SDMS DOCID# 1125268

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 100
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 Feet
DATE STARTED: 9-20-88	DATE COMPLETED: 9-20-88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: BKS/TST	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS	
A	1.5	3, 9, 12			CL		Brown	GRAVELLY CLAY (FILL) Dry; crumbly; gravel to 1.5 inches; roots; compacted at 1.5 feet.	
B	1.5	Pushed	5	Cement-Bentonite Grout	CL		Olive Grey 5Y 3/2	CLAY (BAY MUD) Moist; organic matter.	OVA = 1 ppm AU
C	1.5	Pushed	10					CLAY (BAY MUD) Moist; organic matter.	OVA = 2 ppm AU
D	1.5	Pushed	15					CLAY (BAY MUD) Moist to very moist; organic matter; strong H_2S odor.	OVA = 900 ppm AU = 2 ppm WS

Total Depth = 16.5 feet

HNu <1 ppm WS, AU

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006421

F-40 1 (6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 101
DRILLING COMPANY: ASE Drilling	CRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	CRILL BIT (S) SIZE: 8-inch O.D.
	Project Name SP Liquid Gold
	Project Number 855018.06
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 feet
DATE STARTED: 9/20/88	DATE COMPLETED: 9/20/88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: TST/BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in.)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
								Lost sample at 0-1.5 feet.
A	1.0	14, 21, 17			GC/CL		Brown	CLAYEY GRAVEL/GRAVELLY CLAY (FILL) Dry; crumbly; 50% gravel.
			5	Cement-Bentonite Grout	CL		Brown	GRAVELLY CLAY (FILL) Slightly moist; 0.2 feet of recovery at 5 feet; took second sample at 6.5 feet. OVA = 6 ppm AU
B	0.5	8, 7, 8						
			10		CL		Olive Gray	CLAY WITH GRAVEL Slightly moist. OVA = 6 ppm AU = 1 ppm WS
C	1.5	1, 2, 2						
					CL		Olive Gray	CLAY Moist; strong H_2S odor (BAY MUD). OVA = 20 ppm AU = 1 ppm WS
			15					
D	1.5	Pushed					Dark Gray	CLAY Moist; strong H_2S odor. OVA = 2 ppm AU = 1 ppm WS

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006422

F-40 1
(6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroeder SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE	10 - inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 29.5 TO 0 FT.

Boring/Well Name 102

Project Name SP Liquid Gold

Project Number 855018.06

ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	29.5 feet
DATE STARTED	0/7/88
DATE COMPLETED	9/7/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS	
A	0.5	35, 36, 54			GC		Dark Brown	CLAYEY GRAVEL (FILL) Dry; gravel up to 1 inch; 40% fines; crumbly; dense.	OVA <1 ppm AU, WS, HS
B	1.0	9, 3, 4			CL		N1 Black	Sample disturbed. Sand trap stuck in sample tube.	OVA = 150 ppm AU = 2 ppm WS
			5		SC		Black N1	CLAY Moist; low plasticity; trace sand.	OVA = 100 ppm Heated HS
				Cement-Bentonite Grout				CLAYEY SAND Moist; loose; 5% gravel; 20% clay.	OVA = 50 ppm AU = 1 ppm WS < 1 ppm HS
C	1.5	1, 1, 2			CL		Dark Gray N3		
			10					CLAY Wet; strong H_2S odor; (BAY MUD).	
D	1.5	1, 1, 2						CLAY Wet; strong H_2S odor.	OVA = 50 ppm AU =2 ppm WS = 15 ppm HS
			15					Drilling more dificult.	
E	1.0	5, 5, 6			SC		Grayish Olive Green	CLAYEY SAND Wet; 30% clay; roots; rock fragments (trace).	Noise 78 dB at 10 feet from rig; 68 - 70 dB 200 feet from freeway
			20						
F	1.5	5, 7, 18			SC		Light Olive Brown	CLAYEY SAND Wet; 20% fines.	OVA = 25 ppm AU <1 ppm WS
			25		CL		Gray Green 5Y 5/6	SANDY CLAY Wet; 15% sand	
G	1.0	3, 6, 9						SANDY CLAY Wet; 35% sand.	OVA = 200 ppm AU < 1 ppm WS
								Total Depth 29.5 feet	

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

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(6-87) (3-88) Supervised By JC Goldman Logged By Brian Schroth

SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE:	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 16.5 TO 0 FT.

Boring/Well Name	110
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	16.5 feet
DATE STARTED	9/19/88
DATE COMPLETED	9/19/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS	
A	1.5	13, 14, 25		Cement-Bentonite Grout	GC		Dark Brown	CLAYEY GRAVEL (FILL) Dry; gravel up to 2 inches; 40 - 50% fines.	
	0.0	6, 7, 14	5		CL		Dark Olive Gray	Lost sample at 5 and 5.5 feet.	OVA = 15 ppm AU <1 ppm WS
B	1.0	3, 5, 6						CLAY Slightly moist; trace sand; turns black at 6.7 feet.	
C	1.5	Pushed	10		CL		Dark Gray	CLAY Moist; H_2S odor (BAY MUD).	OVA = 10 ppm AU < 1 ppm WS
D	1.5	Pushed	15					CLAY Moist; H_2S odor.	OVA = 9 ppm AU < 1 ppm WS

Total depth 16.5 feet.

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006424

F-40 1 (6-87) (3-88) Supervised By TC Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name** 111
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name** SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number** 855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed; TOTAL DEPTH: 16.5 feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/20/88; DATE COMPLETED: 9/20/88
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: TST/BKS
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler; WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.	

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.5	6, 14, 18		Cement-Bentonite Grout	GC		Brown	CLAYEY GRAVEL WITH SAND (FILL) Dry; crumbly; 10% sand; 40% clay.
B	1.0	5, 6, 7	5		GC		Brown	CLAYEY GRAVEL (FILL) Moist; brick fragments; old bolt in sample; organic matter. OVA = 7 ppm AU < 1 ppm WS
C	1.5	3, 3, 3	10		CL		N1 Black	SANDY CLAY Wet; 30% sand.
					CL		Black N1	CLAY Moist; trace sand. OVA = 1 ppm AU < 1 ppm WS
D	1.5	Pushed	15		CL		Dark Gray N3	CLAY Moist; trace sand; H_2S odor (BAY MUD). OVA <1 ppm WS

Total depth 16.5 feet.

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006425

F-40 1 (6-87) (3-88) Supervised By [signature] Logged By [signature] SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name** 112
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name** SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number** 855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed; TOTAL DEPTH: 16.5 feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/16/88; DATE COMPLETED: 9/16/88
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: TST/BKS
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler; WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.	

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.1	12, 31, 34			CL		Brown	GRAVELLY CLAY (FILL) Dry; 40% gravel.
					SW		Black N1	GRAVELLY SAND (FILL) Dry; 30% gravel; gravel to 1 inch.
B	1.3	6, 6, 5	5	Cement - Bentonite Grout				SAND (FILL) Wet; trace gravel; wood fragments.
								Rig chatter
C	1.5	2, 2, 2	10		CL		Dark Gray N3	SANDY CLAY Wet; 35% sand. CLAY Moist; trace sand.
D	1.5	Pushed	15					CLAY Wet; trace sand.

OVA = 200 ppm AU
< 1 ppm WS
HNu < 1 ppm AU

Total depth 16.5 feet.

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006426

F-40 1
(6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroeth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 113
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 feet
DATE STARTED: 9/16/88	DATE COMPLETED: 9/16/88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No	Recovery (Feet)	Penetration Resist (Blows 6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	25, 30, 50+		Cement-Bentonite Grout	GC		Brown	CLAYEY GRAVEL (FILL) Dry; 30% fines; 20% sand; gravel to 3 inches.
B	0.8	2, 2, 2	5		CL		Dark Gray N3	CLAY Organic odor; slightly moist: black at 6.5 feet with oily substance. OVA <1 ppm WS <1 ppm WS
C	1.5	Pushed	10					CLAY Moist; trace sand; lost sample at 5 feet. OVA = 400 ppm AU < 1 ppm WS. HNu <1 ppm AU
D	1.5	Pushed	15					CLAY Moist; trace to 7% sand. OVA >1000 ppm AU < 1 ppm WS HNu = 8 ppm AU

Total depth 16.5 feet.

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006427

F-40 1 (6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroeth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 114
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Project Name SP Liquid Gold

Project Number 855018.06

ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 feet
DATE STARTED: 9/16/88	DATE COMPLETED: 9/16/88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: TST/BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.3	15, 19, 13			CL		Brown	GRAVELLY CLAY (FILL) Dry; 30-35% gravel; gravel to 1 inch — OVA = 500 ppm AU, < 1 ppm WS
B	1.0	30, 50+	5	Cement-Bentonite Grout	GW		Black N1	GRAVEL (FILL) Wet; organic odor; wood fragments — HNu<1 ppm WS, AU
C	1.0	16, 12, 8	10		CL		Black N1	CLAY Wet; 10% fine sand; decaying organic matter — OVA >1000 ppm AU, EXP = 4% of LEL
D	1.5	Pushed	15				Dark Gray N3	CLAY Wet; organic material — OVA = 400 ppm AU, < 1 ppm WS, EXP = 2% of LEL

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA), HNu, and Explosimeter (Exp) measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006428

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(6-87) (3-88) Supervised By JC Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 115
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM: Not measured	TOTAL DEPTH: 16.5 feet
DATE STARTED: 9/16/88	DATE COMPLETED: 9/16/88
STATIC WATER ELEVATION: Not surveyed	
LOGGED BY: TST/BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	29, 20, 17			GC		Dark Brown	CLAYEY GRAVEL Dry; 40% clay; 10% sand; gravel to 2 inches
								Rig Chatter at 4 feet OVA = 50 ppm AU < 1 ppm WS
B	0.6	41, 50+	5	Cement-Bentonite Grout	GW		Dark Brown turns to black at 5.5 feet	SANDY GRAVEL Wet; 20% coarse sand; wood fragment bent sampler at 6 feet
					GC		Dark Brown	Driller reports lithology change at 8 feet
C	1.5	Pushed	10					CLAYEY GRAVEL Wet; 30% fines.
					CL		Dark Gray N3	CLAY Very moist; H_2S odor (BAY MUD) OVA = 10 ppm AU < 1 ppm WS
D	1.3	Pushed	15					CLAY Very moist; H_2S odor; decaying organic matter

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006429

F-40 1 (6-87) (3-88) Supervised By TC Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 31.5 TO 0 FT.

