Appendix F
Revised Landfarms Post-Earthquake Inspection and Corrective Action Plan
(June 2, 2015)

REVISED LANDFARMS POST-EARTHQUAKE INSPECTION AND CORRECTIVE ACTION PLAN RICHMOND REFINERY

Revised: June 2, 2015

Original: December 30, 1996

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REVISED LANDFARMS POST-EARTHQUAKE INSPECTION AND CORRECTIVE ACTION PLAN
RICHMOND REFINERY

1. INTRODUCTION

Leidos Engineering, LLC (Leidos) has revised and updated this Landfarms Post-Earthquake Inspection and Corrective Action Plan. Bechtel Environmental, Inc and Dames & Moore (BEDM) initially prepared the Landfarms Post Earthquake Inspection and Corrective Action Plan, to comply with a request by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC), transmitted to Chevron in the DTSC's August 15, 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* The initial Landfarms Post Earthquake Inspection and Corrective Action Plan was incorporated into the Hazardous Waste Facility Post-Closure Permit, dated March 4, 2003 by reference.

Leidos has updated the initial plan based on comments received from the DTSC in the January 12, 2015 First Notice of Deficiency, Post-Closure Permit Renewal Part B Application, Chevron USA Inc. Richmond Refinery, Contra Costa County, EPA ID No CAD009114919. As requested by the DTSC, this Plan has been updated to reflect the final closure unit configuration, and includes the final as-built drawings.

This plan is designed to be implemented by the Environmental Operations Department (EOD) of the Refinery's Utilities/Environmental Area Business Unit (U/E) in the event of any earthquake that generates ground shaking of Modified Mercalli Intensity VI or greater at the Landfarms. An event of this intensity is generally described as follows: "Felt by all. People walk unsteadily. Many frightened. Windows crack. Dishes, glassware, knickknacks, and books fall off shelves. Pictures fall off walls. Furniture moved or overturned. Weak plaster, adobe buildings, and some poorly built masonry buildings cracked. Trees and bushes shake visibly."

This plan discusses the containment facilities that may be impacted at the Landfarms by seismic deformations due to an earthquake. The plan also addresses the corrective actions to be taken in the event of damage due to an earthquake.

The initial November 1996 plan was prepared under the supervision of Mr. Mark J. Wahler, California Registered Engineer No. C-35633. The updated June 2, 2015 plan was prepared under the supervision of J. Austin Bond, California Registered Engineer No. C-66709.

2. POTENTIALLY IMPACTED FACILITIES

The following sections discuss the major elements of the Landfarms containment systems that may be impacted by a major seismic event. Appendix A to this plan contains copies of the design and as-built drawings for the elements discussed in this plan. The nature of the facilities and contaminants at this site are such that fires or explosions are unlikely. Furthermore, there is little likelihood of release of hazardous wastes that would pose an immediate threat to human health or the environment. The only potential releases would occur if either the GPS discharge lines ruptured, resulting in a discharge of the extracted groundwater to the ground, or if heavy rains washed soils out of the closure unit through a rupture of the cover. In either case, the release

would likely be contained within the Refinery and would not likely release constituents at levels that would cause a short-term risk to either people or the environment.

2.1 GROUNDWATER EXTRACTION TRENCH

The extraction trench is a vertical subsurface structure consisting of a geotextile-fabric-wrapped gravel drain. As discussed in the Revised Landfarms Closure Plan, the extraction trench is a somewhat flexible structure. Slope stability analyses presented in the Revised Closure Plan indicated that portions of the Landfarms may displace laterally as much as 1 foot following a Maximum Credible Earthquake due to shear failure in the underlying Bay Muds. The impact to the GPS extraction trench was assumed to be minor as the shear plane would be in the underlying Bay Muds beneath the base of the trenches. Total displacement would be less than the width of the trench, indicating that the trench may not be functional immediately after the event and may require repair. If the fabric is torn, fines from the adjacent soils may enter the trench and eventually clog it. This condition would become obvious during the routine monitoring of the trench piezometers and pumping rates and could be corrected at that time.

The extraction sumps are durable elements and, as with the trench, are only likely to be damaged by a general slope failure during a major event. Limited distortion of the sump or well casing would not significantly impair the operation of the trench or well. If the casing is crushed or severed completely, it may become impossible to operate a pump within the sump or well.

A failure of some or all of the extraction system may result in a slow rise in the groundwater level within the site. Since the normal operating level of the system is below the level of groundwater outside the site, Leidos anticipates a considerable time would pass before the groundwater level rose sufficiently to create an outward gradient from the site or over-top the wall. This time should be sufficient to repair the system.

2.2 GROUNDWATER MONITORING WELLS AND PIEZOMETERS

The groundwater monitoring wells and piezometers at the Landfarms could be disrupted by a significant ground rupture. Since these features are only used to monitor water quality in the “A” and “C” Zones and the long-term effectiveness of the containment system, there would be no significant immediate consequences if they were to be damaged during an earthquake.

2.3 GROUNDWATER EXTRACTION PUMPS AND CONTROLLERS

The pumps are suspended in the sumps and extraction wells and would be immersed in water under normal operating conditions. The sturdy construction combined with the damping effect of the water in the sumps should prevent damage from any movement during an earthquake. The attached hoses will have sufficient slack to accommodate any movements.

The controllers are mounted above grade (see drawings D-318641, D-318643, D-318651, D-318652, D-782424, D-782425, D-782441 and D-782442 in Appendix A) and are connected to the pumps with flexible tubing. The system is flexible and is unlikely to be damaged. However, if damage does occur, it would most likely consist of a separated piping connection and should be readily visible.

The failure of some or all of the pumps would have the same consequences as the failure of the trench or wells themselves, which was discussed above in Section 2.2.

2.4 COMPRESSED AIR SUPPLY LINES

The compressed air supply required to run the pumps and their controllers is supplied through an above-grade 2-inch galvanized steel pipe (see Appendix A). A manual shutoff valve for the No. 1 Landfarm system is at the air filters located just north of the end of the LPG loading tracks. (see drawings D-318640 and D-318641 in Appendix A). A manual shutoff valve for the Nos. 2 through 5 Landfarm systems is with the air filter located near the southwest corner of the Electrical Switchgear Station, which is just east of No. 3 Landfarm (see drawings D-782439 and D-782441 in Appendix A). The connections from the air line to the pump controllers include a shutoff valve. The line is flexible and the worst anticipated occurrence during a substantial earthquake would be the lines bouncing off their supports. If the lines were to break, the rupture should be readily apparent and easy to repair.

The air supply lines are carbon steel pipes that are connected to the existing Refinery compressed air system. It is likely that, during a major seismic event, the Refinery's compressed air system will go out of service, resulting in a loss of supply to the extraction sumps. If this were to occur, the pumps would simply cease operating.

2.5 GROUNDWATER TRANSFER LINES

The discharge lines for the extraction pumps are either carbon steel or HDPE lines that parallel the compressed air supply lines within the Landfarms area and are equipped with similar sets of manual valves. As with the air lines, in the unlikely event that the line is ruptured during a major earthquake, the damage should be readily apparent and easily repaired. Most likely, an event strong enough to rupture the discharge lines would also disable the compressed air supply system, which would in turn stop the pumps. Hence, only the water contained within the discharge line at the time of the event would be available to drain from the line. Water draining from a broken line would flow into an existing swale from which it can be recovered.

The discharge line ultimately drains to the Refinery's No. 1A Separator. A major seismic event may put the separator out of service for a period of time.

2.6 STORMWATER TRANSFER SYSTEM

The stormwater transfer system for No. 1 Landfarm consists of a several permanently installed submersible pumps connected to a 4-inch line that discharges to the No. 1 Oxidation Pond, First Pass. The transfer system for Nos. 2 through 5 Landfarm consists of gravity-feed culverts that discharge to either the Refinery effluent treatment system or the Richmond Refinery water-enhanced wetlands. Damage to this system due to an earthquake is unlikely, but would be readily detected and could easily be repaired. Damage to this system would only be of consequence if a significant rainfall were to occur before the system could be repaired.

2.7 FINAL COVER

The final cover over the Landfarms is a vegetated layer intended to promote the biodegredation of hydrocarbons remaining in the old Landfarms soils and to reduce rainwater infiltration into the old Landfarms soils. The cover consists of a one-foot layer of vegetated fill, as shown on Drawings D-767513, D-767516 and D-767517. If permanent displacement of the Landfarms cover occurs during the earthquake, the fill layer is likely to crack, creating an entry path for rainwater infiltration into the underlying materials. This is only of concern if it is raining. The nature of the underlying materials is such that they do not impose an immediate health hazard simply by being exposed.

3. POST-EARTHQUAKE INSPECTION

Due to the relatively low immediate consequences of earthquake-induced damage to the Landfarms containment systems when compared to the balance of the Refinery, the inspection of the systems has been divided into two phases. The first phase would be performed as soon as an EOD operator could be available, ideally within 24 hours following a qualifying earthquake, and would consist of a quick inspection to ascertain if the systems had sustained major damage that might result in an immediate release of potentially contaminated groundwater to the ground surface. The second phase would consist of a more thorough inspection to ascertain if any less significant damage had occurred. If other post-earthquake demands on the operator are not urgent, the first phase can be skipped and only the more thorough inspection be performed. If conditions at the refinery pose a substantial risk to the health or safety of the inspector, the inspection will be deferred until it is determined to be safe to enter.

3.1 PHASE I INSPECTION

The intent of this initial inspection is to evaluate whether the extraction system should be shut off immediately and remain off until a more careful inspection can be performed or repairs completed. The system is to be shut down if any of the following conditions exist:

- Compressed air service to the Landfarms is discontinued.
- The No. 1A Separator is out of service.
- The discharge pipeline is ruptured, either at the Landfarms or at any point between the Landfarms and the No. 1A Separator.
- The compressed air header at the Landfarms is ruptured.

The locations for the system's shutoff valves were described in Section 2.4. When shutting off the system, the compressed air valve should be closed first and then the water discharge line. When restarting the system, the discharge valve should be opened first, followed by the compressed air valve.

In addition, an individual pump is to be shut off if either its air supply line or discharge line is ruptured between the valve and the pump.

3.2 PHASE I INSPECTION PROCEDURE

The inspection of the Landfarms containment systems shall be performed by an operator who is familiar with the system. During the course of the Phase I inspection, the operator shall keep a record of his observations and actions. The record should include observations of ground ruptures, damage to service roads, pipeway supports, etc. After an earthquake, inspect the system as follows:

- Ascertain, if possible, if either the No. 1A Separator is out of service or if compressed air service to either of the Landfarms areas has been discontinued. If either or both have occurred, proceed to the Landfarms system in question, shut off the extraction system, and discontinue Phase I of the inspection.
- By vehicle or by foot, visually inspect the above-ground air supply and groundwater discharge line piping at each Landfarm, starting at one end of the system and proceeding along the system. If any breaks in the main discharge line or main compressed air line

are seen, shut off the extraction system and discontinue Phase I of the inspection. If any breaks in an individual pump's discharge line or compressed air line are seen, shut off that pump.

- Inspect the first sump to ascertain if compressed air is being supplied to this sump. If no compressed air is being supplied to the pump, shut off the extraction system and discontinue Phase I of the inspection.
- Proceed by vehicle or by foot to inspect the discharge lines. Observe where the line enters or exits any below-grade pipe sleeves to ascertain if the line is ruptured within the sleeve. If any breaks are detected, shut off the extraction system and discontinue Phase I of the inspection.

3.3 PHASE II INSPECTION

The Phase II inspection is intended to be a more thorough inspection of the containment system. As with Phase I, the operator shall keep a written record of his observations during the inspection. After a qualifying earthquake, inspect the system as follows:

- Starting at one end of the groundwater extraction system, carefully inspect the full length of the system. Carefully look for any evidence of damage or leakage, with particular emphasis on the following items. Carefully check the system to ensure that:
- The air supply and groundwater discharge pipelines are leak-free.
- The pipelines are still properly located on all supports.
- The pumps and pump controllers are undamaged and remain functional.
- There is no evidence of a major slope failure or significant ground rupture that may have damaged any of the slurry walls, extraction trenches, extraction wells, monitoring wells, piezometers, or stormwater retention dikes.
- All sumps, wells, and piezometers appear to be intact.
- If a leak is discovered in the air supply line or discharge line for a specific pump, or if the pump or controller are not functioning properly, take the following actions:
  - Immediately shut off the air supply to the individual pump.
  - Shut off the discharge line from the individual pump.
  - Request maintenance to repair the problem in an expeditious manner and restart the pump once the repair is complete.
- If a leak is discovered in the main air supply line or discharge lines, take the following actions:
  - Immediately shut off the air supply to the entire system.
  - Shut off the discharge line from the entire system.
  - Request maintenance to repair the problem in an expeditious manner and restart the system once the repair is complete.
- If the lines have fallen off their supports or if other non-critical damage is noted, request maintenance to repair the problem.

- If there is evidence of a major slope failure or significant ground rupture that may have disrupted the slurry walls or extraction trenches, take the following actions:
  - Immediately shut off the air supply to the entire system.
  - Shut off the discharge line for the entire system.
  - Advise EOD of the problem.
- If there is evidence of a major slope failure that may have disrupted one or more extraction wells, take the following actions:
  - Immediately shut off the air supply to the affected well.
  - Shut off the discharge line from the affected well.
  - Advise EOD of the problem.
- If there is evidence that any of the monitoring wells or piezometers have been damaged beyond repair, advise EOD of the problem.
- If the stormwater transfer system has been damaged, request maintenance to repair the problem.
- Carefully inspect the surfaces of the Landfarms for cracking of the vegetated fill. If any damage is observed, advise EOD of the problem.
- If there is evidence that the vegetated cover is damaged and rainfall is imminent, sandbags shall be placed such that any surface runoff will be diverted away from the damaged area.

3.4 INSPECTION REPORTING

EOD will be prepared to provide the DTSC with a verbal report of the results of inspection of the system within 24 hours of the event. The report will contain a summary of any damage observed, any temporary steps taken to mitigate the damage, and will describe what plans have been made to effect permanent repairs. The information is to be provided on weekdays to EHS's Environmental Supervisor for Hazardous Waste and Groundwater and to EHS's On-Call Public and Environmental Affairs Officer on weekends and holidays. A written report presenting this information will be prepared and submitted to the DTSC within 15 days of the qualifying earthquake.

If there is either a release of the extracted groundwater to the ground or a washout of soils from beneath the cover liner, several State agencies will need to be notified as follows:

Immediately notify the State Office of Emergency Services at 1-800-852-7552 and report the following information:

- the name and telephone number of the person reporting the incident;
- the name and address of the facility;
- the time and type of incident (e.g., release);
- name and quantity of material(s) involved, to the extent known;
- the extent of injuries (caused by the release), if any; and

- the possible hazards to human health, or the environment, outside of the facility.
- Within 15 days of the incident, EHS's Environmental Supervisor for Hazardous Waste and Groundwater shall submit a written report on the incident to the DTSC. The report shall include:
- the name, address, and telephone number of the owner or operator;
- the name, address, and telephone number of the facility;
- the date, time, and type of incident (e.g., release);
- name and quantity of material(s) involved;
- the extent of injuries (caused by the release), if any;
- an assessment of actual or potential hazards to human health, or the environment, where this is applicable; and
- the estimated quantity and disposition of recovered material that resulted from the incident.

A written summary of the damage is to be provided to EOD within one week of the earthquake event.

4. CORRECTIVE ACTION PLAN

Most of the actions required to correct minor damage to the system are included in the inspection procedures described above. However, repair of below-grade structures, such as extraction trenches, low-permeability cover elements, and monitoring wells, is beyond the knowledge and experience of the Refinery's maintenance crews and may require engineered designs. These items are discussed in the following sections. This work will be performed under the direction of Chevron's Environmental Management Company (CEMC).

Prior to the start of any repair activities described below, the DTSC will be given at least two weeks advance notice to allow for sufficient time to present their concerns.

4.1 MONITORING WELLS OR PIEZOMETERS

Any monitoring well or piezometer that is damaged beyond repair will be properly abandoned. If the well or piezometer is included in the Post-Closure corrective action groundwater monitoring program, the well or piezometer will be replaced within six months of its destruction.

4.2 EXTRACTION TRENCH

If the extraction trench has been disrupted by a slope failure or significant ground rupture, it will be necessary to repair the damaged section in order to avoid an excessive inflow of fines from the surrounding soils. Depending on the actual nature of the damage, two courses of action may be taken: 1) the damaged portion of the trench can be excavated and repaired, or 2) a sand-bentonite plug could be installed in the trench and, if needed, additional sumps could be installed to control the groundwater.

4.3 EXTRACTION SUMP

If an individual extraction sump becomes unusable due to excessive distortion and there is an adjacent, undamaged sump that is currently not being pumped, that sump can be substituted for

the damaged sump. If no alternate sump is available, a new sump will be installed into the extraction trench. The old sump will be left in place as it will not interfere with the operation of the trench.

4.4 FINAL COVER

If there is evidence that the vegetated fill cover layer has cracked, it will be necessary repair the damage. If the surface has become sufficiently distorted such that it no longer drains freely, additional grading would be performed to restore proper surface drainage.

4.5 CORRECTIVE ACTION REPORTING

Within 21 days of the completion of any required work, EOD will prepare a written report to the DTSC that describes in detail all repairs that have been completed. If the damage is such that the repaired containment system deviates significantly from the original design, CEMC will prepare and submit to the DTSC an addendum to the Landfarms Closure Certification Report.

5. REFERENCES

Bechtel Environmental, Inc. and Dames & Moore (BEDM), 1996, *Landfarms Closure Plan*, September 15.

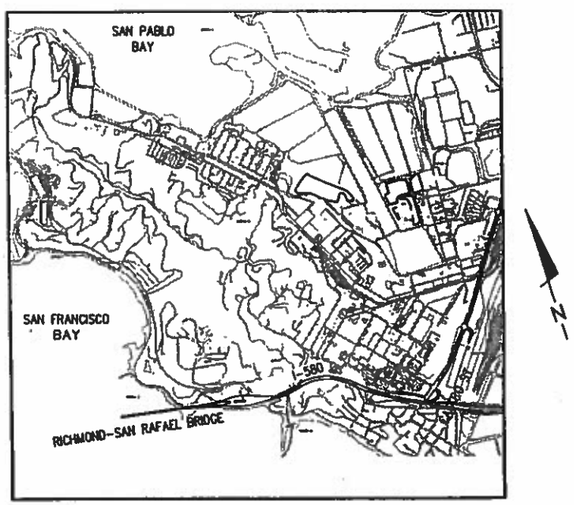
Appendix A:
Construction Drawings

Chevron

RICHMOND REFINERY
RICHMOND, CALIFORNIA

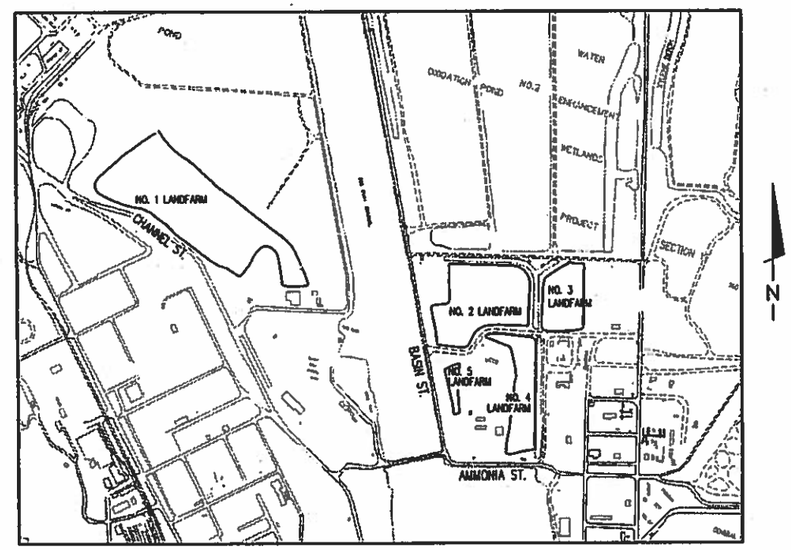
WASTE DISCHARGE ORDER PROJECT

LANDFARMS CLOSURE PLAN
LANDFARMS NO. 1 THROUGH 5



LOCATION MAP

0 2000
Scale in Feet



VICINITY MAP

0 500
Scale in Feet

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.

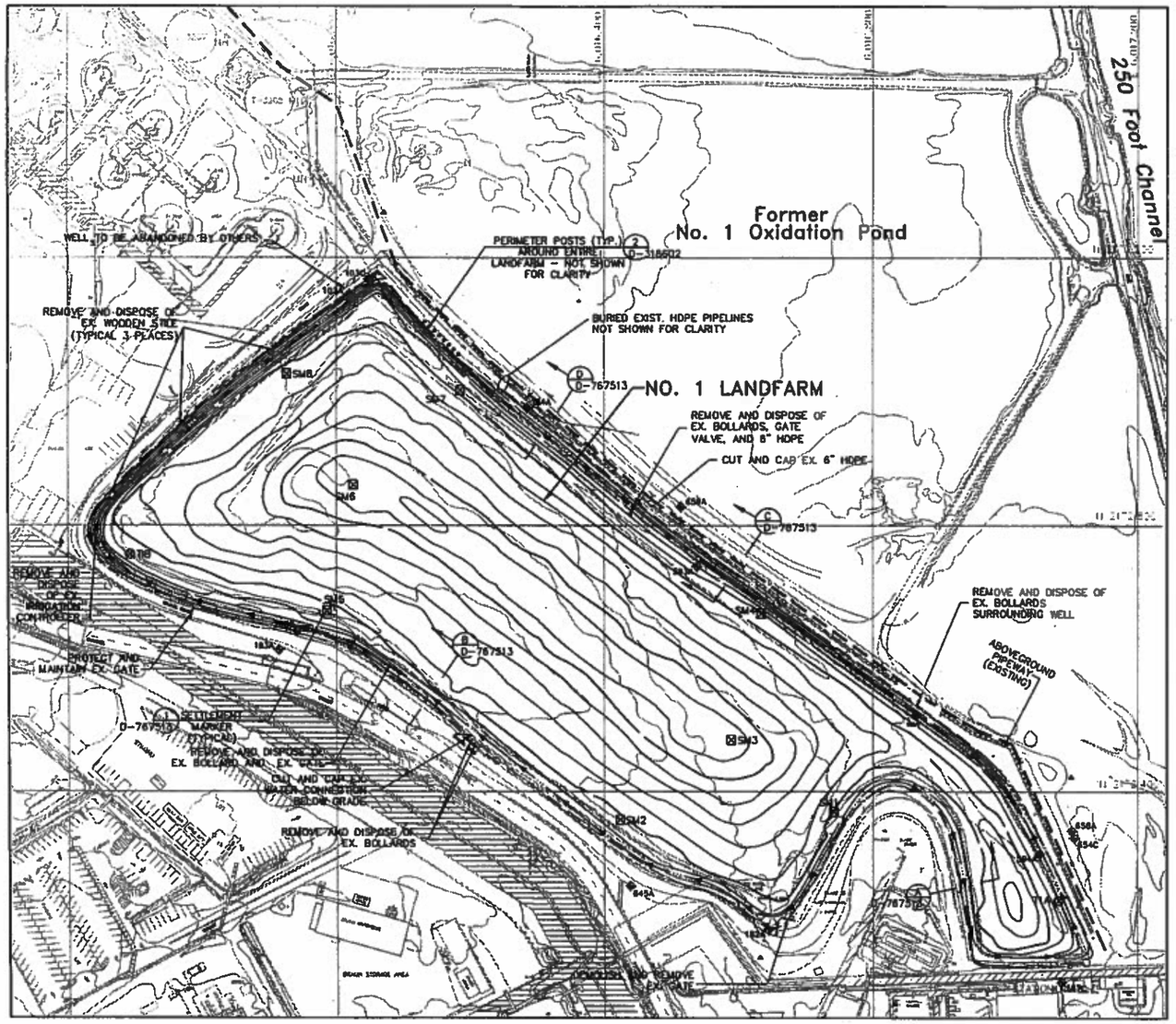
8. IT IS THE INTENTION OF THESE PLANS AND PROJECT SPECIFICATION TO PROVIDE A BALANCED CUT AND FILL DESIGN. EXISTING COUNTOURS MAY DIFFER FROM THOSE SHOWN. DITCH ALIGNMENT SHOWN IS DESIGNED TO PROVIDE THE CLOSEST APPROXIMATE TO A BALANCED CUT AND FILL. ADJUSTMENTS TO THIS ALIGNMENT, AS APPROVED BY THE 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%.

REGISTERED PROFESSIONAL ENGINEER
THOMAS M. SHEET
No. C 58263
EXP.
CIVIL
STATE OF CALIFORNIA

AS-BUILT
SEPTEMBER 1999

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

19000900\CHEV-R\S83\LFARMS\ASBUILT\COVER 071897 1:1 0823998 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	2172880.94	6016024.76
SM7	2173002.96	6016183.78
SM8	2173027.88	6015927.79

TENSIOMETER LOCATION

ID	NORTHING	EASTING
T1A	2172237.46	6017081.94
T1B	2172756.88	6015893.07

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. No. C 58265 Exp. 6/30/01 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

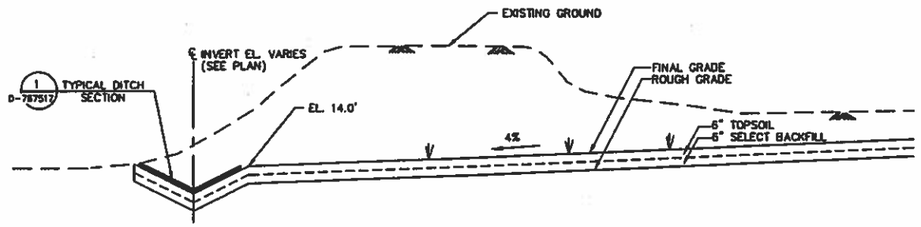
SCALE AS NOTED DR. C.KOSSA DR. APP. DATE 9/21/98 APPROVED
ENGR. ENGR. DEPT.
OPR'G. DEPT.

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\583\LFARMS\ASBUILT\D7675121 062697 1:1 092199 B SLD XREF:LF1BASE

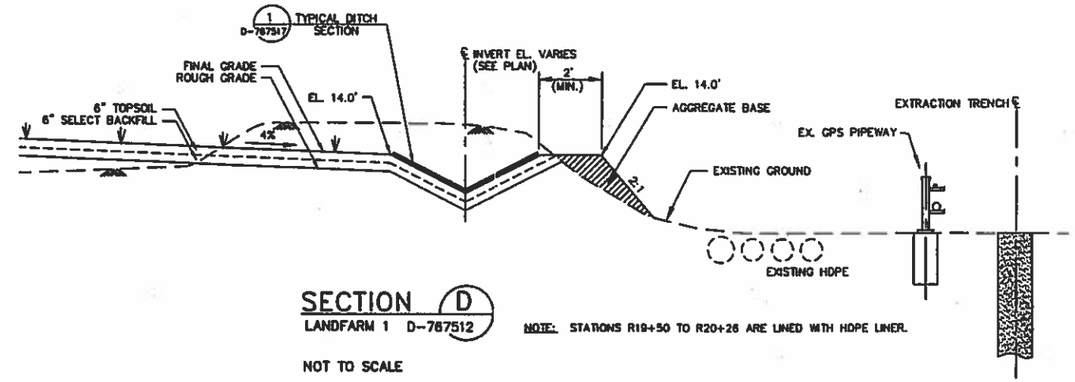


TYPICAL SECTION A

LANDFARM 1 D-767512

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

NOT TO SCALE

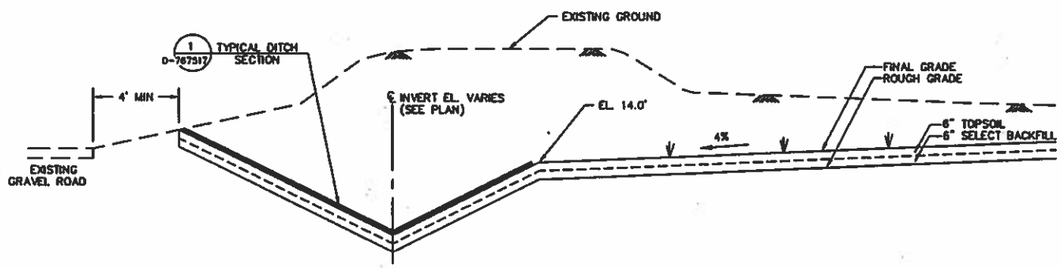


SECTION D

LANDFARM 1 D-767512

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

NOT TO SCALE



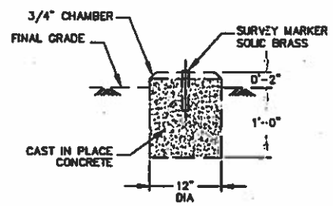
TYPICAL SECTION B

LANDFARM 1 D-767512

STA L2+75 TO L20+36

NOT TO SCALE

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.

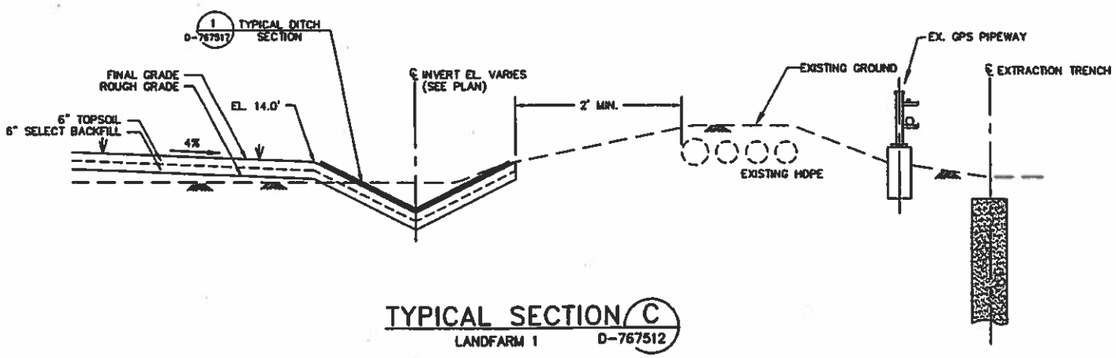


SEE NOTES 1 AND 2.

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. GRANT No. C 35402 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. 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	CK
1 AS BUILT	9/15/98	SLD

Chevron
Richmond Refinery

SCALE AS SHOWN DR. GLS DR. APP. DATE APPROVED
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.

