. al., 1995). This downward fold predates the most recent Coast Range uplift beginning about four million years ago and affects the Franciscan Complex and the overlying mid-Cenozoic marine rocks (Marlow, et. al., 1999).

A seismic cross section through the San Leandro synform from Marlow, et. al. (1999), is shown in Figure 2-10. The figure shows a basement of Franciscan Complex bounded by an upper erosional surface, which is overlain by dipping layers of mid-Cenozoic marine sediments on the eastern side of the section. The synform was probably formed when the originally flat-lying marine sediments were folded by the same forces that reinitiated Coast Range uplift beginning approximately four million years ago (Figure 2-6). The upper surface of the marine sediments is truncated by an erosional surface that extends across the Franciscan Complex on the western side of the section. The deposits above this surface are relatively undisturbed and consist of late Pliocene through recent fluvial, alluvial, estuarine and eolian deposits. Based on drill hole data presented in Figuers (1998), these sediments extend to depths below sea level of at least 665 feet. The two-way travel time to the base of the sediments is approximately 0.3 seconds. Assuming a seismic velocity of 5,000 feet per second, the depth to the base of the flat-lying sediments is approximately 750 feet.

The gravity anomaly associated with the San Leandro synform extends to the north beneath the SEBP Basin in the San Leandro/Oakland area, suggesting a lower density in, or greater depth to, the Franciscan Complex basement in this area.

A map of the earth's magnetic-field intensity contours based on aerial surveys (USGS, 1996) is represented in Figure 2-12. The map helps to delineate basement features with contrasting magnetic susceptibility, which may not be reflected in density contrasts. The map clearly shows the location of the Hayward fault and another northwest trending feature extending across the bay in the same area as the San Leandro synform. Based on additional processing and analysis of the magnetic data, Ponce et. al. (2003) concluded that the northwesterly trending feature is a serpentinite with a high magnetic susceptibility.

The work of Ponce, et. al. (2003) also shows small magnetic anomalies in the northern SEBP Basin, but the significance of these anomalies has not been assessed.

Figure 2-12 shows the location of a seismic reflection transect across the SEBP prepared by the USGS (Catchings, et. al., 2006). Seismic reflection methods detect sonic velocity differences in the subsurface, which are indicative of contrasting rock types. Seismic reflection data can also be used to differentiate aquifer and aquitard material in some depositional environments. Figure 2-13 is a southwest-northeast cross section based on the seismic reflection results, borehole data, and gravity measurements. Based on the results, depth to the Franciscan Complex ranges from approximately 1,000 feet near the northeastern end of the transect to approximately 3,000 feet on the southwestern end, where the transect crosses into the San Leandro synform (Figures 2-9 and 2-10). The USGS identified three aquifer zones along the transect based on the seismic reflection data and available borehole data. The approximate depths of the bottoms of these zones are as follows:

- Shallow Zone: 70 to 230 feet
- Intermediate Zone: 330 to 460 feet
- Deep Zone: 530 to 660 feet

The depth of each zone increases from northeast to southwest.

The USGS identified five zones in which the reflection data indicated faulting extending through the near surface sediments (Figure 2-13). The most significant of these zones is located approximately 7,000 feet east of the bay shore in the vicinity of Arroyo High School. These faults may be related to the Silver Creek fault, which is mapped at the surface in the Morgan Hill area and inferred to exist in the subsurface as far north as Fremont (Wagner, et. al., 1990). Groundwater flow may be impeded across the fault zones. Also, aquifer thickness and permeability (hydraulic conductivity) may be different on either side of a fault zone, because faulting could juxtapose geologic materials formed in different depositional settings.

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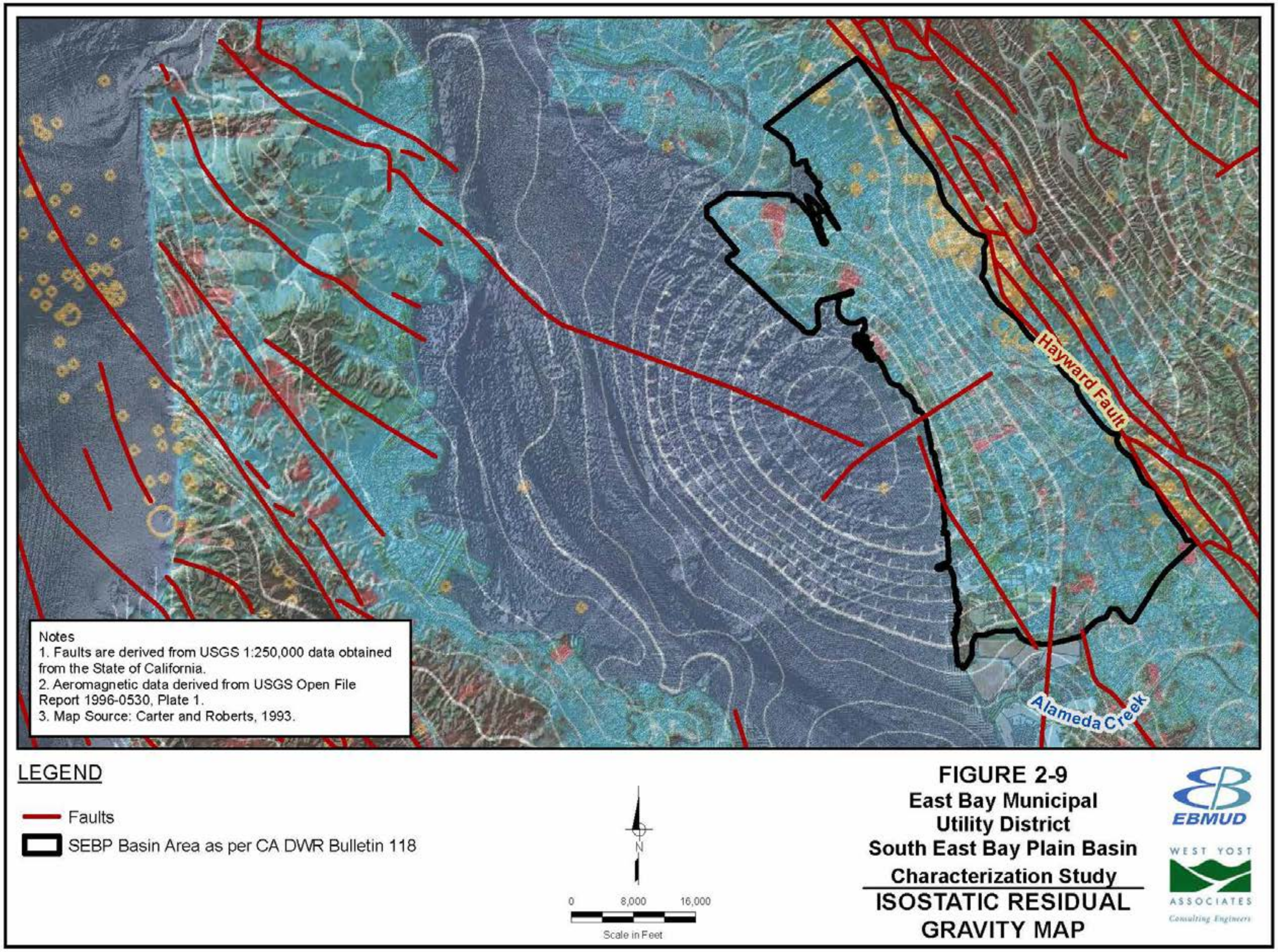
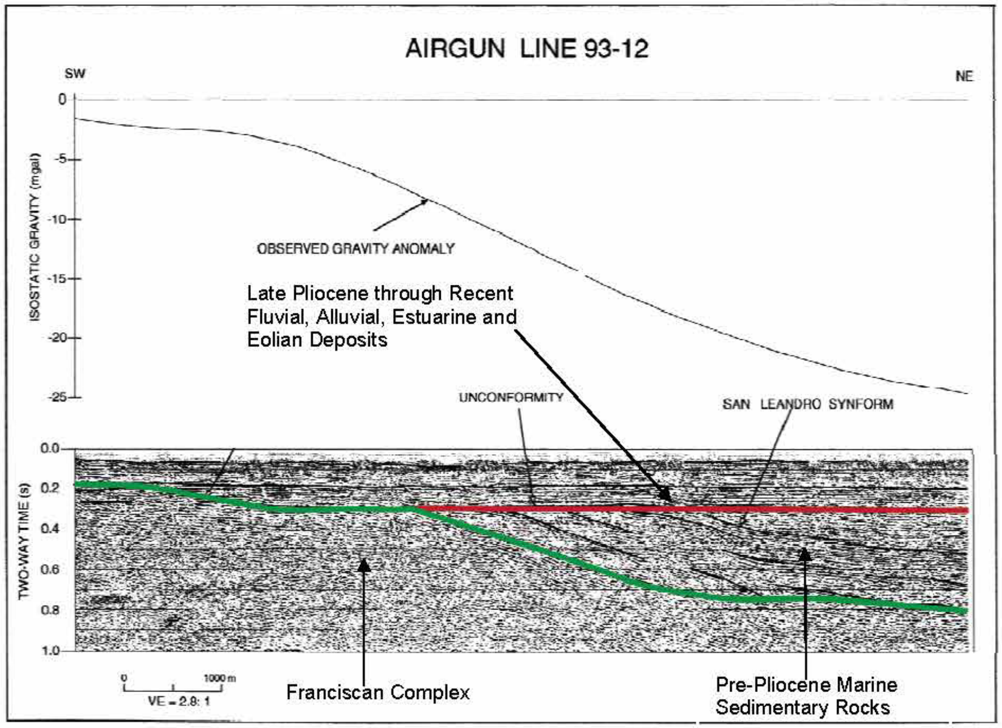
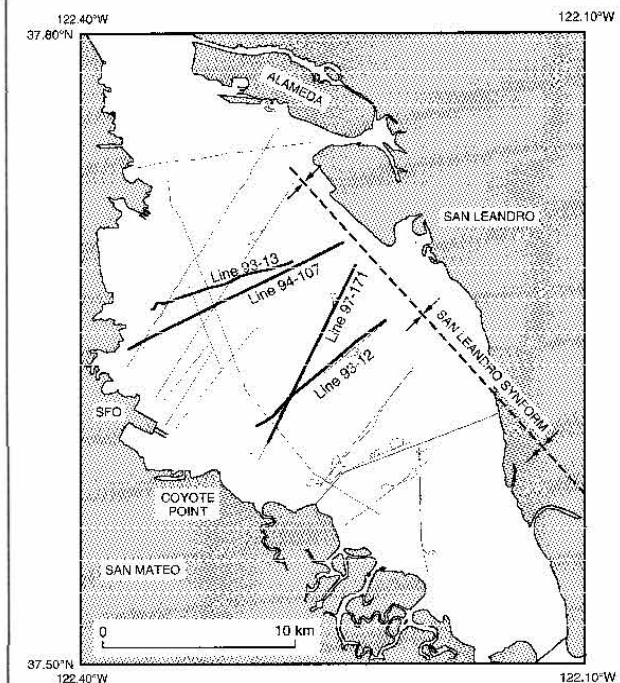


FIGURE 2-9
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
ISOSTATIC RESIDUAL GRAVITY MAP





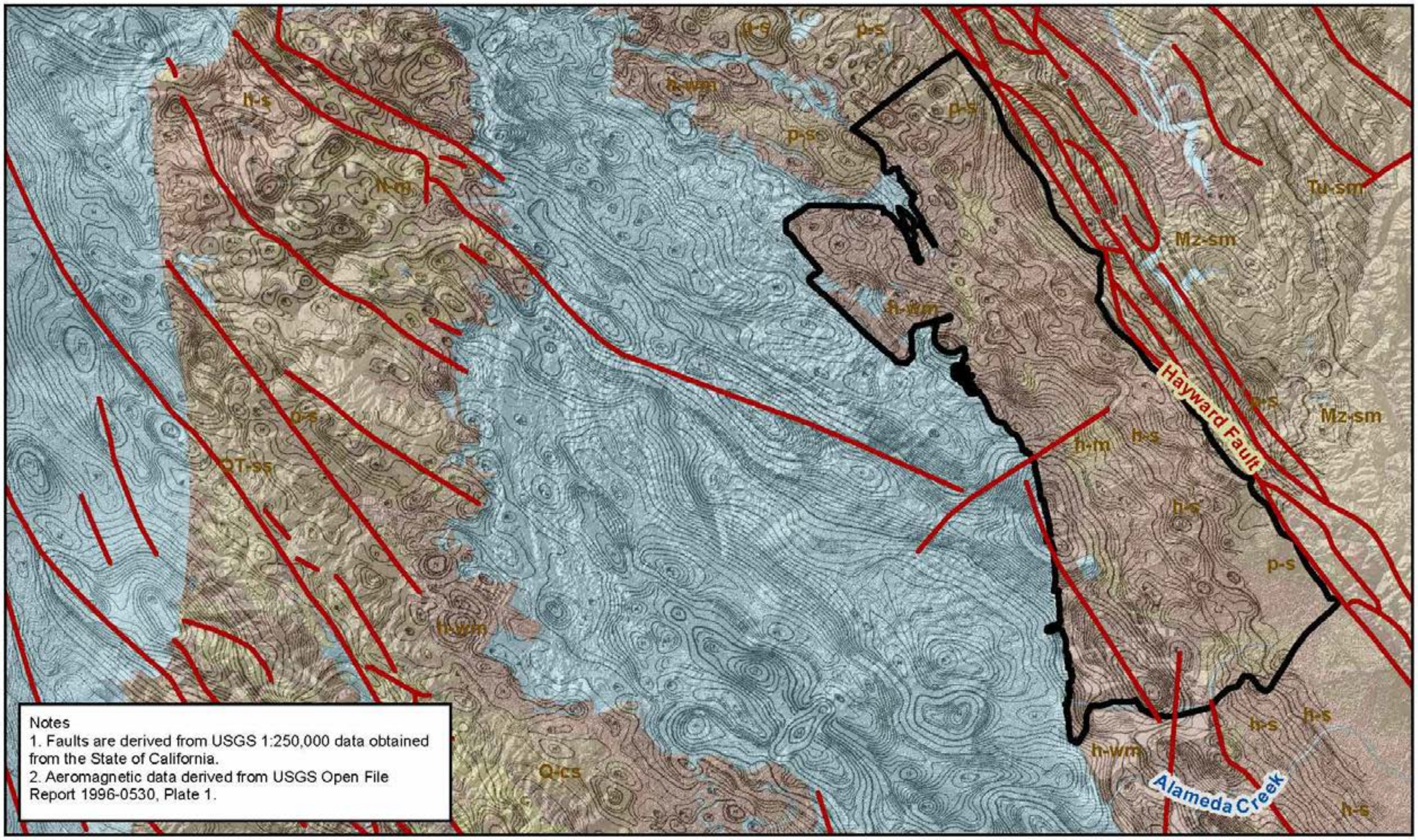
Reference: Marlow, M.S., R.C. Jachens, P.E. Hart, P.R. Carlson, R.J. Anima, J.R. Child, 1999 Development of San Leandro Synform and Neotectonics of San Francisco Bay Block, California, Marine and Petroleum Geology, V. 16, PP 431-442.

FIGURE 2-10

East Bay Municipal Utility District

South East Bay Plain Basin Characterization Report

SAN LEANDRO SYNFORM



LEGEND

Faults

SEBP Basin Area as per CA DWR Bulletin 118

N

0 8,000 16,000
Scale in Feet

FIGURE 2-11
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
AEROMAGNETIC MAP

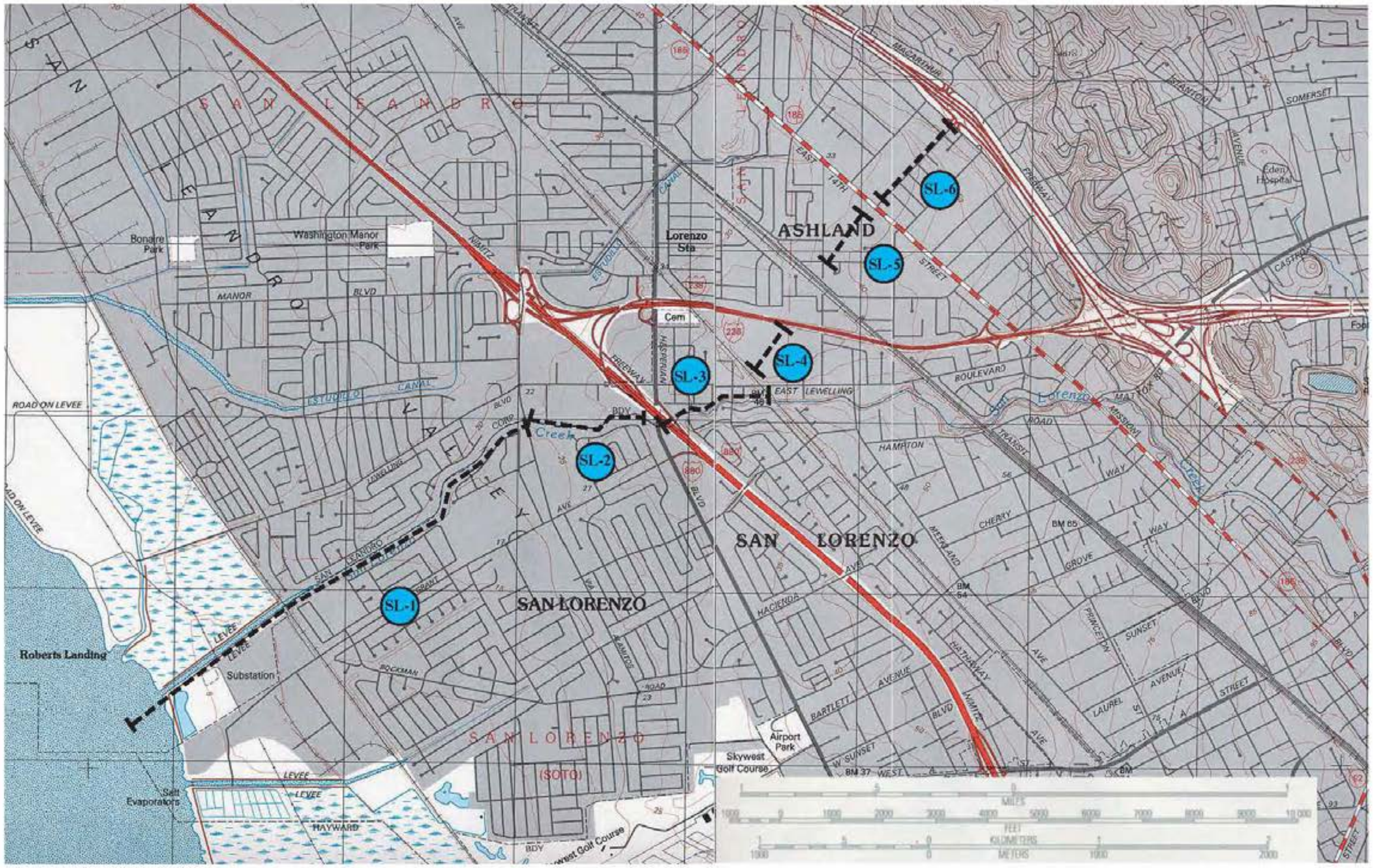
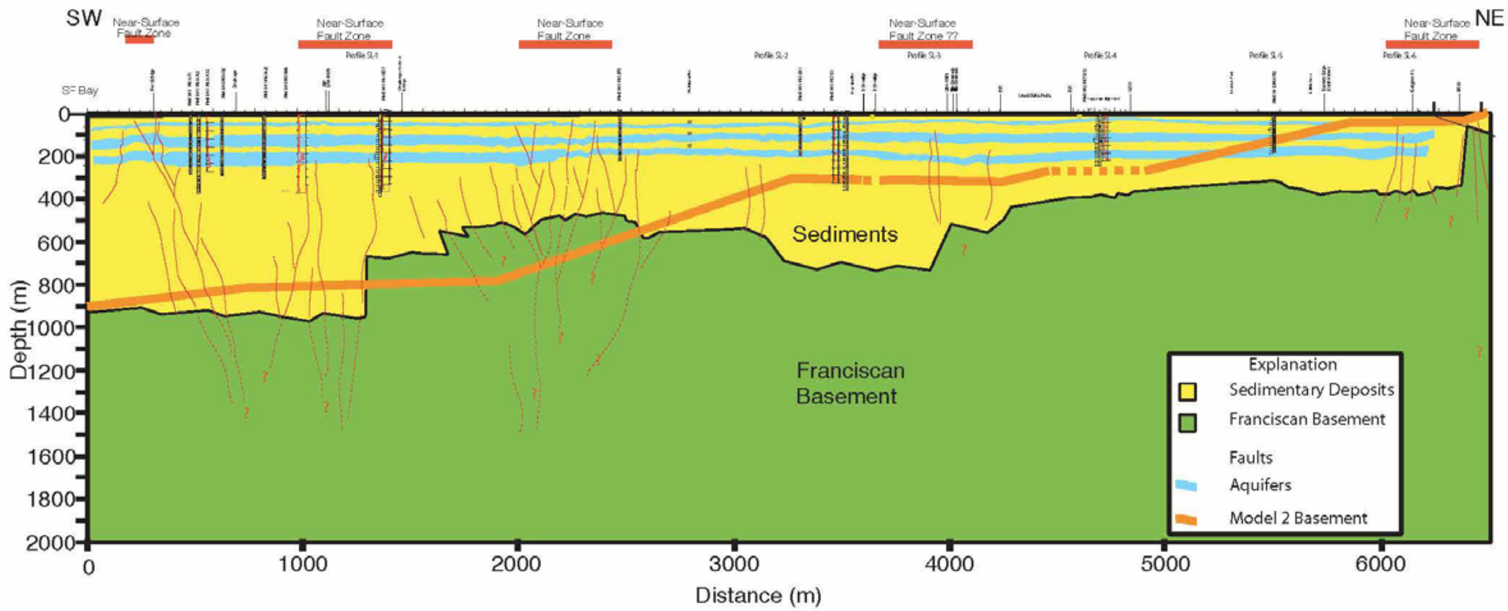


FIGURE 2-12

East Bay Municipal Utility District

South East Bay Plain Basin Characterization Report

EAST BAY PLAIN SEISMIC TRANSECT



Reference: Catchings, R.D., J.W. Borchers, M.R. Goldman, G. Gaudhok, D.A. Ponce, and C.E. Steedman, 2006, Subsurface Structure of the East Bay Plain Groundwater Basin: San Francisco Bay to Hayward Fault, Alameda County, California, USGC Open-File Report 2006-1084.