Boring/Well Name	116
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	31.5 feet
DATE STARTED	9/8/88
DATE COMPLETED	9/8/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	8, 23, 28			GC		Brown	CLAYEY GRAVEL (FILL) Dry; 30% clay; crumbly; rock and brick fragments
B	1.3	6, 4, 8	5	Cement/ Bentonite Grout	SC		Black	CLAYEY SAND WITH GRAVEL (FILL) Wet; 20% clay, 10% gravel — OVA = 400 ppm AU, = 1 ppm WS, = 40 ppm HS
C	1.5	Pushed	10		CL		Dark Gray	CLAY Wet; H_2S odor (BAY MUD) — OVA = 2 ppm AU, <1 ppm WS, = 10 ppm HS
D	1.2	1, 1, 2	15					CLAY Moist; H_2S odor; mottled brown — OVA <1 ppm AU, <1 ppm WS
E	1.5	Pushed	20					CLAY Moist; H_2S odor; becomes black at 20.5 feet — OVA <1 ppm WS
F	0.9	3, 5, 5	25		SC		Brown	CLAYEY SAND Wet; fine to coarse sand; 20% clay; loose; gravel lenses — OVA <1 ppm AU, <1 ppm WS
G	1.5	4, 8, 13	30		CH		Light Olive	CLAY Wet; no odor; more stiff than bay mud; high plasticity — OVA = 200 ppm AU, <1 ppm WS. Total Depth = 31.5

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006430

F-40 1 (6-87) (3-88) Supervised By [signature] Logged By [signature] SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 31.5 TO 0 FT.

Boring/Well Name	117
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	31.5 feet
DATE STARTED	9/7/88
DATE COMPLETED	9/7/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows 6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS	
					GC		Brown	CLAYEY GRAVEL (FILL) Dry; brick fragments; 40% fines; gravel to 2 inches.	
A	0.3	21 26 38						Sample disturbed.	
B	1.0	6 5 7	5					CLAYEY GRAVEL (FILL) Dry; gravel to 1.5 inches.	
					SC		Black	CLAYEY SAND (FILL) Wet; medium sand; 25% fines.	
C	1.5	Pushed	10	Cement - Bentonite Grout	CL		Dark Gray	CLAY Wet; H_2S odor (BAY MUD)	OVA = 15 ppm AU = 1 ppm WS
D	1.5	Pushed	15					CLAY Wet; H_2S odor.	
E	1.5	Pushed	20					CLAY Wet; H_2S odor.	OVA = 100 ppm AU = 1 ppm WS
F	0.8	3 5 7	25				color more blueish	CLAY Wet; H_2S odor; more stiff.	OVA <1 ppm AU <1 ppm WS
									OVA >1000 ppm AU = 2 ppm WS
G	0.8	2 6 8	30		SC		Brown	CLAYEY SAND Wet; 30% fines; clay lenses; fine to coarse sand; trace gravel. Total Depth 31.5 feet	

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006431

F-40 1 (6-87) (3-88) Supervised By [signature] Logged By [signature]

SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE:	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 31.5 TO 0 FT.

Boring/Well Name	118
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	31.5 feet
DATE STARTED	9/21/88
DATE COMPLETED	9/21/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	TST/BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.5	14, 31, 18			GP		Brown	SANDY GRAVEL(FILL) Dry; medium sand; roots.
					GC/CL		Brown	GRAVELLY CLAY/CLAYEY GRAVEL (FILL) Dry; 50% fines.
B	1.0	7, 5, 3	5		SC		Black	CLAYEY SAND Wet; wood fragments; trace gravel. OVA = 100 ppm AU = 2 ppm WS = 40 ppm HS
C	1.5	3, 3, 5	10	Cement-Bentonite Grout				CLAYEY SAND Wet; trace gravel.
					CL		Dark Gray	CLAY Moist; strong H_2S odor (BAY MUD). OVA = 5 ppm WS HNu <1 ppm WS
D	1.5	2, 3, 5	15				Olive Gray	CLAY Moist; strong H_2S odor. OVA = 2 - 12 ppm WS very jumpy HNu switched to span 4 (for H_2S) reading = 30 ppm WS
E	1.5	3, 6, 9	20				Olive Black	CLAY Moist; strong H_2S odor. Increasing sand at 21.5 feet. OVA = 300 ppm AU = 3 ppm WS HNu = 40 ppm AU
F	1.5	7, 10, 30	25		CH		Olive Gray	CLAY Slightly moist; stiff; mottled brown and olive gray; high plasticity. OVA = 300 ppm AU = 6 ppm WS
G	1.5	12, 22, 40	30				Olive Gray	CLAY Slightly moist; stiff; high plasticity. HNu = 7 ppm AU

Total Depth 31.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006432

F-40 1
(6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroeder SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name**	119
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name**	SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number**	855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 31.5 feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/21/88	DATE COMPLETED: 9/21/88
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured	
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: BKS/TST	
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 31.5 TO 0 FT.		

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.3	6, 14, 22			GC/CL		Brown	CLAYEY GRAVEL/GRAVELLY CLAY (FILL) Dry; crumbly; gravel up to 2 inches; roots. OVA = 400 ppm AU, < 1 ppm WS
B	1.0	21, 28, 23	5		GC		Brown	CLAYEY GRAVEL WITH SAND (FILL) Moist; concrete fragments.
					SC		Brown	CLAYEY SAND WITH GRAVEL (FILL) Very moist; 10% gravel. HNu = 10 ppm AU
C	1.5	2, 2, 2	10	Cement-Bentonite Grout	CL		Dark Gray	CLAY Moist; H_2S odor (BAY MUD); decaying organic matter. OVA = 1000 ppm AU, < 1 ppm WS, HNu = 10 ppm AU
D	1.5	2, 2, 2	15					CLAY (BAY MUD) moist to very moist; H_2S odor. OVA = 1000 ppm AU, < 1 ppm WS, HNu < 1 ppm AU
E	1.5	7, 12, 19	20		CL		Dark Greenish Gray	SANDY CLAY Moist; stiff; trace gravel. drilling more difficult
								SANDY CLAY 40% fine sand; wet. OVA = 10 ppm AU, < 1 ppm WS
F	1.5	8, 21, 19	25		SM		Brown	SILTY SAND WITH CLAY Wet; fine to medium sand; 30% fines.
					CH		Brown	CLAY Trace sand; stiff; moist.
					GP		Brown	SILTY GRAVEL WITH SAND Wet; 10% sand.
G	1.5	12, 21, 41	30		CH		Brown	CLAY Moist; sand lenses. Total Depth 31.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006433

F-40 1
(6-87) (3-88) Supervised By T C Goldman Logged By Brian Schroth

SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE:	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 31.5 TO 0 FT.

Boring/Well Name 120

Project Name SP Liquid Gold

Project Number 855018.06

ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 31.5 feet
DATE STARTED: 9/7/88	DATE COMPLETED: 9/7/88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
	0	10, 12, 12			GC		Brown	No recovery. OVA <1 AU, WS
A	1.0	7, 12, 14						CLAYEY GRAVEL (FILL) Dry; gravel up to 2 inches; fines 30%; sand 20 %; crumbly.
B	1.5	4, 4, 6	5	Cement-Bentonite Grout	CL		Greenish Black 5G 2/1	SANDY CLAY Wet; gravel & sand intermittent up to 30%. OVA = 60 ppm HS
C	1.1	1, 2, 2	10		CL		Dark Gray N3	CLAY Wet; H_2S odor (Bay Mud); decaying organic matter evident. CLAY Wet; H_2S odor. OVA = 20 ppm AU < 1 ppm WS
D	1.5	1, 2, 2	15					CLAY Wet; H_2S odor. OVA = 4 ppm AU < 1 WS
E	1.5	4, 6, 10	20					CLAY Wet; H_2S odor; more stiff. OVA = 3 ppm AU < 1 ppm WS
F	1.0	10, 20, 30	25		SP/GP		Brown	GRAVEL/SAND Wet; 50/50 mix of gravel (up to 0.5 inches) and coarse sand; trace fines; lenses of Bay Mud in sample (25.5 feet). OVA = 4 ppm AU < 1 ppm WS
G	1.3	15, 29, 38	30					GRAVEL/SAND Wet; blow counts, sample position suspect as sand flowed into hole. OVA = 3 ppm AU < 1 ppm WS

Total Depth = 31.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

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F-40 1 (6-87) (3-88) Supervised By JC Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE:	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 25 TO 0 FT.

Boring/Well Name	121
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	25 feet
DATE STARTED	9/7/88
DATE COMPLETED	9/7/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.3	50+ / 50+ / 28		Cement-Bentonite Grout	GC		Dark Brown	Refusal at 0-1.5 feet. CLAYEY GRAVEL (FILL) Slightly moist; 30% fines; gravel to 2 inches; mottled green. OVA >1000 ppm AU <1 ppm WS <1 ppm HS
B	1.5	Pushed	5		CL		Dark Gray	CLAY Wet; strong H_2S odor (BAY MUD) (driller reports at 4 feet). OVA = 1 ppm AU <1 ppm WS
C	1.5	Pushed	10					CLAY Moist; H_2S odor. OVA = 1 ppm AU <1 ppm WS
D	1.5	Pushed	15					CLAY Moist; H_2S odor; trace sand. OVA <1 ppm AU <1 ppm WS
E	1.2	5 / 11 / 7	20		SC		Light Olive Brown	CLAYEY SAND Wet; 20% clay; flowing sand. OVA = 3 ppm AU <1 ppm WS
			25					Flowing sand at 25 feet plugs auger; hole terminated. OVA = 3 ppm AU <1 ppm WS

Total Depth 25 feet

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Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

not

F-40 1
(6-87) (3-88)

Supervised By J C Goldman Logged By Brian Schroth

SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name**	122
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name**	SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number**	855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 31.5 feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/15/88	DATE COMPLETED: 9/15/88
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured	
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: BKS	
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 31.5 TO 0 FT.		

