APPENDIX B: SPILL TRAJECTORY MODELING FROM PREVIOUS PROJECTS AT NEARBY LOCATIONS

ATTACHMENT B-1: SHORE TERMINAL 5,830-BARREL SPILL TRAJECTORY MODELING (CSLC 2004)

3.4 OFFSITE CONSEQUENCES ANALYSIS

3.4.1 Introduction

This Offsite Consequence Analysis (OCA) is intended to supplement the Hazard Analysis for identifying the impact area from the Reasonable Worst Case Discharge (RWCD) at the facility. The Hazard analysis, which is documented separately, focused on the identification of possible hazards that may result in an oil spill from the facility. Whereas, the goal of the OCA is to identify from a given spill scenario the credible impact area and the potentially impacted sensitive environmental sites over a 72 hour period.

The Offsite Consequence Analysis involved a progressive study of the spill site involving evaluation of the sensitivity of spill trajectories to pessimistic seasonal weather and environmental conditions, 72 hour spill trajectory for the identified pessimistic conditions, and identification of the area at risk from a spill and the potential impacted sensitive sites. This analysis was performed and documented by BlueWater Consultants, Novato, California using the "OILMAP" spill modeling software by ASA.

The results of the trajectory analyses are shown on color maps delineating time contours for the extent and impact of oil discharged from the terminal location. The trajectory plots display the differences with seasonal conditions and types of products.

The impact areas have been correlated to the sites identified by the ACP (12/97 ed.) The planned protection and recovery strategies would follow the recommendations contained in the ACP. This information includes a description of the area, shoreline characteristics, identification of sensitive marine resources, and strategy for deployment of resources.

3.4.2 Spill Model And Trajectory Analysis Approach

Analysis Approach

The offsite consequence analysis involved a progressive study for each site involving the following tasks:

a. Sensitivity analysis of spill trajectories to seasonal weather and environmental conditions

b. 72 hour spill trajectory for the identified pessimistic conditions

c. Identification of the area at risk from a spill and the potential impacted sensitive sites.

The area at risk from a release at site was evaluated using a trajectory and fates modeling analysis for potential RWCD spill volumes, which may result from oil transfer operations. A sensitivity analysis was performed on these results to evaluate possible seasonal environmental and weather impacts. This was performed using stochastic evaluation technique for trajectories over each seasonal period. The identified pessimistic conditions were used to develop trajectory plots depicting the projected areas of impact over a 72-hour period. These trajectories are based on specific type of products and have incorporated weathering and fates considerations for the oil.

The areas at risk of impact from the analysis have been compared to the sites identified in the latest edition of the Area Contingency Plan. California State representatives, USCG representatives, local city and county representatives, environmental groups, and industry representatives develop the ACP through a joint effort.

The sites considered through the ACP process include:

- water intakes
- lakes and streams
- fish and wildlife
- recreational areas
- endangered flora and fauna
- wetlands or other environmentally sensitive areas
- other areas of economic importance including sensitive terrestrial environments, aquatic environments, and unique habitats

Oil Spill Model

The analyses were completed using oil spill modeling software OILMAP for Windows V2.4 from Applied Science Associates (ASA). Several modeling modes within OILMAP were applied to the analysis. These modes were configured to address specific types of spill impact including assessment of different response scenarios on the spill fate, spill trajectory and weathering prediction, and statistical probabilities of shoreline impact of the spilled oil.

The oil spill trajectory analysis for support of the Offsite Consequence Analysis involved primarily the Trajectory, Fates, and Stochastic modes which are summarized below:

Trajectory and Fates Mode

The trajectory and fates mode of operation predicts both the movement and weathering of surface oil. The fate processes simulated are spreading, evaporation, entrainment, emulsification and shoreline stranding.

Either instantaneous or continuous spills with a constant oil release rate can be simulated. Each spillet is transported and weathered independently. The oil composition, selected by the user from a library of oil types, is characterized by its boiling point curve. This characterization allows the model to accurately predict the weathering of a wide variety of crude and refined oil products.

Stochastic Mode

In the stochastic mode, a user-specified number of spill simulations are executed varying only the environmental conditions at the time of the spill. The stochastic model includes all the weathering processes in the trajectory and fate model.

The spill release occurs at random times over a period of time (by month to over an entire year). Historical wind records from regional meteorological stations can be used, or the model can generate wind time series from zero- or first-order statistical wind distributions.

The multiple trajectories predicted by the stochastic model are summarized as probability contours showing the probability of land and water areas being impacted by oil spilled at the specified release site. The probability contours form an envelope showing the direction(s) oil will move from the site and where it will impact land. Simulation results enable the user to assess potential extent of the area at risk for that seasonal period.

3.4.3 Application Of Oilmap Model To Spill Scenarios

Oil Spill Scenario

The Reasonable Worst Case Discharge (RWCD) scenario identified by the Oil Spill Contingency Plan was used to evaluate the potential impact on the shoreline. The sensitivity Analysis evaluated the potential risk from the RWCD spill at the Martinez Facility. These parameters for the spill risks are summarized in the following table:

Table 3-3 - Oil Spill Modeling Scenario Information

Facility	Shore Terminals – Martinez
Product:	Group 3 oil (Crude Oil)
Quantity	5,830 bbls
Source Location:	Rupture of line at dock Considering: Line pumping rate (20,000 bph) Time for discovery, and S/D (30 min.)
Seasonal Considerations:	Scenario during both summer and winter conditions

In each scenario, the spill was considered to be instantaneous discharge at the identified location. The model calculation time step was 10 minutes, with a dispersion factor of 1.5 m ^{2} / sec. This was considered to provide model simulation for the surface conditions and environmental constraints for the area. The simulations were run until the oil was fully dissipated from either evaporation, dissolution, or grounded on-shore over a period of 72 hours (3 days.)

In each scenario, the spill was considered to be instantaneous discharge at the identified location. The model calculation time step was 10 minutes, with a dispersion factor of 1.5 m ^{2} / sec. This was considered to provide model simulation for the surface conditions and environmental constraints for the area. The simulations were run until the oil was fully dissipated from either evaporation, dissolution, or grounded on-shore over a period of 72 hours (3 days.)

3.4.4 Environmental Data

<u>Hydrodynamic</u>

Tidal current and river induced flows, providing input to OILMAP for San Pablo Bay, were derived from a three- dimensional, depth contoured, finite element hydrodynamic model of San Francisco Bay (ASA et al., 1998). The model generates equations for water motion predicted from the charted depth gradients and forcing conditions.

For development of the hydrodynamic model, the bay was represented by a finite element mesh consisting of three-dimensional (e.g., rectangular, triangular) and two-dimensional elements. The grid covers the entire bay from the entrance at Golden Gate Bridge and both the south and northern branches of the bay.

The model was forced by tidal elevation at the open boundary at the Golden Gate Bridge and river and freshwater flows from the Sacramento and San Joaquin Rivers. The resulting hydrodynamic output incorporates a net outflow longterm condition.

Wind

Wind data used in the model simulation was based on a regional statistical wind summary. Wind speed and direction time series for the Summer (July - August) and Winter (December - February) were created from summary data taken from the International Station Meteorological Climate Summary (NCDC, 1992) for the nearest recording site. Conditions were modified from the historical data from the Port Chicago meteorological station, located along the south shore of Suisun Bay, over the period of January 1995 to December 1996.

This wind data was compiled into monthly speed and direction probability tables. The tables are monthly statistical summaries of the probability of wind coming from a particular direction and within a range of speeds. The monthly data records generated are essentially a synthetic time series based on wind probabilities for the selected period.

3.4.5 Trajectory Results

Figure	Description
3-1.	Spill Time Contour Map - Summer Conditions
3-2.	Spill Time Contour Map - Winter Conditions
3-3.	Probability of Water Surface Oiling Map- Summer Conditions
3-4.	Probability of Water Surface Oiling Map- Winter Conditions

The modeling period was a maximum of 72 hours. The time required the oil to reach the shoreline is determined by the tide stage and the speed, direction of the wind, and the amount of material loss to evaporation.

The Spill Trajectory maps display the extent of oiling over a 72-hour period. A scale is provided on the map for the time period color key. A legend to the time contour color scale is provided on each map. Shoreline impacts are identified by red markings. As a conservative factor, the shoreline characteristics have been negated to allow maximum refloating and circulation of the oil particles.

The model has incorporated weathering effects on the oil and partial loss by evaporation, and mixing with the water column. The Predicted Weathering and Fates Graph – Figure 3-5 in this section represents the relative mass balance over the 72-hour period.

Sensitivity Analysis Results

Seasonal variations have been evaluated through the stochastic model. Historical winds for the period were categorized into summer and winter seasons. Wind velocity and direction vectors representative for the seasons were evaluated creating a range of probable spill trajectories.

Generally, the regional weather has two seasonal conditions, summer and winter. In the summer, winds are dominated by the prevailing west wind and thermal induction from the valley. In the early morning and evening, winds can be light and variable. In the winter or fall, the winds are generally light and variable, with occasional stronger winds representative of passing winter storm systems. Generally, a strong wind across the tidal flow tends to act as a driving function forcing the spill out of the main tidal flow. This can result in earlier grounding on the shoreline and may result in less travel and shoreline area impact.

The Spill Contour maps represent a summary of 100 iterations of spill trajectories from various states of tidal currents and seasonal environmental factors. These results are depicted on color maps delineating contours of oiling probability. A legend to the color scale is provided on each map. Shoreline impacts are identified by red markings or by the overrun of the contour across the shoreline

For the Martinez Facility RWCD Spill Risk, the greatest shoreline impact was determined to be during the winter with the increased impact along the shoreline of Carquinez Straits and along the southeastern shoreline of San Pablo Bay. Impact during the summer is earlier and to the northern reaches of Suisun and Grizzly Bays.

Spill Trajectory Results

The RWCD scenario was modeled in the trajectory and fates mode using the selected pessimistic seasonal data. The modeling time period was up to 72 hours (three days.)

The model incorporates weathering effects on the oil, loss by evaporation, and mixing with the water column. Shoreline characteristics are included in the model and provide consideration for credible shoreline grounding.

The trajectory output information has been extracted from this output to provide a sequential listing of the impacted sites. Table 2-11 in Section 2.6 of this plan lists these sites with their relative time frames and order of impact during the intitial 24 hrs.

A summary of the relative rate of loss to the environment from the spill is provided in the Figure 3.2-5 - Weathering & Fates Graph.