Figure 2-13

East Bay Municipal Utility District
South East Bay Plain Basin Characterization Report

INTERPRETIVE CROSS SECTION BASED ON SEISMIC, GRAVITY, AND WELL LOG DATA

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2.12 HYDROGEOLOGIC UNITS

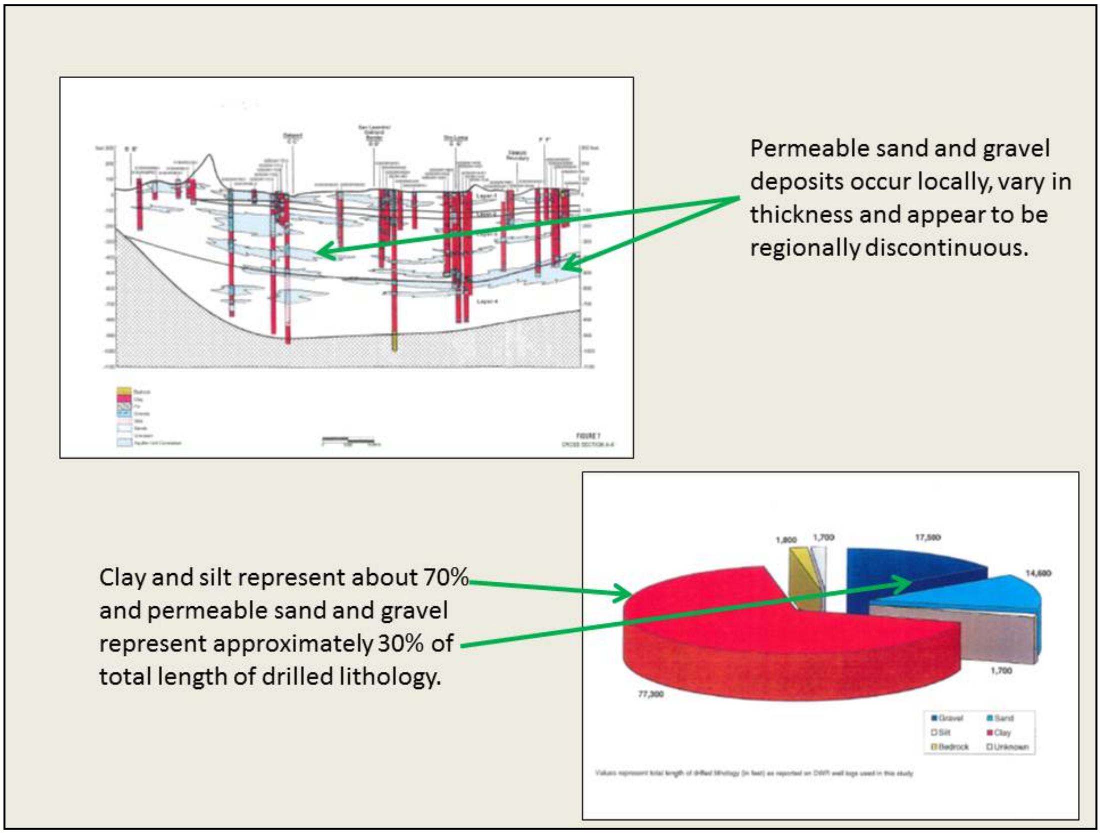
This section describes the hydrogeologic units that comprise the freshwater aquifer system within the SEBP Basin. The discussion provides:

- Rationale for defining the SEBP Basin hydrogeologic units and their relationship to hydrogeologic units in the NCGB
- Summary of the hydraulic properties of the Deep Aquifer Zone, as estimated during previous aquifer testing
- Documentation of groundwater levels, quality and groundwater recharge and discharge areas

Numerous groundwater studies have described the hydrogeology of the SEBP Basin. The objective of this study is to build on previous work and to integrate additional information to better characterize the Deep Aquifer Zone. Information in this section describes the methodology used to incorporate new subsurface information into existing geologic cross sections developed through a joint effort by Alameda County Water District, the City of Hayward, and EBMUD (LSCE, 2003). This updated subsurface information was used along with long-term aquifer tests performed on wells screened in the Deep Aquifer Zone (LSCE, 2003 and Fugro, 2011) to develop updated conceptual and numerical groundwater models.

As introduced in the previous chapter, Holocene to late-Pleistocene alluvial sediments comprise the important groundwater producing zones in the aquifer system of the SEBP Basin. Fine grained sections of the alluvial sequences create confining conditions between the more permeable groundwater producing zones. Near the bay, fine grained estuarine deposits also create confined conditions. It is likely that groundwater producing zones have continuity with similar alluvial and fluvial zones beneath the bay, which are likewise confined by fine-grained estuarine sequences. Franciscan Complex rocks form the base of the aquifer system and limit its easterly extent. As shown in the figure below, in many areas the permeable zones are most likely to be discontinuous, and it is difficult to correlate sand and gravel layers over great distances between wells.

Distribution and Occurrence of Permeable Material Comprising the SEBP Aquifers (Modified from CH2MHill, 2000)



The available geophysical logs, borehole data, and cross sections show that the depth intervals typically containing relatively high percentages of permeable sediments can be grouped into three hydrogeologic units as follows:

- Shallow Aquifer Zone: approximately 30 to 200 feet
- Intermediate Aquifer Zone: approximately 200 to 500 feet
- Deep Aquifer Zone: approximately 400 to 660+ feet

The Shallow Aquifer Zone is present throughout the study area, with permeable zones typically occurring at depths between 30 and 130 feet below land surface (CH2MHill Inc., 2000). The SEBP Basin Shallow Aquifer Zone exists in approximately the same range of depths as the NCGB's Newark and Centerville Aquifers. Groundwater in the Shallow Aquifer Zone is generally confined except near recharge areas along the mountain front. The Intermediate Aquifer Zone generally has discontinuous sand and gravel deposits that are difficult to correlate between wells. It occurs in approximately the same depth range as the NCGB's Fremont Aquifer. The Deep Aquifer Zone contains a significant permeable zone that appears to be continuous throughout the SEBP Basin, but at a greater depth than the NCGB Deep Aquifer. This permeable zone appears to be thickest and most continuous south of San Leandro (Maslonkowski, 1988) and thins, eventually disappearing, to the north (CH2MHill, Inc., 2000). In this area, aquifers are underlain by partly consolidated deposits (Marlow et. al., 1999) having low porosity and low permeability (Izbicki, 2003).

2.12.1 Development of Updated Hydrogeologic Cross Sections

The cross section analysis and update involved integrating and comparing information obtained from numerous sources using ArcHydro Groundwater[3] and other related GIS tools. The information evaluated included published geologic and geophysical cross sections, model surfaces, and hydrogeological and geophysical data. Published cross sections from four sources were reviewed and analyzed.

Figure 2-14 shows the locations and sources of the cross sections evaluated for this study. The first two groups of cross sections were developed by consulting firms Luhdorff & Scalmanini Consulting Engineers (LSCE, 2003) and CH2MHill (CH2MHill. 2000). The third and fourth sets of cross sections reviewed include those prepared by the USGS (Izbicki,2003; Catchings, 2006).

Figure 2-15 shows the locations of the three updated cross sections developed using Arc Hydro Groundwater and other related GIS tools. To fully utilize this existing work, all available cross sections were spatially referenced and new subsurface information was added using GIS tools. This allowed enhanced visual analysis of multiple sets of information in one common environment. The LSCE Cross Sections 1-2, 2-3, 3-4, and 4-9 coincide with the primary north-south cross section updated for this study and designated as Transect A-A' (Figure 2-15). Two east-west sections were developed. The location for B-B' coincides with the A-A' cross section transect provided in Izbicki, 2003. The location for C-C' is midway between Izbicki's B-B' transect (Izbicki, 2003) and the USGS cross section transects in their seismic refraction report (Catchings, 2006).

[3]Arc Hydro Groundwater is a geodatabase design for representing groundwater datasets within ArcGIS. The data models helps archive, display, and analyze multidimensional groundwater data, and includes several components to represent different types of datasets including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models (http://www.archydrogw.com/ahgw/Main_Page).

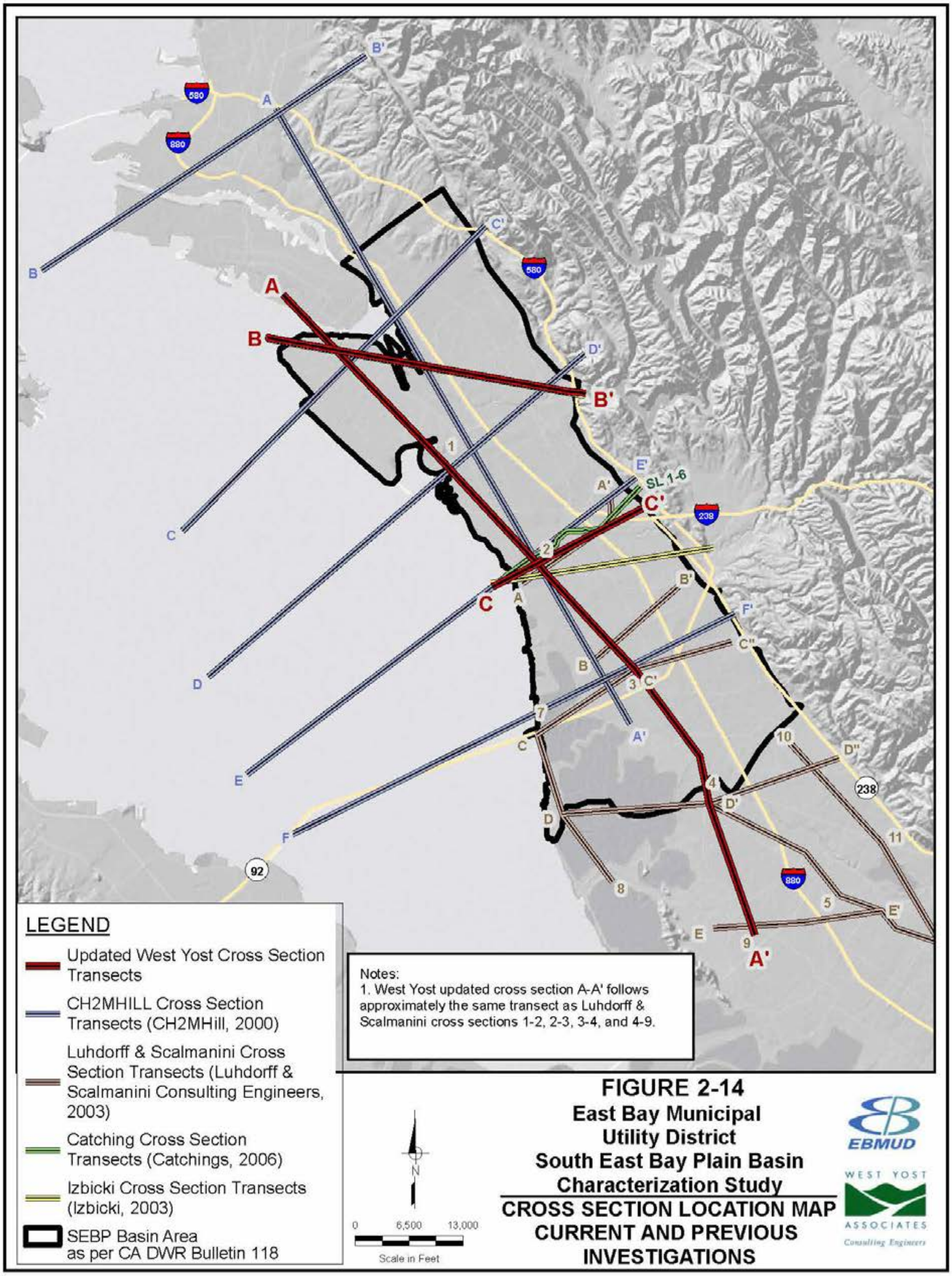


FIGURE 2-14
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
CROSS SECTION LOCATION MAP CURRENT AND PREVIOUS INVESTIGATIONS

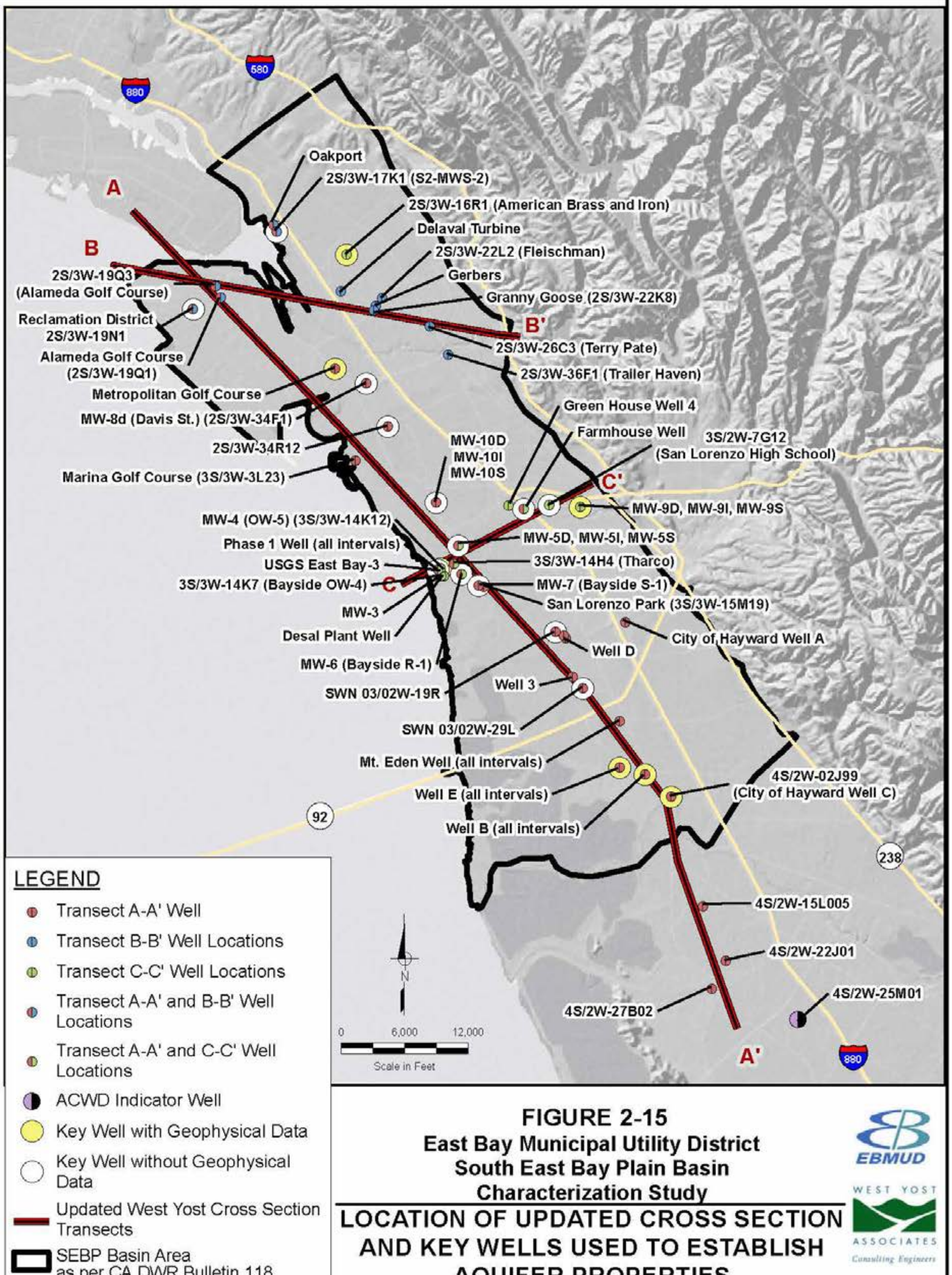


FIGURE 2-15
East Bay Municipal Utility District
South East Bay Plain Basin
Characterization Study

LOCATION OF UPDATED CROSS SECTION AND KEY WELLS USED TO ESTABLISH AQUIFER PROPERTIES

Subsurface Analyst was the primary tool used for cross section analysis. Each transect was georeferenced and digitized so the information was projected in real-world coordinates, within the Arc Hydro Groundwater geodatabase. The benefit of projecting the published literature in real-world coordinates is that it provided a mechanism to overlay external data, enhancing the ability to review existing model input parameters with the most updated hydrogeological information. A complete set of updated cross sections and detailed description of the Arc Hydro approach utilized for the updates is provided in Appendix D.

For this study, the SEBP Basin Deep Aquifer and the NCGB Deep Aquifer are depicted as separate hydrogeologic units. The distinction between the two hydrogeologic units is based largely on work conducted by LSCE (2003). LSCE (2003) documented ten permeable stratigraphic units within the SEBP Basin Deep Aquifer and transition zone based on geophysical and lithologic logs. These were labeled in increasing numerical sequence from deepest to shallowest. With notable exception, units 1 through 6.5 are all located in the SEBP Basin, based on hydraulic responses measured during aquifer testing (LSCE, 2003). Units 7 and 8 are located in the transition zone [LSCE (2003), Figures 2 through 5]. The exception to the previous statement is identified on LSCE (2003) Figure 4, which shows City of Hayward Well B penetrating, from shallowest to deepest, stratigraphic units 8, 7 and 4.5. Units 7 and 8 extend southward to at least City of Hayward Well C, but pinch out to the north in the SEBP Basin. On initial inspection, unit 4.5 appears to be a continuation of stratigraphic unit 4 of the SEBP Basin; however, LSCE (2003) appears to conceptualize units 4 and 4.5 as separate, with unit 4 falling in the SEBP Basin and unit 4.5 falling in the transition zone. This conceptualization is supported by the hydraulic responses to pumping in City of Hayward Wells C and E (LSCE, 2003). Pumping in City of Hayward Well C, which produces water from units 7 and 8 of the Niles Cone Basin, caused a response in City of Hayward Well B that matched the response for a single idealized confined aquifer as represented by the Theis (1935) equation, whereas wells, such as the Mount Eden well, in the SEBP Basin, exhibited hydraulic responses that did not match the idealized response.