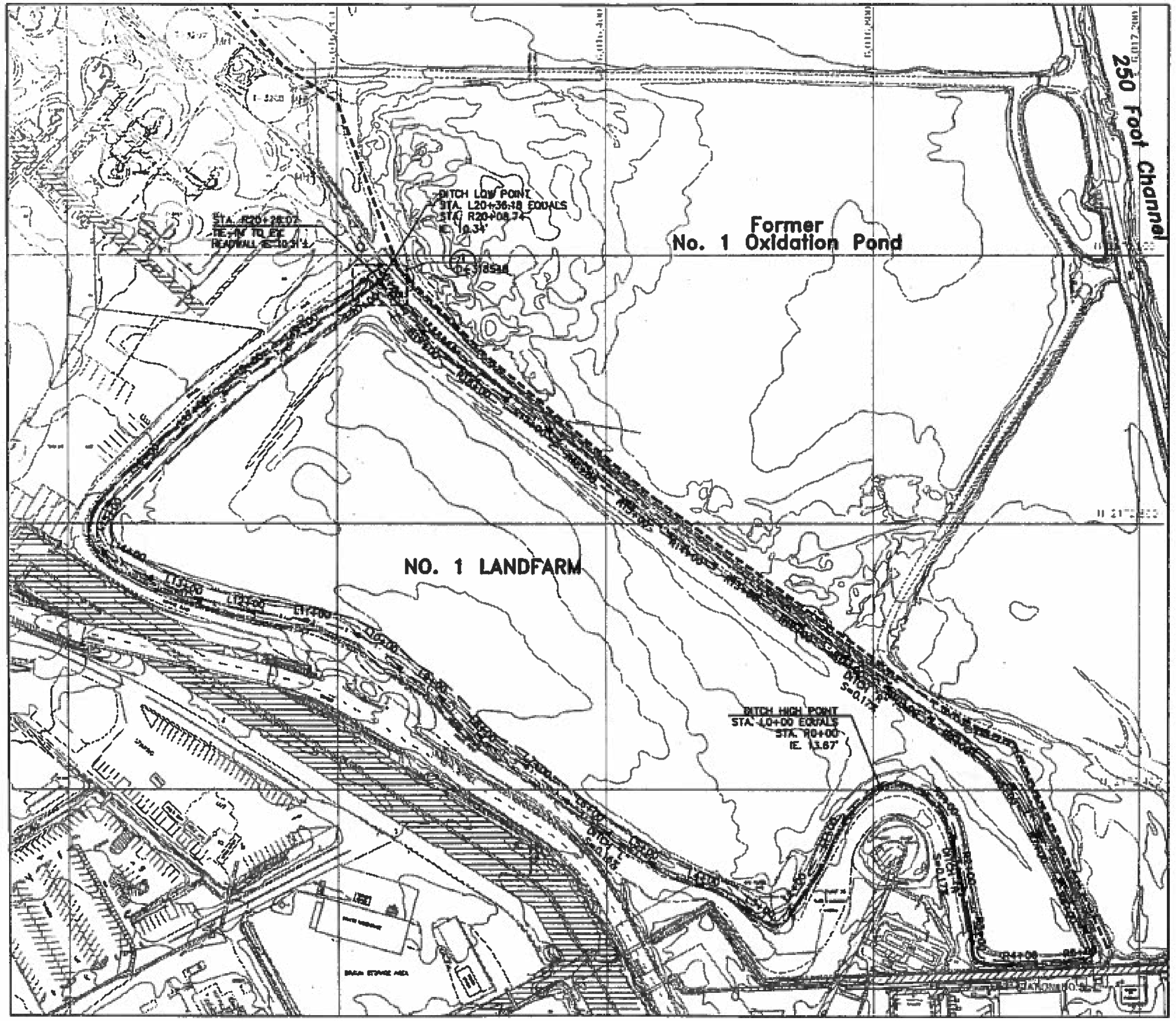
NO. 1 LANDFARM – SECTIONS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767513-1

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

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



LAYOUT DATA – DITCH "L"			
STATION	RADIUS / TAN. LENGTH	LENGTH / BEARING	INCLUDED ANGLE
L0+00.00*			
	152.00'	98.20'	37°01'00" (L)
L0+98.20			
	30.00'	S 24°27'47" W	
L1+28.20			
	300.00'	57.16'	10°55'00" (R)
L1+85.36			
	63.00'	S 35°22'47" W	
L2+48.36			
	18.00'	27.51'	87°33'00" (R)
L2+75.87			
	70.00'	N 57°04'13" W	
L3+45.87			
	135.00'	38.29'	16°15'00" (L)
L3+84.16			
	28.00'	N 73°19'13" W	
L4+12.16			
	200.00'	61.67'	17°40'00" (R)
L4+73.83			
	83.00'	N 55°39'13" W	
L5+56.83			
	400.00'	40.61'	05°49'00" (R)
L5+97.44			
	116.00'	N 49°50'13" W	
L7+13.44			
	115.00'	35.48'	17°40'30" (L)
L7+48.92			
	100.00'	38.94'	22°16'30" (R)
L7+87.86			
	88.00'	N 44°12'13" W	
L8+75.86			
	150.00'	39.20'	14°58'30" (L)
L9+15.06			
	11.00'	N 60°10'43" W	
L9+26.06			
	80.00'	24.69'	17°41'00" (R)
L9+50.75			
	10.00'	N 42°29'43" W	
L9+60.75			
	200.00'	133.40'	38°13'00" (L)
L10+94.15			
	105.00'	N 80°52'43" W	
L11+99.15			
	450.00'	124.09'	15°48'00" (R)
L13+23.24			
	82.50'	N 64°54'43" W	
L14+05.74			
	55.00'	106.45'	110°53'30" (R)
L15+12.19			
	180.00'	N 45°58'47" E	
L16+92.19			
	800.00'	121.01'	08°40'00" (R)
L18+13.20			
	222.98'	N 54°38'47" E	
L20+36.18			

*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*			
	50.00'	39.53'	45°17'54" (R)
R0+39.53			
	105.00'	112.97'	61°38'43" (R)
R1+52.50			
	127.00'	S 11°34'38" E	
R2+79.50			
	180.00'	23.45'	07°27'52" (R)
R3+02.95			
	23.00'	S 04°06'44" E	
R3+25.95			
	17.00'	20.19'	68°03'34" (L)
R3+46.14			
	80.00'	26.81'	19°12'15" (L)
R3+72.95			
	70.00'	N 88°37'27" E	
R4+42.95			
	300.00'	25.23'	04°49'05" (L)
R4+68.18			
	31.00'	N 83°48'22" E	
R4+99.18			
	15.50'	29.69'	109°45'01" (L)
R5+28.87			
	225.00'	N 25°56'39" W	
R7+53.87			
	235.00'	117.74'	28°42'24" (L)
R8+71.61			
	550.00'	N 54°39'02" W	
R14+21.61			
	1300.00'	219.26'	09°39'48" (R)
R16+40.87			
	500.00'	119.77'	13°43'29" (L)
R17+60.64			
	600.00'	217.93'	20°45'37" (R)
R19+78.57			
	47.50'	N 37°54'06" W	
R20+26.07			

*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

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. 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

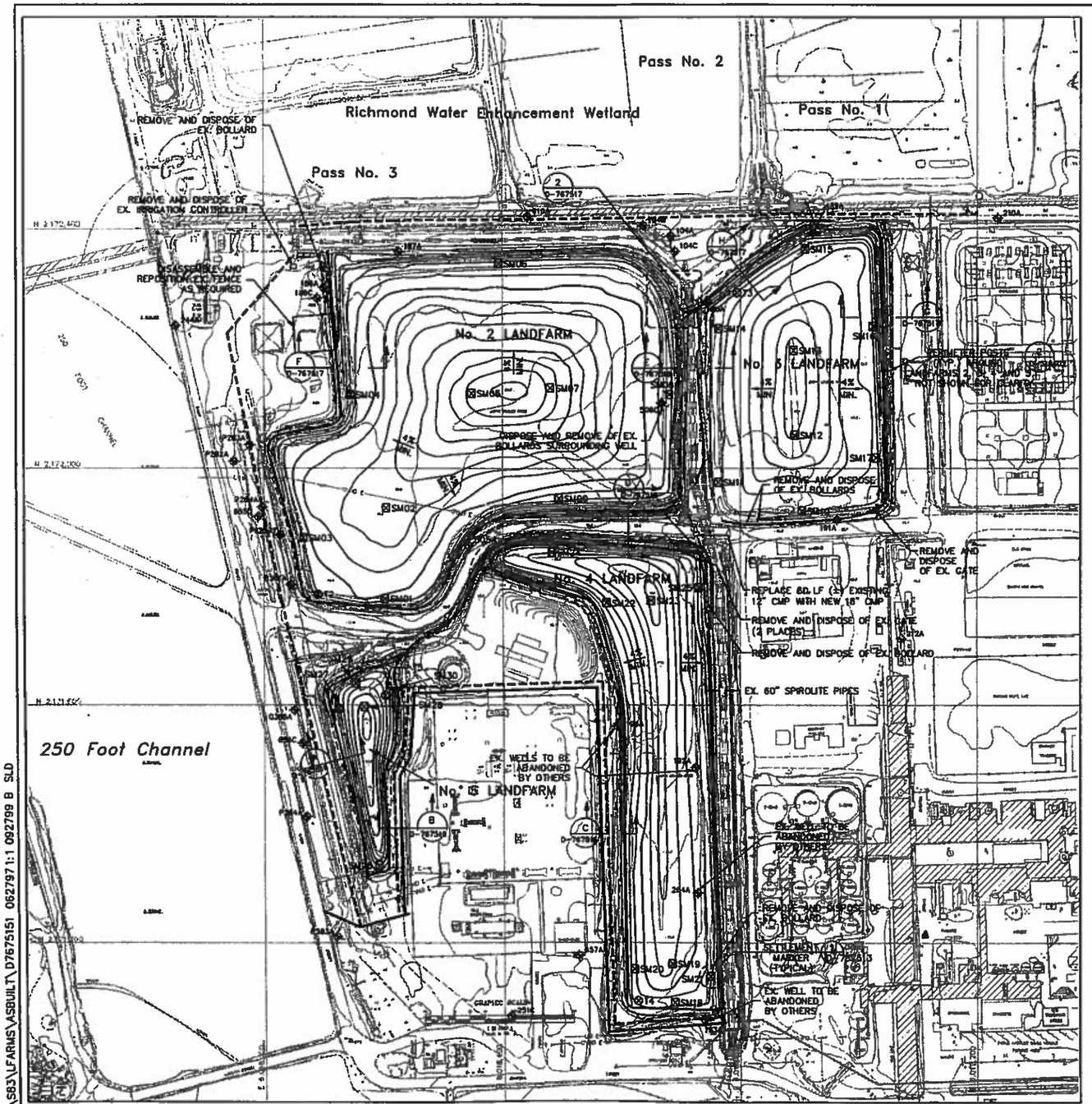
Chevron
Richmond Refinery

SCALE AS NOTED DR. C.KOSSA CK. APP. [illegible] DATE 9/[illegible]/99 APPROVED
ENGR. [illegible] ENGR. DEPT.
OPR'G. DEPT.

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

W.O.
S.O.

D-767514-1



SETTLEMENT MARKER LOCATION

AREA LOCATION	ID	NORTHING	EASTING
NO. 2 LANDFARM	SM01	2171780.12	6018201.63
	SM02	2171933.20	6018204.05
	SM03	2171863.53	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	6018891.87
	SM13	2172198.10	6018890.01
	SM14	2172234.96	6018762.38
	SM15	2172367.19	6018909.27
	SM16	2172238.02	6019022.86
	SM17	2172018.19	6019028.89
NO. 4 LANDFARM	SM18	2171099.80	6018886.95
	SM19	2171164.75	6018683.06
	SM20	2171156.15	6018619.09
	SM21	2171143.98	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	6018090.34
NO. 3 LANDFARM	T3	2172294.18	6018793.85
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
- EXISTING OVERHEAD ELECTRICAL LINE
- EXISTING UNDERGROUND ELECTRICAL LINE
- EXISTING GROUNDWATER MONITORING WELL
- 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. 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

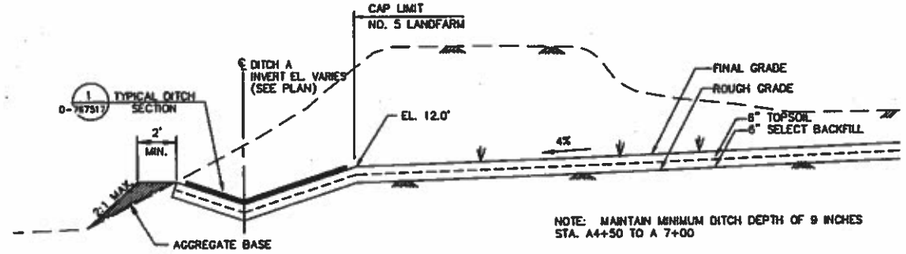
Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. S.D. DATE 9/20/99 APPROVED
ENGR. DENGR. DEPT.
OPN'S. DEPT.

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

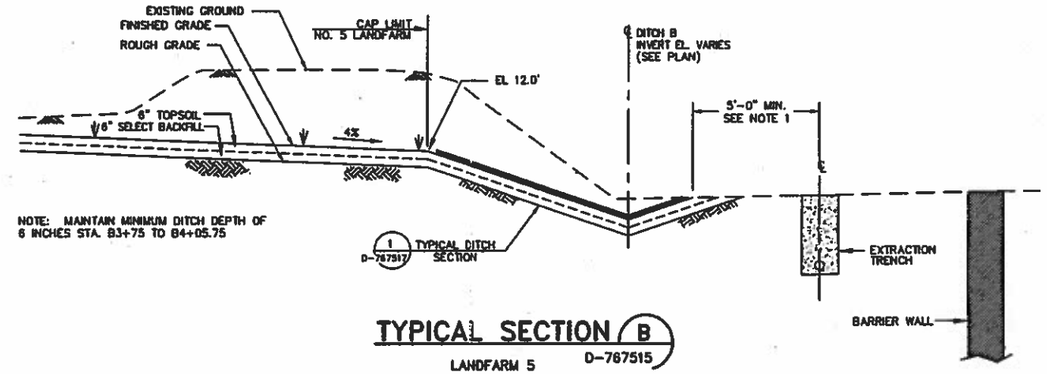
42100001\CHEV-R\S83\LFARMS\ASBUILT\D767515\ 0627971:1 092799 B SLD



TYPICAL SECTION (A)

D-767515

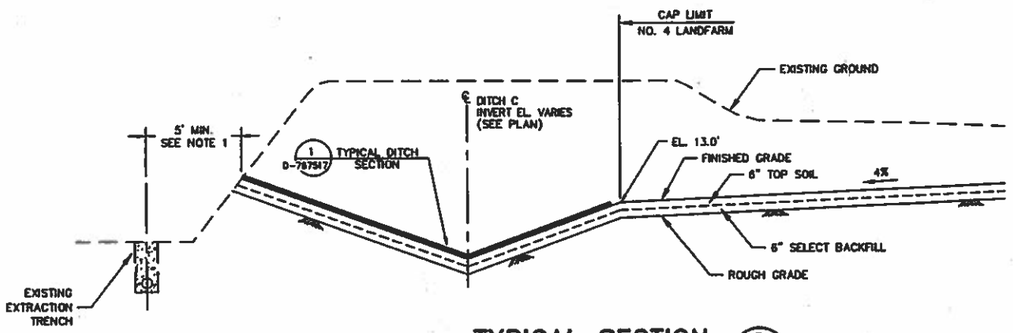
LANDFARM 5
STA A0+00 TO STA A5+00
NOT TO SCALE



TYPICAL SECTION (B)

D-767515

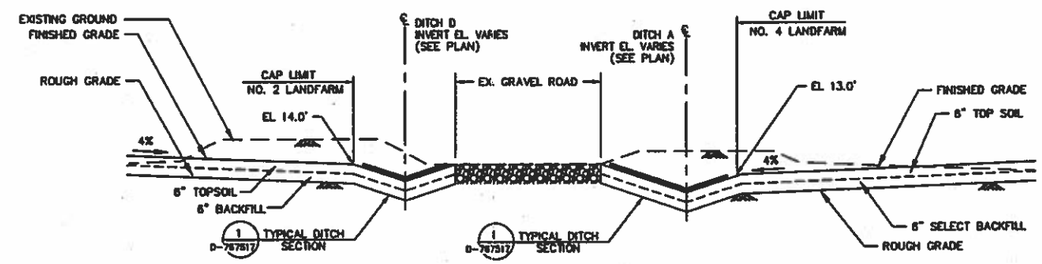
LANDFARM 5
DITCH B
NOT TO SCALE



TYPICAL SECTION (C)

D-767515

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

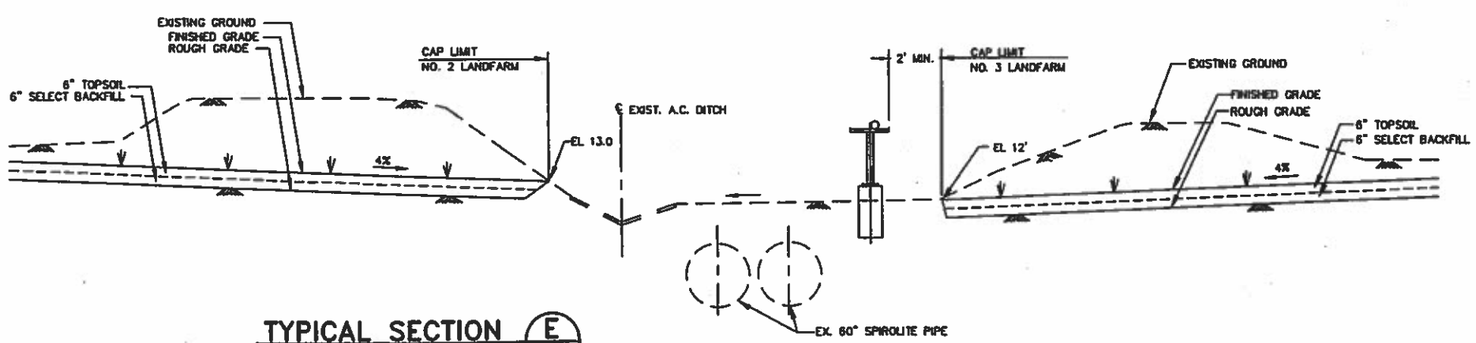


TYPICAL SECTION (D)

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 H. DUNN — No. C 38245 — CIVIL — STATE OF CALIFORNIA

DCM 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 THRU 5 LANDFARMS – DITCH PLAN	D-767518
NO. 2 THRU 5 LANDFARMS – IRRIGATION PLAN	D-318601

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

Chevron
Richmond Refinery

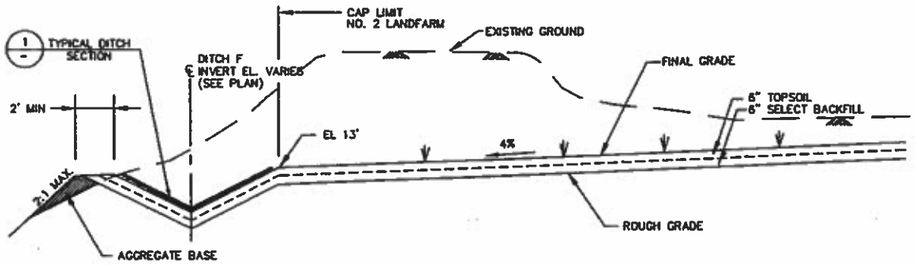
SCALE AS NOTED — DR. C. KOSSA — DR. APP. G.O. — DATE 9/29/97 — APPROVED
ENGR. — ENGR. DEPT.
OPNS. DEPT.

NO. 2 THROUGH 5 LANDFARMS – SECTIONS
SECTOR B3: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767516-1

19000900\CHEV-R\SB3\LFARMS\ASBUILT\ D7675161 071597 1:1 092799 B sld

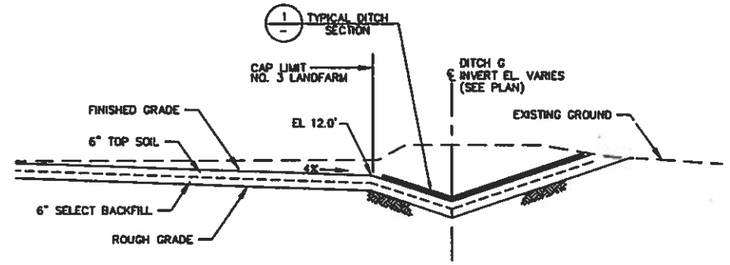


TYPICAL SECTION F

D-767515

LANDFARM 2
DITCH F

NOT TO SCALE

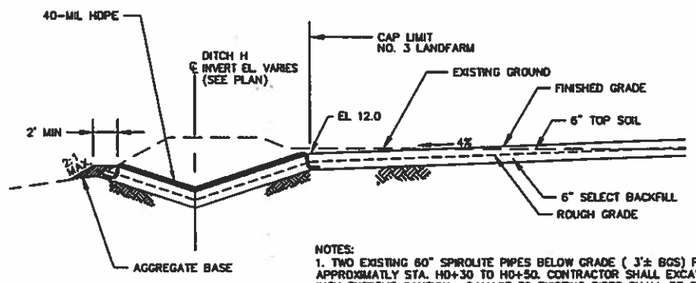


TYPICAL SECTION G

D-767515

LANDFARM 3
DITCH G

NOT TO SCALE



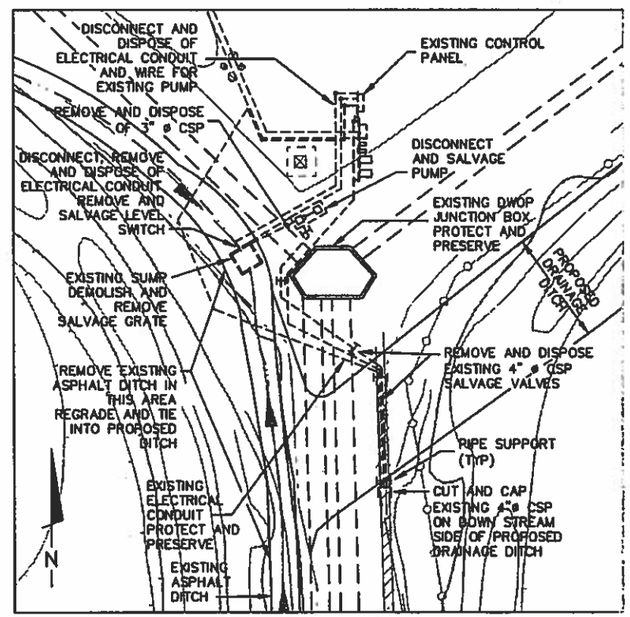
NOTES:
1. TWO EXISTING 60" SPIROLITE PIPES BELOW GRADE (3'± BGS) FROM APPROXIMATLY STA. H0+30 TO H0+50. CONTRACTOR SHALL EXCAVATE WITH EXTREME CAUTION. DAMAGE TO EXISTING PIPES SHALL BE REPAIRED BY CONTRATOR AT NO COST TO COMPANY.
2. MAINTAIN MINIMUM DITCH DEPTH OF 8 INCHES STA H0+00 TO H2+80.

TYPICAL SECTION H

D-767515

LANDFARM 3
DITCH H

NOT TO SCALE

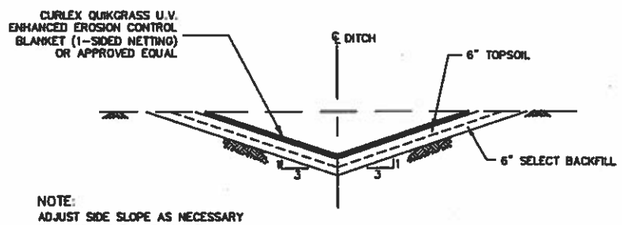


DETAIL 2

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 52[illegible] Exp. 6/30/[illegible] CIVIL STATE OF CALIFORNIA

Waste Discharge Order Project
DAMES & MOORE
DCM 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	CK
1	AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

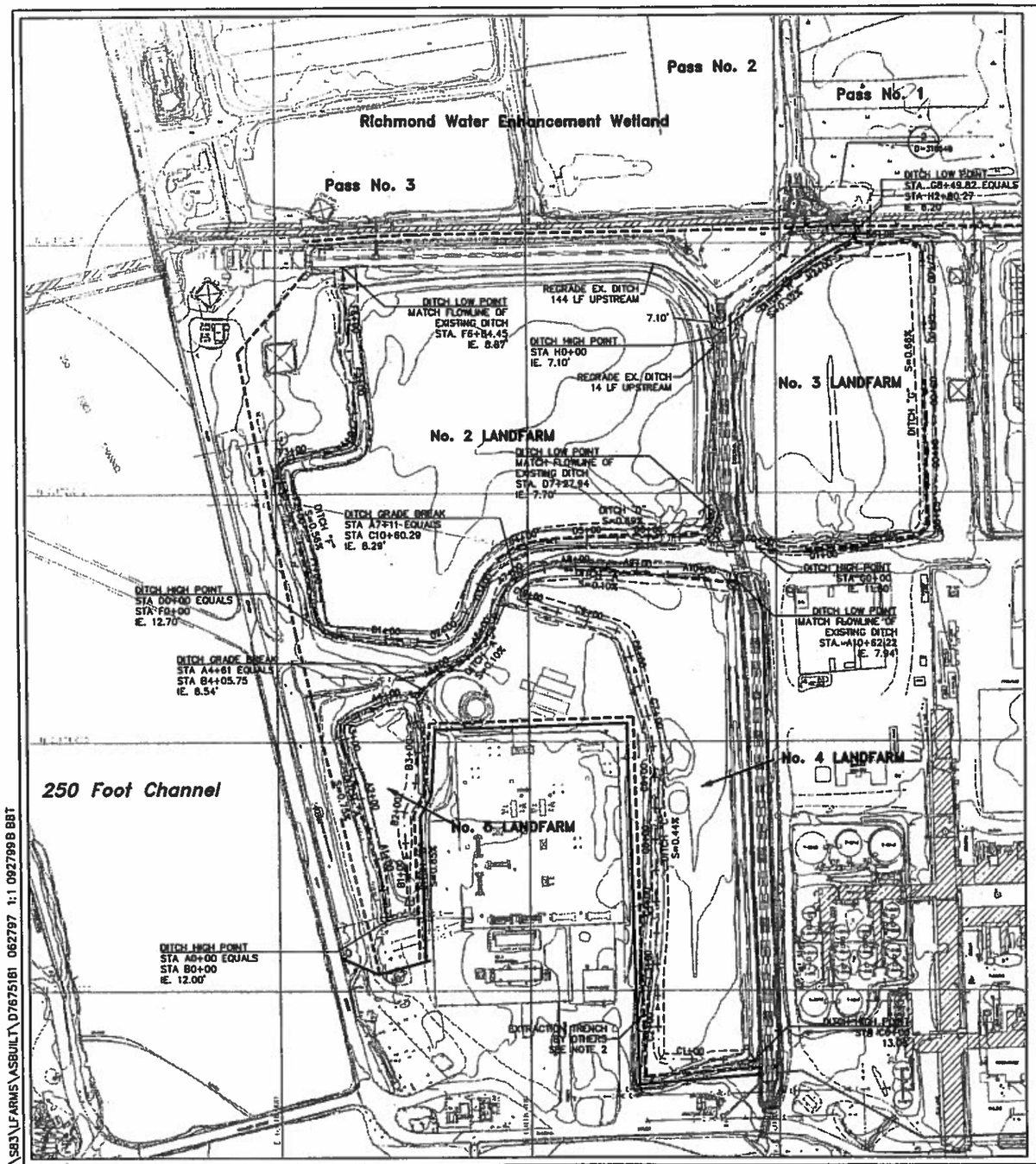
SCALE AS NOTED DR. GLS DR. APP. SLD DATE 9/20/99 APPROVED
ENGR. TMS ENGR. DEPT.
OPR'G. DEPT.

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

W.O. ____
S.O. ____

D-767517-1

19000900\CHEV-R\S83\LFARMS\ASBUILT\D7675171 1:1071497 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°36'56" (L)
A7+24.96	62.00'	72.00'	66°32'16" (R)
A8+45.36	369.50'	120.40'	18°40'13" (R)
A10+82.22	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+16.90	25.00'	16.90'	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°16'11" (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°37'31" (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+67.06	482.81'	105.59'	13°04'16" (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 FRIEDMAN No. C 45611 EXP. 6/30/99 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 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	CK
1 AS BUILT	9/15/99	SLD

Chevron
Richmond Refinery

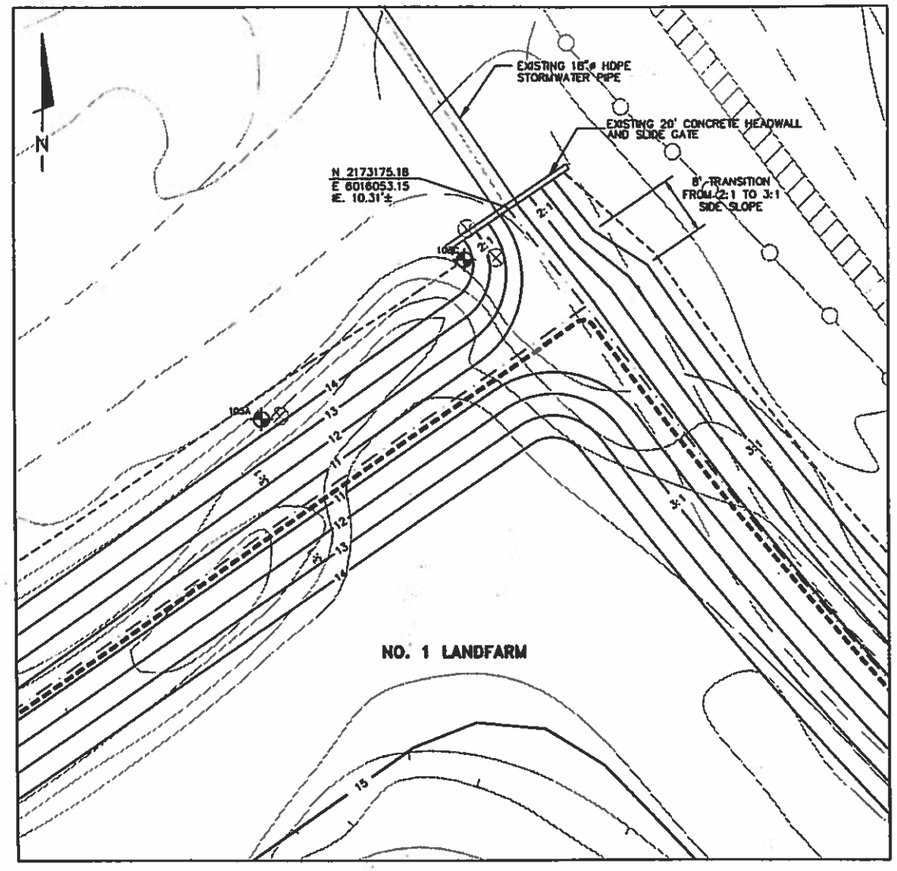
SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 4/29/99 APPROVED
ENGR. ENGR. DEPT.
OPNS. DEPT.

