APPENDIX A

BECHTEL ENVIRONMENTAL AND DAMES & MOORE (BEDM), REVISED CLOSURE PLAN, DATED DECEMBER 30, 1996 and REVISED ON MAY 28, 1997

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

REVISED

LANDFARMS CLOSURE PLAN

Prepared for:

CHEVRON PRODUCTS COMPANY
RICHMOND, CALIFORNIA

December 30, 1996

BECHTEL ENVIRONMENTAL, INC.
P. O. Box 3965, San Francisco, CA 94119, (415) 768-1234

DAMES & MOORE
221 Main St., #600, San Francisco, CA 94105, (415) 896-5858

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1.0 INTRODUCTION

Presented in this document is the Revised Closure Plan for the Nos. 1 through 5 Landfarms at the Chevron Richmond Refinery located in Richmond, California (Plate 1-1). This plan was originally prepared in 1996 by Bechtel Environmental, Inc. and Dames & Moore (BEDM) and was revised by Dames & Moore at the request of Chevron. This revised plan supersedes the previous closure plans submitted by Chevron dated March 31, 1988, June 7,1995, September 24, 1995, and December 31, 1996. This plan presents a revised closure approach that was presented to the California EPA Department of Toxic Substances Control (DTSC) at a meeting on February 27, 1996. As discussed in Section 1.1, Chevron has submitted several documents discussing various elements of the proposed plan to the DTSC for their review in advance of the submittal of this plan. All of these elements have been incorporated into this document.

This revised plan provides a history of activities to date and summarizes the facility and hydrogeologic conditions. The plan also presents details of the Landfarms closure and post-closure activities, the closure and post-closure cost estimate, and evidence of the financial assurance.

1.1 History of Landfarms Activities

Between the mid 1970s and 1987, Chevron conducted landfarming operations at five locations within the Refinery. The landfarming was designed to promote biodegradation of oily soils that had been generated within the Refinery from various operations.

On November 12, 1980, Chevron submitted Part A of the hazardous waste permit application for the Refinery, which included the five Landfarms. Subsequently, in February 1981, Chevron submitted Part B of the hazardous waste permit application as requested by the U.S. Environmental Protection Agency (U.S. EPA). Revisions to both Part A and Part B of the Resource Conservation and Recovery Act (RCRA) permit application were submitted in August 1984. On February 10, 1987, Chevron was notified that the Landfarms did not qualify for a hazardous waste permit because some of the permit conditions could not be met. In response to this condition, Chevron entered into a Consent Agreement with the U.S. EPA and DTSC to close the Landfarm units.

Chevron submitted the original *Landfarms Closure Plan* on March 31, 1988, and initiated closure of the Landfarms under that plan in the first quarter of 1988. This plan included a Biodegradation Activities Plan that outlined details of how the Landfarms would be managed during the closure period to degrade organic residues in the soil. The closure period was estimated to require approximately five years. The plan also included a groundwater monitoring plan to evaluate the condition of the groundwater during the closure period. As part of the plan implementation, BEDM conducted a Reconnaissance Survey to evaluate the vertical and horizontal extent of residual oil in the Landfarms soils. This survey consisted of soil core sampling and soil pore liquid sampling. The results of the survey indicated that the zone of Landfarm influence ranged from 3 to 7 feet below ground surface (bgs) in No. 1 Landfarm, 3 to 5-1/2 feet in No. 2 Landfarm, 1 to 5 feet in No. 3 Landfarm, 3-1/2 to 5 feet in No. 4 Landfarm, and 2 to 4 feet in No. 5 Landfarm (BEDM, January 9, 1989). Results of the pore water testing indicated that concentrations were not statistically different from background levels. The study concluded that the time required to biodegrade the remaining constituents could range from 2.3 to 8.2 years, based on the presence of relatively immobile polynuclear aromatic hydrocarbons (PAHs).

In response to the Regional Water Quality Control Board (RWQCB), San Francisco Bay Region's *Order No. 89-175, Revised Waste Discharge Requirements for: Chevron U.S.A., Inc., Richmond Refinery, Richmond, Contra Costa County*, Chevron and BEDM developed and constructed a Groundwater Protection System (GPS) for the Refinery. The objective of the GPS for the entire Refinery, including the Landfarms areas, is to establish and maintain a physical or hydraulic barrier to prevent the off-site

movement of potentially contaminated near-surface groundwater. Construction of GPS elements in the vicinity of the Landfarms began in 1990 and are scheduled to be completed in 1997. Details of the GPS are discussed in Section 3.6 of this document.

On July 13, 1990, BEDM submitted the *Landfarm Biodegradation Study Report* presenting the progress of biodegradation activities to date (BEDM, July 13, 1990). The study consisted of compiling and evaluating monthly surface soil data to establish a baseline oil concentration value against which future data and trends could be compared. Based on the results of this study, BEDM recommended modifications to the Biodegradation Activities Plan.

On February 27, 1992, BEDM submitted the *Landfarms Bioremediation Assessment Report*. The purpose of the assessment was to evaluate, with existing data, the effectiveness of biodegradation and to propose additional modifications to the Biodegradation Activities Plan. The report concluded that, although the total oil concentrations were decreasing at a very slow rate, biodegradation was likely to have been continuing. However, due to the nature of analytical methods used, the degree of biodegradation could not be quantified. Recommendations were made by BEDM regarding modifications to the Biodegradation Activities Plan and were subsequently implemented.

On August 10, 1993, BEDM submitted the *Landfarms Sampling and Analysis Report*. The purpose of the investigation was to further evaluate the effectiveness of hydrocarbon biodegradation based on a comparison of the current data with the 1988 Reconnaissance Survey data. Results of this assessment indicated that the parameters analyzed were within the target range of levels necessary to support active hydrocarbon biodegradation. Based on these results, it was concluded that the Landfarms had been operating as an active biodegradation unit and had been effective in reducing petroleum wastes applied to the ground surface prior to 1987. However, the degree to which constituents had been degraded suggested that biodegradation activities may have reached a point of diminishing returns. Therefore, BEDM recommended that landfarming activities be discontinued and the Landfarms be permanently closed.

On March 17, 1995, the DTSC issued a letter requesting a revised closure plan for the Landfarms (Letter from Lester Kaufman of DTSC to P.S. Williams of Chevron). Chevron requested BEDM to prepare a closure plan in response to the DTSC's request. The revised Closure Plan was submitted on June 21, 1995. The DTSC reviewed the plan for technical adequacy and issued a *Notice of Deficiency (NOD) for the Revised Closure / Post-Closure Plan, Richmond Refinery Landfarm Nos. 1 Through 5, Chevron U.S.A. Products Company, Richmond, California, 94801 EPA ID. No CAD 009 114 919* on August 15, 1995.

At Chevron's request, BEDM prepared a second revision to the Landfarms closure plan, which was submitted to the DTSC on September 14, 1995. Following discussions with the DTSC, Chevron reconsidered their closure options in relation to a detailed review of the regulatory requirements for closure of land treatment units and requested the DTSC to discontinue reviewing the September 1995 plan. Chevron presented their revised conceptual plan to the DTSC in a meeting with Ms. Wei Wei Chui and Mr. Tony Morales of the DTSC, Elizabeth Christian of the Regional Water Quality Control Board (RWQCB), San Francisco Bay Region, and Mr. Ron Leach of the U.S. EPA on February 27, 1996. After reaching tentative consensus with the DTSC on the revised closure plan elements, Chevron requested BEDM to prepare this final revised closure plan. In the interim, the DTSC requested that Chevron submit documents on the following subjects for the DTSC's review for the purpose of expediting approval of this plan:

- A vegetation plan for the interim period prior to closure;
- A GPS effluent sampling plan to evaluate the nature of the groundwater being removed from the Landfarms;

- The proposed final cover design;
- The plan for free phase hydrocarbon recovery;
- Piezometric monitoring around No. 1 Landfarm; and
- The impact of the 250-Foot Channel on the Nos. 2 and 5 Landfarms.

Consistent with the decision to close the Landfarms, active biodegradation activities were modified and Chevron submitted the *Proposed Interim Vegetation Plan for Nos. 1 through 5 Landfarms* (BEDM) to the DTSC on May 23, 1996. The plan specified the criteria and procedures that will be used to assure continued subsurface biodegradation at the Landfarms until the Post-Closure Maintenance Plan, contained in this Revised Closure Plan, is approved by the DTSC and implemented by Chevron.

BEDM then prepared the *Proposed GPS Effluent Water Sampling Plan* (dated May 6, 1996), which has been transmitted to the DTSC by Chevron. The GPS sampling plan was developed to document that the groundwater being extracted from the vicinity of the Landfarms was non-hazardous. The results of this sampling plan to-date are discussed in Section 3.7 of this document.

The *Final Cap Design Proposal* (dated July 26, 1996) contained preliminary versions of Sections 4.0, 4.1 and 4.2, Table 4-2, Plates 4-1 and 4-2, Drawings D-367512, D-367513, and D-367515, and Appendix O to this report. The design drawings have been revised to those submitted earlier to reflect changes in the surface drainage plan.

2.0 FACILITY CONDITIONS

2.1 General Refinery Information

The Landfarms are located within Chevron's Richmond Refinery. The Richmond Refinery is situated on 2,800 acres roughly bounded by Castro Street to the East, Interstate Highway 580 to the South, and San Pablo Bay to the West and North. A map showing the location of the Refinery is presented on Plate 1-1.

The Refinery street address is:

Chevron Products Company
Richmond Refinery
841 Chevron Way
Richmond, Contra Costa County
California 94801

The Refinery Mailing address is:

Chevron Products Company
Richmond Refinery
P.O. Box 1272
Richmond, California 94802-0272
phone: (510) 242-3000

The facility is within the Richmond Township:

Range	1 North 5 East
Sections	2, 3, 4, 9, 10, 11, 14, 15, 16, 34, and 35

Principle Meridian	Mt. Diablo Base Meridian
Zoning	M-3 Heavy Industrial

The Richmond Refinery is situated at 37 degrees, 56 minutes, 30 seconds, N. latitude and 122 degrees, 23 minutes, 30 seconds, W. longitude. The entire refinery is located between:

Latitude:	37 degrees, 55 minutes, 17 seconds, to 37 degrees, 58 minutes, 30 seconds
Longitude:	122 degrees, 22 minutes, 31 seconds, to 122 degrees, 25 minutes, 31 seconds

The principal products provided by this facility can best be described by the following Standard Industrial Classification (SIC) Directory codes:

2911	Petroleum Refinery
2869	Industrial Organic Chemicals
2819	Industrial Inorganic Chemicals

A discussion of the Hazardous Waste Management Units located within the Refinery is contained in Part A of the RCRA permit application submitted by the Refinery in November 1980, and its revision submitted in August 1984.

2.2 Landfarms Information

2.2.1 General Description

The Landfarms facility covers approximately 29 acres. The facility is made up of five separate areas designated Nos. 1 through 5 Landfarms. The locations of the five Landfarms are shown on Plate 1-1. All of the Landfarms areas are internal to the Refinery and are not adjacent to the perimeter of the Refinery. The approximate size of each Landfarm is as follows:

No. 1 Landfarm	13.5 acres
No. 2 Landfarm	8 acres
No. 3 Landfarm	3.5 acres
No. 4 Landfarm	3 acres
No. 5 Landfarm	1 acre

The Landfarms are comprised of imported fill that was placed at the site prior to landfarm operation. The thickness of this fill ranges from 10 to 25 feet. The perimeter of each Landfarm is encircled by an above-grade berm designed to minimize access and surface water runon/runoff. A typical cross section of these perimeter berms is presented on Plate 2-1. The interior surface of each Landfarm is generally about 3 feet above the surrounding grade elevation, and is graded to control runoff. Plate 2-2 shows the existing topography for No. 1 Landfarm and Plate 2-3 shows the topography for Nos. 2 through 5 Landfarms.

Access to the Landfarms facility is controlled by the Environmental Operations Section of the Refinery's Utilities/Environmental Area Business Unit (ABU). The Environmental Section's security measures are designed to prevent unknowing or unauthorized access to the Landfarms facility.

Areas of the Refinery that do not border the Bay waters are secured by a 6-foot-high cyclone fence, which is generally topped by three rows of barbed wire. The only unfenced landward access to the Refinery is across Herman Slough from the property of Chevron Chemical Company, to which the public does not have access.

All unguarded gates are locked. In the case of the railroad gate, access is controlled electronically. Locked gates fall into two categories:

- Single-locked gates to which only assigned Refinery personnel have access; or
- Double-locked gates (cowboy locks) to which assigned Refinery personnel have access, as well as outside personnel who must service equipment within the area protected by the gate.

Routine entry for Refinery personnel and approved contractors is through guarded gates. Visitors to the Refinery must enter and exit through guarded gates, and must be cleared by authorized personnel prior to entry.

Warning signs are posted at 100-foot intervals around the perimeter of each Landfarm. These signs are posted in English and Spanish and bear the following wording:

CAUTION
HAZARDOUS WASTE
STORAGE AREA

UNAUTHORIZED PERSONS
KEEP OUT

CUIDADO
ZONA DE RESIDUOS
PELIGROSOS

PROHIBA LA ENTRADA A
PERSONAS NO AUTORIZADAS

These signs are yellow and black, which is consistent with the general Refinery usage for caution signs. They each measure 10 inches high by 14 inches wide, and bear 2-1/2-inch yellow letters for the word "CAUTION" against a black background. The balance of the text is in 3/4-inch black letters against a yellow background.

2.2.2 Regulatory Status

As summarized above, Chevron submitted Part A of the RCRA hazardous waste permit application for the Richmond Refinery in November 1980 and Part B of the permit application in February 1984. Revisions to both Part A and Part B of the RCRA permit application were submitted in August 1984. The U.S. EPA, the California Department of Health Services (now the DTSC), and the RWQCB subsequently determined that the Landfarms did not qualify for a RCRA hazardous waste permit, primarily because the Landfarms lacked adequate separation between the treatment zone and the seasonal high groundwater table. The U.S. EPA then issued a Consent Agreement and Final Order in January 1988 to ensure that the Landfarms are closed in accordance with applicable U.S. EPA regulations. The DTSC followed by issuing a Stipulation and Order to ensure that the Landfarms are closed in accordance with applicable California regulations. Chevron ceased all waste applications to the Landfarms in 1987 and submitted a Closure Plan to the U.S. EPA, DTSC, and RWQCB in April 1988.

In summary, the following orders and permits are directly applicable to the site:

- California Environmental Protection Agency Department of Toxic Substances Control (DTSC), 1988, *Stipulation and Order (Docket No. HWCA 87/88-019)*, March 23 (transmittal letter dated April 1, 1988).

- California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB), 1993, Order No. 93-109, Order to Revise and Rescind Order No. 89-175, Waste Discharge Requirements for: Chevron U.S.A., Inc., Richmond Refinery, Richmond, Contra Costa County, September 15.

- DTSC, 1992, Hazardous Waste Facility Permit for a Hazardous Waste Treatment and Storage Facility, September 10.

- United States Environmental Protection Agency, Region 9 (U.S.EPA), 1988, Agreement and Final Order, RCRA 09-88-0005, January 20.

- U.S.EPA, 1990, Administrative Order on Consent (Docket No. RCRA-09-89-0010), June 18.

In addition, the Refinery's treated effluent water is governed by a National Pollutant Discharge Elimination System (NPDES) permit administered by the RWQCB (Order No. 92-111).

2.2.3 Waste Characteristics

For discussion purposes, the Landfarms were divided into three areas. Area I includes No. 1 Landfarm, Area II includes Nos. 2, 4, and 5 Landfarms, and Area III includes No. 3 Landfarm. The Landfarms were in operation for the biological treatment of oily wastes generated form on-site petroleum processing from the mid-1970's to 1987. The principle wastes applied were oil/water separator sludge (Nos. 1, 2, 4, and 5 Landfarms), non-leaded tank bottoms (Nos. 1, 2, 3, and 4 Landfarms), oil/water mixtures, algae water, pond sediments and oily dirt. When in operation, wastes were applied to the surface of the Landfarms and tilled into the top 6 to 12 inches. Prior to 1980, no data are available on waste application rates to the Landfarms. Since 1980, a total of 188,000 tons of waste were applied to the Landfarms. The characterization of the Landfarms wastes presented herein is based on the results presented in the *Landfarms (Soil) Sampling and Analysis Report* (BEDM, August 10, 1993). Additional information on the waste application history can also be found in the 1993 document.

Waste characterization was evaluated based on four criteria: ignitability, corrosivity, reactivity and toxicity. The definitions used in this investigation for the characterization of hazardous waste are defined in California Code of Regulations, Title 22, and are summarized below:

- Ignitability: A substance is considered hazardous when the flash point is below 140° F (60° C).

- Corrosivity: A substance is considered hazardous when the pH is less than or equal to 2.0, or greater than or equal to 12.5.

- Reactivity: A substance is considered hazardous if, when exposed to conditions of pH between 2.0 and 12.5, toxic gases (hydrogen sulfide [H_2S] and hydrogen cyanide [HCN]) are generated at levels that present a danger to human health or the environment. The current EPA action levels are 500 mg/kg for H_2S and 250 mg/kg for HCN.

- Toxicity: A substance is considered hazardous when the total metals concentration is greater than the corresponding Total Threshold Limit Concentration (TTLC) value or when the

soluble metal concentration, following the Waste Extraction Test (WET), is greater than the corresponding Soluble Threshold Limit Concentration (STLC) value.

2.2.3.1 Area I

The flash point was above the ignitability criterion of 140° F in all Area I samples. The corrosivity measurements were recorded between pH 5.1 and pH 8.4. Hydrogen cyanide was not detected in any of the samples. Area I reported 8 detections of hydrogen sulfide ranging from 4.5 mg/kg to 150 mg/kg.

There were no metals detections greater than the TTLC value in Area I. Only 1 sample had a WET result greater than the respective STLC value. Mercury in 1 sample was above the STLC value of 0.2 mg/L at a concentration of 0.25 mg/L. This value is considered suspect because the total concentration of mercury was insufficient to account for a soluble concentration of 0.25 mg/L.

Based on an evaluation of the vertical distribution of constituents in soils samples, the zone of influence of the Landfarms wastes ranges from 3 to 7 feet bgs.

2.2.3.2 Area II

All Area II samples had a flash point above the ignitability criterion of 140° F. The corrosivity measurements were recorded between pH 5.6 and pH 8.1. Hydrogen cyanide was not detected in any of the samples; there were, however, 6 detections of hydrogen sulfide ranging from 4 mg/kg to 196 mg/kg. There were no metals detections greater than the TTLC value in Area II. No WET sample results were greater than the respective STLC value.

No samples in Area II were found to exceed hazardous waste characterization criteria. The zone of influence in Area II ranges from 2 to 5.5 feet bgs.

2.2.3.3 Area III

All Area III samples had a flash point above the ignitability criterion of 140° F. The corrosivity measurements were recorded between pH 5.1 and pH 7.8. Hydrogen cyanide and hydrogen sulfide were not detected in any of the samples. There were no metals detections greater than the TTLC value in Area III. No WET sample results were greater than the respective STLC value.

No samples in Area III were found to exceed hazardous waste characterization criteria. The zone of influence in Area III ranges from 1 to 5 feet bgs.

2.2.3.4 Soil Physical Characteristicss

Physical testing and field observations of the Landfarms soil texture suggested the soils are fine-grained silts and clays, with some residues of construction debris from the original fill. Based on the fine-grained nature of both upper and lower fill, the permeability of the fill strata to both liquids and gases is relatively low. As a result, slow infiltration and areas of ponded water have been observed at the Landfarms during precipitation cycles. Comparing the observed soil moisture content to the field capacity (defined as the soil moisture content of a well-drained soil 2 to 3 days after saturation) suggests that most soil samples were at or above the field capacity moisture content. This fact along with the estimate of the air-filled pore space suggest that the Landfarms soils are poorly drained, possibly limiting the gaseous transport from the surface to the subsurface soils.

2.2.4 1988-1995 Bioremediation Activities

Landfarms activities in the period from 1988 to 1995 were performed in accordance with the U.S. EPA Refinery Landfarm Consent Agreement (January 1988), the California Environmental Protection Agency (California EPA) Stipulation and Order (April 1988), and subsequent negotiations with the California EPA (now DTSC). The objective of the landfarming activities performed in that period was to optimize soil physical, chemical and biologic conditions in order to maximize biodegradation of organic wastes. The Landfarms operations included regularly scheduled soil tilling, irrigation, runoff control, addition of soil amendments (fertilizers and nutrients), and a soil and groundwater monitoring program.

The Landfarms Soil Monitoring Program was conducted in accordance with the 1988 Landfarms Closure Plan to document the progress of bioremediation and to guide Landfarms watering and fertilizing practices. The monitoring program, in its final form, included monthly soil sampling for pH, oil content, moisture content, and microbe count; and quarterly for specific conductance, phenol, total phenolics, total organic carbon (TOC), and four metals: chromium, lead, nickel, and vanadium. The results of these tests were compiled quarterly in the Landfarm Soil and Groundwater Monitoring Program Reports and submitted to the U.S. EPA, the DTSC, and the RWQCB. Information on the chemical and agricultural characterization of the Landfarms soils is contained in the quarterly reports, as well as in the *Landfarms (Soil) Sampling and Analysis Report* (BEDM, August 10, 1993), and are not repeated in this document.

Information collected during the Landfarms Soil Monitoring Program was used to optimize soil conditions for aggressive biodegradation of the residual petroleum hydrocarbons. The effectiveness of the soil optimization activities was evaluated in the *Biodegradation Activities Report* (BEDM, 1992) and again in the *Landfarms (Soil) Sampling and Analysis Report* (BEDM, August 10, 1993). The Biodegradation Activities Report presented a comprehensive summary for the chemical constituents present in the Landfarmed soil, a discussion of sources generating the soil, and histogram plots showing the trend of concentrations against time. The Landfarm (Soil) Sampling and Analysis Plan evaluated the condition of the Landfarms soil at the same locations as those evaluated in 1989. The conclusion was reached that the ongoing active biodegradation activities had reached a point of diminishing returns and that the Landfarms should be covered with a vegetative cap to allow continued passive biodegradation.

2.2.5 Interim Vegetation Plan Activities

As outlined in the interim vegetation plan, Chevron is in the process of optimizing a vegetated surface on the Landfarm soils to promote continued biodegredation of the residual waste constituents until the final closure cover is installed. The activities currently performed on the Landfarms fall into the two general categories that include operations and monitoring. The objectives of the Landfarms operations are to: 1) continue degrading residual organic waste constituents present in the Landfarms soils (primarily in the top 12 inches of the soil); 2) maintain conditions that reduce the potential for metals to become solublized in the soil; and 3) prevent the erosion of the Landfarms soils and berms by wind and water. The objectives of monitoring include: a) tracking the types and concentrations of organic and inorganic hazardous waste constituents in the groundwater; and b) assessing the need for soil amendments to promote the growth of surface vegetation. A brief description of the interim vegetation plan is presented below.

2.2.5.1 Interim Landfarms Vegetation Activities

Vegetation Status Monitoring - A survey of the vegetated surface of the Landfarms is performed quarterly to evaluate plant germination, irrigation, and the need for fertilization, mowing and reseeding. The surveys identify the appearance and nature of vegetative cover on the surface of each Landfarm, symptoms of drought stress, chlorosis (indicative of nutrient deficiency), and the need for mowing and/or reseeding. Maintenance modifications, such as fertilizing, reseeding, and/or irrigation, will be made to address

observations made during the surveys and promote a healthy vegetated surface. These modifications and their resulting effectiveness will be documented in Semi-Annual Landfarms Status Letters.

Mowing / Reseeding - The composition and extent of vegetation present on each Landfarm will largely determine the need to mow and/or reseed. Winter annual grasses such as oats (*Aventa sativa*) and ryegrass (*Poa annua*) normally set seed in spring and early summer and then turn brown and die. If mowed and irrigated, some winter annuals will stay green longer into the summer. Mowing winter annuals would be coupled with over-seeding with common perennial grass/legume mixtures used to maintain year-round vegetative cover. The grass/legume mixture recommended for over-seeding or reseeding Landfarm soils includes:

- "Alta" tall fescue (*Festuca arundinacea*);

- Rose clover (*Trifolium prateuse*);
- White clover (*Trifolium repens*);
- Birdsfoot trefoil (*Lotus corniculatus*);
- Blue wildrye (*Elymus glaucus*);
- Creeping wild rye (*Elymus triticoides*);
- Bermuda grass (*Cynodon dactylon*): and
- California brome (*Bromus carinatus*).

These species are adapted to the Northern California climate and soils, and have been used by various State agencies for vegetation projects.

Irrigation - Irrigation is supplied to the Landfarms soils to enhance seed germination and to meet plant water requirements throughout the warm months when plant evapotranspiration requirements exceed rainfall. An electronically controlled stationary sprinkler system is used to irrigate Nos. 2 through 5 Landfarms as well as a portion of the No. 1 Landfarm. The balance of the No. 1 Landfarm is irrigated with a self-propelled linear sprinkler system. Treated Refinery effluent water that meets the NPDES permit requirements for discharge is used as the water supply for irrigation. Consistent with the current Biodegradation Activities Plan, the target soil moisture content is between 6 and 20 percent. To ensure that the irrigation schedule is adequate, soil moisture monitoring is conducted as part of the soil monitoring program (see Section 2.2.3.3). Results of the soil moisture monitoring will be included in the *Semi-Annual Landfarms Status Reports*.

Stormwater Runoff and Run-on Control - The surface of each Landfarm is graded to control the runoff of rainwater. The interior grading of the Landfarms causes rainwater to pond in a single low area in each Landfarm. When rainwater has ponded in the Landfarms, it is pumped out for treatment in the Refinery effluent treatment system. The first stormwater of the season is sampled and analyzed to verify its suitability for discharge to the Refinery effluent treatment system. Historical results have confirmed that the chemical nature of the stormwater meets effluent treatment system requirements.

Surface water run-on at the Landfarms is prevented by means of above-grade berms that encircle the perimeter of each Landfarm. These berms prevent stormwater in the adjacent areas from running onto the surface of the Landfarms.

General Maintenance - In addition to the above-mentioned activities, the Landfarms are surveyed weekly to check the integrity of the berms and the general condition of the facility. Berms are repaired if any erosion is observed. The vegetative cover on the berms, warning signs, and operating equipment are also regularly maintained.

2.2.5.2 Monitoring

Soil Monitoring Program - The objective of the Soil Monitoring Program is to document maintenance of soil nutrients, pH, and to evaluate soil conditions for plant growth. To meet these objectives, Chevron will collect a minimum of one sample per acre within each Landfarm from the surface to 1 foot below ground surface (bgs) on a quarterly basis. The sample locations will be identified and sampled in accordance with the Landfarms Quarterly Soil Monitoring procedures included in the initial Closure Plan (Chevron, 1988). The collected samples will be analyzed for the following:

- Water soluble ammonia by EPA method 365.3;
- Total acid soluble potassium by EPA method 6010;

- Water soluble orthophosphate by EPA method 300.0;
- Acid hydrolyzed phosphate by EPA method 365.3;
- Soil pH; and
- Total heterotrophic bacteria enumeration (semi-annually only).