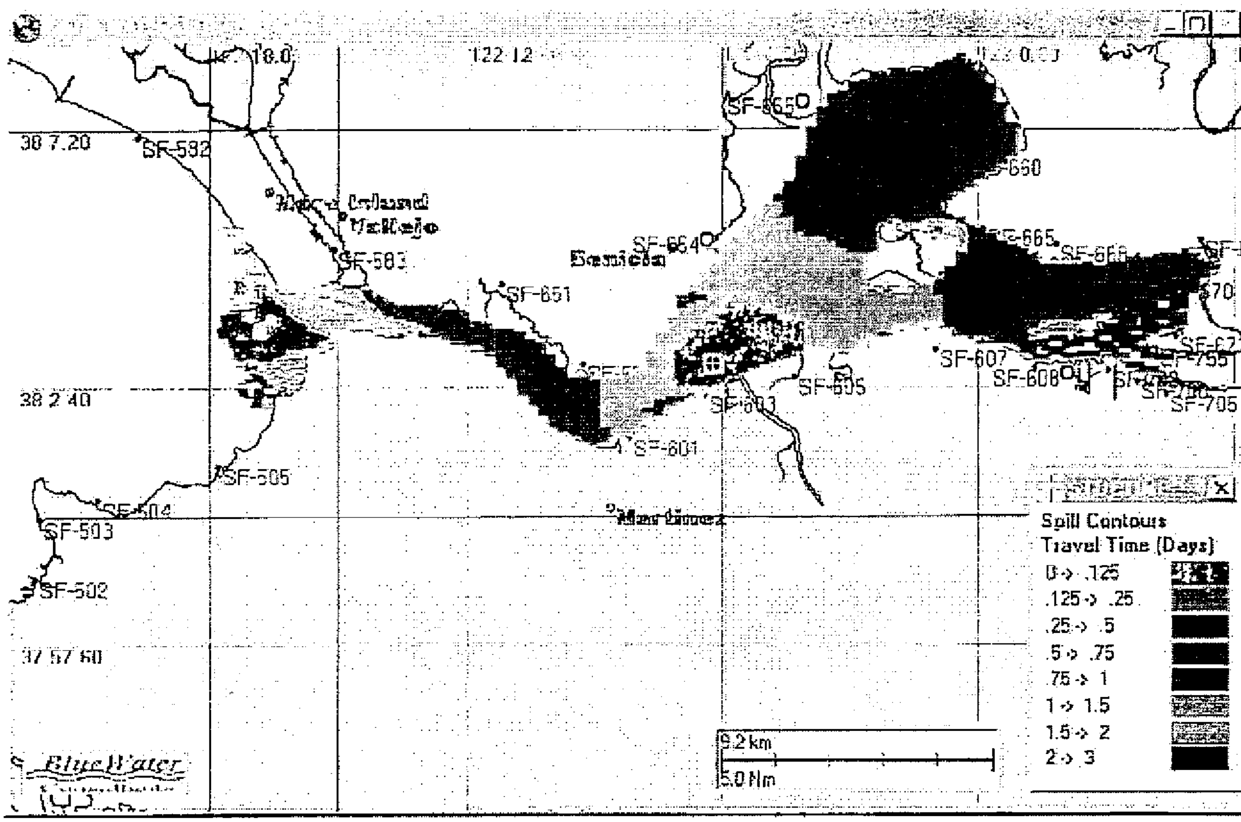


FIGURE 3.4-1 - SPILL TIME CONTOUR MAP - SUMMER CONDITIONS

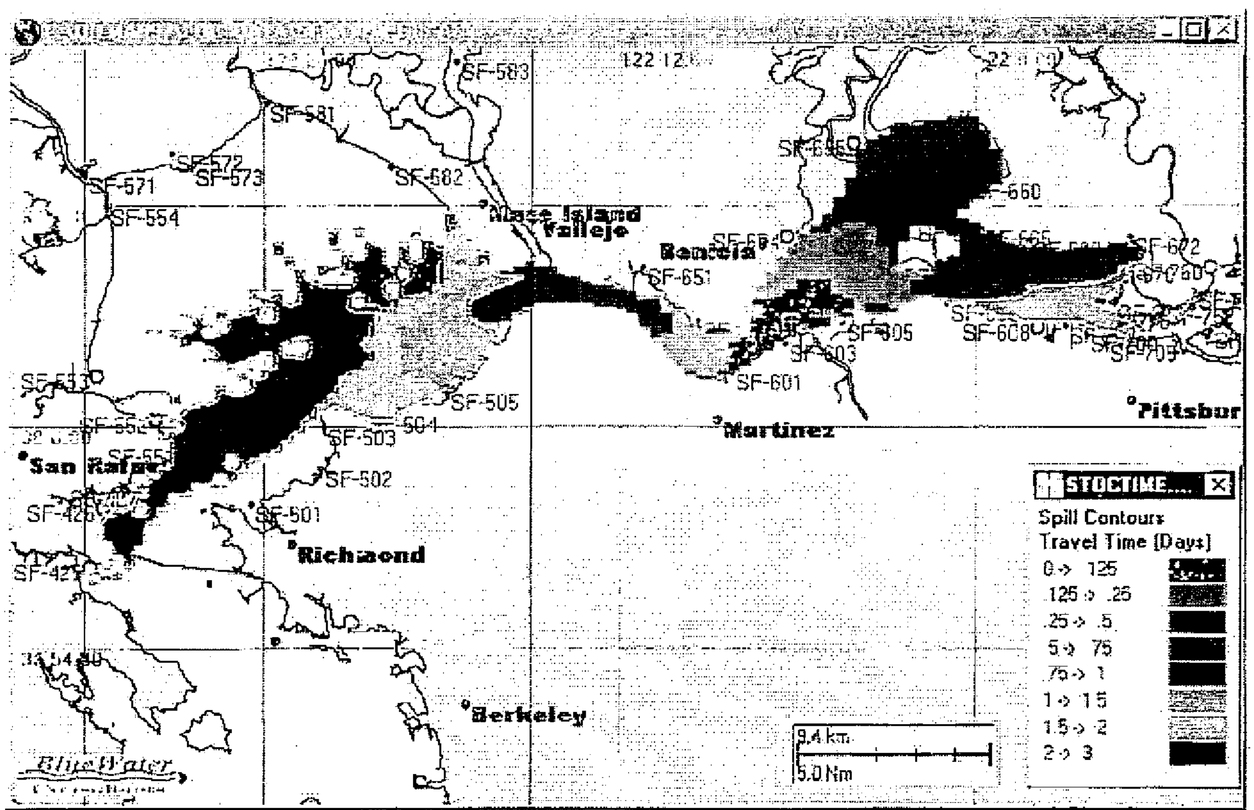


FIGURE 3.4-2 - SPILL TIME CONTOUR MAP - WINTER CONDITIONS

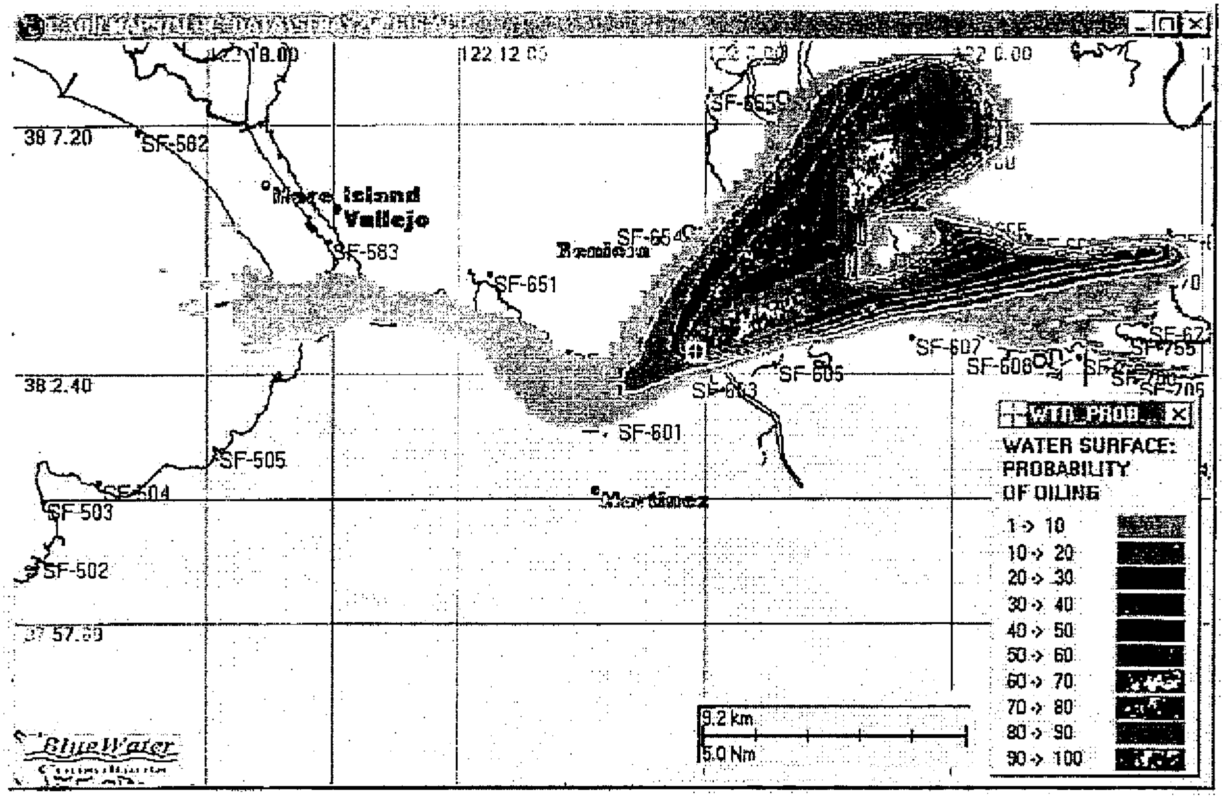


FIGURE 3.4-4 – PROBABILITY OF SURFACE OILING - WINTER CONDITIONS

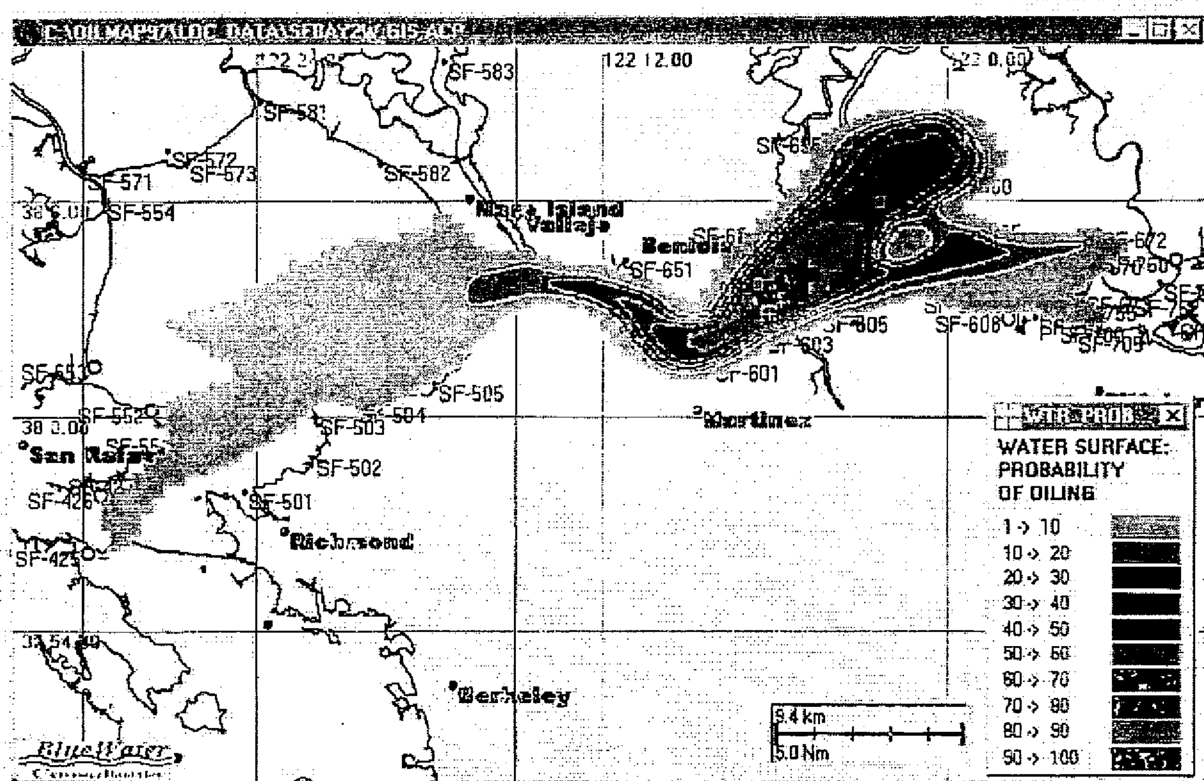


FIGURE 3.4-3 – PROBABILITY OF SURFACE OILING - SUMMER CONDITIONS

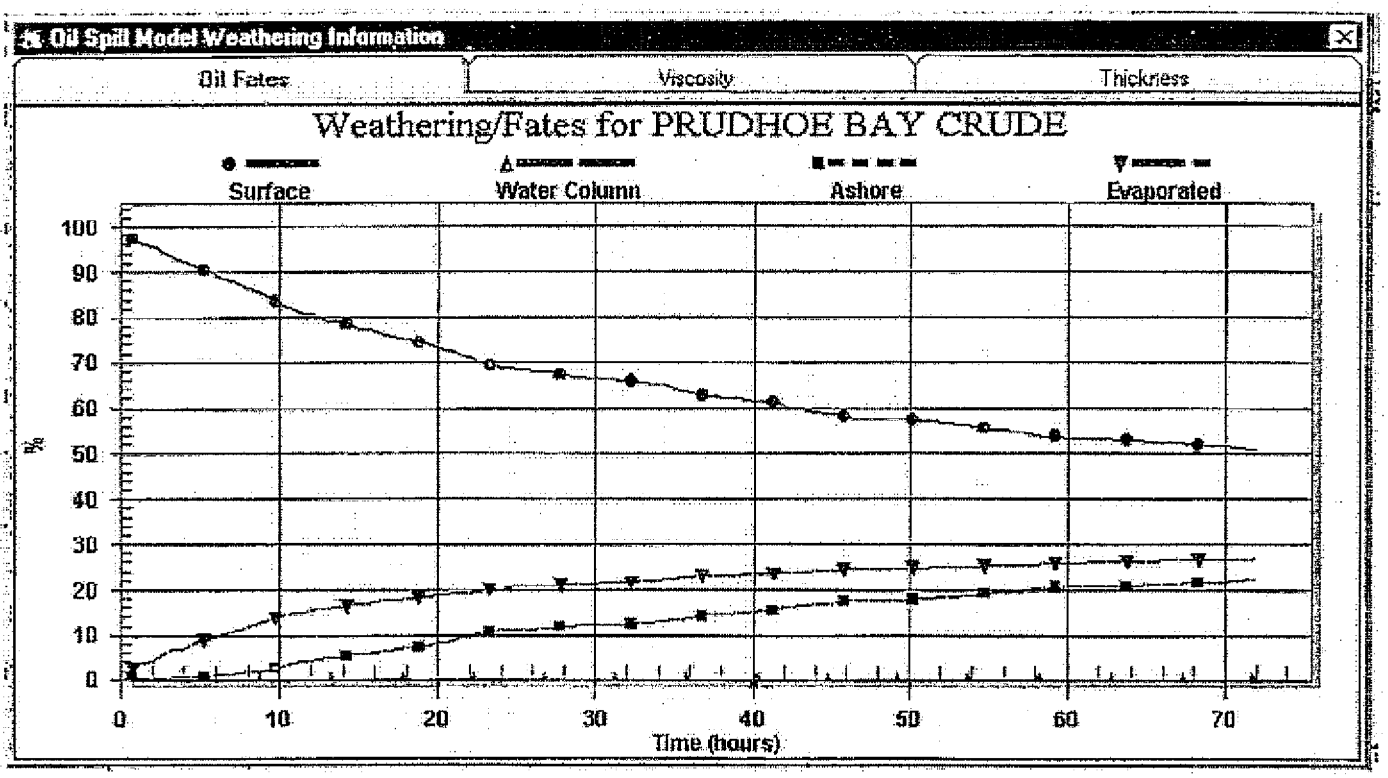


FIGURE 3.4-5 WEATHERING AND FATES GRAPH

ATTACHMENT B-2: BENICIA-MARTINEZ BRIDGE 10,000-BARREL SPILL TRAJECTORY MODELING (CSLC 2004)

202 Trajectory Analysis

202.1 Introduction

The OSPR regulations require that tankers and barges conduct trajectory analyses for the significant hazards identified in the Navigational Hazards Analysis (Section 201). All marine facilities are also required to conduct a trajectory analysis. The results of these trajectory analyses are used to determine the environmental consequences of an oil spill. The regulations state that trajectories be predicted as the basis for determining those areas and shoreline types for which resource strategies must be developed. According to the regulations, a trajectory analysis shall

- apply to the reasonable worst-case oil spill volume;
- determine the potential direction, rate of flow, and time of travel of the reasonable worst-case oil spill;
- determine the outer perimeter of a spill;
- be based on regional extremes of climate, tides, currents, and wind;
- consider seasonal differences; and
- assume pessimistic water and air dispersion and other adverse environmental conditions.

This section describes the trajectory analysis performed for Clean Bay. Spill envelopes were developed that defined the potential limit of a spill under regional extremes of a variety of meteorological and oceanographic conditions. For purposes of this document, a spill envelope encompasses a segment of coastline over which spilled oil may impact the coast over time based on these extreme environmental conditions, and the chemical and mechanical properties of the substance spilled.

It should be noted that the spill envelopes presented here do not represent the trajectory of any one oil spill. In fact, no single spill could possibly impact the coastline over the entire spill envelope, since the envelopes were calculated by considering the entire range of possible spill trajectories. A single spill could not simultaneously move along all of the trajectories used to develop the spill envelope.

As discussed in the following methods section, the oil spill volumes considered varied over several orders of magnitude. Facility spills were generally smaller than spills from vessel hazard areas. In fact, many of the facility spill volumes were much less than the available daily cleanup capacity for the facility. For these facilities, it is likely, however, that spill response and cleanup would occur within 1 day. Nonetheless, for the purposes of calculating a spill envelope, it was conservatively assumed that the facility spills would not be contained until 3 days after the initial release. It was assumed that vessel spills, which are generally larger and farther removed from cleanup equipment, would require more than local resources for response and cleanup. For these spills, a 3-day period before containment was also assumed.