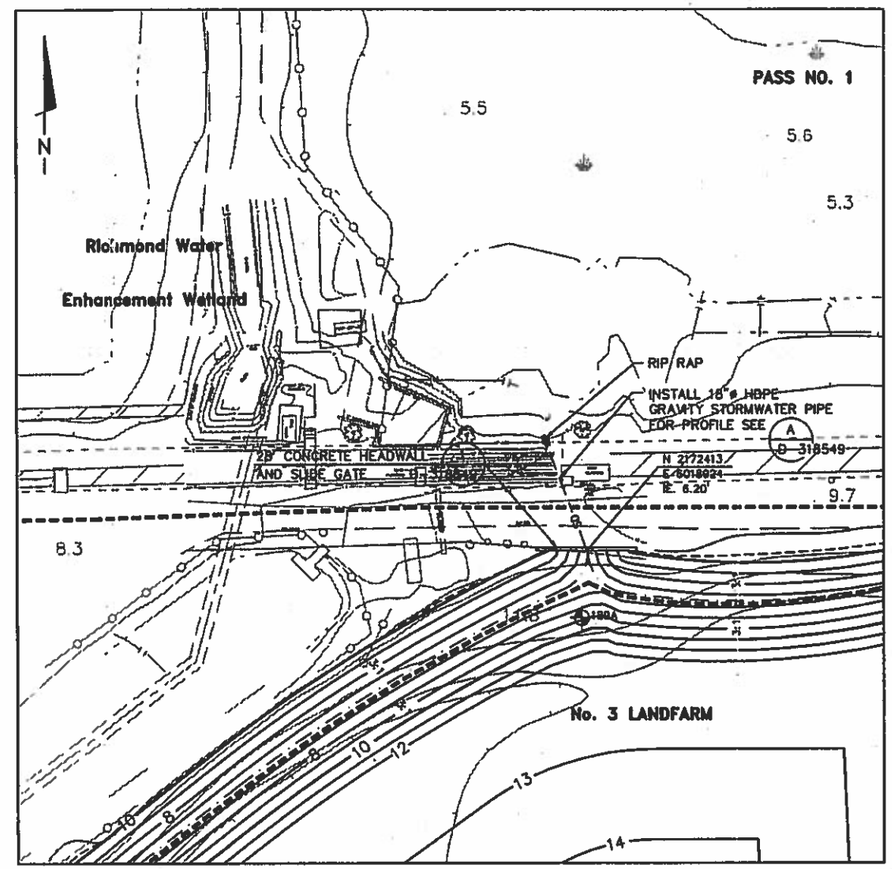
NO. 2 THROUGH 5 LANDFARMS – DITCH PLAN
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767518-1

42100001 \CHEV-R\583\LFARMS\ASBUILT\D7675181 062797 1:1 092799 B BBT





DETAIL 1 D-767514

OUTLET GRADING
NO. 1 LANDFARM

0 5 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. C. 1 DP. 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 9/23/99 APPROVED
ENGR. ENGR. DEPT.
OPNS. DEPT.

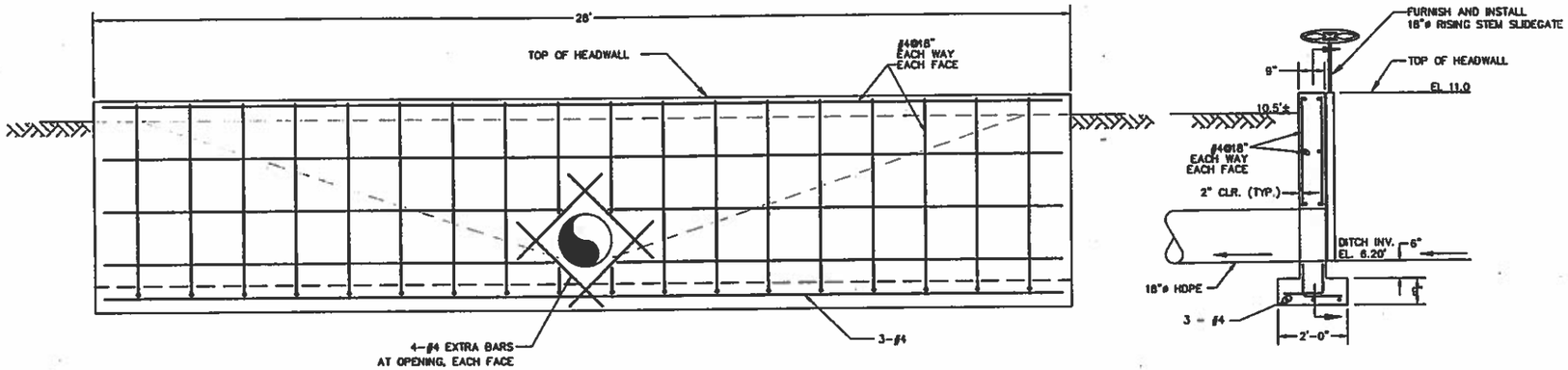
NO. 1 AND 3 LANDFARMS – STORMWATER DRAIN PLANS
SECTOR 83: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-767519-1

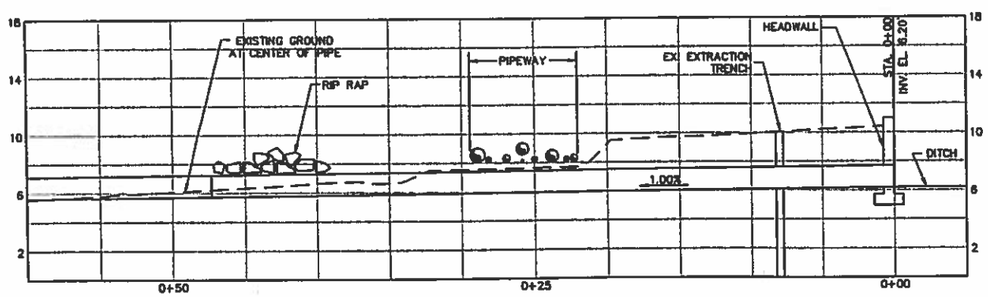
42100001\CHEV-R\S83\LFARMS\ASBUILT\ D7675191 080497 1:1 092799 C SLD

NOTES



DETAIL 1 HEADWALL D-787519

Scale in Feet 0 2



PROFILE A D-787519

Scale in Feet 0 5

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

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. 9/20/99 DATE 9/20/99 APPROVED
ENGR. DLS ENGR. DEPT.
OPR'G. DEPT.

NO. 3 LANDFARM - STORMWATER DRAIN DETAILS
SECTOR 63: LANDFARMS
LANDFARMS CLOSURE PLAN
UTILITIES/ENVIRONMENTAL ABU

W.O.
S.O.

D-318549-1

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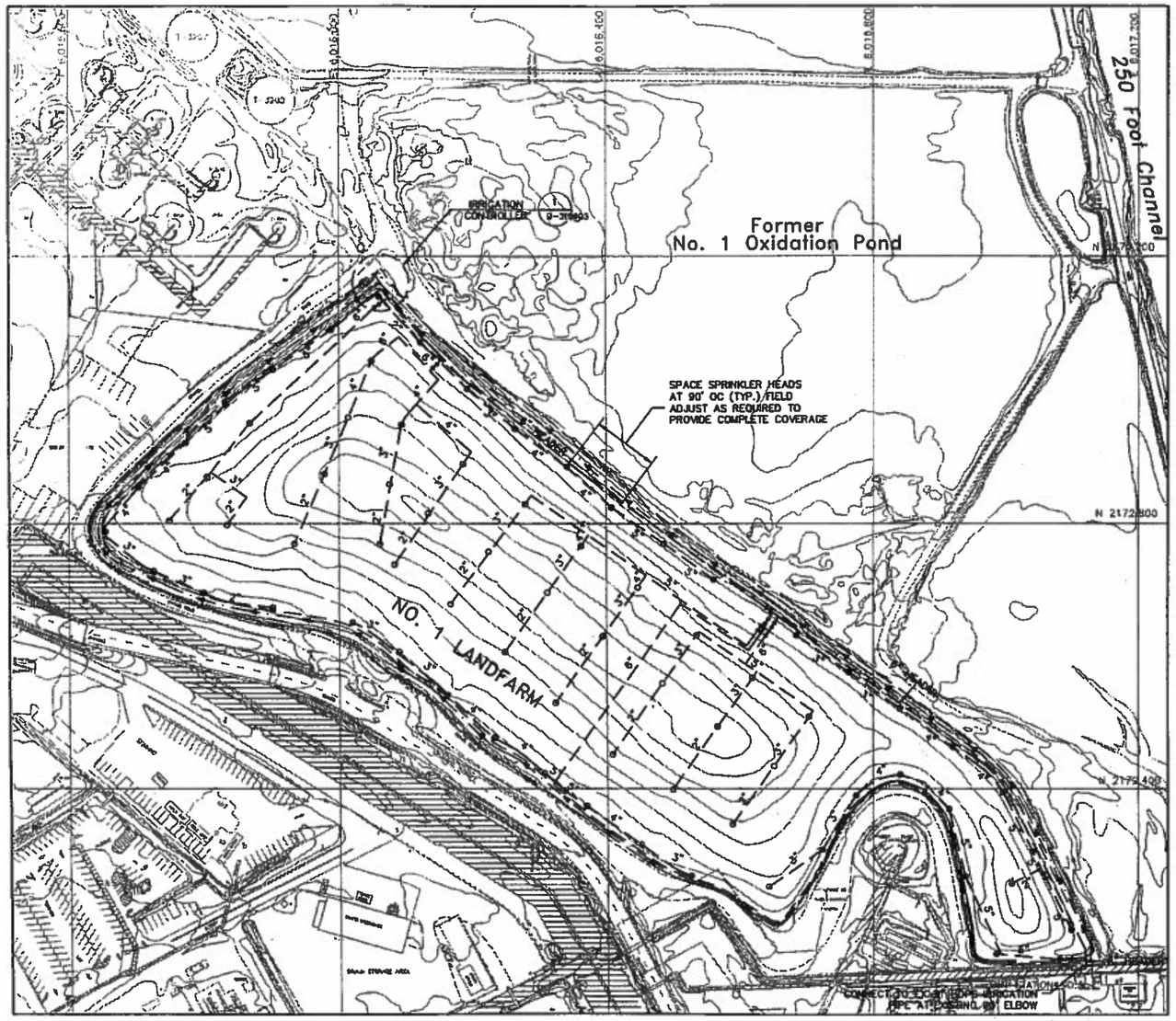


NOTES:

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. GRANT No. C-52821 Exp. 12/31/02 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-787512
NO. 1 LANDFARM – SECTIONS	D-787513
NO. 1 LANDFARM – DITCH PLAN	D-787514

REVISIONS

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

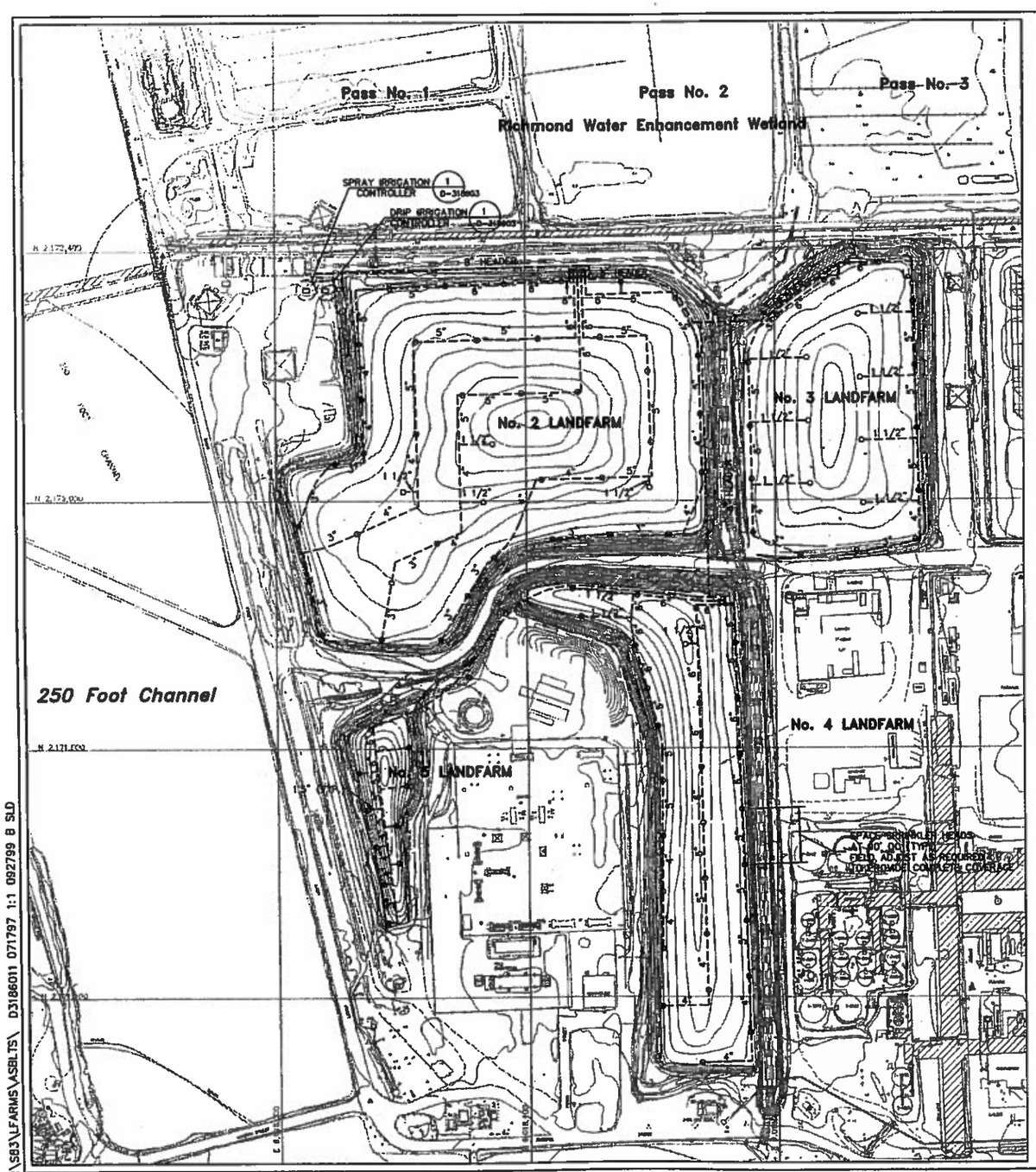
Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. S.O. DATE 9/28/99 APPROVED
ENGR. SLD ENGR. DEPT.
GRWG. DEPT.

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

S W.O. S.O. D-318600-1

42100001\CHEV_R\S83\LFARMS\ASBUILT\ D3186001 071797 1:1 092899 B SLD



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 J. LONGO No. C 42015 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 – 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

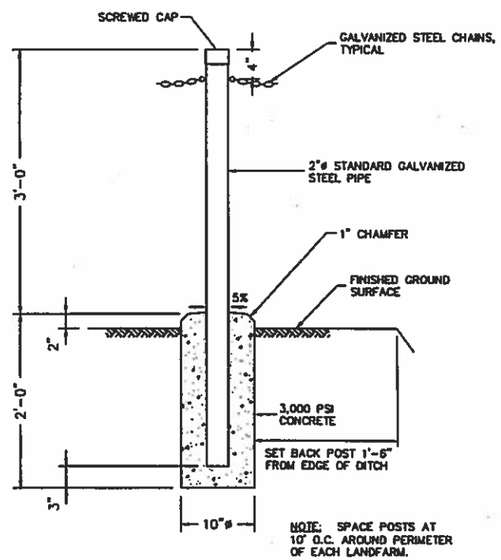
SCALE AS NOTED DR. C. KOSSA DR. APP. SLD DATE 9/28/99 APPROVED
ENGR. JLS ENGR. DEPT.
OPN'G. DEPT.

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

W.O.
S.O.

D-318601-1

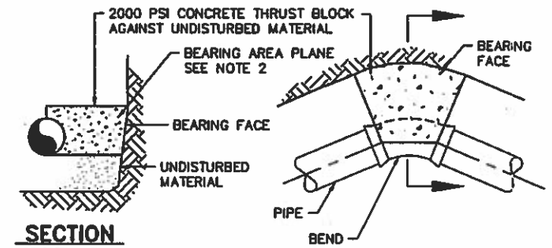
42100001 \CHEV-R\S83\LFARMS\ASBLTS\ D3186011 071797 1:1 092799 B SLD



DETAIL

PERIMETER POST (2 / D-767512) (2 / D-767515)

NOT TO SCALE

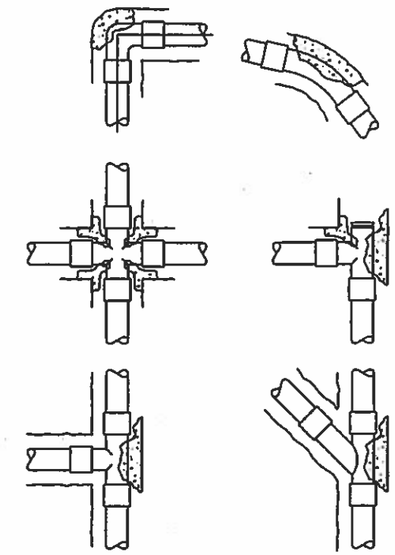


NOTES:

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

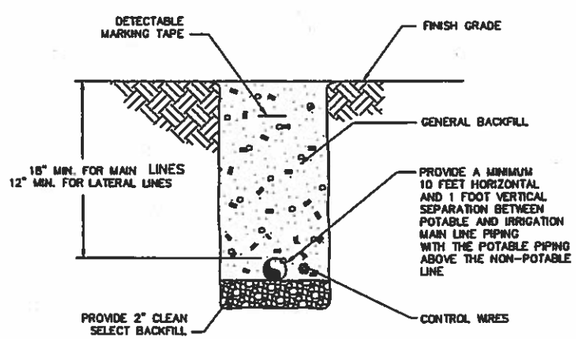
3. BEARING AREA REQUIRED ON VERTICAL PLANE 90° TO RADIUS PLANE PASSING THROUGH MIDPOINT OF BEND.
4. THE SIZES OF THRUST BLOCKS ARE BASED ON 100 PSI TEST PRESSURE AND 2500 PSF PASSIVE SOIL STRENGTH.
5. THE CONTRACTOR SHALL NOTIFY THE ENGINEER AFTER EXCAVATION OF EACH BEND EQUAL TO OR LARGER THAN 11.25° 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. GRANT No. C 0038 EXP. 6/30/01 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 – 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. GJD — DATE 9/28/99 — APPROVED

ENGR. — ENGR. DEPT.

OPN'G. DEPT.

NO. 1 THROUGH 5 LANDFARMS – MISCELLANEOUS DETAILS

SECTOR 83: LANDFARMS

LANDFARMS CLOSURE PLAN

UTILITIES/ENVIRONMENTAL ABU

W.O. ____ S.O. ____

D-318602-1

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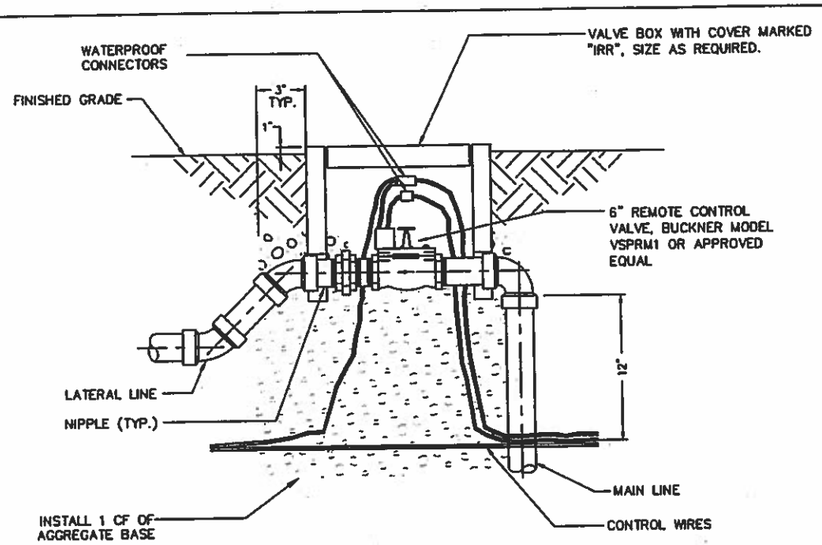
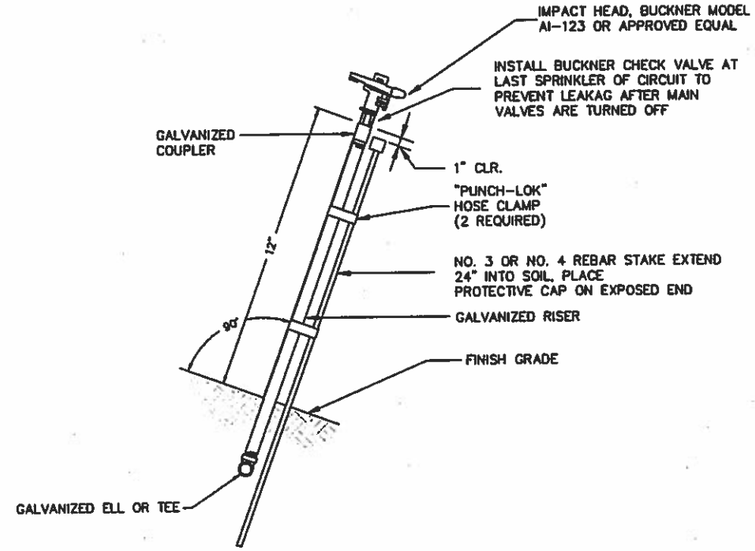


TYPICAL DETAIL

REMOTE CONTROL VALVE

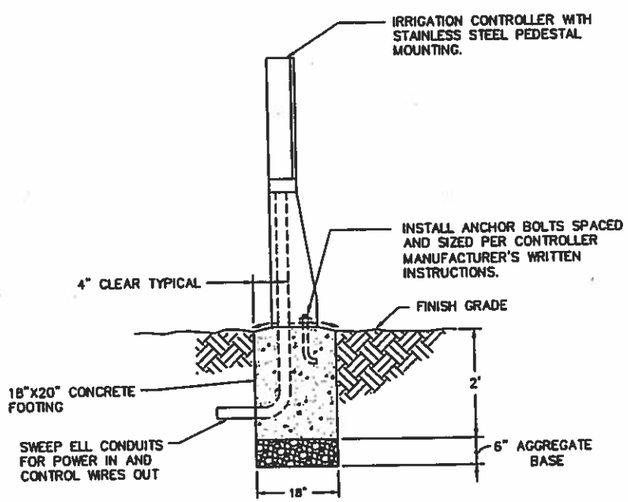
NOT TO SCALE



TYPICAL DETAIL

SPRINKLER HEAD ON SLOPE

NOT TO SCALE



DETAIL 1 D-318600 / 1 D-318601

ELECTRICAL IRRIGATION CONTROLLER

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 58285 EXP. 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 - 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. 6.4.0 DATE 5/08/98 APPROVED

ENGR. ENGR. DEPT.

OPNS. 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

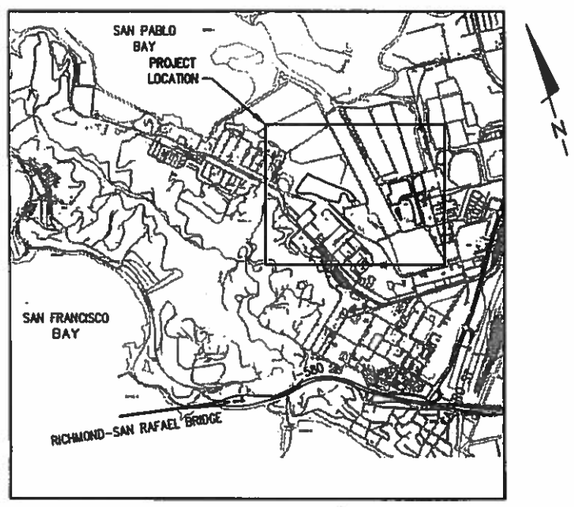
19000900\CHEV-R\S83\LFARMS\D3186031 062697 1:1 092799B SLD

Chevron

RICHMOND REFINERY
RICHMOND, CALIFORNIA

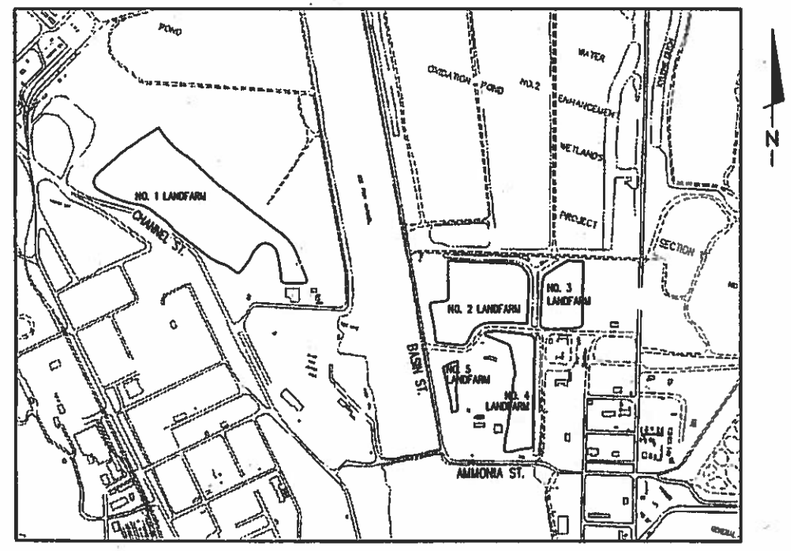
WASTE DISCHARGE ORDER PROJECT

GROUNDWATER PROTECTION SYSTEM
LANDFARMS CLOSURE PLAN
LANDFARMS NO. 1 THROUGH 5



LOCATION MAP

0 2000
Scale in Feet



VICINITY MAP

0 500
Scale in Feet

DWG. NO.	TITLE
D-767522	NO. 1 LANDFARM - GPS PUMP LOCATIONS
D-767523	NO. 2 THROUGH 5 LANDFARMS - GPS PUMP LOCATIONS
D-767524	PUMP INSTALLATION SCHEMATIC
D-767525	NO. 1 LANDFARM - SUMP NO. S-83071
D-767526	NO. 2 LANDFARM - SUMP NO. S-83070
D-767527	NO. 3 LANDFARM - SUMP NO. S-83069
D-767528	NO. 3 LANDFARM - SUMP NO. S-83068
D-767529	NO. 4 LANDFARM - SUMP NO. S-83067
D-767530	PUMP INSTALLATION DETAILS 1
D-767531	PUMP INSTALLATION DETAILS 2
D-767532	CONCRETE BASE DETAIL

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. ALL CONSTRUCTION SHALL CONFORM TO THESE PLANS AND SPECIFICATIONS.

4. 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.

5. 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.

6. 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.

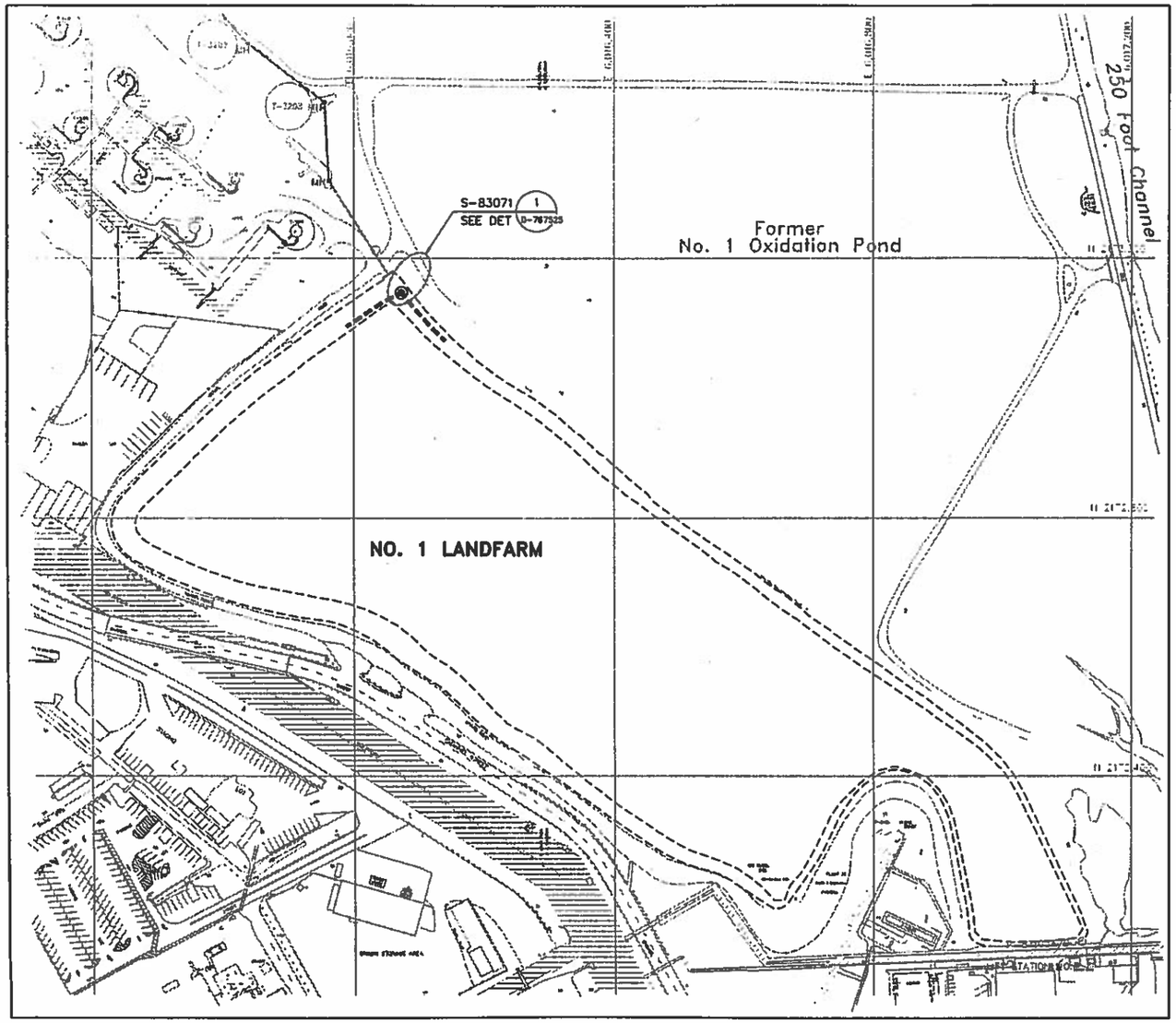
7. ALL HDPE ELBOWS AND TEES SHALL BE FLANGED.

AS BUILT
SEPTEMBER 1999

REGISTERED PROFESSIONAL ENGINEER
THOMAS M. GRAHAM
No. C-23000
EXP. 6/30/01
CIVIL
STATE OF CALIFORNIA

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

4210000 1 \CHEV-R\SBJ\GPS\ASBUILT\ COVER 071897 1:1 0909999 I CIK



NOTES:

1. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
2. LOCATION OF EXISTING GPS TRENCHES ARE APPROXIMATE.