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	5, 7, 31			GC		Light Brown; Black at 1.7 feet	CLAYEY GRAVEL WITH SAND (FILL) Dry; 20% sand; 30% fines.
B	1.0	4, 3, 5	5	Cement - Bentonite Grout	SW		Black N1	GRAVELLY SAND (FILL) Wet; organic odor; 40% gravel; fine to coarse sand; wood fragments. OVA >1000 ppm AU = 2 ppm WS
C	1.5	Pushed	10		CL		Dark Gray N3	CLAY Moist; organic odor; trace sand. OVA = 30 ppm AU < 1 ppm WS
D	1.5	Pushed	15					CLAY Moist; organic odor. OVA = 6 ppm AU < 1 ppm WS
E	1.3	13, 11, 7	20		GC		Olive	CLAYEY GRAVEL WITH SAND Wet; 30% fines; 20% sand; gravel to 1 inch.
					CL		Dark Gray	CLAY Moist; organic odor. OVA = 40 ppm AU < 1 ppm WS
F	1.5	6, 11, 24	25		CH		Light Brown	CLAY Slightly moist:stiff: high plasticity: trace sand. OVA = 60 ppm AU < 1 ppm WS
					GC/SC		Light Brown	CLAYEY GRAVEL/SAND Wet; 35% fines; fine to coarse sand; gravel to 1/4 inch.
G	1.5	15, 21, 30	30		CH		Light Brown	CLAY Slightly moist; stiff; high plasticity; trace sand. OVA <1 ppm AU < 1 ppm WS

Total depth = 31.5 feet.

Notes:
1. Vertical Scale: 1-inch = 5-feet.
2. All contacts are approximate.
3. OVA abbreviations:
   Au = Auger
   WS = Workspace
   HS = Headspace
4. A static water elevation measurement could be made at time of drilling.

LG006436

F-40 1 (6-87) (3-88) Supervised By J C Goldman Logged By Brian Schroth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Boring/Well Name 123

Project Name SP Liquid Gold

Project Number 855018.06

ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 feet
DATE STARTED: 9/15/88	DATE COMPLETED: 9/15/88
STATIC WATER ELEVATION: Not measured	
LOGGED BY: BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	12, 10, 20	5	Cement-Bentonite Grout	GC		Light Brown	CLAYEY GRAVEL (FILL) Dry; 40% clay; trace sand. OVA = 60 ppm AU, < 1 ppm WS
B	0.8	9, 6, 5					Light Brown with Black	CLAYEY GRAVEL (FILL) Soaked with what appears to be oily substance; wood fragments. OVA = 100 ppm AU, <1 ppm WS, = 150 ppm HS
C	1.3	Pushed	10		CL		Dark Gray with Black N1/N3	CLAY Wet; organic odor; trace sand; wash water and auger have oily sheen. OVA >1000 ppm AU, < 1 ppm WS, = 20 ppm HS
D	1.5	2, 3, 5	15					CLAY Wet; organic odor. OVA >1000 ppm AU, <1 ppm WS

Total depth 16.5 feet.

OVA = 20 ppm 3 - 4 inches above open hole = 4 ppm about 2 feet above hole

LG006437

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

not

F-40.1 (6-87) (3-88) Supervised By J C Goldman Logged By Brian Schwetti SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 16.5 TO 0 FT.

Boring/Well Name	124
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	16.5 feet
DATE STARTED	9/15/88
DATE COMPLETED	9/15/88
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.5	6, 15, 29			GC		Brown	CLAYEY GRAVEL WITH SAND (FILL) Dry; 40% fines; 15% sand; gravel to 2 inches; crumbly; iron oxide weathering; black in some spaces
B	0.8	5, 11, 15	5	Cement Bentonite Grout	SP		Black N1	SAND Saturated with oily substance; medium to coarse sand; OVA >1000 ppm AU < 1ppm WS
C	1.5	Pushed	10		CL		Dark Gray N3	CLAY Moist; trace sand; organic odor. OVA = 2 ppm AU <1 ppm WS
D	1.5	Pushed	15					CLAY Moist; trace sand; organic odor. OVA = 300 ppm AU <1 ppm WS

Total depth 16.5 feet.

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006438

F-40 1 (6-87) (3-88) Supervised By J C Goldman Logged By Brian Schwetz SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION	SP Liquid Gold, Richmond, CA
DRILLING COMPANY	ASE Drilling
DRILLER	Chris St.Pierre
DRILLING METHOD (S)	Hollow Stem Auger
DRILL BIT (S) SIZE:	8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT	Cement-Bentonite (2-5% bentonite) FROM 16.5 TO 0 FT.

Boring/Well Name	125
Project Name	SP Liquid Gold
Project Number	855018.06
ELEVATION AND DATUM	Not surveyed
TOTAL DEPTH	16.5 Feet
DATE STARTED	9/15/1988
DATE COMPLETED	9/15/1988
STATIC WATER ELEVATION	Not measured
LOGGED BY	BKS
SAMPLING METHODS	California Modified Drive Sampler
WELL COMPLETION	☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.3	6, 10, 11			GC		Brown turns Black at 1.5 feet	CLAYEY GRAVEL WITH SAND (FILL) Dry; oily substnace at 1.5 feet; wood fragments; 10-15% sand; 40% fines; gravel to 2 inches. OVA = 50 ppm AU, 1 ppm WS
B	1.3	5, 9, 13	5	Cement-Bentonite Grout				CLAYEY GRAVEL WITH SAND (FILL) Moist/oily; free oily product at 5 feet; looks like dirty oil; mixture of gravel up to 2 inches, clayey sand, and sandy clay
C	1.5	Pushed	10		CL		Dark Gray N3	CLAY Moist; organic odor: decaying organic matter (BAY MUD). OVA<1 ppm WS
D	1.5	1, 1, 2	15		CL			CLAY Moist; organic odor. SANDY CLAY Moist; organic odor; 30% sand

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006439

F-40 1 (6-87) (3-88) Supervised By J C Moldman Logged By Brian Schroeth SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA	**Boring/Well Name** 126
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.
ISOLATION CASING	FROM — TO — FT.
BLANK CASING	FROM — TO — FT.
PERFORATED CASING	FROM — TO — FT.
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.
SEAL	FROM — TO — FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.

Project Name SP Liquid Gold

Project Number 855018.06

ELEVATION AND DATUM: Not surveyed	TOTAL DEPTH: 16.5 Feet
DATE STARTED: 9/20/1988	DATE COMPLETED: 9/20/1988
STATIC WATER ELEVATION: Not measured	
LOGGED BY: TST/BKS	
SAMPLING METHODS: California Modified Drive Sampler	WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
					GC		Black	Asphalt in top 3 inches
A	1.3	8, 9, 25			CL		Black N1	CLAYEY GRAVEL (FILL) Dry CLAY Slightly moist: trace brick fragments
B	1.5	2, 1, 1	5		CL		Black N1	GRAVELLY CLAY (FILL) Moist; 15% gravel; mottled brown gray; organic matter
				Cement-Bentonite Grout	CL		Dark Gray N3	CLAY Moist; organic matter; black mottling (BAY MUD) OVA=100 ppm AU < 1 ppm WS
C	1.5	Pushed	10					CLAY Moist; organic matter OVA= 10 ppm AU < 1 ppm WS
							Grayish Olive	
D	1.5	6, 9, 15	15		CL		Grayish Olive	CLAY Moist to slightly moist OVA=2 ppm AU < 1 ppm WS SANDY CLAY Moist to slightly moist: 30% sand: lenses of clayey sand: stiff (FILL)

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006440

F-40 1
(6-87) (3-88) Supervised By JC Goldman Logged By Brian Schroth

SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name** 127
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name** SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number** 855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed; TOTAL DEPTH: 16.5 Feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/20/1988; DATE COMPLETED: 9/20/1988
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: BKS/TST
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler; WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.	

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in.)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.0	15, 29, 50+			GC			ASHPALT to 3 inches CLAYEY GRAVEL WITH SAND (FILL) Dry; gravel up to 2 inches
								Rig chatter
B	1.7	4, 9, 15	5	Cement-Bentonite Grout	CL		Brown	GRAVELLY CLAY (FILL) Moist; 40% gravel OVA= 100 ppm AU < 1 ppm WS
					CL		Black N1	CLAY (FOUND IN CUTTINGS) Moist: trace sand
C	1.5	Pushed	10		CL		Dark Gray N3	CLAY (BAY MUD) Moist; organic matter at 15-15.5 feet OVA = 50 ppm AU < 1 ppm WS
D	1.5	1, 2, 3	15		CL		Grayish Green	SANDY CLAY WITH GRAVEL Moist; 10% gravel; 30% sand

Total Depth 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006441

F-40 1
(6-87) (3-88) Supervised By J.C. Goldman Logged By Brian Chrotti SHEET 1 OF 1

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP Liquid Gold, Richmond, CA		**Boring/Well Name** 128
DRILLING COMPANY: ASE Drilling	DRILLER: Chris St.Pierre	**Project Name** SP Liquid Gold
DRILLING METHOD (S): Hollow Stem Auger	DRILL BIT (S) SIZE: 8-inch O.D.	**Project Number** 855018.06
ISOLATION CASING	FROM — TO — FT.	ELEVATION AND DATUM: Not surveyed; TOTAL DEPTH: 16.5 Feet
BLANK CASING	FROM — TO — FT.	DATE STARTED: 9/20/88; DATE COMPLETED: 9/20/88
PERFORATED CASING	FROM — TO — FT.	STATIC WATER ELEVATION: Not measured
SIZE AND TYPE OF FILTER PACK	FROM — TO — FT.	LOGGED BY: TST/BKS
SEAL	FROM — TO — FT.	SAMPLING METHODS: California Modified Drive Sampler; WELL COMPLETION: ☐ SURFACE HOUSING ☐ STAND PIPE ____ FT.
GROUT: Cement-Bentonite (2-5% bentonite)	FROM 16.5 TO 0 FT.	