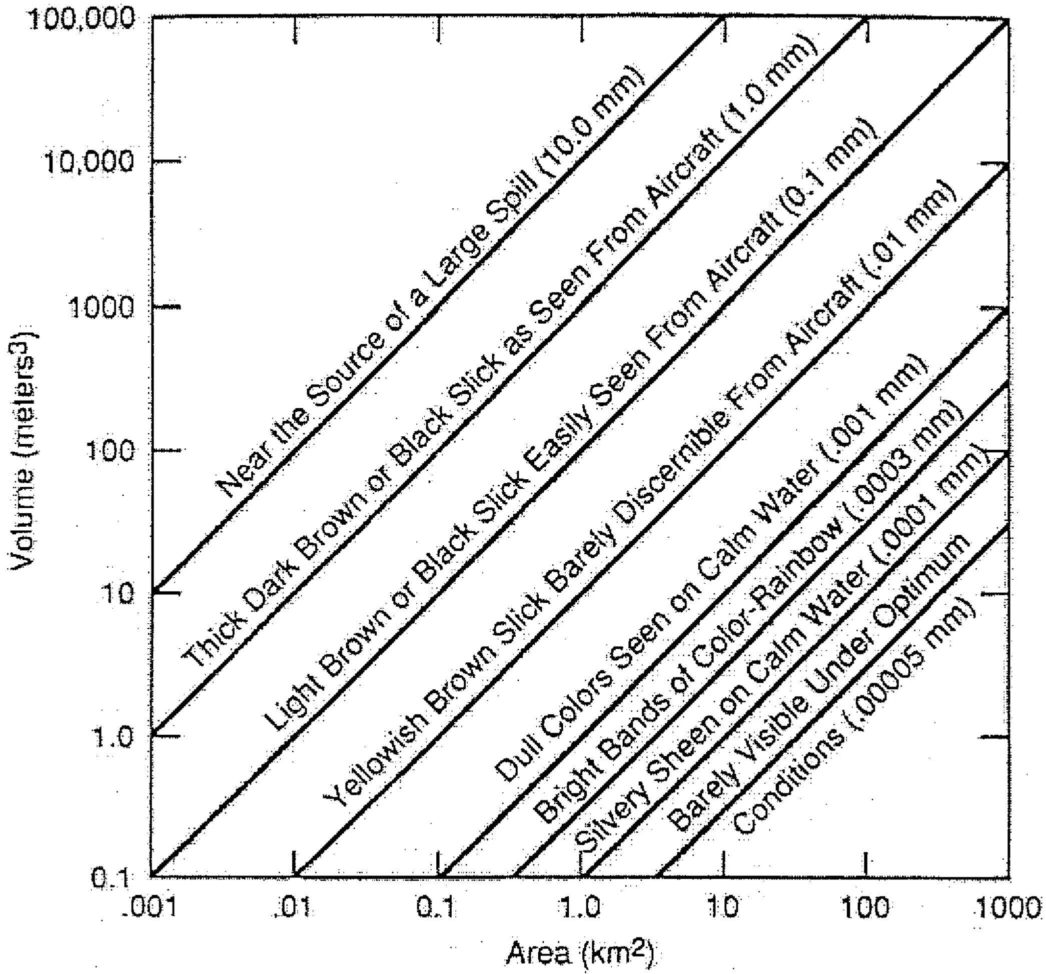
202.2 Methods

Transport of spilled oil was based on two factors: 1) environmental effects and 2) properties of crude oil. The environmental transport mechanisms included wind stress, tidal advection and dispersion, large-scale oceanic currents, and riverine effects. Not all these transport mechanisms applied to each spill site. Other effects that contributed to transport from the spill site or spill volume reduction included evaporation and spreading due to gravity and surface tension.

To simplify the analysis, a generic California crude oil was selected as a target spill hazard because it is the most persistent petroleum substance that is likely to be spilled. As previously mentioned, spill envelopes were developed for all facility and vessel hazards for 3 days.

Calculation of the spreading of a spill was based on the work of Fay (1971). The calculations for spreading included the effects of gravity, inertia, viscous forces, surface tension, evaporation, and dispersion. For simplicity, it was assumed that the spill always spread radially. The model does not account for recovery, stranding, dispersion in high energy waves, or other removal. Nor does the envelope generated represent the amount of oil stranded or contaminating any area within the envelope.

Some second-order mechanisms that affect oil transport and persistence in the marine environment were considered. The spreading calculations considered how loss and degradation processes limit the physical spreading of the spill. The thickness of the oil was factored into the analysis as a function of initial spill volumes. Generally, the slick was no longer considered once it was not visible from the air. For most analyses, the final oil thickness was approximately 0.1 millimeter (mm) and never less than 0.01 mm (Figure 202-1).



Conversion Factors

Area

1 $ft^2 = 9.3 \times 10^{-8}\ km^2$
1 $yd^2 = 8.4 \times 10^{-7}\ km^2$
1 $mi^2 = 2.6\ km^2$

Volume

1 bbl = 0.16 m^3
1 U.S. gal = $3.8 \times 10^{-3}\ m^3$

Source: Exxon 1992, Oil Spill Response Field Manual

FIGURE 202-1. Areal Coverage of Spilled Oil for Different Thicknesses

Beaching of oil was also considered initially, through the use of a Monte-Carlo simulation of oil dispersion near a shore. The dispersion of the spill was modeled by considering the spill to be a collection of "packets," each performing a random-walk, with the step size related to the horizontal dispersion coefficient. This technique is frequently used in numerical models of oil spill transport (e.g., Shen and Yapa 1988). A dispersion coefficient of 5 square meters per second was taken from the literature (Shen and Yapa 1988). The spill was assumed to also spread laterally by the physical spreading processes mentioned above. Any packet of oil striking the beach was not transported further. This analysis predicted that approximately 70 percent of a small spill (300 bbl) would beach within 3 days. A smaller percentage of the large spills would beach over this time period (Figure 202-2). Based on this analysis, it was decided that beaching of oil would remove much, but not all of a spill over a 3-day time period.

The method for developing spill envelopes was based on a simple lagrangian analysis of oil spill transport. This method is based on a vector addition to transport forces at work at the site of the spill. These transport mechanisms were applied sequentially depending on the likelihood of being present during the time of spill. For example, mechanical spreading and transport due to tidal currents were applied prior to transport by wind stress because wind stress may be ephemeral whereas spreading and tidal currents are omnipresent.

The tidal currents for San Francisco Bay were based on the published National Oceanic and Atmospheric Administration (NOAA) current charts (DOC 1973). Tidal currents outside the mouth of the Golden Gate were based on commercially available software (Micronautics 1993). Wind speed and direction data for numerous locations within San Francisco Bay, outside the bay, and in Monterey Bay were derived from California Surface Wind Climatology (1992). Estimates of river flow for the San Joaquin and Sacramento Rivers were obtained from U.S.G.S. gauging station data as compiled by the Hydrodata software.

Facility and vessel hazards sites were classified into five zones based on location and transport mechanisms. The zones are listed below:

- Northern San Francisco Bay
- Central San Francisco Bay
- Southern San Francisco Bay
- Outside San Francisco Bay
- Monterey Bay

Tables 202-1 and 202-2 list the facility and vessel navigation hazards for Clean Bay. Individual trajectory analyses are presented in Section 202.4.

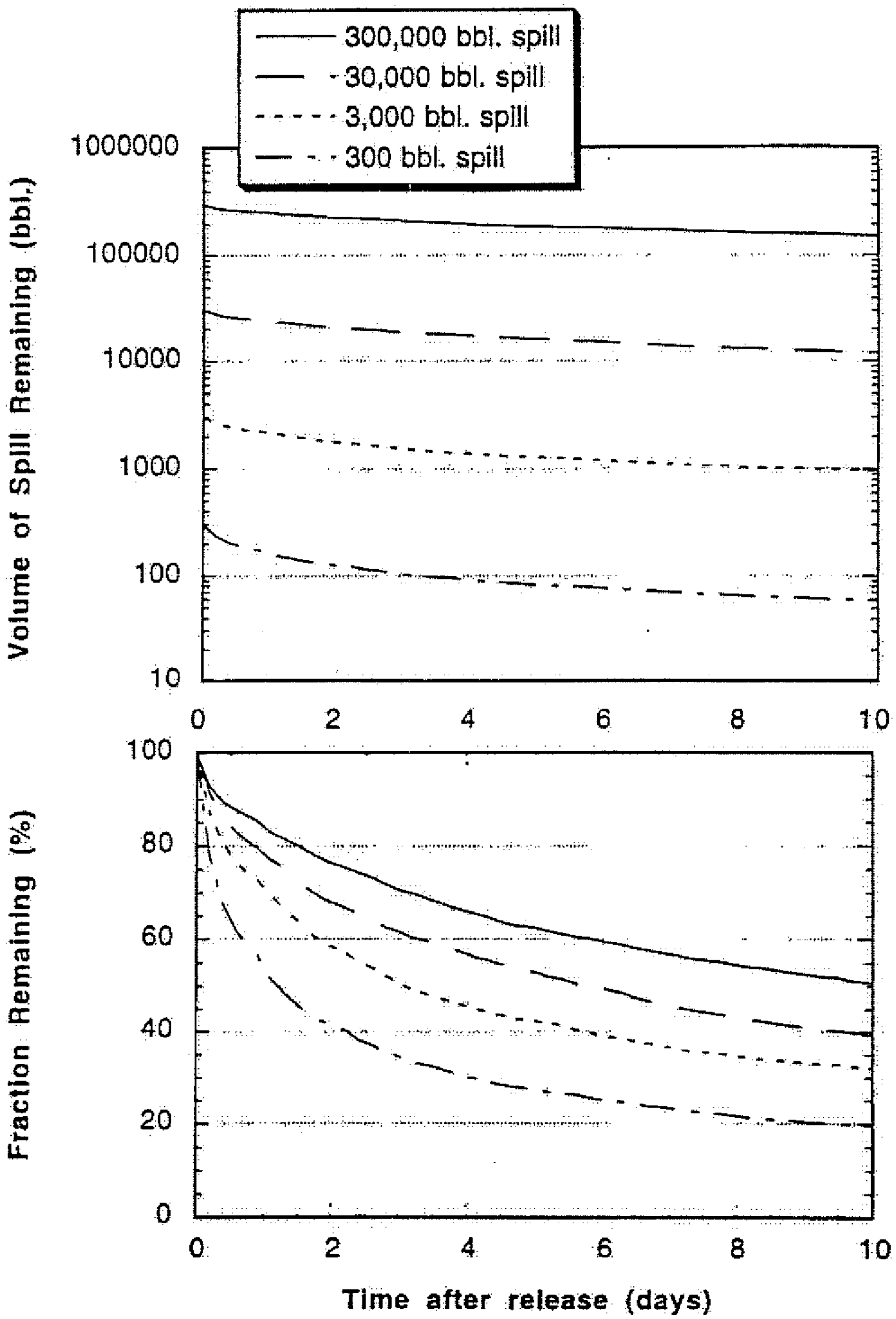


FIGURE 202-2. Effect of Beaching on Volume of Spill Remaining and Fraction of Spill Remaining

TABLE 202-1

Trajectory Analysis Location and Volumes
Facility Worst Cases

	Origin of Trajectory	Affected Facilities	Volume Analyzed (bbl)
1	Benecia/Martinez Bridge	Exxon Refinery Huntway Santa Fe Pacific Pipelines Tosco (Avon) Martinez Terminal (Wickland) Tosco (Amorco) Shell Oil Wharf	4,000 * 10,000 *
2	Union Oil Docks	Unocal Refinery Wickland Oil (Crocket) Pacific Refinery (Rodeo)	10,000 * 20,000 *
3	Chevron Refinery Long Wharf	Chevron Refinery Long Wharf	30,000
4	Mouth of Harbor Channel (Richmond)	Unocal Arco Time Oil GATX (Vegetable Oil) Castrol Texaco	3,826 * 800 *
5	Moss Landing Harbor	PG&E Power Plant	9,000
6	Pittsburg	PG&E	10,000
7	Redwood City	Gibson Oil	2,000
8	San Francisco - Pier 70	PG&E	50,000

* Trajectory analyses were conducted for both volumes.

TABLE 202-2

Trajectory Analysis Location and Volumes
Vessel Worst Cases

Hazard Location		Maximum Vessel Capacity (bbl)	OSPR Worst-Case Spill Size (bbl)
INSIDE SAN FRANCISCO BAY			
1	Harding Rock	1,200,000	300,000
2	Anchorage #9	1,200,000	300,000
3	Richmond/San Rafael Bridge	575,000	143,750
4	Carquinez Bridge	575,000	143,750
5	Benecia/Martinez Bridge	575,000	143,750
OUTSIDE SAN FRANCISCO BAY			
1	Precautionary Area to San Francisco Bay	1,200,000	300,000
2	Moss Landing	350,000	87,500

202.2.1 Consideration of Previous Spill Trajectories

The spill envelopes described in this document were developed by combining a series of trajectory analyses each of which use separate sets of conservative assumptions to predict all areas that could possibly be affected from a spill from a single location. To ensure that no potential receptor was omitted, the analyses included the assumptions that oil would be driven under regional extremes of climate, tide, current, and wind.

For comparison of the modeling assumptions, a study for an earlier contingency planning effort for Clean Bay (Clean Bay 1991) was reviewed. In the earlier study, spill envelopes were calculated for releases at three locations within San Francisco Bay (Anchorages 8 and 9, Richmond Long Wharf, Rodeo). Envelopes were calculated in the same basic way as in this study, i.e., by superposing the oil transport associated with spreading, tidal advection, and wind drift. The previous analysis used a much shorter time frame, however, as envelopes were calculated for a 3-hour, rather than 3-day, time period. Because the time scales and therefore the study assumptions differed, direct comparison of the envelopes is not possible. Nonetheless, a qualitative comparison, which is appropriate, was made of the two trajectory analyses. The two studies were found to be in qualitative agreement.

In order to evaluate the more likely movement of a spill, the results of another spill trajectory modeling effort were also reviewed and compared to the comparable spill envelope developed for this RRM project. The example chosen for comparison is included in a study prepared by the National Oceanic and Atmospheric Administration (NOAA) in which a "worst case" spill of crude oil at Harding Rock was modeled (San Francisco Bay/Delta ACP, 1993). Several assumptions were made as part of the NOAA study which were different from the assumptions required to develop the spill envelopes for the RRM site. Some of the major different assumptions included:

- NOAA used a smaller spill size (12,000 bbl vs. 300,00 bbl for the RRM)
- NOAA considered typical wind patterns compared to extreme winds
- NOAA used common tidal conditions rather than extreme tidal conditions

Based on these assumptions, the NOAA results are more representative of a single spill under typical conditions for this area. The NOAA results for the spill occurring at Harding Rock indicate that only a relatively small area would be affected compared to the results based on the assumptions required for the RRM.

As the purpose of the analysis included in this RRM is "to be used as the basis for determining the areas and shoreline types for which Response Strategies must be developed" [OSPR 817.02 (c)(2)], the envelopes included in Section 202 were developed specifically to fulfill this requirement. Again, the envelopes were developed to identify the outer perimeter of shoreline areas that could receive oil in the event of spills from an identified site.