In addition to the quarterly monitoring, weekly monitoring of the soil moisture will be conducted at locations where there is evidence of insufficient irrigation and/or dry soil. The irrigation plan will be adjusted as necessary to address areas of insufficient soil moisture.

Groundwater Monitoring Program - Quarterly groundwater sampling is performed for the Landfarms facility. The results of the chemical analyses performed on the samples are presented in the Landfarms Groundwater Monitoring Program Quarterly Reports that are submitted to the U.S. EPA, DTSC, and the RWQCB. The groundwater monitoring program involves the sampling of 24 Landfarms area monitoring wells and 5 background monitoring wells. A summary of the Landfarms Groundwater Monitoring Program is presented in Section 3.5 below.

It has been generally recognized by Chevron and the various regulatory agencies that there is no physical separation between the wastes in and under the Landfarms and the first underlying groundwater table, leaving no clean vadose zone to monitor for the migration of constituents. Therefore neither the U.S.EPA nor the DTSC require Chevron to perform vadose zone monitoring. Section 3.6 discusses the corrective actions Chevron has implemented for the potentially contaminated "A" Zone groundwater.

2.2.5.3 Reporting

The results of the quarterly reconnaissance of the Landfarms vegetation and surface soil conditions will be presented to the DTSC in the Semi-Annual Status Letter. The status letter will summarize observations of the Landfarms vegetation and soils analysis, coupled with a description of the modifications made to the operating procedures including mowing, reseeding, irrigation cycles, microbial counts, and fertilizer requirements in response to the quarterly results received.

2.3 Climatology

The marine climate at the Refinery is characterized by prolonged, essentially rainless periods during half of the year, with most of the precipitation falling between the months of November and March. Based on the rainfall data collected between 1950 and 1994 at the City of Richmond's City Hall, which is located 2-1/4 miles southwest of the site, the mean annual precipitation is 22.0 inches. The maximum annual recorded rainfall is 45.77 inches and occurred between July 1, 1982 and June 30, 1983. The minimum annual recorded rainfall is 9.05 inches and occurred between July 1, 1975 and June 30, 1976. The maximum recorded 24-hour rainfall is 6.83 inches, recorded on January 4, 1982.

As presented in the U.S. Department of Commerce Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 years (May, 1961), the precipitation depth for a 24-hour event with a 100-year return frequency at the Refinery is 5.6 inches. Precipitation duration-frequency curves are not available for a 1,000-year recurrence interval. Therefore, the rainfall value for a 1,000-year return period, 24-hour event was extrapolated from the data prepared by the U.S. Department of Commerce for recurrence intervals of 1, 2, 5, 10, 25, 50, and 100 years. The extrapolated depth of precipitation was calculated to be 7.4 inches, as presented in the *Landfill 15 Facilities Construction Workplan* (BEDM, April 30, 1992).

Castro Creek is located in the eastern portion of the Refinery (Plate 2-4). The current flood hazard rating

maps for Castro Creek (FEMA, 1978), adjusted for more recent tidal elevation data (United States Corps of Engineers, 1984) indicate that the still water level in Castro Creek is not expected to rise above an elevation of 8.6 feet Richmond Refinery Datum (RRD) during a 100-year storm event (Elevation 0 RRD corresponds to Elevation -2.2 feet National Geodetic Vertical Datum of 1929).

2.4 Surface Water

As described in the *Refinery-Wide Report of Waste Discharge (ROWD*, Dames & Moore, August 31, 1988), several surface water bodies exist within a one-mile radius of the Richmond Refinery perimeter. Those identified include the saline waters of the San Francisco and San Pablo Bays, and the man-made shipping harbor channel, Santa Fe Channel, and the Lauritzen Canal. Wildcat Creek and San Pablo Creek are two tidally influenced freshwater streams located northeast of the Refinery. Castro Creek is located on the boundary between the Chevron Refinery property and the Chevron Chemical property. Two marsh areas are located north of the Refinery between San Pablo Creek and Wildcat Creek. These contain many small tidal tributaries that drain and feed the marshes. Seasonal changes in surface water and representative chemical analyses are discussed in the *1988 Refinery-Wide ROWD*.

The surface water bodies that lie in the vicinity of the Landfarms facility are: Castro Creek (800 feet from No. 3 Landfarm), Herman Slough (2,000 feet from No. 3 Landfarm), Wildcat Creek (2,500 feet from No. 3 Landfarm), and Castro Cove (2,500 feet from No. 1 Landfarm). These surface water features lie in the north and eastern portions of the Refinery, to the north of the Landfarms (Plate 2-4).

3.0 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The regional geologic setting of the Richmond Refinery is described in detail in the *1988 Refinery-Wide ROWD*. Excerpts of the geology section as it pertains to this closure plan are included in the following sections. The seismic setting section from the *1988 Refinery-Wide ROWD* is included in its entirety in Appendix C. A supplementary section discussing the expected Maximum Credible Earthquake (MCE) for the site can be found in Section B.2.2.2 of Appendix B.

3.1 Regional Geology

The Refinery is located within a localized northwest trending graben, or trough, along the eastern margin of San Francisco Bay, as shown on Plate 3-1. Franciscan bedrock below the graben has been down-dropped along the now inactive San Pablo Fault, which parallels the eastern face of the Potrero-San Pablo Ridge, and along the Hayward Fault Zone, which forms the western scarp of the Berkeley Hills.

Throughout the Pleistocene, there were cycles of sea level rise and fall. Because the site is located near the edge of the inundated zone, in an area that is nearly level, even minor fluctuations in the Bay water level would have resulted in extensive interfingering of alluvial and estuarine sediments as the site area underwent episodic shallow flooding. Because of uncertainty surrounding the stratigraphic classification of the Pleistocene bay and alluvial sediments, the interfingering alluvial and estuarine deposits underlying the site have been identified only in terms of their environments of deposition rather than by correlation with deposits in other parts of the Bay. The Refinery can be subdivided geologically into two areas: the Bay margins and the Potrero-San Pablo Ridge.

3.1.1 Bay Margin Area

In general, the developed portions of the Refinery in the flat Bay Margin zone are underlain by a layer of fill that ranges in thickness between 2 and 15 feet. Below the fill is a layer of soft silty clay with organic matter known as Young Bay Mud. The upper 2 to 3 feet of the Young Bay Mud layer are generally peat-rich. The configuration of the bottom of the Bay Mud seems to define a northwest trending valley that

parallels the Potrero-San Pablo Ridge and an east-west trending valley through the center of the Refinery (Dames & Moore, 1981). The thickness of the Bay Mud under the Refinery ranges from 60 feet, below the No. 1 Oxidation Pond northwest dike, to 4 feet, below the Kelham Warehouse parking lot near the junction of Interstate 580 and Castro Street. East of Castro Street and toward the Potrero-San Pablo Ridge, the Bay Mud pinches out, and it is not present in areas landward of and higher than the 1898 shoreline. In these areas, recent fill is underlain by alluvium.

In areas where the Young Bay Mud is present, it is underlain by 3 to 15 feet of a stiff silty clay known as Old Bay Mud, which is underlain in turn by a thick sequence of interfingering alluvial fan and estuary deposits over Franciscan bedrock. The Young Bay Mud and Old Bay Mud are the most recent estuary layers in the alluvial/estuarine sequence described below.

The alluvial deposits are highly variable, ranging from brown and grayish-brown silty clays to silty sands with occasional fine gravel lenses. This variability reflects two major processes. The first is the internal depositional regime of the alluvial fans, which are formed as sediment is gradually eroded from hills and deposited in a series of poorly sorted sheet wash deposits. In general, coarser gravel and sands are deposited in the upper, or proximal, part of the fan, while silts and clays are deposited out along the more flat-lying, distal portion of the fan. The second process takes place as runoff channels on the fan surface further transport and sort sediments of varying size, and large storms carry pulses of coarse sediment onto the distal end of the fan.

The basic alluvial fan structure has been complicated by sea level changes that may be related to Pleistocene glacial cycles. As sea level rises and falls, the fan base level changes so that the boundaries of the proximal and distal environments, gradational in any case, are constantly migrating. In addition, the fans that overlapped in the Refinery area originated from two sources, the Berkeley Hills to the east acting as the major sedimentary source with the Potrero-San Pablo ridge yielding smaller quantities of material.

The estuary deposits generally consist of brownish-gray to gray silty clays and clayey silts that were deposited in the shallow marine environment of the early Bay. These clays can be calcareous and frequently contain shell fragments. Localized thin sandy deposits within the estuarine sequence could represent former tidal inlets or channels within the estuary environment. Because the Refinery is located near present and past Bay shorelines, the estuary sediments frequently contain an alluvial component. In general, the shallow, near-shore environment receives an influx of alluvial sands and silts, which are then reworked by current action and benthic organisms.

Bedrock under the Refinery consists of sandstones and siltstones of the Franciscan Formation, and its depth is variable. It can be found at the surface in the form of the Potrero-San Pablo Ridge.

3.1.2 Potrero-San Pablo Ridge

The ridge areas are typically underlain by thin soil and colluvium, over bedrock. The colluvium typically consists of gravelly clay with angular rock fragments. In downslope areas near the flatland, it is anticipated there will be alluvial deposits as described in Section 3.1.1, which may be locally covered by structural fills, overlying colluvium. The underlying bedrock consists of sandstones and shales of the Franciscan assemblage.

3.2 Site-Specific Geology

Based on the regional geologic setting described above, the Refinery has been divided into four physiographic/geologic provinces: the "Flats", the "Ridge", the "Alluvial", and the "Transition" Zones (Plate 3-2). The Flats Zone comprises the flatland Bay Margin areas adjacent to San Pablo Bay that were once marshlands. The Ridge Zone comprises the San Pablo Ridge above an elevation of approximately +50

feet RRD. The Alluvial Zone comprises flatland areas of alluvial fan deposits, derived from the Berkeley Hills, east of the Refinery. The Transition Zone is the area that separates the Flats Zone from the Alluvial Zone and the Ridge Zone.

The Landfarms are located in the Flats Zone of the Refinery. Site stratigraphy in this area is interpreted from observation of surface conditions and the evaluation of data obtained from monitoring wells and borings drilled during the Landfarms Reconnaissance Survey (Dames & Moore, January 9, 1989) and previous studies in the vicinity. The locations of geologic cross sections through the Landfarms are shown on Plate 3-3. The stratigraphy beneath No. 1 Landfarm is shown on Plate 3-4. The stratigraphy beneath Nos. 3 and 4 Landfarms is shown on Plate 3-5. Details regarding site groundwater conditions are presented in Section 3.3.

The stratigraphic units within this area consist of fill that is underlain, in order, by Young Bay Mud, Old Bay Mud, inter-fingering alluvial and estuarine deposits, and Franciscan bedrock. Bedrock was not encountered in any of the borings drilled within the area and none of these borings extended through the alluvial/estuarine deposits. Therefore, the actual thickness of the alluvial/estuarine deposits beneath this area is unknown. The presence of bedrock is inferred based on borings drilled elsewhere in the Refinery and on exposures in the adjacent hills. Bedrock probably occurs at a depth greater than 200 feet beneath the Landfarms. The artificial fill and underlying units are discussed below.

3.2.1 Fill

Fill at the Landfarms generally consists of two stratigraphically distinct layers that differ in color, grain size, and material type. The upper layer, or Landfarms fill, is 1.5 to 7.5 feet thick and consists of dark gray to brown silty clay with black mottling, plant roots, and scattered gravel and sand. Currently, each Landfarm fill zone is tilled and watered and has soil amendments added to promote biodegradation. The lower fill layer (the fill underlying the upper Landfarms fill) ranges from 3 to 19 feet, and is generally composed of gravelly to silty clay with variable amounts of gravel, sand, silt, man-made materials such as brick, concrete and glass, and pockets of black, soft sludge (silty clay saturated with oily and tarry substances). The present location of the northwestern part of the No. 1 Landfarm and the Isomax Plant area to the north of the No. 1 Landfarm and the present Nos. 2 through 4 Landfarms areas were underlain by several ponds that were backfilled. A detailed summary of the history and a chemical characterization of the landfills are presented in the *RCRA Facilities Investigation for the Landfills Under Isomax and No. 1 Landfarm and Landfill Under Nos. 2 and 3 Landfarms* (BEDM, November 24, 1992). The pockets of sludge found within the lower fill probably represent old fill material and oily wastes within the ponds. Portions of the lower fills have been historically described as "the Landfills beneath the Landfarms." A description of the former ponds and pre-Landfarm fill material is presented in the Biodegradation Activities Report (BEDM, 1992) and the RCRA Facilities Investigation, referenced above.

3.2.2 Young Bay Mud

The Young Bay Mud underlies the fill, overlies the Old Bay Mud, and ranges between 5 and 30 feet in thickness beneath the Landfarms. The Young Bay Mud generally consists of dark brown to dark gray, soft to medium-stiff silty clay that contains varying percentages of organic material, peat, and occasional sandy units. Trace to abundant amounts of peat are present in the upper 1 to 7 feet of the Young Bay Mud and are referred to as the Peaty Bay Mud unit. The available stratigraphic data suggest that the Young Bay Mud thins in a southeasterly direction toward Castro Street and in a southwesterly direction toward San Pablo Ridge.

3.2.3 Old Bay Mud

The Old Bay Mud is generally stiffer than the overlying Young Bay Mud and ranges from 1 to 15 feet thick beneath the Landfarms. The Old Bay Mud consists of bluish to greenish gray, medium-stiff to stiff silty clay that contains organic material and local trace amounts of sand. The Old Bay Mud also thins to the

southeast toward Castro Street, and to the southwest toward San Pablo Ridge.

3.2.4 Alluvial/Estuarine Deposits

The alluvial and estuarine deposits are inter-fingered, laterally variable, and generally stiffer and more consolidated than the overlying Bay Mud deposits. The alluvial sediments range from silty clays and sandy silts to silty sands, and vary from brown to olive-gray in color. The estuarine deposits are commonly finer grained, consisting of silty clays with local sand lenses and traces of gravel. Color may vary from dark gray to mottled orange, brown and gray. Lenses of coarse material within the estuarine deposits probably represent former tidal channels or inlets. The complex inter-fingering of the alluvial and estuarine deposits is related to periods of submergence and emergence of the shoreline environment during past fluctuations in sea level.

3.3 Regional Hydrogeology

Six water-bearing zones (designated A through F) have been identified in the unconsolidated sediments beneath the Refinery (Dames & Moore, 1981). Four of the uppermost zones (designated A, C, B, and D in order with increasing depth) have been investigated by means of observation wells, water sampling, and chemical analyses. Each of the zones is separated by a layer of either Bay Mud or estuarine clay, which acts as an aquitard between water-bearing units.

In general, groundwater flows to the northeast, from the San Pablo Hills toward San Pablo Bay, and to the northwest from the Berkeley Hills toward San Francisco Bay. Groundwater flow rates are relatively low beneath the Refinery due to the heterogeneity and low permeability of the sediments in each of the water-bearing units. Hydraulic characteristics for the upper units were investigated by Dames & Moore (Dames & Moore, 1985, 1988) and were used to estimate average flow rates for the various units. The flow rates were previously estimated (Dames & Moore, 1988) by calculating the average linear horizontal flow velocity using the equation:

$$V = (k/n)\ I$$

Where: V = linear velocity

k = permeability

n = porosity

I = hydraulic gradient

Based on previous investigations (Dames & Moore, 1985, 1988) and our understanding of soil conditions at the site, the porosity was assumed to be 0.3. Average permeabilities for the "A" and "C" Zones were established by conducting limited aquifer testing in 9 "A" Zone wells and 2 "C" Zone wells throughout the Landfarm area. Permeability in the "B" Zone were calculated from a number of "B" Zone wells throughout the Refinery.

A summary of the aquifer properties and average flow rate ranges in the Landfarms area is presented below.

ZONE	CASE	HORIZONTAL PERMEABILITY[1] (CM/SEC)	AVERAGE HYDRAULIC GRADIENT (FT/FT)	AVERAGE HORIZONTAL VELOCITY (FT/DAY)
A	Minimum	1.4×10^{-7}	0.001	1.3×10^{-6}
A	Maximum	$>10^{-3}$	0.001	9.5×10^{-3}
C	Minimum	5.5×10^{-4}	0.1	5.2×10^{-3}
C	Maximum	9.7×10^{-4}	0.8	4.2×10^{-3}
B	Minimum	1.0×10^{-6}	0.001	9.4×10^{-6}
B	Maximum	3.0×10^{-2}	0.001	2.8×10^{-1}

1. Wells with slow recharge and untested aquiclude layers were assigned a horizontal permeability of 1.0×10^{-7} cm/sec.

The two water bearing zones nearest the surface of the Landfarms ("A" Zone and "C" Zone) contain brackish water, have never been suitable for use as drinking water, and can not be practically used for any beneficial purpose. The uppermost potentially usable "aquifer" underlying the site occurs at an approximate depth of 100 feet ("B" Zone). Chemical test results have shown that this water-bearing zone is effectively separated from overlying water-bearing units by a thick layer of estuarine clay and is more representative of fresh water as opposed to the brackish water typical of the shallower water-bearing units (Dames & Moore 1985, 1988). This distinction is enhanced by hydraulic separation due to an upward component of the groundwater gradient from the lower "B" Zone into the upper "A" and "C" Zones (Dames & Moore, 1985). Based on the hydrogeologic data collected across the Refinery, it does not appear that features such as faults or other natural features exist beneath the Landfarm area. The lack of such features suggests that conduits do not exist which prevents an artificially enhanced downward migration of chemical constituents. The "B" Zone is further protected by the nature of the contaminants; being light non-aqueous phase liquids which float on the groundwater as opposed to dense non-aqueous phase liquids which tend to sink to the bottom of aquifers (BEDM, 1992, 1993).

3.4 Site-Specific Hydrogeology

Two upper groundwater zones appear to be continuous across the Landfarms areas. For the purposes of this report, and to be consistent with other groundwater studies in this area, we have designated the zones "A" and "C," with increasing depth.

3.4.1 "A" Water Table Zone

The "A" Zone, or water table zone, is a brackish water-bearing zone that is usually encountered at depths less than 15 feet bgs. The "A" Zone water table contour maps for this zone during the second quarter 1996 are shown on Plates 3-6 and 3-7. A Refinery-wide contour map for the second quarter of 1996 is presented on Plate 3-8.

Soils within the "A" Zone typically consist of fill materials and the upper organic-rich portion of the Young Bay Mud, referred to as Peaty Bay Mud. These "A" Zone soils are underlain by the peat-free portion of Young Bay Mud and Old Bay Mud. The "A" Zone matrix is highly variable, consisting of silty, sandy and gravelly clay with low to moderate hydraulic conductivities and silty sand and gravel with moderate to high hydraulic conductivities. The Peaty Bay Mud may be orders of magnitude more permeable than the relatively peat-free Bay Mud and, therefore, is considered to be part of the "A" Zone. The peat-free portion of the Young Bay Mud and the Old Bay Mud together act as a low-permeability barrier, or aquitard, between the "A" and "C" Zones.

Overall "A" Zone flow in the Flats Zone at the Refinery is northeast toward the Bay. However, local mounding of groundwater occurs in the vicinity of the Landfarms. This mounding, due to watering activities on the Landfarms, causes local reversals in gradient. Once the proposed Landfarm vegetative cover becomes fully established and acts to reduce infiltration, the local mounding of the water table will likely be reduced and the gradient will resume an overall northeasterly direction under No. 1 Landfarm. Groundwater flow under Nos. 2 through 5 Landfarms will be toward the existing and planned groundwater extraction systems. Other anthropogenic features that affect the configuration of the water table surface in the vicinity of the Landfarms include the 250-Foot Channel, the Bioreactor, and the Water Enhancement Wetlands Project (Plate 2-4).

Groundwater flow in the "A" Zone beneath the Landfarms is expected to be relatively slow due to the low hydraulic conductivity of the fill material. Based on aquifer tests conducted in 6 wells in the No. 1 Landfarm area and 9 wells in the Nos. 2 through 5 Landfarms area, hydraulic conductivities in the No. 1 Landfarm area range from 2.52×10^{-5} cm/sec to greater than 10^{-3} cm/sec, with an average of 2.0×10^{-4} cm/sec. Hydraulic conductivities in the Nos. 2 through 5 Landfarms area range from 1.4×10^{-7} cm/sec to greater than 10^{-3} cm/sec, with an average of 1.8×10^{-5} cm/sec. As can be seen on Plates 3-6, 3-7, and 3-8, the groundwater gradient across the Landfarms away from the influence of GPS is relatively flat and, when coupled with the low hydraulic conductivity, suggests a slow component of groundwater flow.

3.4.2 "C" Zone

The "C" Zone is a brackish water-bearing zone underlying the Bay Mud and generally occurring between approximately 20 and 110 feet bgs in the Landfarms areas. The "C" Zone comprises a stratigraphic interval between aquitards that separates it from the overlying "A" Zone and the underlying "B" Zone and is comprised primarily of lower-permeability alluvial and estuarine silts and clays. A number of intermittent sandy lenses occur at different depths and locations within the "C" Zone deposits. In general, these sandy lenses do not appear to be laterally continuous. The "C" Zone water level contour map for the second quarter 1996 is shown on Plate 3-9. In general, "C" Zone water levels indicate a lateral gradient toward the southeast beneath the No. 1 Landfarm and to the west beneath the Nos. 2 through 5 Landfarms.

Groundwater flow in the "C" Zone beneath the Landfarms is also expected to be relatively slow for the same reasons as in the "A" Zone. Based on aquifer tests conducted on 2 wells in the Nos. 2 through 5 Landfarms, hydraulic conductivities ranged from 5.5×10^{-4} cm/sec, to 9.7×10^{-4} cm/sec, with an average of 7.6×10^{-4} cm/sec. These values are generally consistent with those measured in other "C" Zone wells throughout the Refinery (BEDM, 1991) and are also expected to be reflective of conditions beneath the No. 1 Landfarm. As seen on Plates 3-9, the groundwater gradient across the Landfarms is relatively flat and, when coupled with the low hydraulic conductivity, suggests a slow component of groundwater flow.

3.4.3 Bay Mud Aquitard

The "A" and "C" Zone are separated by Young and Old Bay Mud units that collectively range from

approximately 5 feet to 30 feet thick beneath the Landfarms, as stated above. The permeability of the Bay Mud is approximately equal to or less than 1.0×10^{-7} cm/sec. The Bay Mud acts essentially as a low-permeability layer providing an effective barrier to the downward vertical movement of potentially contaminated groundwater.

Locally the Bay Mud contains peat zones in the upper 1 to 2 feet of the Bay Mud layer. Where present, the peat tends to slightly increase the horizontal permeabilities of the Bay Mud. Where present, elements of the closure unit will be keyed into the lower permeability non-peaty Bay Mud (See Section 3.6). The integrity of this low-permeability barrier is evidenced by the confined conditions and varied groundwater elevations between "C" Zone and the "A" Zone. Evaluation of groundwater elevations in "C" Zone wells presented in Plates 3-9 supports the integrity of the Bay Mud barrier and confined groundwater conditions. For example, water levels in many of the "C" Zone wells rise well above the Bay Mud into the "A" Zone and groundwater elevations in the "C" Zone are notably different than those in the "A" Zone. Additionally, influences of groundwater extraction in the "A" Zone (see Section 3.6) are not observed in the "C" Zone.

3.5 Landfarms Groundwater Monitoring Program

The Landfarms Groundwater Monitoring Program (LGMP) is implemented in conjunction with the Refinery-wide Groundwater Monitoring Program (RGMP). The LGMP is designed to comply with the U.S. EPA and DTSC Consent Agreements and the California Code of Regulations (CCR) Title 23, Article 5 requirements for corrective action monitoring programs. The LGMP corrective action monitoring program includes 24 on-site groundwater monitoring wells located at Nos. 1 through 5 Landfarms (Plate 3-8) and 5 background wells (Plate 1-1). Monitoring is conducted on a quarterly basis. Details of the monitoring program are summarized in the sections below.

3.5.1 Monitoring Points, Constituents, and Frequencies

The LGMP includes 19 "A" Zone wells and 5 "C" Zone wells located on site and 3 "A" Zone and 2 "C" Zone background wells located off site. The on-site wells are shown on Plate 3-10. The off-site wells are located north and east of the Refinery property. Water levels, free-phase hydrocarbon thickness, and chemical constituents are monitored on a quarterly basis in all 29 LGMP wells. Metals, VOCs, and SVOCs are tested for in those wells that do not contain free-phase hydrocarbons. A detailed list of the specific chemical constituents is presented on Table 3-1.

3.5.2 Concentration Limits/Groundwater Quality

The results of the chemical testing are compared quantitatively against both background levels and historical levels within each respective well. The most recent data reported are for the second quarter 1996 and were reported in the *Landfarms Groundwater Monitoring Program, Second Quarter 1996 Report* (Chevron, September 27, 1996). Results for the third quarter 1996 will be submitted on or before December 29, 1996. This information is included as part of this Closure Plan by reference.

3.6 Corrective Action

As part of the overall Refinery-wide Groundwater Protection System (GPS), groundwater extraction trenches were installed along the downgradient perimeter of the Landfarms between 1990 and 1993. The Landfarms GPS also serves as corrective action for the Landfills that underlie portions of the Landfarms (see Section 3.2.1). The objective of the GPS for the entire Refinery, including the Landfarms areas, is to establish and maintain a physical or hydraulic barrier to prevent the off-site movement of potentially contaminated "A" Zone groundwater. The GPS includes a perimeter system that consists of either extraction trenches, or a combination of soil/bentonite barrier walls with either extraction trenches or

extraction wells. Groundwater is continually pumped from the trenches and wells to treatment facilities, and the resulting hydraulic depression establishes and maintains a capture zone intended to prevent the migration of potentially contaminated groundwater past the GPS alignment. The associated physical barriers are intended to provide secondary containment for the hydraulic barriers, and to provide additional protection to wetlands or water bodies from the effects of groundwater extraction. The laterally extensive Bay Mud deposit constitutes the floor of the system and restricts the flow of groundwater from the "A" Zone to the "C" Zone. The GPS concept and details were approved by the RWQCB as appropriate corrective action for potentially contaminated "A" Zone groundwater.

The major GPS groundwater control features for the Landfarms are: 1) a laterally extensive deposit of low-permeability Bay Mud underlying the entire Landfarms site; 2) a physical barrier (soil-bentonite slurry wall) to the northeast adjacent to Castro Creek and to the south of Nos. 2 through 5 Landfarms (the southern wall is partially constructed and is scheduled for completion in 1997); 3) an "A" Zone hydraulic barrier (groundwater extraction trench or extraction well) between the northeast perimeter of No. 1 Landfarm, along the north and west perimeter of Nos. 2 through 5 Landfarms, and in the gap in the new barrier wall where it crosses the Deep Water Outfall Project (DWOP) pipelines; 4) a transfer system for extracted groundwater; and 5) a potentiometric and water quality monitoring system sufficient to evaluate the effectiveness of the GPS. The northeastern-most end of the Nos. 2 through 5 Landfarms groundwater extraction trench is tied into the Landfill 15 extraction trench and the southeastern-most end of the new barrier wall to the south of Nos. 2 through 5 Landfarms is tied to the Landfill 15 barrier wall, providing a continuous barrier completely around the Nos. 2 through 5 Landfarms (Plate 3-10). This configuration provides hydraulic control and in some areas physical control on the downgradient and cross gradient sides of the Landfarms.