Conversely, pumping in City of Hayward Well E, which produces water from units 4 and 6 of the SEBP Basin, caused a response in City of Hayward Well B that proved a hydraulic connection but did not match the response for a single idealized confined aquifer. Other Deep Aquifer wells clearly in the SEBP Basin, such as the Mount Eden well, exhibited hydraulic responses that matched the response for a single idealized confined aquifer.

2.12.2 Deep Aquifer Hydraulic Properties

Hydraulic properties have been estimated from a variety of aquifer tests conducted in the Deep Aquifer Zone as documented in LSCE (2003) and Fugro (2011). Based on review of these results, transmissivity of the Deep Aquifer Zone of the SEBP Basin ranges from approximately 33,000 gallons per day per foot (gpd/ft) to 141,000 gpd/ft and storativity ranges from 0.00005 to 0.005. Figure 2-16 shows the locations of the pumping and observations wells included in aquifer tests conducted by LSCE (2003) and Fugro (2011).

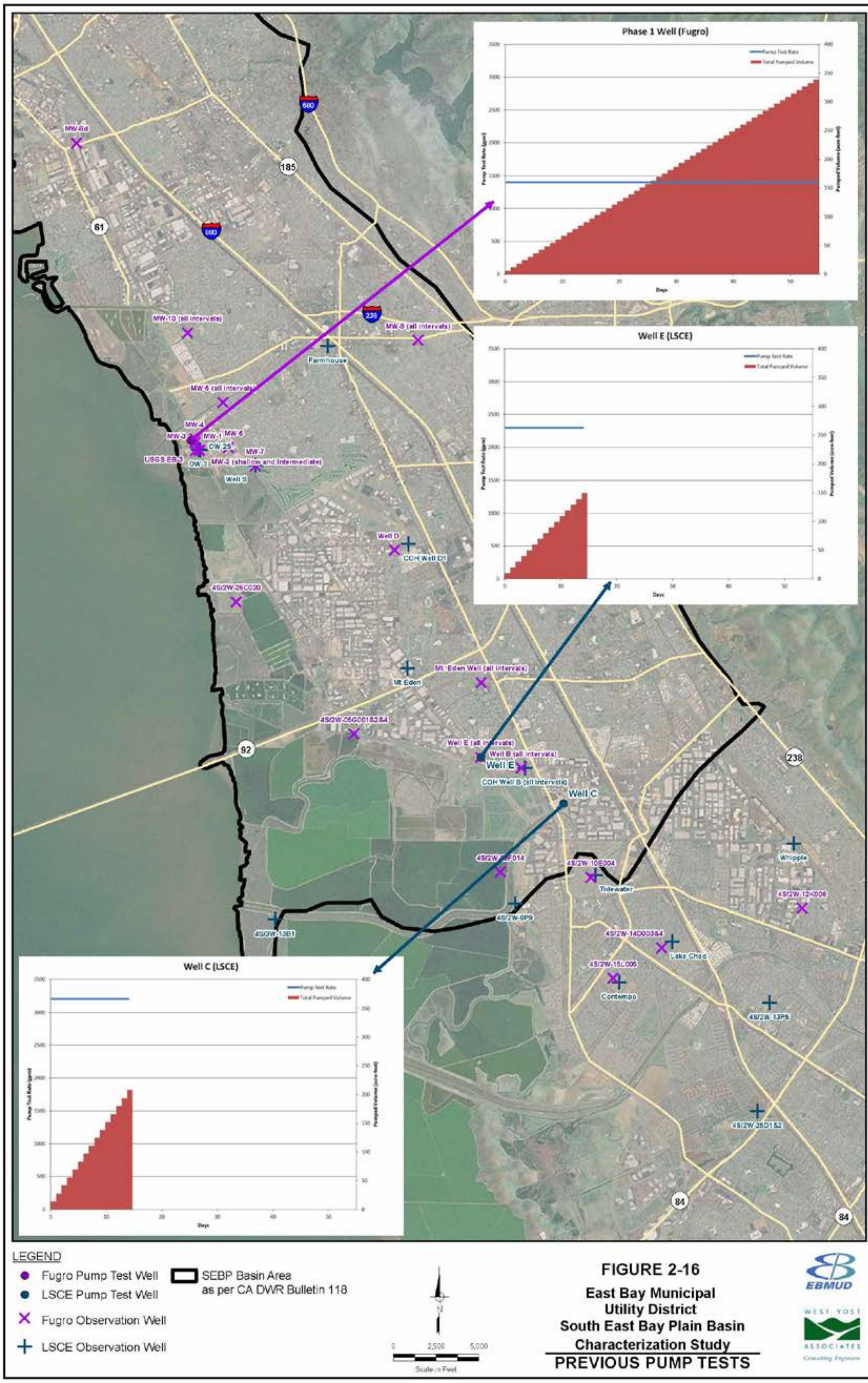


FIGURE 2-16

East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
PREVIOUS PUMP TESTS

Generally, the highest transmissivity values were measured in the vicinity of the EBMUD Bayside Project Phase 1 well. In this area, transmissivity ranged from approximately 96,000 gpd/ft to 141,000 gpd/ft. Wells farther to the east tended to have lower transmissivity. For example, transmissivity measured during testing of the Farmhouse well ranged from 33,000 gpd/ft to 52,000 gpd/ft, and testing of City of Hayward Well D resulted in an estimated transmissivity of 30,000 gpd/ft. The lower values cited in these examples may be further evidence for a north-trending fault extending between the EBMUD Oro Loma ASR demonstration well and the Farmhouse well. Offset along the fault may have caused differences in the depositional setting between the east and west sides of the fault, resulting in lower permeability or reduced aquifer thickness to the east. Changes in permeability (hydraulic conductivity) and thickness were evaluated during model development.

The LSCE (2003) and Fugro (2011) transmissivity estimates for City of Hayward Well E differ significantly. The LSCE (2003) estimate of 12,000 gpd/ft was based on limited spatial information gained over a shorter duration of testing than the Fugro (2011) test, and, therefore, is considered to be subject to greater uncertainty. The LSCE (2003) estimate is based on pump testing and water level measurements in Well E. The test was conducted for a period of 14 days. Because the estimate was not based on any other observation wells, any uncertainties related to the site-specific conditions at Well E affected the estimate. These uncertainties include geologic variability, and the adequacy of the well design, construction and development for the site-specific conditions. The Fugro (2011) estimate was based on pumping in the Bayside well while using Well E as an observation well. The aquifer test was conducted for a much longer period of time (approximately 56 days), and included multiple observation wells. The Fugro (2011) transmissivity estimates for Well E ranged from 93,000 gpd/ft to 98,000 gpd/ft. These estimates were consistent with the estimates based on other observation wells in the area. Therefore, the Fugro (2011) transmissivity estimates appear to be characteristic of the SEBP Basin Deep Aquifer near City of Hayward Well E, and these values were used to develop the initial hydraulic property estimates in the updated numerical model.

2.13 GROUNDWATER ELEVATIONS AND FLOW

Figure 2-17 shows the groundwater elevation contours for the Shallow/Newark aquifer (EBMUD, 2006) and changes in groundwater levels over time for key wells throughout the study area (DWR Water Data Library). Groundwater generally flows from east to west across the study area from a high of 30 to 40 ft. msl to at or slightly below sea level in the western portion of the study area. Fewer data points are available to generate groundwater contour maps for wells screened entirely in the deep aquifer, but a review of available data suggests a pattern in the orientation of the potentiometric surface, again indicating that groundwater flows from east to west. However, groundwater elevation in the deep aquifer ranges from a high of 10 to 20 feet above msl in the east to a low of -20 feet above msl on the west (CH2MHill, 2000). Because the deeper aquifer zone has lower head than the shallow aquifer(s), the potential exists for downward movement of water through non-pumped wells, if hydraulic cross connectivity exists. The upper and lower systems may also be connected through corroded and failed casings of abandoned wells (Izbicki, 2003).

Changes in groundwater elevation data for key wells in the study are available online at DWR's water data library, http://www.water.ca.gov/waterdatalibrary/.

Changes in groundwater levels over time are shown for eight wells throughout the study area. Many of these hydrographs show a recovery in groundwater levels from a low of -120 to -60 ft. sml in the

1960s to very near sea level in the 1990s.Wells in the east central portion of the study area (0302W008, 0302W29F, 0302W36L) have had more stable groundwater levels ranging generally between 5 to 40 ft. msl over the period of record. DWR discontinued monitoring water levels in these wells 10 to 15 years ago, and more recent data were not available for this study. Also, DWR does not specify well depths for these key wells, so much of the variability seen between hydrographs may be the result of wells screened in different aquifer zones.

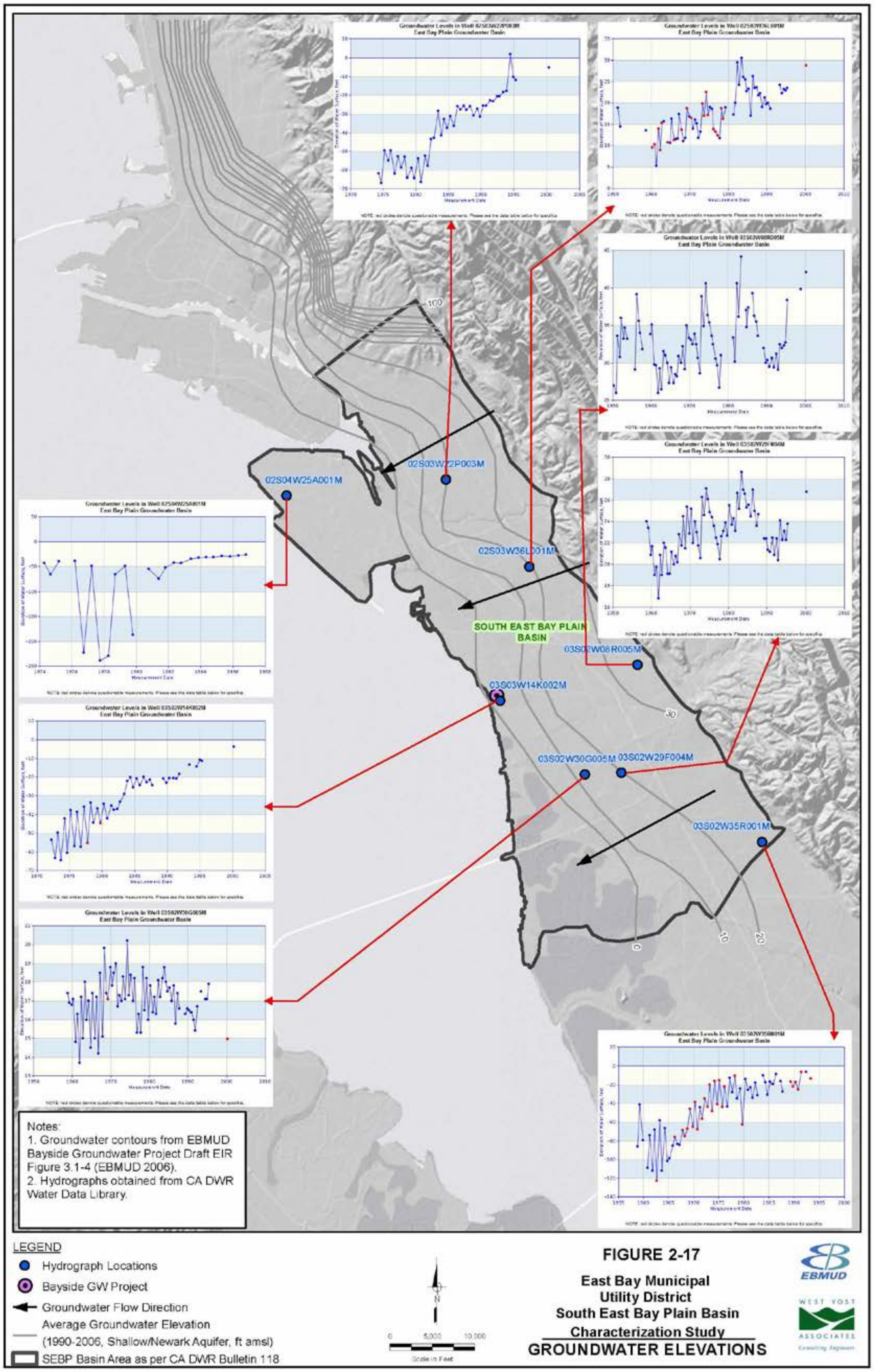


FIGURE 2-17

East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
GROUNDWATER ELEVATIONS

2.14 GROUNDWATER QUALITY

2.14.1 General Chemistry

Four key sources of information were utilized in the documentation of general groundwater quality provided in this section. These sources are listed and key findings summarized below.

2.14.2 Regional Hydrogeologic Investigation, South East Bay Plain (CH2MHill, 2000)

This report evaluated the distribution of water quality parameters as a function of depth within the SEBP Basin and makes the following observations:

- Compared to deeper levels, groundwater less than 200 ft below ground surface (ft. bgs) is characterized by relatively high concentrations of total dissolved solids (TDS), chloride, nitrate, and sulfate. Shallow wells exceed the MCL for nitrate (45 mg/L as NO_3), and the secondary MCL for TDS (1,000 mg/L), chloride (250 mg/L), sulfate (250 mg/L), iron (0.30 mg/L) and manganese (0.05 mg/l). Nitrate is elevated in large parts of the San Leandro/San Lorenzo area, probably due to septic tank effluent and past farming activities in these areas.
- Wells with total depths greater than 500 ft. bgs are located primarily in the southern portion of the study area. These wells have high iron and manganese levels that commonly exceed their secondary MCLs. Elevated TDS and chloride concentrations are probably related to the presence of shallow well screens in the deeper wells.

2.14.2.1 Hydrogeology and Geochemistry of Aquifer Underlying the San Lorenzo and San Leandro Areas of the East Bay Plain, USGS Water-Resource Investigation Report 02-4259 (Izbicki, 2003)

The purpose of this report was to evaluate hydrogeologic, and geochemical conditions in aquifers underlying the SEBP. Key findings relevant to the current study include the following:

- Water level measurements in observation wells and downward flow measured in selected wells during non-pumped conditions suggest that water may flow through wells from the upper aquifer system into the lower aquifer system during non-pumped conditions. Even given the potentially large number of abandoned wells in the study area, the total quantity of flow through abandoned wells and subsequent recharge to the lower/deep aquifer system is still considered small on a regional basis. However, where this water contains contaminants from overlying land uses, flow through abandoned wells may be a potential source of low-level contamination.
- Oxygen-18 and deuterium data do not indicate that leaking water supply pipes are a significant source of recharge. Rather, noble-gas data indicate recharge results from highly focused recharge processes from infiltration of winter stream flow and more diffuse recharge from infiltration of precipitation within the study area.
- Groundwater in the deep aquifer tends to be higher in sodium and potassium relative to calcium and magnesium, likely the result of precipitation of calicite and ion exchange reaction occurring as groundwater passes through the aquifer from recharge areas to the deeper aquifer system.
- Arsenic concentrations ranged from non-detect to 37 ppb, and the USEPA MCL for arsenic is 10 ppb.

- Carbon-14 ages (time since recharge) of deep groundwater ranged from 500 years before present (in water from wells near recharge areas along the mountain front) to 20,000 years before present (in partly consolidated deposits underlying the Oakport injection site).These data suggest that the lower aquifer system is isolated from surface sources of recharge.
- The presence of poor quality water at depth may limit extended pumping of deeper aquifer in excess of injection, especially near faults where partly consolidated deposits may have been uplifted and are adjacent to freshwater aquifers.

2.14.2.2 Characterization of Existing Groundwater Quality for Bayside Groundwater Project, (Fugro, 2007)

This report documents the sampling and analysis of groundwater collected from two deep monitoring wells in the vicinity of the Bayside Phase I well. In July of 2007, Fugro West Inc. collected samples from MW-5d and MW-6, both screened in the deep aquifer, and performed full Title 22 analysis. Table 2-1 is modified from this report, includes well construction information, and summarizes the analytical results. Both samples include a water quality that is sodium chloride to sodium bicarbonate in chemical character. The TDS concentrations in MW-5d and MW-6 were 460 and 420 mg/l. Selenium was present in only MW-5d at 0.39 ug/l.Arsenic was detected in MW-5d and MW-6 at very low concentrations of, 0.45 and 0.77 ug/l, respectively.

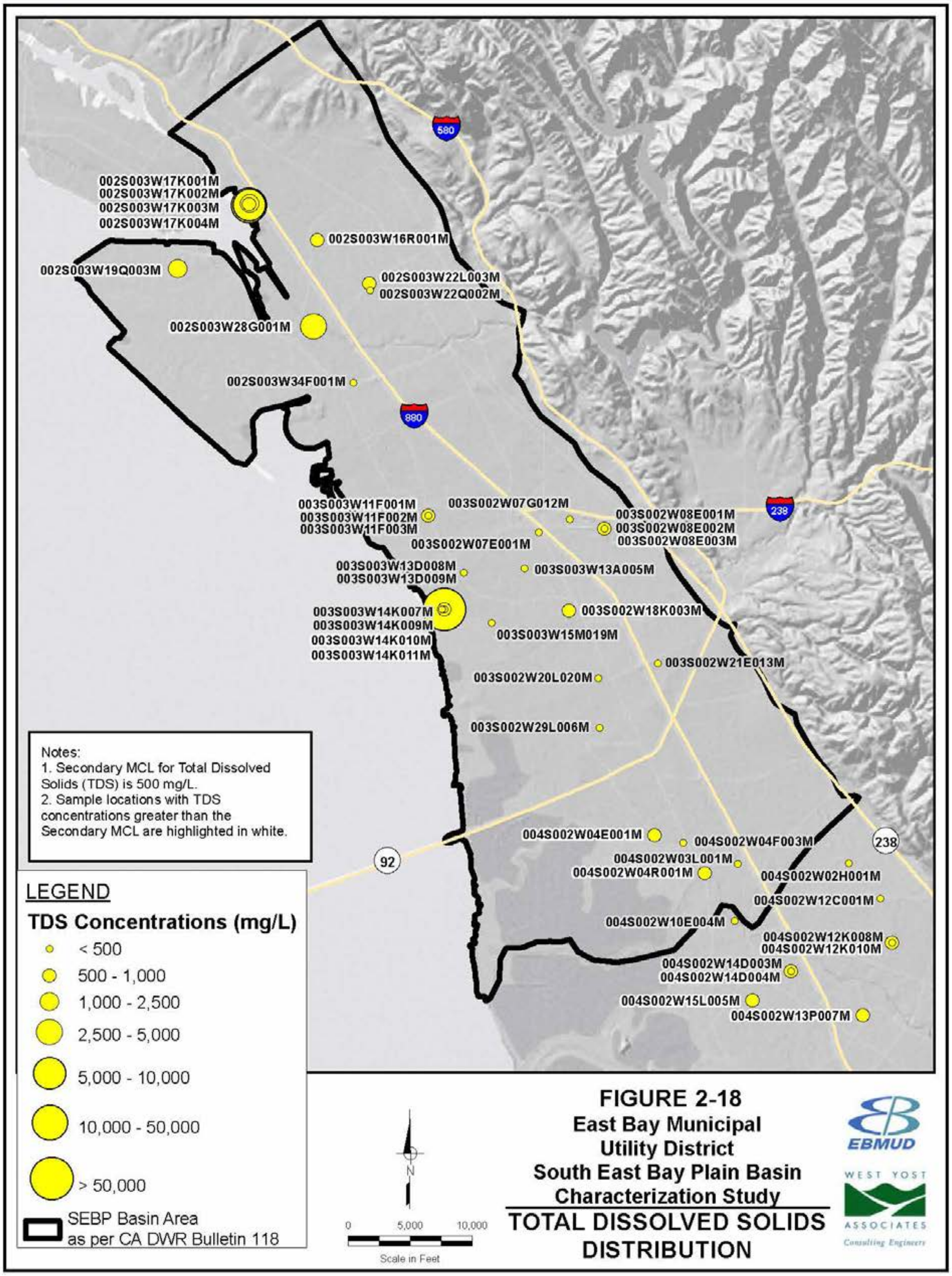
2.14.2.3 USGS National Water System Information Database

West Yost obtained water quality data maintained by the USGS and available at the National Water Information System (NWIS) Database, http://waterdata.usgs.gov/nwis. NWIS is a comprehensive database of historic and recent water quality data obtained from public agencies including local water purveyors, DWR, and federal agencies, such as the USGS. West Yost prepared summary tables of TDS, chloride, and nitrate included in Appendix E which presents analytical results sorted by well depth. These data are visually displayed on maps showing the aerial distribution of TDS (Figure 2-18), chloride (Figure 2-19), and nitrate (Figure 2-20). The highest concentrations of TDS and chloride occur in two shallow wells adjacent to the San Francisco Bay. Appendix E also provides a summary of median concentrations of TDS, Cl^-, and NO_3- with depth in SEBP Basin Study Area.