202.2.2 Selection of Reasonable Worst-Case Scenarios

Table 202-3 indicates how the reasonable worst-case scenarios were selected for each of the five zones studied.

202.3 Spill Trajectory Prediction

Several tools are readily available for the real-time prediction of oil spill trajectories, including satellite photos, existing meteorological facilities, and tracker buoys. Satellite photos are available in near-real time from federal agencies, research institutions, and universities (e.g., NOAA and Jet Propulsion Laboratory [JPL]), which show, for example, sea surface temperature and sea surface roughness. These photos can provide synoptic overview of current patterns and wave conditions. These data can be used to assist prediction of oil spill transport and weathering. A network of existing on-shore meteorological facilities and offshore data buoys can provide real-time wind speed and direction information for transport prediction.

The National Weather Service (NWS), which is a line office within the NOAA, is responsible for providing up to date weather information in response to oil spills. NWS can provide such information as wind direction and speed, air and sea temperature, and direction and height of sea and swell. The NWS can also provide daily weather forecasts, as well as longer range forecasts (2 to 5 days).

Additionally, if the oil spill is in, or near to, a riverine system, the NWS's River Forecast Office can provide river flow rates and predicted flow rates as well.

In a spill response, river and weather information can be provided to the incident Commander or FOSC by the NWS via the NOAA Scientific Support Coordinator (SSC). An agreement between NOAA's Hazardous Materials Response and Assessment Division and NWS establishes the SSC as the point of contact in order to streamline the flow of information and to provide specialized weather needs without affecting the normal operating procedures of

TABLE 202-3

Methods for Selection of Reasonable Worst-Case Scenarios

Zone	Primary Driving Forces	Worst-Case Scenario	Sites
1 Outside San Francisco Bay	Wind stress and the California Current/Davidson Current Influences	1 Davidson Current influence with southerly winds resulting in a northward flow, and 2 California Current influence with northerly winds resulting in a southward flow. 3 Minimum oceanic current influence with easterly wind stress resulting in a westerly flow	Precautionary Area west of the entrance to San Francisco Bay Point Reyes (if it gets included)
2 Monterey Bay	Wind stress and the California Current/Davidson Current Influences	1 Davidson Current influence with southerly winds resulting in a northward flow, and 2 California Current influence with northerly winds resulting in a southward flow.	Moss Landing PG&E
3 North San Francisco Bay	Wind stress and tidal currents	1 Westerly or southerly wind stress on a flood tide 2 Easterly or northerly wind stress on an ebb tide	All sites north and east of the Richmond/San Rafael Bridge
4 South San Francisco Bay	Wind stress and tidal currents	1 Northerly wind stress on a flood tide 2 Southerly or easterly wind stress on an ebb tide	All sites south of the Bay Bridge
5 Central San Francisco Bay	Wind stress and tidal currents	1 Easterly wind on an ebb tide	The sites bounded by the Bay Bridge, the Richmond/San Rafael Bridge, and the Golden Gate Bridge

the forecast office. Furthermore, the agreement provides for a dedicated meteorologist to assist NOAA in obtaining the most accurate and current information for operational planning and trajectory analysis.

The NOAA Scientific Support Coordinator can be contacted at:

NOAA/HMRAD
Suite 5110
501 West Ocean Blvd.
Long Beach, California 90802
(310) 980-4107
(800) SKY-PAGE (Pager - PIN# 579-8818)

Another readily available tool is the tracker buoy. A tracker buoy consists of a surface float rigged with a light, radar reflector, radio transmitter, or satellite tracking system. Tracker buoys can be deployed by boat or airplane at the periphery of an existing oil spill and used to monitor in real time the trajectory of an oil spill. Clean Bay has tracker buoys and tracker equipment available.

The California Oil Spill Cooperatives have also contracted for the use of a radiometric oil spill surveillance system (ROSSS) to provide almost real-time tracking of oil. A more detailed discussion of ROSSS is included in Section 500.

202.4 Trajectory Analyses

Spill trajectory envelopes have been calculated for the facilities and vessel navigation hazards within the Clean Bay area of interest. Analyses and corresponding maps are presented in this section.

Trajectory Maps

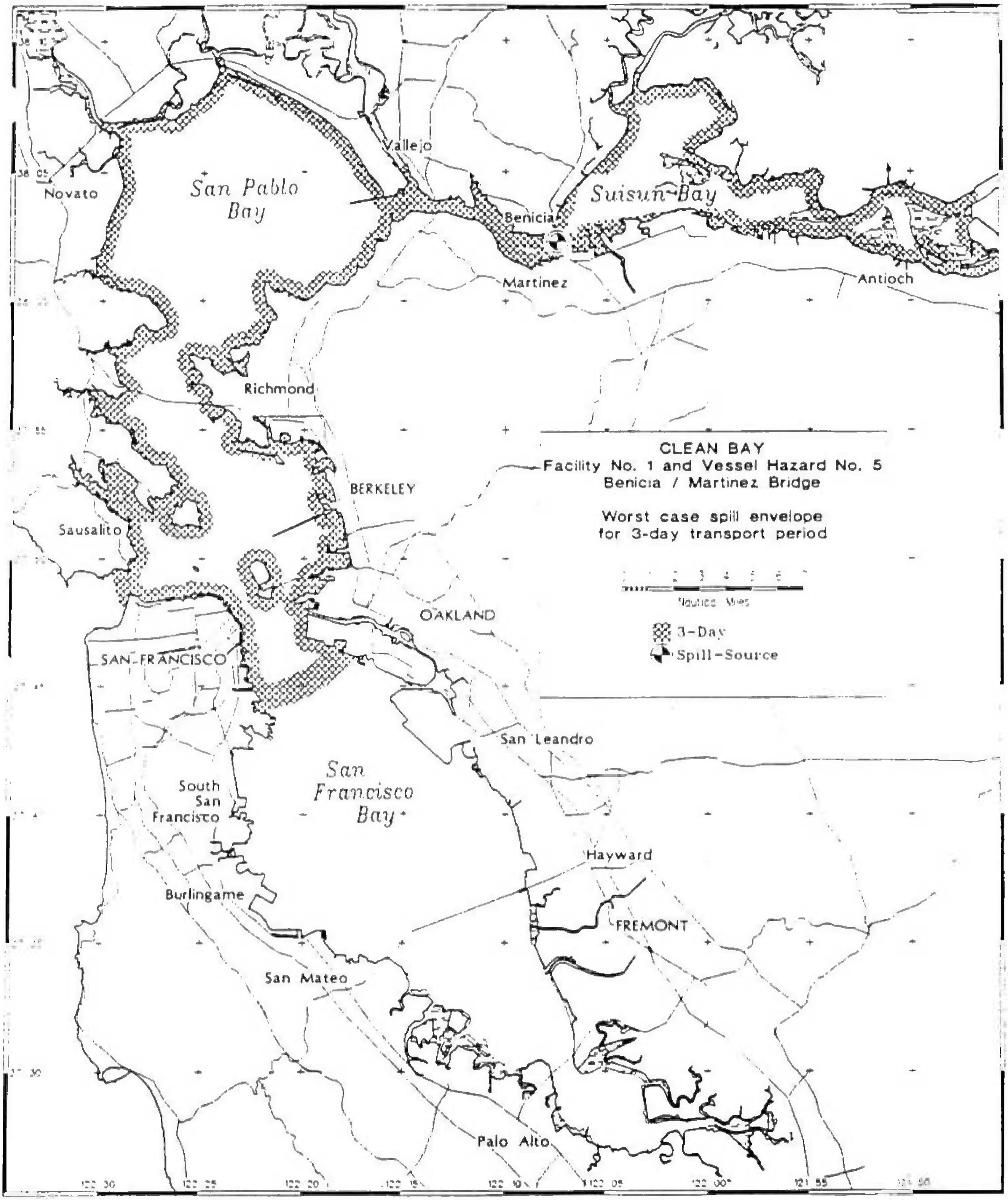
SITE:	Facilities near the Benicia/Martinez Bridge Tosco-Avon Tosco-Amorco Wickland-Martinez terminal Shell Oil wharf Exxon refinery Huntway facility Santa Fe pipeline	LATITUDE:	38-02.5
HAZARD:	Facility	LONGITUDE:	122-07.0
VOLUME:	4,000/ 10,000 bbl		
DURATION:	3 days		

TRAJECTORY ANALYSIS

A spill trajectory envelope was calculated for a cluster of facilities located near the Benicia/Martinez Bridge. The trajectory analysis considered oil transport by the wind, tidal currents, and river flow, and spreading of the oil spill by physical processes such as gravity, surface tension, and tidal dispersion. Spill transport on the flood tide would be expected to move the oil eastward across Suisun Bay. A spill during the ebb tide would be expected to transport the oil westward into San Pablo Bay to approximately Pinole Point. Physical spreading would cause the 4,000 bbl spill to spread across San Pablo Bay approximately 2 miles north of the channel. Spreading of this spill in Suisun Bay would carry the oil to the southern boundary of Grizzly Bay. A 10,000 bbl spill would spread approximately ½ mile farther into San Pablo and Grizzly Bays after 3 days.

Wind-induced surface currents could cause additional transport of oil depending on the direction, strength and persistence of local winds. Northerly winds could transport the oil into San Francisco Bay as far as Oakland Harbor. Oil transported south this way could spread westward to the Golden Gate area. Westerly and southwesterly winds could transport oil on the flood tide across Suisun Bay to the mouths of the San Joaquin and Sacramento Rivers. Transport up these rivers would be limited by the seasonal river flow.

These spill trajectory envelopes represent the outer perimeter of shoreside areas that could receive oil in the event of any spill. The envelopes are based on regional extremes of climate, tide, current, and wind and assume pessimistic dispersion and other adverse weather conditions. These trajectory envelopes <u>do not</u> represent the trajectory of any one spill. A full discussion of the details used for preparing these spill envelopes is provided in Section 202.2.


CLEAN BAY
Facility No. 1 and Vessel Hazard No. 5
Benicia / Martinez Bridge
Worst case spill envelope
for 3-day transport period
Nautical Miles
3-Day
Spill-Source
San Pablo Bay
Suisun Bay
San Francisco Bay
Novato
Vallejo
Benicia
Martinez
Antioch
Richmond
BERKELEY
Sausalito
OAKLAND
SAN FRANCISCO
San Leandro
South San Francisco
Hayward
Burlingame
FREMONT
San Mateo
Palo Alto

1688-001-820

ATTACHMENT B-3: AMORCO WHARF 22,178-BARREL SPILL TRAJECTORY MODELING (TESORO 2012)

D.9 OFFSITE CONSEQUENCES ANALYSIS

D.9.1 Introduction

This Offsite Consequence Analysis (OCA) is intended to supplement the Hazard Analysis for identifying the impact area from the Reasonable Worst Case Discharge (RWCD) at the facility. The Hazard Analyses, which is documented separately, focused on the identification of possible hazards that may result in an oil spill from the facility. Whereas, the goal of the OCA is to identify from a given spill scenario the credible impact area and the potentially impacted sensitive environmental sites over a 72 hour period.

The Offsite Consequence Analysis involved a progressive study of the spill site involving evaluation of the sensitivity of spill trajectories to pessimistic seasonal weather and environmental conditions, 72 hour spill trajectory for the identified pessimistic conditions, and identification of the area at risk from a spill and the potential impacted sensitive sites. This analysis was performed and documented by BlueWater & Associates, Novato, California using the “OILMAP” spill modeling software by ASA.

The results of the trajectory analyses are shown on color maps delineating time contours for the extent and impact of oil discharged from the terminal location. The trajectory plots display the differences with seasonal conditions and types of products.

The impact areas have been correlated to the sites identified by the San Francisco Bay Area Contingency Plan (ACP) (12/20085 ed.) The planned protection and recovery strategies would follow the recommendations for the sites at risk as described by ACP Section 9973 – GRP 3, 4, 5, 6, and 7. This information includes a description of the area, shoreline characteristics, identification of sensitive marine resources, and strategy for deployment of resources.

D.9.2 Spill Trajectory Analysis Approach and Spill Model

D.9.2.1 Analysis Approach

The offsite consequence analysis involved a progressive study for each site involving the following tasks:

a) Sensitivity analysis of spill trajectories to seasonal weather and environmental conditions
b) 72 hour spill trajectory for the identified pessimistic conditions

c) Identification of the area at risk from a spill and the potential impacted sensitive sites.

The area at risk from a release at site was evaluated using a trajectory and fates modeling analysis for potential RWCD spill volumes, which may result from oil transfer operations. A sensitivity analysis was performed on these results to evaluate possible seasonal environmental and weather impacts. This was performed using stochastic evaluation technique for trajectories over each seasonal period. The identified pessimistic conditions were used to develop trajectory plots depicting the projected areas of impact over a 72-hour period. These trajectories are based on specific type of products and have incorporated weathering and fates considerations for the oil.

The areas at risk of impact from the analysis have been compared to the sites identified in the Area Contingency Plan. California State representatives, USCG representatives, local city and county representatives, environmental groups, and industry representatives develop the ACP through a joint effort. The sites considered through the ACP process include:

- water intake
- lakes and streams
- fish and wildlife
- recreational areas
- endangered flora and fauna
- wetlands or other environmentally sensitive areas
- other areas of economic importance including sensitive terrestrial environments, aquatic environments, and unique habitats

D.9.2.2 Oil Spill Model

The analyses were completed using oil spill modeling software OILMAP for Windows V6 from Applied Science Associates (ASA). Several modeling modes within OILMAP were applied to the analysis. These modes were configured to address specific types of spill impact including assessment of different response scenarios on the spill fate, spill trajectory and weathering prediction, and statistical probabilities of shoreline impact of the spilled oil.

The oil spill trajectory analysis for support of the Offsite Consequence Analysis involved primarily the Trajectory and Fates, and Stochastic modes which are summarized below:

<u>Trajectory and Fates Mode</u>

The trajectory and fates mode of operation predicts both the movement and weathering of surface oil. The fate processes simulated are

spreading, evaporation, entrainment, emulsification and shoreline stranding.
Either instantaneous or continuous spills with a constant oil release rate can be simulated. Each spillet is transported and weathered independently. The oil composition, selected by the user from a library of oil types, is characterized by its boiling point curve. This characterization allows the model to accurately predict the weathering of a wide variety of crude and refined oil products.

Stochastic Mode

In the stochastic mode, a user-specified number of spill simulations are executed varying only the environmental conditions at the time of the spill. The stochastic model includes all the weathering processes in the trajectory and fate model.
The spill release occurs at random times over a period of time (by month to over an entire year). Historical wind records from regional meteorological stations can be used, or the model can generate wind time series from zero- or first-order statistical wind distributions.