ABBREVIATIONS:

#, DIA	DIAMETER
BGS	BELOW GROUND SURFACE
CS	CARBON STEEL
CY	CUBIC YARDS
E	EAST
EF	EACH FACE
EL	ELEVATION
EOR	EDGE OF ROAD
EX	EXISTING
EWEF	EACH WAY, EACH FACE
GALV.	GALVANIZED
GPS	GROUNDWATER PROTECTION SYSTEM
HDPE	HIGH DENSITY POLYETHYLENE
MAX.	MAXIMUM
MIN.	MINIMUM
IE.	INVERT ELEVATION
INV	INVERT
LF	LINEAL FOOT
NO.	NUMBER
N	NORTH
O.C.	ON CENTER
SCH	SCHEDULE
SD	STORM DRAIN LINES
SS	STAINLESS STEEL
STA	STATION
TYP	TYPICAL

LEGEND:

- EXISTING GPS EXTRACTION TRENCH
- DAYLIGHT LINE OF EXISTING V-DITCH
- EXISTING SUMP / NEW PUMP LOCATION

N

0 100
Scale in Feet

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	

REVISIONS		
0 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGF	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. DATE OCT. 1998 APPROVED
ENGR. ENGR. DEPT.
OPN'S. DEPT.

NO. 1 LANDFARM-GPS PUMP LOCATIONS
SECTOR B3: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767522-1

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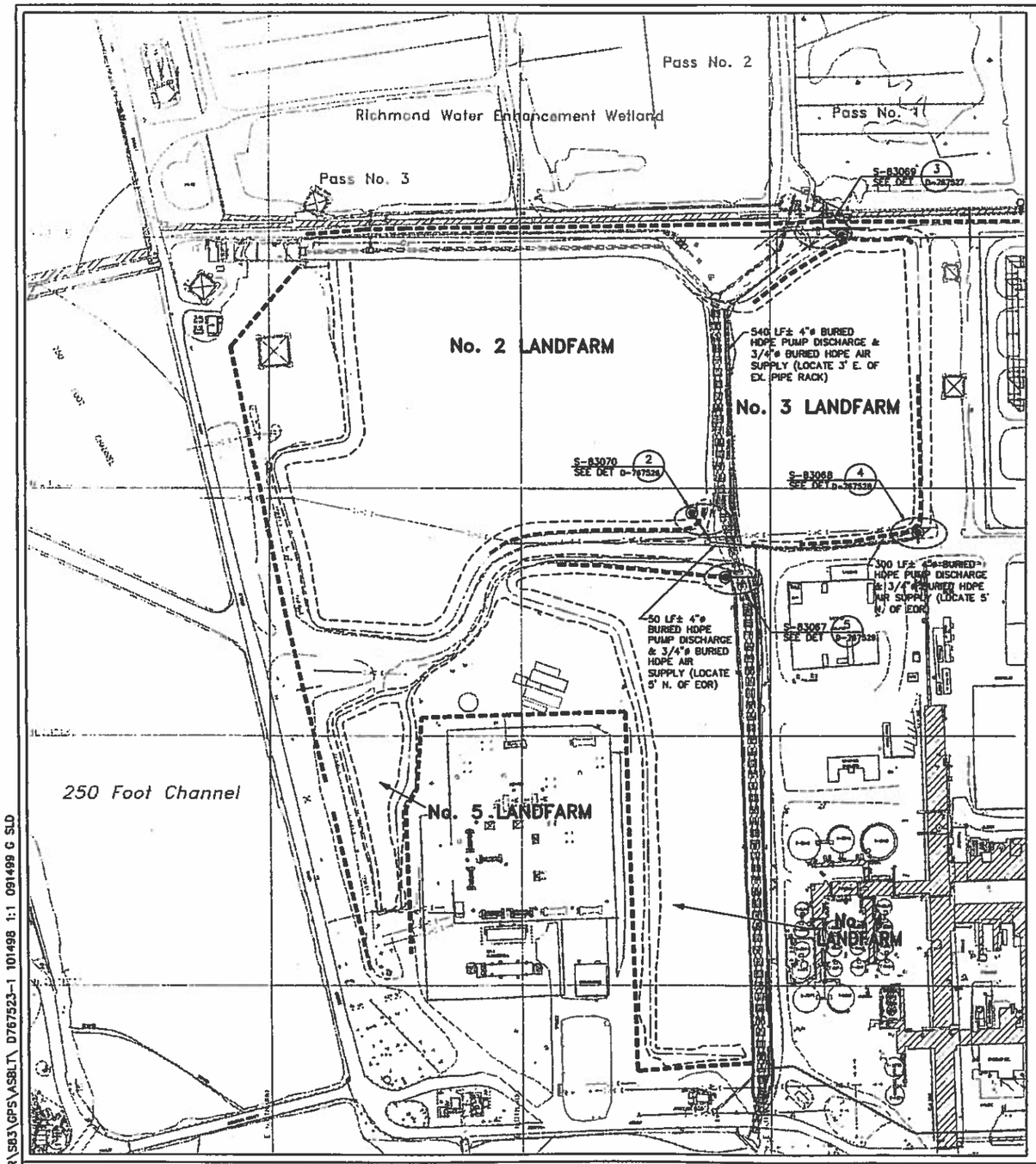

NOTES:

1. SEE DETAILS FOR PIPE LENGTHS IN VICINITY OF SUMPS.
2. HDPE PUMP DISCHARGE LINE OVER 100 LINEAL FEET IN LENGTH SHALL HAVE A FLANGED SECTION AT LEAST EVERY 100 LINEAL FEET.
3. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
4. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EXISTING GPS EXTRACTION TRENCH
- DAYLIGHT LINE OF EXISTING V-DITCH
- EXISTING SUMP / NEW PUMP LOCATION
- EXISTING OVERHEAD ELECTRICAL LINE
- EXISTING UNDERGROUND ELECTRICAL LINE

N

0 100
Scale in Feet

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

REFERENCE DRAWINGS	
NO. 2 THROUGH 5 LANDFARMS - FINISHED GRADING PLAN	D-767515
NO. 2 THROUGH 5 LANDFARMS - DITCH PLAN	D-767516

REVISIONS		
1 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS	12/98	CIK
2 AS-BUILT	9/15/99	AGP

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Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. S.J.R. DATE OCT. 1998
ENGR. ENGR. DEPT.
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APPROVED

NO.2 THROUGH 5 LANDFARMS - GPS PUMP LOCATIONS
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767523-1

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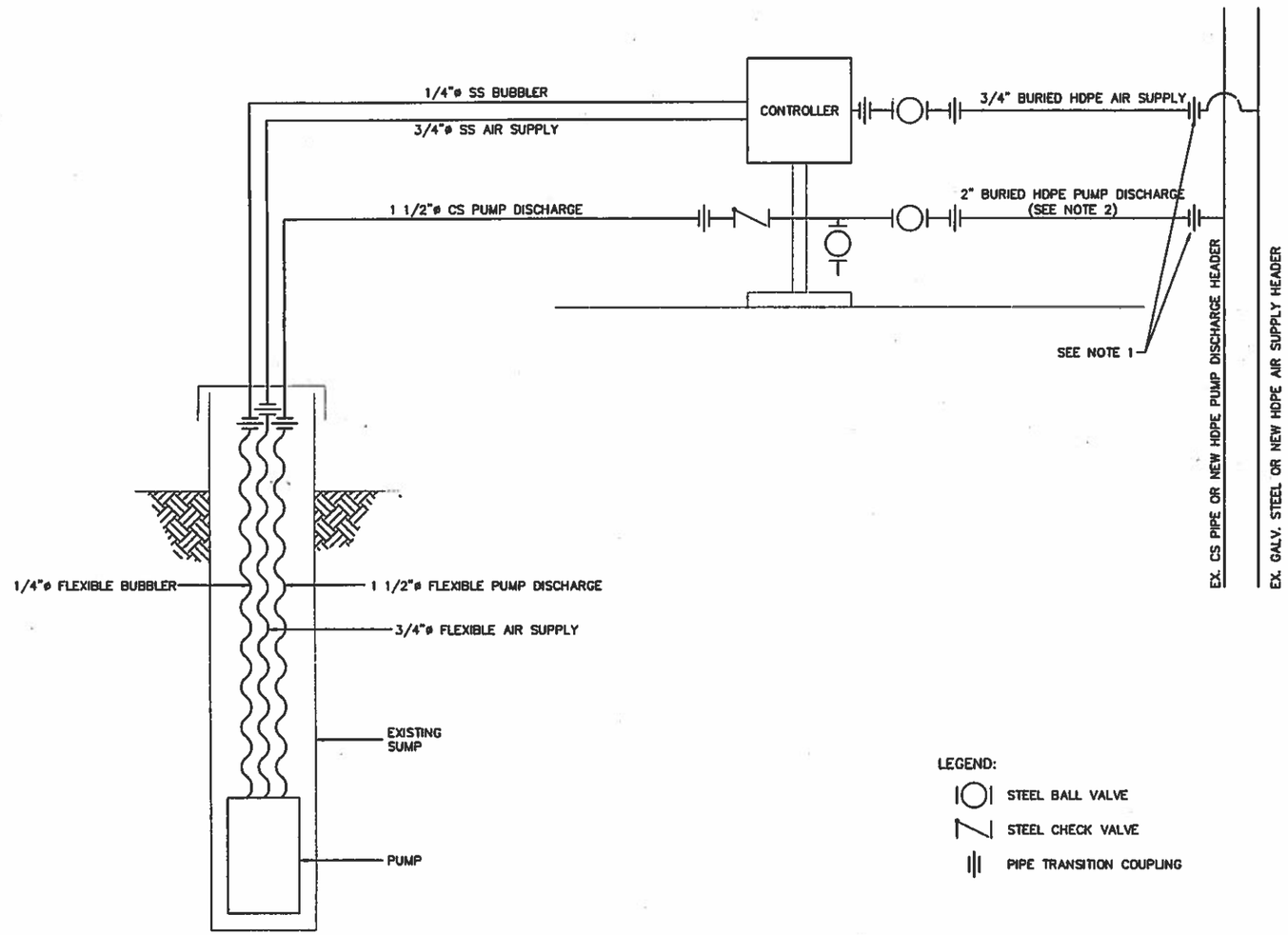

LEGEND:

- STEEL BALL VALVE
- STEEL CHECK VALVE
- PIPE TRANSITION COUPLING

NOTES:

1. TRANSITION COUPLINGS AT CONNECTION TO GPS HEADERS ARE ONLY NECCESSARY WHEN CONNECTING TO EXISTING METAL MAIN LINES. SEE SUMP DETAILS 1 THROUGH 5 FOR SITE SPECIFIC DETAILS.
2. PIPE SHALL BE CS FOR SUMP S-83071.
3. SEE D-767530 AND D-767531 FOR PUMP INSTALLATION DETAILS.

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

REFERENCE DRAWINGS

REVISIONS

0	ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1	AS-BUILT 9/15/99	AGF	

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Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. DATE OCT. 1999 APPROVED
CHOR. CHOR. DEPT.
CPNTL DEPT.

PUMP INSTALLATION SCHEMATIC
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767524-1

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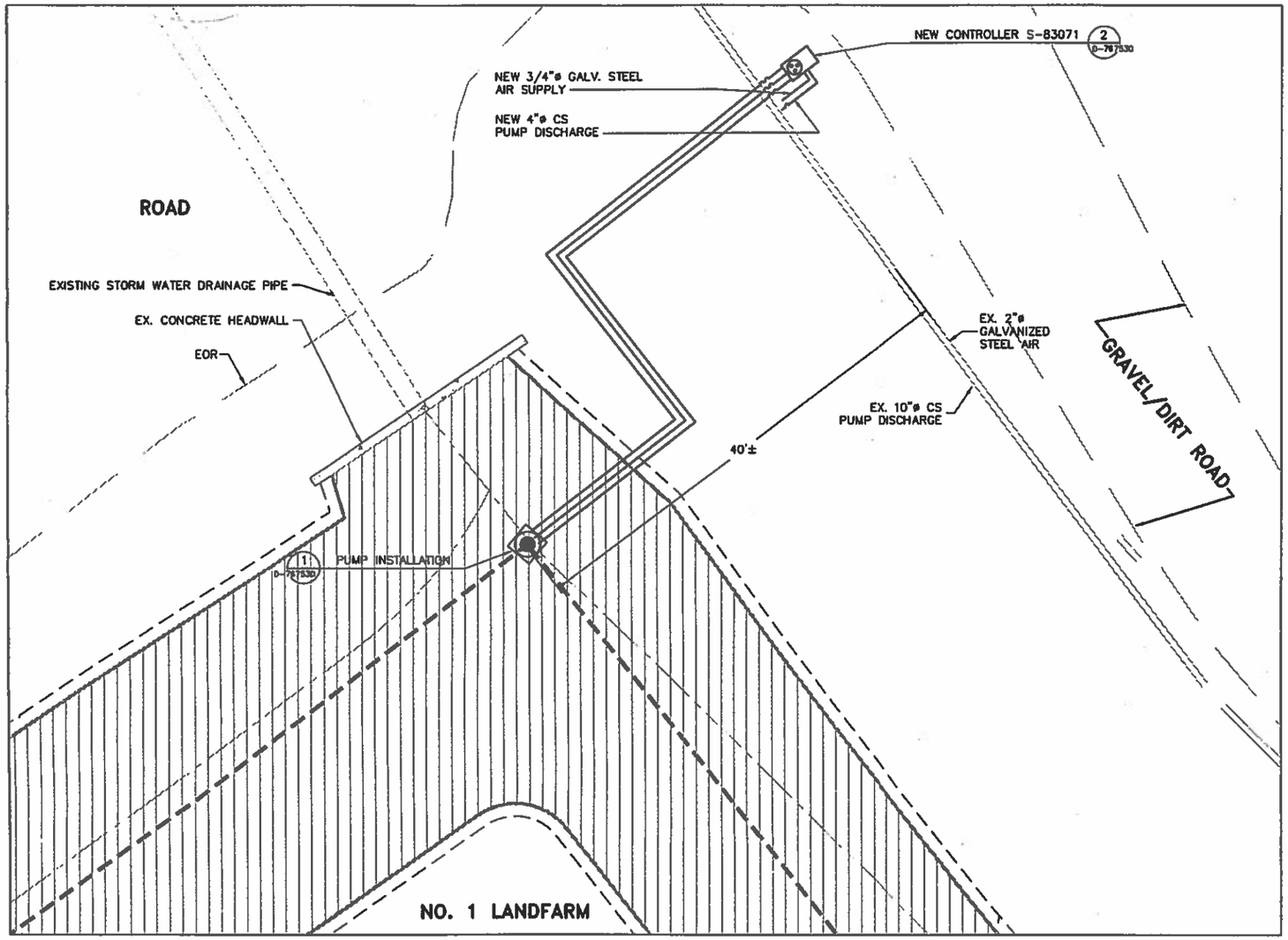

DETAIL 1 D-767522
S-83071

NOTES:

1. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND UTILITY LINES.
2. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
3. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EX. GPS EXTRACTION TRENCH
- EX. ROAD
- CENTERLINE OF EX. V-DITCH
- DAYLIGHT LINE OF EX. V-DITCH
- EX. HDPE V-DITCH LINER
- EX. SUMP / NEW PUMP LOCATION
- EX. ABOVE GROUND PIPELINE
- EX. BURIED PIPELINE
- NEW ABOVE GROUND PIPELINE
- CONTROLLER LOCATION

N

0 5
Approximate Scale in Feet

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

REFERENCE DRAWINGS	
LFM1-STORM WATER PIPING	D-782416-1
LFM1-STORM WATER PIPING	D-782417-1
LFM1-HEADWALL PLAN & SECTIONS	D-782418-1
LFM1-OUTFALL & MANHOLE DETAILS	D-782419-1

REVISIONS		
0 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGF	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. MOSSIA DR. APP. DATE OCT. 1998 APPROVED
ENGR. TRG ENGR. DEPT.
OPER'G. DEPT.

NO. 1 LANDFARM - SUMP NO. S-83071
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767525-1

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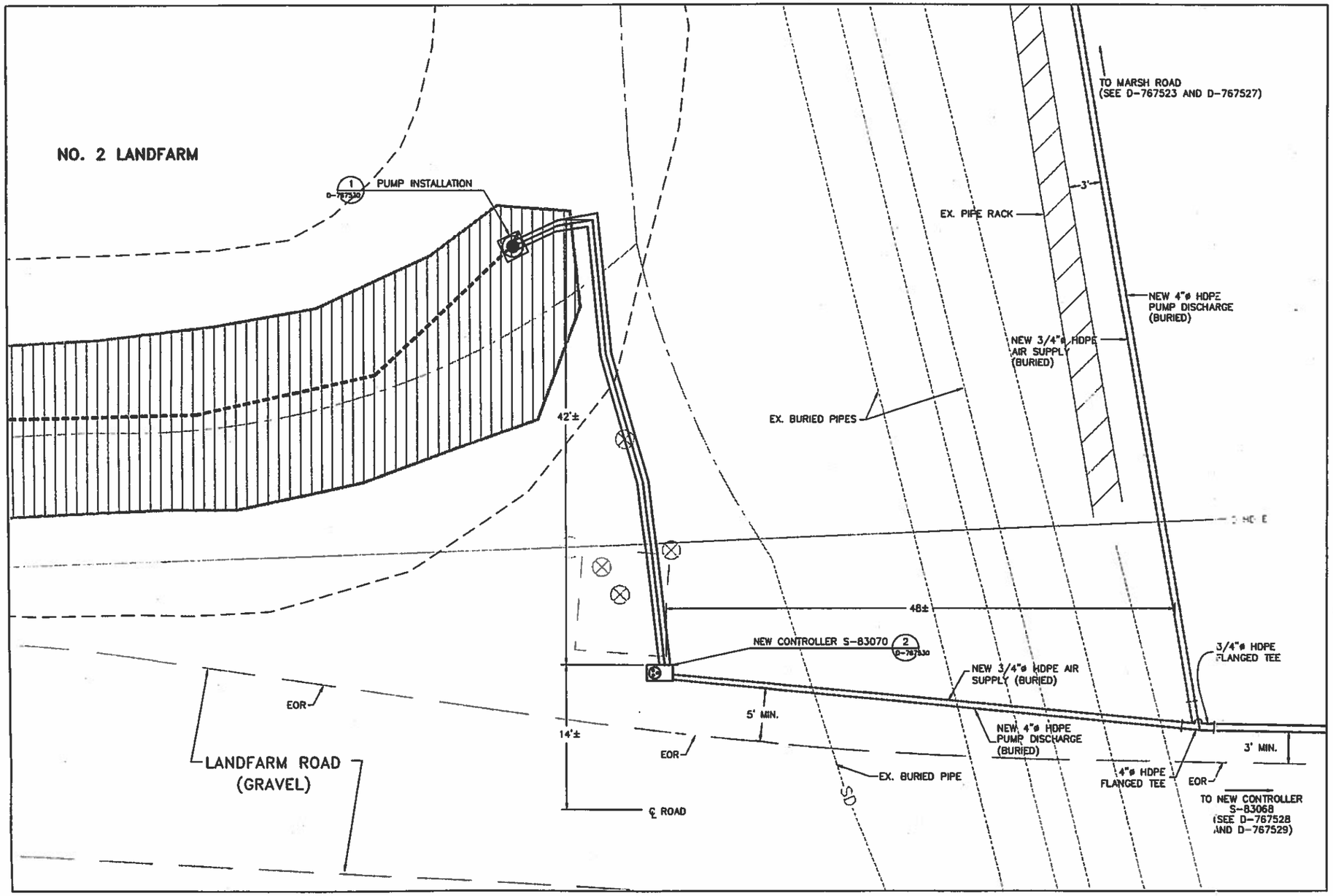

DETAIL 2 D-767523
S-83070

NOTES:

1. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND UTILITY LINES.
2. ALL NEW HDPE PIPING TO BE BURIED.
3. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
4. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EX. GPS EXTRACTION TRENCH
- EX. ROAD
- CENTERLINE OF EX. V-DITCH
- DAYLIGHT LINE OF EX. V-DITCH
- EX. OVERHEAD ELECTRICAL
- EX. HDPE V-DITCH LINER
- EX. SUMP / NEW PUMP LOCATION
- EX. ABOVE GROUND PIPELINE
- EX. BURIED PIPELINE
- NEW ABOVE GROUND PIPELINE
- NEW BURIED PIPELINE
- CONTROLLER LOCATION

N

0 5
Approximate Scale in Feet

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

REFERENCE DRAWINGS		
LFM1-STORM WATER PIPING	D-782416-1	
LFM1-STORM WATER PIPING	D-782417-1	
LFM1-HEADWALL PLAN & SECTIONS	D-782418-1	
LFM1-OUTFALL & MANHOLE DETAILS	D-782419-1	

REVISIONS		
0 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGF	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSKA DR. APP. DATE OCT. 1998 APPROVED
ENGR. ENGR. DEPT.
OPR'G. DEPT.

NO. 2 LANDFARM – SUMP NO. S-83070
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767526-1

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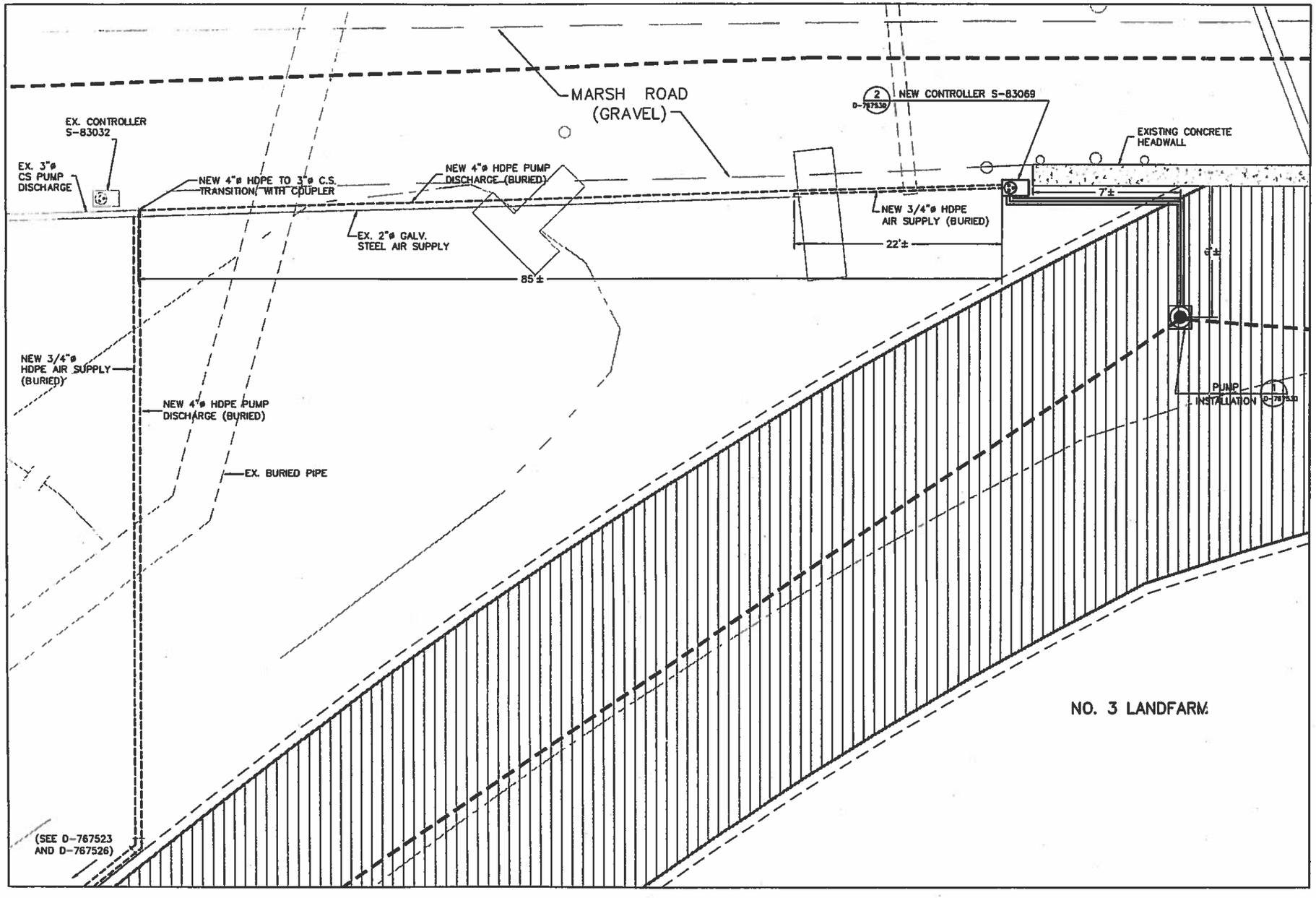

DETAIL 3 D-767523
S-83069

NOTES:

1. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND UTILITY LINES.
2. ALL NEW HDPE PIPING TO BE BURIED.
3. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
4. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EX. GPS EXTRACTION TRENCH
- EX. ROAD
- CENTERLINE OF EX. V-DITCH
- DAYLIGHT LINE OF EX. V-DITCH
- EX. OVERHEAD ELECTRICAL
- EX. HDPE V-DITCH LINER
- EX. SUMP / NEW PUMP LOCATION
- EX. ABOVE GROUND PIPELINE
- EX. BURIED PIPELINE
- NEW ABOVE GROUND PIPELINE
- NEW BURIED PIPELINE
- CONTROLLER LOCATION

N

0 5
Approximate Scale in Feet

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

REFERENCE DRAWINGS		
LFM1-STORM WATER PIPING	D-782416-1	
LFM1-STORM WATER PIPING	D-782417-1	
LFM1-HEADWALL PLAN & SECTIONS	D-782418-1	
LFM1-OUTFALL & MANHOLE DETAILS	D-782419-1	

REVISIONS		
0 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGP	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOZSA DR. APP. DATE OCT. 1998 APPROVED
ENGR. ENGR. DEPT.
OPNS. DEPT.

NO. 3 LANDFARM - SUMP NO. S-83069
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767527-1

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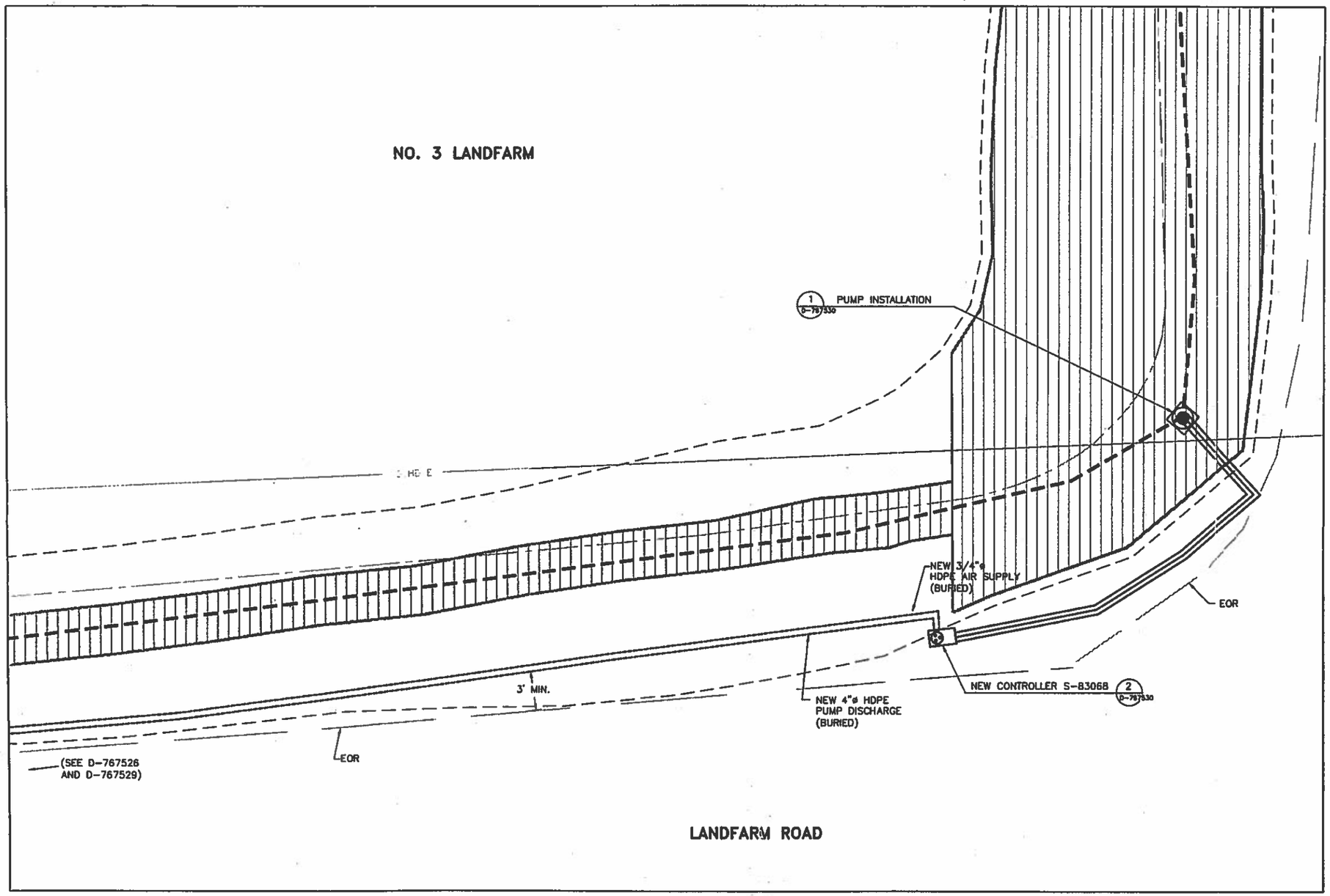

DETAIL 4 D-767523
S-83068

NOTES:

1. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND UTILITY LINES.
2. ALL NEW HDPE PIPING TO BE BURIED.
3. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
4. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EX. GPS EXTRACTION TRENCH
- EX. ROAD
- CENTERLINE OF EX. V-DITCH
- DAYLIGHT LINE OF EX. V-DITCH
- EX. OVERHEAD ELECTRICAL
- EX. HDPE V-DITCH LINER
- EX. SUMP / NEW PUMP LOCATION
- EX. ABOVE GROUND PIPELINE
- EX. BURIED PIPELINE
- NEW ABOVE GROUND PIPELINE
- NEW BURIED PIPELINE
- CONTROLLER LOCATION

N

0 5
Approximate Scale in Feet

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

REFERENCE DRAWINGS		
LFM1-STORM WATER PIPING	D-782416-1	
LFM1-STORM WATER PIPING	D-782417-1	
LFM1-HEADWALL PLAN & SECTIONS	D-782418-1	
LFM1-OUTFALL & MANHOLE DETAILS	D-782419-1	

REVISIONS		
0 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGF	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. ROSSIA DR. APP. DATE OCT. 1998 APPROVED
ENGR. DEPT.
OPRG. DEPT.