Table 2-1. Summary of Deep Aquifer Water Quality Data near the Bayside Project – South East Bay Plain Basin

Constituent	Basin Water Quality Objective	California MCL	Bayside Phase 1 Well[1]	MW-5D 4" diameter PVC, 500-630 fbgs	MW-6 4" diameter PVC, 480-650 fbgs
pH (pH units)	MCL	NA	7.7	7.47	7.57
Total dissolved solids	MCL	500 (2)	410	460	420
Residual Cl_2, Total	--	--	0.02	0.04	0.08
Fluoride	--	--	0.23	0.16	< 0.79
Chloride	MCL	250 (2)	71	93	57
Nitrite as N	MCL	1	< 0.004	< 0.035	< 0.35
Nitrate as N	MCL	10	< 0.003	< 0.085	< 0.085
Sulfate	MCL	250 (2)	48	51	52
Alkalinity, Total (as $CaCO_3$)	--	--	220	240	230
Ammonia: Total	--	--		< 0.30	< 0.30
Cyanide	MCL	0.15	NA	< 0.1	< 0.1
Hardness (as $CaCO_3$)	--	--	130	150	110
Total Coliform (CFU/100 ml)	--	--	0	110	< 1.0
Total Colony Count (CFU/100 ml)	--	--	74	ND	< 1.0
Heterotrophic Plate Count, Avg. (CFU/ml)	--	--	53	28	< 1.0
Haloacetic Acids and Dalapon (EPA 552.2)	MCL	0.06	ND	ND	ND
Volatile Organics (EPA 524.2)	--	--	ND	ND	ND
Semi-volatile Organics (EPA 525.2)	--	--	ND	ND	ND
Metals (EPA 200.7) –					
Aluminum	MCL	0.2 (2)	< 0.055	< 0.050	< 0.050
Boron	--	--	0.37	0.467	0.436
Calcium	--	--	35.4	41	30
Iron	MCL	0.3 (2)	< 0.07	< 0.1	< 0.1
Potassium	--	--	1.78	2	1.6
Magnesium	--	--	9.98	10	7.9
Manganese	MCL	0.05 (2)	0.113	0.205	0.168
Sodium	--	--	123.2	130	110
Silicon	--	--	NA	12	11.4
Element Scan (EPA 200.8) –					
Barium (EPA 200.8)				0.0970	0.0650
Chromium (EPA 200.8)				0.0010	0.0021
Copper (EPA 200.8)				<.0.0004	0.0082
Nickel (EPA 200.8)				<0.0002	0.0073
Zinc (EPA 200.8)				0.0012	<.0.0001
Arsenic				0.0005	0.0077
Selenium				0.0004	<0.0003

Note: 1 – Sample Date: November 18, 1998
2 – Secondary Maximum Contaminant Level
MCL – Maximum Contaminant Limit
NA – Not analyzed
ND – Analyte not detected at or above the CaDPH DLR (detection limit for reporting)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003S003W13D009M
003S003W13A005M
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003S003W14K009M
003S003W14K010M
003S003W14K011M
003S002W18K003M
003S003W15M019M
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003S002W20L020M
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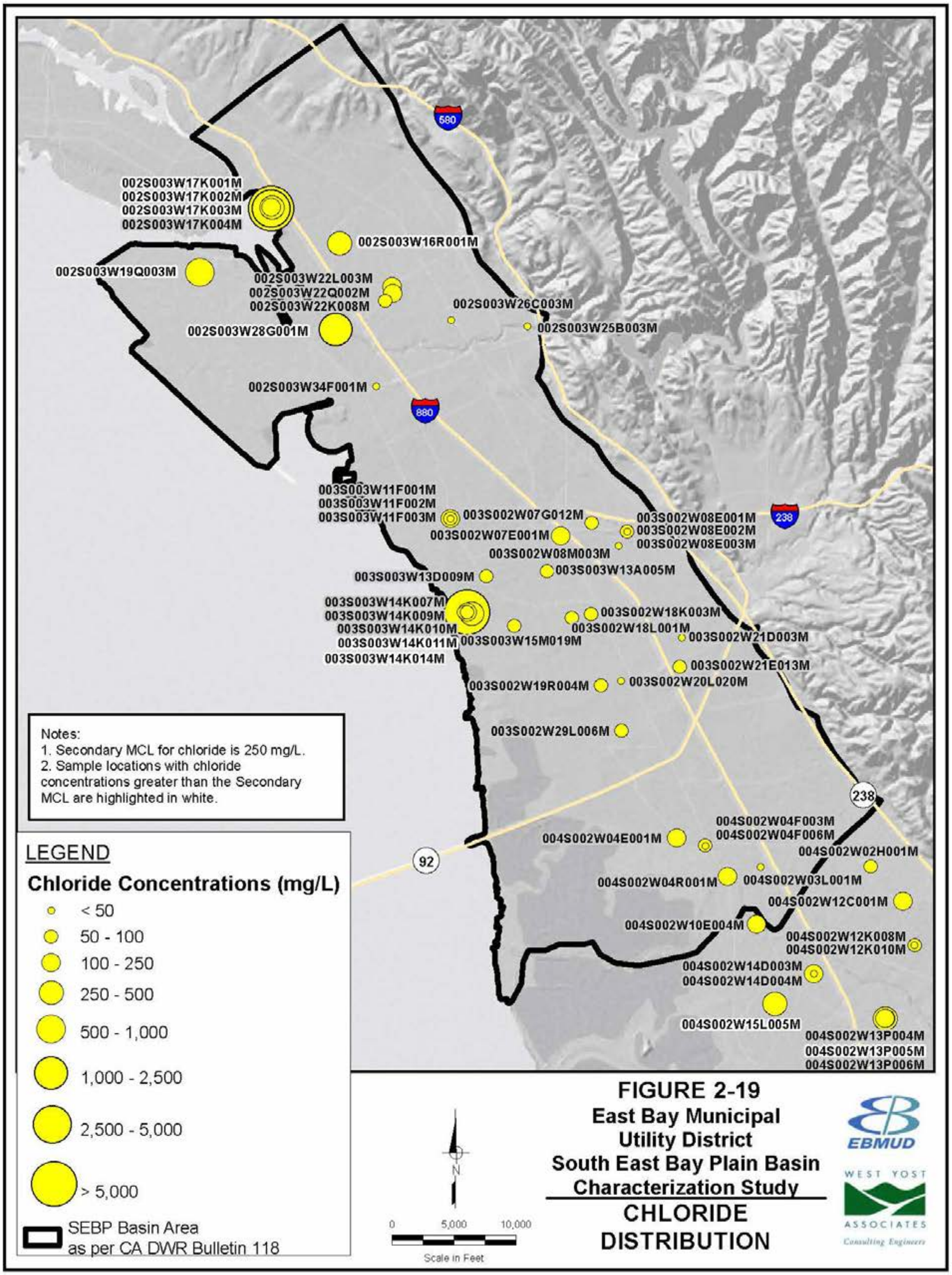
004S002W04R001M
004S002W02H001M
004S002W12C001M
004S002W10E004M
004S002W12K008M
004S002W12K010M
004S002W14D003M
004S002W14D004M
004S002W15L005M
004S002W13P007M
580
880
238
92
238
Notes:
1. Secondary MCL for Total Dissolved Solids (TDS) is 500 mg/L.
2. Sample locations with TDS concentrations greater than the Secondary MCL are highlighted in white.
LEGEND
TDS Concentrations (mg/L)
< 500
500 - 1,000
1,000 - 2,500
2,500 - 5,000
5,000 - 10,000
10,000 - 50,000
> 50,000
SEBP Basin Area as per CA DWR Bulletin 118
N
0
5,000
10,000
Scale in Feet
FIGURE 2-18
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
TOTAL DISSOLVED SOLIDS DISTRIBUTION
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers



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002S003W28G001M
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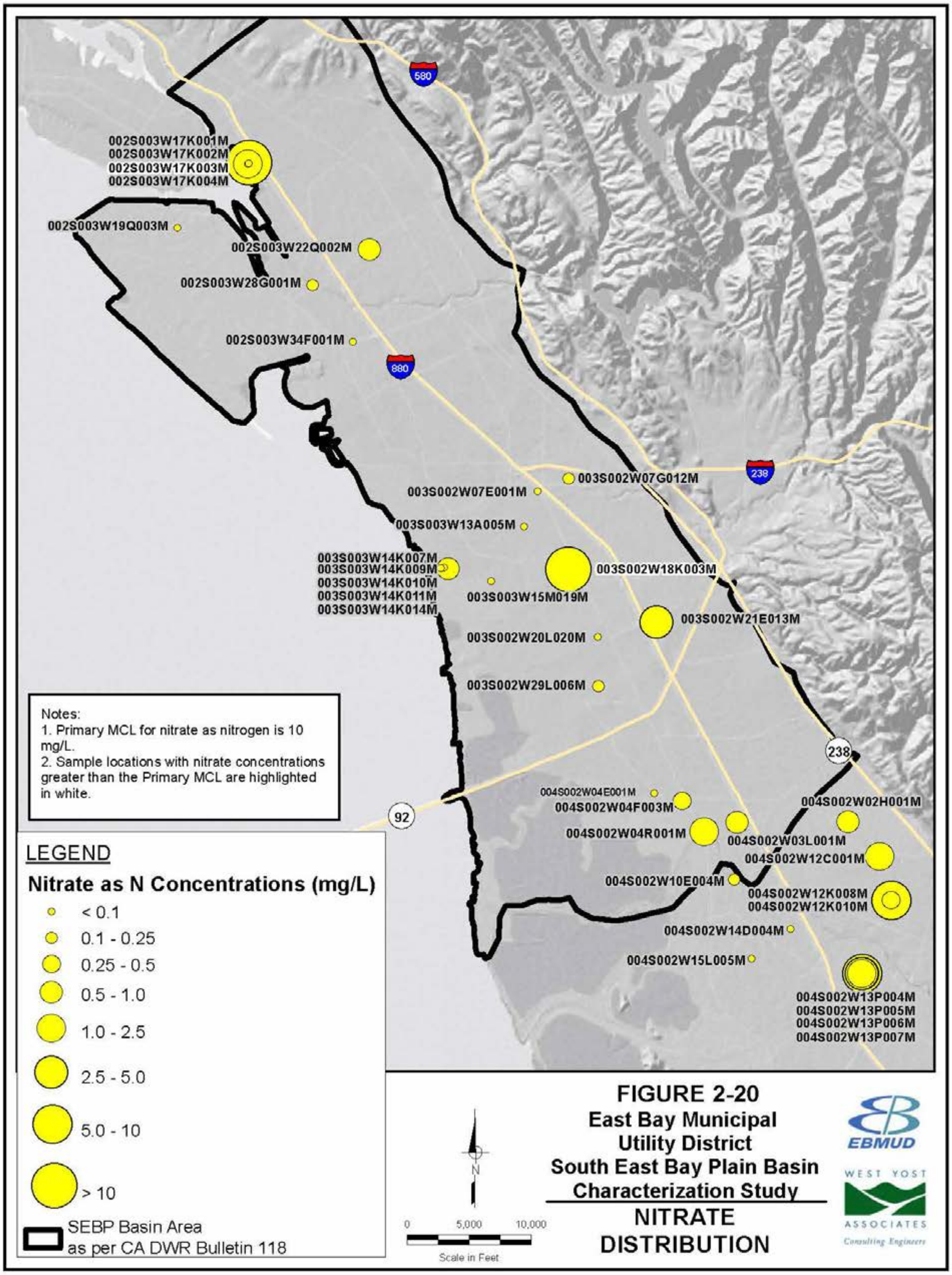
003S003W14K011M
003S003W14K014M
003S003W15M019M
003S002W18K003M
003S002W18L001M
003S002W21D003M
003S002W21E013M
003S002W19R004M
003S002W20L020M
003S002W29L006M
004S002W04F003M
004S002W04F006M
004S002W04E001M
004S002W02H001M
004S002W04R001M
004S002W03L001M
004S002W12C001M
004S002W10E004M
004S002W12K008M
004S002W12K010M
004S002W14D003M
004S002W14D004M
004S002W15L005M
004S002W13P004M
004S002W13P005M
004S002W13P006M
580
880
238
92
Notes:
1. Secondary MCL for chloride is 250 mg/L.
2. Sample locations with chloride concentrations greater than the Secondary MCL are highlighted in white.
LEGEND
Chloride Concentrations (mg/L)
< 50
50 - 100
100 - 250
250 - 500
500 - 1,000
1,000 - 2,500
2,500 - 5,000
> 5,000
SEBP Basin Area as per CA DWR Bulletin 118
N
0
5,000
10,000
Scale in Feet
FIGURE 2-19
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
CHLORIDE DISTRIBUTION
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers


002S003W17K001M
002S003W17K002M
002S003W17K003M
002S003W17K004M
002S003W19Q003M
002S003W22Q002M
002S003W28G001M
002S003W34F001M
580
880
238
003S002W07G012M
003S002W07E001M
003S003W13A005M
003S003W14K007M
003S003W14K009M
003S003W14K010M
003S003W14K011M
003S003W14K014M
003S003W15M019M
003S002W18K003M
003S002W21E013M
003S002W20L020M
003S002W29L006M
Notes:
1. Primary MCL for nitrate as nitrogen is 10 mg/L.
2. Sample locations with nitrate concentrations greater than the Primary MCL are highlighted in white.
238
92
004S002W04E001M
004S002W04F003M
004S002W02H001M
004S002W04R001M
004S002W03L001M
004S002W12C001M
004S002W10E004M
004S002W12K008M
004S002W12K010M
004S002W14D004M
004S002W15L005M
004S002W13P004M
004S002W13P005M
004S002W13P006M
004S002W13P007M
LEGEND
Nitrate as N Concentrations (mg/L)
< 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 1.0
1.0 - 2.5
2.5 - 5.0
5.0 - 10
> 10
SEBP Basin Area as per CA DWR Bulletin 118
N
0
5,000
10,000
Scale in Feet
FIGURE 2-20
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
NITRATE DISTRIBUTION
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers

2.14.3 Threats to Water Quality

Locations of contaminant sites were obtained from the California State Water Resources Control Board (SWRCB). Sites were downloaded from SWRCB's Geotracker website on March 15, 2012 and represent all open-status contaminant sites determined by the SWRCB to potentially impact groundwater in the East Bay Plain and Niles Cone Basins. Within the SEBP Basin GMP area, there are 672 sites. Of those 672 sites, only 212 are still open cases in varying stages of remediation. Figure 2-21 shows the locations of these open cases in the SEBP Basin. Thirty-five have a status of "Verification Monitoring;" 138 have a status of "Site Assessment;" 18 have a status of "Remediation;" 14 have a status of "Inactive;" and 7 have a status of "Assessment & Interim Remedial Action."

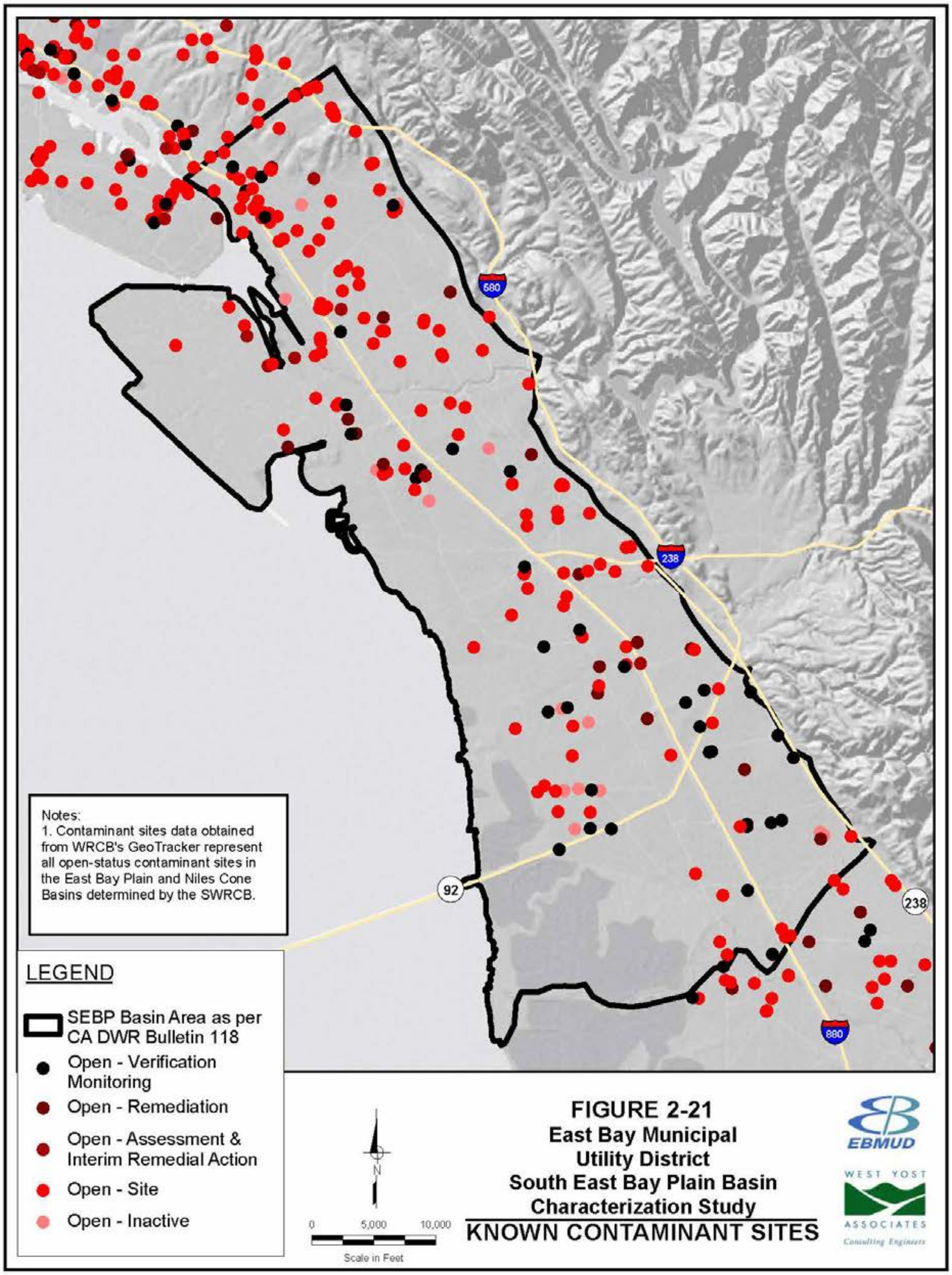
Figure 2-22 shows the locations of local and regional groundwater contaminant plumes in the SEBP Basin. This information was prepared in 1999 by the Bay Area RWQCB (RWQCB, 1999) and represents the most current published information on the nature and extent of these contaminant plumes based on verbal communications with RWQCB and DTSC staff during the course of this study. This map should be updated using more recent groundwater quality information.

2.15 GROUNDWATER RECHARGE

San Leandro and San Lorenzo Creeks were important areas of recharge to the SEBP Basin before development occurred in the area. The predevelopment estimate of stream recharge was about 3,500 acre-ft per year (afy) and infiltration of precipitation was about 800 afy (Muir 1996). As the result of urbanization, natural recharge may have decreased because of the channelization of streams and an increase in pavement covering permeable soil surfaces. Figure 2-23 shows the amount of recharge used for the groundwater model. The source of information for the estimated recharge amounts, by model subregions, was ACWD's NEBIGSM (WRIME, 2005). Factors considered in assigning recharge or net deep percolation as shown on Figure 2-23 include:

- Surface geology/soil type
- Land use
- Applied Water
- Precipitation
- Steamflow

Average annual recharge for the SEBP Basin study area is the sum of Hayward North, San Leandro and Oakland subregions, approximately 5,446 afy, which is about 33 percent of the 16,452-afy total for the entire IGSM model area.