The multiple trajectories predicted by the stochastic model are summarized as probability contours showing the probability of land and water areas being impacted by oil spilled at the specified release site. The probability contours form an envelope showing the direction(s) oil will move from the site and where it will impact land. Simulation results enable the user to assess potential extent of the area at risk for that seasonal period.

D.9.3 Application of OILMAP Model to Spill Scenarios

D.9.3.1 Oil Spill Scenario

The Reasonable Worst Case Discharge (RWCD) scenario identified by the Oil Spill Contingency Plan was used to evaluate the potential impact on the shoreline. The parameters of the spill are summarized below:

Figure D.11
MODELING SCENARIO INFORMATION

Product:	Crude Oil
Quantity	22,178 bbls
Source Location:	Rupture of 20 " pipeline from Amorco dock to refinery
Seasonal Considerations:	Scenario in both summer and winter

Refer to Section D.8 of this plan for a discussion of the basis for the Relative Worst Case Discharge and factors determining the planning volume used in this analysis.
In the scenario, the spill was considered to be instantaneous discharge at the identified location. The model calculation time step was 10 minutes, with a dispersion factor of 1.5 m^2/sec. The simulations were run until the oil was fully dissipated from either evaporation, dissolution, or grounded on-shore over a period of 72 hours (3 days.)

D.9.3.2 Environmental Data

<u>Hydrodynamic</u>

Tidal current and river induced flows, providing input to OILMAP for San Pablo Bay, were derived from a three- dimensional, depth contoured, finite element hydrodynamic model of San Francisco Bay (ASA et al., 1998). The model generates equations for water motion predicted from the charted depth gradients and forcing conditions.

For development of the hydrodynamic model, the bay was represented by a finite element mesh consisting of three-dimensional (e.g., rectangular, triangular) and two-dimensional elements. The grid covers the entire bay from the entrance at Golden Gate Bridge and both the south and northern branches of the bay.

The model was forced by tidal elevation at the open boundary at the Golden Gate Bridge and river and freshwater flows from the Sacramento and San Joaquin Rivers. The resulting hydrodynamic output incorporates a net outflow long-term condition.

Wind

Wind data used in the model simulation was based on a regional statistical wind summary. Wind speed and direction time series for the Summer (July - August) and Winter (December - February) were created from summary data taken from the International Station Meteorological Climate Summary (NCDC, 1992) for the nearest recording site. Conditions were modified from the historical data from the Port Chicago meteorological station, located along the south shore of Suisun Bay, over the period of January 1995 to December 1996.

This wind data was compiled into monthly speed and direction probability tables. The tables are monthly statistical summaries of the probability of wind coming from a particular direction and within a range of speeds. The monthly data records generated are essentially a synthetic time series based on wind probabilities for the selected period.

D.9.4 Results

D.9.4.1 Sensitivity Analysis Results

Seasonal variations have been evaluated through the stochastic model. Historical winds for the period were categorized into summer and winter seasons. Wind velocity and direction vectors representative for the seasons were evaluated creating a range of probable spill trajectories.

Generally, the regional weather has two seasonal conditions, summer and winter. In the summer, winds are dominated by the prevailing west wind and thermal induction from the valley. In the early morning and evening, winds can be light and variable. In the winter or fall, the winds are generally light and variable, with occasional stronger winds representative of passing winter storm systems. Generally, a strong wind across the tidal flow tends to act as a driving function forcing the spill out of the main tidal flow. This can result in earlier grounding on the shoreline and may result in less travel and shoreline area impact.

The model incorporates weathering effects on the oil, loss by evaporation, and mixing with the water column. Shoreline grounding characteristics were negated to provide a more conservative analysis of extent of oiling from the scenario.
As illustrated in the following spill trajectory maps, the RWCD spill was tested for both summer and winter wind influences on the spill trajectory. It can be observed that the greatest shoreline impact occurs during the winter season with increased impact to the northern reaches of Honker, Suisun and Grizzly Bays and further propagation outside of Carquinez Straits into San Pablo Bay.

D.9.4.2 Spill Trajectory Results

The RWCD scenario trajectory analysis was modeled for both of the predominant seasonal conditions. The modeling time period was up to 72 hours (three days.)

The Spill Time Contour maps represent a summary of 100 iterations of spill trajectories from various states of tidal currents and seasonal environmental factors. These results are depicted on color maps delineating time contours in ¼ day (6 hour) increments. A legend to the color scale is provided on each map. Shoreline impacts are identified by red markings or by the overrun of the time contour across the shoreline. Either name or colored shoreline identifies key geographic and sensitive environmental site references. A legend of the color key is also provided on each map.

The results are displayed on the following trajectory maps for the summer season and winter season. Each trajectory is presented with information displaying the extent of oiling by time periods. In addition, a separate map describes the relative probability of oiling for those geographic areas identified to be at risk.

FIGURE D.12 - SPILL TIME CONTOUR MAP - SUMMER CONDITIONS

FIGURE D.13 - SPILL TIME CONTOUR MAP - WINTER CONDITIONS

FIGURE D.14 - SPILL PROBABILITY OF OILING MAP - SUMMER CONDITIONS

FIGURE D.15 - SPILL PROBABILITY OF OILING MAP – WINTER CONDITIONS

A summary of the relative rate of loss to the environment from the spill is provided in the **FIGURE D.16 - WEATHERING & FATES GRAPH**.

FIGURE D.12
OIL TRAVEL TIME CONTOURS IN THE SUMMER
IN FRACTIONS OF DAYS FOR A RWCD SPILL OF CRUDE OIL

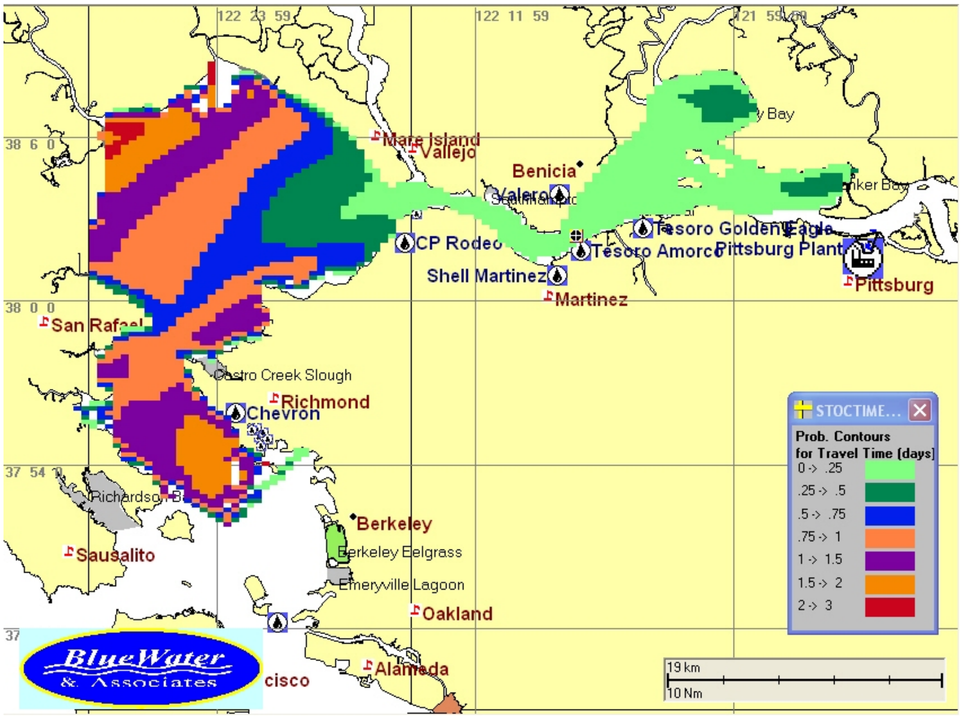


FIGURE D.13
OIL TRAVEL TIME CONTOURS IN THE WINTER
IN FRACTIONS OF DAYS FOR A RWCD SPILL OF CRUDE OIL

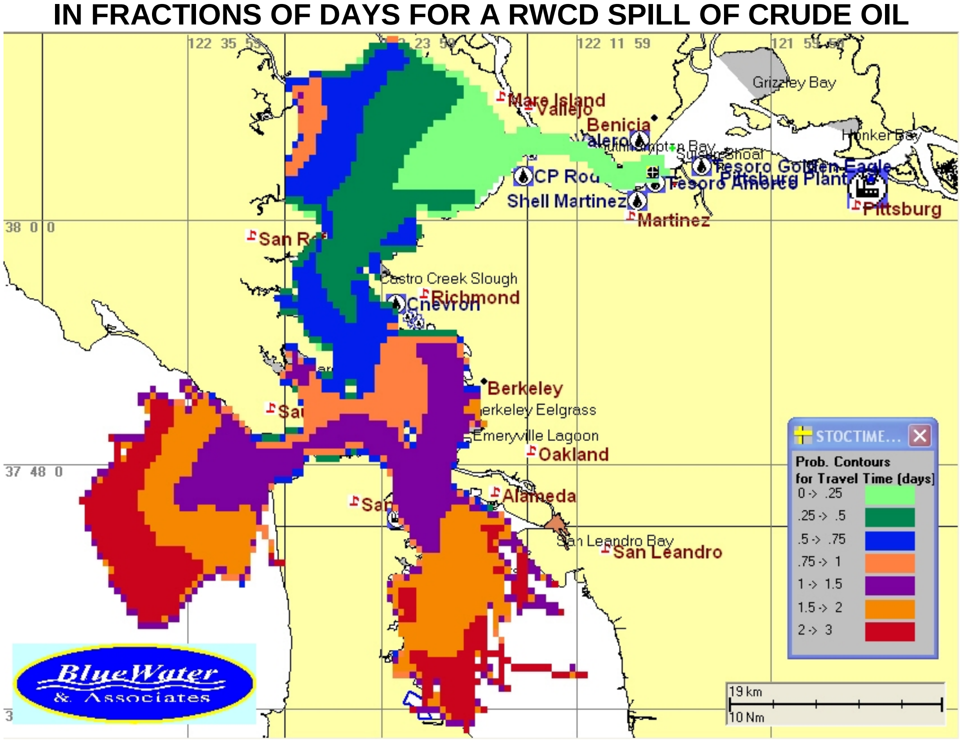


Figure D.14
PROBABILITY OF SURFACE OILING IN SUMMER
(Over a three-day period in percent (%) for a RWCD spill of Crude Oil.)

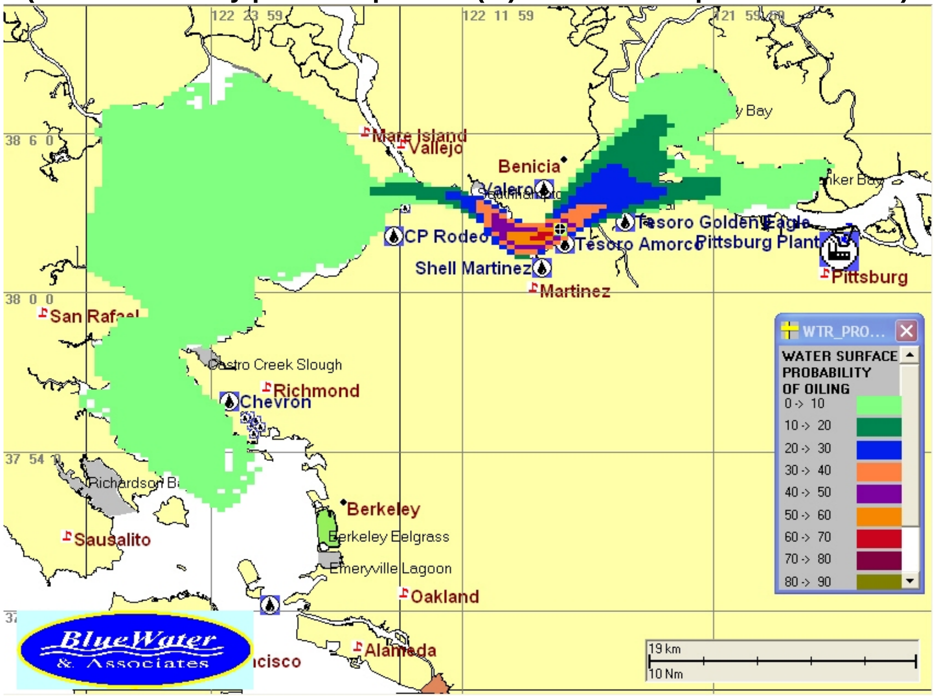


Figure D.15
PROBABILITY OF SURFACE OILING IN WINTER
(Over a three-day period in percent (%) for a RWCD spill of Crude Oil.)