NO. 3 LANDFARM – SUMP NO. S-83068
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767528-1

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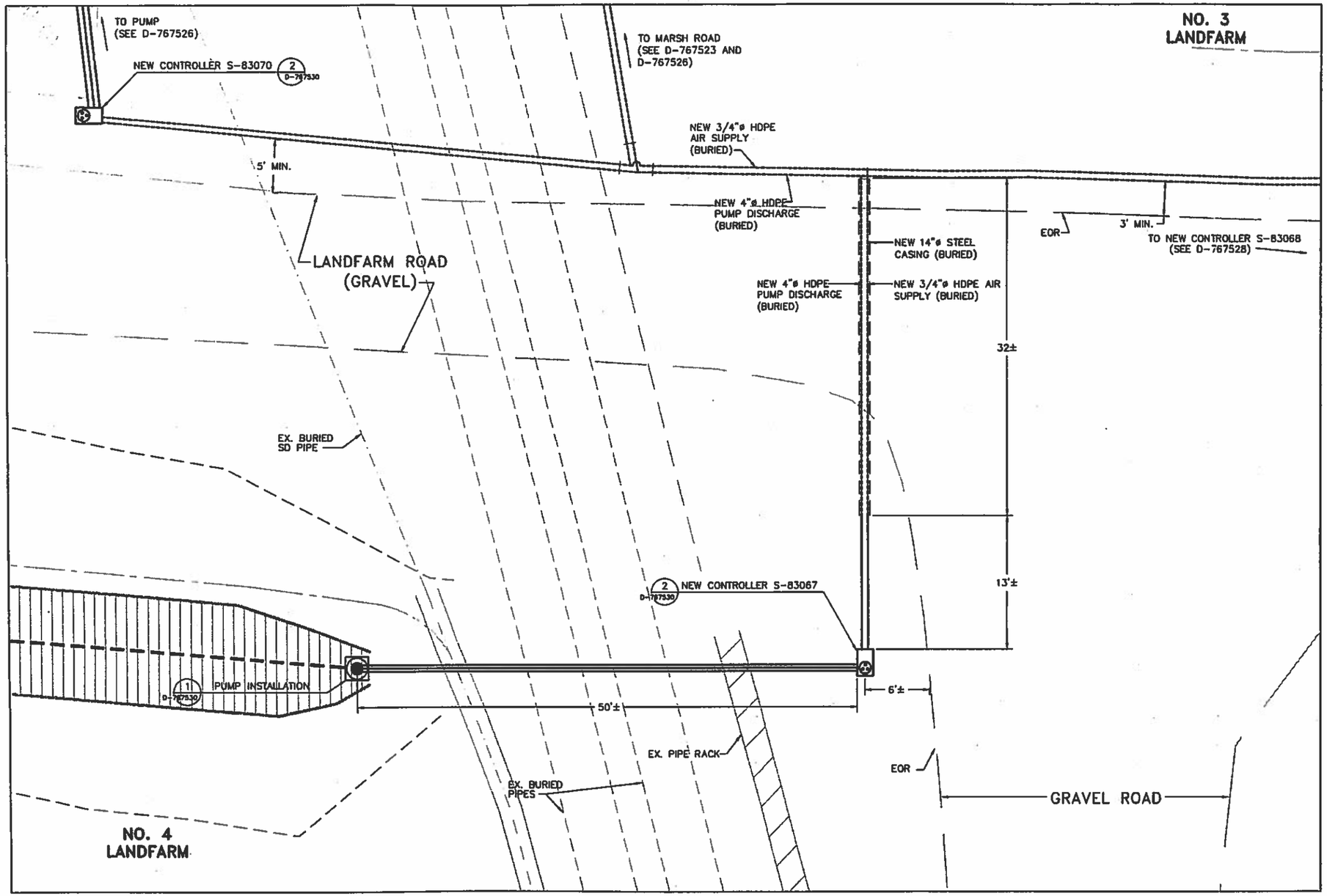


DETAIL 5 D-767523
S-83067

NOTES:

1. NOTE PRESENCE OF EXISTING OVERHEAD AND UNDERGROUND ELECTRICAL LINES.
2. ALL NEW HDPE PIPING TO BE BURIED.
3. CONTOURS AND GRADES ARE NOT SHOWN FOR CLARITY.
4. LOCATION OF EXISTING GPS EXTRACTION TRENCHES ARE APPROXIMATE.

LEGEND:

- EX. GPS EXTRACTION TRENCH
- EX. ROAD
- CENTERLINE OF EX. V-DITCH
- DAYLIGHT LINE OF EX. V-DITCH
- EX. OVERHEAD ELECTRICAL
- EX. HDPE V-DITCH LINER
- EX. SUMP / NEW PUMP LOCATION
- EX. ABOVE GROUND PIPELINE
- EX. BURIED PIPELINE
- NEW ABOVE GROUND PIPELINE
- NEW BURIED PIPELINE
- NEW BURIED CASING
- CONTROLLER LOCATION

N

0 5
Approximate Scale in Feet

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

REFERENCE DRAWINGS		
LFM1-STORM WATER PIPING	D-782416-1	
LFM1-STORM WATER PIPING	D-782417-1	
LFM1-HEADWALL PLAN & SECTIONS	D-782418-1	
LFM1-OUTFALL & MANHOLE DETAILS	D-782419-1	

REVISIONS		
2 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1 AS-BUILT 9/15/99	AGF	

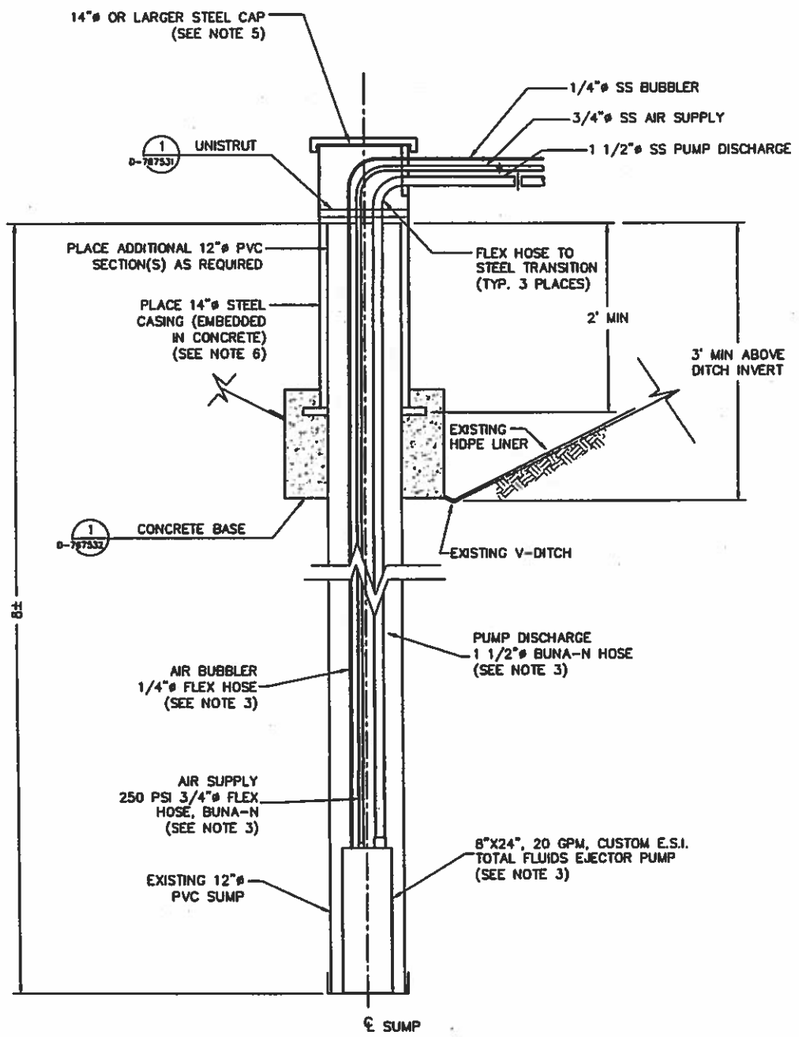
Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. SLP DATE OCT. 1998 APPROVED
ENGR. DES ENGR. DEPT.
OPR'G. DEPT.

NO. 4 LANDFARM – SUMP NO. S-83067
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767529-1

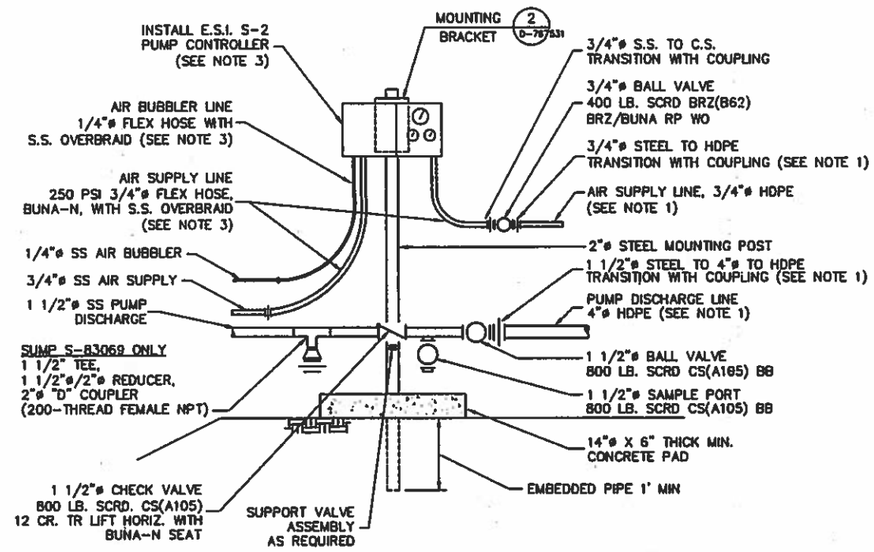
42100001 \CHEV_R\S83\GPS\ASBLT\D767529-1 101398 1:1 092899 1 SLD



DETAIL 1
PUMP INSTALLATION — D-767525, D-767526, D-767527, D-767528, D-767529

NOT TO SCALE

NOTE: THIS DETAIL FOR SUMPS S-83067, S-83068, S-83069, S-83070 AND S-83071.



DETAIL 2
NEW CONTROLLER — D-767525, D-767526, D-767527, D-767528, D-767529

NOT TO SCALE

NOTE: THIS DETAIL FOR CONTROLLERS S-83067, S-83068, S-83069, S-83070 AND S-83071.

NOTES:

1. 3/4"ø AIR SUPPLY AND 4"ø PUMP DISCHARGE LINES SHALL BE CARBON STEEL FOR SUMP S-83071, AND HDPE FOR ALL OTHER SUMP LOCATIONS.
2. NEW HDPE AIR SUPPLY AND PUMP DISCHARGE SHALL BE LAID ON GROUND OR BURIED (SEE DWGS. D-767522 THROUGH D-767529). CONTRACTOR SHALL PROVIDE AND INSTALL PIPELINES AND FITTINGS NECESSARY TO CONNECT THE NEW BURIED LINES TO THE EXISTING ABOVE GROUND GPS LINES.
3. ITEMS SUPPLIED BY PUMP MANUFACTURER.
4. FINISHED ELEVATION OF TOP OF CONCRETE SLAB AND TOP OF STEEL CASING TO BE DETERMINED BY THE FIELD ENGINEER.
5. CONTRACTOR SHALL SIZE STEEL CAP APPROPRIATELY.
6. STEEL CASING SHALL HAVE SLOTS CUT TO SEAT THE UNISTRUT AND FOR HOSES AND ANCHOR CABLE

REGISTERED PROFESSIONAL ENGINEER — No. C 68894, 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

REVISIONS

0	ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1	AS-BUILT 9/15/99	AGP	

Chevron — Richmond Refinery

SCALE AS NOTED — DR. C. KOESA — DR. APP. — DATE OCT. 1999 — APPROVED
ENGR. — ENGR. DEPT. — OPRG. DEPT.

PUMP INSTALLATION DETAILS 1
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A — W.O. — S.O. — D-767530-1

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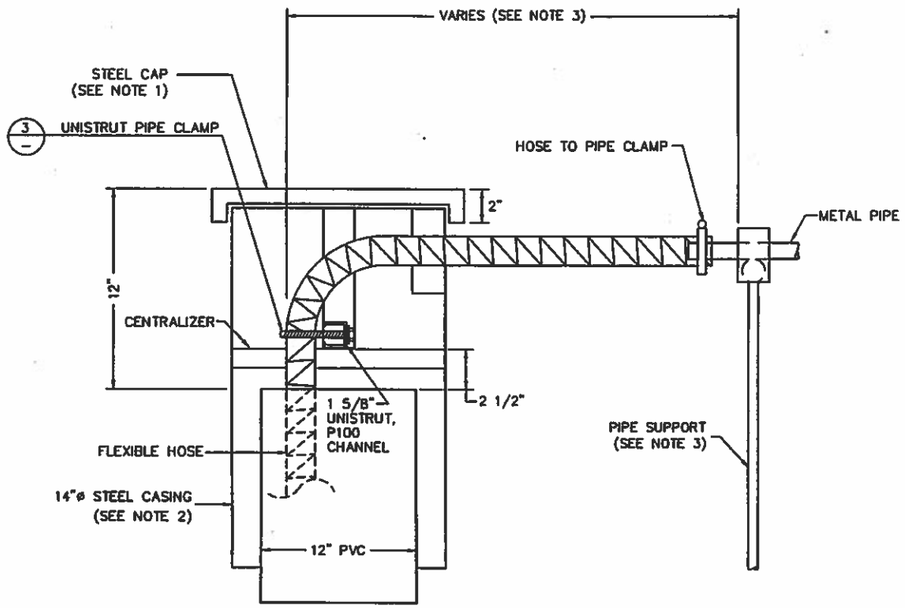
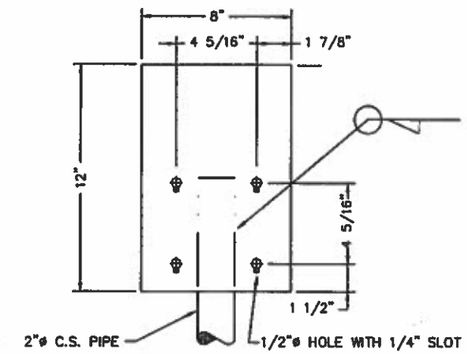


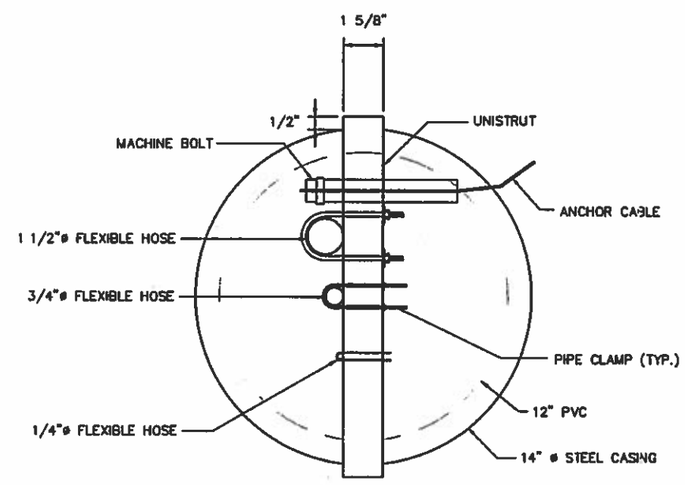
DETAIL 1 D-767530
UNISTRUT

NOT TO SCALE



DETAIL 2 D-767530
MOUNTING BRACKET

NOT TO SCALE



DETAIL 3 -
UNISTRUT PIPE CLAMP

NOT TO SCALE

NOTES:

1. CONTRACTOR SHALL SIZE STEEL CAP.
2. STEEL CASING SHALL HAVE SLOTS CUT TO SEAT THE UNISTRUT, HOSES, AND ANCHOR CABLES.
3. CONTRACTOR SHALL PROVIDE SUFFICIENT SUPPORTS FOR PUMP DISCHARGE PIPES BETWEEN THE SUMP AND THE SUBHEADER OR HEADER. PIPE SUPPORT LOCATIONS SHALL BE DETERMINED BY THE FIELD ENGINEER.
4. CONTRACTOR SHALL CONFIRM DIMENSIONS OF MOUNTING BRACKETS WITH THE MANUFACTURER AND INSTALL PER MANUFACTURER'S RECOMMENDATIONS.

REGISTERED PROFESSIONAL ENGINEER
No. C 62333
CIVIL
STATE OF CALIFORNIA

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

REFERENCE DRAWINGS

REVISIONS

1	ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
1	AS-BUILT 9/15/99	AGP	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOSSA DR. APP. 2.2 DATE OCT. 1998 APPROVED
ENGR. TAS ENGR. DEPT.
OPERS. DEPT.

PUMP INSTALLATION DETAILS 2
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767531-1

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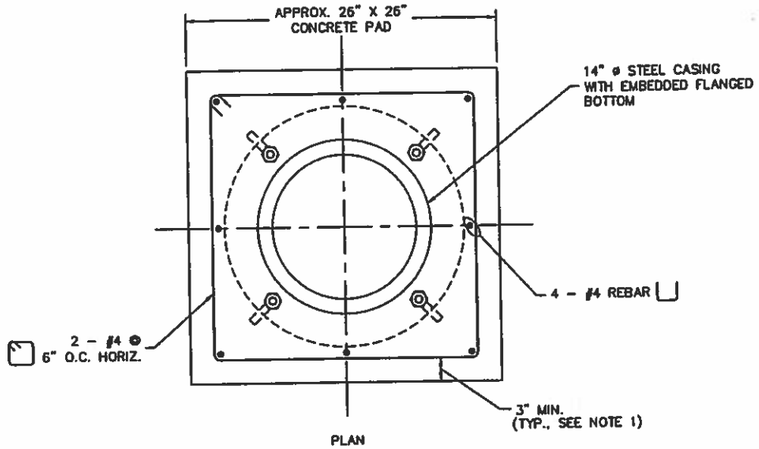
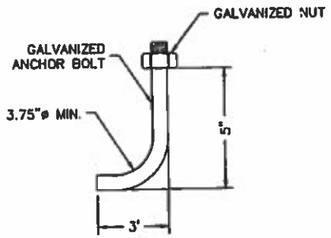
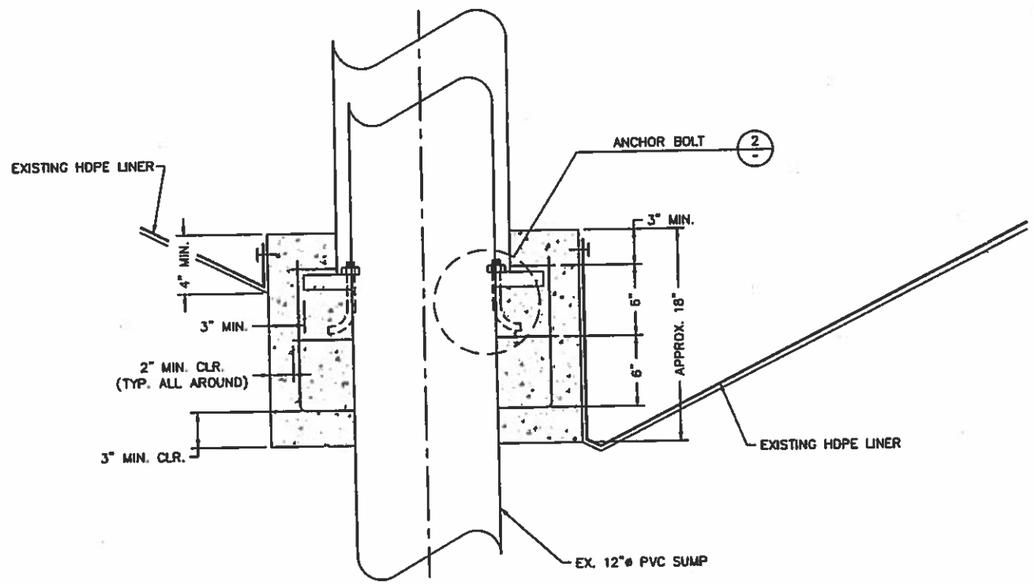


PLAN



DETAIL 2
ANCHOR BOLT



SECTION

DETAIL 1
CONCRETE BASE D-767530-0

NOT TO SCALE

NOTES:

1. MINIMUM CLEARANCE TO REINFORCEMENT SHALL BE 3" WHEN CAST AGAINST SOIL AND 2" ELSEWHERE (UNLESS OTHERWISE NOTED).

2. REBARS SHALL BE GRADE 60 STEEL AND BE DEFORMED BARS.

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

REFERENCE DRAWINGS	REVISIONS		
	1 ISSUE FOR CONSTRUCTION NO. 1-5 LANDFARMS 12/98	CIK	
	2 AS-BUILT 9/15/99	AGF	

Chevron
Richmond Refinery

SCALE AS NOTED DR. C. KOESA DR. APP. DATE MAR. 1999
ENGR. DEPT.
OPR'G. DEPT.
APPROVED

CONCRETE BASE DETAIL
SECTOR 83: LANDFARMS
GROUNDWATER PROTECTION SYSTEM
UTILITIES/ENVIRONMENTAL ABU

A W.O. S.O. D-767532-1

42100001 \CHEV-R\S83\GPS\ASBLT\D767532-1 030599 1:1 090999J CIK

Appendix G
Revised Landfarms Closure Plan (May 28, 1997)

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

REVISED

LANDFARMS CLOSURE PLAN

Prepared for:

CHEVRON PRODUCTS COMPANY
RICHMOND, CALIFORNIA

December 30, 1996

Rev May 28, 1997

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

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Richmond, California
May 28, 1997

221 Main Street, Suite 600
San Francisco, CA 94105-1917
415 896 5858 Tel
415 882 9261 Fax

Mr. Pete Duda
Chevron Products Company
841 Chevron Way
Richmond, CA 94802-0627

Waste Discharge Order Project
Response to Comments from the DTSC
Landfarms Closure Plan

Dear Mr. Duda,

In response to a facsimile transmitted to us by the Department of Toxic Substances Control (DTSC) on April 24, 1997, we have prepared some minor revisions to the Landfarm Closure Plan. Our responses reflect a telephone discussion between Mr. Tony Morales of the DTSC and myself on May 2, 1997 during which we discussed each issue and agreed on what would be an acceptable level of response for each. Based on my discussions with Mr. Morales, he requests that Chevron forward the revised pages to him so he can replace them in the current Closure Plan document. In general, our responses consist of including more detailed information on parameters used to conduct the various analyses and including references for specific information presented in the report. Specific responses are presented below. In each case, the DTSC comment is presented first in italics and our response follows. In their transmittal, the DTSC identified the page and section number for each comment. In preparing our responses, we attempted to retain the original pagination. However, in a few instances, that was not practical, and we have noted the revised locations in our responses.

Comment 1: Page 8, Section 2.2.4, 1988-1995 Bioremediation Activities.

A. *What work on optimization of soil condition has been done up to the present? What kind of soil amendment material has been added? Has the effect of addition of amendment materials been assessed?*
B. *What are the common metals involved in petroleum processing other than Cr, Pb, Ni and V?*
C. *What is the meaning of "Foru metals" on the fifth line, second paragraph?*
D. *Are there histogram plots showing the trend of contaminant concentrations vis time?*

Response to Comment 1: The text in Section 2.2.4was revised to reference the Bioremediation Activities Report (BEDM, 1992) and the Landfarm (Soil) Sampling and Analysis Plan (BEDM, 1993). The text was further revised to state that these reports addressed work done to optimize soil conditions, addition of soil amendments, identify and detect contaminants (including metals), and histogram plots of concentrations vs. time. "Foru" was a typographical error and should have read "four".

Comment 2: Page 13, Section 3.2, 1st line, Plates 3 and 4.
Abbreviation "RRD" is used but no explanation is given. It is suggested that a list of acronyms be compiled and included in the closure plan.
Groundwater levels of monitoring wells should be presented on geologic cross sections A-A' and B-B' (Plates 3 and 4) and also groundwater line of A zone should be included.
Response to Comment 2: We have reviewed the document to verify that all acronyms were defined. In addition, we have provided a list of acronyms that can be inserted into the Closure Plan immediately following the Table of Contents. We have also revised the text to refer the reader to a detailed discussion of groundwater conditions in Section 3.3. The cross sections were not revised to include "A" Zone groundwater levels because of the variable nature of water levels at any one time and the fact that the cross sections were intended to depict site stratigraphy rather than groundwater conditions.

Comment 3: Page 13, Section 3.2.1, Fill
This section describes that Landfarms were underlain by several ponds that were backfilled. No further details on locations, sizes, and depths of the ponds, and their uses. Those important information should be presented.
Response to Comment 3: We revised the text to refer the reader to the Bioremediation Activities Report (BEDM 1992) and the RCRA Facilities Investigation for the Landfill under Landfarms report (BEDM, 1992) for a description of the ponds formerly underlying the Landfarms.

Comment 4: Page 14, Section 3.3, Summary Table of Hydraulic Parameters.
The assumed horizontal permeabilities show in this table is not site specific hydraulic parameters. Presentation of site specific parameters is more important. From the unit illustrated, the horizontal permeability heading is likely meaning hydraulic conductivity. Presentation of a range of measured hydraulic conductivities, hydraulic gradients, flow velocities, mean and median values would be more meaningful. The last column shows average horizontal velocity in ft/day. To prevent confusion, the heading should indicates if they are Darcy velocity of $V=Ki$, or the average linear pore velocity of $Vp = Ki/n$. If the listed velocities are the Darcy velocity, the conversion factor used could be wrong.
Response to Comment 4: We have clarified in the text that the velocity calculated is the average linear horizontal flow velocity and have included the equation. We have further defined the parameters and their sources used to calculate the velocity.

Comment 5: Page 15, Section 3.3, Last paragraph
It states that the B Zone aquifer underlying the site is located at an approximate depth of 100 ft, and chemical test results have shown that B Zone is effectively separated from overlying water-bearing units (A and C Zones) by a thick layer of estuarine clay. It also points out the hydraulic gradient of B Zone is upward to the upper A and C Zones. The above mentioned statements are very convincing. However, the Owner/Operator should elaborate more on the chemical test results, and provide more recent data on the upward hydraulic gradient of B Zone. A question may be raised if there is a easy pathway, such as fault zone, joints or cracks connecting the upper Zones and B Zone. With the presence of DNAPLs in the Landfarms, what is the chance of contaminants migrating to the B Zone aquifer? An assessment of such condition should be performed.
Response to Comment 5: We have revised the text to include a statement indicating that we do not expect natural features such as faults to influence the downward migration of constituents from the "A" and "C" Zones to the "B" Zone. We have also clarified that the constituents of concern are light non-aqueous phase liquids which tend to float as opposed to dense non-aqueous phase liquids which tend to sink.

Comment 6: Page 15, Section 3.4.1, "A" Water Table Zone, Plate 3-7
Piezometers are scattered and separated from each other for more than 200 ft. On Plate 3-7, groundwater levels in a number of piezometers were not measured. With scarcity of groundwater level information, all available information should be collected and used to construct a groundwater table map.
Response to Comment 6: We have revised the text on Page 33, Post Closure Monitoring, to state that Chevron will monitor as many piezometers in the Landfarms area as is practical to develop a representative picture of the water table.

Comment 7: Plate 3-8
The 9ft contour line surround No. 2 Landfarm is wrong, it should be a 10 ft contour line.
Response to Comment 7: We have revised the Plate as requested.

Comment 8: Page 15, Section 3.4.1, "A" Water Table Zone, 3rd and 4th Paragraphs
The third paragraph in this section states that overall "A" Zone flow in the Flats Zone at the Refinery is northwest toward the Bay, and that once the vegetative cover becomes fully established, the local mounding of the water table will likely be reduced and the gradient will resume an overall northwesterly direction under No. 1 Landfarm. In fact under No. 1 Landfarm, the general groundwater flow direction is currently northeast. Even after placement of vegetative cover, the groundwater flow direction may not be changed toward northwest

direction, because of the topography (see Plate 3-8, "A" Zone water Table Map). This paragraph also mentioned a Bioreactor and a Water Enhancement Wetlands Project, however, the locations and the reference map were not stated.

The range and average hydraulic conductivities of "A" zone are presented in the fourth paragraph. Methods adopted to determine these hydraulic conductivities and number of data collected, and the average hydraulic conductivity of how many data should be described in the text so that the reviewer can have some sense of data quality.
Response to Comment 8: (New page 16, second paragraph) We have revised the text to present the correct groundwater flow direction and have included a reference to Plate 2-4 which includes the location of the features in question (Plate 2-4 was not revised).

We have addressed the second part of the comment in our Response to Comment 4, above.

Comment 9: Page 16, Section 3.4.2, "C" Zone
It is noticed that there are only few monitoring wells in "C" zone. There is no hydraulic conductivity data of "C" zone in No. 1 Landfarm.
Response to Comment 9: We have revised the last paragraph of the Section 3.4.2 text to include a reference to the "C" Zone Investigation reports which include all of the data requested.

Comment 10: Page 16, Section 3.4.3, Bay Mud Aquitard
Peat zones and lenticular sand layers occur commonly in Bay Mud everywhere in the San Francisco Bay area. Occurrence of these permeable units in the landfarm areas has not been described and assessment of these units becoming a possible easy path way has not been presented. This section describe the hydraulic conductivity of Bay Mud being approximately equal to or less than 1.0 x 10-7 cm/sec. which appears to be an assumption not a measured value. Moreover, it states that the integrity of this low-permeability barrier is evidenced by the confined conditions and upward hydraulic gradient from the "C" Zone into the "A" Zone. This statement needs to be supported by cluster wells information. Examining the groundwater table maps of "A" Zone (Plate 3-8) against the "C" Zone (Plate 3-9), the stated upward hydraulic gradient from "C" to "A" is not convincing.
Response to Comment 10: (New page 17, last paragraph of Section 3.4.3) The text has been revised to include a discussion of Peat layers within the Bay Mud and their significance with respect to the closure plan details. The text has also been revised to include additional supporting evidence that the Bay Mud provides an effective barrier between the "A" and "C" Zones.

Comment 11: Page 16, Section 3.5, Landfarms Groundwater Monitoring Program
The stated 5 background monitoring well locations should be shown on a map and presented.
Response to Comment 11: (New page 17, Section 3.5) Plate 1-1 has been revised to include the 5 background wells and a reference to the Plate has been added to the text.

Comment 12: Page 17, Section 3.6, Corrective Action
Barrier walls are mentioned in this section, however, it cannot be found on the maps. The barrier wall locations should be exhibited clearly on a map or referred to a certain map.

A small groundwater mound is present in the northwest corner, not in the northeast corner, of the No. 1 Landfarm.
Response to Comment 12: (New page 18) A reference to Plate 3-10 has been included in the text (second paragraph) and the location of the groundwater mound has been revised (third paragraph).

Comment 13: Page 17, Section 3.6, Corrective Action, 3rd Paragraph
This paragraph describes groundwater mounding on Landfarms and predicts that once the groundwater levels have stabilized, predominant groundwater flow direction should resume toward the GPS extraction trenches. The groundwater mounding is attributed to irrigation activities. It may be pointed out that groundwater level normally follows ground surface slope in nature. The groundwater mounding at Landfarms may be due to hydraulic conductivity, low hydraulic gradient, and the resultant slow groundwater flow. Regardless of local groundwater mounding, the general groundwater flow will be toward the GPS.
Response to Comment 13: (New page 18, third paragraph) The text has been revised to include the requested wording.