580
238
92
238
880
Notes:
1. Contaminant sites data obtained from WRCB's GeoTracker represent all open-status contaminant sites in the East Bay Plain and Niles Cone Basins determined by the SWRCB.
LEGEND
SEBP Basin Area as per CA DWR Bulletin 118
Open - Verification Monitoring
Open - Remediation
Open - Assessment & Interim Remedial Action
Open - Site
Open - Inactive
N
0
5,000
10,000
Scale in Feet
FIGURE 2-21
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
KNOWN CONTAMINANT SITES
EBMUD
WEST YOST ASSOCIATES
Consulting Engineers

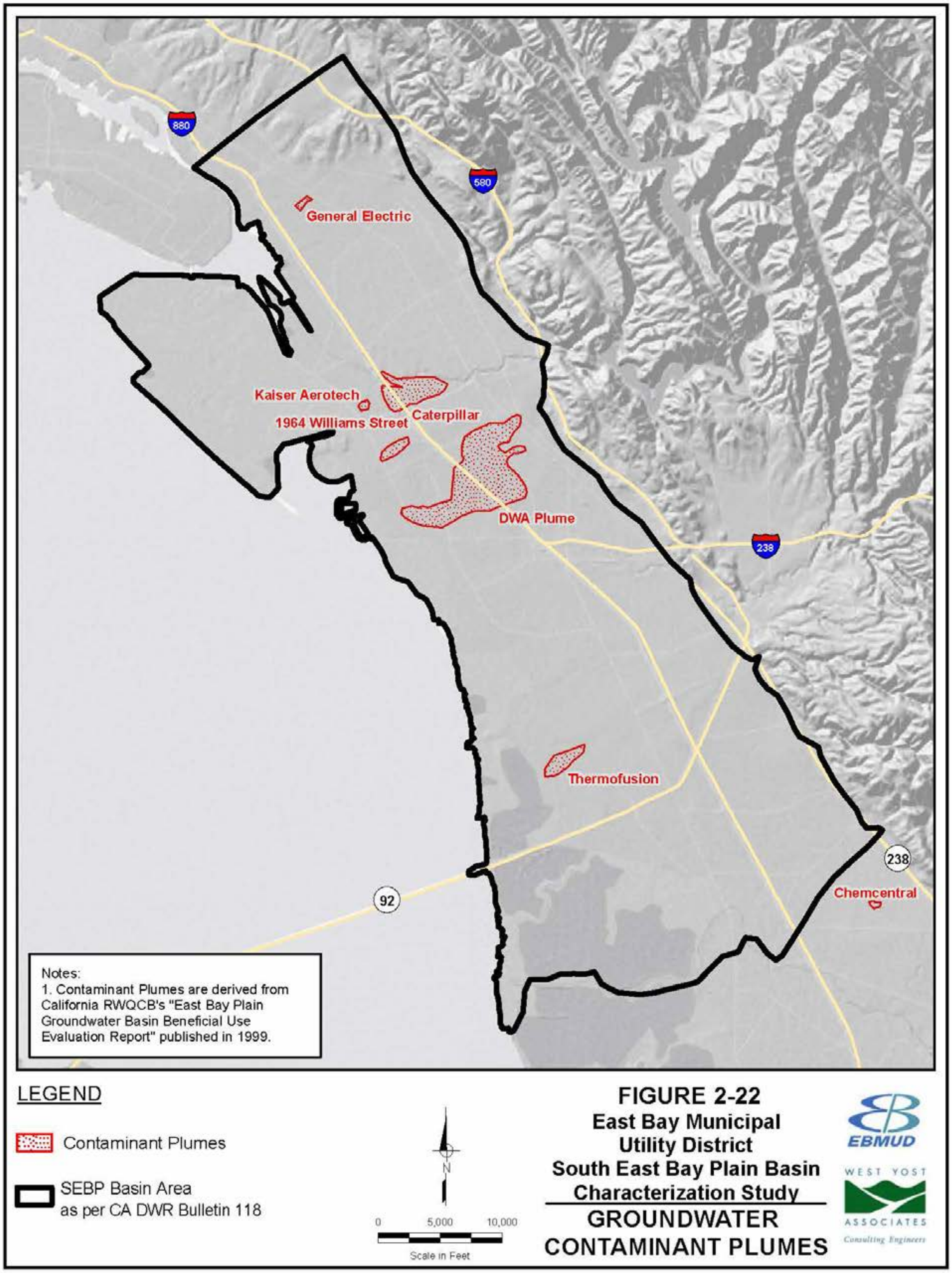
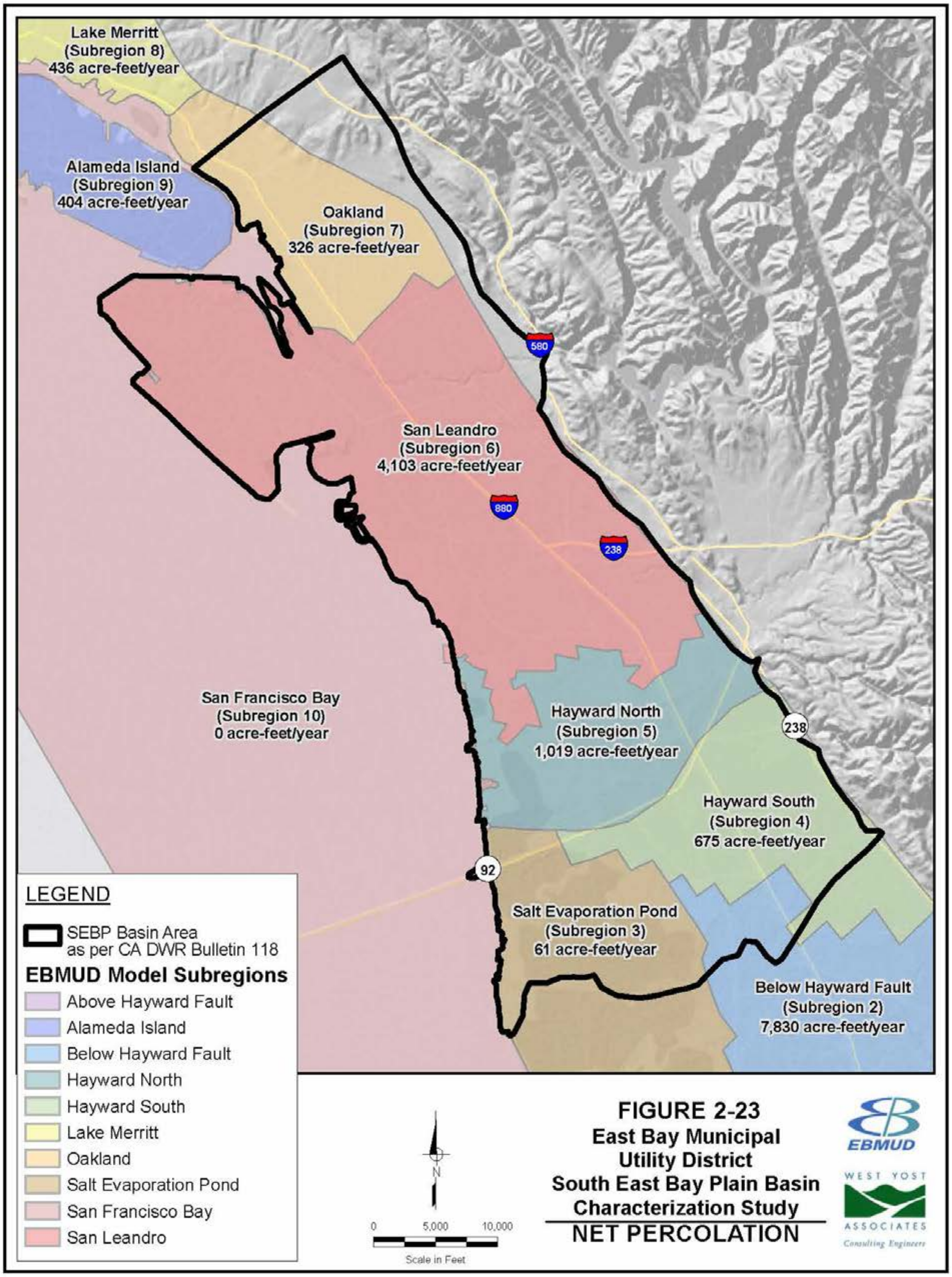
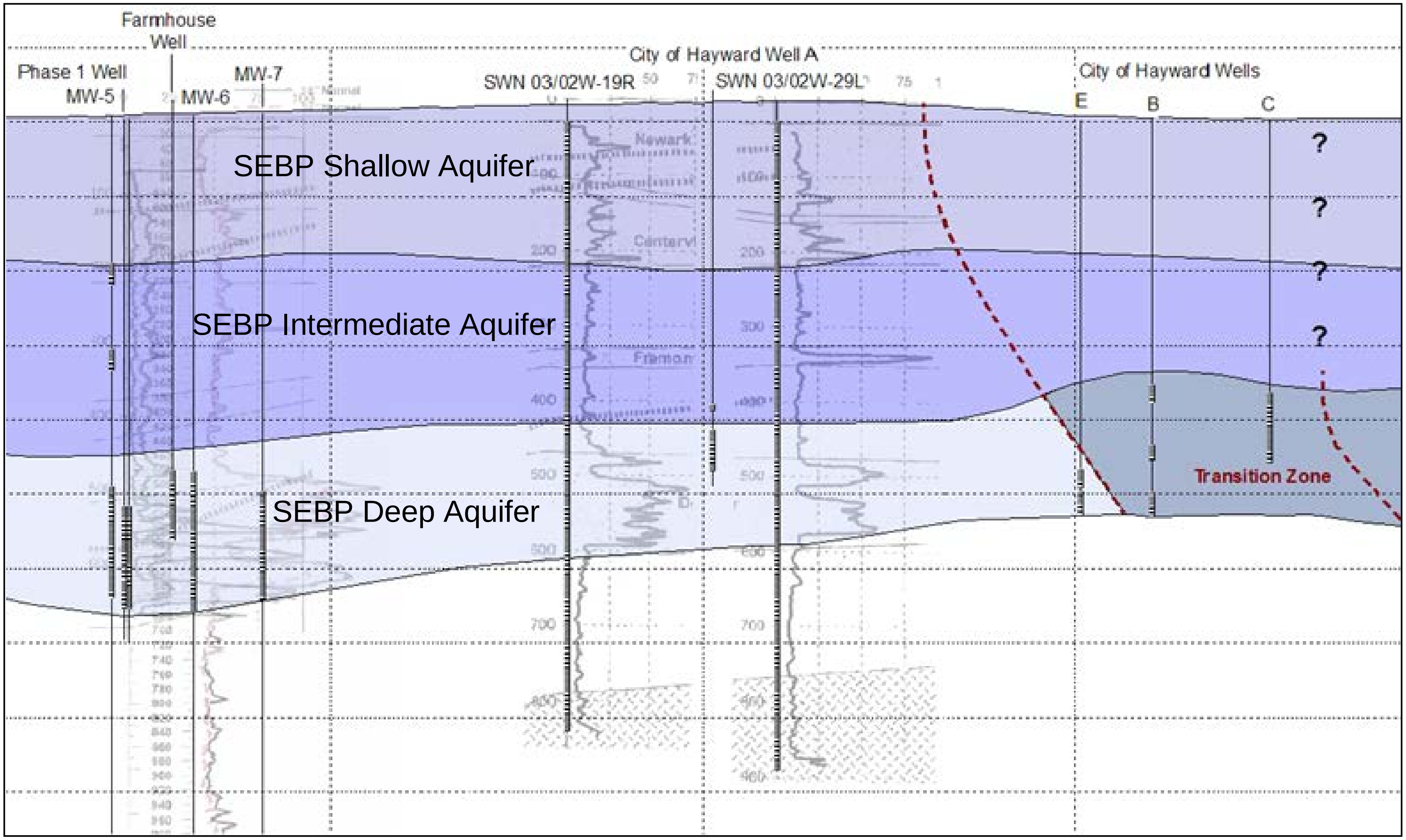


FIGURE 2-22
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
GROUNDWATER CONTAMINANT PLUMES


Lake Merritt
(Subregion 8)
436 acre-feet/year
Alameda Island
(Subregion 9)
404 acre-feet/year
Oakland
(Subregion 7)
326 acre-feet/year
San Leandro
(Subregion 6)
4,103 acre-feet/year
San Francisco Bay
(Subregion 10)
0 acre-feet/year
Hayward North
(Subregion 5)
1,019 acre-feet/year
Hayward South
(Subregion 4)
675 acre-feet/year
Salt Evaporation Pond
(Subregion 3)
61 acre-feet/year
Below Hayward Fault
(Subregion 2)
7,830 acre-feet/year
580
880
238
238
92
LEGEND
SEBP Basin Area
as per CA DWR Bulletin 118
EBMUD Model Subregions
Above Hayward Fault
Alameda Island
Below Hayward Fault
Hayward North
Hayward South
Lake Merritt
Oakland
Salt Evaporation Pond
San Francisco Bay
San Leandro
N
0
5,000
10,000
Scale in Feet
FIGURE 2-23
East Bay Municipal
Utility District
South East Bay Plain Basin
Characterization Study
NET PERCOLATION
EBMUD
WEST YOST
ASSOCIATES
Consulting Engineers

Cross Section Update



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2.16 GROUNDWATER RIGHTS IN CALIFORNIA[4]

Water is protected for the use and benefit of all Californians. Article 10, Section 2 of the California Constitution, enacted in 1928, prohibits the waste of water and requires reasonable use, reasonable method of use and reasonable method of diversion for all surface and groundwater rights. The doctrine of reasonable and beneficial use is the basic principle defining California water rights.

Surface Water Rights: The chronological order of surface water rights starts from pre-1848 "Pueblo Rights", to "federally reserved right", the common law "riparian rights", and "appropriated rights". Prior to 1914, appropriative rights could be acquired simply by posting or filing a notice, and then diverting and using the water for reasonable, beneficial purposes (referred to as "pre-1914 water rights"). Since 1914, California statutory law has required that an application be filed and a permit obtained from a State agency, currently from the State Water Resources Control Board.

Groundwater Rights: Like surface water, use of groundwater is not only dependent upon water rights but is also subject to environmental and water quality consideration.

In 1903, the "Correlative Rights" doctrine was introduced by a well-known California water rights case (Katz v. Walkinshaw). It established a "sharing" rule similar to that achieved under the torts doctrine. Under the correlative rights doctrine, the right to groundwater is a usufructuary right that is appurtenant to the overlying land. The right to use groundwater is shared by all overlying owners of a groundwater basin.

Unlike prior appropriation, correlative rights do not allow a precise definition of an individual's water rights. In the event of conflict, parties are forced to seek an optimal solution that allows all competing uses to continue with as little conflict as possible. A groundwater shortage is likely shared among all users.

Solutions to conflicts between rights: In the history of California groundwater management, legal and regulatory solutions to the conflict between the correlative rights of landowners overlying a groundwater basin and the long-held prior appropriation rights of users both outside and inside the groundwater basin have had a major impact on the distribution of groundwater but also on the conjunctive use of groundwater and surface water.

Unlike surface water rights, groundwater rights in California are not governed by a permit system, except in the case of basin adjudication. Through the adjudication process, courts have rendered decisions establishing precedents including doctrine of "mutual prescription" in key cases – City of Pasadena v. City of Alhambra by Supreme Court of California in 1949; City of Los Angeles v. City of San Fernando, the Supreme Court of California in 1975; Alameda County Water District v. Niles Sand and Gravel by California Court of Appeal, 1st District in 1974; High Desert County Water District v. Blue Skies Country Club, Inc. by California Appellate Court in 1994, City of Barstow v. Mojave Water Agency by the California Supreme Court in 2000.

If contending water users in the same groundwater basin cannot resolve their issues, and one or more individuals pursue resolution through a lawsuit, the result may be adjudication. Under

[4] Reference: Watersheds, Groundwater and Drinking Water: A Practical Guide by Thomas Harter and Larry Rollins, University of California Agriculture and Natural Resources Publication 3497

adjudication, courts establish the safe yield of the basin and decide how much each individual water user can extract annually. The process can take a long time (years to multiple decades), because of the number of parties involved, general lack of judicial experience in water law and science, and California's lack of special water courts. These are costly legal battles involving hired experts, attorneys, and multiple studies. By all accounts, it is preferable to manage groundwater basins by basin users through collaboration. This GMP process enacted by AB3030 and SB 1938 is now the common practice to manage groundwater basin for sustainable use of all basin users.

3.0 GROUNDWATER MANAGEMENT PLAN ELEMENTS

The elements of the plan include the overarching goal, management objectives and components that identify and discuss relevant actions to meet these goal and objectives of the plan.

3.1 GROUNDWATER MANAGEMENT GOALS

The overarching goal of the plan is to – ***preserve the local groundwater resource as a reliable and sustainable water supply for current and future beneficial uses.***

3.2 BASIN MANAGEMENT OBJECTIVES

To achieve the goal, the plan outlines four basin management objectives (BMOs):

1. **Preserve groundwater storage by maintaining long-term groundwater elevations in the GMP area to ensure sustainable use of the groundwater basin:** Groundwater elevation is a direct indicator of the volume of groundwater stored in the basin as well as the groundwater gradient. The historical record of groundwater elevations show that the basin experienced the lowest storage in the early 1960s. Since then, groundwater elevations have recovered significantly. Under this management objective, is basin users will work collaboratively to manage groundwater extraction and recharge in the basin to maintain the basin's long-term groundwater elevations.

2. **Maintain or improve groundwater quality in the GMP area to ensure sustainable use of the groundwater basin:** The groundwater quality of the basin in the GMP area is pristine in the deep aquifer of the basin. However, some locations within the basin area present water quality concerns, especially in shallow and intermediate aquifers. This management objective is to preserve the existing water quality condition and prevent it from degradation.

3. **Manage potential inelastic land surface subsidence from groundwater pumping:** If groundwater level declines occur, land subsidence is possible from compaction of underlying formations. Subsidence can be either recoverable elastic subsidence or irrecoverable inelastic subsidence.

   The risk of irrecoverable subsidence from the operation of groundwater extraction depends on basin hydrogeology and, the extent of groundwater pumping and recharge. Groundwater usage therefore can result in changes to the internal water pressure (groundwater levels). This management objective is to avoid irrecoverable land surface changes caused by excessive groundwater extraction by monitoring and managing groundwater levels.

4. **Manage the SEBP basin through coordination and collaboration:** The success of basin management activities depends upon the involvement of key stakeholders including basin users, municipalities, regulatory agencies and the public. This management objective is to foster collaboration and coordination through information sharing and cooperation.

3.3 GMP COMPONENTS

3.3.1 Stakeholder Involvement

The sustainability of the groundwater basin concerns a broad range of stakeholders in both the private and public sectors. Water suppliers consider the basin as a source of emergency and supplemental water supply. Private well owners rely upon the basin for their irrigation water supply. Local entities view it as a future source of water. State and local regulatory agencies are tasked to enforce the water quality standards for the basin. Municipalities like to protect the basin as a local resource for their constituents. As such, the development and implementation of basin management goals and associated management actions must take into account stakeholder interest in achieving the overarching objective of maintaining the basin's sustainability.

For that reason, as a lead agency, EBMUD has taken a set of actions to ensure stakeholder involvement to develop the GMP in accordance with statutory requirements. These actions include:

- Promoting public participation.
- Involving other local agencies and groundwater suppliers within the SEBP basin and neighboring basin in GMP development.
- Forming a stakeholder liaison group to guide the GMP process.
- Developing relationships with state and local agencies.
- Pursuing a variety of key partnerships to achieve a sustainable local water supply.

3.3.1.1 Public Involvement and Outreach

In accordance with CWC § 10753.2, a Notice of Intent (NOI) to prepare a GMP was published in local newspapers. The notice discussed the fact that EBMUD's governing board would meet to pass the NOI, and that the public was invited to said meeting. EBMUD Board of Directors meeting inviting the public to attend. In addition, EBMUD staff reached out to private well owners, state and local agencies, local government entities, local utilities, communities and businesses informing them of the plan to craft a GMP and inviting them to participate in the process. The following entities agreed to participate:

- City of Hayward
- City of Oakland
- Port of Oakland
- City of San Leandro
- City of Alameda
- Alameda County Public Works
- Alameda County Environmental Health Department
- San Lorenzo Unified School District
- Hayward Area Park District
- Alameda County Water District
- San Francisco Bay Regional Water Quality Control Board

On August 16, 2012, EBMUD launched a dedicated web portal for GMP development to provide information to the public on GMP activities. Following GMP certification, the website will be used to disseminate plan implementation activities to the stakeholders and public. On behalf of stakeholders, EBMUD will:

- Continue efforts to encourage public participation as opportunities arise.
- Reach out to local and business communities via EBMUD's Bayside Groundwater Project Community liaison group
- Assist stakeholders in disseminating information through other various meetings and public forums.