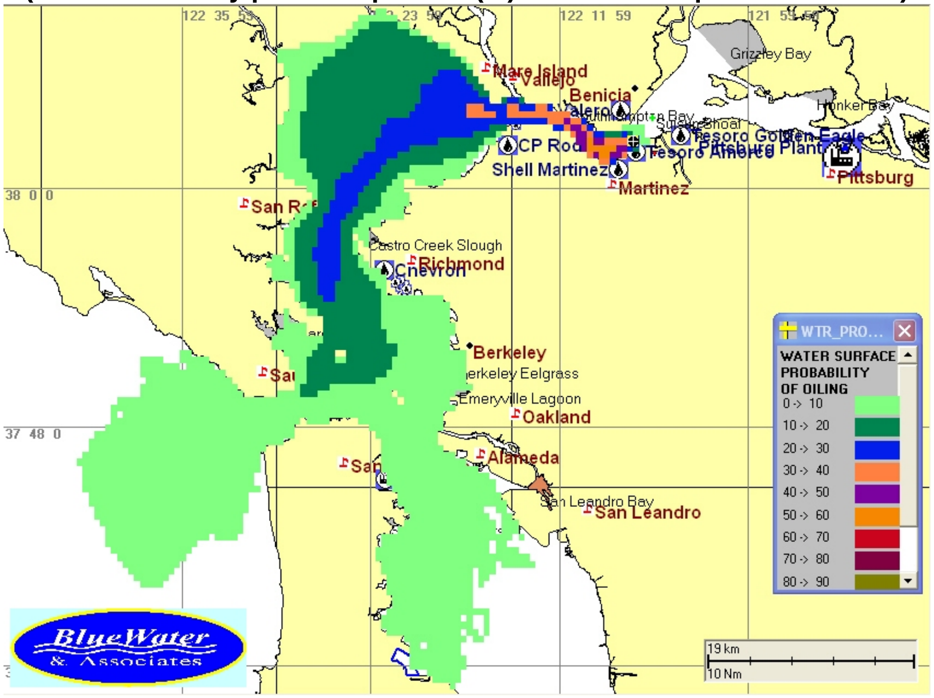
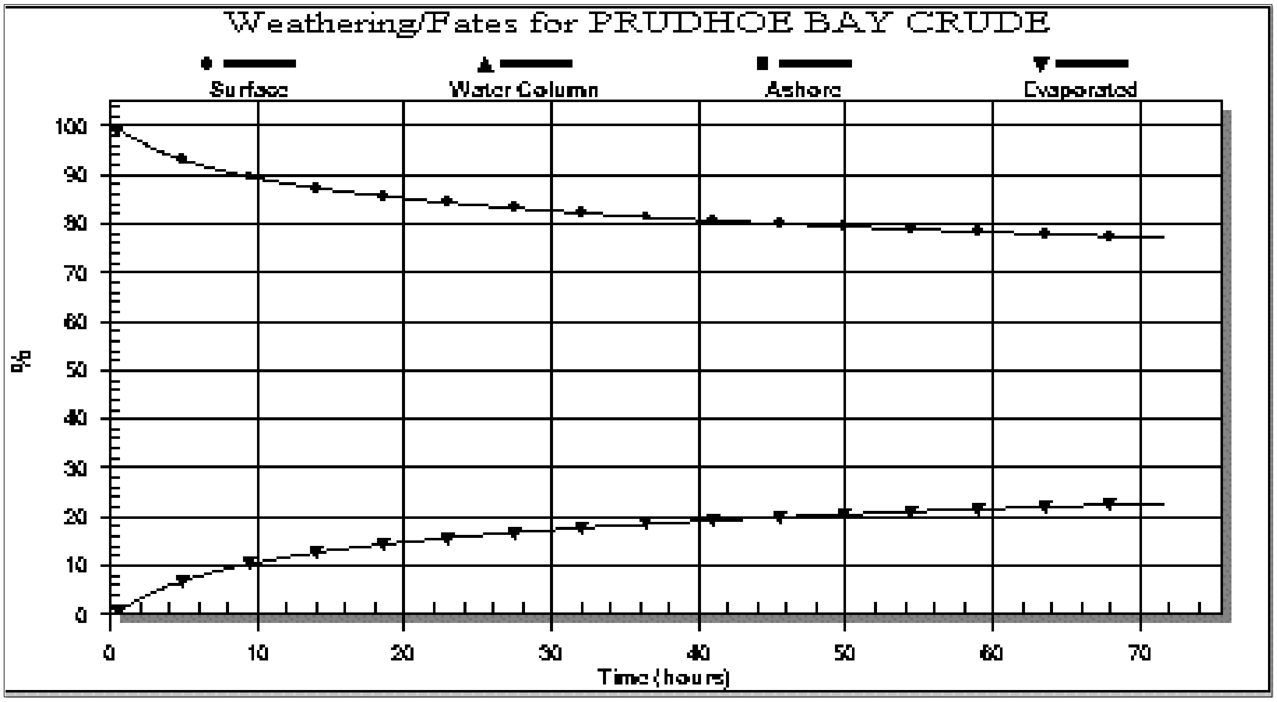


FIGURE D.16
WEATHERING AND FATES GRAPH



D.9.5 Fate and Persistence

There are no strict rules regarding the fate and persistence of petroleum hydrocarbons in the environment. The fate and persistence of materials potentially released from Tesoro facilities will vary significantly, depending on the specific material and factors including season and weather. However, the following guidelines can be used for approximation of potential fate and effects:

Non-Persistent Materials

Materials including gasoline and MTBE will generally evaporate very rapidly, and not present significant environmental threats in terms of persistence.

Group II Materials

Group II materials will also be subject to significant volumetric reduction and usually total loss due to evaporation, mechanical dispersion and other processes. In cases where fresh Group II materials soak into wetland substrate (especially peat) or are incorporated in muddy sediments in protected areas, extended persistence and subsequent impacts can be expected.

Group III Materials

Group III materials will also exhibit significant evaporative loss and typically demonstrate moderate persistence. They may exhibit persistence if incorporated in peat or fine-grained sediment. These materials may leave a residue that can be tar-like and adhere to surfaces. Unless buried, these materials typically persist for a season.

Group IV Materials

This group of petroleum hydrocarbons includes the more viscous crude oils and residuals. Evaporative loss is low and viscosity is high, a factor which typically reduces its tendency to penetrate into sediments. These materials tend to form stable emulsions and form asphalt-like pavement on shorelines. They are typically removed by mechanical dispersion although they may persist for significant periods of time in low energy environments. Group IV materials have specific gravities near that of water and may sink when weathered.

Group V Materials

Group V materials are heavier than water and will sink. Group V materials sinking off the Amorco Wharf will be subject to significant mechanical energy in the Carquinez straits and may be subject to considerable submarine movement. While degradation will be accelerated in the dispersed state, the ultimate fate of a sunken spill in this general area is uncertain, and certainly dependent on factors including the overall size of the spill. Note that the trajectories previously described do not necessarily reflect potential subsurface movement.

D.9.6 Toxic Effects

Toxic effects (and other mechanisms for ecological damage such as smothering, loss of insulation, etc.) are dependent on factors including the type of material spilled, its concentration, the nature of the environment and the organism impacted. A realistic evaluation of potential toxic effects requires investigations conducted at the time of the event.

For planning purposes, however, evaluation of relative effects which are probable satisfactory for setting protection and cleanup priorities can be based on the potential impact data presented in the ACP and RRM for various shoreline types, and sensitivity information provided in the ACP and RRM.

D.9.7 Resources at Risk

The trajectory analyses identifies a potential area at risk from a the RWCD spill over a 72 hour period to include parts of GRA 3, GRA 4, GRA 5, GRA 6, and GRA 7. It is recognized that the accepted guidance document for identification and prioritization of the environmental and economic sites is the San Francisco Bay Area Contingency Plan. Each GRA of the ACP provides a listing of the sites and identifies the response strategies for minimizing impact. An area map from Section 9840 is included in this plan for reference and can be found in Section 6, Figure 6.5.

ATTACHMENT B-4: CARQUINEZ BRIDGE 20,000-BARREL SPILL TRAJECTORY MODELING (CONTRA COSTA COUNTY 2011)

Oil Spill Analysis
Shell Crude Tank Replacement Project (CTRP) EIR
Martinez, CA

1. Introduction

The following Technical Memorandum describes analysis performed for Alameda County in support of the Crude Tank Replacement Project (CTRP) EIR, Shell Oil Facility, Martinez, California. Coast & Harbor Engineering, Inc.'s (CHE) Scope of Work included spill analysis using the NOAA Trajectory Analysis Planner II (TAPII) software. The Shell Martinez Terminal is located in the Carquinez Straight, immediately west of the Benicia-Martinez Bridge, as shown in Figure 1.

Figure 1. Shell Martinez Terminal project site location

2. Spill Evaluation

CHE performed analysis of potential spills at the Shell Martinez Terminal and in transit to assist the project team in evaluation of potential environmental impacts. CHE did not perform modeling of spill propagation; rather, CHE utilized statistical data summarizing spill modeling results already included within the NOAA Trajectory Analysis Planner II (TAPII) software (NOAA, 2000). The software consists of a database of spill modeling results for various materials, time periods, volumes and physical conditions. The TAPII system database is generated using a large set of individual spill trajectory modeling runs performed with NOAA's "On-Scene Spill Model (OSSM)." Each run consists of a randomly-chosen start time with its corresponding wind/tide/current conditions and a spill location of interest, then spill trajectories are calculated with subsequent calculation of spill volumes that accumulate within each segmented shoreline impact area (called "shoreline zones") over a 5-day simulation period (Barker, 2009).

The results obtained from the TAPII system on the Shell Martinez Terminal EIR include probabilities of spill volumes within the shoreline zones resulting from a spill of a certain material and volume at the terminal and also at one in-transit location at the Carquinez Bridge.

2.1. Modeling Scenarios and Approach

Spill scenarios were developed by the project team prior to the analysis using United States Coast Guard (USCG) spill response spill volume planning protocols and following consultation with Shell personnel (Gordon Johnson, Shell, personal communication, 2011). Two locations were selected for the origin of modeled accidental oil spills that included the Shell Martinez Terminal (MT) and Carquinez Bridge. Table 1 shows the spill analysis scenarios, consisting of different spill locations, times of year that the spill would occur and spill volumes.

Table 1. Spill Analysis Scenarios

Scenario	Location	Season	Volume (bbl)	Type of Spill
1	Shell Martinez Terminal	Summer	1,680	Reasonable Worst Case MT Spill
2	Shell Martinez Terminal	Winter	1,680	Reasonable Worst Case MT Spill
3	Shell Martinez Terminal	Summer	168	Maximum Most Probable MT Spill
4	Shell Martinez Terminal	Winter	168	Maximum Most Probable MT Spill
5	Shell Martinez Terminal	Summer	50	Average Most Probable MT Spill
6	Shell Martinez Terminal	Winter	50	Average Most Probable MT Spill
7	Carquinez Bridge	Summer	20,000	Reasonable Worst Case Tanker Spill
8	Carquinez Bridge	Winter	20,000	Reasonable Worst Case Tanker Spill

Winter and summer time periods differ presumably due to larger tidal ranges and river flows during the winter; however, insufficient detail regarding the simulations used to develop the TAPII database was available from NOAA to confirm these assumptions. Results generally indicate wider spread of higher probabilities of material during the winter. The results from the TAPII modeling system consist of probabilities that a certain number of barrels of spill material will be present within each shoreline zone. Shoreline zones are pre-defined within the TAPII system (185 different zones), and consist of areas approximately 8,200 ft long (on average), that extend approximately 1,650 ft offshore (on average).

Spill transport was evaluated at multiple times during a five-day simulation period (nine times were available, from six hours to five days after each spill), and the maximum probabilities of spill volumes exceeding a critical threshold value (level of concern) in each shoreline zone were determined. The TAPII system assumes that spill materials do not mix, but are all present on the surface as a sheen.

The approach to material volume calculation within each shoreline zone was coordinated and approved by the project team prior to final spill analysis. The level of concern in each shoreline zone, defined in TAPII as the volume of material present in each shoreline zone, was determined based on the shoreline zone area (8,200 by 1,650 ft) and reported thickness of crude oil sheen (Wikipedia 2011). Oil sheen thickness information for different appearance criteria were available ranging from "barely visible" to "colors are much darker". Crude oil sheen thickness for a "silvery sheen" (herein chosen as the level of concern for oil spill impact analysis) is such that 50 gallons are typically present in one square nautical mile. Based on this reported sheen thickness, a volume of 0.6 barrels per shoreline zone was determined to be the level of concern upon which probabilities of impact were calculated in the TAPII system.

2.2. Modeling Results

The TAPII database was used to analyze the scenarios described in Section 2.1 and the results were analyzed in coordination with the project team. Appendix A shows plan view plots of the TAPII results of the maximum probabilities of spill volumes present in each shoreline zone on a rectified satellite image of San Francisco Bay, San Pablo Bay, and Suisun Bay for each modeling scenario. Sections 2.2.1 to 2.2.8 describe the results of the maximum probabilities of spill volumes along the shorelines of San Francisco Bay, San Pablo Bay, and Suisun Bay for each modeling scenario.

2.2.1. Scenario 1

Scenario 1 consists of 1,680 barrels of crude oil spill at the Shell Martinez Terminal (Reasonable Worst Case MT Spill) during summer. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shorelines west of the terminal past the Carquinez Bridge and east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance up to 40 percent can be found in San Pablo Bay to Point San Pablo and Point San Pedro. Probabilities of exceedance up to 15 percent can be found to Tiburon. Probabilities of exceedance drop to values less than 5 percent south of Tiburon.

2.2.2. Scenario 2

Scenario 2 consists of 1,680 barrels of crude oil spill at the Shell Martinez Terminal (Reasonable Worst Case MT Spill) during winter. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shorelines west of the terminal past the Carquinez Bridge and east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance of up to 50-60 percent can be found in San Pablo Bay to Point San Pablo and Point San Pedro. Probabilities of exceedance up to 25 percent can be found to the Golden Gate. Probabilities of exceedance drop to values less than 5 percent south of Alameda.

2.2.3. Scenario 3

Scenario 3 consists of 168 barrels of crude oil spill at the Shell Martinez Terminal (Maximum Most Probable MT Spill) during summer. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shorelines west of the terminal past the Carquinez Bridge (north shoreline) and east of the terminal to Seal Islands/Roe Island. Probabilities of exceedance up to 50 percent can be found along the shorelines east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance drop to values less than 5 percent outside Suisun Bay.

2.2.4. Scenario 4

Scenario 4 consists of 168 barrels of crude oil spill at the Shell Martinez Terminal (Maximum Most Probable MT Spill) during winter. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shoreline west of the terminal past the Carquinez Bridge (north shoreline) and east of the terminal to Seal Islands/Roe Island. Probabilities of exceedance up to 40 percent can be found along the shoreline east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance of up to 30 percent can be found in San Pablo Bay to Point San Pedro. Probabilities of exceedance drop to values less than 10-15 percent south of San Pablo Bay with peaks at Tiburon and Angel Island. Probabilities of exceedance drop to values less than 5 percent south of Angel Island.

2.2.5. Scenario 5

Scenario 5 consists of 50 barrels of crude oil spill at the Terminal (Average Most Probable MT Spill) during summer. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent west of the terminal to Port Costa/Crockett along the south shoreline and up to approximately one mile east of the Carquinez Bridge along the northern shoreline. Probabilities of exceedance range from 75 to 100 percent for approximately 2.2 miles east of the terminal along the south shoreline. Probabilities of exceedance up to 50 percent can be found along the shoreline west of the terminal past the Carquinez Bridge (north shoreline) and east of the terminal to the shoreline area north of Port Chicago. Probabilities of exceedance up to 30 percent can be found along the shoreline east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance drop to values less than 5 percent outside Suisun Bay.

2.2.6. Scenario 6

Scenario 6 consists of 50 barrels of crude oil spill at the Shell Martinez Terminal (Average Most Probable MT Spill) during winter. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent west of the terminal all the way to Port Costa/Crockett along the south shoreline and past the Carquinez Bridge along the north shoreline. Probabilities of exceedance range from 75 to 100 percent for approximately 3.2 miles along the south shoreline east of the terminal. Probabilities of exceedance up to 50 percent can be found along the south shoreline west of the terminal past the Carquinez Bridge, and east of the terminal to the shoreline area north of Port Chicago. Probabilities of exceedance up to 20 percent can be found along the shoreline east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance drop to values less than 5 percent outside San Pablo Bay.

2.2.7. Scenario 7

Scenario 7 consists of 20,000 barrels of crude oil spill at Carquinez Bridge (Reasonable Worst Case Tanker Spill) during summer. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shoreline west of the Carquinez Bridge into San Pablo Bay and east of the Carquinez Bridge to the shoreline area north of Port Chicago. Probabilities of exceedance up to 40-50 percent can be found in San Pablo Bay to the Richmond-San Rafael Bridge and east of the Carquinez Bridge to Chipps Island and Mallard Island. Probabilities of exceedance of up to 30 percent can be found at Richmond, and up to 20 percent can be found to the Golden Gate and to Alameda. Probabilities of exceedance drop to values less than 5 percent south of Alameda.