Comment 14: Page 18, Last Sentence
It states that chemical monitoring in "C" Zone verifies that water quality below the Bay Mud at the point of compliance has not been degraded. The chemical data of "C" Zone is not presented nor referred to a specific report.
Response to Comment 14: (New page 18 - a, last sentence) The text has been revised to include a reference to the "C" Zone Investigation reports.

Comment 15: Page 22, Section 4.2.4.1, General:
The quoted Drawing D-767519 in Appendix J is not included, neither the drawing showing the cross section details of the final grading for No. 2 Landfarm through No. 5 Landfarm. Apparently some drawings are missing in Appendix J.

Response to Comment 15: Text has been revised to reflect the correct current drawing numbers. No drawings were missing from Appendix J.

Comment 16: Page 24, Section 4.3, Closure Unit Design
This section states that the drainage control systems are designed to be capable of handling a 25-year and 24 hours storm. An additional assessment should be performed to ascertain no possible serious damages to the protection systems and the environment if a heavier storm occurs.
Response to Comment 16: A discussion of the consequences of and contingency planning for a storm with a recurrence interval of greater than 25 years has been added to the first paragraph of the text for Section 4.3.

Comment 17: Page 32, Section 5.8, Free-Phase Hydrocarbon Monitoring and Recovery
The monitoring and recovery processes stated in this section appear reasonable and technically feasible.
Response to Comment 17: None required

Comment 18: Page 33, 2nd Paragraph, Last Sentence
The statement that chemical monitoring in the "C" Zones verifies that water quality below the Bay Mud at the point of compliance has not been degraded, requires further scrutiny.
Response to Comment 18: A reference to the "C" Zone Investigations has been added to the sentence in question.

Comment 19: Plates 3-3, 3-4, 3-5, and 3-10
Some wells and a borehole shown on geological cross sections A-A' and B-B' are not plotted on Plates 3-3 nor on Plate 3-10. The following cannot be found:
1) *GW-184C;*
2) *GW-181C which is likely GW-587C;*
3) *B-3*
4) *GW-190A*
5) *GW-104B*

The above wells and a boring should be shown on Plates 3-3 and 3-10.
Response to Comment 19: The missing well and boring locations have been added to Plate 3-3, Plate 3-10 is intended to show only those wells that are part of the current LGMP. GW-181C was abandoned and replaced by GW-587C several years ago.

Comment 20: Appendix A
Calculation of ground settlement for 50 years along 2 sections is presented in the appendix. Input parameters are listed, nevertheless, how those data are collected or cited from somewhere are not described. The listed coefficients of consolidation have wrong units (Ex., instead of 6.0 ft/yr, it should be 6.0 sqft/yr). More detained theoretical background involved in the calculation should be presented. Estimated settlements along A-A' and B-B' sections are presented, however, the reviewer is unable to validate the estimated values of settlement because important background information is missing. From the data presented, it appears that consolidation of Old Bay Mud and existing fills were not estimated. It will help reviewer if a schematic drawing of consolidation is added in Plates 2 and 3.

Response to Comment 20: The text has been revised to present the background of the parameters selected for analysis and elaborate further on the rational for the calculations (Section A1.0, third paragraph and Section A2.0, third paragraph). The DTSC agreed that a schematic drawing of consolidation was not required. Plates A-2 and A-3 were revised to show the correct units for the coefficients of consolidation.

Comment 21: Appendix B, Geotechnical Evaluation - Slope Stability
This portion of the report presents the results of static and dynamic slope stability analyses using computer models. Only two sections, A-A' and B-B' were analyzed, and it appears that a judgment call was involved in selection of the two sections and the slide circles. More sections should have been analyzed. The input parameters in the computer program calculations are not presented, therefore, the reviewer is unable to determine the adequacy of the analysis.
Response to Comment 21: The first paragraph of the text has been revised to discuss the rational behind the limited number of surfaces analyzed and the basis of the parameters selected. The parameters used in the analysis have been included in a new Table B-1), with the former Table B-1 becoming Table B-2.present the parameters selected for analysis, their basis, and background information on the calculation. The DTSC agreed that additional analysis were not necessary.

Comment 22: Appendix C, Seismic Hazard Study
Plate 6-1 shows most of the active faults surrounding the site, however, San Pablo fault which is closest to the site is not shown on the plate. In the text on page 6-2, it states that the fault has been classified as inactive and in conformance with interpretation of the 1975 US Geological survey and the 1975 California Division of Mines and Geology publications. I have checked a more recent 1994 Fault Activity Map of California, Division of Mines and Geology, for an

interpretation of the San Pablo fault and find that is classified as a pre-Quarternary fault consistent with the above interpretation.
Response to Comment 22: We have revised Section 3.0 of the parent document to this Appendix to include the information from the 1994 Fault Activity Map confirming that the San Pablo fault is inactive (Appendix C is reprinted from an earlier document and was not modified).

Comment 23: Appendix D Hydrogeologic Evaluation - Infiltration
Evaluation of infiltration is performed using the US EPA HELP model. The input parameters for the model are listed in Tables D-1 and D-2. Total subsurface inflow is assumed to be zero which may be re-evaluated. According to the Plate 3-8, A-Zone Water Table Map there is subsurface inflow from the eastern edge of the San Potrero-San Pablo Ridge. The inflow could be insignificant, nevertheless, it should be evaluated. In Table D-2, input parameters are listed with four significant figures which are presumably meaningless.
Response to Comment 23: The text has been revised to address the issue of subsurface flow (Section 2.4, second paragraph). The number of significant figures presented on Table D-2 were taken directly from the HELP model documentation and are not intended to imply that level of accuracy. As the parameters are inter-related, rounding them prior to performing the analyses may have caused some conflicts. The text was revised to indicate the source of the values. The DTSC agreed that additional analysis to evaluate the impact of sub surface flow would not significantly impact the findings of the analyses and were not necessary.

Comment 24: Appendix E, hydrogeologic Evaluation - Erosion
Soil erosion at the Landfarms are predicted by an equation developed by Wischmeier and Smith (1965). The methodology is adequate, however, some of the parameters involved in calculation are not presented in the appendix. Those parameters are described on page E-2, however, the numerical numbers, for example, M for particle size parameter, b for soil structural code, and c for the profile-permeability class are not presented. All parameters used in calculation should be presented.
Response to Comment 24: The text in Section E.2.2 has been revised to present the parameters selected for analysis.

Other Changes / Additions:
- The table of contents was revised to reflect the changes made to the text;
- The document history on page 1 was updated to reflect changes since the original submittal;
- Pages 36 and 37 include new references; and
- Plate 1-1 was modified to include the locations of the five background wells.

We trust these revisions meet your requirements. If you have any questions regarding our responses or the DTSC comments, please call myself in our San Jose office at (408) 451-1133 or Mark Wahler in our San Francisco office at (415) 243-3734.

Very truly yours,
DAMES & MOORE

Randolph C. Brandt, R.G.
Project Coordinator

Attachment

cc: Mark Wahler, D&M
Don Kinkela, ESD
WDO Project File
SFO Project File

December 30, 1996
Richmond, California

P.J. Duda
Chevron Products Company
841 Chevron Way
Richmond, California 94802

Waste Discharge Order Project
Revised Landfarm Closure Plan
Landfill Landfarm Sector

Dear Mr. Duda,

Transmitted with this letter is a copy of the third version of the Revised Landfarm Closure Plan. This plan replaces the earlier revised plans dated June 21, 1995 and September 14, 1995. The first revised plan was prepared by Bechtel Environmental, Inc. and Dames & Moore, Inc. (BEDM) at the request of Chevron and in response to a letter dated March 17, 1995 from the California Environmental Protection Agency Department of Toxic Substances Control (DTSC) requesting closure of the Landfarms. That plan was revised based on review comments made by the DTSC and was resubmitted in September, 1995. The September version was rescinded on January 24, 1996 by Chevron based upon a decision to pursue closing the Landfarms with a vegetative cover. No comments were received by Chevron from the DTSC on the September version of the plan.

Chevron and BEDM presented the revised conceptual plan elements to the DTSC in a meeting with Ms. Wei Wei Chui and Mr. Tony Morales on February 27, 1996. This meeting was also attended by representatives of the U.S. EPA, and the RWQCB.

A follow-up meeting was held on May 14, 1996 with Mr. Tony Morales and Dr. Stanley Sun of the DTSC to clarify several issues and identify areas where the DTSC needed additional information. It was agreed at the meeting that Chevron would submit a series of interim documents discussing various aspects of the proposed closure plan at roughly monthly intervals. This schedule was intended to allow the DTSC time to evaluate each aspect of the plan on an individual basis. Hence, when the Revised Closure Plan was submitted at the end 1996, it would contain nothing of significance that the DTSC had not already seen, thereby resulting in a quick and smooth approval process. The interim and other related documents submitted by Chevron to the DTSC consisted of the following:

- *Proposed GPS Effluent Water Sampling Plan* (dated May 6, 1996). The GPS sampling plan was developed to document that groundwater being extracted by GPS from the vicinity of the Landfarms was characteristically non-hazardous. Actual sampling of the GPS effluent began

in July, 1996 and is still ongoing. Results for samples collected through September 26 are presented in Appendix M.

- *Proposed Interim Vegetation Plan for Nos. 1 through 5 Landfarms* (dated May 23, 1996). The plan specified criteria and procedures that will be used to promote continued subsurface biodegradation at the Landfarms until the Post-Closure Maintenance Plan contained in this Revised Closure Plan is approved by the DTSC.

- *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.

- *Response to DTSC Comments on Landfarms Closure Plan - GPS and Related Issues* (dated September 12, 1996). This document addressed several GPS related issues that Dr. Sun, DTSC geologist, expressed interest in at the May 14 meeting. These issues included: 1) the ability of GPS to influence the presence of free phase hydrocarbon in wells that exist within the Landfarms footprint; 2) the apparent lack of piezometric monitoring points along the upgradient boundary of the No. 1 Landfarm; and 3) the effects of water in the 250-foot Channel on the ability of the GPS to maintain a hydraulic barrier along the western border of the Nos. 2 and 5 Landfarms.

On November 7, 1996, Mr. Morales of the DTSC forwarded Dr. Sun's review comments on the above referenced September 12 document. We have incorporated several of Dr. Sun's comments in the Revised Closure Plan and recommend that Chevron address the remaining issues in a separate document. Dr. Sun presented his comments in the form of six bulleted items. Our responses to each of his bulleted items are as follows:

Bullet one: As the LNAPLs are contained within GPS and can not cross its alignment, the issue of LNAPL floater and how it responds to fluctuating water levels is only urgent if the GPS does not perform properly. BEDM recommends that Chevron propose evaluating the LNAPL issue as part of post-closure groundwater monitoring and has prepared the attached plan accordingly.

Bullet two: We have added a plan for periodic recovery of LNAPLs with vacuum trucks as Section 5.8 in the Revised Closure Plan.

Bullet three: Information on the design of GPS is included in Sections 3.6 and 4.3.3 and Appendix J of the Closure Plan. If Dr. Sun wishes additional information, BEDM recommends Chevron refer him to the *Groundwater Protection System Engineering Report* (BEDM, 1991) and the RWQCB's *Order No. 93-109, Waste Discharge Requirements for: Chevron U.S.A., Inc., Richmond Refinery, Richmond, Contra Costa County* (December 1, 1993). The first document describes the GPS in detail while the second discusses the regulatory basis for the acceptance of GPS.

Bullet four: We have placed two "A" Zone compliance wells between the No. 1 Landfarm and the No. 1 Oxidation Pond's fourth and fifth passes. These wells, along with the four installed on the other three sides of the No. Landfarm will give the six wells that Dr. Sun requested.

Bullets five and six: BEDM recommends that these two items be addressed separately from the Closure Plan. Bullet five is easily handled by sending the requested material. Bullet six will require a brief letter report which BEDM would be happy to help Chevron prepare.

We have prepared the attached closure plan to comply with the general prescriptive standards of Title 22 of the California Code of Regulations for closure of land treatment units. This plan is intended to replace and supersede the original closure plan prepared by Chevron Research and Technology Company, dated March 31, 1988.

This letter also transmitts a draft version of a completed CEQA Initial Study checklist (the actual checklist must be prepared by the DTSC). Included is one 3.5 inch floppy disk containing the document in Word Perfect 5.1 format, as requested by Mr. Morales of the DTSC. As discussed with Mr. Sedgwick, we have not prepared a copy of a DTSC closure plan checklist with cross references to the appropriate sections of this Closure Plan. Apparently, such checklists are prepared independently by each region of the DTSC on an as-needed basis and we have not yet located a version of the checklist relevant to Land Treatment Units and suitable for submittal to the local DTSC. We would be pleased to prepare a cross-referenced checklist if one can be identified. In addition, we have provided Chevron with a draft (dated December 23) version of the Screening Risk Assessment requested by the DTSC in their letter of September 20, 1996. We will finalize the risk assessment document after we have received Chevron's review comments.

We trust this plan meets your requirements. If you have any questions regarding this plan, please call me at extension 2-4965.

M.J. Wahler, P.E.
Site Investigation Manager

L05404/MJW

Attachments

cc: R.C. Brandt
G.E. Martinez
C.J. Hunt/J.E. Sedgwick

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

REVISED

LANDFARMS CLOSURE PLAN

Prepared for:

CHEVRON PRODUCTS COMPANY
RICHMOND, CALIFORNIA

December 30, 1996

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ACRONYM	DEFINITION
ABU	Area Business Unit
BEDM	Bechtel Environmental, Inc. and Dames & Moore
CCR	California Code of Regulations
CEL	Chevron Environmental Laboratory
COC	constituents of concern
CQA	Construction Quality Assurance
DTSC	Department of Toxic Substances Control
GDS	Groundwater Data Storage System
GPS	Groundwater Protection System
H2S	hydrogen sulfide
HCN	hydrogen cyanide
HWLT	hazardous waste land treatment
LGMP	Landfarms Groundwater Monitoring Program
LNAPL	Light non-aqueous phase liquid
MACL	maximum allowable concentration limits
MCE	Maximum Credible Earthquake
NOD	Notice of Deficiency
NPDES	National Pollutant Discharge Elimination System
PAH	polynuclear aromatic hydrocarbons
RCRA	Resource Conservation and Recovery Act
RGMP	Refinery-Wide Groundwater Monitoring Program
ROWD	Refinery-Wide Report of Waste Discharge
RRD	Richmond Refinery Datum
RWQCB	Regional Water Quality Control Board
STLC	Soluble Threshold Limit Concentration
TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
TTLC	Total Threshold Limit Concentration
U.S. EPA	U.S. Environmental Protection Agency
U/E	Utilities/Environmental
WDO	Waste Discharge Order
WET	Waste Extraction Test

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

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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

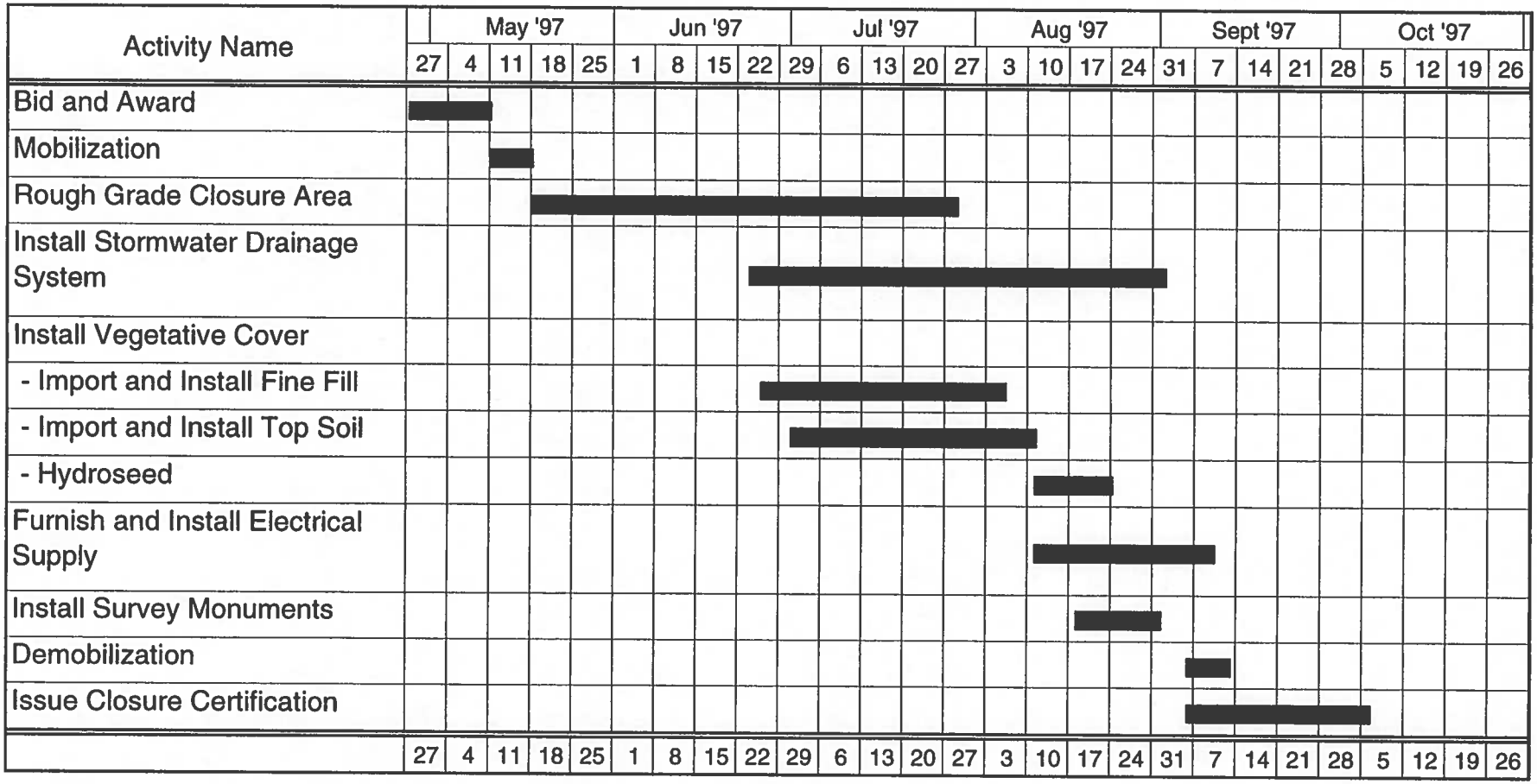
Flash (Method 1020)
pH (Method 9045)
Reactivity (9010A for cyanide and APHA427C for sulfide)

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

Analytical Parameters	Reporting Limit	Units	GPS ID: 1	2	3	4	Maximum	Regulatory Values 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

Table 4-1. Construction Schedule
Landfarms Closure Plan
Chevron Richmond Refinery



Note: The planting of shrubs and trees is not shown on this schedule and will occur in subsequent years.

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*)

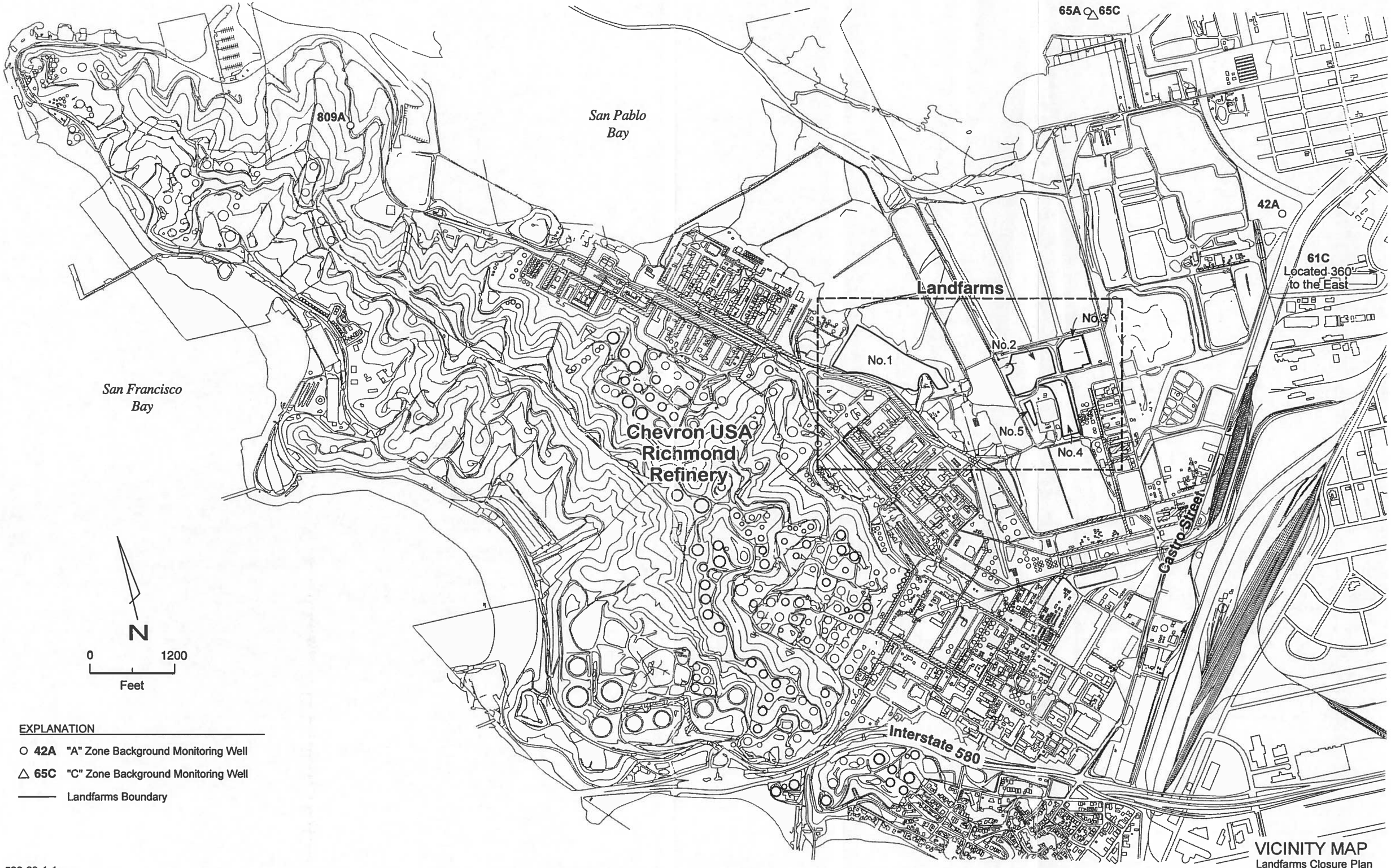
DEEP ROOTED SPECIES

- 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)

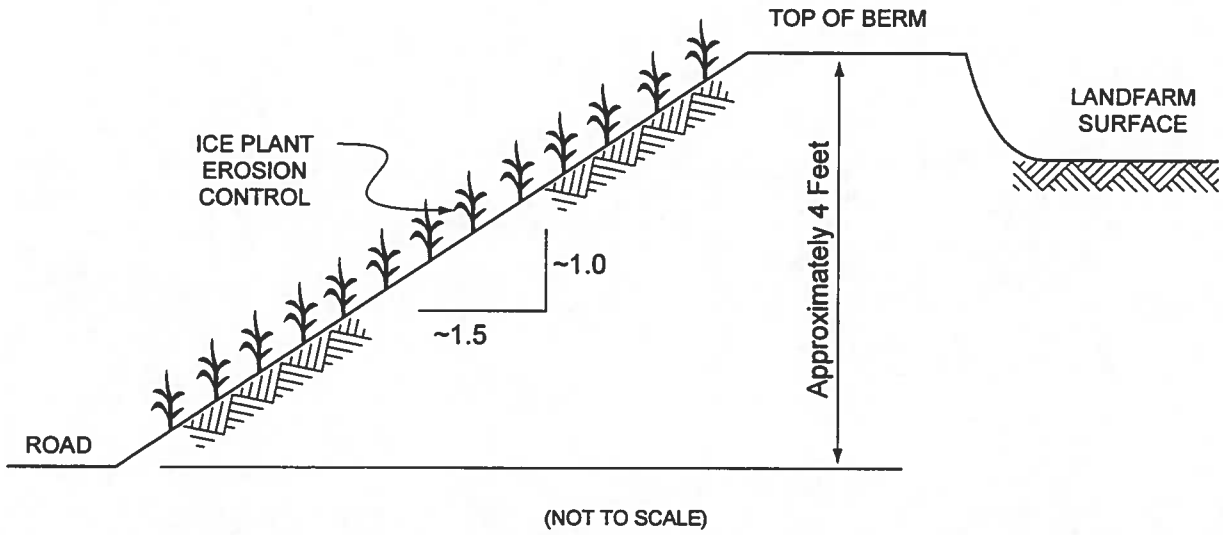


522-83-1-1a

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

VICINITY MAP
Landfarms Closure Plan

PLATE 1-1



TYPICAL LANDFARMS BERM CROSS SECTION

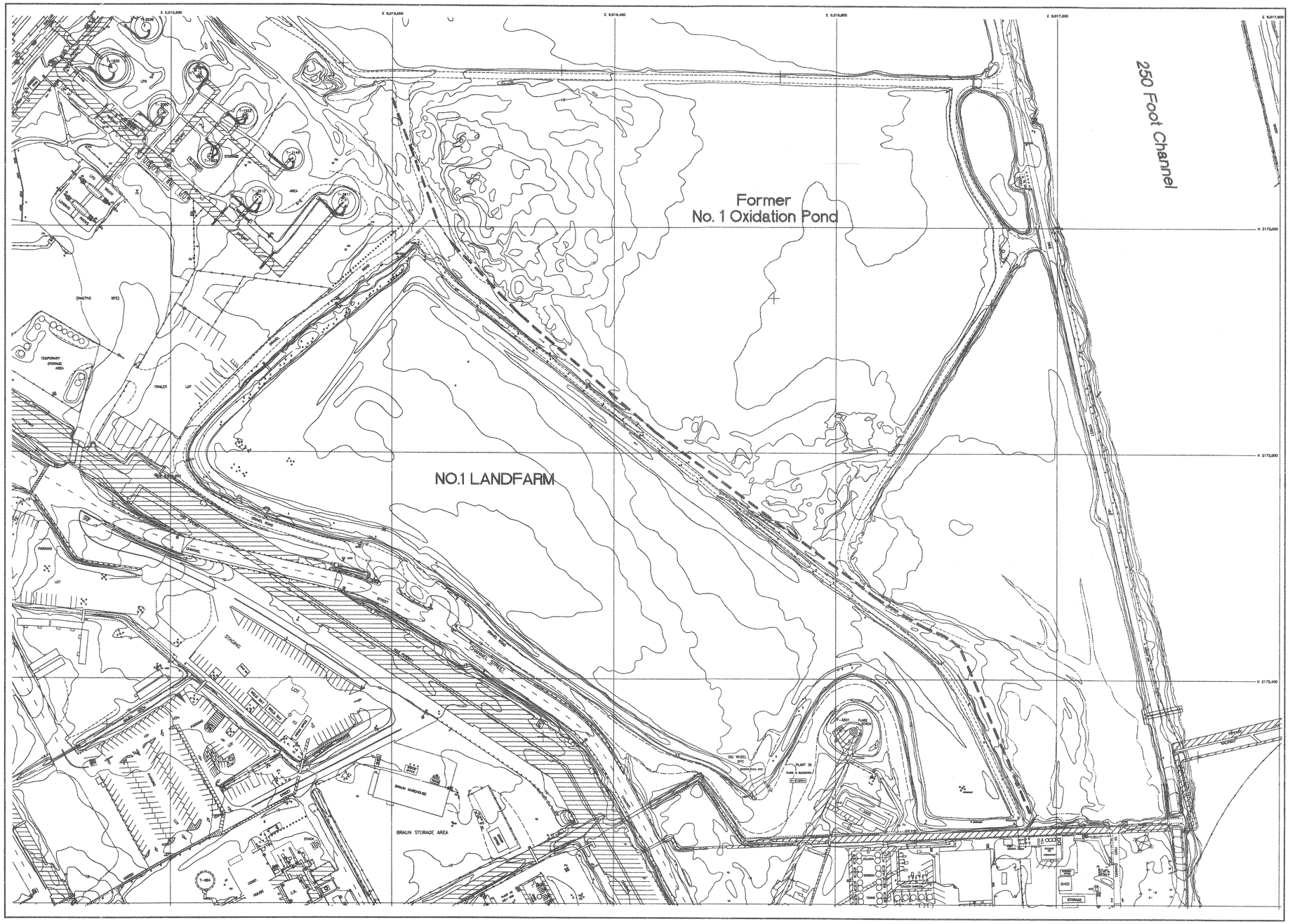
Landfarms Closure Plan

P5404-2-1

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 2-1



LEGEND

GPS Extraction Trench

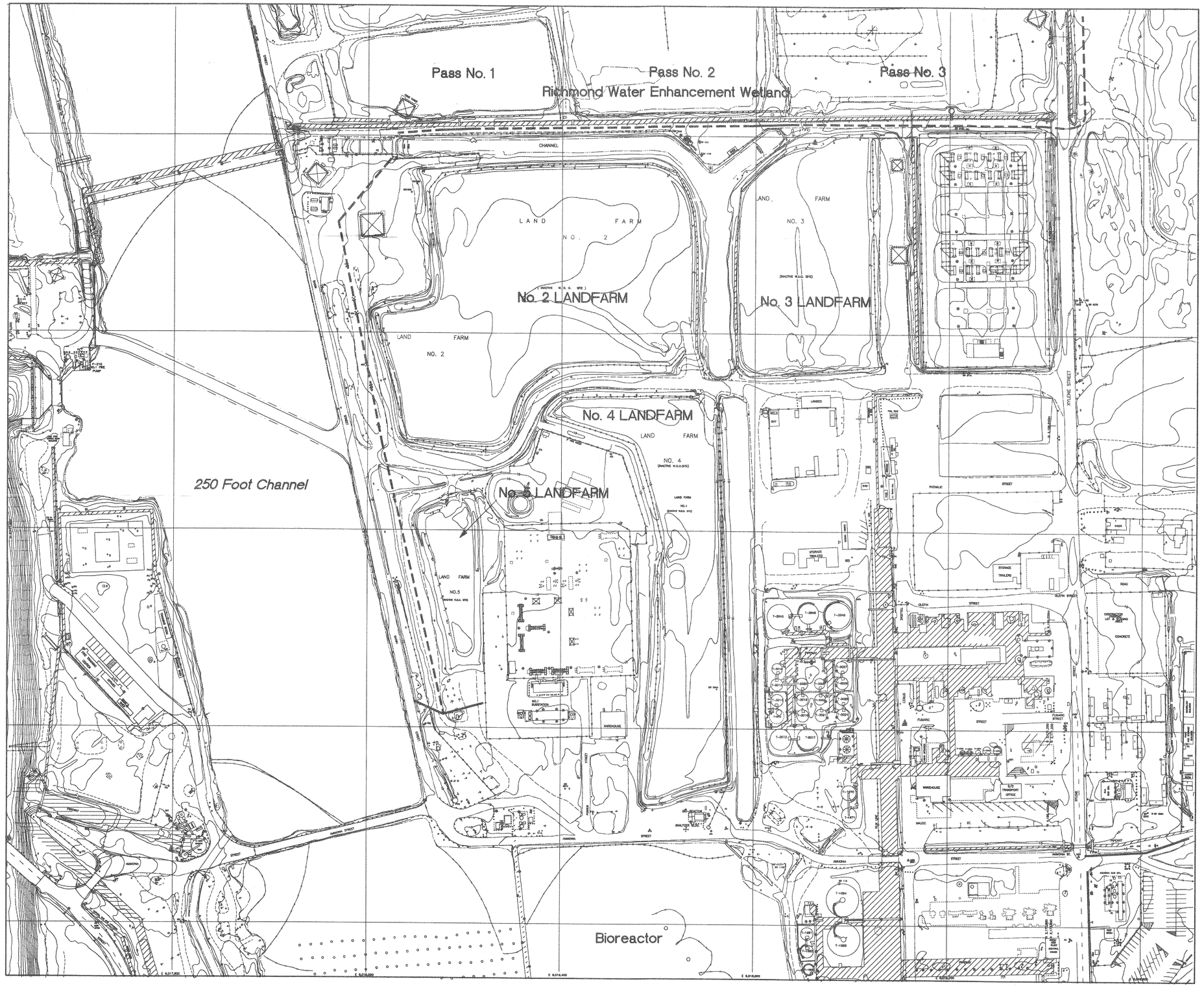
Notes:
1. Coordinates shown are based on 1983 North American Datum (N.A.D.) Coordinate System.
2. Elevations shown are based on Richmond Refinery Datum elevation 0.00' equals elevation -2.17' National Geodetic Vertical Datum (NGVD).
3. Contour lines are at 1 foot intervals based on aerial photographs dated August 1990.