SAMPLES Type No.	Recovery (Feet)	Penetration Resist (Blows/6 in)	Depth (Feet)	WELL CONSTRUCTION	USCS Log	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.5	19, 31, 44			CL/GC		Brown	ASPHALT AND GRAVEL 0-1 feet GRAVELLY CLAY/CLAYEY GRAVEL (FILL) Dry; gravel lens; crumbly; 50% clay; 50% gravel; trace sand
B	1.2	NA	5		CL		Brown	GRAVELLY CLAY (FILL) Slightly moist to moist: trace sand: 15% gravel OVA = 100 ppm AU < 1 ppm WS
C	1.5	Pushed	10		CL		Dark Gray	CLAY Moist; organic matter (BAY MUD) OVA = 2 ppm AU < 1 ppm WS HNu = 20 ppm AU
D	1.5	Pushed	15					CLAY Moist; increasing sand at 16.5 feet OVA = 10 ppm AU < 1 ppm WS

Total Depth = 16.5 feet

Notes:
1. Vertical Scale: 1 inch = 5 feet.
2. All contacts are approximate.
3. Organic Vapor Analyzer (OVA) and HNu measuring points:
   AU = Auger
   WS = Workspace
   HS = Headspace

LG006442

F-40 1
(6-87) (3-88) Supervised By [signature] Logged By [signature] SHEET 1 OF 1

APPENDIX B

Monitoring Well Logs

LG006443

MONITORING WELL LOG

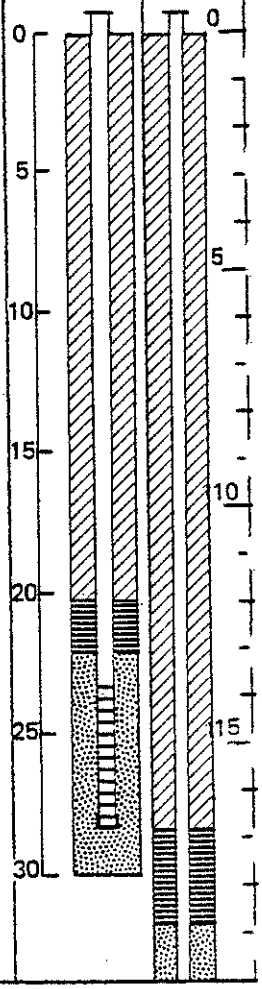
BORING NUMBER MW-1 | TOC ELEVATION 9.04 feet above MSL | DATE 11/8/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered 24.5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 5 feet			
				water between 5-6'		
5			5-6.5' blue silty clay			
10			10-11.5' blue silty clay			
15						



LG006444

MONITORING WELL LOG

BORING NUMBER MW-1 TOC ELEVATION _____ DATE 11/8/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20					20
				@ 24.5' may have hit gravels, water bearing	
25			25-26' very coarse sand with angular gravel	water saturated sample	25
			26-26.5' blue silt, very wet		
30			30-31.5' tan clay		30
35					35

LG006445

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ecology and environment

MONITORING WELL LOG

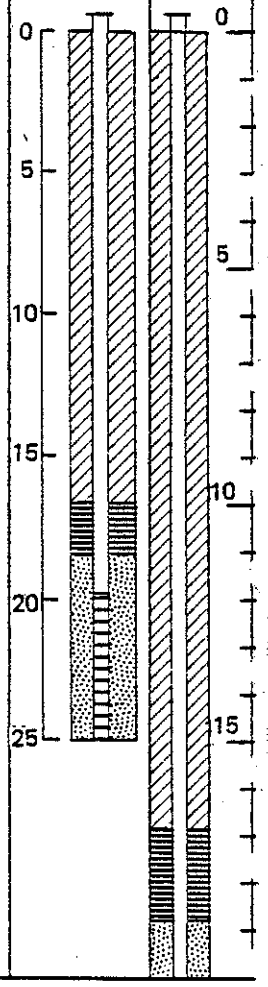
BORING NUMBER MW-2 | TOC ELEVATION 7.87 feet above MSL | DATE 11/9/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered approx. 17 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 20 feet			
5						
10						
15			17-18.5' water bearing sand			



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MONITORING WELL LOG

BORING NUMBER MW-2 TOC ELEVATION _____ DATE 11/9/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20			20-21.5' tan clay		20
			22-23.5' coarse sand and gravel, water bearing		
25			25-26.5' silt grading downward to silty clay, water bearing		25
30					30
35					35

LG006447

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ecology and environment

MONITORING WELL LOG

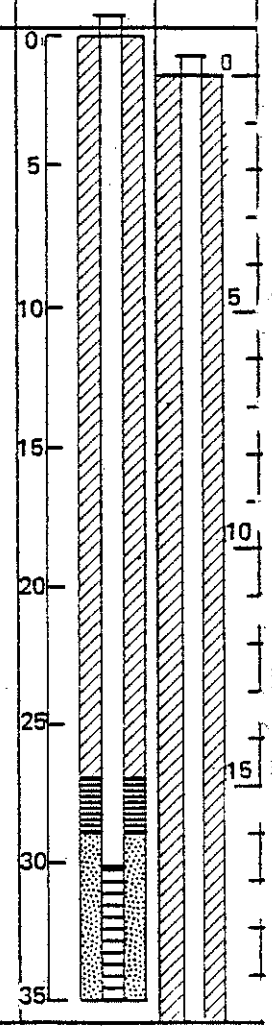
BORING NUMBER MW-3 | TOC ELEVATION 7.72 feet above MSL | DATE 11/9/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered 31 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			0-1.5' sand and silt with trace cobbles			
5			5-6.5' blue silty clay			
10			10-11.5' blue silty clay			
15			Augered to 35 feet			



LG006448

MONITORING WELL LOG

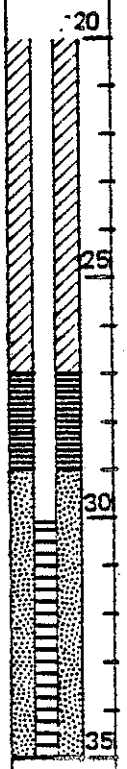
BORING NUMBER MW-3 TOC ELEVATION _____ DATE 11/9/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20					20
25					25
30			31' water bearing sand		30
35			35-36.5' stiff tan clay		35



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ecology and environment

MONITORING WELL LOG

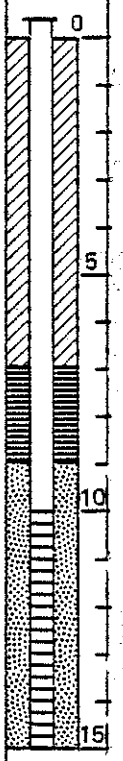
BORING NUMBER MW-4 | TOC ELEVATION 7.95 feet above MSL | DATE 11/9/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 1

WATER LEVEL encountered 11.5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 10 feet			0
5						5
10			11.5-13' medium grained sand and gravel, water bearing, black stain			10
15			15-16.5' blue clay			15



LG006450

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 8/1/86

BY: PMM

BORING MW-4R

Details of Boring and Well Construction

SURFACE ELEVATION: 8.30 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN ID CALIF. MOD SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	Well Construction	DEPTH IN FEET	USCS	SYMBOLS	
A B C	C.M.	10 28 33	LOCKING CASING; 2 IN PVC CAP; NEAT CEMENT GROUT; BENTONITE PELLETS				GRAVEL: BROWN, COURSE GRADE SOME SAND (FILL)
D E F	C.M.	10 19 23	FILTER SAND (MONTEREY); 2 IN. PVC SLOTTED SCREEN 0.020 IN SLOTS	5	GP		WATER LEVEL MEASURED 8/1/86
G H I	C.M.	1 1 3	2 IN. PVC BOTTOM CAP; BENTONITE PELLETS		CL		SILTY CLAY: GREEN-BLUE (BAY MUD)

BOTTOM HOLE AT 10 FT. 8/1/86

LG006451

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

MONITORING WELL LOG

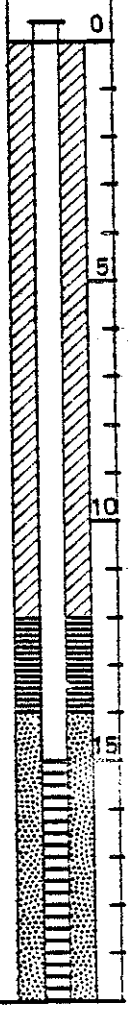
BORING NUMBER MW-5 | TOC ELEVATION 6.54 feet above MSL | DATE 11/9/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered 15.5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			0-5' augers spoil: clay			0
5			Augered to 15 feet			5
10						10
15			16.5-18' coarse sand and gravel, water bearing			15



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ecology and environment

MONITORING WELL LOG

BORING NUMBER MW-5 TOC ELEVATION _____ DATE 11/9/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20			20-21.5' stiff blue clay	bottom of well: 20 feet	20
25					25
30					30
35					35

LG006453

Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP LIQUID GOLD - TEST BORING ADJACENT TO MW-5		Boring/Well Name	Cr-4 (MW-5)
DRILLING COMPANY: HEW DRILLING INC.	DRILLER	Project Name	SP LIQUID GOLD
DRILLING METHOD (S): HOLLOW STEM AUGER	DRILL BIT (S) SIZE: 3.75-INCH O.D.	Project Number	855018.09
ISOLATION CASING: N/A	FROM TO FT	ELEVATION AND DATUM: NOT SURVEYED	TOTAL DEPTH: 20 FEET
BLANK CASING: N/A	FROM TO FT	DATE STARTED: 9/13/90	DATE COMPLETED: 9/13/90
PERFORATED CASING: N/A	FROM TO FT	STATIC WATER ELEVATION: NOT MEASURED	
SIZE AND TYPE OF FILTER PACK: N/A	FROM TO FT	LOGGED BY: WWM/JCG	
SEAL: N/A	FROM TO FT	SAMPLING METHODS	WELL COMPLETION: ☐ SURFACE HOUSING
GROUT: CEMENT WITH 5-10% BENTONITE	FROM 0 TO 20 FT		☐ STOVE PIPE _____ FT