2.2.8. Scenario 8

Scenario 8 consists of 20,000 barrels of crude oil spill at Carquinez Bridge (Reasonable Worst Case Tanker Spill) during winter. Results indicate that probabilities of exceeding the levels of concern range from 75 to 100 percent along the shoreline west of the Carquinez Bridge, into San Pablo Bay to Point San Pablo and Point San Pedro, and east of the Carquinez Bridge to the shoreline area north of Port Chicago. Probabilities of exceedance of up to 50 percent can be found at Richmond, to the Golden Gate and to Treasure Island. Probabilities of exceedance up to 30 percent can be found along the shoreline east of the terminal to Chipps Island and Mallard Island. Probabilities of exceedance drop to values less than 5 percent south of Hunters Point.

3. Conclusion

Oil spill dispersion predictions were provided using the NOAA TAPII system in support of environmental impact analysis for the Shell Martinez Crude Tank Replacement Project (CTRP) EIR, Martinez, California. Oil spill analysis results in the form of probabilities of spills exceeding levels of concern were provided to the project team for environmental analysis.

4. References

Barker, C. 2009. The NOAA Trajectory Analysis Planner: TAP II. Downloaded from NOAA website.

Johnson, G. 2011. Personal Communication with Gordon Johnson, Shell.

Wikipedia. 2011. http://en.wikipedia.org/wiki/Oil_spill.

National Oceanic and Atmospheric Administration (NOAA). January 2000. TAPII 1.1 User Manual, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Response and Restoration.

APPENDIX A

Plan Views of Maximum Probabilities of Spill Volumes above Level of Concern in Each Shoreline Zone

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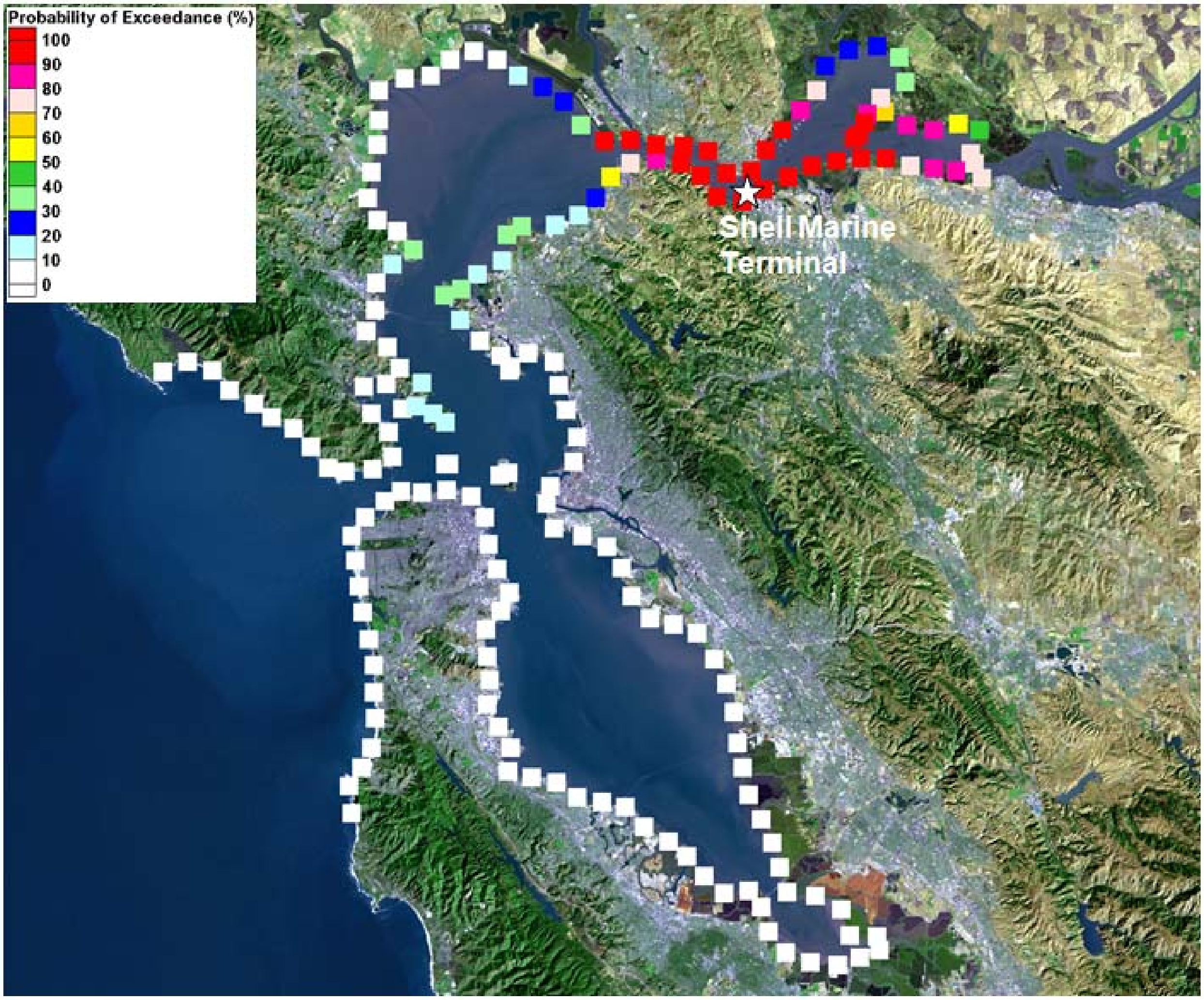

Figure A1. Scenario 1, Reasonable Worst Case MT Spill, 1,680 Barrels, Shell Martinez Terminal, Summer

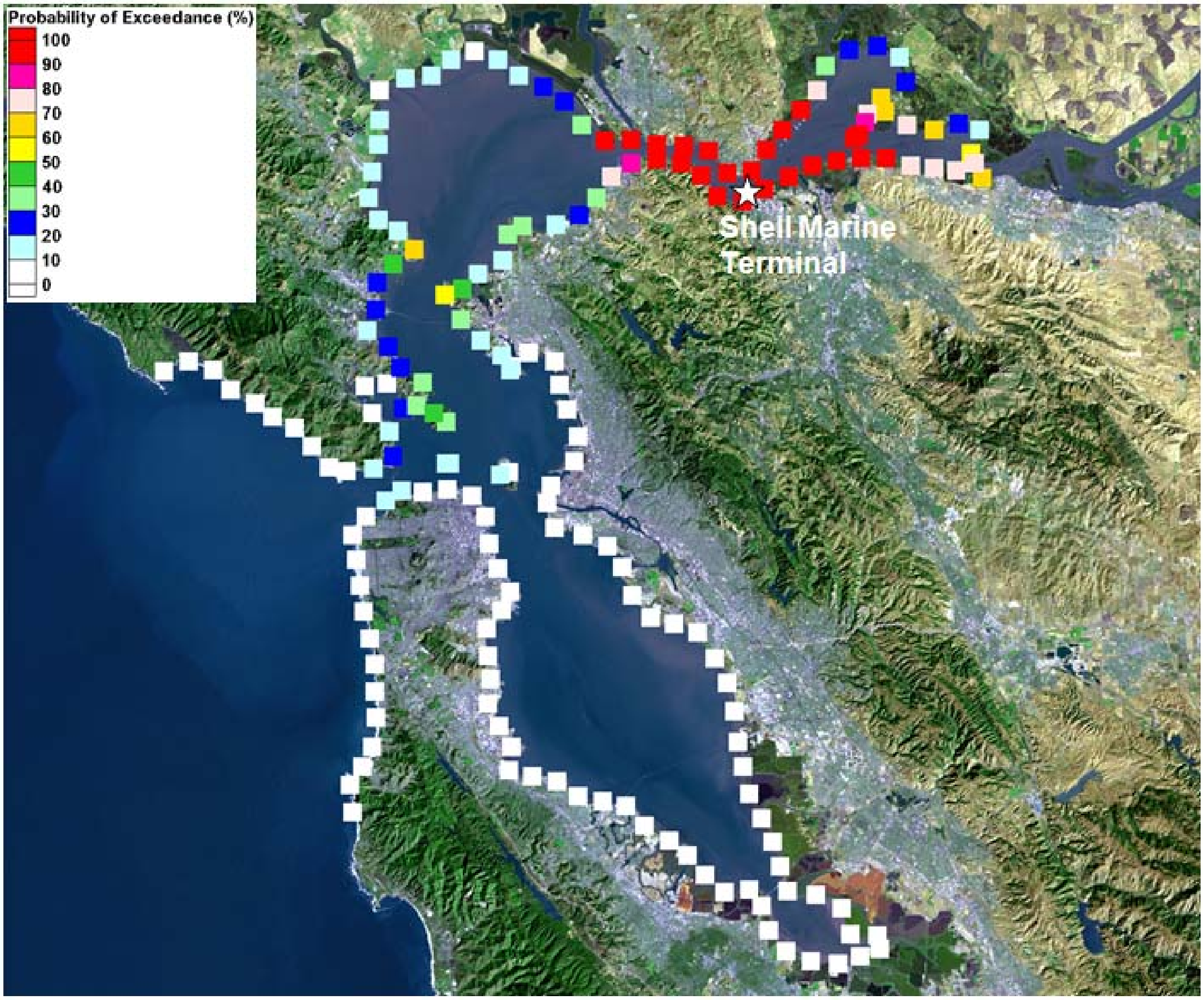

Figure A2. Scenario 2, Reasonable Worst Case MT Spill, 1,680 Barrels, Shell Martinez Terminal, Winter

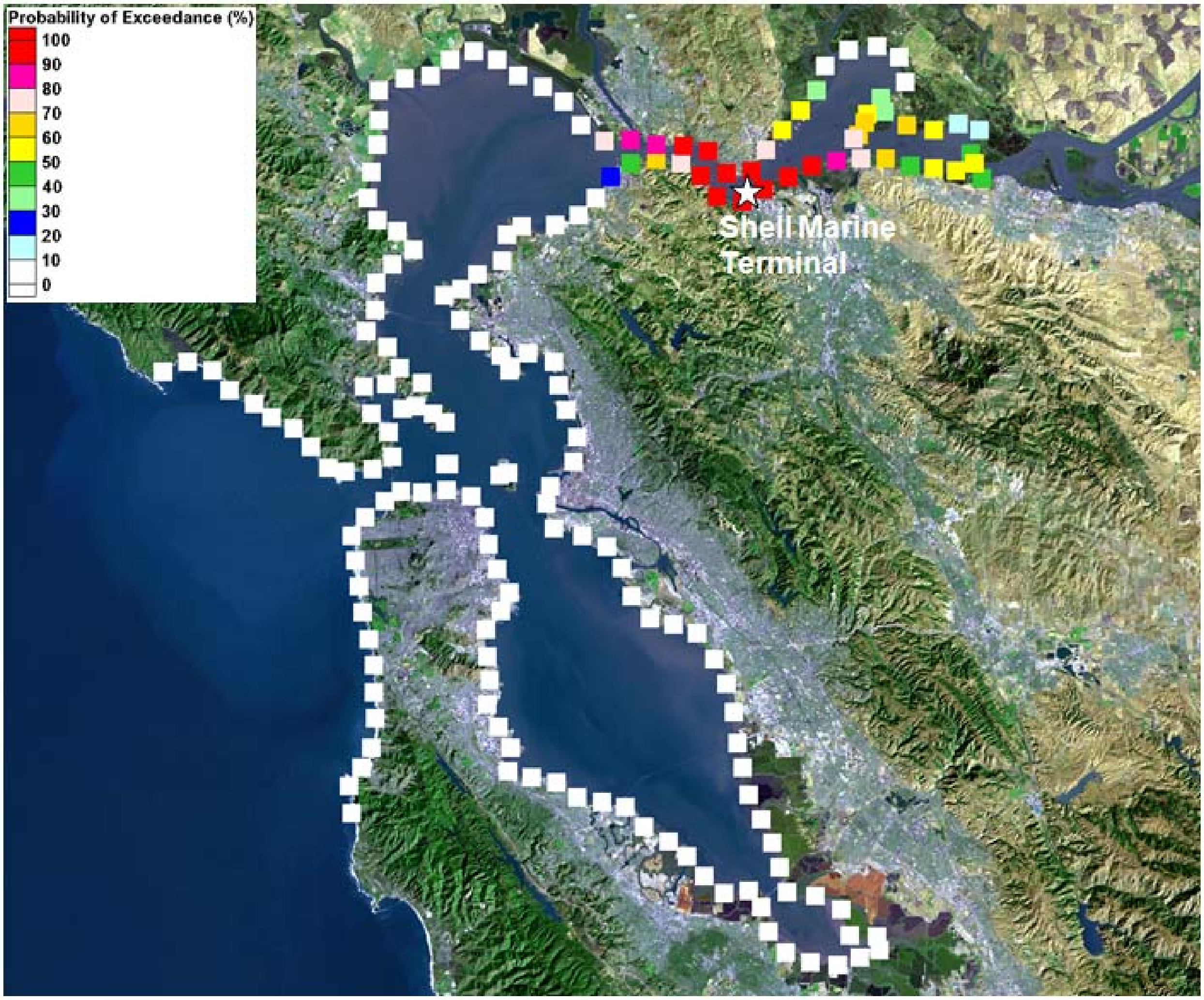

Figure A3. Scenario 3, Maximum Most Probable MT Spill, 168 Barrels, Shell Martinez Terminal, Summer