The design of the extraction trenches and wells was based on the groundwater flow characteristics of the "A" Zone water-bearing unit. In general, groundwater flows to the north in the vicinity of Nos. 2 through 5 Landfarms with localized mounding directly beneath the Landfarms. This mounding is likely due to a combination of surface mounding, topographic configuration, irrigation activities, rainfall, slow percolation, low hydraulic conductivity, low hydraulic gradient, and resultant slow groundwater flow. Regardless of local groundwater mounding, the general groundwater flow will be toward the GPS. Groundwater flow in the vicinity of No. 1 Landfarm is generally to the northeast, directly toward GPS. A small mound is present in the northwest corner of the No. 1 Landfarm, which is also suspected to be an artifact of irrigation activities. Regardless of the source, the small mound in No. 1 Landfarm does not significantly affect the groundwater flow in the area.

The groundwater extraction trenches are approximately 1.5 to 2 feet wide and extend to a depth of approximately 2 feet into non-peaty Young Bay Mud. The trenches are excavated through sheet piles using a backhoe, lined with geotextile filter fabric and backfilled with coarse-grained drain rock. A groundwater extraction sump is placed approximately every 100 to 150 linear feet along the trench. The sumps are typically 12-inch-diameter Schedule 40 carbon steel pipe, screened with 1/4-inch by 6-inch slots across the entire length of the casing. The groundwater extraction wells, to be constructed behind the short gap where the new barrier wall south of the Nos. 2 through 5 Landfarms crosses the DWOP pipelines alignment (drawing D-318541), will consist of 12-inch-diameter slotted PVC casing extended approximately 13 feet bgs.

A shallow drainage trench will be located directly adjacent to the new barrier wall south of Nos. 2 through 5 Landfarms on the Landfarms side and extending from the Nos. 2-5 Landfarms GPS to the DWOP pipelines (drawing D-318541). The drainage trench will be designed to intercept groundwater migrating south from the Landfarms area that may otherwise build up and over-top the barrier wall. The drainage trench will differ from GPS extraction trenches in that it will not penetrate to Bay Mud, and will not be designed to affect a hydraulic barrier; rather it will be designed to maintain groundwater levels at least one

foot below the top of the barrier wall. The trench will include a perforated drain pipe that will drain the intercepted groundwater to strategically placed sumps. Water collected in the sumps will be pumped to the Refinery's effluent system for treatment.

The groundwater transfer system consists of interconnected air ejector pumps placed in each of the sumps, pump controllers, piping, and associated instrumentation. The designed groundwater extraction rate from the Landfarms extraction trenches is 200 gpm for No. 1 Landfarm and 240 gpm for Nos. 2 through 5 Landfarms. Actual extraction rates during the first quarter of 1996 for No. 1 Landfarm averaged 70 gallons per minute (gpm) with a maximum recorded rate of 146 gpm; rates for the Nos. 2 and 3 Landfarms trench averaged 45 gpm with a maximum recorded rate of 70 gpm; and rates for the Nos. 2 and 5 Landfarms trench averaged 41 gpm with a recorded maximum of 85 gpm. Details of the groundwater extraction trenches and transfer system are included in Appendix J.

Based on chemical analytical data for groundwater samples from wells in the area of the Landfarms GPS, the extracted groundwater is non-hazardous and is compatible with the Refinery's effluent treatment system. Therefore, the extracted groundwater is routed through nearby oil-water separators to remove and recycle the recoverable free-phase hydrocarbons. The water then flows to the Refinery's Bioreactor, where it is further treated prior to discharge through the deep water outfall pipeline into San Pablo Bay under the Refinery's NPDES permit.

The Environmental Operations Section of the Refinery's Utilities/Environmental Area Business Unit (U/E) is responsible for operating and maintaining the GPS. Environmental Operations Section personnel visually inspect all pipelines and controllers several times a week to assure that the system is operating properly. The design of the GPS extraction system, with pumps located at roughly 200-foot intervals, is inherently redundant. Hence the malfunction of any one pump is not expected to significantly reduce the effectiveness of the system at containing the Landfarms groundwater as the groundwater normally recovered by the malfunctioning pump would flow laterally towards the adjacent pumps until the pump could be repaired or replaced. The Refinery maintains a supply of spare pumps, so pump replacement could be performed in a matter of hours. If needed, Refinery personnel would supplement the GPS pumps with temporary air or diesel powered pumps.

The effectiveness of the GPS in containing "A" Zone groundwater is monitored and reported to the RWQCB, DTSC, and the U.S. EPA as part of the Refinery-wide Groundwater Monitoring Program (RGMP). The scope of the RGMP is specified in the Monitoring and Reporting Program of RWQCB Order 93-109. "A" Zone piezometric monitoring is performed as part of the RGMP to demonstrate that a hydraulic barrier is maintained by the GPS at the perimeter of the closure units. Chemical monitoring in the "A" Zone supplements piezometric monitoring and assists in evaluating the effectiveness over time of the GPS corrective action. Chemical monitoring in the "C" Zone verifies that water quality below the Bay Mud at the point of compliance has not been degraded (BEDM, 1991).

3.7 GPS Effluent Water Quality Monitoring

As part of preliminary discussions regarding closure details for the Landfarms, the DTSC requested Chevron evaluate the GPS effluent water to verify that it was indeed compatible with the Refinery's effluent treatment system and should not be subject to RCRA leachate requirements. As has been confirmed in discussions with DTSC staff, if the water collected from the GPS in the vicinity of the Landfarms tests to be characteristically non-hazardous, the water is considered non-hazardous and can be routed directly to the Refinery NPDES treatment system without pre-treatment, even accepting the DTSC's position that leachate may be co-mingled with the groundwater.

To evaluate the potentially hazardous nature of the extracted water, BEDM developed a sampling methodology, chemical testing program, and data analysis methodology that followed the general guidelines presented in the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities" (February, 1989). Details of the evaluation program were presented to the DTSC with Chevron's letter dated May 6, 1996 *Waste Discharge Order Project, Richmond Refinery Landfarm Closure, Proposed GPS Effluent Water Sampling Plan.* Briefly, the program consists of collecting a statistically representative number of time-integrated composite effluent samples from several locations along the Landfarms GPS and evaluating the samples for hazardous waste criteria as specified in 22CCR261. Sixteen sampling rounds from the four locations shown on Plate 3-11 were proposed in Chevron's letter. Chemical testing is being conducted by CEL of Richmond, California. The effluent water samples are being tested for hazardous waste characteristic criteria including:

- Ignitability (flash point less than 60°C (140° F);
- Corrosivity (pH less than or equal to 2 or greater than 12.5);
- Reactivity (in terms of reactive cyanide and reactive sulfide); and
- Toxicity (by the Toxicity Characteristic Leaching Procedure (TCLP), 96-hour acute aquatic toxicity test (as described in "Static Acute Bioassay Procedures for hazardous Waste Samples," California Department of Fish and Game, Water Pollution Control Laboratory, revised November 1988) and the California Waste Extraction Test (WET) (22 CCR methodology).

Seven sampling rounds have been completed to date, with the first round having been collected on July 11, 1996 and the most recent on October 25, 1996 (due to equipment problems, only location GPS-1 was sampled in the second round). The most recent set of results presented in this document was for samples collected on September 26, 1996. A complete list of the chemical analyses being performed on the water is presented in Table 3-2, and the maximum levels of each constituent tested to-date are presented in Table 3-3.

As shown in Table 3-3, of the metals analyzed by the TCLP, barium was detected in samples from all four sampling points at concentrations up to 0.810 mg/L, and selenium at two locations at concentrations up to 0.014 mg/L, all well below the regulatory limits. For the WET metals, arsenic was detected at location 3 with concentrations up to 0.384 mg/L; barium was detected in all samples, with concentrations up to 1.35 mg/L; chromium at three locations at concentrations up to 0.084 mg/L; cobalt was detected at two locations at concentrations up to 0.084 mg/L; copper was detected at least once at each location at concentrations up to 0.592 mg/L; molybdenum at each location with concentrations up to 0.304 mg/L; lead was detected in one sample from location 4 at a concentration of 0.103 mg/L; mercury and nickel were detected at location three at concentrations up to 0.459 ug/L and 0.144 mg/L respectively; selenium was detected at three locations at concentrations up to 0.005 mg/L; vanadium was detected at all locations at

concentrations up to 0.122 mg/L; and zinc was detected at each of the locations at concentrations up to 3.90 mg/L. All of the detected WET metals were at concentrations below the regulatory limits. Only one of the samples collected contained detectable amounts of reactive cyanide or sulfide. The measured pH values ranged from 7.06 to 8.17, all well within the limits for corrosivity. No volatile organic compounds of concern were detected in any of the samples. Only one semi-volatile organic compound was detected (pentachlorophenol at 0.0277 mg/L). No samples failed the acute aquatic toxicity or flash point tests.

The chemical test data will be evaluated according to the statistical procedures outlined in the *"Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities"* guidance manual. The methods, procedures, and results of the sampling will be submitted in a letter report to the DTSC within eight weeks of collecting the last sample.

3.8 Free-Phase Hydrocarbons

In accordance with the current Waste Discharge Order (WDO, 1992), Chevron evaluates the presence and recoverability of free-phase hydrocarbons (LNAPLs) in wells throughout the Refinery. As part of this evaluation program, BEDM conducted studies to measure and track the trends of hydrocarbon accumulation in the Landfarms monitoring wells, assess the recoverability of the hydrocarbon by conducting LNAPL recharge tests and performed hydrocarbon fingerprint analyses. Based on the results of the evaluations, Chevron implemented an LNAPL recovery program whereby LNAPLs were extracted from several of the wells within the Landfarms footprint on a regular basis. The frequency of recovery ranged from weekly to quarterly, dependent on the rate of LNAPL recovery observed in each well. Recovery of LNAPLs by vacuum trucks was discontinued in mid-1995 because the thickness of free-phase hydrocarbons was consistently less than ½ foot in the interior wells and the GPS in the area of the Landfarms had become fully operational. Based on results of LNAPL thickness monitoring performed since mid-1995, Chevron has proposed to re-institute periodic LNAPL recovery within the Landfarms, as discussed in Section 5.8.

4.0 LANDFARMS CLOSURE ACTIVITIES

Presented in this section is a discussion of the closure elements for the Richmond Refinery Landfarms. This includes a discussion of the closure strategy, the closure design, and the closure schedule. This closure plan was prepared to conform with State regulations 22CCR66265 and Federal regulations 40CFR265, both of which address the closure of interim status land treatment facilities. As required by the DTSC 1988 Stipulation & Order (HWCA 87/88-019), and the EPA 1988 Consent Agreement (RCRA 09-88-0005), this plan has been developed following the guidelines set forth in the EPA's *Guidance Manual on Hazardous Waste Land Treatment Closure / Post-Closure,* (EPA Guidance Document) April 1987.

4.1 Closure Plan Design

Based on the site and waste characteristics as detailed in Sections 2.0 and 3.0, a site closure plan was developed for the Landfarms. At Chevron's direction, this plan was based on in-place closure of the Landfarms, which is one of the options that the applicable regulations provide for.

The proposed closure units have been designed to reduce surface water infiltration through the surface of the Landfarms fills and soils and to prevent lateral off-site migration of "A" Zone groundwater from the Landfarms sites. The performance standards for this closure are spelled out in 22 CCR 66265.111, which require that the facilities be closed in a manner that:

- Minimizes the need for further maintenance; and

- Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated rainfall or runoff, or waste decomposition products to the ground or surface waters or to the atmosphere.

In compliance with applicable regulations, Chevron has elected to close the Landfarms by establishing a final vegetated cover over the units. As discussed in Section 3.4.1 of the EPA Guidance Document, the use of vegetation as the final surface cover is highly recommended by the EPA. A major reason for this preference is cited in Section 3.4.1.2 of the EPA Guidance Document, which states "an advantage of closing the HWLT (Hazardous Waste Land Treatment) unit by establishing a vegetative cover is that the wastes are left in place and continued treatment of any remaining constituents can occur in the soil system."

Chevron considered and rejected closing the Landfarms with low-permeability caps (essentially as if they were landfills) for much the same reasons stated cited in Section 3.4.2.2 of the EPA Guidance Document. The same section also states that the use of capping as a closure method for a HWLT unit is not recommended by the EPA.

Additional regulatory objectives for the closure of land treatment facilities, as spelled out in 22 CCR 66265.280(a), are:

- Prevention of the migration of hazardous waste and hazardous waste constituents from the treated area into the groundwater;
- Prevention of the release of contaminated runoff from the facility into surface water;
- Prevention of the release of airborne particulate contaminants caused by wind erosion; and
- Compliance with Section 66265.276 concerning the growth of food-chain crops.

The remainder of this section discusses the closure of the five Landfarms located within the Chevron Richmond Refinery. Section 5.0 presents the post-closure monitoring and maintenance plan and Section 5.2 contains a discussion of post-closure site usage. The drawings referred to in this section (e.g., D-767512) can be found in Appendix J, Construction Drawings.

4.2 Closure Unit Description

4.2.1 Closure Unit Configuration and Topography

To accommodate the final cover configuration of the Landfarms, the surface soils will be graded to improve the stability of the perimeter slopes and to allow for settlement of the final cover while maintaining proper drainage. Grading will involve cutting in some areas and using the cut material as fill in other areas, with clean imported fill used to make up shortfalls in the required fill volumes. Fill material will be placed in 8-inch or 12-inch lifts and compacted as described in Section 4.2.4, below. In areas of cut, and areas where existing grade is adequate, the soil will be scarified 6 inches and compacted as described in Section 4.2.4. The specifications for earthwork are contained in Appendix H.

4.2.2 Overall Configuration - No. 1 Landfarm

The No. 1 Landfarm site is bounded by a GPS extraction trench along its northeastern perimeter. As shown on Plate 4-1, Layout of Proposed Closure Units, the final cover will extend to the outer toe of the existing containment dike on the perimeter of the site, an area of approximately 13 acres. The closed Landfarm will be in the form of a low ridge with gentle slopes. A concrete-lined surface runoff collection ditch will be

provided on the perimeter of the Landfarms to collect surface runoff and route it to the Refinery's clean stormwater impoundment system. The cover will be vegetated with grasses, shrubs, and trees designed to optimize post-closure biodegredation of remaining constituents.

The final cover design and planned drainage control features are described in Sections 4.2.4 and 4.2.5, below. The existing GPS facilities in the Landfarms area were described earlier, in Section 3.6.

4.2.3 Overall Configuration - Nos. 2, 3, 4, and 5 Landfarms

The Nos. 2, 3, 4, and 5 Landfarms closure units will consist of a final cover constructed over the entire footprint of each Landfarm and over most of the existing perimeter dikes, as shown on Plate 4-1. The site containing the four Landfarms is bounded by GPS facilities along its western, southern, and northern perimeters, with Landfill 15 and its GPS facilities to the east. The final cover will extend to the outer toes of the existing containment dikes on most of the Landfarm perimeters, an area of approximately 23 acres. As with No. 1 Landfarm, a concrete-lined surface runoff collection ditch will be provided on the perimeter of the Landfarms to collect surface runoff and route it to the Refinery's clean stormwater impoundment system. The cover will be vegetated with grasses, shrubs, and trees designed to optimize post-closure biodegredation of remaining constituents.

The existing and proposed GPS facilities in the Landfarms area, the final cover design, and planned drainage control features, are described below.

4.2.4 Final Cover Configuration

4.2.4.1 General

As mentioned above, the cover design consists of a vegetated surface. Sections illustrating the final engineered cover design are provided on drawings D-767513 & D-767516 (Appendix J). As discussed with the DTSC (February 27, 1996 Landfarms presentation), the final vegetative cover over the closure units will consist of a minimum of 12 inches of vegetated fill (see Section A on drawing D-757513, Appendix J). The extent of the final cover is shown in plan view for No. 1 Landfarm on the Closure Unit Finished Grading Plan, drawing D-767512, and for Nos. 2 through 5 Landfarms on drawing D-767515.

The Landfarms will be regraded into low mounds to facilitate surface drainage and improve the visual appearance of the sites. The Landfarm soils will be lightly compacted or recompacted with light tracked equipment to support the construction of the final cover while still allowing for easy vegetation root penetration. The final grades are designed to divert rainfall runoff away from the former Landfarms sites. Infiltration into the Landfarms soils will be reduced by the improved surface grading and the surface vegetation, which will take up water by evapotranspiration. The inclusion of a layer of clean soil over the entire Landfarm area will serve to prevent run-off from direct contact with the wastes and also prevent wind erosion of the wastes.

Each of the materials included in the design is described below. A brief description of quality control measures to be used during construction is also provided, with a more complete discussion in Appendices G and H.

4.2.4.2 Perimeter Berms

The portions of the existing perimeter berms that are not spread into the Landfarms areas may require additional compaction to serve as a foundation for the drainage ditches and provide lateral support for the Landfarm soils. The soil will be proof-rolled to locate areas that are soft or loose. These areas will be tested in accordance with ASTM D-1557 to confirm that the materials are compacted to at least 90 percent

of maximum dry density to a depth of 2 feet. If the test results indicate that adequate compaction has not been achieved, the materials will be excavated and recompacted.

4.2.4.3 Interior Soils

The fills within the closure units will need to be graded and lightly compacted to support the construction of the final Landfarms cover, but not overcompacted to a degree that will impede the growth of plant roots and inhibit the continued bioremediation of the remaining hydrocarbons. Fill spreading and compaction will be performed on 8-inch lifts by tracked vehicles. The use of heavy equipment or trucks will be minimized where practical.

4.2.4.4 Vegetated Layer

The top 12-inch soil layer of the cover will consist of two layers. The 6-inch-thick lower clean fill layer provides a firm base suitable for supporting future shrubs and trees, while the 6-inch upper layer will be a relatively loose topsoil that is higher in nutrients in order to facilitate initial plant growth. The vegetation specified for the final cover will be similar to the native grasses, plants, and trees. This will result in a low-maintenance cover with limited need for long-term irrigation. Prior to establishing vegetation, an erosion mat will be attached to the final surface on any steep slope that may be susceptible to erosion.

4.2.4.5 Vegetation

The establishment of vegetation on the Landfarms will be conducted in stages based on the growth rate and performance of different plant species in the field. This section presents an overview of the establishment of the vegetation of the Landfarms.

The purpose of establishing vegetation on the Nos. 1 through 5 Landfarms is to reduce soil erosion by water and wind and to increase microbial populations in the vadose zone leading to enhanced biodegradation of remaining petroleum hydrocarbons. Vegetation will be established in three phases, as depicted on Plate 4-2. A variety of plant and tree species will be used in order to draw from the largest population of species adapted to the soils and climatic conditions of the Landfarms. A list of potential plants is listed in Table 4-2. Chevron will not manage any of these plants as crops intended for either human or animal consumption.

The first phase will establish fast-growing grasses and herbaceous plants, capable of tolerating soil and climatic conditions at the Landfarms in order to establish full cover as soon as possible to prevent erosion. Seeding and irrigation of these plants is scheduled to occur immediately on completion of soil placement for the final cover, with the intent to establish the cover prior to the onset of heavy winter rains. The second phase will focus on selecting deeper-rooted perennial herbs that will enter the subsoils in addition to the upper foot of soil. Placement of the plants identified as "intermediate rooted species" on Table 4-2 will occur during the spring following the planting of the shallow-rooted species. Establishment of hybrid poplar trees and other tree species (if appropriate) will be accomplished by transplanting tree seedlings in a fairly dense stand (1,000 to 5,000 trees/acre) while allowing the herbs planted between rows to remain. Placement of the trees will occur after the deeper rooted herbs have become fully established, which is anticipated to be the third year following the completion of the Landfarms cover. In the third phase, the trees will be thinned enough to allow an understory of herbaceous plants to continue to grow.

By manipulating the vegetation, and the associated rooting depths of the different plants, the entire vadose zone soils will be inhabited by roots. Once colonized by a relatively high density of roots, the soil microbial populations will increase and hydrocarbon biodegradation in the subsoils will be greatly enhanced. The subject of plant-aided remediation of hydrocarbon-containing soils has been the subject of

extensive research in recent years. A collection of recent documents on this subject is attached as Appendix O to this closure plan.

4.2.4.6 Surface Grading

The final surface of the vegetative portions of the Landfarms will be graded such that the surface will retain at least a 3 percent slope, after settlement, to minimize ponding. The slopes will initially be constructed with 4 percent minimum slopes to accommodate the long-term settlements discussed in Section 4.3.1, as shown on drawings D-767512 and D-767515 (Appendix J). The areas surrounding the closure units will be graded to drain away from the closure units such that any runoff from the surrounding areas will flow away from the Landfarms surfaces.

4.2.5 Surface Drainage Control Facilities

The surface drainage control facilities are shown in plan view on drawing D-767512 for No. 1 Landfarm and drawing D-767515 for Nos. 2 through 5 Landfarms (Appendix J). Surface runoff from the exterior slopes of the closure units will be collected in existing or new lined perimeter drainage ditches. Runoff collected at the Landfarms will be pumped to the Refinery's stormwater retention basins. The design basis for the surface drainage facility is discussed in Section 4.3.4.

4.3 Closure Unit Design

The basis of the vegetation to be established on the final cover of the Landfarms was discussed in Section 4.2.4.5. The physical design of the closure units was based on results of settlement analyses, slope stability analyses for both static and dynamic cases, and groundwater protection analyses. The precipitation and drainage control systems were designed to handle runoff from a 24-hour storm event with a 25-year recurrence interval. If a more severe storm were to occur the drainage system would most likely back-up, resulting in localized flooding at the edges of the cap, with the possibility that some of the run-off would drain to other areas. Due to the topography of the adjacent areas, run-off from other areas is unlikely to impact the Landfarms sites. In the event that a more severe storm were to occur, the Refinery would implement inspection and repair operations similar to those outlined in Appendix N.

Descriptions of the analyses performed for design of the physical elements of the closure units are provided below. Results of settlement and slope stability analyses are summarized here, and described in detail in Appendices A and B, respectively.

4.3.1 Long-Term Settlements

Analyses were performed to estimate changes in the long-term surface elevations of the completed closure units due to settlements within the underlying Bay Mud. A detailed description of these analyses is provided in Appendix A. Analyses were made for both No. 1 Landfarm and Nos. 2 through 5 Landfarms. Estimated settlements up to approximately 1.4 feet for No. 1 Landfarm and 0.9 feet for Nos. 2 through 5 Landfarms are expected to occur over approximately 50 years following construction. The majority of the settlement is predicted to occur during the first 20 years following construction. Settlements will result from consolidation of the relatively soft peaty and non-peaty Bay Mud that underlie the Landfarms, and is expected to be greatest below the top of the perimeter slope where the new fill thickness will be greatest. Actual long-term settlements will also vary with the thickness and compressibility of the peaty and non-peaty Bay Mud.

The initial maximum and minimum final elevations of the planned closure units are +23.0 and +14.0 feet RRD for No. 1 Landfarm, and +22.5 and +12.0 feet RRD for Nos. 2 through 5 Landfarms. The final range in elevations is estimated to be +14.0 to + 21.6 feet RRD for No. 1 Landfarm and +12.0 to +21.6 feet RRD for Nos. 2 through 5 Landfarms following long-term settlements. The initial elevations were selected to allow for constructing minimum slopes of 4 percent for the vegetated Landfarms areas. Analyses of differential settlements indicate that a reduction in slope of up to 0.8 percent could occur, producing a minimum exterior slope of 3.2 percent.

Following long-term consolidation of the underlying Bay Mud, positive surface drainage will be generally maintained. Some future maintenance may be needed depending on the differential settlements that occur, as discussed in Appendix A. In addition to settlements that may occur due to the underlying Bay Mud, some surface settlement may occur as a result of compression of loosely compacted Landfarms soils due to a variety of possible causes including, but not limited to, the effects of soil saturation, groundwater flow, or surface loading. Settlements due to these causes are difficult to predict due to the variable nature of the materials and may generate the need for additional future maintenance to maintain surface drainage.

4.3.2 Slope Stability

Both static and dynamic slope stability analyses were performed for the initial configuration of the outer slope, as described in Appendix B. Analyses were performed for conditions at the end of construction. The stability of the system will improve over time when the underlying Bay Mud has undergone long-term settlement and consolidation. Two sections representing the most extreme slopes planned for the perimeter of the closure units were analyzed. One section analyzed is located along the northeast perimeter of No. 1 Landfarm adjacent to the former No. 1 Oxidation Pond, and a second section analyzed is located at No. 3 Landfarm adjacent to the Richmond Water Enhancement Wetland (former No. 2 Oxidation Pond). Results of the stability analyses are summarized in Table B-1 (Appendix B). A discussion of the rationale for selection of these sections, along with the details of the analyses, are included in Appendix B.

On the basis of results of the Newmark Procedure for Dynamic Analyses (Newmark, 1965) presented in Table B-1 (Appendix B), we conclude that the Landfarms closure units will be sufficient to withstand the Maximum Credible Earthquake (MCE), although some of the containment facilities may require repair following such an event.

The analyses indicated that portions of the Landfarms may displace laterally as much as 1 foot during an MCE event due to shear failure in the underlying soft Bay Muds. The potential for damage to the final Landfarms cover is dependent on the actual distribution of movement within the Landfarms fills. The surface may crack as a result of tensile movement. Following a major earthquake, the cover should be inspected for cracks. The cracks can then be filled and the surface re-graded and re-planted, if necessary. It is expected that the impact on the environment from GPS structures would be minor in such an event since the anticipated shear plane would be in the underlying Bay Mud beneath the base of the extraction trenches and the total displacement would be less than the thicknesses of the barrier walls. It is anticipated that repair of groundwater monitoring wells may be necessary following such an event.

4.3.3 Groundwater Protection Analysis

Mobility of constituents within the closure units is anticipated to occur primarily as dissolved constituents within groundwater and also as phase-separated hydrocarbons. The design of the closure unit includes graded slopes to reduce surface water ponding and infiltration. The effect of this cover will be to minimize the amount of water that can infiltrate through the Landfarms and mobilize constituents into the "A" Zone groundwater and reduce the volume of water that the GPS will have to handle. An evaluation of the potential for water to infiltrate through the cover is presented in Appendix D, Hydrologic Evaluation - Infiltration.

As stated above, Chevron has already implemented groundwater corrective action at the site by installing and operating the GPS in compliance with our RWQCB Waste Discharge Order No. 93-109. Based on our evaluation of the groundwater flow characteristics and considering the effects of minimizing irrigation and covering the site, the current configuration of GPS should provide adequate control of potentially contaminated "A" Zone groundwater and collection of free-phase hydrocarbons. Specifically, the Bay Mud should provide an adequate "floor" or horizontal barrier against the downward migration of potentially

contaminated "A" Zone groundwater into the "C" Zone. The groundwater extraction system will create a hydraulic barrier against potentially contaminated "A" Zone groundwater flowing from upgradient locations beneath the Landfarms and off site beyond the downgradient perimeter of the Landfarms. The low-permeability soil-bentonite slurry wall constructed adjacent to Castro Creek, northeast of Nos. 2 through 5 Landfarms, will provide a physical barrier, in addition to the hydraulic barrier, against groundwater migration into the creek.