SAMPLES Type No.	Recovery (Feet)	Pen. Resist Blows/6in	Depth (Ft)	WELL CONSTRUCTION	USCS LOG	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
	100%				SM			BROKEN CONCRETE, 3-4 INCHES SILTY SAND (FILL) DARK BROWN, FINE GRAINED, POORLY GRADED, APPROXIMATELY 20% SILT, DRY.
					SM			GRAVELLY SAND (FILL) BROWN, FINE-COARSE GRAINED, POORLY GRADED, APPROXIMATELY 5% GRAVEL TO 3/4 INCH.
	100%		5		CL		5B 5/1	LEAN CLAY (BAY MUD) BLUE-GRAY COLOR, MODERATELY PLASTIC, MOIST, H_2S ODOR.
	100%		10		CL		5B 5/1	LEAN CLAY (BAY MUD) BLUE-GRAY COLOR, MODERATELY PLASTIC, TRACE OF SILT, WET, H_2S ODOR. ROOTS ENCOUNTERED 11-12.5 FT.
	100%		15		ML		5B 5/1	CLAYEY SANDY SILT (BAY MUD) BLUE-GRAY COLOR, 10% SAND, MOIST, H_2S ODOR.
					ML		5B 5/1	CLAYEY SILT (BAY MUD) BLUE-GRAY COLOR, MOIST, H_2S ODOR.
					ML		10 YR 5/4	CLAYEY SILT BROWN, MOIST, NO H_2S ODOR.
			20		CH		10 YR 5/4	SILTY FAT CLAY BROWN, MODERATELY PLASTIC, TRACE OF SILT, WET, NO ODOR.

TOTAL DEPTH = 20.0 FEET

NOTES:

1. ORGANIC VAPOR MEASUREMENTS NOT MADE; INSTRUMENT BROKEN.
2. BORING CONTINUOUSLY-CORED, NO SAMPLES COLLECTED FOR LAB ANALYSIS.

LG006454

MONITORING WELL LOG

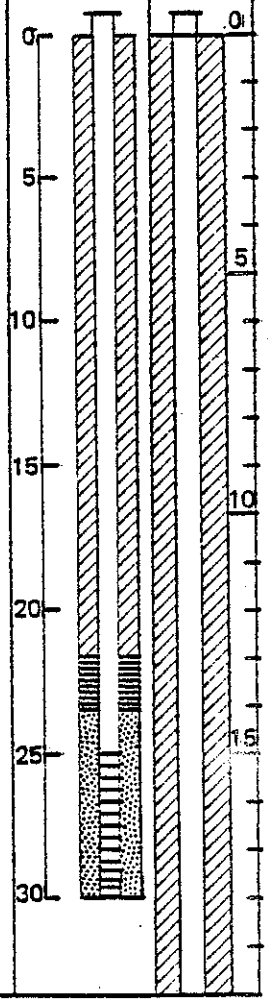
BORING NUMBER MW-6 | TOC ELEVATION 6.68 feet above MSL | DATE 11/8/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered 27-28 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 5 feet			
5			5-6.5' black sand, water bearing			
10			10-11.5' blue stiff clay, with some silt and black streaks in places			
15			Augered to 25 feet			



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MONITORING WELL LOG

BORING NUMBER MW-6 TOC ELEVATION _____ DATE 11/8/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20					20
25			25-26.5' mottled tan clay		25
			27-28' fine to medium grained sand overlying a fine sand-silt, water bearing		
30			30-31.5' blue clay		30
35					

LG006456

MONITORING WELL LOG

BORING NUMBER MW-7 | TOC ELEVATION 5.43 feet above MSL | DATE 11/7/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 1

WATER LEVEL encountered 5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 5 feet			0
5						5
			6.5-7.5' medium grained sand, black, few fines, saturated with water			
			8.0-9.5' blue clay, from 6.5-7.1 feet, black streaks in clay			
10						10
15						15

LG006457

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Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 8/1/86

BY: PMM

BORING MW-7R

Details of Boring and Well Construction

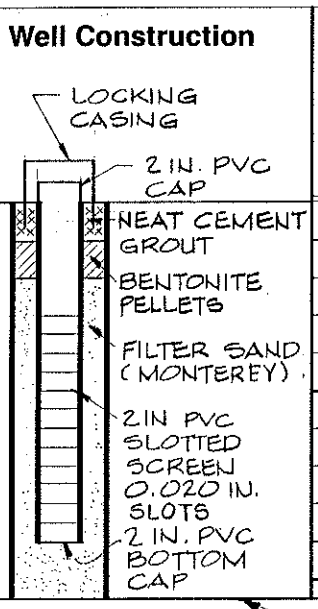
SURFACE ELEVATION: 8.13 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN I.D. CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS
A	CM	50		SW	
B C D	C.M.	16 26 10	5		
E F G	C.M.	7 10 7			
H I J	C.M.	PUSH	10	CL	



SANDY GRAVEL: DRY TO WET (FILL)

SILTY CLAY: BLUE GRAY (BAY MUD)

BOTTOM HOLE 10.5 FT. 8/1/86

LG006458

F-37 (8/85)

CM = CALIFORNIA MODIFIED

SHEET 1 OF 1

MONITORING WELL LOG

BORING NUMBER MW-8 TOC ELEVATION 6.08 feet above MSL DATE 11/7/83

TYPE Monitoring LOCATION Liquid Gold Site NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger City of Richmond PAGE 1 OF 1

WATER LEVEL encountered 6.5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			Augered to 6 feet			0
5						5
			6.5-8.0' black medium grained sand, few fines, saturated with water			
			8.0-9.5' stiff blue clay with some silt			
10						10
15						

LG006459

MONITORING WELL LOG

BORING NUMBER MW-9 TOC ELEVATION 6.32 feet above MSL DATE 11/8/83

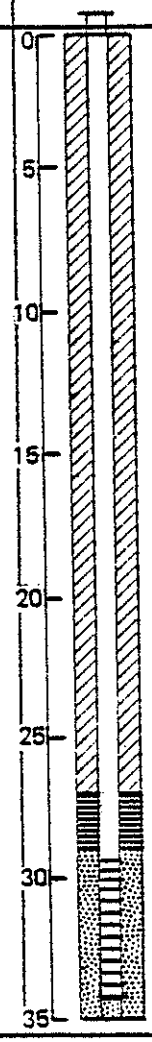
TYPE Monitoring LOCATION Liquid Gold Site NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger City of Richmond PAGE 1 OF 2

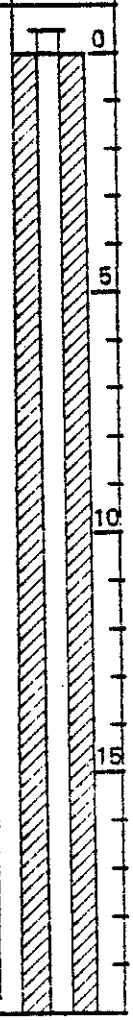
WATER LEVEL encountered 30 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS
0			Augered to 5 feet	
5			5-5.3' brown sand and silt	
			5.3-6.5' blue clay and silt, with a black stain	
10			10-11.5' blue stiff clay with some silt, black stain	
15			Augered to 25 feet	

WELL SCHEMATIC



WELL DESIGN



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MONITORING WELL LOG

BORING NUMBER MW-9 TOC ELEVATION _____ DATE 11/8/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20					20
25			25-26.5' blue silty clay		25
30			30-33.5' tan coarse sand, water bearing		30
35					35

LG006461

MONITORING WELL LOG

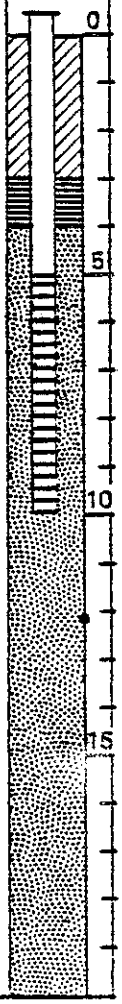
BORING NUMBER MW-10 | TOC ELEVATION 7.43 feet above MSL | DATE 11/9/83

TYPE Monitoring | LOCATION Liquid Gold Site | NAME M. A. Ortega

DRILL METHOD Hollow Stem Auger | City of Richmond | PAGE 1 OF 2

WATER LEVEL encountered 5 ft. while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL SCHEMATIC	WELL DESIGN
0			0-1.0' coarse sand and gravel			0
			1-1.5' blue clay			
5			5-6.5' coarse sand and gravel, water bearing			5
10			10-11' coarse sand grading downward to silt, black stained			10
			11-11.5' silty blue clay	The borehole for monitoring well 10 is 26.5 feet deep, no water bearing zones were encountered below 5-6.5 feet. The borehole was back-filled with sand to a depth of 10 feet. The monitoring well was then installed from 0-10 feet.		
15			Augered to 25 feet			15



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MONITORING WELL LOG

BORING NUMBER MW-10 TOC ELEVATION _____ DATE 11/9/83

WELL TYPE _____ LOCATION _____ NAME _____

DRILL METHOD _____ _____ PAGE 2 OF 2

WATER LEVEL encountered _____ while drilling

DEPTH IN FEET	LITH COL	SAMPLE	LITHOLOGIC DESCRIPTION	OBSERVATIONS	WELL DESIGN
20					20
25			25-26.5' mottled tan clay		25
30					
35					