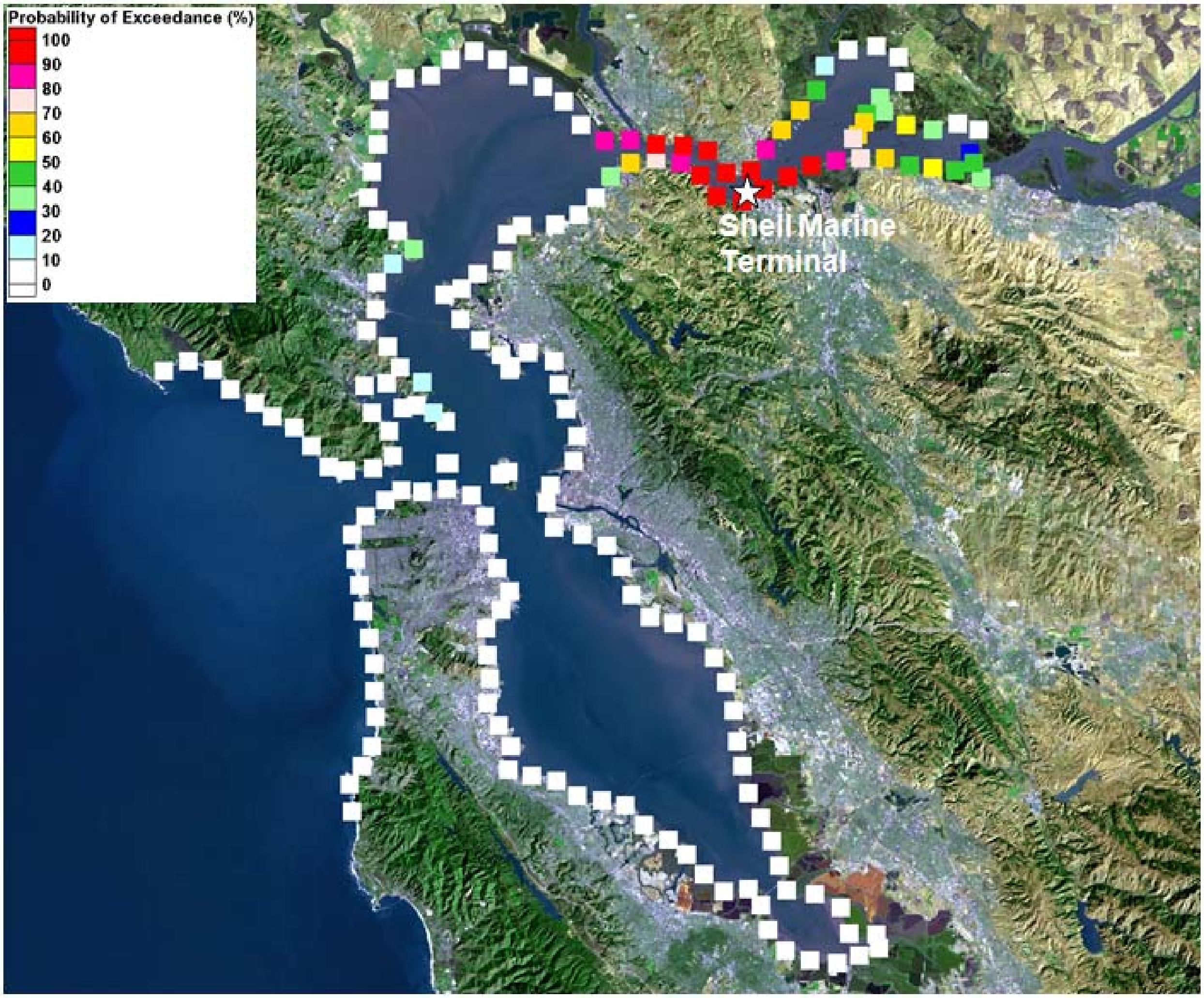

Figure A4. Scenario 4, Maximum Most Probable MT Spill, 168 Barrels, Shell Martinez Terminal, Winter

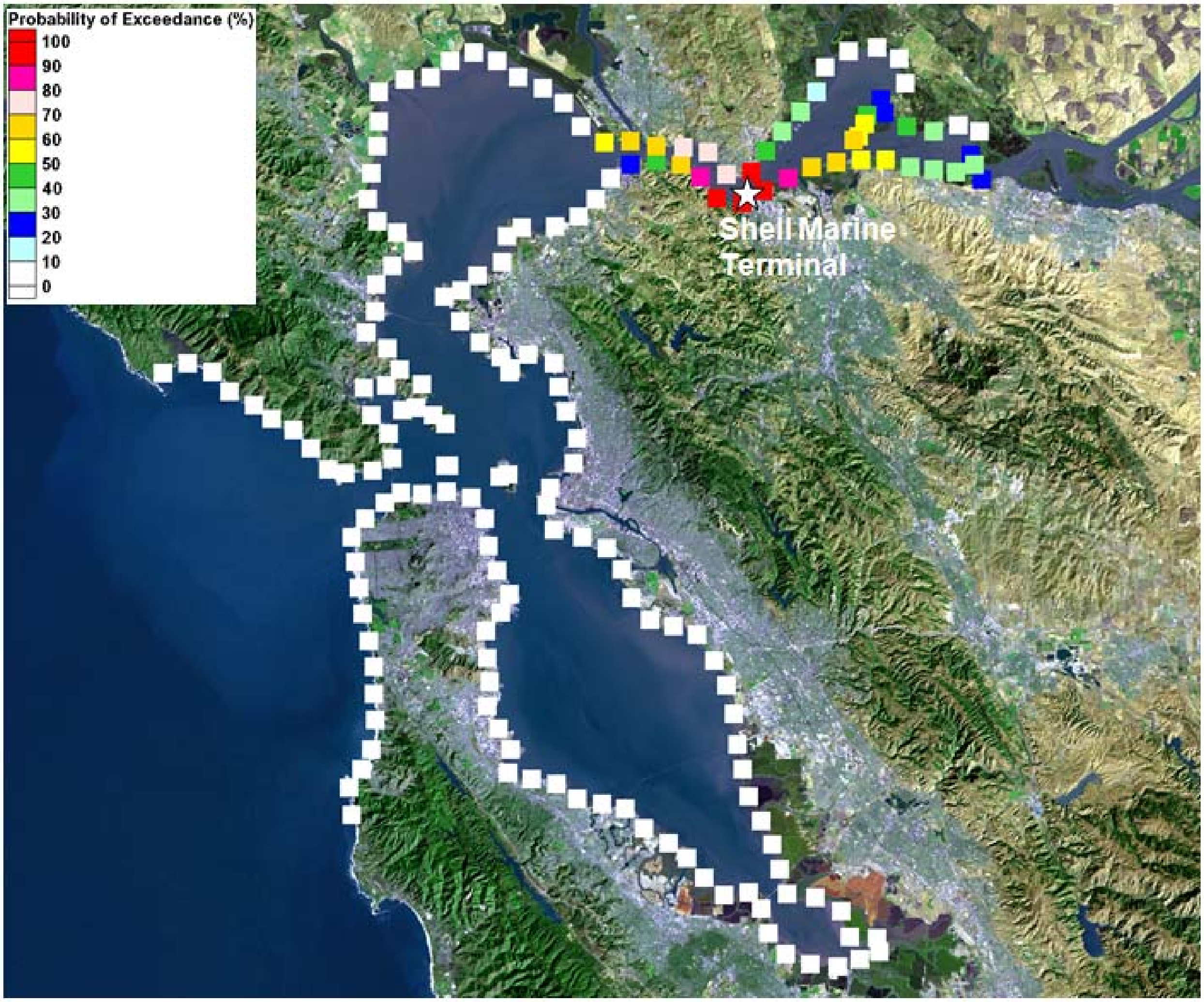

Figure A5. Scenario 5, Average Most Probable MT Spill, 50 Barrels, Shell Martinez Terminal, Summer

Figure A6. Scenario 6, Average Most Probable MT Spill, 50 Barrels, Shell Martinez Terminal, Winter

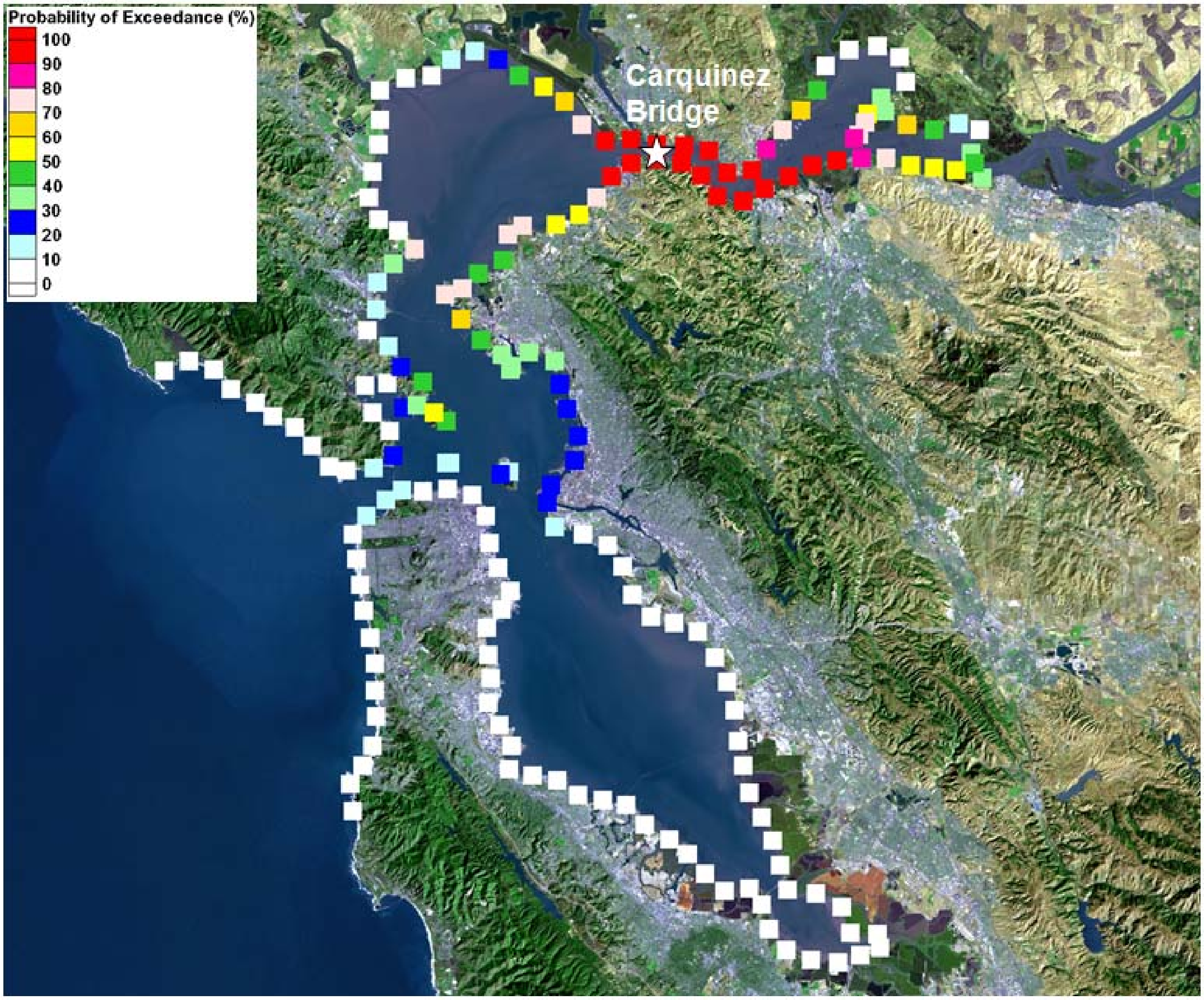

Figure A7. Scenario 7, Reasonable Worst Case Tanker Spill, 20,000 Barrels, Carquinez Bridge, Summer

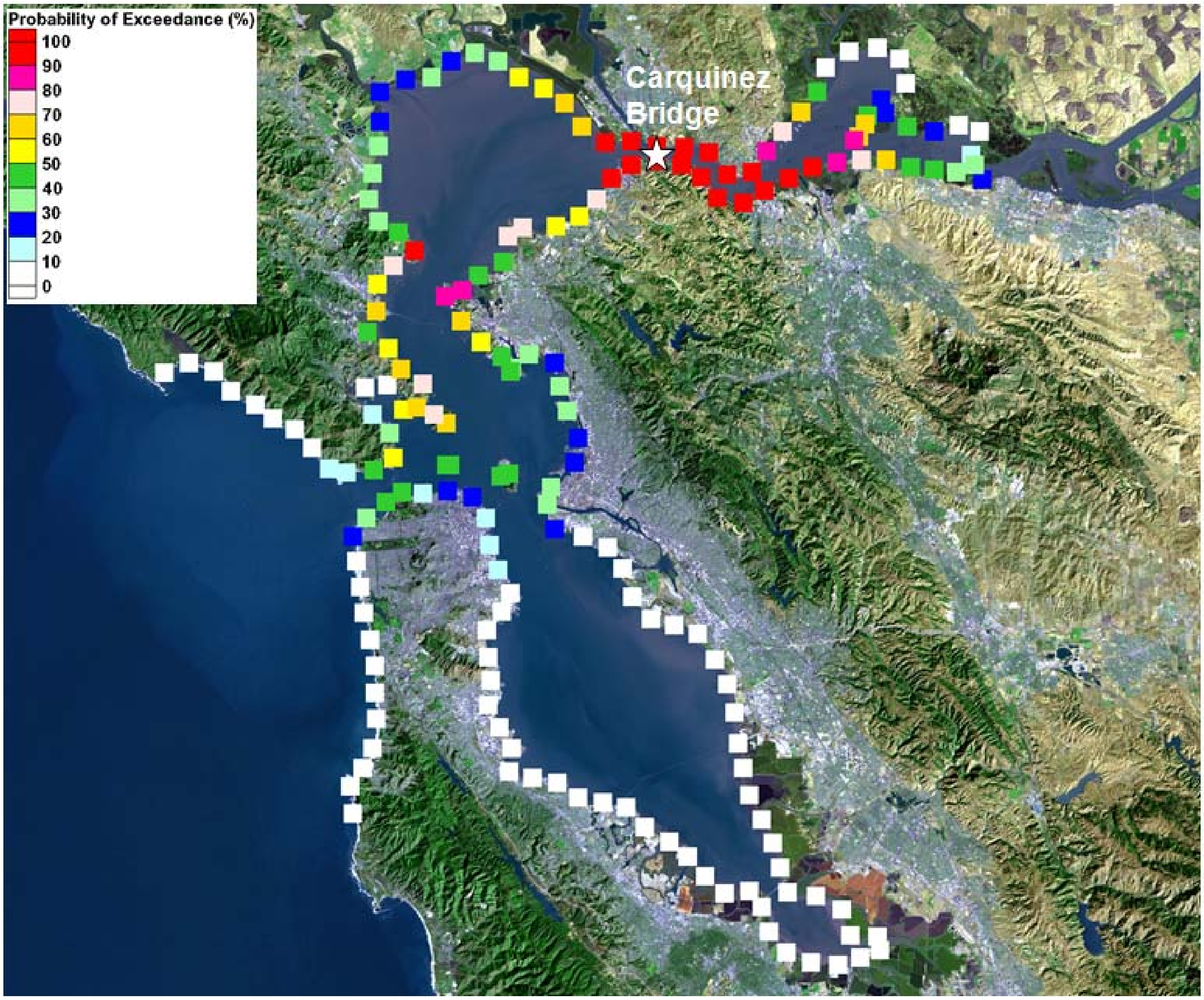

Figure A8. Scenario 8, Reasonable Worst Case Tanker Spill, 20,000 Barrels, Carquinez Bridge, Winter