During the course of discussions related to the formulation of this closure plan, the DTSC requested Chevron install an additional 6 piezometers to better delineate the hydraulic conditions around the No. 1 Landfarm (DTSC letter of November 7, 1996). Chevron installed 4 of these piezometers in November, 1996 at the locations shown on Plate 3-10. Chevron intends to use the 2 proposed Point of Compliance Monitoring Wells (see Section 5.9) as the remaining 2 piezometers. These 2 wells will be located between the No. 1 Landfarms GPS extraction trench and the former No. 1 Oxidation Pond, as shown on Plate 4.3.

Operation and maintenance will continue through the closure and post-closure period by Chevron's Utilities/Environmental Area Business Unit (ABU). The performance and effectiveness of the GPS will be reported to the agencies semi-annually in accordance with the RGMP and the Post-Closure LGMP (see Section 5.9). As necessary, modifications and adjustments will be made to maintain an adequate hydraulic barrier around the perimeter of the closure units. The security provisions for the closure units will be essentially the same as those for the operating Landfarms.

4.3.4 Precipitation and Drainage Control

Design of precipitation and drainage control features of the final cover have been prepared to control a 24-hour storm event with a 25-year recurrence interval in conformance with the requirement cited in 22 CCR 66265.272(c). Details of the design are discussed in Appendix F. Precipitation data for the Landfarms are provided in Section 2.3. The final cover on the surface of the Landfarms area will be sloped and built to a sufficient elevation to provide drainage of rainfall and to prevent localized ponding. The runoff will be routed as described in Section 4.2.5. The system has also been designed such that, if the capacity of the pumps is exceeded, the overflow will run away from the closure units and will not inundate the final cover. Infiltration through the final cover will ultimately be collected in the GPS extraction trenches and extraction wells, or in the shallow drainage collection trench south of Nos. 2 through 5 Landfarms. Based on the results of the infiltration analysis presented in Appendix D, BEDM calculated that, after the vegetative cover is fully established, the typical infiltration would be less than 700,000 gallons per year, with nearly 15,000,000 gallons being consumed by evapotranspiration per year.

The lowest anticipated final elevations of the closed Landfarms is Elevation +9.0 (RRD). This elevation is above the anticipated maximum 100-year flood elevation of +8.6 (see Section 2.3). Hence, inundation of the final cover should not occur. The sites are not adjacent to any significant water bodies, so wave overtopping is also not an issue.

The potential for erosion of the final cover is addressed in Appendix E. The anticipated amount of erosion is generally less than 0.5 tons/acre/year, which is significantly less than the U.S. EPA recommended maximum of 2 tons/acre/year. Minor erosion that does occur will be identified during the annual inspections and will be promptly repaired. If warranted, an erosion control mat, such as jute netting, can be applied to the steeper slopes that suffer chronic erosion problems.

4.4 Closure Activities

The Refinery schedule for closure of the Landfarms is shown on Table 4-1. The schedule shown is tentative at this time and is dependent on weather conditions, which may impact the earthwork and

planting, and regulatory approval of this closure plan. The Refinery plans to construct the Landfarms closure unit elements for all five Landfarms in 1997. If the weather patterns for early 1997 follow normal patterns, then regulatory approval of the plan will need to be received by April, 1997 to achieve this goal. The major steps involved in closing the Landfarms are outlined in the following sections.

Chevron is required by 22 CCR Section 66265.113 (b) to complete final closure activities within 180 days after the approval of the closure plan. Because most of the elements presented in this plan has been previously submitted to the DTSC, BEDM anticipates that the closure plan will be approved in early 1997, which would mean that the closure would have to be completed early in the second half of 1997. The proposed closure plan requires extensive earthwork, which cannot be done when the soils are wet or during periods of significant rainfall. As the first part of the year is likely to be wet and rainy, we do not anticipate starting construction until mid-May, 1997. As shown on Table 4-1, due to the magnitude of the work we do not anticipate completing construction until at least September of 1997, which may be beyond the required 180-day period. If regulatory approvals are not received prior to the summer of 1997, then it may not be prudent to attempt to complete the closure of the Landfarms prior to the onset of winter rains. Rather, some or all of the work would have to be delayed until 1998. In accordance with the regulations, Chevron will submit a request for an extension of the closure period at least 30 days prior to the expiration of the 180-day period if it is needed. The request would document that the closure activities will, of necessity, take longer than 180 days to complete.

Due to the contaminated nature of the soils present at the site, work will be performed using an appropriate health and safety plan. Appendix I contains the plan that Chevron and BEDM propose to use for their personnel at the site. Each contracting firm working on the site will be required to adopt a health and safety plan for their own personnel. The contractor's plans must be at least as stringent as the plan presented in Appendix I.

4.4.1 Facility Decontamination

Prior to closing the Landfarms, the Landfarms operating equipment used during the bioremediation period will be decontaminated. The decontamination will be performed by the Landfarms operations technicians and will consist of triple-rinsing with pressurized water. Decontamination procedures will be performed on existing gravel areas within the berms of each Landfarm. This will allow the rinsate to drain back into the Landfarms. When no longer required, the temporary facilities used to handle stormwater runoff will be rinsed and removed. The Landfarms operating equipment that will be decontaminated includes the following:

- Water Trucks
- Tractor (710) and Disc
- Fertilizer Spreader
- Safety Showers
- Automated Sprinkler System

In addition, several monitoring wells within the Landfarms will need to be abandoned to accommodate the new grades. These will be abandoned in accordance with Contra Costa County and State of California guidelines and procedures. Equipment used in the abandonment will be decontaminated in the same manner as the Landfarms operating equipment.

4.4.2 Final Cover Construction

After all of the existing sprinkler systems have been removed, the construction of the final covers for the Landfarms will proceed as follows:

- Rough-grade the Landfarms soil into the shape of the final closure unit and lightly compact the soil as discussed in Section 4.2.4.1.
- Spread any excess portions of the perimeter containment dikes over the Landfarms soil and grade the Landfarms surfaces (the containment dike soil may be considered as part of the lower 6-inch layer of the final cover fill). Condition and compact the soil as discussed in Section 4.2.4.1.
- Place the final cover fills in vegetated areas.
- Install the new sprinkler system.
- Hydroseed and plant the finished earthen surfaces of the closure unit.

Shrubs and trees will be planted in subsequent years as discussed in Section 4.2.4.5. After the Landfarms soils have been covered, any of the construction equipment that came into contact with the waste material will be decontaminated in a manner similar to that described in Section 4.4.1. All work will be performed in accordance with the drawings and specifications included in Appendix J and H, respectively. In addition, all work will comply with the Construction Quality Assurance (CQA) program outlined in Appendix G and detailed in the specifications.

The existing Landfarms soils will be kept moist during construction operations to control wind erosion. The moisturizing will continue until the soils have been covered with either relocated berm soils or imported clean fill. The perimeter berms will not be removed until a period of dry weather of sufficient length to completely cover the adjacent Landfarm soils is anticipated. This will be done to ensure that run-off from rainfall does not wash any of the Landfarm soils away from the site. Run-on is not considered to be an issue for the Landfarms as the sites are located above the maximum anticipated flood level and the perimeter of the Landfarms will always be protected by berm soils, even after the berms have been pushed into the Landfarms. In addition, all earthwork is anticipated to be performed during one construction season.

4.4.3 Closure Certification Submittal

The construction of the final cover will be performed under the supervision of an independent qualified professional engineer, registered in California. The engineer will ascertain whether the activities described in Section 4.4.1 have been performed as specified and whether the Landfarms have been closed in a manner consistent with the intent of the approved closure plan. On completion of the hydroseeding, a closure certification report for the Landfarms will be prepared. The report will conform to 22 CCR Section 66265.115 and will be signed by an authorized representative of the facility operator and by the independent professional engineer who supervised the work. The certification report will contain as-built drawings for the closure facilities and will include a summary of the results of quality control testing (details of the quality control testing program are presented in Appendices G and H). In addition, Chevron will notify the DTSC in writing when the Third Phase of the vegetation plan outlined in Section 4.2.4.5 has been implemented.

4.4.4 Post-Closure Notice Submittals

In accordance with 22 CCR Sections 66265.116 and 66265.119, Chevron will prepare a survey plat indicating the locations and dimensions of the Landfarms cells. The survey plat will contain notes describing the nature and quantities, to the best of Chevron's knowledge, of the waste within the closure cells. The plat will also show the locations of two existing permanent survey monuments from which the closed units may be located. These are Refinery monuments Nos. 413 and 2651. Monument No. 413 is located at the intersection of Petrolite and Channel Streets, southwest of the No. 1 Landfarm. Monument No. 2651 is located at the intersection of Ammonia and Toluene Streets, southeast of No. 4 Landfarm. This plat will be filed with the City of Richmond's Planning Department and the DTSC. A copy of the plat will also be attached to the deed for the property.

4.5 Closure Plan Development

The closure plan was prepared to conform with the intent of State Regulations 22CCR66265 and Federal Regulations 40CFR265, both of which address the closure of interim status land treatment facilities. As required by the DTSC 1988 Stipulation & Order, and the EPA 1988 Consent Agreement, this plan has been developed following the guidelines set forth in the EPA's "Guidance Manual on Hazardous Waste Land Treatment Closure / Post-Closure," April 1987. Reproduced below are several key passages from these regulatory documents, which guided Chevron and BEDM in developing this closure plan.

Section 66265.111 of 22CCR, which defines the Closure Performance Standard, states "The owner or operator shall close the facility in a manner that: (a) minimizes the need for further maintenance, and (b) controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated rainfall or run-off, or waste decomposition products to the ground or surface waters or to the atmosphere, and c) complies with the closure regulations of this chapter...". Section 265.111 of 40CFR contains almost identical language.

Section 3.4.1 of the EPA's guidance manual states that, where a cover is to be used, "The use of vegetation as the final surface cover is highly recommended at the HWLT (hazardous waste land treatment) unit to prevent water and wind borne erosion and transport of soil/waste materials, to provide infiltration control into soil, and to allow continued treatment of hazardous constituents." Whereas Section 3.4.2.2 states that "In general, the use of capping as a closure method for a HWLT unit is not recommended. HWLT relies on aerobic soil conditions to degrade applied hazardous waste constituents. Conditions under a cap are likely to become anaerobic, thus inhibiting or preventing additional treatment that could occur during the post-closure period. Anaerobic conditions may also favor the production of toxic compounds (e.g., methylation of mercury and arsenic) and the mobilization of toxic metals."

Section 3.4.1.2 states "An advantage of closing the HWLT unit by establishing a vegetative cover is that the wastes are left in place and continued treatment of any remaining constituents can occur in the soil system. Vegetation will also help to reduce the potential for transport of hazardous constituents from the HWLT unit by control of wind and water erosion and by evapotranspiration, which by decreasing the amount of percolating water, may decrease the transport of hazardous constituents to the groundwater."

To reduce future long-term maintenance and maximize the future biodegradation of the remaining petroleum hydrocarbons within the Landfarms, Chevron has elected to close the Landfarms with a vegetative cover. The potential for direct exposure to the wastes will be reduced by placement of the one-foot thick layer of topsoil over the Landfarm soils and by the use of non-food crop plants in the cover. The primary remaining pathway for waste constituent exposure is the possibility of the transport of constituents into the groundwater by percolating rain or irrigation water. As discussed in Section 3.7, Chevron has been

collecting samples of the groundwater captured by the GPS and has found no evidence that constituents are migrating into the groundwater at concentrations that are considered hazardous.

5.0 LANDFARMS POST-CLOSURE MONITORING AND MAINTENANCE PLAN

5.1 General

Post-closure care of the Landfarms will continue after completion of construction of the final closure units. Access to the sites during post-closure will be restricted by the overall Refinery guard and security system maintained by Plant Protection, as discussed in Section 2.2.1. Appropriate warning signs will be placed around the perimeters of the closed Landfarms similar to those discussed in Section 2.2.1. The inspection, monitoring, and maintenance plans that will be followed during the post-closure period are described below.

During the post-closure period, the Chevron contact person will be the Refinery Environmental and Safety Manager located at:

Chevron Products Company
Richmond Refinery
P.O. Box 1272
Richmond, California 94802
Attention: Manager Environmental and Safety Division

(510) 242-1400

Elements of the Landfarms closure units included in the post-closure monitoring plan include: vegetation performance, surface settlement, final cover integrity, surface drainage control facilities, groundwater quality, and GPS piezometric monitoring. Post-closure monitoring for most elements will be performed on an annual basis. Monitoring frequencies that differ from an annual frequency are described below. Results of the monitoring will be compiled on an annual basis. These frequencies will be evaluated annually and modified as appropriate. Monitoring for each of the plan elements is addressed below.

In general, inspection of the Landfarms closure elements will be performed at a minimum of once per year prior to the onset of the rainy season. The inspections will be performed by qualified individuals and will include, but not be limited to, inspections of the final cover (including vegetation), drainage control facilities, piezometers, groundwater monitoring wells, GPS extraction system including pumps and piping, security systems, and for signs of differential settlement that may lead to ponding. The inspectors will prepare reports of their findings and will promptly rectify any deficiencies.

5.2 Post-Closure Usage

No Refinery operations are planned on the Landfarms sites following construction of the final covers. Drawings D-767512 and D-767515 (Appendix J) show the anticipated post-closure configuration of the sites. The only traffic anticipated on the covers of the closure units would be limited to that required to operate and maintain the GPS and the cover vegetation. If, at some time in the future, Chevron plans to use the sites for other purposes, approvals would be required from the appropriate government agencies (the DTSC at a minimum) and additional maintenance may be required to maintain the integrity of the final covers.

5.3 Vegetation Monitoring

An inspection of the vegetated surface of the Landfarms will be performed quarterly, by a qualified person, to evaluate plant germination, irrigation, and the need for fertilization, mowing, and reseeding. The inspection will identify whether the vegetation is adequately covering the surface of each Landfarm, symptoms of drought stress, chlorosis (indicative of nutrient deficiency), and the need for mowing and/or reseeding. Maintenance modifications will be made to address observations made during the inspections, including the need and timing for reseeding and modifications to irrigation and/or mowing schedules. These modifications and their resulting effectiveness will be documented in Chevron's files.

Additionally, the inspector will monitor the growth of the various plants and recommend when it is appropriate to begin the planting of the trees discussed in Section 4.2.4.5.2. The inspector will then monitor the growth of the trees, prepare recommendations on modifying the irrigation plan to encourage deep rooting of the trees, and identify the appropriate time to initiate the third phase of the vegetation plan and begin to thin the trees.

Soil monitoring well be performed semi-annually to document maintenance of soil pH and to evaluate soil conditions for plant growth. To meet these objectives, two samples per acre within each Landfarm will be collected from the surface 0 to 1 foot bgs on a semi-annual basis. The sample locations will be identified and sampled in accordance with the former Landfarms Quarterly Monitoring procedures. The collected samples will be chemically analyzed for the following:

- Plant nutrients, which include nitrate, ammonium, and phosphate; and
- Soil pH.

In addition to the quarterly monitoring, weekly inspections will be performed during the non-rainy portions of the year to evaluate the effectiveness of irrigation. The soil moisture will be monitored with a field soil moisture monitoring device at locations where there is evidence of insufficient irrigation and/or dry soil. The irrigation plan will be adjusted as necessary to address areas of insufficient soil moisture.

5.4 Vegetation Maintenance

Maintenance practices will vary depending on the type of vegetation. In the initial stages (Phase I), mowing, irrigating, and possibly weeding may be required. When trees are planted in Phase II, the irrigation scheduling and method may be modified to encourage deep rooting of the tree species. As the trees mature in Phase III, watering the understory herbaceous plants will continue, since the trees will use groundwater.

Fertilizing, mowing, and reseeding will be performed as needed and as recommended as a result of the inspections described in Section 5.3. Irrigation will be supplied to the Landfarms soils to enhance seed germination and to meet plant water requirements throughout the warm months when plant evapotranspiration requirements exceed rainfall. Irrigation frequencies and amounts will be modified as needed based on the results of the weekly inspections.

5.5 Surface Settlement Monitoring

The final cover will be monitored for signs of differential settlement, which may cause ponding. Two existing survey monuments, Refinery Nos. 69 and 115, located on pile-supported structures adjacent to the Landfarms, have been identified to serve as permanent survey control monuments. The current location of monument No. 115 is at the top of sphere base 1694 on Ammonia Street west of Toluene Street and is near Nos. 2 through 5 Landfarms. Monument No. 69 is located on the top of the wall at the northwest corner of

Bridge No. 162, which is north of the intersection of Channel Street and Petrolite Street, and is near No. 1 Landfarm. Settlement markers will be installed within the final cover of the Landfarms to monitor settlements. Proposed locations for the markers are shown on drawings D-767512 and D-767515 (Appendix J). The Landfarms surfaces will be inspected on an annual basis for evidence of differential settlement. If differential settlement has occurred and the grades of the final cover will no longer prevent ponding in that area, the surface will be regraded to maintain positive drainage. If warranted, a survey of the settlement monument elevations may be performed to quantify the actual amount of settlement that may have occurred.

5.6 Soil Cover Inspection and Maintenance Program

In addition to supporting the vegetation, the soil cover provides protection from wind and water erosion of the Landfarm soils. An annual inspection of the cover will be performed by a qualified engineer prior to onset of the rainy season. The inspector will identify and recommend appropriate repairs for areas where the soil cover may have become eroded, attacked by rodents, or otherwise damaged, or where the paved areas have become damaged. Repairs will be performed prior to the rainy season. Supplemental monthly inspections will be performed by Chevron at areas that have seen surface usage subsequent to the previous inspection. Damage detected at these or any other times will be promptly repaired. Records of all inspections and repairs will be maintained by the Refinery.

The cover will also be inspected after major rainfall events to identify areas where ponding or excessive erosion has occurred. Areas where ponding or erosion has occurred will be repaired to maintain positive drainage.

5.7 Surface Drainage System

The drainage swales and culverts will be observed for cracking, clogging, erosion, and operating performance. The drainage control system will be monitored annually before the beginning of the rainy season to be sure the surface drainage facilities are intact and clear of debris. The pumps will be inspected and tested annually. After heavy rainfalls, additional inspections will be made to monitor their performance. If deficiencies are found, they will be corrected as soon as practicable.

5.8 Free-Phase Hydrocarbon Monitoring and Recovery

The thickness of LNAPLs in the existing monitoring wells will be measured semi-annually in conjunction with the post-closure LGMP (discussed below). The GPS will provide both effective long term containment for the possible offsite migration of LNAPLs and capture of LNAPLs within the Landfarms areas. The design of the GPS extraction system, with pumps located at roughly 200-foot intervals, is inherently redundant. Hence the malfunction of any one pump is not expected to reduce the effectiveness of the system at containing the LNAPLs within the Landfarms as the groundwater normally recovered by the malfunctioning pump would flow laterally towards the adjacent pumps. However, if the GPS as a whole were to be out-of-service for a period exceeding one week and temporary pumps could not be used to maintain drawdown in the extraction trenches, supplemental LNAPL recovery would be performed with vacuum trucks from the extraction sumps and monitoring wells whenever the measured thickness of LNAPL exceeded six inches.

5.9 Groundwater Quality Monitoring Program

The Post-Closure Landfarms Groundwater Monitoring Program (LGMP) will follow the general framework of the Refinery-wide Groundwater Monitoring Program (RGMP). The scope of the RGMP is specified in the Monitoring and Reporting Program of RWQCB Order 93-109. The post-closure LGMP is designed to

provide piezometric and chemical monitoring of the "A" and "C" Zones along the point of compliance. The point of compliance for the Landfarms closure units is the vertical surface located at the downgradient limit of the facility that generally coincides with the GPS.

As reported in previous RGMP reports, the "A" Zone has been historically impacted with petroleum hydrocarbons and metals. In response to this, Chevron has implemented a groundwater pump and treatment system, known as the groundwater protection system (GPS), along the downgradient perimeter of the Refinery as a corrective action on the "A" Zone groundwater. The GPS currently exists along the northeastern boundary of Landfarm No. 1 and along the north, south, and west boundaries of Landfarms Nos. 2 through 5. Because the GPS is a corrective action program, the existing RGMP and the future Post-Closure LGMP for the "A" and "C" Zones will follow the corrective action monitoring program outlined in 22 CCR 66264.100.

The objective of "A" Zone piezometric monitoring is to demonstrate that a hydraulic barrier is maintained by the GPS at the perimeter of the closure units. Chemical monitoring in the "A" Zone supplements piezometric monitoring and assists in evaluating the effectiveness over time of the GPS corrective action. Chemical monitoring in the "C" Zone verifies that water quality below the Bay Mud at the point of compliance has not been degraded (BEDM, 1991).

The point of compliance monitoring wells for piezometric levels includes approximately 400 groundwater monitoring wells, sumps, piezometers, and recovery wells around the Refinery that are monitored on a quarterly basis to document the groundwater gradient and flow patterns in the vicinity of the GPS. Approximately 250 of the 400 monitoring points are monitored semi-annually to document the Refinery-wide groundwater gradient and flow patterns in the "A" and "C" Zones. This will include the four piezometers installed adjacent to No. 1 Landfarm in November 1996, and the additional point of compliance monitoring wells proposed below. Other piezometers will also be measured as appropriate to develop as complete a groundwater picture as possible. The information collected is reported on a semi-annual basis along with the chemical monitoring results, as described below.

The point of compliance monitoring wells for chemical monitoring will be as indicated in the following table.

	POINT OF COMPLIANCE MONITORING WELLS	
LANDFARM AREA	**"A" ZONE WELLS**	**"C" ZONE WELLS**
No. 1	New "A" Zone Well (658A)	103C
	New "A" Zone Well (659A)	New "C" Zone Well (654C)
Nos. 2 - 5	384A	104C
	244A	114C
	551A	186C
	610A	251C
	New "A" Zone Well (657A)	New "C" Zone Well (655C)
		New "C" Zone Well (656C)

The locations of these wells are depicted on Plate 4-3. Logs of the borings and well construction diagrams for the currently existing monitoring wells are included in Appendix J. Wells 654C, 655C, 656C, 657A, 658A, and 659A are being installed during the fall of 1996, their boring logs and completion diagrams will be included in the Closure Certification Report.

Because the GPS is a corrective action monitoring program, the constituents of concern (COC) in the "A" Zone groundwater may exceed background levels at some locations. In light of this condition, it is not practicable to rely on a comparison with background water quality as a measure of effectiveness of corrective action. Rather, maximum allowable concentration limits (MACLs) have been established by the RWQCB as concentration limits against which GPS corrective action effectiveness will be evaluated.

Chemical monitoring at the point of compliance wells will follow two levels of testing. The first level will consist of the list of COCs, which will be monitored on a biennial basis in the first semester of every even-numbered year. The second level is a subset of the COCs (monitoring parameters) and will be monitored semi-annually. The COCs and monitoring parameters are summarized in Table 5-1.

Groundwater samples will be collected by Chevron's Utilities and Environmental Area Business Unit (U/E) personnel. Chemical testing will be conducted by Chevron Environmental Laboratory (CEL), which is a DTSC-certified laboratory. After the results are received from the laboratory, quality assurance checks will be performed on the data to verify accurate results or to identify data quality concerns. The data will then be entered into Chevron's Groundwater Data Storage System (GDS) database for permanent storage.

As supported in RWQCB Order No. 93-109, the MACLs are used to determine when compliance has been achieved by the GPS. In other words, the MACLs are cleanup goals for corrective action and exceedences may occur until the extraction system has had sufficient time to remediate groundwater in the vicinity.

The MACL for each COC and monitoring parameter is shown on Table 5-1. If a chemical result from the "A" Zone exceeds the MACL and sufficient historical data are available, the results are further evaluated to identify if the concentration is "significant" compared with previous historical results. Statistical analyses of the current and historical analytical data of a particular well will then be used to evaluate concentrations that exceed the MACL. Chemical results from the "C" Zone compliance monitoring wells will be similarly evaluated.

To evaluate whether a release or degradation of groundwater has occurred, other criteria are used in conjunction with the analytical data, since concentrations exceeding an MACL alone would not be indicative of a significant release or necessarily pose an imminent threat to the waters of the State. The other criteria for evaluation of chemical data include: GPS performance, location of the point of compliance well relative to the closure unit, Refinery operations that occurred in the area, and seasonal hydrogeologic conditions. Information generated during the LGMP will be compiled and reported to the DTSC in conjunction with the RGMP on a semi-annual basis.

As discussed above, there is no physical separation between the wastes in the Landfarms and the first underlying groundwater table, leaving no vadose zone to monitor for the migration of constituents. This condition has been historically recognized by Chevron and the various regulatory agencies Therefor, no vadose zone monitoring is currently required, and no post-closure vadose zone monitoring will be performed.

5.10 Completion of Post-Closure Care Certification Submittal

Pursuant to 22 CCR 66265.120, within 60 days of the completion of the established post-closure period, Chevron will submit to DTSC a certification that the post-closure care period for the Landfarms closure units was performed in accordance with this closure plan. The certification will be signed by Chevron and

an independent Registered Professional Engineer. Documentation supporting the independent engineer's certification will be kept on site until Chevron is released from financial assurance requirements for post-closure care.

5.11 Major Natural Event Response

In addition to routine wear and tear, the Landfarms closure facilities may be damaged by sudden events, such as earthquakes and major storms. While the nature of the wastes in the closure cells is such that damage would not result in a major release to the environment, prompt attention is advisable. After the occurrence of a potentially damaging event, the Landfarms closure facilities will be inspected by Refinery personnel and temporary repairs will be performed as necessary to the closure facilities as soon as is practicable. Chevron will immediately notify the DTSC of suspected releases of wastes or waste byproducts to the environment as a result of a major natural event. As soon as practicable, Chevron will have a qualified engineer perform an inspection of the facility. The engineer will identify damage and recommend appropriate repairs. Chevron will then implement the repairs in a timely manner. On completion of the repair work, Chevron will prepare and submit a report to the DTSC identifying what damage occurred and certifying that the appropriate repairs have been completed. A copy of the inspector's findings and recommendations will be included in the document.

The most severe natural event that the facilities might experience would be the occurrence of the Maximum Credible Earthquake (MCE) identified in Appendix C. As discussed in Section 4.3.2, displacements on the order of one foot may occur to the closure units. Displacements of that magnitude may damage the cover and groundwater monitoring and control facilities. To aid Chevron in evaluating the impact of an earthquake and mitigate the damage it may cause to the facilities, BEDM has prepared the Landfarms Post-Earthquake Inspection and Corrective Action Plan, which is included as Appendix N to this document. This contingency plan may be used by Chevron any time the Landfarms incur damage and need not be limited to earthquake response.

6.0 CLOSURE AND POST-CLOSURE ESTIMATED COST

The cost to implement the proposed Landfarms Closure Plan is estimated at $1,930,000. These costs are detailed in Appendix K. Annual post-closure operating, maintenance, and monitoring costs (including GPS and LGMP) are estimated at $90,400. The 30-year projected cost for the operation and maintenance of the Landfarms Closure Units, including an allowance for implementing the contingency plan discussed in Section 5.9, is $2,780,000.

7.0 CERTIFICATION OF FINANCIAL ASSURANCE

Chevron has provided certification of financial assurance demonstrating that they can meet the requirements of closure as specified in this plan. A copy of the certification is included in Appendix L.