N

0 100
Scale in Feet

SITE TOPOGRAPHY
NO.1 LANDFARM

Landfarms Closure Plan
Landfarms/Landfill Sector



LEGEND

GPS Extraction Trench

GPS Barrier Wall

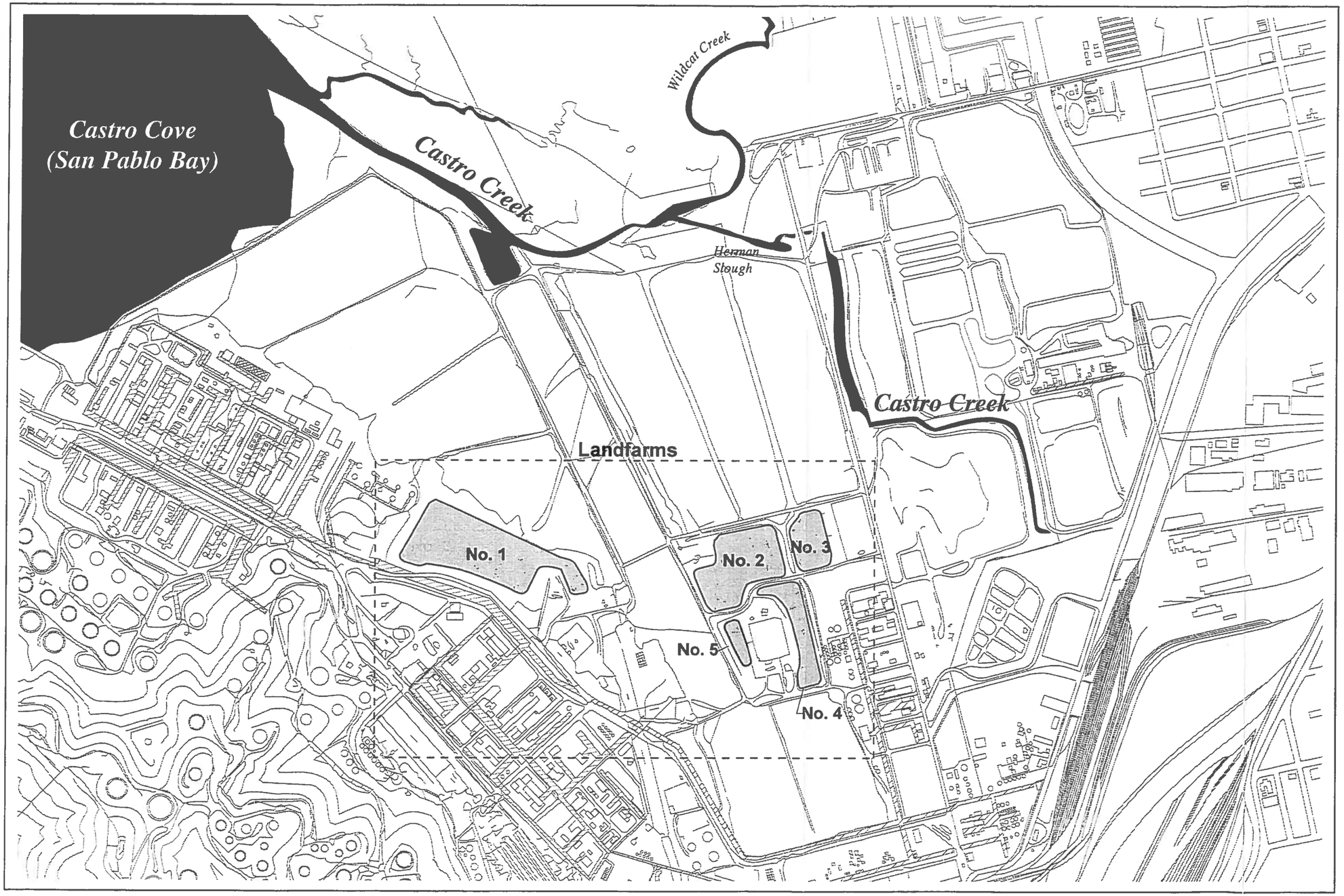
Notes:
1. Coordinates shown are based on 1993 North American Datum (N.A.D.) Coordinate System.
2. Elevations shown are based on Richmond Refinery Datum elevation 0.00' equals elevation -2.17' National Geodetic Vertical Datum (NGVD).
3. Contour lines are at 1 foot intervals based on aerial photographs dated August 1990.

N

0 100
Scale in Feet

SITE TOPOGRAPHY
NOS. 2,3, 4 AND 5 LANDFARMS

Landfarms Closure Plan
Landfarms/Landfill Sector



EXPLANATION

Surface Water Body Location

Landfarms Areas

N

0 1200

Scale in Feet

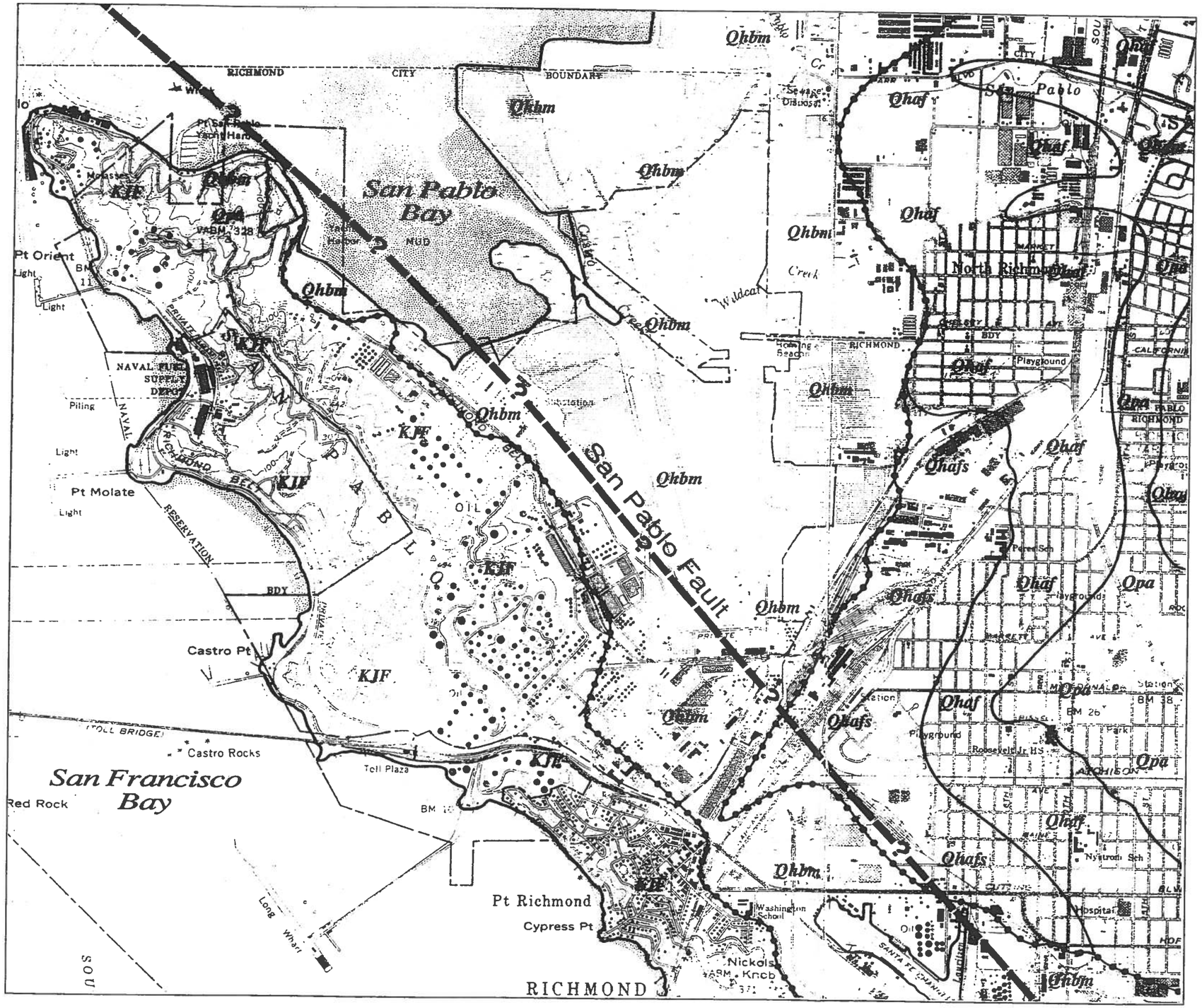
SURFACE WATER BODY LOCATION MAP

Landfarms Closure Plan

5404-2-4

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

Plate 2-4



EXPLANATION

Qham	MEDIUM-GRAINED ALLUVIUM - Unconsolidated moderately sorted permeable fine sand, silt, and clayey silt with a few thin beds of coarse sand.
Qhaf	FINE-GRAINED ALLUVIUM - Unconsolidated plastic moderately to poorly sorted carbonaceous silt and clay.
Qhafs	FINE-GRAINED SALT-AFFECTED ALLUVIUM - Unconsolidated plastic moderately to poorly sorted carbonaceous silt and clay. Irregularly bedded with carbonate nodules.
Qhbm	BAY MUD - Unconsolidated water-saturated dark plastic carbonaceous clay and silty clay.
Qpa	LATE PLEISTOCENE ALLUVIUM - Weakly consolidated slightly weathered poorly sorted irregularly interbedded clay, silt, sand, and gravel.
KJF	FRANCISCAN COMPLEX-CRETACEOUS - Interbedded sandstone, siltstone, and chert.

INACTIVE FAULT - Queried where location uncertain

1898 SHORELINE

NOTES

1. Contour interval = 20 feet.
2. Bedrock geology after Knox, 1973 in CDMG PR 19, Plate 5.
3. Flatland geology adapted from USGS Professional Paper No. 943.
4. Basemap does not reflect current configuration of Refinery facilities; current facilities shown on Plate 1-1.

REFERENCE

USGS 7.5 Minute Topographic Series; San Quentin, CA, 1959; Richmond, CA, 1959; Photorevised 1980.

N

0 2000

Scale in Feet

Quadrangle Locations

522-83-3-1

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

GEOLOGIC MAP OF RICHMOND AREA

Landfarms Closure Plan

PLATE 3-1

REGIONAL SITE MAP WITH GEOMORPHIC BOUNDARIES

Landfarms Closure Plan

522-83-3-2

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 3-2

No. 1 Oxidation Pond

No. 2 Oxidation Pond

250 Foot Channel

50/100 Foot Channel

Bioreactor

No. 1 Landfarm

No. 2 Landfarm

No. 3 Landfarm

No. 4 Landfarm

No. 5 Landfarm

A

A'

B

B'

103C

103A

184A

184C

185A

183A

182A

587C

181A

181C

B-3

243A

244A

187A

186C

104A

104B

104C

189A

190A

196A

210A

191A

212A

194A

192A

264A

193A

114C

EXPLANATION

210A	Landfarms "A" Zone Monitoring Well Location
104C	Landfarms "C" Zone Monitoring Well Location
104B	"B" Zone Monitoring Well Location
181C	Former "C" Zone Monitoring Well Location
A A'	Geologic Cross Section Location

N

0 400

Scale in Feet

522-83-3-3

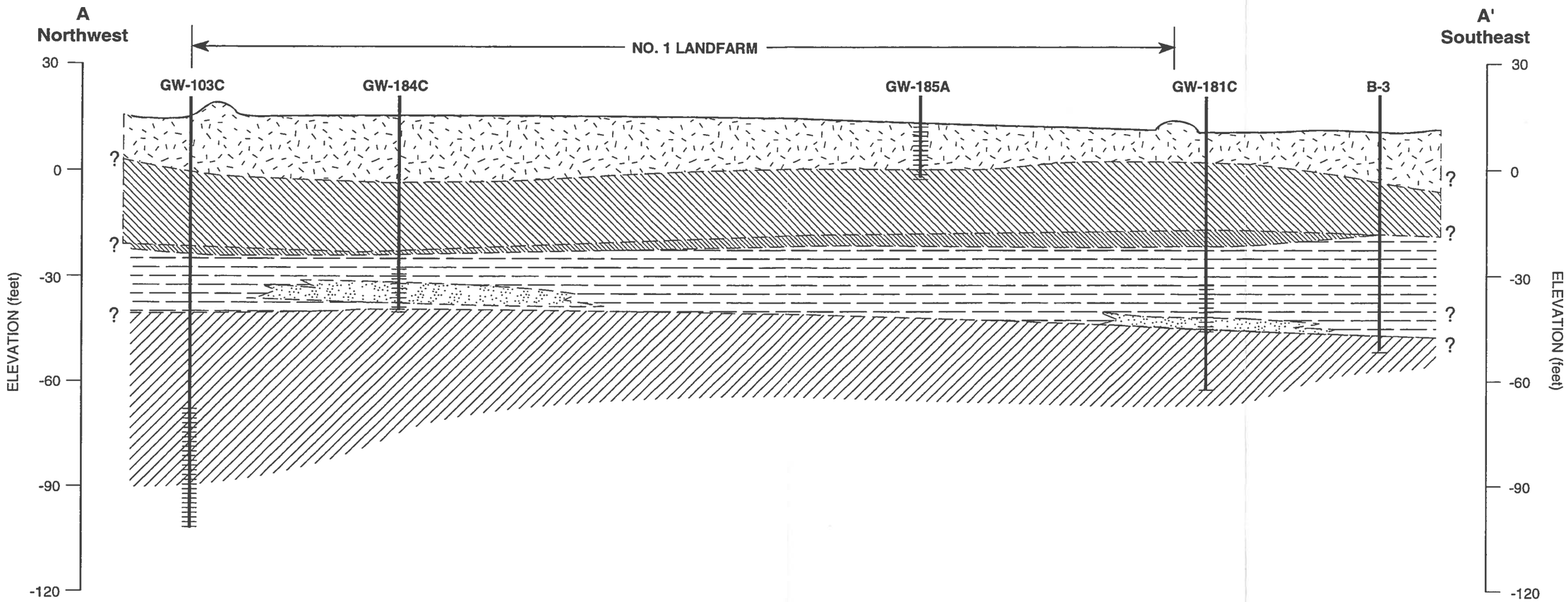
BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

GEOLOGIC CROSS SECTION LOCATIONS

Landfarms Closure Plan

PLATE 3-3



EXPLANATION

- FILL
- Young Bay Mud
- Old Bay Mud
- Silty Sandy Clay (Alluvium)
- Sand Lens (Alluvium)
- Silty Clay (Estuarine deposits)
- Stratigraphic Contact
- Boring
- Screened Interval of Monitoring Well

0 150
Feet
Vertical Exaggeration = 5x

NOTES

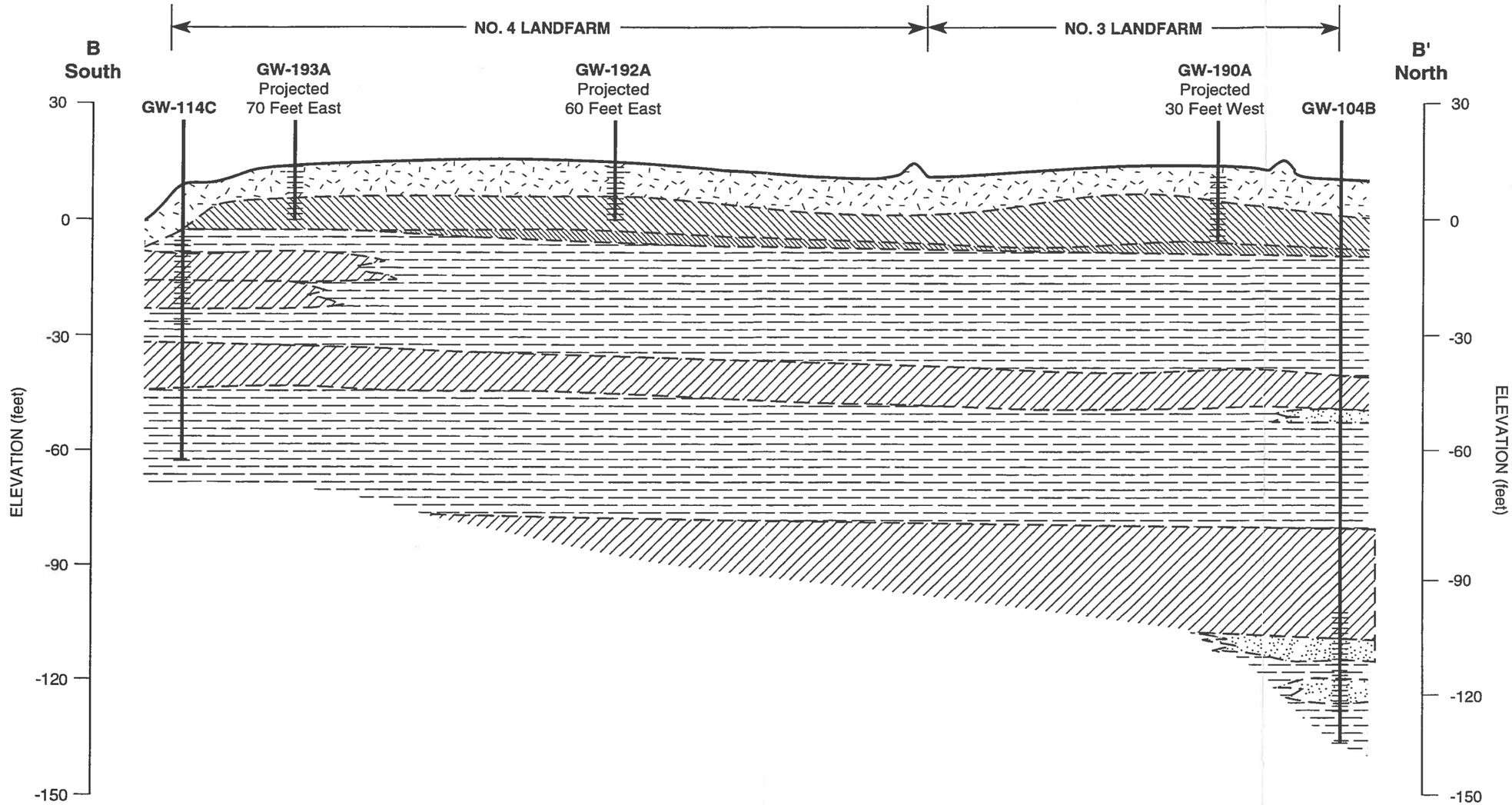
1. See Plate 3-3 for section location.
2. Elevations are referenced to Richmond Refinery Datum (-2.2 feet NGVD).
3. The stratigraphy shown between boring locations is based on interpretation of information known only at the boring locations.
4. Boring B-3 is from Dames & Moore Job No. 113-123-003 dated 1/25/82; GW-181C, 184C and 185A from Kleinfelder and Associates Job No. B-1533-1; GW-103C is from Aqua Resources.

GEOLOGIC CROSS SECTION A-A'
NO. 1 LANDFARM
Landfarms Closure Plan

522-83-3-4

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 3-4



EXPLANATION

- FILL
- Young Bay Mud
- Old Bay Mud
- Silty Sandy Clay (Alluvium)
- Sand Lens (Alluvium)
- Silty Clay (Estuarine deposits)
- Stratigraphic Contact
- Boring
- Screened Interval of Observation Well

0 150
Feet
Vertical Exaggeration = 5x

NOTES

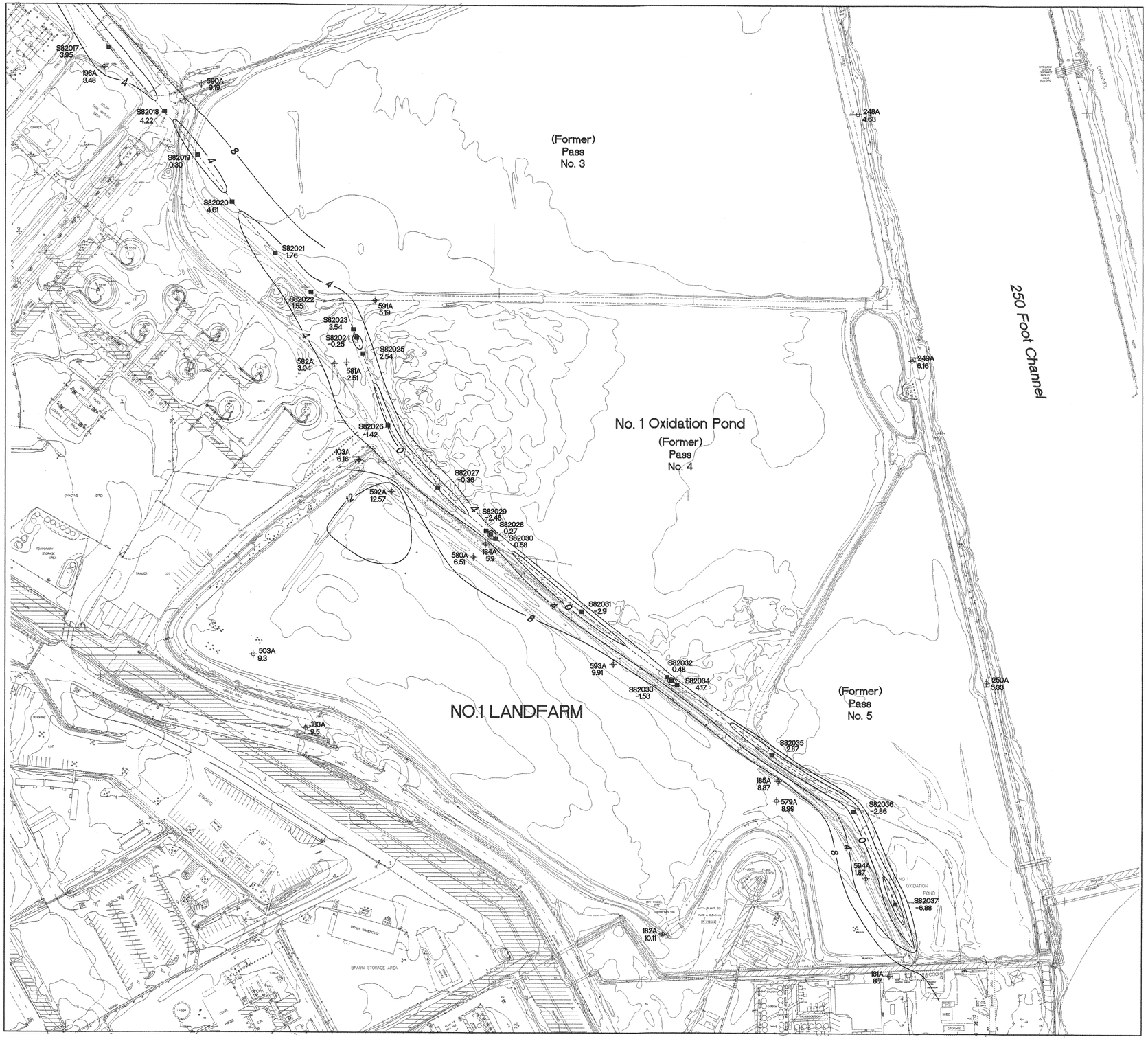
1. See Plate 3-3 for section location.
2. Elevations are referenced to Richmond Refinery Datum (-2.2 feet NGVD).
3. The stratigraphy shown between boring locations is based on interpretation of information known only at the boring locations.

GEOLOGIC CROSS SECTION B-B'
NOS. 3 & 4 LANDFARMS
Landfarms Closure Plan

522-83-3-5

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 3-5



EXPLANATION

185A 5.33	Groundwater Well Groundwater Elevation
S82035 3.52	Extraction Sump Groundwater Elevation
4	Lines of Equal Groundwater Table Elevation in Feet, Above Richmond Refinery Datum (RRD)
- - - - - -	GPS Extraction Trench

NOTES:

1. This schematic contour map is based on a limited number of data points. Contours shown are approximate and should not be used to predict flow rates. The direction of groundwater flow can be interpreted in a general manner.
2. Contours are shown as solid lines for clarity and are not meant to imply certainty.
3. Water levels measured on May 15, 1996.
4. Contour interval = 4 feet. Water levels measured in feet.
5. Richmond Refinery Datum (RRD) is equivalent to -2.2 feet, Mean Sea Level.
6. Ther lateral extent of the capture zone is inferred where piezometric water levels are limited or absent.
7. Extraction sump and well measurements may vary by 0.5 feet depending on pump stroke at time of hand measurements.
8. Pumps were not installed in sumps S82023, S82025, S82028, S82030, S82032, and S82034 at time of measurement.
9. Wells with free-phase hydrocarbon were corrected to the equivalent potentiometric surface.

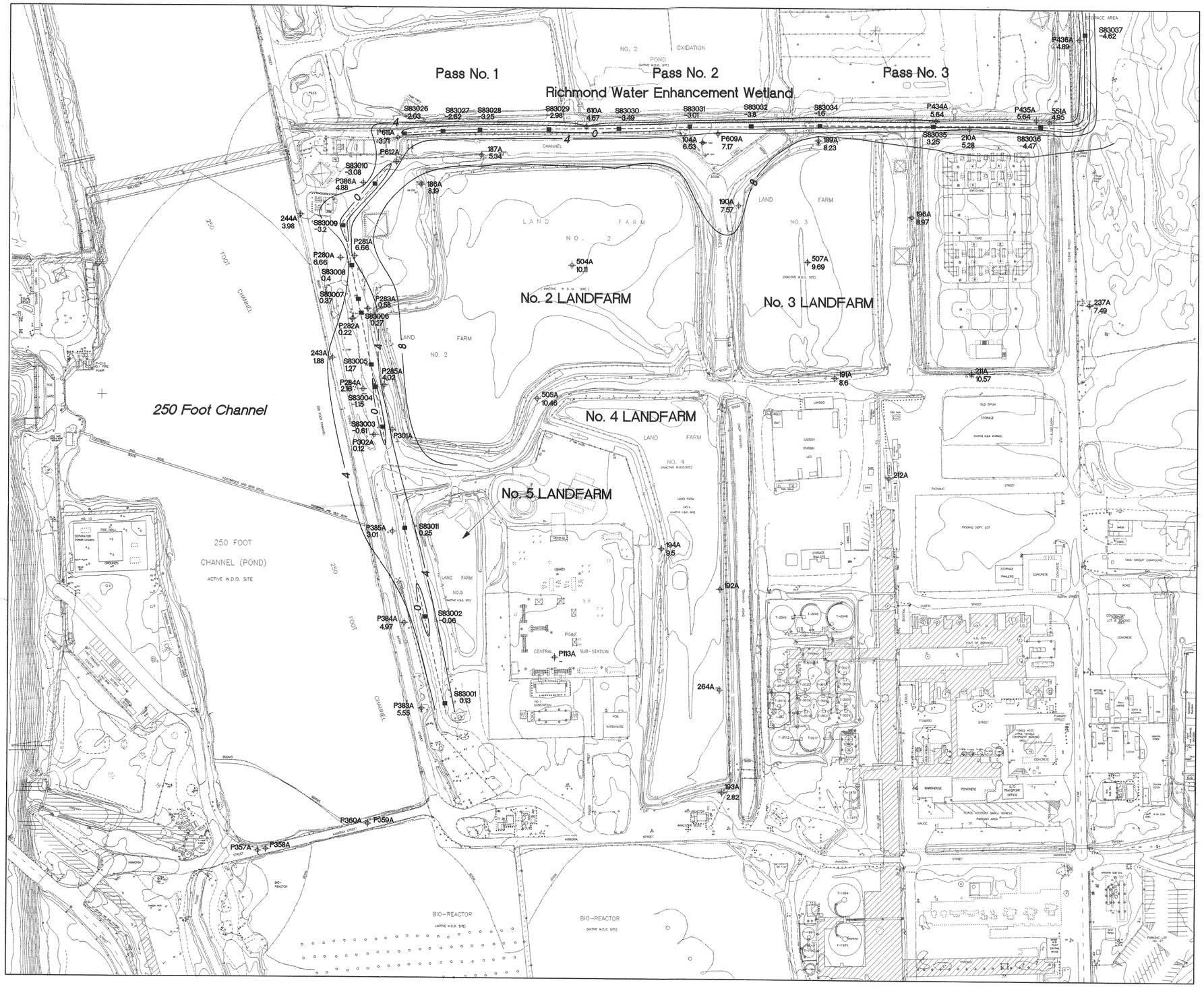
N

0 100
Scale in Feet

"A" ZONE WATER TABLE

No. 1 Landfarm
April 4, 1996

Landfarms Closure Plan



EXPLANATION

P434A 5.64	Groundwater Well or Piezometer Groundwater Elevation
S83035 3.25	Extraction Sump Groundwater Elevation
A	Lines of Equal Groundwater Table Elevation in Feet, Above Richmond Refinery Datum (RRD)
———	GPS Barrier Wall
- - - - -	GPS Extraction Trench

NOTES:

1. This schematic contour map is based on a limited number of data points. Contours shown are approximate and should not be used to predict flow rates. The direction of groundwater flow can only be interpreted in a general manner.
2. Contours are shown as solid lines for clarity and are not meant to imply certainty.
3. Water levels measured May 14 and May 15, 1996.
4. Contour interval = 4 feet. Water levels measured in feet.
5. Richmond Refinery Datum (RRD) is equivalent to -2.2 feet, Mean Sea Level.
6. The lateral extent of the capture zone is inferred where piezometric water levels are limited or absent.
7. Sumps S83005 and S83006 did not contain pumps at time of measurement.
8. Extraction sump and well measurements may vary by 0.5 feet depending on pump stroke at time of hand measurement.
9. Wells with free-phase hydrocarbon were corrected to the equivalent potentiometric surface.