LG006463

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 8/1/86

BY: PMM

BORING MW-11

Details of Boring and Well Construction

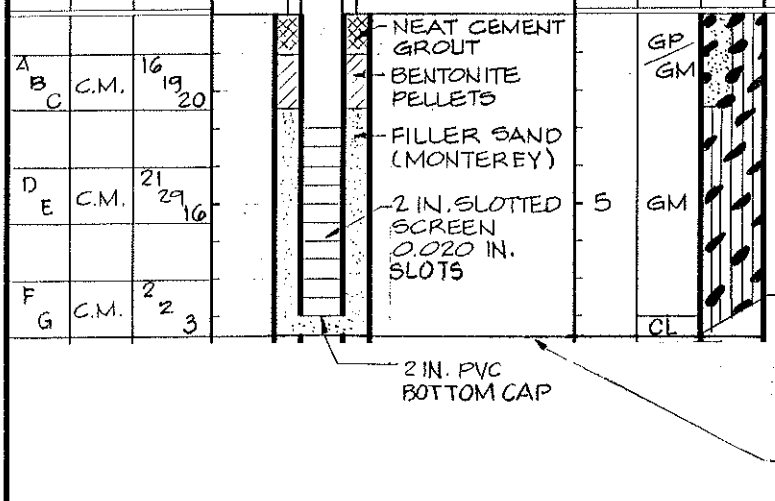
SURFACE ELEVATION: 11.33 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. O.D. HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN I.D. CAL. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS
A B C	C.M.	16 19 20		GP/GM	
D E	C.M.	21 29 16	5	GM	
F G	C.M.	2 2 3		CL	



GRAVEL: SOME ASPHALT AD CEMENT (FILL) COARSE

WATER LEVEL MEASURED 8/7/86

CLAY: BLUE TO DARK BROWN SOME SILT

BOTTOM HOLE 8.5 FT. 8/1/86

LG006464

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 7/28/86

BY: EFP

BORING MW-12

Details of Boring and Well Construction

SURFACE ELEVATION: 7.92 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN. I.D. CALIF MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS	
A B C	C.M.	5 8 8		GP		GRAVEL: POORLY SORTED, SOME SILT (FILL)
				CL		SILTY CLAY: BROWN, SOME GRAVEL AND ROCKFRAGMENTS, MOIST (FILL)
						▼ WATER LEVEL MEASURED 8/7/86
D	C.M.	7 7 6	5			
				CL		SILTY CLAY: BLUE GRAY (BAY MUD)
E F G	C.M.	1 1 2				

Well Construction

BOTTOM HOLE AT 8.5 FT. 7/28/86

LG006465

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 7/28/86

BY: EFP

BORING MW-13

Details of Boring and Well Construction

SURFACE ELEVATION: 7.15 FT. MSL (TOP OF CASING)

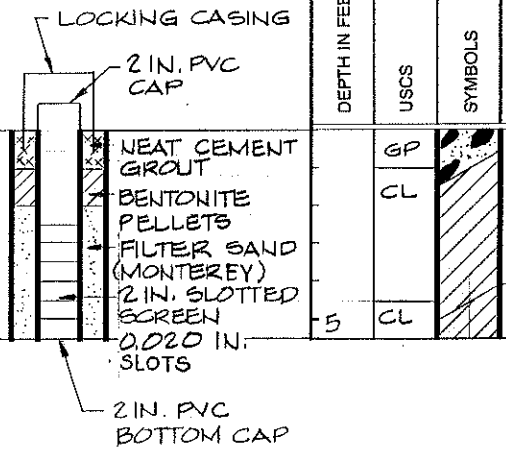
DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN. I.D. CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS	
A B C	C.M.	13 14 8		GP		GRAVEL: COARSE POORLY SORTED (FILL)
				CL		CLAYEY GRAVEL: BROWN, POORLY SORTED, WOOD FRAGMENTS (FILL)
D E	C.M.	2 2 3	5	CL		▼ WATER LEVEL 8/7/86 SILTY CLAY: BLUE, GRAY, SATURATED, PLASTIC (BAY MUD)

Well Construction



BOTTOM HOLE AT 5.5 FT. 7/28/86

LG006466

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 7/28/86

BY: EFP

BORING MW-15

Details of Boring and Well Construction

SURFACE ELEVATION: 7.58 FT. MSL (TOP OF CASING)

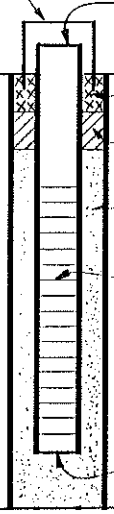
DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN ID CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS	
A B C	C.M.	21 46 48		GM		SILTY GRAVEL: BROWN, POORLY SORTED (FILL)
						▼ WATER LEVEL MEASURED 8/7/86
D	C.M.	6 1 1	5	CL		SILTY CLAY BROWN TO BLACK, SATURATED, WOOD FRAGMENTS (FILL)
E F	C.M.	PUSH				
G H I	C.M.	1 1 1	10	CL		SILTY CLAY BLUE GRAY, SATURATED, PLASTIC (BAY MUD)

Well Construction



BOTTOM HOLE AT 11.5 FT. 7/28/86

LG006467

F-37 (8/85) C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 7/29/86

BY: EFP

BORING MW-16

Details of Boring and Well Construction

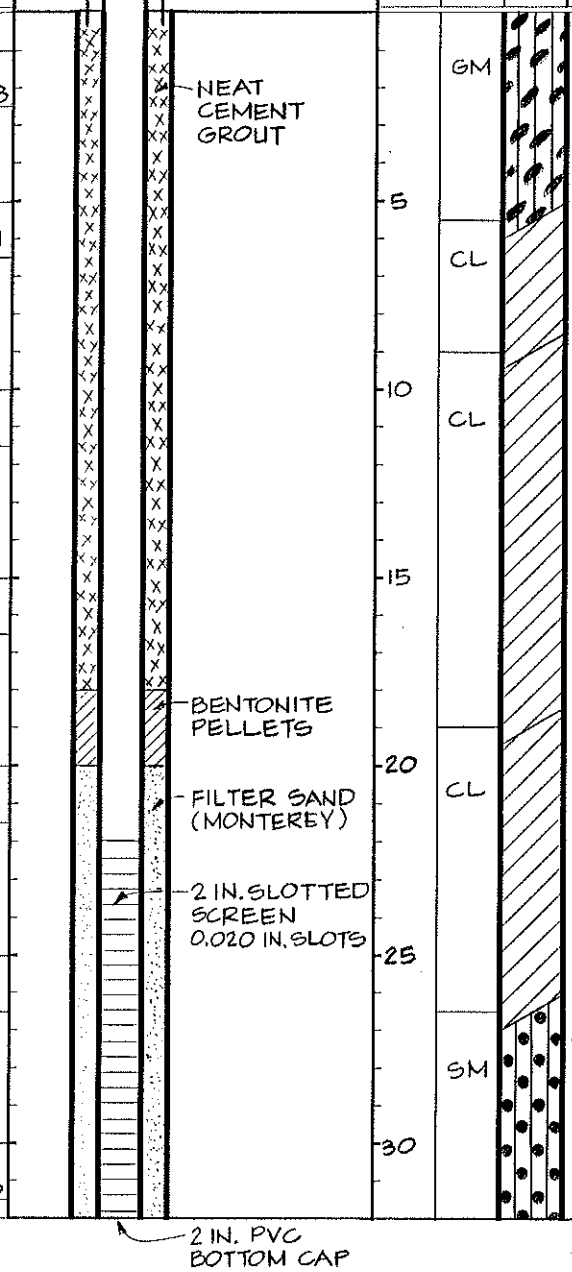
SURFACE ELEVATION: 7.56 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS
A B	C.M.	45 27 18		GM	
C D	C.M.	5 7 11	5	CL	
E F G	C.M.	3 5 5	10	CL	
H I J	C.M.	3 5 5	15		
K L M	C.M.	7 9 13	20	CL	
N O P	C.M.	10 14 8	25		
Q R S	C.M.	14 11 18	30	SM	



SILTY GRAVEL: BROWN, POORLY SORTED (FILL)

▼ WATER LEVEL MEASURED 8/7/86

SILTY CLAY: BLACK, SOME GRAVEL SATURATED (FILL)

SILTY CLAY: BLUE GRAY, PLASTIC TRACE SAND, (BAY MUD) SATURATED

SANDY CLAY: BLUE TO TAN, SATURATED, INCREASING SAND

SILTY SAND: TAN, SATURATED, INCREASING COARSENESS

BOTTOM HOLE AT 32.0 FT 7/29/86

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F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 7/29/86

BY: EFP

BORING MW-17

Details of Boring and Well Construction

SURFACE ELEVATION: 6.63 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN ID CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS
A	C.M.	50		GM	
B	C.M.	PUSH			
C D	C.M.	PUSH	5	CL	
E F G	C.M.	1 2 2	10	CL	

Well Construction

SILTY GRAVEL: BROWN GRAVEL TO 1 INCH ASPHALT AND BRICK DEBRIS (FILL)

▼ WATER LEVEL MEASURED 8/7/86

CLAY: BLACK, SOME SILT OILY SHEEN, TIMBER DEBRIS, SATURATED

SILTY CLAY: BLUE GRAY PLASTIC SATURATED (BAY MUD)

BOTTOM HOLE AT 8.5 FT. 7/28/86

LG006469

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

Figure **Kennedy/Jenks Engineers**

PROJECT: LIQUID GOLD

JOB NO. 5018

DATE: 8/4/86

BY: EFP

BORING MW-18

Details of Boring and Well Construction

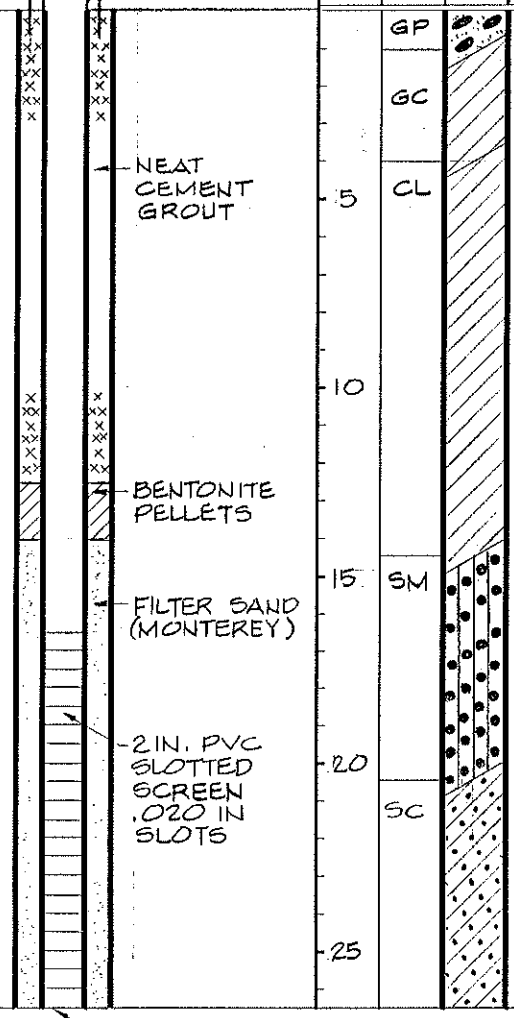
SURFACE ELEVATION: 7.34 FT. MSL (TOP OF CASING)

DRILLING METHODS: 8 IN. OD HOLLOW STEM AUGER

SAMPLING METHODS: 2.5 IN ID CALIF. MOD. SAMPLER WITH BRASS LINERS

DRILLER: HEW DRILLING CO.