8.0 REFERENCES

Bechtel Environmental, Inc. and Dames & Moore (BEDM), 1996, *Final Cap Design Proposal* for Chevron Products Company, July 26.

BEDM, 1996 *Proposed Interim Vegetation Plan for Nos. 1 through 5 Landfarms,* for Chevron Products Company, May 23,.

BEDM, 1996 *Proposed GPS Effluent Water Sampling Plan* (dated May 6, 1996), which has been transmitted to the DTSC by Chevron. The GPS sampling plan was developed to document that the

groundwater being extracted from the vicinity of the Landfarms was non-hazardous. The results to-date of this sampling plan are discussed in Section 3.7 of this document.

BEDM, 1995, *Landfarms Closure Plan*, for Chevron U.S.A. Products Company, June 21.

BEDM, 1993, *Landfarms (Soil) Sampling and Analysis Report* , Richmond Refinery, California, for Chevron U.S.A. Products Company, August 10.

BEDM, 1992, *RCRA Facilities Investigation Report for the Landfills Under Isomax and No. 1 Landfarm and Landfill Under Nos. 2 and 3 Landfarms*, Richmond Refinery, California, for Chevron U.S.A. Products Company, November 24.

BEDM, 1992, *Landfill 15 Facilities Construction Workplan*, Richmond Refinery, California, for Chevron U.S.A. Products Company, April 30.

BEDM, 1992, *Landfarms Bioremediation Assessment Report*, Richmond Refinery, California, for Chevron U.S.A. Products Company, February 27.

BEDM, 1991, *Groundwater Protection System Engineering Report,* for the Chevron U.S.A. Inc., Richmond, California, December 20.

BEDM, 1991. *"C" Zone Investigation*, Phase II, Richmond Refinery, California for Chevron U.S.A. Products Company, December 16.

BEDM, 1991, *"C" Zone Investigation*, Richmond Refinery, California for Chevron U.S.A. Products Company, February 7.

Chevron Products Company, 1996, *Landfarms Soil and Groundwater Monitoring Program Second Quarter 1996 Report,* September 27.

Chevron U.S.A. Inc., 1988, Engineering Technology Department, *Closure/Post Closure Plan for the Richmond Refinery Landfarm*, Richmond Refinery, California, March 31.

Dames & Moore, 1989, *Landfarms Reconnaissance Survey,* Chevron Richmond Refinery for Chevron U.S.A., Job No. 18300-009-114, January 9.

Dames & Moore, 1988, *Refinery-Wide Report of Waste Discharge,* (ROWD) Richmond, California Refinery for Chevron U.S.A. Inc., Job No. 16000-063-03, to RWQCB, August 31.

Dames & Moore, 1985, Final Draft Report - Hydrogeologic Assessment Report, Richmond, California Refinery for Chevron U.S.A. Inc., Job No. 00113-877-03.

Dames & Moore, 1981, *Report, Landfarm Subsurface Investigation,* Richmond Refinery, for Chevron U.S.A. Inc., Job No. 113-531-03, to RWQCB, July 6.

Dames & Moore, 1981, Groundwater Investigation, Richmond, California Refinery for Chevron U.S.A. Inc., Job No. 00113-531-03.

Department of Toxic Substances Control, Cal/EPA (DTSC), 1995, *Notice of Deficiency (NOD) for the Revised Closure / Post-Closure Plan, Richmond Refinery Landfarm Nos. 1 Through 5, Chevron U.S.A. Products Company, Richmond, California, 94801 EPA ID. No CAD 009 114 919*, August 15.

FEMA, 1978, *Flood Insurance Study*, City of Richmond, California.

Regional Water Quality Control Board, San Francisco Bay Region (RWQCB), 1989, Order No. 89-175, Revised Waste Discharge Requirements for: Chevron U.S.A., Inc., Richmond Refinery, Richmond, Contra Costa County, November 20.

Slymen, D.J., de Peyster, A., and Donohoe, R.R., 1994, *Hypothesis Testing with Values Below Detection Limit in Environmental Studies,* Environ. Sci. Techno., 28, No. 5, 898.

United States Corps of Engineers, San Francisco District, 1984, *San Francisco Bay Tidal Stage vs. Frequency Study*.

U.S. Department of Commerce, 1961, *U.S. Department of Commerce Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 years,* May.

Table 3-1. Groundwater Chemistry and Analyte List
Landfarms Soil and Groundwater Monitoring Program
Landfarms Closure Plan
Chevron Richmond Refinery

General Chemistry
- Conductivity
- pH
- Temperature
- Turbidity

Metals (1)
(EPA Method 6010)
- Chromium
- Lead
- Nickel

Volatile Organic Compounds
(EPA Method 8240)
- Benzene
- Carbon tetrachloride
- Chlorobenzene
- Chloroform
- Ethylbenzene
- Methylene chloride
- Tetrachloroethene
- Toluene
- Trichloroethene
- Total Xylenes
- 1,1,1-Trichloroethane
- 1,1,2-Trichloro-2,2,1-Trifluoroethane (Freon 113)
- 1,1,2-Trichloroethane

Semi-Volatile Organic Compounds
(EPA Method 8270)

Acid Extractable Analytes
- Benzenethiol
- Benzoic acid
- Phenol
- 2-Methylphenol
- 2-Nitrophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 3/4-Methylphenol

Base/Neutral Extractable Analytes
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(k)fluoranthene
- Benzyl butyl phthalate
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-butylphthalate
- Fluoranthene
- Naphthalene
- Phenanthrene
- Pyrene
- 1-Methyl naphthalene
- 7,12-Dimethylbenz(a)anthracene

Notes
(1) In addition, well 103A Is only analyzed for organic lead (Method 7420 modified), as outlined in the Groundwater Monitoring Plan, Amendment (Revision #3, May 1, 1989).

Table 3-2. Groundwater Chemistry Analyte List
Landfarms GPS Effluent Sampling
Landfarms Closure Plan
Chevron Richmond Refinery

Volatile Organic Compounds (TCLP)
(Method 8240)

Benzene
2-Butanone (MEK)
Carbon tetrachloride
Chlorobenzene
Chloroform
1,2-Dichloroethane
1,1-Dichloroethylene
1,4-Dichlorobenzene
Tetrachloroethene
Trichloroethylene
Vinyl Chloride

Semi-Volatile Organic Compounds (TCLP)
(Method 8270)

1,4-Dichlorobenzene
2,4-Dinitrotoluene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
2-Methylphenol
3/4-Methylphenol
Nitrobenzene
Pentachlorophenol
Pyridine
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

Metals (TCLP)
(Method 6010)

Arsenic
Barium
Cadmium
Chromium
Lead
Mercury (Method 7470)
Selenium (Method 7742)
Silver

Metals (Total)
(Method 6010)

Antimony
Arsenic
Barium
Cadmium
Chromium
Cobalt
Copper
Lead
Mercury (Method 7470)
Molybdenum
Nickel
Selenium (Method 7742)
Silver
Thallium
Vanadium
Zinc

General Parameters

Flash (Method 1020)
pH (Method 9045)
Reactivity (9010A for cyanide and APHA427C for sulfide)

Table 3-3. Summary of Groundwater Chemical Analysis Results
Landfarms GPS Effluent Sampling
Lanfarms Closure Plan
Chevron Richmond Refinery

		GPS ID:	1	2	3	4		Regulatory Values	
Analytical Parameters	Reporting Limit	Units					Maximum	RWQCB MACL	CCR Tittle 22
TCLP Metals									
Barium	0.007	mg/L	0.810	0.092	0.136	0.247	0.810	~	100
Selenium	0.002	mg/L	0.002	*	*	0.014	0.014	0.05	1
Total Metals		mg/L							
Arsenic	0.092	mg/L	*	*	0.384	*	0.384	0.036	5
Barium	0.007	mg/L	0.986	1.080	1.350	0.363	1.350	~	100
Chromium	0.040	mg/L	*	0.047	0.084	0.044	0.084	**	5
Cobalt	0.015	mg/L	*	0.020	0.028	*	0.028	~	80
Copper	0.020	mg/L	0.073	0.054	0.154	0.592	0.592	~	25
Lead	0.084	mg/L	*	*	*	0.103	0.103	0.0056	5
Mercury	0.120	ug/L	*	*	0.459	*	0.459	0.6	200
Molybdenum	0.022	mg/L	0.103	0.033	0.304	0.032	0.304	~	350
Nickel	0.056	mg/L	*	*	0.144	*	0.144	0.0083	20
Selenium	0.002	mg/L	0.005	0.005	0.002	*	0.005	0.05	1
Vanadium	0.010	mg/L	0.031	0.086	0.122	0.027	0.122	~	24
Zinc	0.025	mg/L	0.712	1.730	3.900	1.010	3.900	0.058	250
Volatile Organics									
None									
Semi-volatile Organics									
Pentachlorophenol	0.01	mg/L	*	*	0.028	*	0.028	0.0079	100
Other Parameters									
Reactive Cyanide	0.1	mg/L	*	*	*	0.107	0.107	~	250
pH - minimum			7.42	7.35	7.06	7.13	7.06	6.5	2.0
pH - maximum			7.79	8.17	7.56	7.75	8.17	8.5	12.5

Notes:
* = Analyte not detected above specified reporting limit.
** = MACL for Chromium VI is 0.0028 mg/L.
~ = No regulatory value.
NA = Not Applicable
Only analytical parameters detected above the reporting limits are presented. See Table 3-2 for Analyte List.
RWQCB MACL = Regional Water Quality Control Board, San Francisco Bay Region, Maximum Allowable Concentration Limit.
TCLP = Toxicity Characteristic Leaching Proceedure
STLC = Soluble Threshold Limit Concentration

CHEVRON LANDFARMS CLOSURE CAP CONSTRUCTION
SCHEDULE OF REMAINING WORK

Item No.	LFM No.	ACTIVITY	MARCH				APRIL				MAY				JUNE			
1	1-5	Install groundwater protection system pumps																
2	1	Reseed area																
3	1	Place hay over the new seeds																
4	1-5	Order in-line pump and filter for irrigation systems																
5	1-5	Install in-line pump and filter for irrigation systems																
6	1-5	Flush out drip irrigation system pipelines and bring system online																
7	2-5	Reseed area																
8	2-5	Place hay over the new seeds																
9	1	Install solar-powered irrigation controller																
10	2-5	Install controller for drip irrigation system																
11	2-5	Install drip irrigation system																
12	1-5	Plant additional wild roses																
13	1-5	Botanist will evaluate plants and make final recommendations																
14	1-5	Finalize planting activities																
15	1-5	Install tensiometers																

Table 4-2. List of Potential Plant Species
Landfarms Closure Plan
Chevron Richmond Refinery

SHALLOW ROOTED SPECIES

- Tall fescue (*Festuca arundinacea*)
- Bermuda grass (*Cynadon dactylon*)
- Creeping wild rye (*Elymus triticoides*)
- California brome (*Bromus carinatus*)
- Alfalfa (*Medicago sativa*)
- White clover (*Trifolium repens*)
- Saltgrass (*Distichlis spicata*)
- Annual fescue (*Vulpia myuros*)

INTERMEDIATE ROOTED SPECIES

- Saltbrush (*Atriplex sp.*)
- Coyotebrush (*Baccharis pilularis*)
- Bush Lupine (*Lupinus arboreus*)
- California broom (*Lotus scoparius*)
- California encelia (*Encelia californica*)

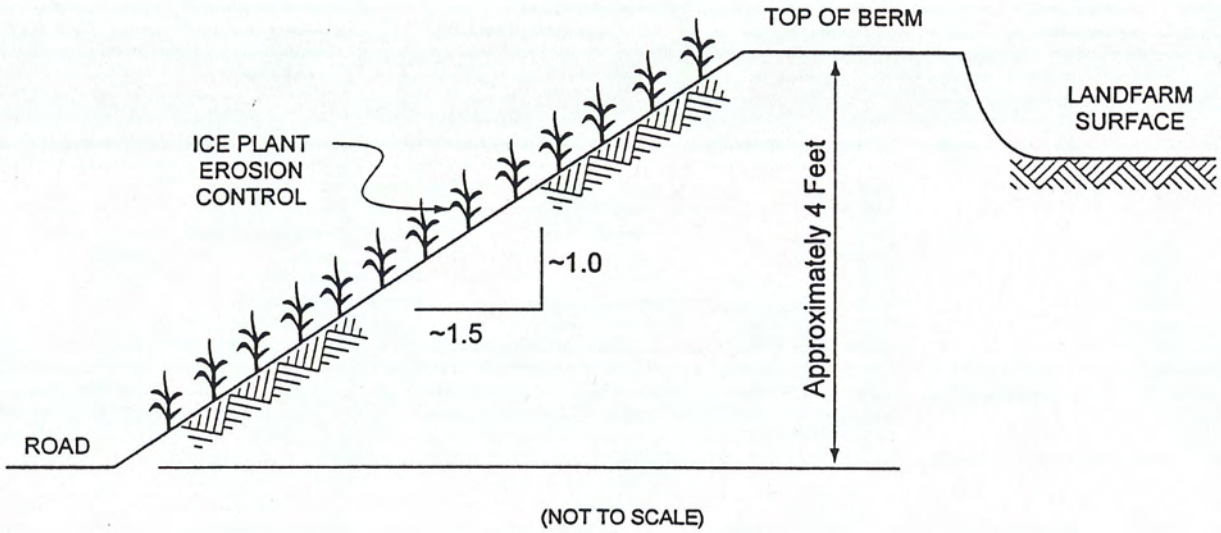
DEEP ROOTED SPECIES

- Hybrid Poplar (*Poplus deltoides nigra*)
- Cottonwood (*Populus fremontii*)
- Willow (*Salix sp.*)
- Toyon (*Heteromeles arbutifolia*)

Table 5-1. List of Constituents of Concern, Monitoring Parameters and MACLs
Landfarms Post-Closure Groundwater Monitoring Program
Landfarms Closure Plan
Chevron Richmond Refinery

Constituents of Concern	MACL (mg/L)		Landfarms/Landfills Sector
TVH-Gasoline	1	c	X
TEH-Diesel	1	c	X
Dissolved Sulfide	0.100	c	/
1,2 Dichlorobenzene	18	a	/
1,3 Dichlorobenzene	2.6	a	/
1,4 Dichlorobenzene	0.064	a	/
Benzene	0.021	a	X
Toluene	300	a	X
Halomethanes	0.480	a	/
PAH (Total)	0.015	d	/
Pentachlorophenol	0.0079	a	/
Total Phenolics	0.05	c,d	/
Selenium	0.05	b	/
Arsenic	0.036	b	/
Cadmium	0.0093	b	/
Chromium VI	0.05	b	/
Total Soluble Lead	0.0056	b	X
Mercury	0.0006	d	/
Nickel	0.0083	b	/
Zinc	0.086	b	/
pH	6.5 to 8.5	a	X
Turbidity (NTUs)	N/A	N/A	X
Temperature (°F)	N/A	N/A	X

MACL = Maximum Allowable Concentration Limit (M&RP, December 1, 1993)
/ = Constituent of Concern per Sector
X = Monitoring Parameter per Sector
N/A = Not Applicable
a = California Enclosed Bays and Estuaries Plan, Water Quality Objectives for Enclosed Bays and Estuaries for Protection of Human Health
b = California Enclosed Bays and Estuaries Plan, Water Quality Objectives for Protection of Saltwater Aquatic Life
c = Tentative Value
d = Method Detection Limit
(NTUs) = Nephelometric Turbidity Unit(s)



TYPICAL LANDFARMS BERM CROSS SECTION

Landfarms Closure Plan

P5404-2-1

BEDM

PLATE 2-1

APPENDIX B

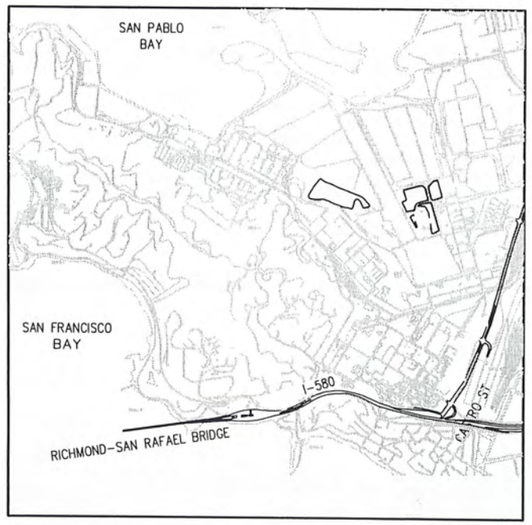
AS-BUILT DRAWINGS OF THE LANDFARM CLOSURE CONSTRUCTION

Chevron

RICHMOND REFINERY
RICHMOND, CALIFORNIA

WASTE DISCHARGE ORDER PROJECT

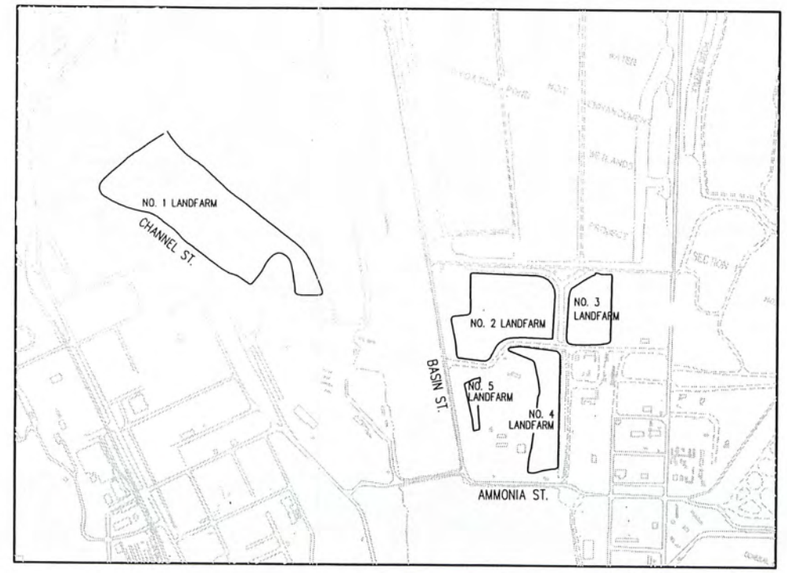
LANDFARMS CLOSURE PLAN
LANDFARMS NO. 1 THROUGH 5



LOCATION MAP

0 2000
Scale in Feet

N



VICINITY MAP

0 500
Scale in Feet

N

DWG. NO.	TITLE
D-767512-1	NO. 1 LANDFARM - FINISHED GRADING PLAN
D-767513-1	NO. 1 LANDFARM - SECTIONS
D-767514-1	NO. 1 LANDFARM - DITCH PLAN
D-767515-1	NO. 2 THROUGH 5 LANDFARMS - FINISHED GRADING PLAN
D-767516-1	NO. 2 THROUGH 5 LANDFARMS - SECTIONS
D-767517-1	NO. 2 THROUGH 5 LANDFARMS - SECTIONS AND DETAILS
D-767518-1	NO. 2 THROUGH 5 LANDFARMS - DITCH PLAN
D-767519-1	NO. 1 AND 3 LANDFARMS - STORMWATER DRAIN PLANS
D-318549-1	NO. 3 LANDFARM - STORMWATER DRAIN DETAILS
D-318600-1	NO. 1 LANDFARM - IRRIGATION PLAN
D-318601-1	NO. 2 THROUGH 5 LANDFARMS - IRRIGATION PLAN
D-318602-1	NO. 1 THROUGH 5 LANDFARMS - MISCELLANEOUS DETAILS
D-318603-1	NO. 1 THROUGH 5 LANDFARMS - MISC. IRRIGATION DETAILS
D-782119	EXTRACTION WELLS AND MONITORING WELLS DETAILS

GENERAL NOTES

1. COORDINATES SHOWN ARE BASED ON 1983 NORTH AMERICAN DATUM (N.A.D.) COORDINATE SYSTEM.

2. ELEVATIONS SHOWN ARE BASED ON RICHMOND REFINERY DATUM. ELEVATION 0.00' EQUALS ELEVATION -2.17' NATIONAL GEODETIC VERTICAL DATUM (NGVD)

3. HYDROSEED ALL DISTURBED AREAS PER PROJECT SPECIFICATION RS-781.

4. ALL CONSTRUCTION SHALL CONFORM TO THESE PLANS AND SPECIFICATIONS.

5. THE TYPES, LOCATIONS, SIZES AND/OR DEPTHS OF EXISTING UTILITIES AS SHOWN ON THESE DRAWINGS ARE FROM THE BEST INFORMATION AVAILABLE. THE ENGINEER ASSUMES NO RESPONSIBILITY FOR THE COMPLETENESS OR ACCURACY OF THE DELINEATION OF SAID UTILITIES NOR FOR THE EXISTENCE OF OTHER BURIED OBJECTS OR UTILITIES WHICH MAY BE ENCOUNTERED BUT WHICH ARE NOT SHOWN ON THESE DRAWINGS.

6. THE CONTRACTOR IS RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING STRUCTURES, UTILITIES, AND FACILITIES. ANY DAMAGE TO EXISTING FACILITIES BY THE CONTRACTOR OR HIS SUBCONTRACTORS SHALL BE RESTORED (TO AND EQUAL OR BETTER CONDITION) OR REPLACED (TO AN EQUAL OR BETTER CONDITION) AT NO COST TO THE COMPANY.

7. THE CONTRACTOR IS RESPONSIBLE FOR ALL EROSION CONTROL REQUIREMENTS. CONTRACTOR SHALL IMPLEMENT ANY NECESSARY BEST MANAGEMENT PRACTICES AS OUTLINED IN THE PROJECT SPECIFICATIONS OR AS DIRECTED BY THE ENGINEER.

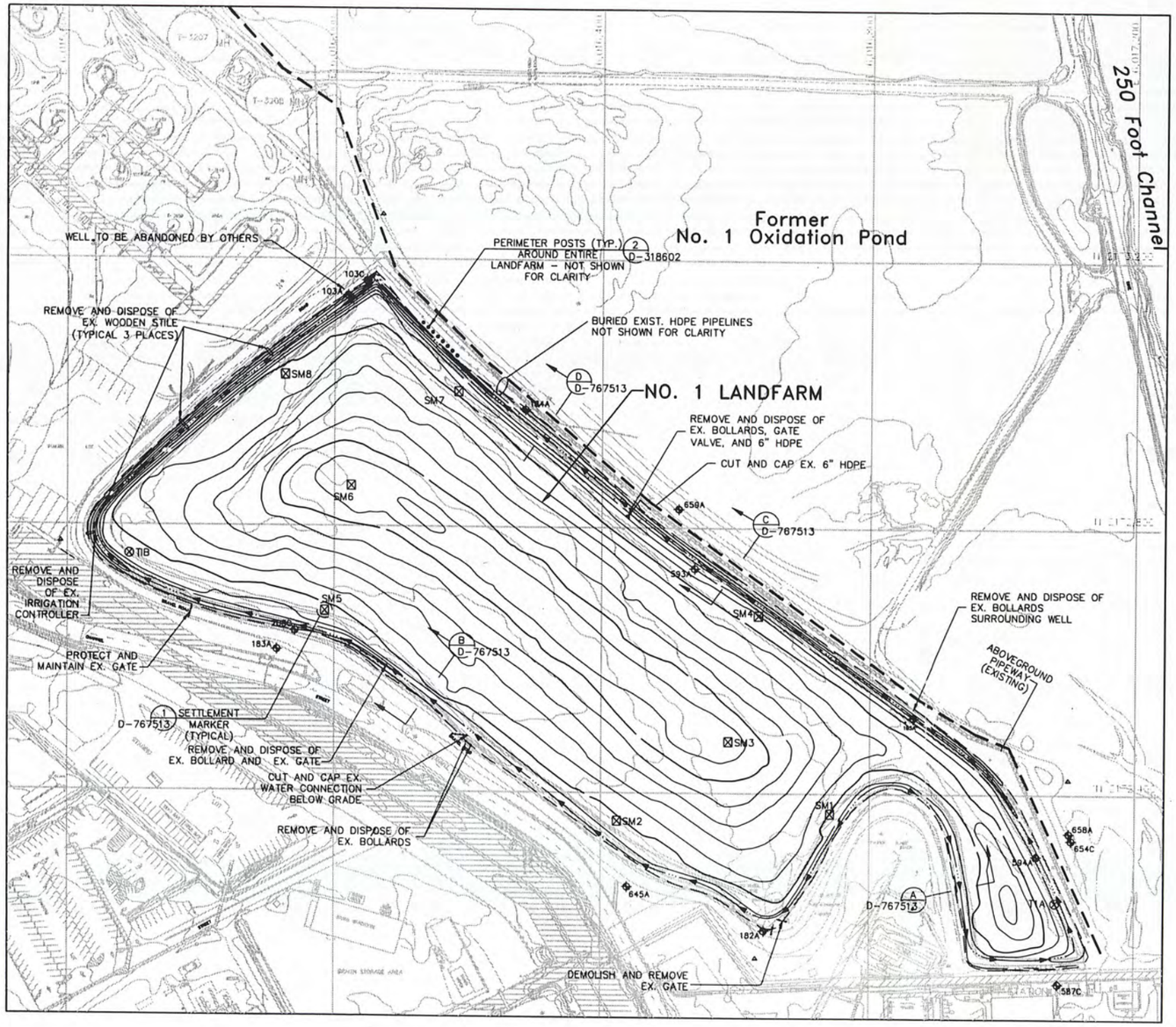
8. IT IS THE INTENTION OF THESE PLANS AND PROJECT SPECIFICATION TO PROVIDE A BALANCED CUT AND FILL DESIGN. EXISTING COUNTOURS MAY DIFFER FROM THOSE SHOWN. DITCH ALIGNMENT SHOWN IS DESIGNED TO PROVIDE THE CLOSEST APPROXIMATE TO A BALANCED CUT AND FILL. ADJUSTMENTS TO THIS ALIGNMENT, AS APPROVED BY THE ENGINEER, ARE PERMISSIBLE TO MAINTAIN NECESSARY CLEARANCE REQUIREMENTS FOR EXISTING STRUCTURES. THE SLOPE OF CAPS MAY ALSO BE VARIED TO YIELD A BALANCED DESIGN, BUT MAY NOT BE LESS THAN 4% SHOWN OR GREATER THAN 10%.

AS-BUILT
SEPTEMBER 1999

REGISTERED PROFESSIONAL ENGINEER
THOMAS M. SWEET
No. C 58265
EXP.
CIVIL
STATE OF CALIFORNIA

DAMES & MOORE GROUP
A DAMES & MOORE GROUP COMPANY
SAN FRANCISCO, CA.