3.3.1.2 Collaboration Among Basin Stakeholders and Adjacent Basins

DWR's bulletin 118 delineates the boundary of the East Bay Plain and adjacent basins. Multiple stakeholders such as local communities, overlying water rights holders, regulatory agencies, existing basin users, business entities, municipalities and local governments have various interests and jurisdiction over the basins. Although currently the SEBP Basin is not a primary source of drinking water supply for most of overlying stakeholders, it is considered as an important source for water supply reliability, future water supply planning and irrigation. EBMUD reached out to current and future stakeholders with various interests and formed the Stakeholders Liaison Group.

Among these adjacent basins, Alameda County Water District (ACWD) manages and uses the Niles Cone basin for its public water supply. On average ACWD obtains about 40% of its water supplies from the Niles Cone Groundwater Basin. In fiscal year 2010-2011, about 25,400 acre-feet of groundwater was pumped from the Niles Cone Groundwater Basin. Recognizing the importance of the Niles Cone Basin and the connective relationship between the SEBP Basin and Niles Cone Basin, EBMUD included ACWD in the Stakeholder Liaison Group.

The main purpose of the group is to share information among the stakeholders, solicit input and foster collaboration in developing the GMP and implementing the basin management activities driven by the GMP.

3.3.1.3 Coordination with State and Federal Agencies

State agencies including the California Department of Water Resources all are interested parties in protecting the basin water quality and preserving water quantity (supply).

For example, the State Water Resources Control Board develops and enforces statewide water quality policies. Their regional office, the San Francisco Regional Water Quality Control Board, prepares and implements the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan). The Basin Plan designates beneficial uses and water quality objectives for the basin, covering both surface water and groundwater. It also includes programs of implementation to achieve water quality objectives. California Department of Toxic Substances Control (DTSC) oversees and regulates the water quality standards, and California Department of Water Resources assists in developing local water resources.

As a part of the stakeholder outreach process, EBMUD sought State agencies' participation. As the lead agency, EBMUD plans to constantly coordinate with these entities during the GMP implementation. EBMUD plans to take the following actions:

- Continue to develop working relationships with local, state and as necessary, federal agencies.
- Coordinate GMP implementation activities with the local, state and federal agencies as appropriate.

3.3.1.4 Pursuing Partnership Opportunities

As the lead agency, EBMUD is committed to facilitating partnership arrangements at the local, state, and federal levels in seeking grant funding opportunities for the preservation and sustainable development of local water resources. To date, EBMUD has fostered partnership opportunities with a number of interested parties. For example, EBMUD has worked with the USGS to construct a subsidence monitoring station in the basin. Under the objectives of the GMP, EBMUD will continue to facilitate and participate in partnership opportunities among stakeholders. EBMUD plans to take the following actions:

- Continue to seek grant opportunities to fund local projects that can improve groundwater management

3.3.2 Monitoring Programs

A key component of the GMP is a monitoring program designed to assess the status of the basin and trigger actions to preserve the basin. The program includes monitoring groundwater elevations, groundwater quality, and land surface referenced elevations for tracking elastic and inelastic land surface subsidence, and salt and nutrients concentrations. The monitoring tasks are to be implemented under the following programs:

- Groundwater Elevation Monitoring Program
- Groundwater Quality Monitoring Program
- Subsidence Monitoring Program

3.3.2.1 Groundwater Elevation Monitoring Program

Groundwater level monitoring is an important component to manage basin storage, groundwater gradients, detect pumping or recharge activities, and develop a replenishment strategy. Currently EBMUD operates a network of 17 monitoring wells covering a part of the basin. Additional monitoring wells are needed to cover the remaining parts of the SEBP basin. A number of stakeholders - such as Port of Oakland, City of Alameda, City of Hayward and Hayward Area Park District - either own or operate wells within the basin. As such, individual monitoring activities can be coordinated to collect comprehensive data for the basin.

Groundwater Elevation Monitoring Protocols: Without standard monitoring protocols, potential differences in data collection techniques, reference datum, monitoring frequencies and documentation methods in groundwater level measurement as well as groundwater quality sampling could lead to incomparable data sets and discrepancies. Although individual groundwater data collection protocol may be adequate to meet a stakeholder's needs, the lack of standardizing protocols could result in misrepresentation of basin-wide groundwater conditions.

EBMUD plans to work with the local stakeholders in developing the groundwater elevation monitoring program for this GMP. Over time, establishing a regional monitoring network, comprising monitoring and production wells to integrate existing monitoring wells with additional wells owned by stakeholders and private owners, would benefit the basin. Although dedicated monitoring wells yield more accurate data, idle production wells can be used as an alternative for data collection.

In accordance with provisions of SBX7 6, State Department of Water Resources (DWR) is implementing the California Statewide Groundwater Elevation Monitoring (CASGEM) program for the DWR Bulleting 118 basins including SEBP basin. EBMUD is one of the monitoring agencies which volunteers to report groundwater elevation data to DWR under the CASGEM program. DWR has developed the groundwater elevation monitoring guideline for the CASGEM program. Hence for the SEBP basin integrated monitoring well network, DWR's monitoring guidelines (Appendix F) are to be used as recommended monitoring protocols.

Monitoring Frequency: A consistent measurement frequency would help identify seasonal and long-term trends in groundwater levels. Semi-annual monitoring of the designated wells could be planned to coincide with the high and low seasonal water-levels of the year for the basin. Ideally, as the SEBP Basin is influenced by daily tidal activities, continual measurement at predetermined frequencies (such as hourly or every four hours using programmable pressure transducers) is recommended for future improved data collection. Currently, EBMUD deploys pressure transducers in its monitoring wells to measure and record groundwater level changes.

Integrated SEBP Basin Monitoring Well Network: Currently EBMUD monitors a portion of SEBP basin by using 17 monitoring wells for its Bayside Groundwater Project Phase 1. As a part of groundwater management effort, EBMUD is working with City of Hayward and City of Alameda to expand the monitoring network coverage by integrating additional wells.

The following Table 3-1 summarizes the EBMUD's Bayside Project monitoring wells designated for the SEBP groundwater elevation monitoring well network. Figure 3-1 shows the location of these existing wells along with potential wells being considered for the proposed integrated regional monitoring well network.

FIGURE 3-1
Existing and Potential Future Monitoring Wells

Table 3-1: Bayside Project Groundwater Monitoring Wells

No.	Well ID	X Coordinate	Y Coordinate	Address	City	Completion Date	Drilled Depth	Casing Depth	Depth of Perforation Begin	Depth of Perforation End	Casing Diameter	Remark
							ft	ft	ft	ft	inches	
1	MW-1	6082071	2069939	2600 Grant Ave	San Lorenzo	-	665	650	520	640	2	Deep Well
2	MW-2S	6082078	2069948	2600 Grant Ave	San Lorenzo	-	210	60	40	60	2	Shallow Well
3	MW-2I	6082078	2069948	2600 Grant Ave	San Lorenzo	-	210	200	160	190	2	Intermediate Well
4	MW-3	6081842	2069940	2600 Grant Ave	San Lorenzo	-	665	660	520	650	2	Deep Well
5	MW-4	6081803	2070628	2575 Grant Ave	San Lorenzo	-	705	650	520	650	2	Deep Well
6	MW-5S	6083469	2072797	2006 Via Barrett	San Lorenzo	Sep-08	460	210	200	210	2	New Shallow Well
7	MW-5I	6083469	2072797	2005 Via Barrett	San Lorenzo	Sep-08	460	325	315	325	2	New Intermediate Well
8	MW-5D	6083469	2072797	2007 Via Barrett	San Lorenzo	Feb-01	1025	640	500	630	4	Deep Well
9	MW-6	6083784	2070120	15600 Worthley	San Lorenzo	Nov-00	1000	655	480	650	4	Deep Well
10	MW-7	6085379	2069033	Westrern tip of San Lorenzo Park	San Lorenzo	Nov-00	972	680	510	630	4	Deep Well
11	MW-8D	6074793	2088139	1970 Davis Street	San Leandro	-	910	490	420	480	2	Deep Well
12	MW-9S	6094992	2076460	589 E. Lewelling Ave	San Lorenzo	Jan-08	460	120	110	120	2	New Shallow Well
13	MW-9I	6094992	2076460	589 E. Lewelling Ave	San Lorenzo	Jan-08	460	210	200	210	2	New Intermediate Well
14	MW-9D	6094992	2076460	589 E. Lewelling Ave	San Lorenzo	Jan-08	460	335	325	335	2	New Deep Well
15	MW-10S	6081364	2076905	15528 Wick Blvd	San Leandro	Sep-08	680	120	100	120	2	New Shallow Well
16	MW-10I	6081364	2076905	15528 Wick Blvd	San Leandro	Sep-08	680	360	340	360	2	New Intermediate Well
17	MW-10D	6081364	2076905	15528 Wick Blvd	San Leandro	Sep-08	680	610	590	610	2	New Deep Well

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Actions:

The following actions are planned to monitor and manage groundwater elevation:

- Use CASGEM Groundwater Elevation Monitoring Guidelines for water level data collection.
- Provide stakeholder agencies with guidelines on the collection of water quality data as per USEPA sampling standards.
- Assist stakeholders in developing and implementing monitoring programs.
- Coordinate with stakeholder agencies to develop standardized reference elevations for monitoring well.
- Coordinate with stakeholders and request that the timing of water level data collection occurs on or about April 15 and October 15 of each year.
- Provide a periodic assessment of groundwater elevation trends and conditions to stakeholders.
- Assess the adequacy of the groundwater elevation monitoring well network periodically.

3.3.2.2 Groundwater Quality Monitoring Program

For basin management, managing water quality is as important as managing basin groundwater quantity. Significant use of the SEBP Basin for drinking water supply ceased in the early 20th century, therefore historic water quality data is not available. While regulatory agencies and various entities have collected water quality data in specific locations and various purposes, comprehensive and historical water quality data sets are not available.

In the last decade, the USGS has completed research and analysis of the East Bay Plain Basin water quality in collaboration with EBMUD also as a part of State's Groundwater Ambient Monitoring and Assessment (GAMA) Program. The USGS study shows that the water quality of deep aquifer in the SEBP Basin remains pristine and the age of groundwater is dated at 9,200 years since it was recharged. This is attributed to the basin hydrogeology consisting of protective thick clay layers shielding contaminants. However, multiple perforated wells and improperly constructed or abandoned wells could act as artificial conduits by allowing contaminants from shallow zones to penetrate deeper aquifers, which is a potential threat to basin water quality. Accordingly, this GMP proposes well standards for existing wells and future wells to preserve basin water quality from threats of contaminants including salts and nutrients.

It is a future goal of this GMP to eventually develop and maintain an integrated groundwater database using a GIS platform. For that purpose, annual water quality sampling would be planned and groundwater quality data from stakeholder and public sources would be integrated into a water quality database. Appendix G contains a possible groundwater quality sampling plan listing the water quality constituents to be analyzed when resources are available. The water quality monitoring well network would continue to be modified to cover greater basin area as resources available.

Actions:

The following actions are planned to monitor and manage groundwater quality:

- Coordinate with stakeholders to assist in using standardized water quality sampling protocols

- Maintain stakeholder's existing monitoring well network for purposes of groundwater quality monitoring
- Collaborate with local, state, and federal agencies such as USGS to identify opportunities to continue conducting water quality analysis in less known areas of the basin
- Review and assess the effectiveness of the groundwater quality monitoring program periodically and recommend improvements as necessary
- Secure grant funding to initiate a GIS based groundwater quality database, and
- To collect, compile and integrate groundwater quality data

3.3.2.3 Subsidence Monitoring Program

Land subsidence can result from compaction of underlying formations caused by groundwater level decline. Subsidence can be categorized as recoverable elastic subsidence or irrecoverable inelastic subsidence. Subsidence concerns, within the SEBP basin, while certainly not as serious as in other areas of California are nevertheless present.

The risk of irrecoverable subsidence from operation of groundwater extraction depends on basin hydrogeology, the extent of groundwater pumping and the resulting change in the internal water pressure (groundwater levels). Groundwater contained within aquifers and aquitards helps support the weight of the overlying sediments because the water contained in the pore spaces in the sediments creates an internal water pressure. Land subsidence can occur if groundwater pumping reduces the water pressure within the pore space of the saturated sediments over a period of time, thereby causing the sediments to compress.

Elastic Subsidence: Subsidence in the coarser-grained materials of the aquifers is elastic. A small amount of elastic subsidence is expected to occur over a broad area of the SEBP Basin in response to pumping, which is what happens when any well in a confined aquifer produces water. Under conditions of elastic subsidence, the compaction is relatively small and is reversed when pore pressures increase due to rising water levels, including during injection of groundwater. The amount of this elastic subsidence is a function of the amount of drawdown. As occurs in nearly any basin with groundwater pumping, elastic subsidence will completely reverse following each groundwater pumping cycle as water levels recover.

Inelastic Subsidence: Under certain conditions, groundwater pumping can result in a permanent change in the structure of the sediments, known as *inelastic* subsidence. These conditions may result in a non-recoverable compaction of the aquifer system. Inelastic subsidence occurs when the water pressure in finer-grained sediments is reduced beyond their historic low water levels. The result is a permanent change to the intergranular structure of the sediments that cannot be reversed when water levels recover. The compressibility of sediments under inelastic conditions is much greater than it is under elastic conditions, and may require decades to millennia to complete.

The potential for inelastic subsidence depends on both the magnitude and duration of drawdown. Inelastic subsidence is highly unlikely to occur if water levels are maintained above historical lows.

Subsidence Monitoring in the SEBP basin: In coarser-grained materials, such as the sands and gravels that comprise the East Bay Plain Deep Aquifer, the change in pore pressure is roughly uniform throughout the thickness of the sediments and can be monitored by measuring changes in water levels in observation wells. As a part of the EBMUD's Bayside Project, direct measurement of ground elevation changes for Bayside Phase 1 are being accomplished using high-resolution extensometers, as shown in Figure 3-2. These instruments which were constructed and calibrated by the USGS detect compression in the deep and shallow aquifer sediments. The accuracy of well-constructed extensometers is on the order of 0.001 millimeters. Extensometer data is being reviewed continuously by EBMUD to assess whether subsidence is occurring and whether it is elastic or inelastic. If any inelastic subsidence is detected the accuracy of the extensometers is such that it will be a very small amount measurable near the Bayside Well No. 1.

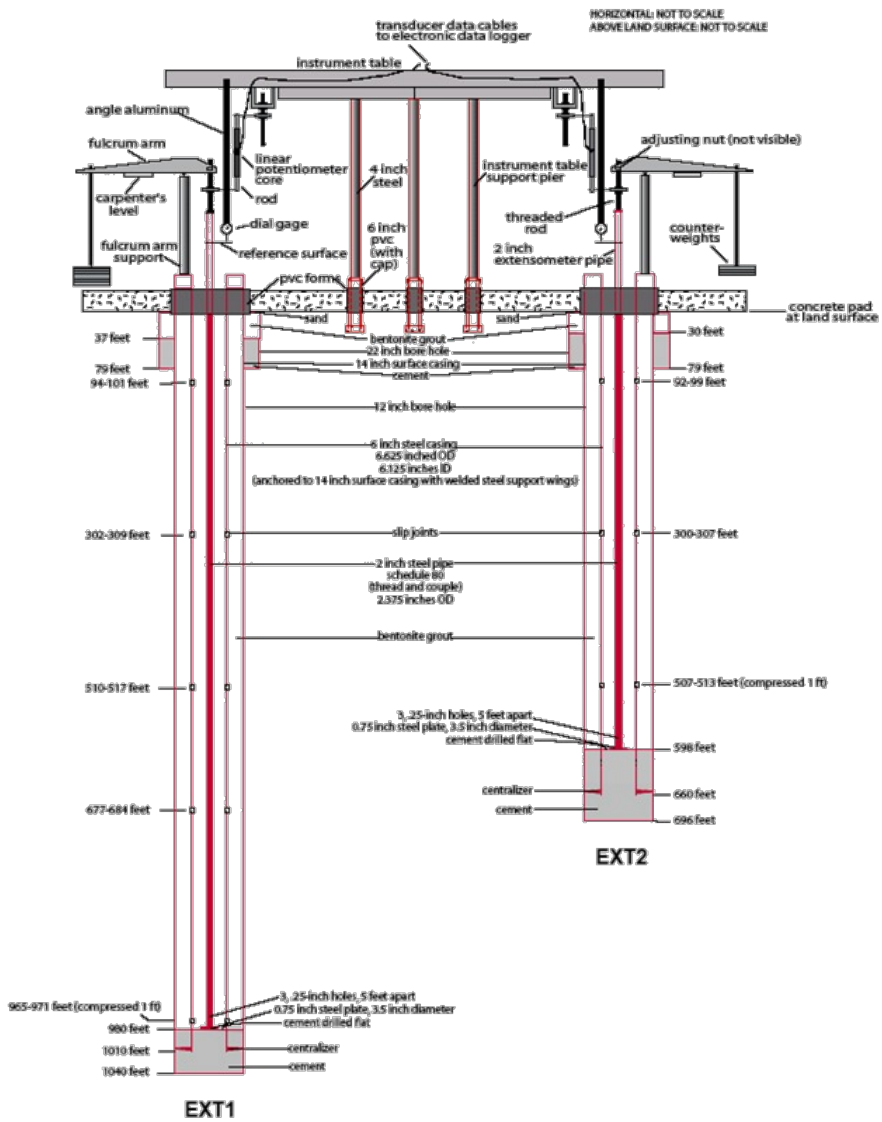

Figure 3-2
Bayside Groundwater Project Extensometer

Along with measurement of land surface movement using the above mentioned extensometer, contingent upon availability of funding, a periodic survey of reference elevations for the monitoring network would enable stakeholders to better track land surface movements including subsidence of the SEBP Basin.

Actions:

The following actions are identified to monitor and manage potential subsidence. The program will continue to monitor land subsidence and pursue additional actions as necessary if resources are available. These will include:

- Periodically re-survey the established reference elevations at groundwater monitoring locations.
- Collaborate with State and federal agencies, particularly USGS, to collect and analyze land surface movement data for potential land subsidence using various methodologies including InSAR remote sensing.

3.3.2.4 Data Management and Data Sharing

Groundwater data management requires data compilation and database maintenance. As the lead agency, EBMUD will continue to collect data required for the operation of the Bayside Groundwater Project Phase 1 and maintain a database of well information, well logs, groundwater quality and elevation data, and, when readily available, known groundwater contamination sites. These databases support water resources development, basin management, and groundwater model calibration.

3.3.3 Groundwater Basin Management Tools

3.3.3.1 SEBP Groundwater Model

As a part of GMP development, a groundwater model of the SEBP Basin and the NCGWB using the USGS finite difference flow model, MODFLOW was created to simulate groundwater management strategies. Further refinements and/or verification of the model will become necessary to accurately define basin sustainability and interbasin relationships to better manage the SEBP basin under increased levels of groundwater use.

Hydrologic Model of the SEBP Basin: The new model was constructed utilizing two existing models.

One model was developed by CH2M Hill in 2001. It was developed on behalf of EBMUD as part of the planning for their Bayside Groundwater Project. The model was constructed using the USGS's MODFLOW groundwater modeling code. That MODFLOW model consisted of seven layers.

The other model was developed also in the early 2000s by Wrime, Inc. on behalf of the Alameda County Water District, EBMUD and the City of Hayward. Titled the NCGB-SEBPB model (NEBIGSM), it uses the finite element IGSM model code.

The NEBIGSM model consists of four layers. The NEBIGSM model has been used extensively by ACWD as a basin management tool. Since its development, significant updates/contributions have been made to the model.

Code Selection: The USGS MODFLOW code was selected as the primary platform to develop the new groundwater flow model (NEB MODFLOW Model), as it provided the option to support both immediate and future modeling needs for basin stakeholders. Specifically, it is the most widely used groundwater modeling code publically available. MODFLOW has an ability to simulate three-dimensional problems involving recharge and evapotranspiration, wells, drains, and stream-aquifer interactions. It also has a suite of technically sound companion modules that have been reviewed and validated throughout the groundwater community that provide options (at some future date) to simulate the basin's response to groundwater contamination (predicting contaminant transport). It also allows one to identify and predict the risk of saltwater intrusion and basin subsidence. In addition, MODFLOW is integrated into the Arc Hydro Groundwater (AHGW) suite of tools that were used to support the data management, data analysis and visualization work completed for the technical study prepared as part of the GMP development effort.