SAMPLE NUMBER	SAMPLER TYPE	BLOWS/FT-INTERVAL	DEPTH IN FEET	USCS	SYMBOLS	
A B C	C.M.	36 19 13		GP		GRAVEL: COARSE, POORLY SORTED
				GC		CLAYEY GRAVEL: BROWN, POORLY SORTED (FILL)
			5	CL		SILTY CLAY: PLASTIC BLUE GRAY (BAY MUD) SATURATED SOME COARSE SAND SECTIONS WITH SHELL FRAGMENTS
D E F	C.M.	PUSH	10			
G H I	C.M.	13 21 22	15	SM		SILTY SAND: GRAY TO BROWN, SATURATED
J K L	C.M.	12 13 15	20	SC		SILTY SANDY CLAY: LIGHT BROWN, SATURATED
M N O	C.M.	9 16 26	25			



BOTTOM HOLE AT 26.5 FT. 8/4/86

LG006470

F-37 (8/85)

C.M. = CALIFORNIA MODIFIED

SHEET 1 OF 1

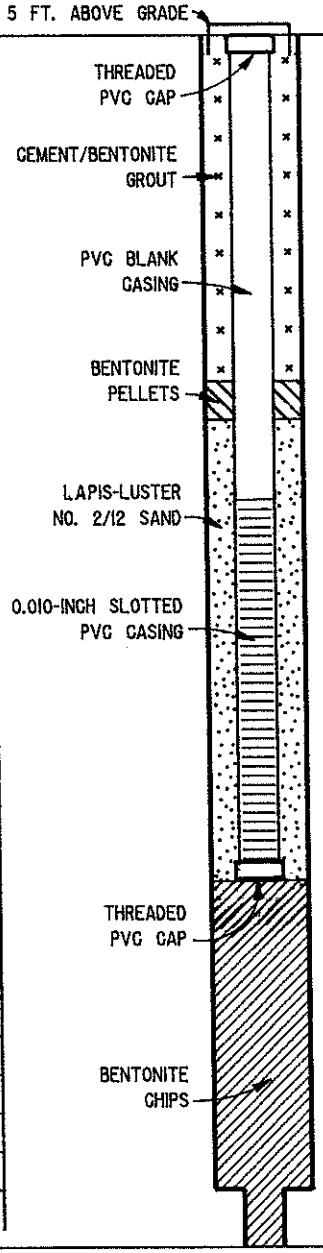
Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP LIQUID GOLD, RICHMOND, CA		Boring/Well Name	MW-19
DRILLING COMPANY: ASE DRILLING	DRILLER: CHRIS ST. PIERRE	Project Name	SP Liquid Gold
DRILLING METHOD (S): HOLLOW STEM AUGER	DRILL BIT (S) SIZE: 8-INCH O.D.	Project Number	855018.06
ISOLATION CASING: NONE	FROM - TO - FT	ELEVATION AND DATUM	TOTAL DEPTH: 30 FEET
BLANK CASING: SCHEDULE 40, 2-INCH PVC CASING	FROM 12 TO 0 FT	DATE STARTED: 9/19/88	DATE COMPLETED: 9/19/88
PERFORATED CASING: 2-INCH 0.010-INCH SLOTTED PVC CASING	FROM 22 TO 12 FT	STATIC WATER ELEVATION: NOT MEASURED AT TIME OF DRILLING	
SIZE AND TYPE OF FILTER PACK: LAPIS-LUSTER NO. 2/12 SAND	FROM 22 TO 10 FT	LOGGED BY: B.K. SCHROTH	
SEAL: BENTONITE PELLETS	FROM 10 TO 9 FT	SAMPLING METHODS: CALIFORNIA MODIFIED DRIVE SAMPLER	WELL COMPLETION: ☐ SURFACE HOUSING ☒ STANDPIPE 5 FT
GROUT: CEMENT-BENTONITE (2%-5% BENTONITE)	FROM 9 TO 0 FT		

SAMPLES Type No.	Recovery (Feet)	Pen. Resist Blows/6in	Depth (Ft)	USCS LOG	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	1.5	5, 17, 21		GC/CL		BROWN	GRAVELLY CLAY / CLAYEY GRAVEL DRY, MANY ROOTS, GRAVEL TO 2 INCHES, CLAY 40%-70%. OVA = 4 ppm AU, < 1 ppm WS
B	1.3	6, 11, 16	5	CH		LIGHT BROWN	CLAY SLIGHTLY MOIST, STIFF, TRACE SAND, SILTY AT 5 FEET WITH ROOTS, TURNING TO CLAY.
C	1.3	5, 5, 6	10				CLAY SLIGHTLY MOIST, TRACE SAND. OVA < 1 ppm AU, < 1 ppm WS. DRILLER REPORTS LITHOLOGY CHANGE AT 14 FEET.
D	1.3	5, 5, 5	15	SG/SM		BROWN	CLAYEY SAND / SILTY SAND WET, 30% FINES, FINE TO MEDIUM SAND.
				CH		LIGHT BROWN	CLAY SLIGHTLY MOIST, TRACE SAND.
E	1.3	7, 7, 9	20				CLAY SLIGHTLY MOIST, SMALL AMOUNT OF CLAYEY SAND AT 20 FEET. OVA < 1 ppm WS
				CL		BROWN	SANDY CLAY MOIST, TRACE GRAVEL, FINE SAND (35%)
F	1.5	10, 15, 28	25	SC		BROWN	CLAYEY SAND VERY MOIST, 30% CLAY, FINE TO MEDIUM SAND.
				CL		BROWN	SANDY CLAY SLIGHTLY MOIST, TRACE GRAVEL.
G	1.5	12, 29, 34	30	CH		PALE OLIVE	CLAY MOIST TO VERY MOIST, STIFF, TRACE SAND.

WELL CONSTRUCTION: LOCKING STL. STANDPIPE 5 FT. ABOVE GRADE



TOTAL DEPTH 31.5 FEET

NOTES:
1. VERTICAL SCALE: 1 INCH = 5 FEET.
2. ALL CONTACTS ARE APPROXIMATE.
3. FOXBORO ORGANIC VAPOR ANALYZER (OVA)
   ABBREVIATIONS: AU = AUGER WS = WORKSPACE
   HS = HEADSPACE

LG0064471

SUPERVISED BY: _____ LOGGED BY: _____ SHEET 1 OF 1

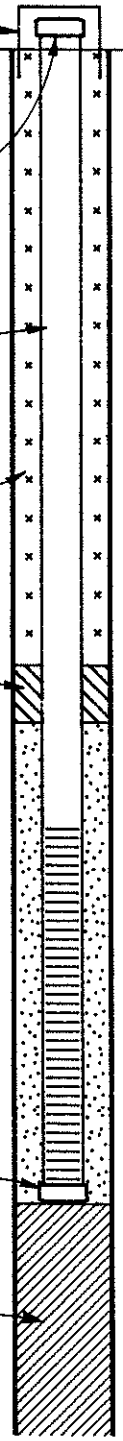
Boring & Well Construction Log

Kennedy/Jenks/Chilton

BORING LOCATION: SP LIQUID GOLD, RICHMOND, CA		Boring/Well Name	MW-20
DRILLING COMPANY: ASE DRILLING	DRILLER: CHRIS ST. PIERRE	Project Name	SP Liquid Gold
DRILLING METHOD (S): HOLLOW STEM AUGER	DRILL BIT (S) SIZE: 8-INCH O.D.	Project Number	855018.06
ISOLATION CASING: NONE	FROM - TO - FT	ELEVATION AND DATUM	TOTAL DEPTH: 51.5 FEET
BLANK CASING: 2-INCH O.D. SCHEDULE 40 PVC CASING	FROM 20 TO 0 FT	DATE STARTED: 9/8/88	DATE COMPLETED: 9/9/88
PERFORATED CASING: 2-INCH O.D., 0.010-INCH SLOTTED PVC CASING	FROM 30 TO 20 FT	STATIC WATER ELEVATION: NOT MEASURED AT TIME OF DRILLING	
SIZE AND TYPE OF FILTER PACK: LAPIS-LUSTER NO. 2/12 SAND	FROM 30 TO 17.5 FT	LOGGED BY: B.K. SCHROTH	
SEAL: BENTONITE PELLETS	FROM 17.5 TO 16 FT	SAMPLING METHODS: CALIFORNIA MODIFIED DRIVE SAMPLER	WELL COMPLETION: ☐ SURFACE HOUSING ☒ STANDPIPE: 5 FT
GROUT: CEMENT-BENTONITE (2%-5% BENTONITE)	FROM 16 TO 0 FT		