19000900\CHEV-R\S83\LFARMS\ASBUILT\COVER 071897 1:1 082399B AGP



SETTLEMENT MARKER LOCATION

ID	NORTHING	EASTING
SM1	2172370.02	6016741.13
SM2	2172357.91	6016423.56
SM3	2172478.08	6016590.09
SM4	2172668.33	6016634.56
SM5	2172672.11	6015985.62
SM6	2172860.94	6016024.76
SM7	2173002.96	6016183.78
SM8	2173027.68	6015927.79

TENSIOMETER LOCATION

ID	NORTHING	EASTING
T1A	2172237.46	6017081.94
T1B	2172756.88	6015693.07

NOTES:

1. EXISTING CONTOUR LINES ARE AT 1 FOOT INTERVALS BASED ON AERIAL PHOTOGRAPHS DATED AUGUST 1990.
2. LINES AND GRADES SHOWN ARE FINAL GRADES BASED ON AS-BUILT SURVEY DATED AUGUST 1999.
3. LINES AND GRADES SHOWN ARE FINAL GRADES.
4. CONTRACTOR WILL REMOVE EXISTING IRRIGATION SYSTEM PRIOR TO START OF WORK.
5. ANY WELLS WITHIN DISTURBED AREA OF LANDFARMS NOT LABELED "TO BE ABANDONED" SHALL BE RESTORED TO PREVIOUS CONDITION AS PER D-782119.

LEGEND:

- EXISTING OR PLANNED GPS EXTRACTION TRENCH
- EXISTING GROUNDWATER MONITORING WELL
- CENTERLINE OF PROPOSED DITCH
- DAYLIGHT LINE OF PROPOSED DITCH
- SM SETTLEMENT MARKER LOCATION
- T1 TENSIOMETER LOCATION
- AS-BUILT CONTOURS
- EXISTING CONTOURS

N

0 100
Scale In Feet

ABBREVIATIONS:

ø, DIA	DIAMETER
BGS	BELOW GROUND SURFACE
CLR	CLEARANCE
CMP	CORRUGATED METAL PIPE
CSP	CARBON STEEL PIPE
CY	CUBIC YARDS
DWOP	DEEP WATER OUTFALL PROJECT
E	EAST
EF	EACH FACE
EL	ELEVATION
EW	EACH WAY
EX	EXISTING
EWEF	EACH WAY, EACH FACE
HDPE	HIGH DENSITY POLYETHYLENE
MAX.	MAXIMUM
MIN.	MINIMUM
IE.	INVERT ELEVATION
INV	INVERT
LF	LINEAL FOOT
NO.	NUMBER
N	NORTH
O.C.	ON CENTER
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
SCH	SCHEDULE
STA	STATION
TAN	TANGENT
TYP	TYPICAL
U.V.	ULTRA-VIOLET

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SHEET No. C 58265 EXP. 6/30/99 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
GROUP
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 1 LANDFARM – SECTIONS	D-767513
NO. 1 LANDFARM – DITCH PLAN	D-767514
NO. 1 LANDFARM – IRRIGATION PLAN	D-318600
EXTRACTION WELLS & MONITORING WELLS DETAILS	D-782119

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS-BUILT	9/15/98	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C.KOSSA DR. APP. SLD DATE 9/29/99 APPROVED
ENGR. ENGR. DEPT.
OPR'G. DEPT.

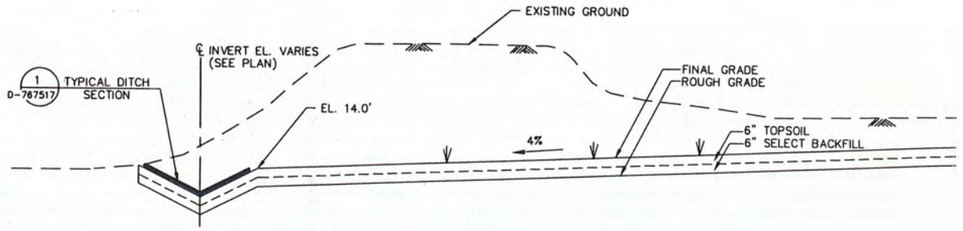
092899SLD

NO. 1 LANDFARM – FINISHED GRADING PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

S W.O. S.O.

D-767512-1

19000900\CHEV-R\S83\LFARMS\ASBUILT\D7675121 062697 1:1 092199 B SLD XREF:LF1BASE

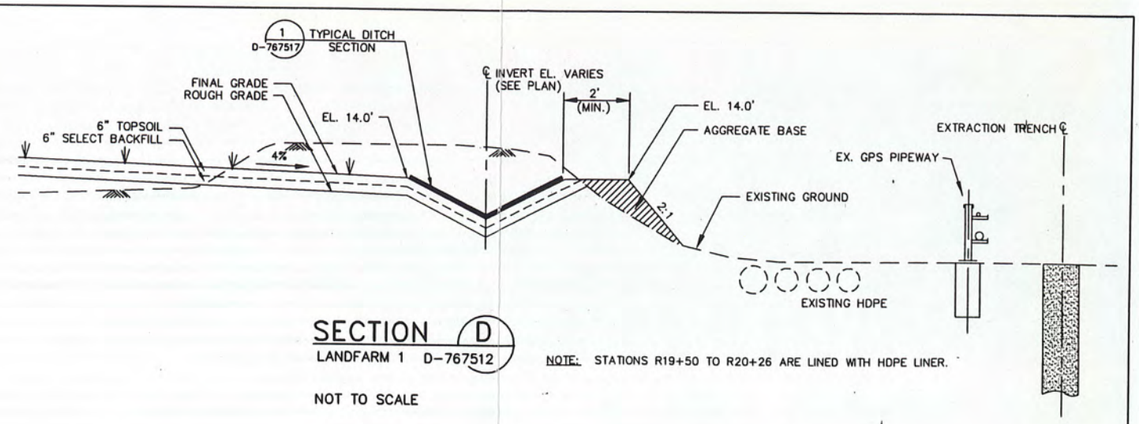


TYPICAL SECTION A

LANDFARM 1 D-767512

STA L0+00 TO STA L2+75
STA R0+00 TO STA R5+25

NOT TO SCALE

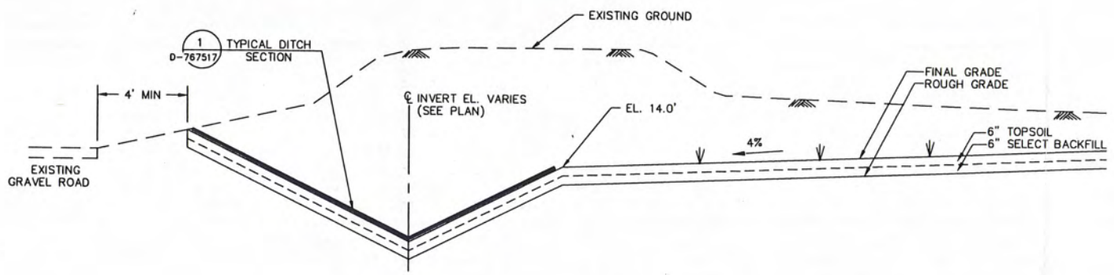


SECTION D

LANDFARM 1 D-767512

NOTE: STATIONS R19+50 TO R20+26 ARE LINED WITH HDPE LINER.

NOT TO SCALE



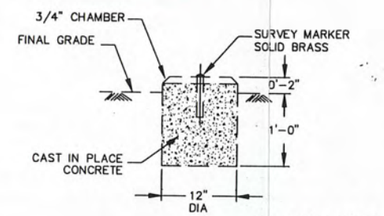
TYPICAL SECTION B

LANDFARM 1 D-767512

NOTE: STATIONS L15+00 TO L20+36 ARE LINED WITH HDPE LINER INSTEAD OF CURLEX. STATIONS L2+75 TO L15+00 CONFORM TO THE TYPICAL DITCH SECTION.

STA L2+75 TO L20+36

NOT TO SCALE

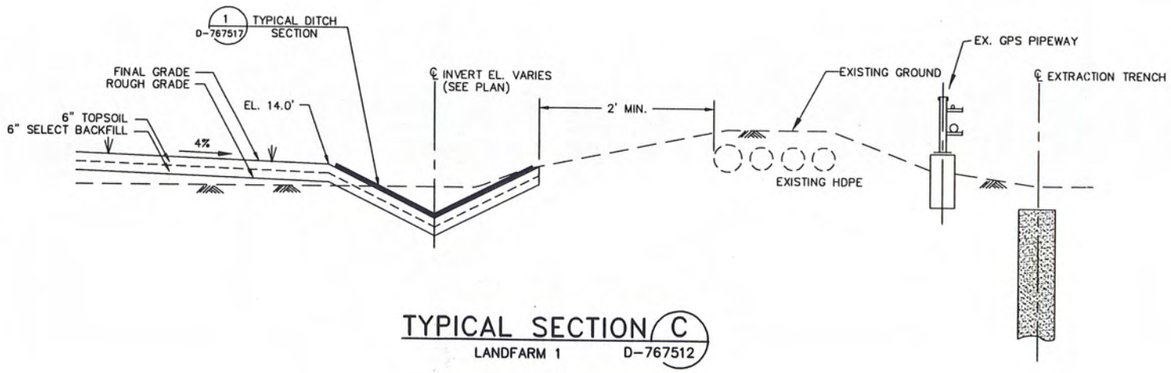


SEE NOTES 1 AND 2.

DETAIL 1 / 1

SETTLEMENT MARKER D-767512 / D-767515

NOT TO SCALE



TYPICAL SECTION C

LANDFARM 1 D-767512

STA R5+25 TO R16+50

NOT TO SCALE

NOTES:

1. FOR SETTLEMENT MARKER LOCATIONS SEE SETTLEMENT MARKER TABLES, DRAWING D-767512 AND D-767515
2. CONTRACTOR SHALL LABEL EACH SETTLEMENT MARKER WITH CORRESPONDING NUMBER AS SHOWN ON PLAN VIEWS. NUMBER SHALL BE STAMPED INTO TOP OF BRASS SURVEY MARKER.

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SHORT No. C 58268 EXP. 6/30/02 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
GROUP
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 1 LANDFARM – FINISHED GRADING PLAN	D-767512
NO. 1 LANDFARM – DITCH PLAN	D-767514
NO. 1 LANDFARM – IRRIGATION PLAN	D-318600

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/98	SLD

Chevron
Richmond Refinery

SCALE AS SHOWN DR. RLS DR. APP. SLD DATE 9/29/97
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

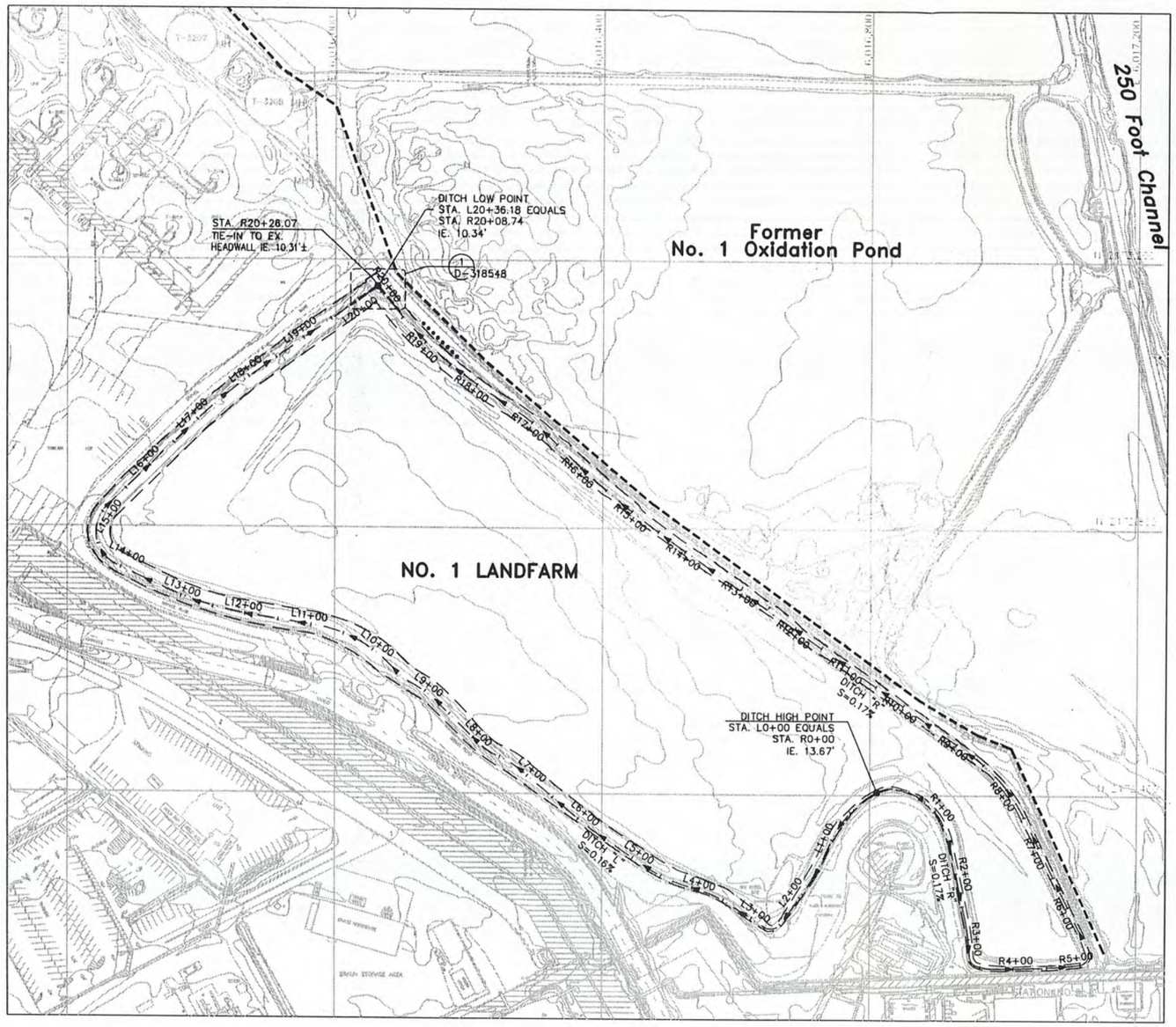
092899SLD

NO. 1 LANDFARM – SECTIONS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767513-1

19000900\CHEV-R\S83\LFARMS\ASBUILT\ D7675131 071497 1:1 092799 B AGP



LAYOUT DATA – DITCH "L"			
STATION	RADIUS	TAN. LENGTH / LENGTH	BEARING / INCLUDED ANGLE
L0+00.00*			
L0+98.20	152.00'	98.20'	37°01'00" (L)
L1+28.20	30.00'	S 24°27'47" W	
L1+85.36	300.00'	57.16'	10°55'00" (R)
L2+48.36	63.00'	S 35°22'47" W	
L2+75.87	18.00'	27.51'	87°33'00" (R)
L3+45.87	70.00'	N 57°04'13" W	
L3+84.16	135.00'	38.29'	16°15'00" (L)
L4+12.16	28.00'	N 73°19'13" W	
L4+73.83	200.00'	61.67'	17°40'00" (R)
L5+56.83	83.00'	N 55°39'13" W	
L5+97.44	400.00'	40.61'	05°49'00" (R)
L7+13.44	116.00'	N 49°50'13" W	
L7+48.92	115.00'	35.48'	17°40'30" (L)
L7+87.86	100.00'	38.94'	22°18'30" (R)
L8+75.86	88.00'	N 44°12'13" W	
L9+15.06	150.00'	39.20'	14°58'30" (L)
L9+26.06	11.00'	N 60°10'43" W	
L9+50.75	80.00'	24.69'	17°41'00" (R)
L9+60.75	10.00'	N 42°29'43" W	
L10+94.15	200.00'	133.40'	38°13'00" (L)
L11+99.15	105.00'	N 80°52'43" W	
L13+23.24	450.00'	124.09'	15°18'00"(R)
L14+05.74	82.50'	N 64°54'43" W	
L15+12.19	55.00'	106.45'	110°53'30"(R)
L16+92.19	180.00'	N 45°58'47" E	
L18+13.20	800.00'	121.01'	08°40'00" (R)
L20+36.18	222.98'	N 54°38'47" E	

*L0+00 = N2172405.04, E6016810.24
S61°28'47"W

LAYOUT DATA – DITCH "R"			
STATION	RADIUS	TAN. LENGTH / LENGTH	BEARING / INCLUDED ANGLE
R0+00.00*			
R0+39.53	50.00'	39.53'	45°17'54" (R)
R1+52.50	105.00'	112.97'	61°38'43" (R)
R2+79.50	127.00'	S 11°34'36" E	
R3+02.95	180.00'	23.45'	07°27'52" (R)
R3+25.95	23.00'	S 04°06'44" E	
R3+46.14	17.00'	20.19'	68°03'34" (L)
R3+72.95	80.00'	26.81'	19°12'15" (L)
R4+42.95	70.00'	N 88°37'27" E	
R4+68.18	300.00'	25.23'	04°49'05" (L)
R4+99.18	31.00'	N 83°48'22" E	
R5+28.87	15.50'	29.69'	109°45'01" (L)
R7+53.87	225.00'	N 25°56'39" W	
R8+71.61	235.00'	117.74'	28°12'24" (L)
R14+21.61	550.00'	N 54°39'02" W	
R16+40.87	1300.00'	219.26'	09°39'48" (R)
R17+60.64	500.00'	119.77'	13°43'29" (L)
R19+78.57	600.00'	217.93'	20°48'37" (R)
R20+26.07	47.50'	N 37°54'06" W	

*R0+00 = N2172405.04, E6016810.24
N61°28'47"E

NOTES:

1. EXISTING CONTOUR LINES ARE AT 1 FOOT INTERVALS BASED ON AERIAL PHOTOGRAPHS DATED AUGUST 1990.
2. THE LAYOUT DATA TABLES FOR DITCHES "L" AND "R" AND THE DITCH LOW AND HIGH POINTS INDICATE DESIGN LOCATIONS, AND DO NOT REFLECT AS-BUILT LOCATIONS OF THE DITCH CENTERLINE ARE AS SHOWN ON THE PLAN.
3. STATIONS ARE BASED ON DESIGN CENTERLINES OF THE DITCHES.
4. LOCATIONS OF EXISTING GPS EXTRACTION TRENCH WITHIN THE LANDFARM LIMITS ARE APPROXIMATE.

LEGEND:

- EXISTING OR PLANNED GPS EXTRACTION TRENCH
- CENTERLINE OF PROPOSED DITCH
- DAYLIGHT LINE OF PROPOSED DITCH

N

0 100
Scale In Feet

REGISTERED PROFESSIONAL ENGINEER THOMAS M. GRANT No. C 56769 EXP. 6/30/99 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DCM GROUP
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS	
NO. 1 LANDFARM – FINISHED GRADING PLAN	D-767512
NO. 1 LANDFARM – SECTIONS	D-767513
NO. 1 LANDFARM – IRRIGATION PLAN	D-318600
EXTRACTION WELLS & MONITORING WELLS DETAILS	D-782119

REVISIONS		
0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS-BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C.KOSSA DR. APP. DATE 9/24/99
ENGR. JMS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

092899SLD

NO. 1 LANDFARM – DITCH PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767514-1

19000900\CHEV-R\S83\LFARMS\ASBUILT\D7675141 062697 1:1 092799 C SLD XREF:LF1BASE

SETTLEMENT MARKER LOCATION

AREA LOCATION	ID	NORTHING	EASTING
NO. 2 LANDFARM	SM01	2171780.12	6018201.33
	SM02	2171933.20	6018204.05
	SM03	2171883.53	6018065.66
	SM04	2172124.17	6018144.85
	SM05	2172127.24	6018348.05
	SM06	2172340.12	6018400.02
	SM07	2172133.11	6018466.16
	SM08	2172124.79	6018679.29
	SM09	2171950.04	6018494.27
NO. 3 LANDFARM	SM10	2171927.97	6018904.04
	SM11	2171976.81	6018762.10
	SM12	2172056.32	6018891.97
	SM13	2172198.10	6018890.01
	SM14	2172234.96	6018762.38
	SM15	2172367.19	6018909.27
	SM16	2172238.02	6019022.96
	SM17	2172018.19	6019028.89
NO. 4 LANDFARM	SM18	2171099.80	6018686.95
	SM19	2171164.75	6018683.06
	SM20	2171156.15	6018619.09
	SM21	2171143.96	6018748.43
	SM22	2171773.11	6018574.23
	SM23	2171777.05	6018648.91
	SM24	2171859.13	6018482.19
	SM25	2171798.88	6018729.02
NO. 5 LANDFARM	SM26	2171330.00	6018191.89
	SM27	2171594.20	6018124.60
	SM28	2171597.32	6018166.86
	SM29	2171637.08	6018153.07
	SM30	2171622.99	6018215.01

TENSIOMETER LOCATION

AREA LOCATION	ID	NORTHING	EASTING
NO. 2 LANDFARM	T2	2171787.15	6018090.84
NO. 3 LANDFARM	T3	2172294.18	6018793.65
NO. 4 LANDFARM	T4	2171102.42	6018624.89
NO. 5 LANDFARM	T5	2171616.16	6018201.85

NOTES:

1. EXISTING CONTOUR LINES ARE AT 1 FOOT INTERVALS BASED ON AERIAL PHOTOGRAPHS DATED AUGUST 1990.
2. LINES AND GRADES SHOWN ARE FINAL GRADES AT 1 FOOT INTERVALS BASED ON AS-BUILT SURVEY DATED AUGUST 1999.
3. CONTRACTOR WILL REMOVE EXISTING IRRIGATION SYSTEM PRIOR TO START OF WORK.
4. ANY WELLS WITHIN DISTURBED AREA OF LANDFARMS NOT LABELED "TO BE ABANDONED" SHALL BE RESTORED TO PREVIOUS CONDITION AS PER D-782119.
5. EXISTING CONTOURS SHOWN ARE NOT VALID IN NORTHERN PORTION OF NO. 4 LANDFARM DUE TO PLACEMENT OF EXCESS FILL. MATERIAL CAN BE USED AS GENERAL BACKFILL, AFTER PROCESSING TO CONFORM TO PROJECT SPECIFICATIONS.
6. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND ELECTRICAL LINES.

LEGEND:

- EXISTING GPS EXTRACTION TRENCH
- EXISTING GPS BARRIER WALL
- OVHD E — EXISTING OVERHEAD ELECTRICAL LINE
- UG E — EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING GROUNDWATER MONITORING WELL
- SD — PROPOSED STORM DRAINAGE PIPE
- DAYLIGHT LINE OF PROPSED DITCH
- SM — SETTLEMENT MARKER LOCATION
- T2 — TENSIOMETER LOCATION
- EXISTING CONTOURS
- AS-BUILT CONTOURS

N

0 100
Scale In Feet

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SLOAN NO. 52785 EXP. 6/30/07 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 2 THROUGH 5 LANDFARMS - SECTIONS	D-767516
NO. 2 THROUGH 5 LANDFARMS - SECTIONS	D-767517
NO. 2 THROUGH 5 LANDFARMS - DITCH PLAN	D-767518
NO. 2 THROUGH 5 LANDFARMS - IRRIGATION PLAN	D-318601
EXTRACTION WELLS & MONITORING WELLS DETAILS	D-782119

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 9/28/99
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

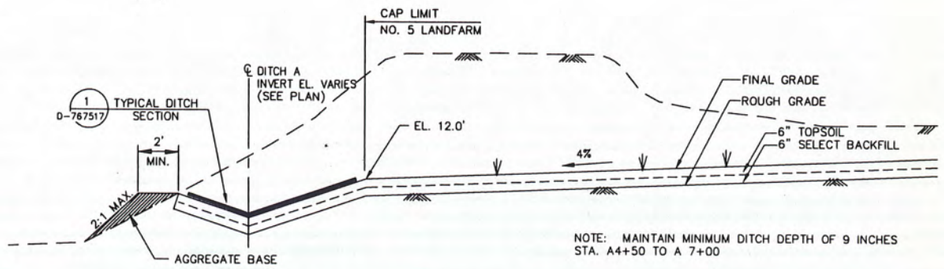
NO. 2 THROUGH 5 LANDFARMS - FINISHED GRADING PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

S W.O. S.O.

D-767515-1

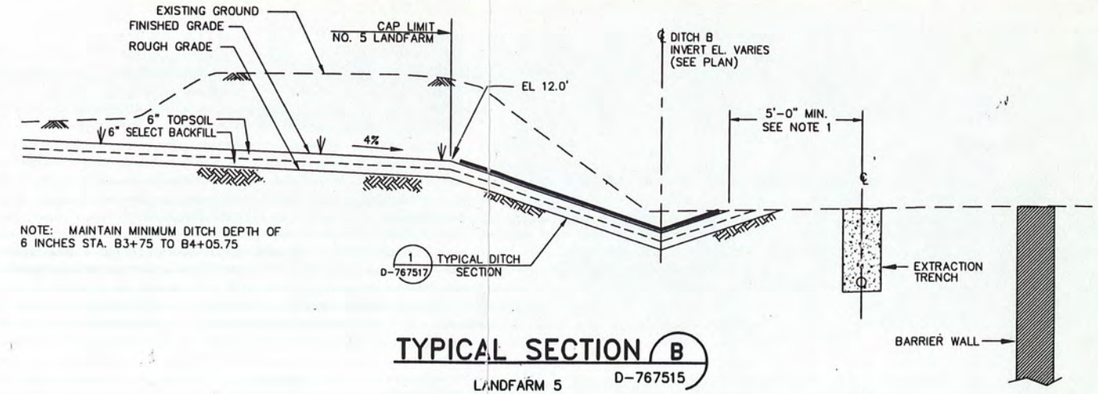
092899SLD

42100001\CHEV-R\S83\LFARMS\ASBUILT\D7675151 0627971:1 092799 B SLD



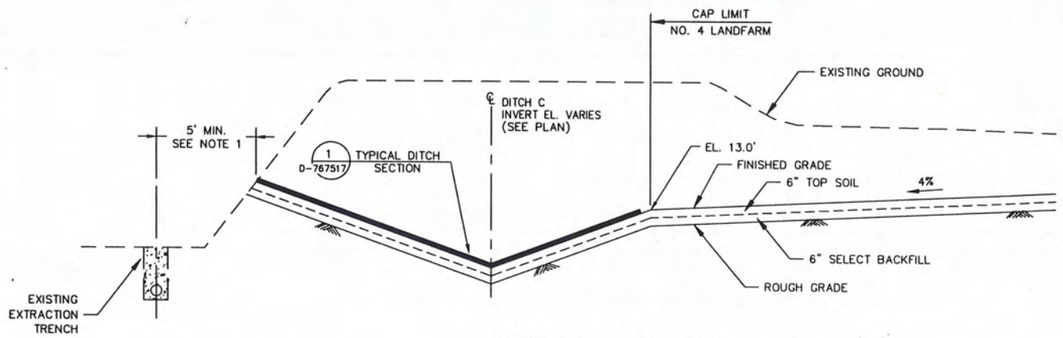
TYPICAL SECTION (A) D-767515

LANDFARM 5
STA A0+00 TO STA A5+00
NOT TO SCALE



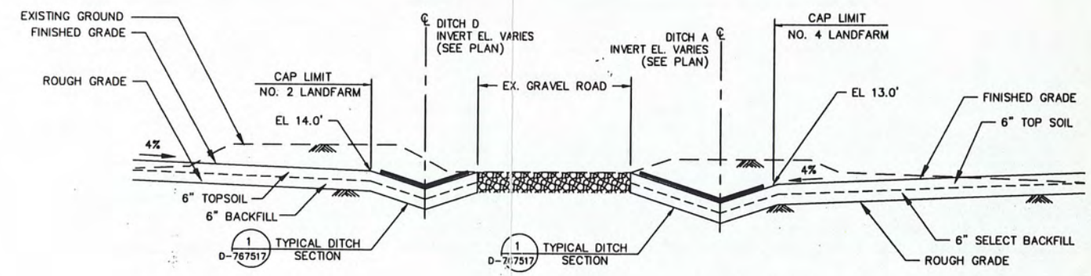
TYPICAL SECTION (B) D-767515

LANDFARM 5
DITCH B
NOT TO SCALE



TYPICAL SECTION (C) D-767515

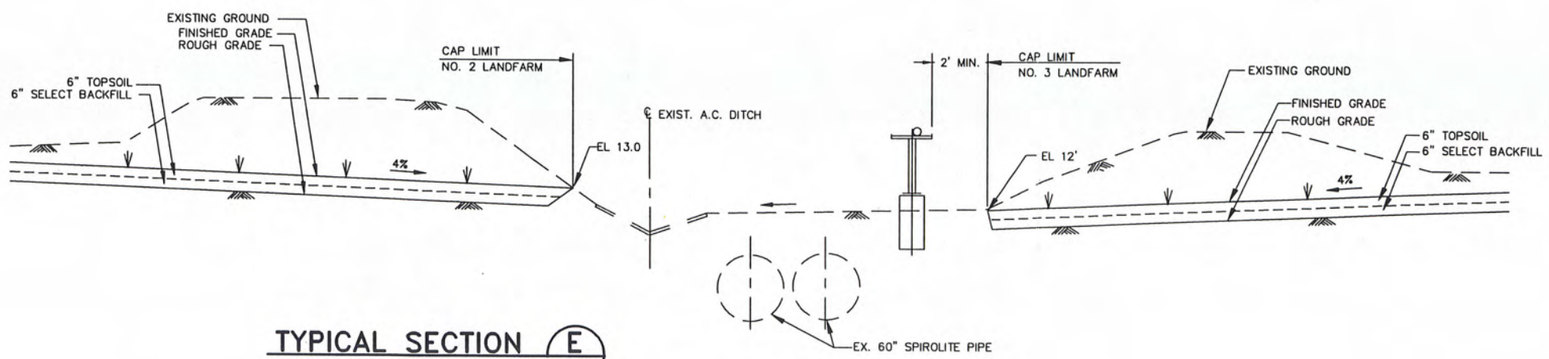
LANDFARM 4
STA C0+00 TO STA C7+00
NOT TO SCALE



TYPICAL SECTION (D) D-767515

LANDFARM 2 AND 4
NOT TO SCALE

NOTE: STATIONS A7+00 TO A10+62 AND STATIONS D0+00 TO D7+28 ARE LINED WITH HDPE LINER.