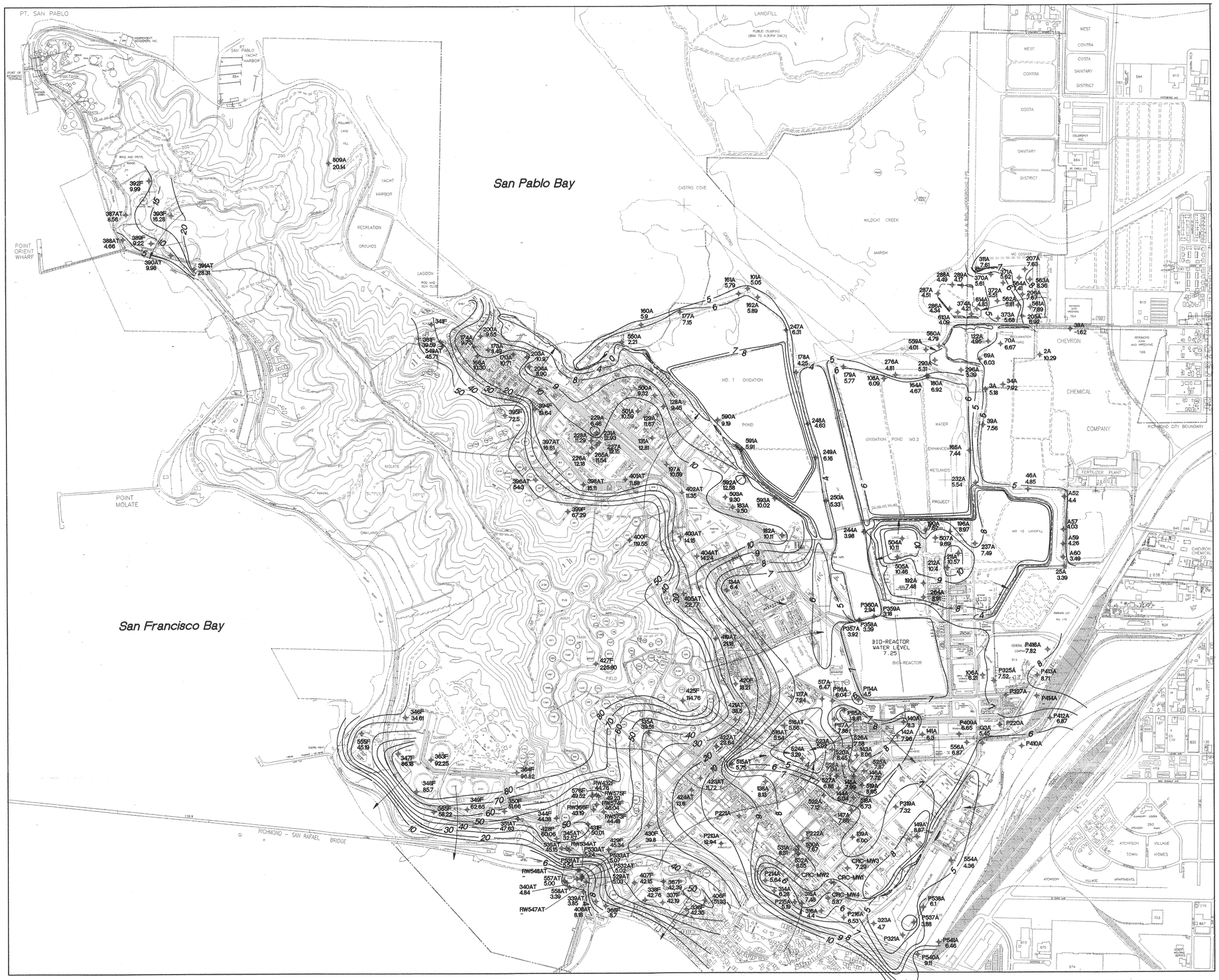
N

0 100
Scale in Feet

LANDFARMS NO. 2 AND 5 GPS

"A" ZONE WATER TABLE
April 4, 1996

Landfarms Closure Plan



EXPLANATION

P511A 4.33	Groundwater Well or Piezometer with Groundwater Elevation Measured in Feet Above Richmond Refinery Datum (RRD)
6	Lines of Equal Groundwater Table Elevation in Feet, Above Richmond Refinery Datum (RRD)
	GPS Barrier Wall
	GPS Extraction Trench
	Non Operational GPS
	Flow Direction

NOTES:

1. This schematic contour map is based on a limited number of data points. Contours shown are approximate and should not be used to predict flow rates. The direction of groundwater flow can only be interpreted in a general manner.
2. Contours are shown as solid lines for clarity and are not meant to imply certainty.
3. Water levels measured April 10 to May 17, 1996.
4. Contour intervals are variable. Water levels measured in feet. Line of equal groundwater elevation shown in feet, above Richmond Refinery Datum (RRD).
5. Richmond Refinery Datum (RRD) is equivalent to -2.2 feet, Mean Sea Level.
6. "A" Zone water table elevations also include water table surface in Ridge, Transition and Alluvial Zones.
7. Areas near active GPS Extraction System are shown in detail on Plates 2-1 through 2-16.
8. Wells with free-phase hydrocarbon are corrected to the equivalent potenionetric surface.

N

0 700
Scale in Feet

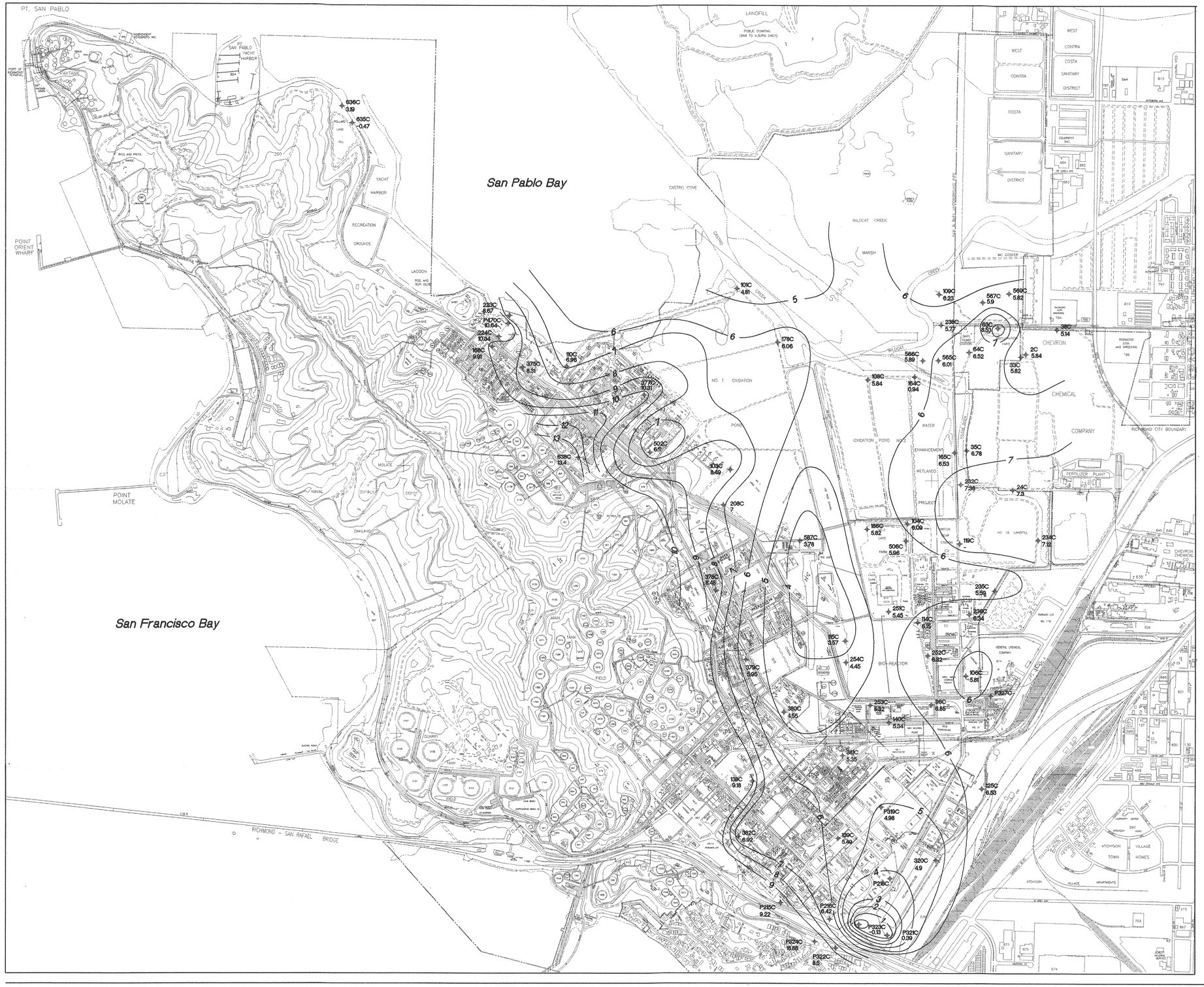
"A" ZONE WATER TABLE

1996 First Semester
Landfarms Closure Plan

PLATE 3-8

AZM-96

Rev 1



EXPLANATION

238C 5.53 — Groundwater Well or Piezometer with Potentiometric Surface Elevation Measured in Feet Above Richmond Refinery Datum (RRD)

A — Potentiometric Surface Elevation in Feet, Above Richmond Refinery Datum (RRD)

NOTES:

1. This schematic contour map is based on a limited number of data points. Contours shown are approximate and should not be used to predict flow rates. The direction of groundwater flow can only be interpreted in a general manner.
2. Contours are shown as solid lines for clarity and are not meant to imply certainty.
3. Water levels measured April 10 to May 18, 1996.
4. Contour interval = 1 foot.
5. Richmond Refinery Datum (RRD) is equivalent to -2.2 feet, Mean Sea Level.
6. Well 16-4C was not used in contouring, value appears suspect.

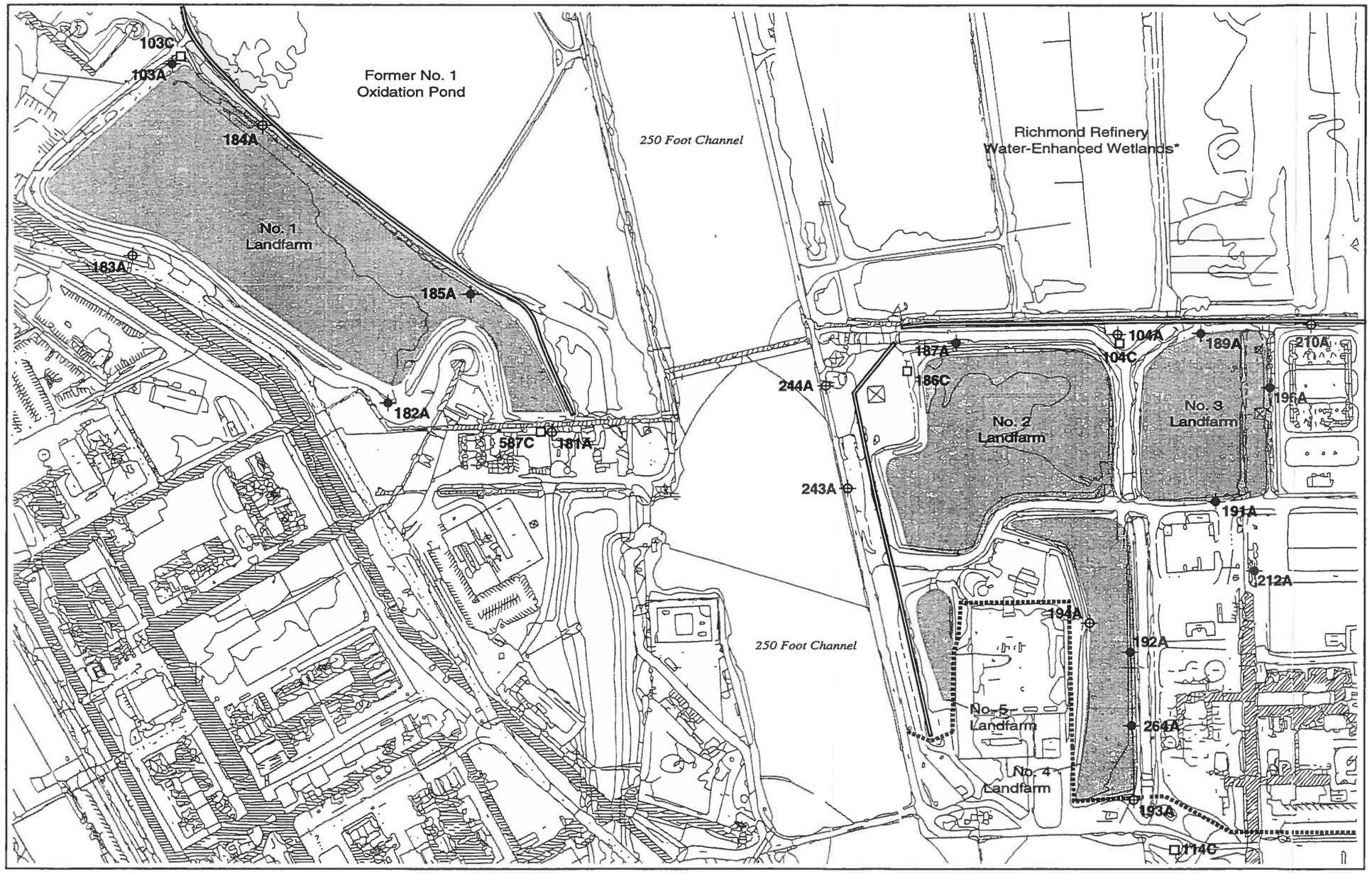
N

0 700
Scale in Feet

"C" ZONE WATER TABLE

1996 First Semester
Landfarms Closure Plan

CZM-196



EXPLANATION:

244A "A" Zone Monitoring Well Analyzed for the Full Analyte List

104C "C" Zone Monitoring Well Analyzed for the Full Analyte List

103A Groundwater Monitoring Well Containing a Measurable Thickness of Free-Phase Liquid Hydrocarbons

GPS Extraction Trench

GPS Barrier Wall

N

0 300

Feet

NOTE

1. * Active wetlands used for tertiary treatment of Refinery effluent.

LANDFARMS GROUNDWATER MONITORING WELL LOCATIONS

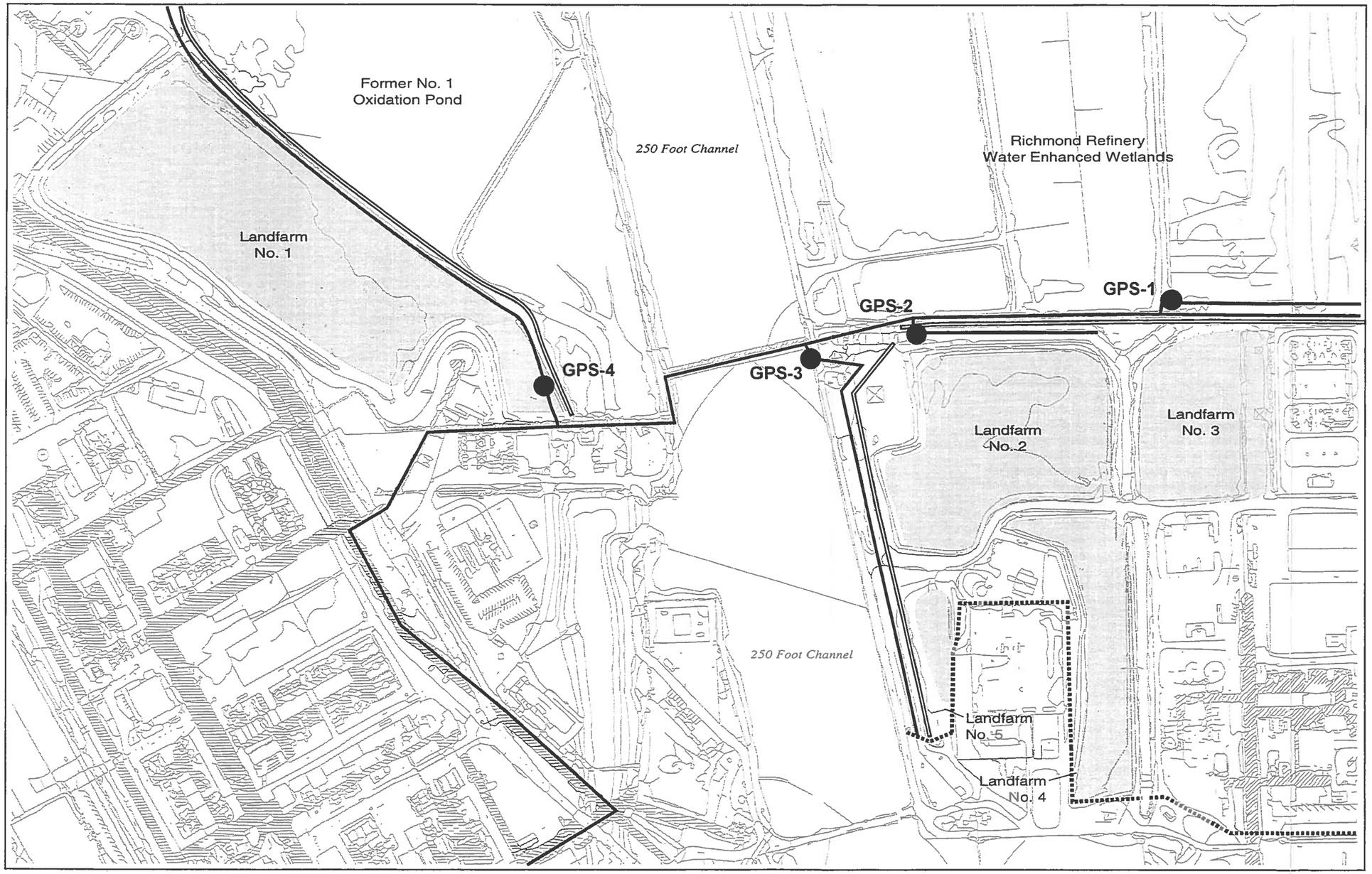
Landfarms Closure Plan

5404-3-10

BEDM

BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 3-10



EXPLANATION

GPS-1 ● Extracted Water Sample Location

GPS Extraction Trench

GPS Barrier Wall

GPS Header Alignment (Schematic)

N

0 300

Feet

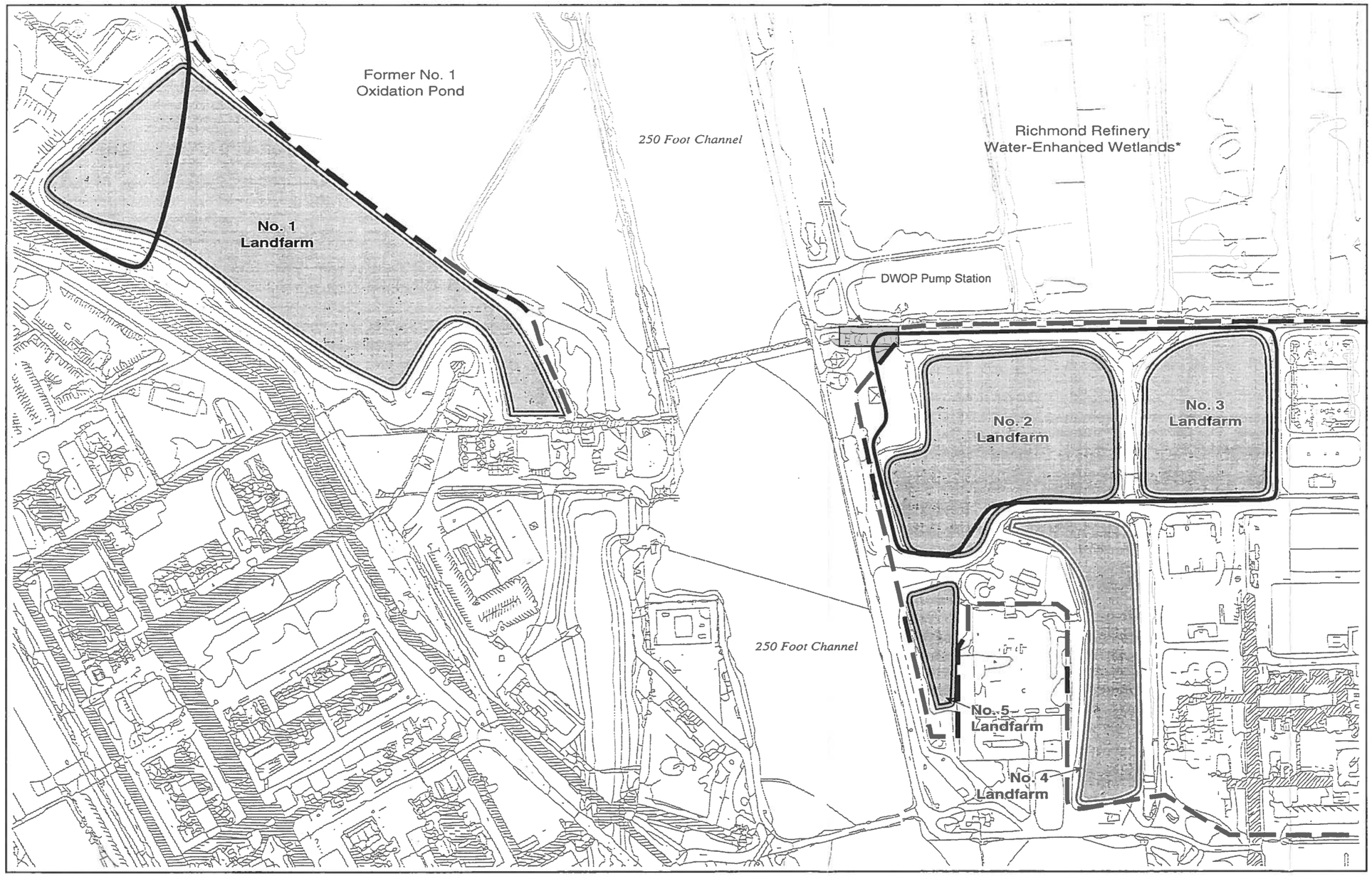
GPS EFFLUENT SAMPLING LOCATIONS

Landfarms Closure Plan

5404-3-11

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

Plate 3-11



EXPLANATION:

- Limits of Existing Landfarms
- Limits of Landfills under Landfarms
- Groundwater Protection System (GPS) Alignment
- Proposed Vegetative Cover

N

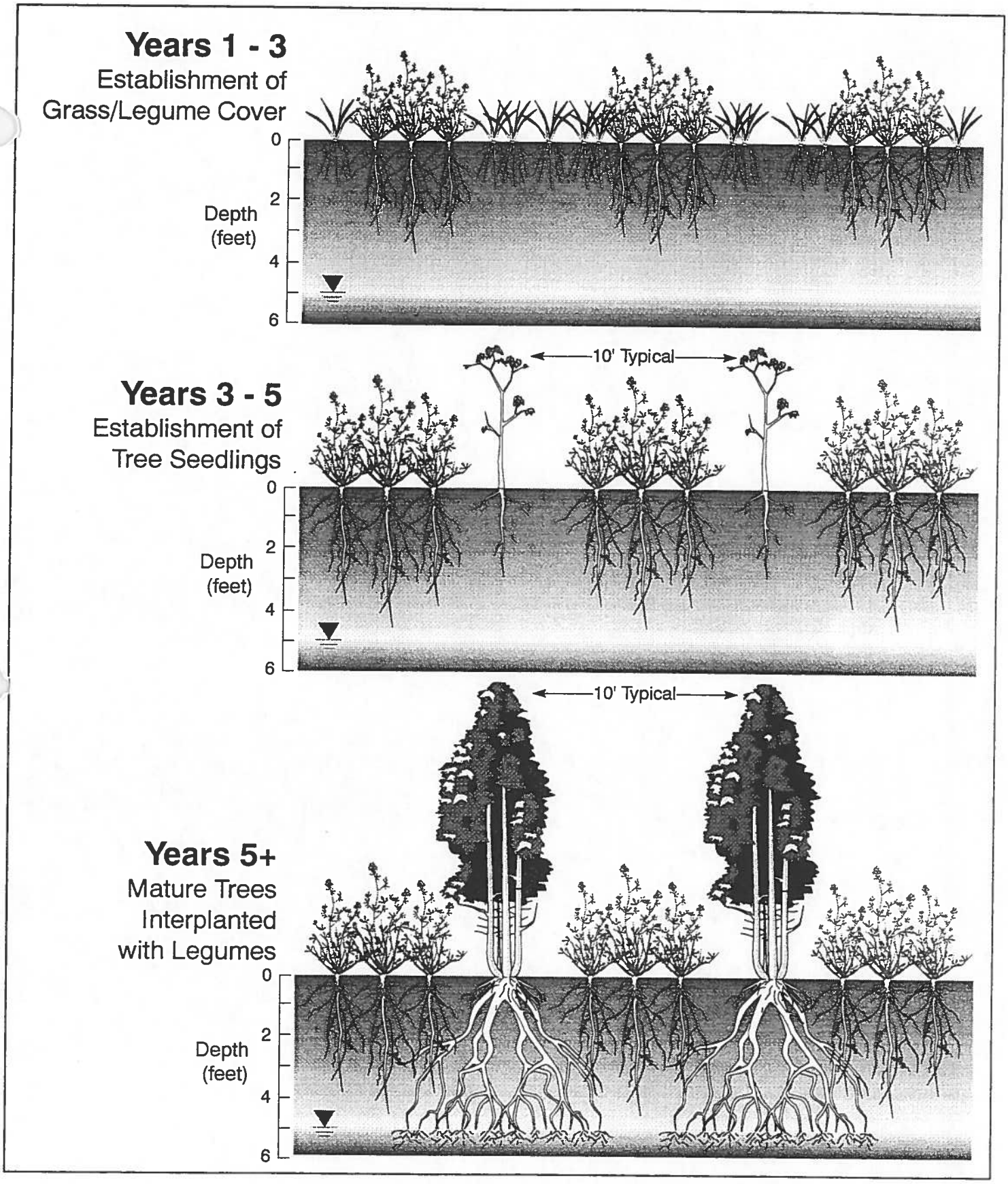
0 300
Feet

NOTE
1. * Active wetlands used for tertiary treatment of Refinery effluent.

LAYOUT OF PROPOSED CLOSURE UNITS
Landfarms Closure Plan

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 4-1



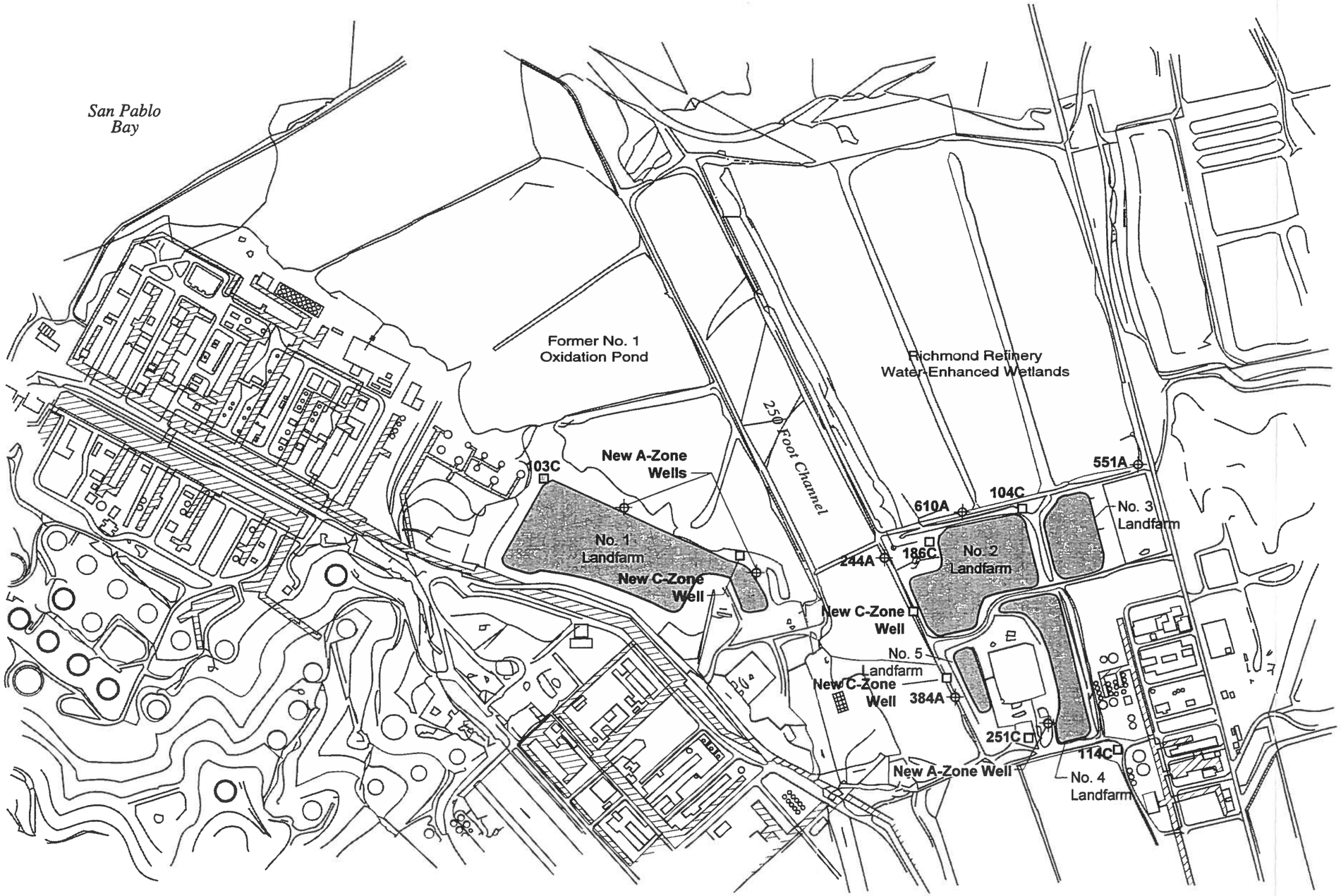
ESTABLISHMENT OF VEGETATION ON LANDFARMS

Landfarms Closure Plan

5404-4-2

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

PLATE 4-2



EXPLANATION

244A ⊕ Point of Compliance "A" Zone Monitoring Well Location

104C □ Point of Compliance "C" Zone Monitoring Well Location

Landfarms Areas

N

0 600

Scale in Feet

POINT OF COMPLIANCE MONITORING WELL LOCATION MAP

Landfarms Closure Plan

5404-4-3

BEDM
BECHTEL ENVIRONMENTAL/DAMES & MOORE

Plate 4-3