For the new model development, the NEBIGSM model was selected as the primary data source for the new MODFLOW model.

Model Description: The NEB MODFLOW model, prepared for this GMP, is a seven-layer, finite difference groundwater flow model developed using the USGS MODFLOW code. The new model establishes/calculates a water balance for the GMP area. It also provides baseline estimates of key parameters (e.g., water levels, boundary flow conditions, etc.) for basin management purposes.

The simulation period of the NEB MODFLOW model starts from October 1, 1964 and runs through October 1, 2012. The model simulation period is monthly, except for the duration from August 2010 through September 2010. Additional stress periods were added during this time period to match the actual pumping that occurred during 2010 from EBMUD's pump test at the Bayside Well (Fugro, 2011). The models ability to replicate water level changes in observation wells was then assessed.

3.3.4 Groundwater Resource Protection

In this GMP, resource protection entails both prevention of contamination from entering the groundwater basin and remediation of existing contamination. Prevention measures include adoption and enforcement of relevant well standards including proper well construction and destruction practices, development of wellhead protection measures, protection of recharge areas, controlling groundwater contamination, and managing salts and nutrients.

3.3.4.1 Well Standards

As per authority provided by County General Ordinance Code, Chapter 6.88, the Alameda County Public Works Agency (ACPWA), administers the well permitting program for Alameda County. The code authorizes ACPWA to regulate groundwater wells and exploratory holes as required by the California Water Code. The provisions of these laws are administered and enforced through ACPWA's Well Standards Program.

ACPWA's Water Resources Section is responsible for all well permitting activities for nine cities and unincorporated western Alameda County including the SEBP Basin area. The Water Resources Section manages all drilling permit applications within its jurisdiction, and oversees compliance via guidelines for well construction and destruction, geotechnical and well contamination investigations, well data searches that meet specific criteria, and other activities.

To better protect the SEBP basin from water quality degradation, pollution or contamination caused by improper construction, use, operation, maintenance, repair, reconstruction, improvement, inactivation, decommissioning, or destruction of wells, exploratory holes, other excavations, and appurtenances, the current well standards were reviewed and updated to meet current well standard enforcement needs. The updated standards are included in the Appendix H. These standards are derived from water well industry procedures and processes deemed most effective at meeting local groundwater protection needs and are based on the standards developed by ACWD and the State of California Department of Water Resources (DWR). Note that following GMP adoption, stakeholders will work to see that these updated standards are considered for adoption by Alameda County.

Actions:

The GMP will implement the following tasks:

- Ensure that all stakeholders are provided a copy of the County well ordinance and understand the proper well construction procedures.
- Support ACPWA in adopting the updated well standards.
- Support stakeholders in educating public about the updated well standards and in adopting local ordinances to implement the well standards.

3.3.4.2 Wellhead Protection

EBMUD and City of Hayward serve the SEBP Basin area primarily from surface water sources. Both these water suppliers have developed supplemental drought supply and/or emergency sources using groundwater. These sources are subject to permitting requirements of California Department of Public Health (DPH). DPH requires water suppliers to identify wellhead protection areas under the Drinking Water Source Assessment and Protection (DWSAP) Program administered by the DPH in order to issue a drinking water supply permit. EBMUD has completed a DWSAP assessment in 2012 by completing the following three major components required by DPH:

- A delineation of capture zones around sources (wells); an inventory of Potential Contaminating Activities (PCAs) within protection areas.
- A vulnerability analysis to identify the PCAs to which the source is most vulnerable.
- A delineation of capture zones using groundwater gradient and hydraulic conductivity data to calculate the surface area overlying the portion of the aquifer that contributes water to a well within specified time-of-travel periods. Areas are delineated representing 2, 5, and 10 year time-of-travel periods.

Protection areas are managed to protect the drinking water supply from viral, microbial, and direct chemical contamination. Inventories of PCAs include identifying potential origins of contamination to the drinking water source and protection areas. PCAs may consist of commercial, industrial, agricultural, and residential sites, or infrastructure sources such as utilities and roads. Depending on the type of source, each PCA is assigned a risk ranking, ranging from “very high” for such sources such as gas stations, dry cleaners, and landfills, to “low” for such sources such as schools, lakes, and non-irrigated cropland. Vulnerability analysis includes determining the most significant threats to the quality of the water supply by evaluating PCAs in terms of risk rankings, proximity to wells, and Physical Barrier Effectiveness (PBE). PBE takes into account factors that could limit infiltration of contaminants including type of aquifer, aquifer material (for unconfined aquifers), pathways of contamination, static water conditions, hydraulic head (for confined aquifers), well operation, and well construction. The vulnerability analysis scoring system assigns point values for PCA risk rankings, PCA locations within wellhead protection areas, and well area PBE; the PCAs to which drinking water wells are most vulnerable are apparent once vulnerability scoring is complete.

Actions:

The GMP will recommend the following actions:

- Obtain an updated coverage of potentially contaminating activities and provide that information to stakeholders.
- Share current wellhead protection measures and provide a summary of actions taken by others as a tool in managing their individual wellhead protection programs.

3.3.4.3 Protection of Recharge Areas

Although the productive aquifers in most parts of the SEBP Basin are confined by thick clay layers and the surface water does not directly contribute to aquifer recharge, it is important to recognize the link between activities that take place on the surface and the potential impact of these activities on the long-term quality and quantity of groundwater recharge. As such, the GMP includes delineation of recharge areas to be protected and recognized for planning purposes. It is recommended that land use authorities recognize the need to protect groundwater recharge areas and pay special attention to overlying land use practices that either impede (e.g., large pavement areas) or could pollute (e.g., proper oil disposal) water as it makes its way from the surface to the aquifer.

Actions:

The GMP recommends the following action:

- Inform and assist groundwater authorities and the land-use planners to consider the need to protect prominent groundwater recharge areas in land use planning processes.

3.3.4.4 Groundwater Contamination

The known contaminated sites in the SEBP basin area are in the shallow zone. The shallow zone in the Basin area is not considered to be a water source for industrial and municipal water supply but traditionally has been used for irrigation purposes. However, there is a concern that the contaminants in the shallow zone could be transmitted through multiple-perforated wells into productive intermediate and deep aquifer units. As the Basin area has industrial and manufacturing activities, sources of contaminants known are recorded in environmental databases such as GeoTracker. Thus far, there is no significant adverse impact to the deeper production zones of the groundwater basin. However, the concern of potential contaminations from various sources does exist.

Although the GMP stakeholders do not have authority or the direct responsibility for taking action against responsible parties, they are committed to coordinating with responsible parties and regulatory agencies to foster appropriate actions and remediation. For example, should any contaminants exceeding water quality standards be detected or a spill event is observed, the GMP stakeholders will inform and coordinate with SFRWQCB and DTSC.

Actions:

The GMP stakeholders will take the following actions:

- If contaminants exceeding water quality standards are detected in monitoring wells, contact appropriate regulatory agencies
- Coordinate with SFRWQCB and DTSC to encourage these agencies to take necessary actions

3.3.4.5 Salt and Nutrient Management (SNM)

3.3.4.5.1 Background

The California State Water Resources Control Board (SWRCB) adopted the Recycled Water Policy on February 3, 2009. The purpose of the Policy is to increase the use of recycled water in a manner that implements state and federal water quality laws. The policy encourages water recycling with the stated goals of:

- Increasing recycled water use by at least one million acre-feet per year (AFY) by 2020 and by at least two million AFY by 2030.
- Substituting as much recycled water for potable water as possible by 2030.

The SWRCB is also encouraging every region in California to develop a salt/nutrient management plan by 2014. Because each groundwater basin or watershed is unique, the plan detail and complexity will depend on the extent of local salt and nutrient problems. Plan components include:

- Basin-wide water quality monitoring
- Water recycling goals and objectives
- Salt and nutrient source identification
- Basin loading - assimilative capacity estimates
- Salt mitigation strategies
- Anti-degradation analysis
- Emerging constituents consideration (e.g., PPCPs, EDs)

Currently, only limited recycled water supply is available within the SEBP Basin area. However, in the future, recycled water supply could become a significant source. In addition, because of the proximity to the San Francisco Bay, high concentrations of TDS are observed in shallow zones of the Basin.

3.3.4.5.2 Objectives

The primary goal of SNM is to facilitate basin-wide management of salts and nutrients from all sources in a manner that optimizes recycled water use while ensuring protection of groundwater supply and beneficial uses, agricultural beneficial uses, and human health. In addition, SNM is required for seawater intrusion related salt loading. Considering that limited to no recycled water use is taking place within the most productive area of the SEBP Basin, and as based on existing hydrogeology, the following are the objectives of the SNM plan for the SEBP Basin:

- To recognize the importance of monitoring salt and nutrient compounds.
- To evaluate the need for SNM.
- To establish a base line water quality condition for the basin.
- To evaluate existing and potential future sources.
- To integrate additional constituents in water quality monitoring for salt and nutrients management.
- To collect water quality data.

3.3.4.5.3 Salt & Nutrient Source Analysis

Existing Salt and Nutrient Composition of the SEBP basin: The SEBP Basin interfaces with San Francisco Bay. The shallow aquifer unit of the Basin is exposed to seawater and higher concentrations of TDS are detected in the shallow zone.

Section 2.13 of the GMP details the current water quality condition in the Basin area. As discussed in that section, previous studies evaluate the distribution of water quality parameters as a function of depth within the SEBP Basin and make the following observations:

- Compared to deeper levels, groundwater less than 200 ft bgs is characterized by relatively high concentrations of total dissolved solids (TDS), chloride, nitrate, and sulfate. Shallow wells exceed the MCL for nitrate (45 mg/L as NO3), and the secondary MCL for TDS (1,000 mg/L), chloride (250 mg/L), sulfate (250 mg/L), iron (0.30 mg/L) and manganese (0.05 mg/l).Nitrate is elevated in large parts of the San Leandro/San Lorenzo area, probably due to septic tank effluent and past farming activities in these areas.
- Wells with total depths greater than 500 ft bgs are located primarily in the southern portion of the study area. These wells have high iron and manganese levels that commonly exceed their secondary MCLs. Elevated TDS and chloride concentrations are probably related to the presence of shallow well screens in the deeper wells.

Potential Source of Salt and Nutrient: Depending upon the quality of recycled water, recycled water use could become an additional source of salt and nutrients for the basin. Currently, all existing recycled water uses are in the least productive area of the basin portion that is not used for public water supply). As a part of the basin management activities, recycled water use within the basin will be periodically observed and the monitoring plan will be modified as needed to manage the basin water quality.

3.3.4.5.4 Salt & Nutrient Plan and Implementation

- Options: As a part of the water quality monitoring program, the water quality sampling and analysis is to be done periodically to monitor the basin water quality. In addition, the water supply wells are to be sampled and analyzed for permit compliance purposes.
- Strategies: Although the water quality monitoring network is sufficient to track water quality objectives, the network can be improved by adding dedicated monitoring wells and sampling events. To improve water quality monitoring capabilities, under the implementation of this GMP, available state and federal grants will be pursued. In addition, periodic bi-lateral

meetings with San Francisco Regional Water Quality Control Board (SFRWQB) will be planned to review and discuss the water quality data and plan actions. The stakeholders will seek collaboration and support in obtaining grant funding and in developing any necessary actions.

- Implementation: A key component of the GMP is monitoring basin water quality. Section 3.3.2.2 of this document details the groundwater quality monitoring program including aater quality monitoring constituents and sampling protocols. Salt and nutrient constituents will be included as a part of monitoring program. Details of the monitoring plan are discussed in these sections.

3.3.5 Groundwater Sustainability

3.3.5.1 Coordinated Management Activities

Following GMP adoption, basin stakeholders recognize the need to perform various activities on a routine basis that when combined serve as the means to manage the basin thereby insuring its conjunctive capabilities (Conjunctive Management Activities). Activities are grouped into the following categories:

- Stakeholder Efforts;
- Basin Monitoring;
- Groundwater Protection Measures (& Enforcement);
- Other Sustainability Measures; and
- Integration with Other Agency & Organization Planning Efforts.

Stakeholder Efforts (Public Outreach & Coordinated Stakeholder Activities): Maintaining and strengthening stakeholder involvement in the groundwater management effort will be a key conjunctive management activity moving forward. The process of encouraging broad involvement will be successful if the public is engaged.

Public Outreach and Involvement: The stakeholder committee formed for the GMP preparation will spearhead outreach efforts. Initially, those efforts will focus on informing key elected officials and the public about the GMP.

Communication activities could be within or outside the SEBP basin boundary, depending on the audience and their interest(s). However, the focus of public outreach will be to reach residents and business owners that overlie the basin.

The following actions may be used to encourage public involvement:

- Hold an annual stakeholders workshop with public involvement as a standing agenda item.
- Agency leads for GMP implementation shall work with stakeholders to assure continued communication following GMP adoption (including participation in discussion with stakeholders, electeds and staff)
- Make available printed copies of the GMP at public libraries within the basin footprint
- Make available an electronic version of the GMP
- Maintain the EBMUD-hosted website for the SEBP basin GMP

- Through the stakeholder group, coordinate outreach to inform the public and key elected officials
- Present GMP details at community forums, in conjunction with existing neighborhood outreach efforts
- Maintain a mailing list of those interested in participating on any GMP-related committees
- Meet with representatives from business groups and other interested organizations as appropriate

Coordinated Stakeholder Activities: Stakeholders are committed to advancing the knowledge of the Basin to promote Basin sustainability. The following activities are future means to meet that commitment:

- Working together to seek grant funding for key projects and planned actions beneficial for the Basin
- Working proactively to address potential conflicts of groundwater interests

Basin Monitoring: Comprehensive, long-term monitoring provides data needed to evaluate changes in the Basin over time. GMP implementation will call for continued groundwater monitoring coupled with updated groundwater modeling when appropriate in order to assist in decision making as it pertains to basin management.

Monitoring of the groundwater basin shall include the following elements:

- Groundwater elevation monitoring
- Groundwater quality monitoring
- Land subsidence monitoring
- Data management/storage

Groundwater Elevation Monitoring: While agencies such as EBMUD have been performing groundwater elevation monitoring for a number of years, there is an interest to continue and perhaps expand that effort over time. As funding is available, the following activities could be performed on a periodic basis:

- Surveys of existing monitoring wells: The City of Hayward and EBMUD have wells that are routinely monitored as part of their ongoing operations. Additional known wells can be added to monitoring program assignments based on whether such information is necessary and additional resources are available
- Expansion of monitoring activities: If additional resources become available, monitoring could be expanded beyond those wells which have been instrumented by the City of Hayward and EBMUD
- Data Sharing: Data would be shared with a stakeholder team (likely led by EBMUD) and can be made available to the public and interested parties to track basin sustainability over time

The following actions are planned regarding groundwater elevation monitoring:

- Assess groundwater elevations collected as part of ongoing agency activities for network adequacy
- Work with private well owners who wish to continue to operate their groundwater wells to 1) comply with well standards and 2) collect and share groundwater data.
- Seek grant funding to expand the monitoring program.

Groundwater Quality Monitoring: Water quality information has been collected over the years by several of the basin stakeholders. The following actions are proposed moving forward:

- Stakeholders will review groundwater quality data collected as part of on-going activities associated with agency operations to determine trends, conditions and adequacy of the groundwater quality monitoring network. If there appears to be an acute need for additional modeling, the stakeholders will work to identify funding mechanisms.

Land Subsidence Monitoring: EBMUD has a program in place, in partnership with the U.S. Geological Survey, to monitor Land Subsidence adjacent to its Bayside Groundwater Project facilities in San Lorenzo, CA. Plans are to continue to use that facility to monitor land subsidence in that general portion of the SEBP Basin. Additional subsidence monitoring performed by stakeholders such as the City of Alameda will be periodically reviewed to assess the behavior of the SEBP Basin.

Monitoring Protocols: Stakeholders are to adhere to water quality data collection procedures developed by the State of California Department of Public Health.

Data Management: Assuming a source of funding can be secured, EBMUD could serve as a centralized agency for the purpose of data management as it pertains to the SEBP basin. Specifically, EBMUD could:

- Maintain and update a data management system to store information collected by the various stakeholders in regards to groundwater elevations and groundwater quality.
- Use the data collected to prepare periodic evaluations of the groundwater condition in the SEBP basin, which in turn can be shared with other stakeholders and the general public.

Groundwater Protection Measures: Groundwater quality protection is a key factor to ensuring the sustainability of a groundwater resource. As part of this GMP, groundwater quality protection includes both the prevention and minimization of groundwater quality degradation, as well as measures for the minimization of contamination. Prevention measures include proper well construction and deconstruction practices, development of wellhead protection measures, and source control of potential contaminants.

Well Construction, Abandonment and Deconstruction: Alameda County Public Works Department, a GMP stakeholder, is responsible for rules and procedures associated with well construction, abandonment and deconstruction. Those rules and procedures are detailed in Appendix H.

Wellhead Protection: Identification of wellhead protection areas is a component of the Drinking Water Source Assessment and Projection (DWSAP) Program administered by DPH. EBMUD, as part of its Bayside Groundwater Project, has provided DPH with the following information:

- A delineation of the capture zone around the Bayside Groundwater Project's extraction well.
- An inventory of potential contaminating activities (PCAs) within the project's protection areas.
- A vulnerability analysis to identify the PCAs to which the project is most vulnerable.

The following are potential future/further actions regarding this topic:

- Continue to identify source areas and protection zones as needed when and if the SEBP Basin is used as part of any future activity (such as the expansion of the Bayside Groundwater Project by EBMUD).
- Update management approaches that can be used to provide better protection to the water supply from PCAs including voluntary control measures and expanded public education.

Controlling Migration and Remediation of Contaminated Groundwater: The known groundwater contamination plumes within the SEBP Basin are discussed in Section 2.13.

To address contamination, the stakeholders will coordinate with responsible parties and regulatory agencies to keep those interested informed on the status of potential contamination in the SEBP Basin. The actions listed below are to be considered as a means to improve protection of groundwater quality from contamination:

- Provide well owners with information regarding DPH and ACPWD well requirements.
- Incorporate any new known high risk PCAs into the data management system(s) created for the SEBP Basin.
- Make contaminant plume information available to well owners through various informational avenues (the SEBP Basin GMP webpage, etc).

Control of Saline Water Intrusion: Seawater intrusion from San Francisco Bay is a challenge, particularly for the upper most aquifers in the SEBP Basin. Section 3.3.4.5 addresses salt and nutrient management efforts proposed, however, aside from those efforts, this GMP proposes that the following additional actions could be implemented over time, particularly if and when seawater intrusion issues become problematic for the lower-most aquifer:

- Track saline water movement from San Francisco Bay through on-going groundwater monitoring efforts.
- Examine TDS, chloride and sulfate concentrations collected for the Bayside Groundwater Project monitoring to identify any trends over time.
- Perform studies (when and if funding can be secured) to review salinity sources and their distribution; to identify mitigation alternatives.
- Develop projects (when and if funding can be secured and assuming mitigation is needed) to address saline water intrusion.

Other Sustainability Measures: Various water management options are available to address groundwater supply sustainability. The primary method in play for the deep aquifer of the SEBP Basin is direct aquifer recharge/groundwater banking, managed as a strategy to replenish the Basin and serve as a secure storage means for water that could be sourced during times of drought. As EBMUD and others (such as the City of Hayward) utilize the basin for water supply, there are no plans at this point in time to consider alternatives such as storm water recharge and/or recycled water recharge. However, the use of other supplies (such as recycled water) for irrigation, etc. can be promoted as a means to limit the use of groundwater supplies. Similarly, conservation and demand reduction measures can be employed that will reduce the reliance on the SEBP Basin.

Direct Aquifer Recharge/Groundwater Banking: The deep aquifer in the SEBP Basin is being utilized by EBMUD to store treated water for later use during droughts. The project, the Bayside Groundwater Project is an Aquifer Storage and Recovery Project, and demonstrates how direct aquifer recharge can be utilized to assure the long term sustainability of the basin. The following planned actions are possible to build upon this concept:

- Possible expansion studies to assess the feasibility of a larger, Phase 2 of the Bayside Groundwater Project (moving from an existing 1 mgd operation to as large as a 10 mgd operations)
- Full scale Phase 2 project development (based on the results of feasibility studies and the ensuing planning efforts)

If or when other parties are shown to have depleted storage within the lower aquifer, there is the possibility that direct aquifer recharge could be utilized to counter or correct for the depletion.