TYPICAL SECTION (E) D-767515

LANDFARM 2 AND 3
NOT TO SCALE

NOTES:

1. ADJUST DITCH SIDE SLOPES TO MEET CLEARANCE CRITERIA, MAXIMUM OF 2:1 SLOPE.

REGISTERED PROFESSIONAL ENGINEER THOMAS M. DRAKE No. C 58265 EXP. 6-30-02 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE GROUP
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS	
NO. 2 THRU 5 LANDFARMS – FINISHED GRADING PLAN	D-767515
NO. 2 THRU 5 LANDFARMS – DITCH PLAN	D-767518
NO. 2 THRU 5 LANDFARMS – IRRIGATION PLAN	D-318601

REVISIONS		
0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

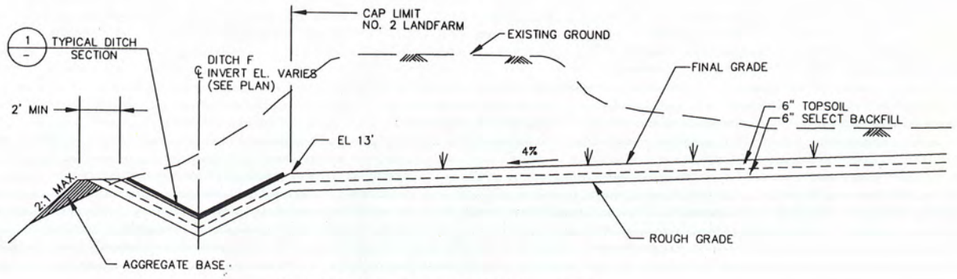
SCALE AS NOTED DR. C. KOSSA DR. APP. DATE 9/29/99
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

NO. 2 THROUGH 5 LANDFARMS – SECTIONS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767516-1

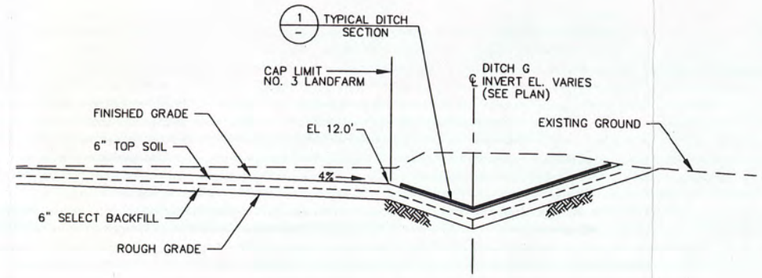
19000900\CHEV-R\S83\LFARMS\ASBUILT\ D7675161 071597 1:1 092799 B sld



TYPICAL SECTION F

LANDFARM 2
DITCH F
D-767515

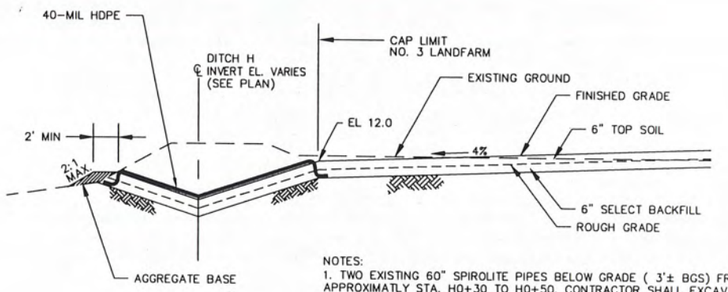
NOT TO SCALE



TYPICAL SECTION G

LANDFARM 3
DITCH G
D-767515

NOT TO SCALE



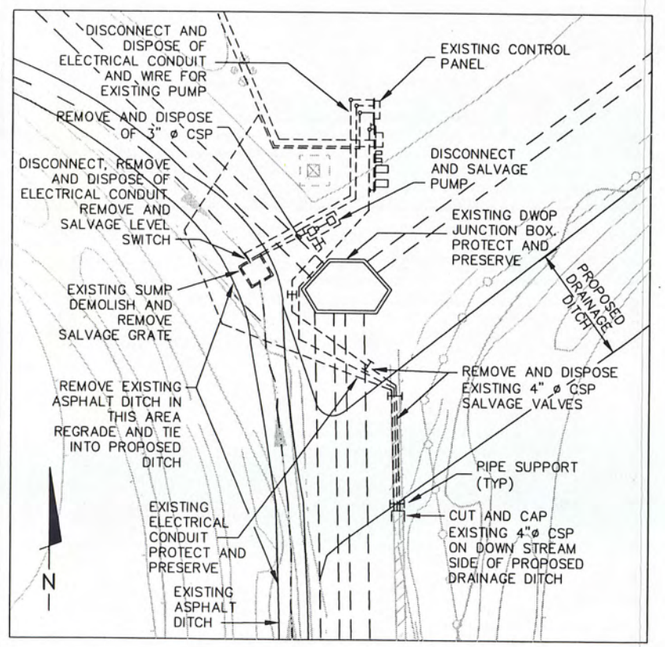
NOTES:

1. TWO EXISTING 60" SPIROLITE PIPES BELOW GRADE (3'± BGS) FROM APPROXIMATLY STA. H0+30 TO H0+50. CONTRACTOR SHALL EXCAVATE WITH EXTREME CAUTION. DAMAGE TO EXISTING PIPES SHALL BE REPAIRED BY CONTRATOR AT NO COST TO COMPANY.
2. MAINTAIN MINIMUM DITCH DEPTH OF 8 INCHES STA H0+00 TO H2+80.

TYPICAL SECTION H

LANDFARM 3
DITCH H
D-767515

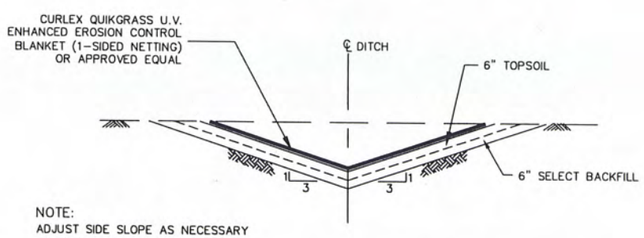
NOT TO SCALE



DETAIL 2

REMOVE CATCH BASIN AND PUMP
D-767515

NOT TO SCALE



NOTE:
ADJUST SIDE SLOPE AS NECESSARY TO MEET CLEARANCE CRITERIA, MAX. OF 2:1 SLOPE.

DETAIL 1/1/1

TYPICAL DITCH SECTION
D-767513 / D-767516

NOT TO SCALE

NOTES:

REGISTERED PROFESSIONAL ENGINEER THOMAS M. [illegible] No. C 48265 EXP. 6/30/02 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS	
NO. 2 THRU 5 LANDFARMS - FINISHED GRADING PLAN	D-767515
NO. 2 THRU 5 LANDFARMS - DITCH PLAN	D-767518
NO. 2 THRU 5 LANDFARMS - IRRIGATION PLAN	D-318601

REVISIONS		
0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. RLS DR. APP. SLD DATE 9/28/99
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

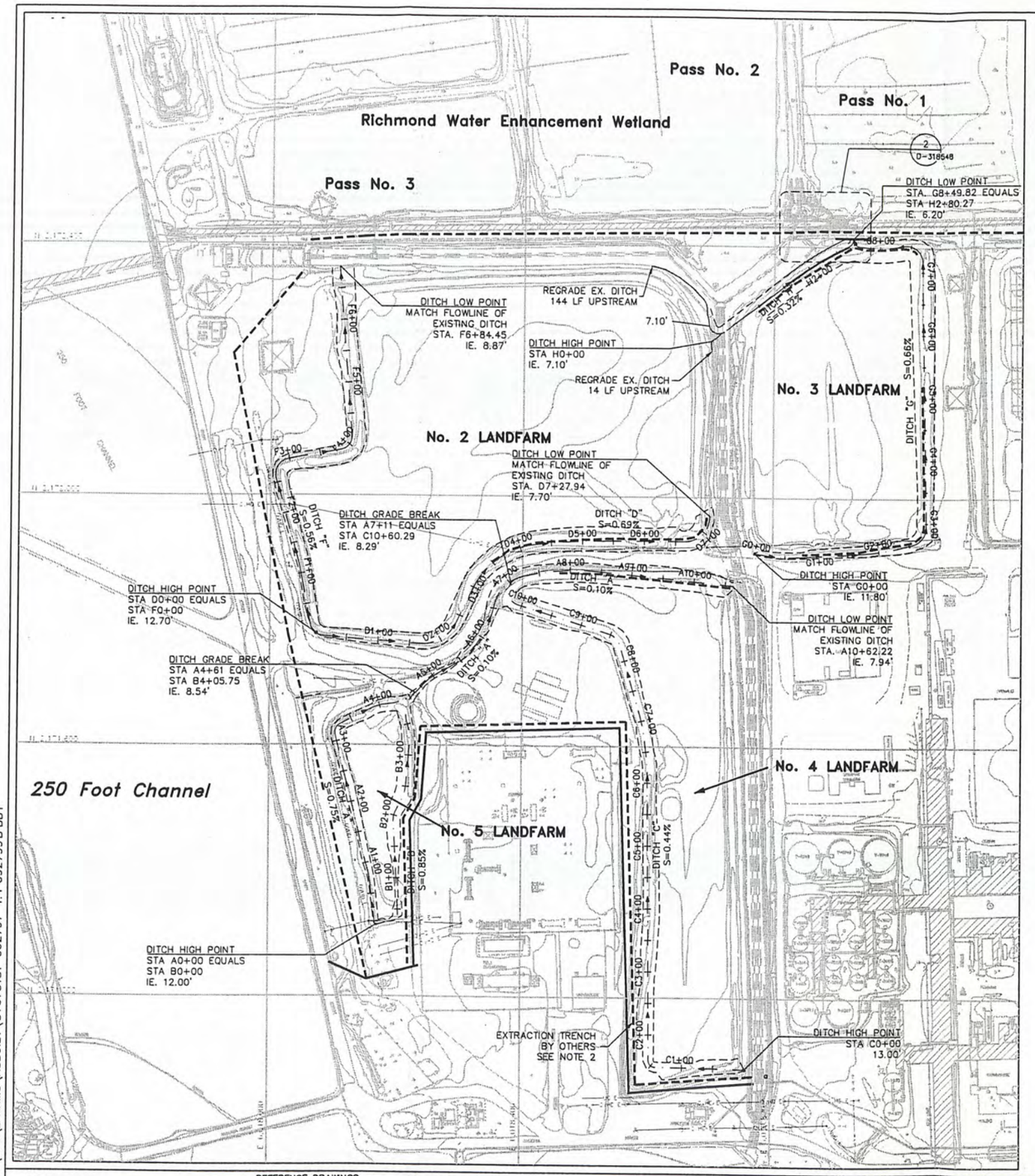
NO. 2 THROUGH 5 LANDFARMS - SECTIONS AND DETAILS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767517-1

92899SLD

19000900\CHEV-R\S83\LFARMS\ASBUILT\D767517 1:1 071497 092799 A SLD



LAYOUT DATA – DITCH "A"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
A0+00*			
A0+02.90	2.52'	2.90'	65°48'49" (R)
A0+65.83	62.93' N 07°03'23" W		
A0+83.19	150.00'	17.36'	06°37'56" (L)
A3+10.69	227.50' N 13°41'19" W		
A3+30.71	15.00'	20.02'	76°28'46" (R)
A3+87.71	57.00' N 62°47'27" E		
A4+12.25	60.00'	24.54'	23°25'59" (R)
A4+74.35	75.00'	62.10'	47°26'18" (L)
A5+15.61	90.00'	41.26'	26°16'09" (R)
A6+52.96	144.00'	137.35'	54°38'56" (L)
A7+24.96	62.00'	72.00'	66°32'16" (R)
A8+45.36	369.50'	120.40'	18°40'13" (R)
A10+62.22	216.86' N 84°23'10" E		

*A0+00 = N2171313.50, E6018172.50
TAN = N 72°56'39" W

LAYOUT DATA – DITCH "B"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
B0+00*			
B0+01.47	2.52'	1.47'	33°27'24" (L)
B0+12.97	11.50' N 73°35'57" E		
B0+28.53	100.00'	15.56'	08°54'46" (R)
B0+40.48	8.00'	11.95'	85°36'35" (L)
B1+92.48	152.00' N 03°05'52" W		
B2+04.92	24.00'	12.44'	29°41'32" (R)
B2+30.92	26.00' N 26°35'40" E		
B2+50.24	50.00'	19.32'	22°08'34" (L)
B3+16.24	66.00' N 04°27'07" E		
B3+53.99	100.00'	37.75'	21°37'44" (L)
B4+05.75	45.00'	51.76'	65°54'08" (R)

*B0+00 = N2171313.50, E6018172.50
TAN = S 72°56'39" E

LAYOUT DATA – DITCH "C"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
C0+00*			
C1+43.50	143.50' N 88°52'55" W		
C1+58.93	10.00'	15.43'	88°23'31" (R)
C6+17.93	459.00' N 00°29'24" W		
C6+41.59	200.00'	23.66'	06°46'39" (L)
C6+79.59	38.00' N 07°16'04" W		
C7+11.07	200.00'	31.48'	09°01'09" (L)
C8+26.57	115.50' N 16°17'13" W		
C8+52.10	26.00'	25.53'	56°15'18" (L)
C10+05.99	153.89' N 72°32'31" W		
C10+60.29	22.50'	54.30'	138°17'06" (R)

*C0+00 = N2171088.00, E6018759.00

LAYOUT DATA – DITCH "D"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
D0+00*			
D0+14.09	25.00'	14.09'	32°17'41" (L)
D1+64.59	150.50' S 85°35'03" E		
D2+37.42	60.00'	72.83'	69°33'02" (L)
D2+97.42	60.00' N 24°51'56" E		
D4+25.39	125.00'	127.97'	58°39'33" (R)
D5+35.59	980.00'	110.20'	06°26'34" (R)
D6+64.59	129.00' N 89°58'02" E		
D7+27.94	40.00'	63.35'	90°44'18" (L)

*D0+00 = N2171779.00, E6018074.00
TAN = S 53°17'72" E

LAYOUT DATA – DITCH "F"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
F0+00*			
F0+18.90	25.00'	18.90'	43°19'28" (R)
F0+92.73	73.83' N 09°57'48" W		
F1+12.12	200.00'	19.39'	05°33'15" (L)
F2+58.25	146.13' N 15°30'43" W		
F2+98.96	25.00'	40.71'	93°18'11" (R)
F3+84.96	86.00' N 79°44'20" E		
F4+14.36	20.00'	29.40'	84°12'51" (L)
F6+84.54	270.09' N 04°28'31" W		

*F0+00 = N2171779.00, E6018074.00
TAN = N 53°17'72" W

LAYOUT DATA – DITCH "G"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
G0+00*			
G0+65.78	285.16.'	65.78'	13°12'58" (L)
G1+65.60	89.82' N 86°32'46" E		
G2+56.35	397.97'	90.75	13°03'54" (L)
G2+95.14	29.74'	38.79'	74°44'55" (L)
G7+17.51	422.37' N 01°16'01" W		
G7+61.12	25.00'	43.61'	99°56'52" (L)
G8+33.40	207.44.'	72.28'	19°57'51" (R)
G8+49.82	11.58'	16.42'	81°15'05" (R)

*G0+00 = N2171912.00, E6018770.00
TAN = S78°13'46"E

LAYOUT DATA – DITCH "H"			
STATION	TAN. LENGTH BEARING RADIUS	LENGTH	INCLUDED ANGLE
H0+00*			
H1+61.49	161.49' N 52°11'58" E		
H2+67.08	462.81'	105.59'	13°04'18" (R)
H2+80.27	11.58'	13.19'	65°16'15" (L)

*H0+00 = N2172248.50, E6018700.00

N

0 100
Scale In Feet

NOTES:

1. EXISTING CONTOUR LINES ARE AT 1 FOOT INTERVALS BASED ON AERIAL PHOTOGRAPHS DATED AUGUST 1990.
2. CONTRACTOR SHALL COORDINATE ALL GRADING AND EARTH WORK FROM STA. C0+00 TO C7+00 AND B0+25 TO B3+50 WITH EXTRACTION TRENCH INSTALLATION CONTRACTOR.
3. THE DITCH LAYOUT TABLES, LOW AND HIGH POINTS, SLOPES AND CENTERLINES INDICATE DESIGN LOCATIONS AND DO NOT REFLECT AS-BUILT CONDITIONS.
4. STATIONS ARE BASED ON DESIGN CENTERLINES OF THE DITCHES.
5. LOCATION OF EXISTING GPS EXTRACTION TRENCH WITHIN THE LANDFARM LIMITS ARE APPROXIMATES.

LEGEND:

- EXISTING OR PLANNED GPS EXTRACTION TRENCH
- EXISTING OR PLANNED GPS BARRIER WALL
- CENTERLINE OF PROPOSED DITCH
- DAYLIGHT LINE OF PROPSED DITCH

REGISTERED PROFESSIONAL ENGINEER THOMAS M. No. C 36265 EXP. 6/30/00 CIVIL STATE OF CALIFORNIA

DEM GROUP
Waste Discharge Order Project
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO.2 THRU 5 LANDFARMS – FINISHED GRADING PLAN	D-767515
NO. 2 THROUGH 5 LANDFARMS – SECTIONS	D-767516
NO. 2 THROUGH 5 LANDFARMS – SECTIONS	D-767517
NO. 2 THROUGH 5 LANDFARMS – IRRIGATION PLAN	D-318601
EXTRACTION WELLS & MONITORING WELLS DETAILS	D-782119

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 4/20/99 APPROVED
ENGR. ENGR. DEPT.
OPR'G. DEPT.

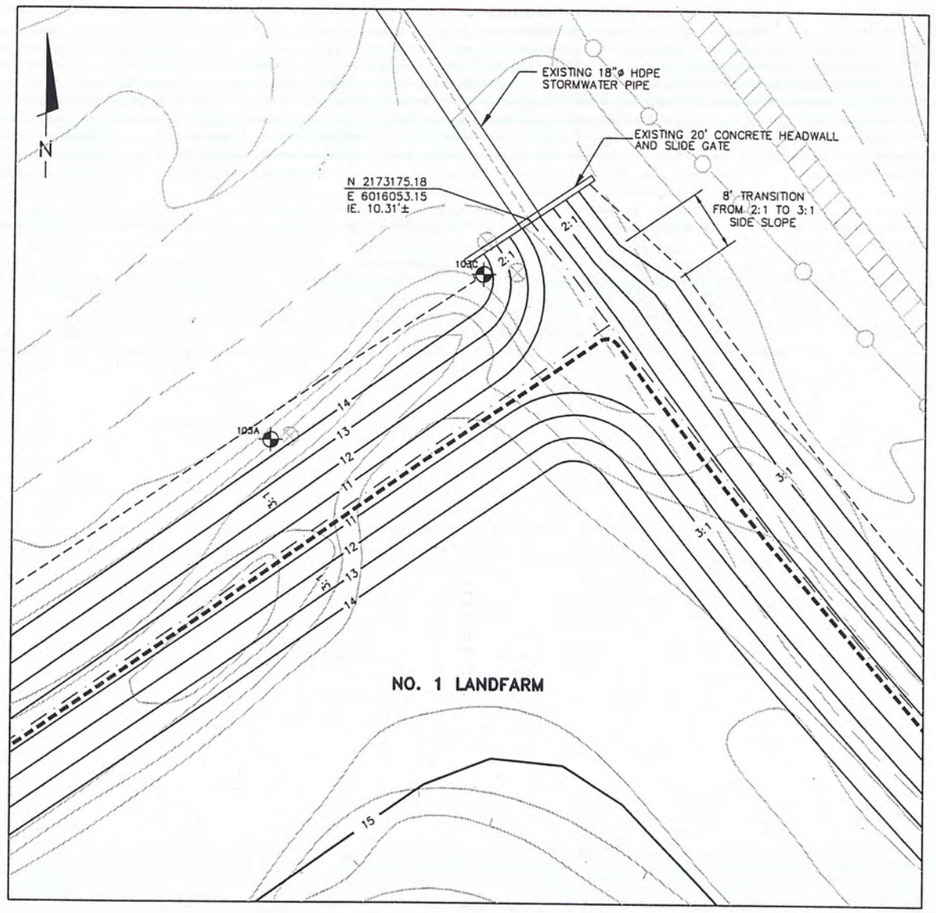
092899SLD

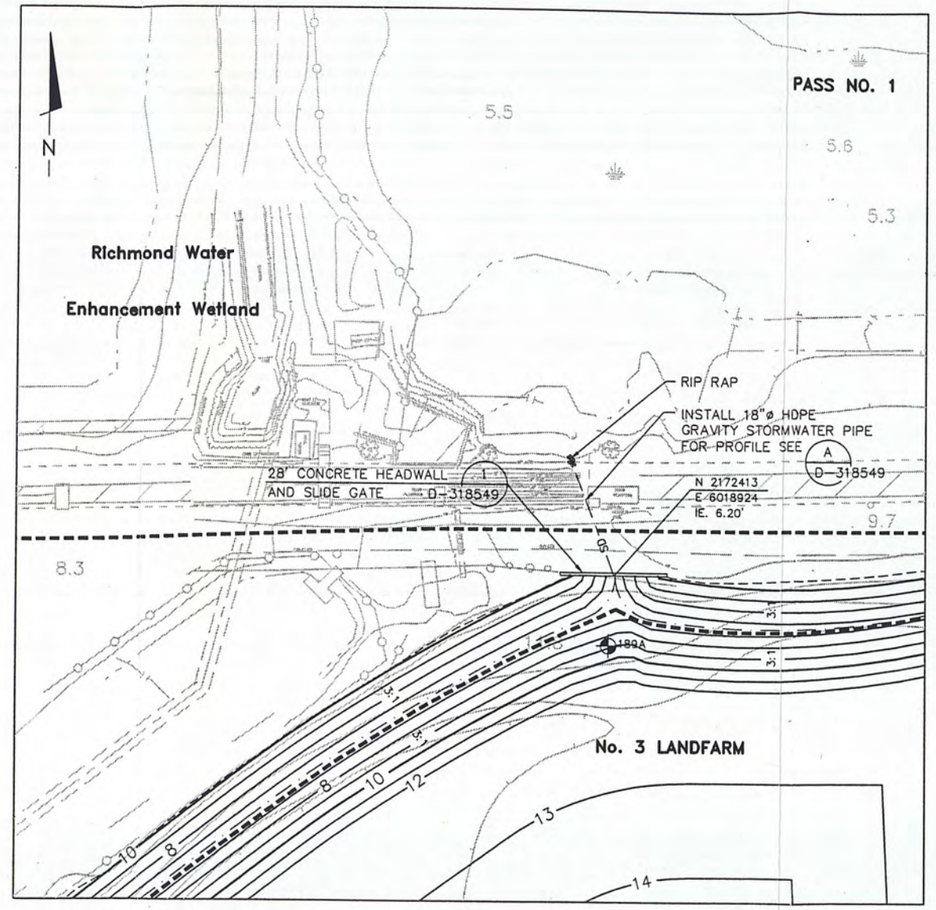
NO. 2 THROUGH 5 LANDFARMS – DITCH PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767518-1

42100001 \CHEV-R\S83\LFARMS\ASBUILT\D767518I 062797 1:1 092799B BBT





DETAIL 1 D-767514

OUTLET GRADING
NO. 1 LANDFARM

0 10
Scale in Feet

DETAIL 2 D-767518

OUTLET GRADING
NO. 3 LANDFARM

0 20
Scale in Feet

NOTES:

1. ELEVATIONS SHOWN ARE ORIGINAL DESIGN ELEVATIONS AND DO NOT NECESSARILY REFLECT AS-BUILT ELEVATIONS.

2. LOCATION OF EXISTING GPS EXTRACTION TRENCHES WITHIN THE LANDFARMS ARE APPROXIMATES.

LEGEND:

- EXISTING OR PLANNED GPS EXTRACTION TRENCH
- EXISTING GROUNDWATER MONITORING WELL
- SD — PROPOSED STORM DRAINAGE PIPE
- CENTERLINE OF PROPOSED DITCH
- DAYLIGHT LINE OF PROPOSED DITCH

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SHEETS No. C 58785 EXP. 6/30/07 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 1 LANDFARM – FINISHED GRADING PLAN	D-767512	NO. 2 THRU 5 LANDFARMS – DITCH PLAN	D-767518
NO. 1 LANDFARM – SECTIONS	D-767513	NO. 1 LANDFARM – IRRIGATION PLAN	D-318600
NO. 1 LANDFARM – DITCH PLAN	D-767514	NO. 2 THRU 5 LANDFARMS – IRRIGATION PLAN	D-318601
NO. 2 THRU 5 LANDFARMS – FINISHED GRADING PLAN	D-767515		
NO. 2 THROUGH 5 LANDFARMS – SECTIONS	D-767516		
NO. 2 THROUGH 5 LANDFARMS – SECTIONS	D-767517		

REVISIONS

0 ISSUE FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. DATE 9/28/99 APPROVED
ENGR. ENGR. DEPT.
OPR'G. DEPT.

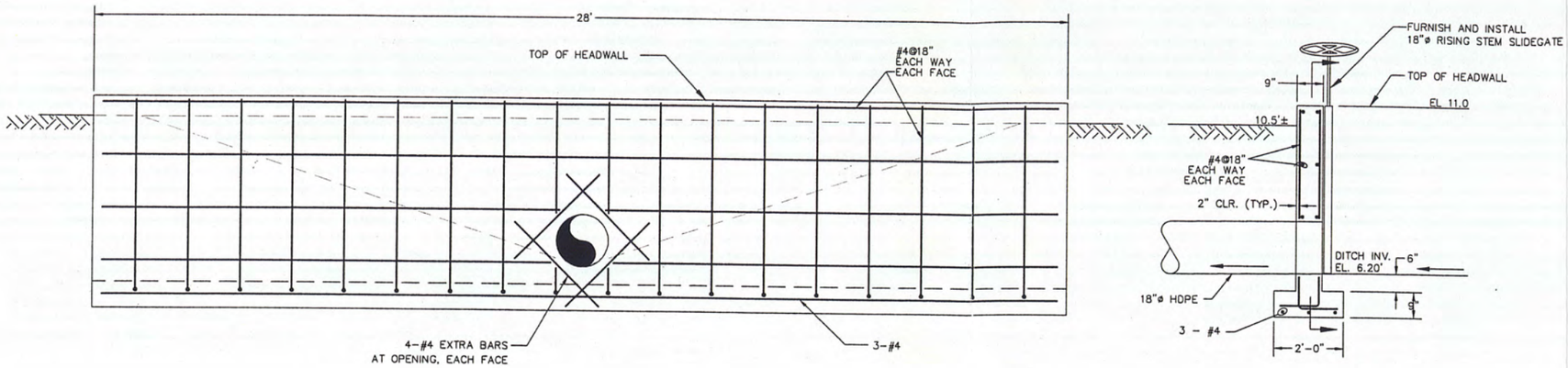
092899SLD

NO. 1 AND 3 LANDFARMS – STORMWATER DRAIN PLANS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

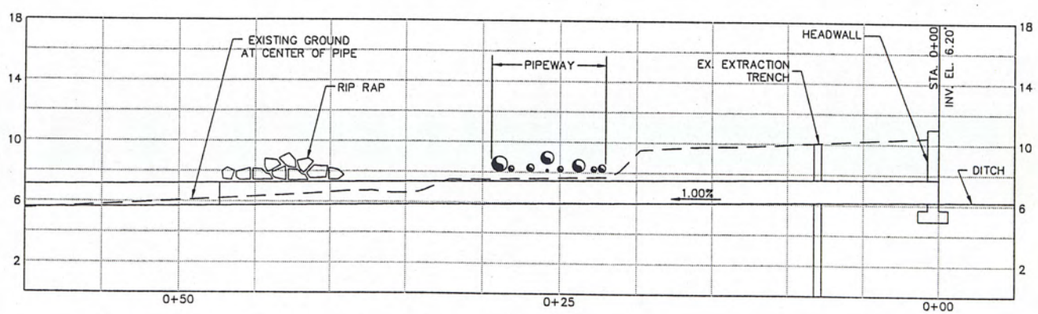
D-767519-1

42100001 \CHEV-R\S83\LFARMS\ASBUILT\ D7675191 080497 1:1 092799 C SLD



DETAIL 1
HEADWALL D-767519

0 2
Scale in Feet



PROFILE A
D-767519

0 5
Scale in Feet

NOTES

REFERENCE DRAWINGS

REVISIONS

A ISSUED FOR CONSTRUCTION 4/10/98	CIK	
1 AS-BUILT 9/15/99	AGP	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. S.O. DATE 9/23/99
ENGR. TWS ENGR. DEPT.
OPR'G. DEPT.
APPROVED

Waste Discharge Order Project
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

NO. 3 LANDFARM - STORMWATER DRAIN DETAILS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-318549-1

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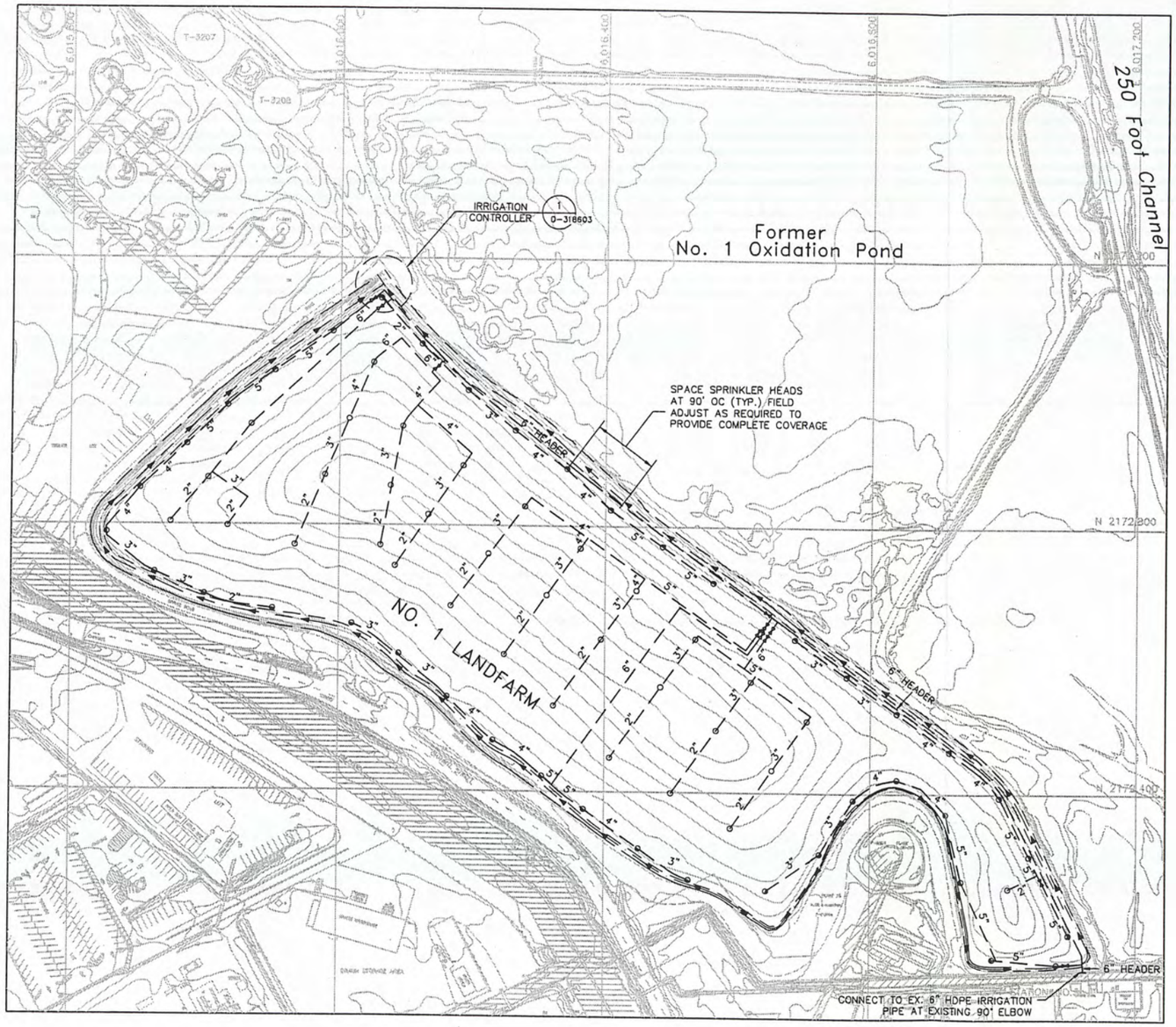

NOTES:

1. CONTOUR LINES AND GRADE SHOWN ARE FINAL GRADES BASED ON AS-BUILT SURVEY DATED AUGUST 1999.

LEGEND

- PROPOSED DITCH
- 360-DEGREE SPRAY SPRINKLER HEAD
- 180-DEGREE SPRAY SPRINKLER HEAD
- 270-DEGREE SPRAY SPRINKLER HEAD
- 3" IRRIGATION PIPE AND SIZE

N

0 100
Scale in Feet

REGISTERED PROFESSIONAL ENGINEER THOMAS M. REED REG. C 56265 EXP. 6/30/02 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
GROUP
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 1 LANDFARM – FINISHED GRADING PLAN	D-767512
NO. 1 LANDFARM – SECTIONS	D-767513
NO. 1 LANDFARM – DITCH PLAN	D-767514

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. S.L.O. DATE 9/28/99 APPROVED
ENGR. JWS ENGR. DEPT.
OPR'G. DEPT.

92899SLD

NO. 1 LANDFARM – IRRIGATION PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

S W.O. S.O.

D-318600-1

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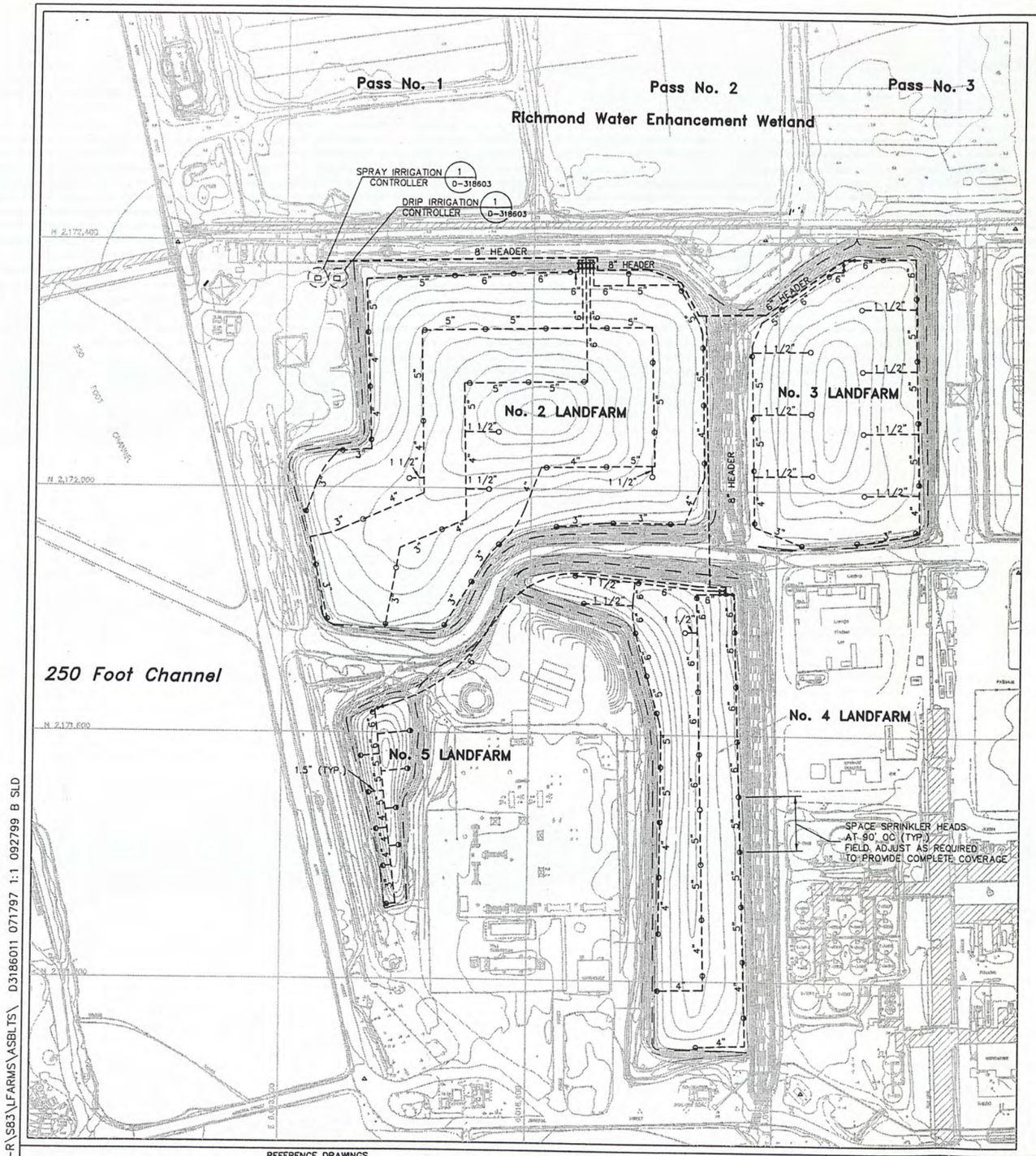

NOTES:

1. CONTOUR LINES AND GRADE SHOWN ARE FINAL GRADES BASED ON AS-BUILT SURVEY DATED AUGUST 1999.

LEGEND:

- PROPOSED DITCH
- EXISTING GROUNDWATER MONITORING WELL
- 360-DEGREE SPRAY SPRINKLER HEAD
- 180-DEGREE SPRAY SPRINKLER HEAD
- 90-DEGREE SPRAY SPRINKLER HEAD
- 3" IRRIGATION PIPE AND SIZE

N

0 100
Scale In Feet

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SHEEHY No. C 58245 EXP. 6/30/03 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE GROUP
A DAMES & MOORE GROUP COMPANY
JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 2 THRU 5 LANDFARMS - FINISHED GRADING PLAN	D-767515
NO. 2 THRU 5 LANDFARMS - SECTIONS	D-767516
NO. 2 THRU 5 LANDFARMS - SECTIONS	D-767517
NO. 2 THRU 5 LANDFARMS - DITCH PLAN	D-767518

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 9/28/99 APPROVED
ENGR. TUS ENGR. DEPT.
OPR'G. DEPT.

092699SLD

NO. 2 THROUGH 5 LANDFARMS - IRRIGATION PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-318601-1

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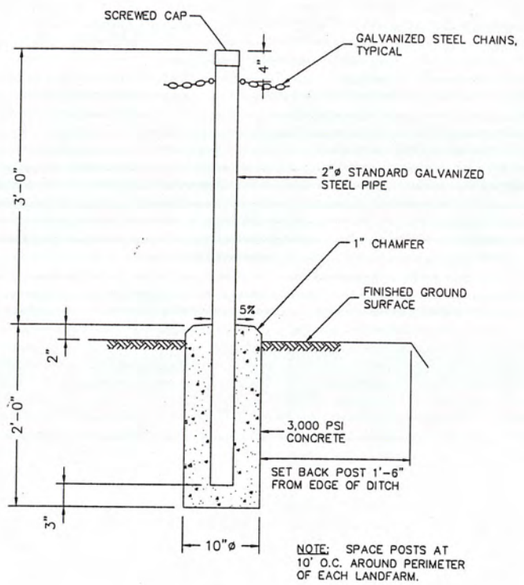
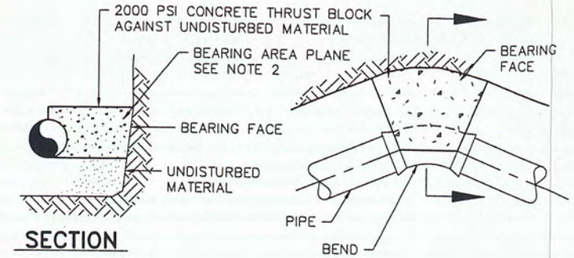


DETAIL (2/D-767512) (2/D-767515)

PERIMETER POST

NOT TO SCALE



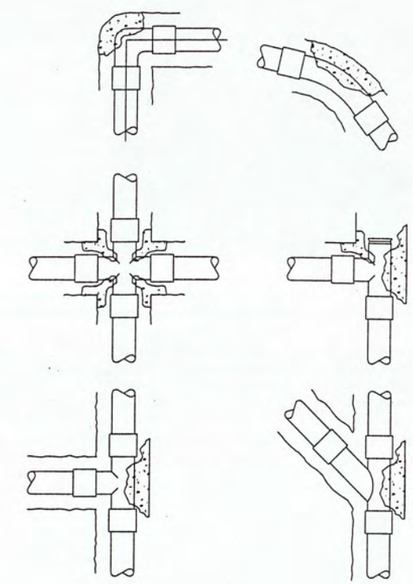
SECTION

NOTES:

1. ALL PIPE BENDS SHALL BE BACKED UP WITH A CONCRETE THRUST BLOCK, CONCRETE 2000 psi, BETWEEN THE PIPE AND UNDISTURBED MATERIAL.
2. ALL THRUST BLOCKS SHALL HAVE A MINIMUM AREA OF 1 SF. MAJOR BENDS SHALL HAVE A BEARING AREA ACCORDING TO THE FOLLOWING SCHEDULE:

	ANGLE OF BEND			
	11.25	22.5	45	90
SIZE	BEARING AREA			
2"ø	1.0 SF	1.0 SF	1.0 SF	1.0 SF
3"ø	1.0 SF	1.0 SF	1.0 SF	1.0 SF
4"ø	1.0 SF	1.0 SF	1.0 SF	1.0 SF
6"ø	1.0 SF	1.0 SF	1.0 SF	1.6 SF
8"ø	1.0 SF	1.0 SF	1.5 SF	2.8 SF

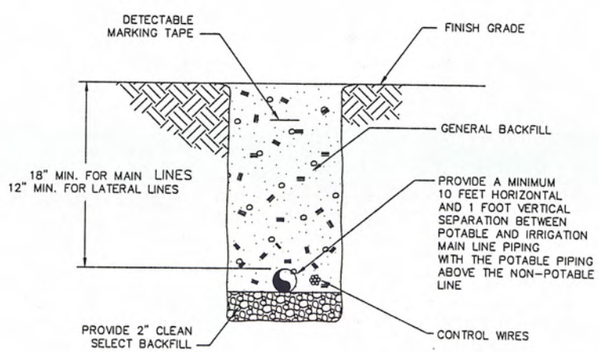
3. BEARING AREA REQUIRED ON VERTICAL PLANE 90° TO RADIUS PLANE PASSING THROUGH MIDPOINT OF BEND.
4. THE SIZES OF THRUST BLOCKS ARE BASED ON 100 PSI TEST PRESSURE AND 2500 PSF PASSIVE SOIL STRENGTH.
5. THE CONTRACTOR SHALL NOTIFY THE ENGINEER AFTER EXCAVATION OF EACH BEND EQUAL TO OR LARGER THAN 11.25° IN ORDER TO OBTAIN A CONFIRMATION OF THE PASSIVE SOIL STRENGTH.
6. FOR VERTICAL UP-THRUST BLOCKS, PLACE #5 REBAR WITH 3" COVER AND 5" HOOKS AROUND FITTINGS AND EMBEDDED INTO CONCRETE. USE A MINIMUM OF 4 CY OF CONCRETE WITH A HORIZONTAL BEARING AREA OF 2 SF. PLACE VERTICAL UP-THRUST BLOCKS WHERE THRUST ON THE FITTING IS UP OR USE RESTRAINED JOINT FOR 18" IN EACH DIRECTION.
7. FOR DOWN THRUST FITTINGS USE TYPICAL THRUST BLOCK UNDER FITTING.



TYPICAL DETAIL

THRUST BLOCKING

NOT TO SCALE



TYPICAL DETAIL

PIPE TRENCH

NOT TO SCALE

REGISTERED PROFESSIONAL ENGINEER THOMAS M. BRIGHT No. C 58261 EXP. 6/30/07 CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project

DAMES & MOORE GROUP — A DAMES & MOORE GROUP COMPANY

JOB NO. 42100-001-043

REFERENCE DRAWINGS	
NO. 1 LANDFARM – FINISHED GRADING PLAN	D-767512
NO. 1 LANDFARM – DITCH PLAN	D-767514
NO. 2 THRU 5 LANDFARMS – FINISHED GRADING PLAN	D-767515
NO. 2 THRU 5 LANDFARMS – DITCH PLAN	D-767518
NO. 1 LANDFARM – IRRIGATION PLAN	D-318600
NO. 2 THRU 5 LANDFARMS – IRRIGATION PLAN	D-318601

REVISIONS		
0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron — Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 9/28/99 APPROVED

ENGR. JMS ENGR. DEPT.

OPR'G. DEPT.

W.O.

S.O.

NO. 1 THROUGH 5 LANDFARMS – MISCELLANEOUS DETAILS

SECTOR 83: LANDFARMS

LANDFARMS CLOSURE PLAN

UTILITIES/ENVIRONMENTAL ABU

D-318602-1

092899SLD

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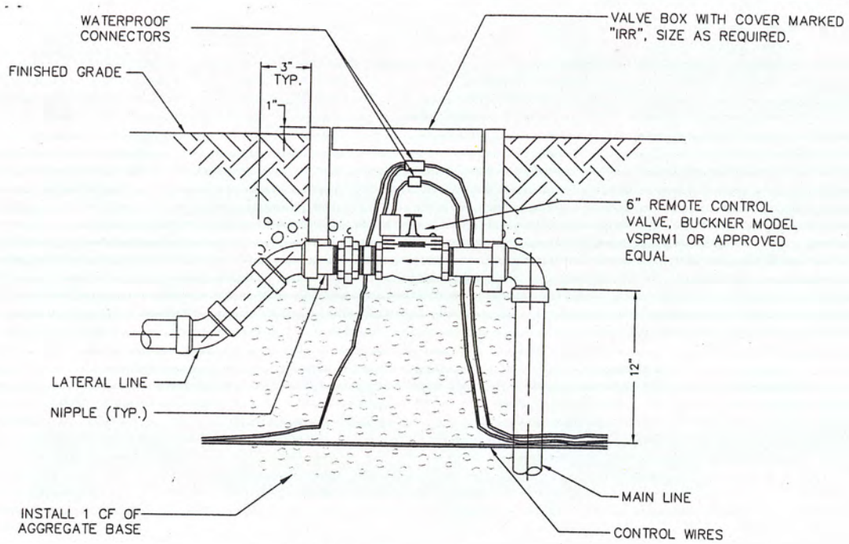
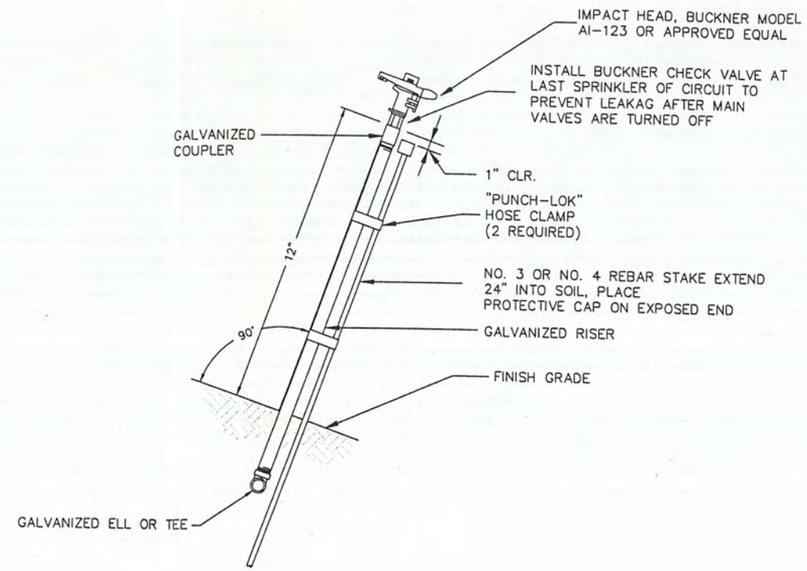


TYPICAL DETAIL

REMOTE CONTROL VALVE

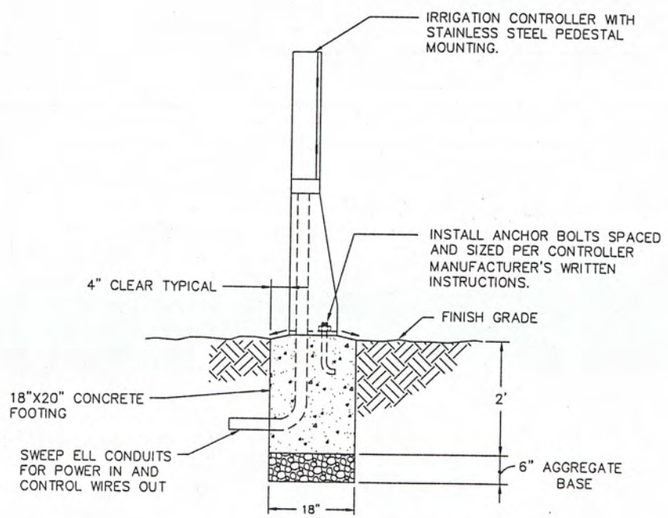
NOT TO SCALE



TYPICAL DETAIL

SPRINKLER HEAD ON SLOPE

NOT TO SCALE



DETAIL

ELECTRICAL IRRIGATION CONTROLLER

1 D-318600 1 D-318601

NOT TO SCALE

NOTES:

1. AFTER INSTALLATION APPLY 2 COATS OF RUSTOLEUM 5737 IVY GREEN PAINT.
2. DISCONNECT, DEMOLISH, AND REMOVE EXISTING IRRIGATION CONTROLLERS AT LANDFARMS 1 AND 2. REMOVE EXISTING CONDUIT TO A LEVEL TO ALLOW CONSTRUCTION OF CAP. CONNECT NEW CONTROLLERS TO EXISTING POWER SUPPLY.
3. INSTALL IRRITROL SYSTEMS, IBOC PLUS SOLAR-POWERED CONTROLLER TO CONTROL BOTH SPRAY AND DRIP IRRIGATION SYSTEMS ON LANDFARM NO. 1.
4. INSTALL BUCKNER, MODEL MD-8 TO CONTROL THE DRIP IRRIGATION SYSTEM ON LANDFARM NOS. 2 THROUGH 5.
5. INSTALL BUCKNER, MODEL MD-12 TO CONTROL THE SPRAY IRRIGATION SYSTEM ON LANDFARM NOS. 2 THROUGH 5.

REGISTERED PROFESSIONAL ENGINEER THOMAS M. SWEET No. C 58265 EXP. CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project

DAMES & MOORE GROUP — A DAMES & MOORE GROUP COMPANY

JOB NO. 42100-001-043

REFERENCE DRAWINGS

NO. 1 LANDFARM – IRRIGATION PLAN	D-318600
NO. 2 THRU 5 LANDFARMS – IRRIGATION PLAN	D-318601

REVISIONS

0 ISSUED FOR CONSTRUCTION	5/11/98	CIK
1 AS BUILT	9/15/99	SLD

Chevron — Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. GLD DATE 9/26/99 APPROVED

ENGR. ENGR. DEPT.

OPR'G. DEPT.

NO. 1 THROUGH 5 LANDFARMS – MISC. IRRIGATION DETAILS

SECTOR 83: LANDFARMS

LANDFARMS CLOSURE PLAN

UTILITIES/ENVIRONMENTAL ABU

W.O.

S.O.

D-318603-1

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092899SLD