Integration with Other Agency and Organization Planning Efforts: There are various planning efforts underway within basin stakeholder organizations where integration is possible, however the three that are most-likely to benefit from integration include:

- Urban Water Management Plans
- General Plans/Land Use Plans
- Integrated Regional Water Management Plans

Urban Water Management Plans: Two Basin stakeholders (EBMUD and the City of Hayward) have developed Urban Water Management Plans (UWMP). These UWMPs, are required by the State of California for all retail water purveyors who have more than 3,000 customers. UWMPs are designed to encourage efficient water use and identify ways to meet future customer demands and issues such as the sustainability of groundwater resources, should such resources play a factor.

General Plans/Land Use Plans: Stakeholder agencies are committed to providing GMP information to those entities responsible for the preparation and update of land use plans and general plans for cities and counties. The goal of such interaction will be to enable all land use agencies to have access to information regarding activities taking place for the protection and availability of groundwater resources within the SEBP basin.

3.3.5.2 Water Conservation and Recycling

EBMUD and the City of Hayward are the two water suppliers within the SEBP Basin. Each has water conservation programs in place to reduce the demand for water. The following section briefly discusses the programs of the two agencies.

EBMUD's Water Conservation Program: EBMUD provides technical and financial assistance to encourage customers to help assure an adequate water supply by using water efficiently. Their water conservation staff advises customers on selecting water-efficient products, implementing best management practices, and designing/maintaining *WaterSmart* landscaping and efficient irrigation methods. Water conservation services include water use surveys, incentives for high-efficiency plumbing fixtures, appliances, process equipment and irrigation systems, and free distribution of conservation self-survey kits and water efficient devices (*i.e.*, showerhead, faucet aerators) that reduce water use. EBMUD is also very active in new water conservation technology research and the development of education and demonstration projects. In 2011, EBMUD updated its Water Conservation Master Plan ("WCMP") to help meet long-term water supply needs through the year 2020. The WCMP serves as a blueprint for implementation strategies, goals and objectives for achieving additional water savings consistent with the targets identified in EBMUD's 2010 Urban Water Management Plan as well in their recently adopted Water Supply Management Program 2040 (WSMP 2040). The WCMP incorporates elements of the State of California's Water Conservation Act of 2009 (SB7) which calls for achieving a statewide goal of a 20 percent reduction in urban per capita water use by 2020.

City of Hayward's Water Conservation Program: The City of Hayward has one of the lowest per capita water usage among agencies that purchase water from the San Francisco Public Utilities Commission (SFPUC). This is perhaps partially due to the fact that, as one of the original signatories to the California Urban Water Council (CUWC) Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), Hayward has long been committed to effective water conservation. The CUWC was created to increase water use efficiency through partnerships among urban water agencies, public interest organizations and private entities that provide services and equipment to promote water conservation.

Hayward has and will continue to actively participate in regional demand management efforts, including development and implementation of the regional Water Conservation Implementation Plan as developed by Bay Area Water Supply and Conservation Agency (BAWSCA) in 2009. Hayward evaluates each regional conservation program individually to assess the benefits to Hayward customers. To date, Hayward has participated in regional programs such as:

- High efficiency clothes washing machine rebates
- High efficiency toilet rebates
- Indoor water efficiency standards for new development
- Residential water efficient landscape classes
- School education programs (in-class and assembly)
- Distribution of pre-rinse spray valves
- Adoption of bay friendly landscape ordinances and standards

Hayward intends to continue to implement cost effective water conservation programs. Moving forward, the City will continue to assess and implement additional cost effective water conservation measures in order to achieve SB7 targets and to carry Hayward City Council's mission of efficient and sustainable use of resources. Potential future programs may include:

- Rebates for weather-based irrigation controllers and efficient irrigation systems
- Water use surveys for commercial/industrial sites, including hotels and motels
- Incentives to replace inefficient commercial and industrial equipment

3.3.5.3 Periodic Basin Assessment and Reporting

Contingent upon available funding, the basin management actions will be reviewed and analyzed to evaluate effectiveness of the actions. Necessary modification may be considered to achieve the GMP objectives. These analyses and findings are to be reported to the basin stakeholders.

3.3.5.4 Basin Replenishment

Using the GMP as a guide, all stakeholders led by EBMUD are to collaboratively manage the Basin. EBMUD has not committed to exclusively taking on basin management authority, although the agency will continue to provide guidance and coordination for other stakeholders. When basin storage conditions warrant the need to address replenishment matters, EBMUD will work with GMP stakeholders to undertake necessary actions.

3.3.5.5 Basin Water Budget

The new groundwater flow model (NEB MODFLOW) for the SEBP Basin area as well as the water budget prepared for the Basin are primarily intended for groundwater planning purposes to assist in managing ground water resources.

As a numerical analysis tool, a groundwater model assists water managers and basin stakeholders in understanding the general dynamics of the groundwater flow system within the SEBP Basin. During the GMP preparation, upon completion of model calibration, the model was used to generate a water balance and baseline estimates for the GMP area. In addition, major components of the groundwater budget were developed using the model.

From model results, groundwater elevations within the SEBP Basin appear to be reaching an equilibrium. Groundwater levels have been increasing since the 1960s, primarily as a result of the decrease in volume of groundwater extraction throughout the area since that time.

Based on a technical review of current information, the primary inflow into the GMP area can be categorized as recharge to the aquifers as a result of deep percolation of precipitation and applied water, subsurface inflow, and inflow from ungauged watersheds. The source of groundwater flow in the shallow zone is percolation primarily from the foothill region that lies to the east. That water move from east to west in the shallow aquifer, flowing towards San Francisco Bay. It is believed that the flow entering the intermediate and deep aquifers systems consists of contributions from beneath the San Francisco Bay.

If there are modifications to the volume and/or rate of groundwater extraction in the SEBP Basin, it would likely influence the overall flow balance and distribution of inflow into the GMP area. The overall water balance for the GMP area is provided in the Figure 3-3. Table 3-2 provides a summary of the simulated water budget for the GMP area for a 20-year period from 1993 through 2012. On average, inflows and outflows were in balance across the period, resulting in relatively small changes in storage in the aquifer. The average annual change in storage for the period was 152 acre-feet, a small annual increase. This is consistent with the relatively stable groundwater elevation trends over the same period as detailed in previous basin studies. Those studies indicated that the basin was refilling at a rate of 1,300 acre-feet per year in the mid-1990s (CH2MHILL, 2000). The results from the hydrologic study performed as part of this GMP preparation indicates that the basin has nearly stabilized, and the rate of increase in storage is decreasing as a consequence.

These estimates and findings are influenced by the assumptions necessary to create an "initial condition" for the Basin (as well as by how the model conceptualized various operational details of the Basin). Modifications to either of these components could be called for when and if additional Basin data becomes available in the years ahead. In turn, the water balance as prepared for the SEBP Basin should be updated.

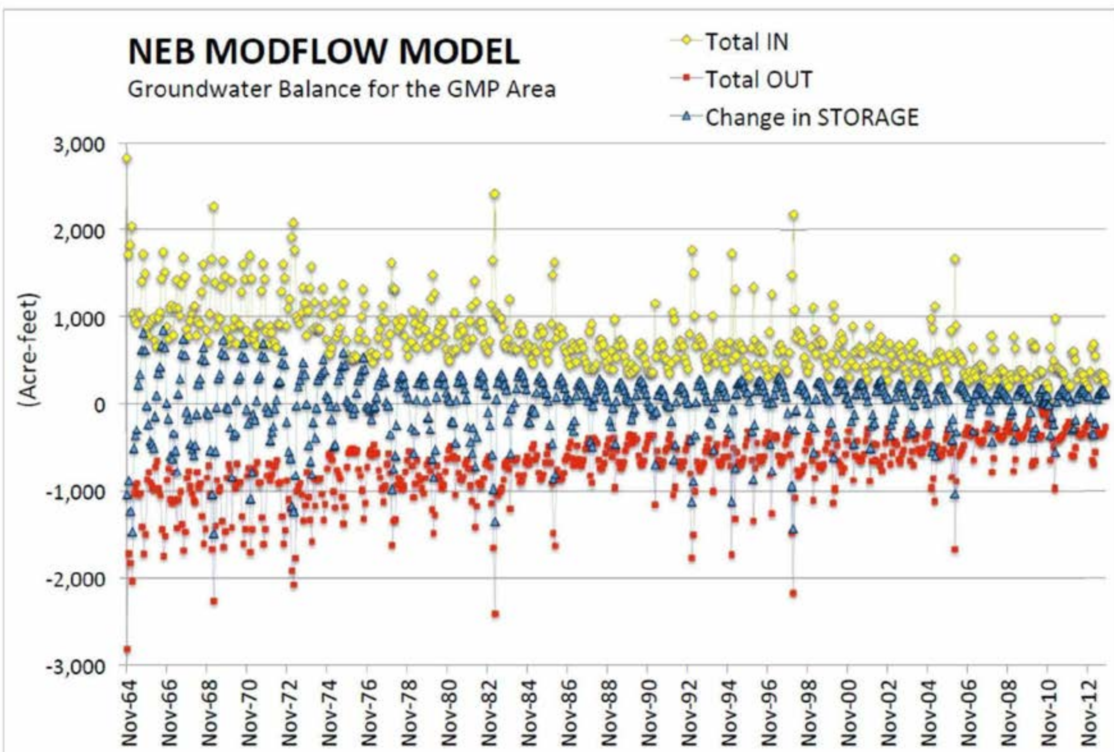

FIGURE 3-3
East Bay Municipal Utility District
South East Bay Plain Basin Characterization Study
NEB MODFLOW MODEL WATER BALANCE

Table 3-2: Simulated Annual Water Budget for the SEBP Groundwater Basin, 1993 through 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Inflows										
Recharge	4,207	2,157	4,027	2,547	2,290	4,325	2,508	2,393	1,947	2,355
Ungauged Watersheds	472	0	552	571	262	997	246	265	10	87
Lake Seepage	74	68	61	101	98	50	36	44	49	55
Subsurface Inflow From:										
Below Hayward Fault	645	624	418	212	311	847	799	739	524	571
Salt Evaporation Ponds	576	587	340	161	251	630	639	578	469	450
Hayward South	723	631	477	296	356	837	806	724	568	599
Hayward North	3	2	3	2	2	3	2	2	2	2
San Leandro	8	6	7	4	4	6	5	5	4	4
Oakland	61	53	48	57	54	34	31	36	33	40
Alameda Island	157	141	125	135	131	105	90	97	97	106
Beneath San Francisco Bay	1,551	1,448	1,234	1,252	1,271	1,191	1,151	1,137	1,058	1,110
Total Subsurface Inflow	3,724	3,493	2,652	2,119	2,380	3,652	3,523	3,318	2,755	2,883
Total Inflows	8,476	5,719	7,291	5,338	5,030	9,024	6,312	6,019	4,761	5,380
Outflows										
Groundwater Extraction	3,549	3,359	3,100	3,125	3,135	3,097	3,053	3,344	2,661	3,115
Lake Evaporation	1,244	862	1,224	760	755	1,419	1,197	1,099	933	960
Subsurface Outflow To:										
Below Hayward Fault	480	255	565	615	473	617	409	382	323	322
Salt Evaporation Ponds	224	194	155	144	122	291	307	242	227	203
Hayward South	132	65	203	259	191	154	81	89	88	100
Hayward North	0	0	0	0	0	0	0	0	0	0
San Leandro	4	4	3	2	2	3	3	3	3	2
Oakland	32	34	34	27	29	39	35	31	36	33
Alameda Island	101	86	91	86	86	80	79	81	83	89
Beneath San Francisco Bay	1,126	1,046	815	483	619	1,260	1,291	1,049	994	872
Total Subsurface Outflow	2,100	1,684	1,866	1,616	1,523	2,443	2,205	1,875	1,754	1,621
Total Outflows	6,893	5,906	6,190	5,501	5,414	6,959	6,456	6,318	5,348	5,696
Change in STORAGE	1,583	-187	1,102	-164	-384	2,064	-143	-299	-586	-316

Future Governance Plans: It is anticipated that at some point in time, there may be a need to enter into a more formal governance structure. Such a structure would enable the following:

- Collective management of a well protection program, well destruction program/policies, well installation policies, etc.
- Integration of Basin objectives into the Bay Area Integrated Regional Water Management Plan.
- Collective means to apply for grant monies.
- Development of means and procedures whereby Basin replenishment is managed (should one or more entities be deemed responsible for extracting groundwater from the Basin to cause overdraft).
- Collective preparation of updates to the GMP as well as of periodic State-of-the-Basin reports.
- While undertaking all the sustainability measures, if the Basin becomes overdrafted, EBMUD will collaborate with stakeholders to develop a replenishment plan.

SECTION 4.0 PLAN IMPLEMENTATION AND INTEGRATION

4.1 PERIODIC GMP IMPLEMENTATION MEETINGS

Working with other Basin stakeholders, EBMUD will review the progress made implementing the GMP. Stakeholders will hold meetings to facilitate the review process, tentatively assumed to be annual State of the Basin meetings. Those meetings will discuss the groundwater conditions in the SEBP Basin area and document groundwater management activities from the previous year. Much of the data reviewed as part of preparing annual State of the Basin summaries will come from the monitoring and successful implementation of the action items as developed and detailed in Section 3.0 of this GMP.

During periods where significant changes have occurred within the Basin, the stakeholders (as an action item following the State of the Basin meeting) may elect to craft a summary report. That summary will document conditions that have occurred since last State of the Basin meeting. The report may include:

- A summary of monitoring results that includes a discussion of historical trends and an interpretation of water quality and groundwater elevation data.
- A summary of management actions during the period covered by the report.
- A discussion of the need (if any) to collected additional groundwater basin data to aid in the analysis of conditions observed.
- A discussion, supported by monitoring results, of whether management actions are achieving progress in meeting Basin management objectives.
- A discussion of the need to modify any GMP component, including the Basin management objectives.

Description of Action	Implementation Schedule (approximate time for commencing activity following GMP adoption)
I. Stakeholder Involvement	
Involving the Public	
▪ Continue efforts to encourage public participation as opportunities arise. ▪ Reach out to local and business communities via EBMUD's Bayside Groundwater Project's Community Liaison Group. ▪ Assist stakeholders in disseminating the information through other various public forums.	On-going 6 months 6 months
Coordinate with State and Federal Agencies	
▪ Continue to develop working relationships with local, state, and federal regulatory agencies. ▪ Coordinate GMP implementation activities with local, state and federal agencies as appropriate.	On-going On-going

Pursuing Partnership Opportunities	
▪ Continue to foster partnership opportunities to achieve both local supply reliability and broader regional and statewide benefits. ▪ Continue to seek grant opportunities to fund local projects that can improve groundwater management and improve local water infrastructure.	On-going On-going
II. Monitoring Programs	
Groundwater Elevation Monitoring	
▪ Use CASGEM groundwater elevation monitoring guidelines for water level data collection. ▪ Provide stakeholder agencies with guidelines on the collection of water quality data as per USEPA sampling standards. ▪ Assist stakeholders in developing and implementing monitoring programs. ▪ Coordinate with stakeholder agencies to develop standardized reference elevations for monitoring wells. ▪ Coordinate with stakeholders and request that the timing of water level data collection occur on or about April 15 and October 15 of each year. ▪ Provide a period assessment of groundwater elevation trends and conditions to stakeholders. ▪ Assess the adequacy of the groundwater elevation monitoring network periodically.	On-going On-going and as needed On-going and as needed On-going and as needed On-going On-going 12 months
Groundwater Quality Monitoring Programs	
▪ Coordinate with stakeholders in using standardized water quality sampling protocols. ▪ Monitor stakeholder's existing monitoring well network for purposes of groundwater quality monitoring. ▪ Collaborate with local, state, and federal agencies such as USGS to identify opportunities to continue conducting water quality analyses in less known areas of the basin. ▪ Review and assess the effectiveness of the groundwater quality monitoring program periodically and recommend improvements as necessary. ▪ Develop a GIS based groundwater quality database. ▪ Apply for state and federal grants to collect, compile and integrate groundwater quality data.	On-going and as necessary On-going On-going 12 months 12 months (if grant funding is available) 12 months (depending on grant program opportunities)

Subsidence Monitoring Program	
▪ Periodically re-survey the established reference elevations at groundwater monitoring stations. ▪ Collaborate with state and federal agencies, particularly the USGS, to collect and analyze land surface movement data for potential land surface subsidence using various methodologies including InSAR remote sensing.	36 months (if grant funding is available) 36 months (if grant funding is available)
III. Groundwater Management Tools	
Groundwater Resources Protection	
▪ Ensure that all stakeholders are provided a copy of the county well ordinance and understand the proper well construction procedures. ▪ Support ACPWA in adopting the updated well ordinance. ▪ Support stakeholders in educating the public about the updated well standards and in adopting local ordinances to implement those well standards.	6 months+ (assumes county passes new well ordinance) 3 months 6-12 months
Wellhead Protection	
▪ Obtain an updated coverage of potentially contaminating activities and provide that information to stakeholders. ▪ Share current wellhead protection measures and provide a summary of actions taken by others as a tool in managing their individual wellhead protection programs.	24 months 24 months
Protecting Recharge Areas	
▪ Inform and assist groundwater authorities and land use planners to consider the need to protect prominent groundwater recharge areas in the land use planning process.	24 months
Groundwater Contamination	
▪ If contaminants exceeding water quality standards are detected in monitoring wells, initiate facilitation between the responsible parties and the potentially impacted stakeholders to manage the contamination. ▪ Inform and coordinate with SFRWQCB and DTSC to encourage these agencies to take necessary actions.	On-going and as needed On-going and as needed

IV. Groundwater Sustainability	
Public Outreach and Involvement	
▪ Hold an annual stakeholders workshop whereby the matter of public involvement is a standing agenda item.	12 months
▪ Agency leads for GMP implementation shall work with other stakeholders to assure continued communication following GMP adoption (including participation in discussions with stakeholders, electeds and staff).	3 months
▪ Make available printed copies of the GMP at select public libraries within the basin footprint.	3 months
▪ Alert the public as to the availability of an electronic version of the GMP (by mentioning it in existing newsletters, newspaper articles, etc.).	1 month – 12 months
▪ Maintain the EBMUD-hosted website for the SEBP basin GMP.	On-going
▪ Through the stakeholders group, develop a coordinated outreach plan to inform the public and key electeds.	3 months
▪ Present GMP details at community forums, in conjunction with existing neighborhood outreach efforts.	3-12 months

4.2 FUTURE REVIEW OF THE SEBP BASIN GMP

This GMP is intended to be a framework for future coordinated management efforts in the South East Bay Plain area. As such, many of the identified actions will likely evolve as the stakeholder agencies begin to work together to cooperatively manage and learn more about the basin. Over time, and in the event that the basin usage grows such that it becomes an even greater relied-upon resource to the various stakeholders, the potential need for a more formal groundwater management entity may be considered.

There is the potential, as described in section 4.1, that additional actions could also be identified as part of the GMP implementation periodic review process. The GMP is therefore intended to be a living document, and it will be important to evaluate all of the actions and objectives over time to determine how well they are meeting the overall goal of the plan.

4.3 FINANCING

Implementation of the GMP, as well as many other groundwater management-related activities could be funded from a variety of sources including in-kind services by agencies; state or federal grant programs; and local, state, and federal partnerships. Some of the items that would require additional resources include:

- Monitoring for groundwater quality or elevations in non-purveyor wells
- Preparation of GMP annual reports

- Updates of the overall GMP
- Updates of data sets and recalibration/improvement of the groundwater model produced for the SEBP Basin
- Collection of additional subsidence data (beyond what EBMUD is required to collect as part of its operation of their Bayside Groundwater Project Phase 1)
- Construction of monitoring wells where critical data gaps exist
- Stream-aquifer interaction studies
- Implementation of the GMP including:
  - Committee coordination
  - Project management

4.4 INTEGRATED WATER RESOURCES MANAGEMENT

Integration of various water management programs that are underway in the Bay Area is a complex activity, as part of the update of the Bay Area Integrated Regional Water Management Plan (Bay Area IRWMP). The Bay Area IRWMP will reference the GMP effort and document moving forward as part of the periodic updates of the Bay Area IRWMP.