SAMPLES Type No.	Recovery (Feet)	Pen. Resist Blows/6in	Depth (Ft)	USCS LOG	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
A	0.7	28, 30, 30		GW	LIGHT BROWN	LOST SAMPLE AT SURFACE. ASPHALT FRAGMENTS TO 3-FEET. DISTURBED SAMPLE-MATERIAL FROM 0-3 FEET. GRAVEL (FILL) DRY, BRICK FRAGMENTS.
				CL	BROWN	CLAY SLIGHTLY MOIST, TRACE SAND. OVA < 1 ppm AU, < 1 ppm WS
B	1.5	7, 14, 16	5	GC	BROWN	CLAYEY GRAVEL MOIST, 20% FINES, GRAVEL TO 2 INCHES. OVA < 1 ppm AU, < 1 ppm WS
C	1.0	12, 10, 7	10	SC	BROWN	CLAYEY SAND WET, 20% GRAVEL, 20% CLAY, MEDIUM GRAINED SAND. OVA < 1 ppm AU, < 1 ppm WS
D	1.5	2, 5, 9	15	CH	LIGHT BROWN	CLAY WET, MOTTLED BLACK, TRACE GRAVEL.
E	1.5	4, 5, 7	20			CLAY VERY MOIST, TRACE SAND. OVA < 1 ppm AU, < 1 ppm WS
				SC	BROWN	CLAYEY SAND WET, 30% FINES, FINE TO MEDIUM SAND.
F	1.5	8, 18, 30	25			CLAY VERY MOIST TO MOIST, TRACE SAND. OVA < 1 ppm AU, < 1 ppm WS
G	1.5	12, 20, 24	30	CH	LIGHT BROWN	CLAY MOIST. OVA < 1 ppm AU, < 1 ppm WS
H	1.1	21, 40	35			

WELL CONSTRUCTION



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Boring & Well Construction Log

Kennedy/Jenks/Chilton

Project Name MW-20 Project Number SP Liquid Gold Boring/Well Name 855018.06

SAMPLES Type No.	Recovery (Feet)	Pen. Resist Blows/6in	Depth (Ft)	WELL CONSTRUCTION	USCS LOG	Lithology	Color	SAMPLE DESCRIPTION and DRILLING REMARKS	
		30			CH		LIGHT BROWN	CLAY SLIGHTLY MOIST TO MOIST, TOP OF SAMPLE IS SANDY CLAY WITH 35% SAND.	NOISE: 82 dB AT 10-FEET FROM RIG. BACKGROUND: 75 dB AT 200-FEET FROM RIG.
I	1.3	18 35 40	40	BENTONITE CHIPS				CLAY SLIGHTLY MOIST, TRACE SAND, MORE STIFF.	OVA < 1 ppm AU
J	1.5	19 44 42	45		CH		GREENISH GRAY	CLAY SLIGHTLY MOIST, TRACE SAND AND GRAVEL.	OVA < 1 ppm AU
K	1.5	20 34 37	50					CLAYEY SAND WET, 40% FINES, FINE TO COARSE SAND, TRACE GRAVEL.	OVA < 1 ppm AU

TOTAL DEPTH
51.5 FEET

NOTES:
1. VERTICAL SCALE: 1-INCH = 5 FEET.
2. ALL CONTACTS ARE APPROXIMATE.
3. FOXBORO ORGANIC VAPOR ANALYZER (OVA)

ABBREVIATIONS: AU = AUGER WS = WORKSPACE
HS = HEADSPACE

LG006473

APPENDIX C

Ecological Study

LG006474

LIQUID GOLD SITE/HOFFMAN MARSH
BIOLOGICAL INVESTIGATIONS
FINAL REPORT

Prepared for:

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Prepared by:

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Novato, California 94949
(415) 883-6425

LG006475

December 7, 1990
KJC 8802

EXECUTIVE SUMMARY

Prior to 1982, the Liquid Gold Oil Corporation operated a waste oil storage and transfer facility adjacent to tidal wetlands in Richmond, along the east side of San Francisco Bay, California. As part of the investigations of the Liquid Gold site, Western Ecological Services Company, Inc. (WESCO) conducted a study to evaluate whether chemicals from the Liquid Gold operations have caused impacts to the biota of Hoffman Marsh, an adjacent pickleweed marsh, and other property drainages.

WESCO's study approach was designed to distinguish the Liquid Gold site's chemical contribution from the background levels of chemical concentrations across the marsh, and to assess the potential impact of the site's chemicals upon the marsh's biota. Focusing on indicator organisms within the food chain, sediment analysis, and endangered species, the objective was to compare the marsh's chemical and biotic conditions adjacent to, and further away from, the Liquid Gold site. The study approach included the following components:

- Sediment analysis for organic and inorganic chemicals
- Benthos sampling for abundance and relative composition
- Crab tissue analysis for organic and inorganic chemicals
- Vegetation mapping
- Pickleweed tissue analysis for inorganic chemicals
- Salt marsh harvest mouse live-trapping
- Small mammal live-trapping
- California clapper rail and black rail surveys

Sample collections of sediment, benthos, and crab tissue were conducted in October 1988. From the 28 primary sample stations distributed over six transects, the following total number of samples were collected: 62 sediment samples, 184 benthos samples, 14 crab tissue samples, and 16 pickleweed tissue samples. Other components of the field data collections were conducted between November 1988 and April 1989. Wet season sampling of benthos and sediment scheduled for February or March of 1989 was aborted because drought conditions failed to produce representative wet season conditions.

Analysis of data generated by this investigation lead to the following conclusions:

- There is no evidence that the Liquid Gold site is a point source contributor of heavy metals to the pickleweed marsh (Transects 1 through 4).

- Although a sample location near the Liquid Gold site has relatively higher levels of oil and grease and the presence of polynuclear aromatic hydrocarbons (PAHs), there is no evidence that the Liquid Gold site is significantly affecting the benthic fauna of the pickleweed marsh (Transects 1 through 4).

- The upper end of the southwest drainage from the Liquid Gold site has relatively higher levels of oil and grease and lead, plus the lowest total benthos density in the study area. Benthos at this sample site also receive greater exposure to desiccation and freshwater runoff. Given the uncertainty in determining the reason for the

LG006476

depressed benthos density, the cause may be due to the following: environmental factors, chemical concentrations at this location (T6-1), or a combination of these conditions. However, it appears slightly more likely that the cause is one of the latter two possibilities rather than being attributable to environmental factors alone. Because the other three sample stations within 30 meters of this location have benthos densities typical of the study area, it is concluded that there is no impact on aquatic biota through this drainage with the possible exception of the uppermost end of the Transect 6 tidal slough.

- The locations of sediment samples containing PCBs indicate that incoming tides have carried the PCBs into a portion of the study area from a source other than the Liquid Gold site's drainages sampled for this study.

- The absence of detectable PAHs and elevated heavy metals in the tissue of yellow shore crab, and the apparent health of the crab populations, suggests that the Liquid Gold site is not affecting this species.

- The absence of elevated levels of metals or PAHs in pickleweed and yellow shore crab tissue, plus a general lack of correlation between metal concentrations in sediment with those in plant and animal tissue, lead to the conclusion that these two species are not significant pathways into the food web for chemicals originating on the Liquid Gold site.

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Attachment C Sediment Analyses Results
Attachment D Benthos Data
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LG006481

1.0 INTRODUCTION

Prior to its closing in 1982, the Liquid Gold Oil Corporation (Liquid Gold) operated a waste oil storage and transfer facility adjacent to tidal wetlands along the east side of San Francisco Bay, California. This 18-acre property is owned by Southern Pacific Transportation Company and is located on the west side of Interstate 580 (formerly Hoffman Blvd.) about 1 mile northwest of Central Avenue in Richmond, Contra Costa County (Figure 1). During its years of operation, the Liquid Gold facility was responsible for improper chemical storage on the site and occasional discharges to the surrounding lowlands. The primary offsite recipient of these discharges was Hoffman Marsh, a pickleweed marsh located immediately south of the property. As part of the investigations of the Liquid Gold site, Western Ecological Services Company, Inc. (WESCO) was contracted to evaluate whether significant quantities of chemicals from the Liquid Gold operations have caused impacts to the biota of Hoffman Marsh and other property drainages.

1.1 STUDY OBJECTIVE

The objective of the biological investigations was to determine if significant quantities of potentially toxic chemicals from the Liquid Gold site have entered the wetlands adjacent to the site, and are impacting the biota of these wetlands. The biota of greatest concern are shorebirds (including the endangered California clapper rail), waterfowl, and small mammals (potentially including the endangered salt marsh harvest mouse). Shorebirds and waterfowl constitute the majority of wildlife feeding on the site. They have reproductive systems that are particularly sensitive to chemicals. Small mammals are near the base of the food chain and are preyed upon by more visible species such as raptors. The ways in which these species could potentially be impacted by toxic chemicals from the site are: 1) the ingestion of toxic substances through the food chain, 2) reduction in their food supply as food organisms die or fail to reproduce because of exposure to toxins, and 3) a loss of habitat for the species of concern or their food organisms because of vegetation loss resulting from toxic exposure. The following study was designed to address these possibilities using data obtained from sampling various portions of Hoffman Marsh.

1.2 STUDY AREA

Study area boundaries for the biological investigation are Highway 580 on the east, the old Santa Fe railroad tracks on the west, the Highway 580 exit to Central Avenue on the south, and the Stege channel on the north (Figure 1). Terrestrial wildlife and vegetation studies encompassed both uplands and wetlands throughout these boundaries. Aquatic studies were limited to the pickleweed marsh adjacent to Highway 580. The southern boundary of the aquatic study area is a berm bisecting this lower end of the marsh. Also included in the aquatic studies are two tidal sloughs draining the central portion and west side of the Liquid Gold site.

1.3 STUDY APPROACH

To answer the question of the potential impact from the Liquid Gold site on the wetland species of concern, it is necessary to distinguish between the impacts associated with the Liquid Gold site and other local sources of chemicals. Chemicals entering the marsh from other sources may mask those impacts caused primarily by the Liquid Gold site. Alternatively, chemicals from these

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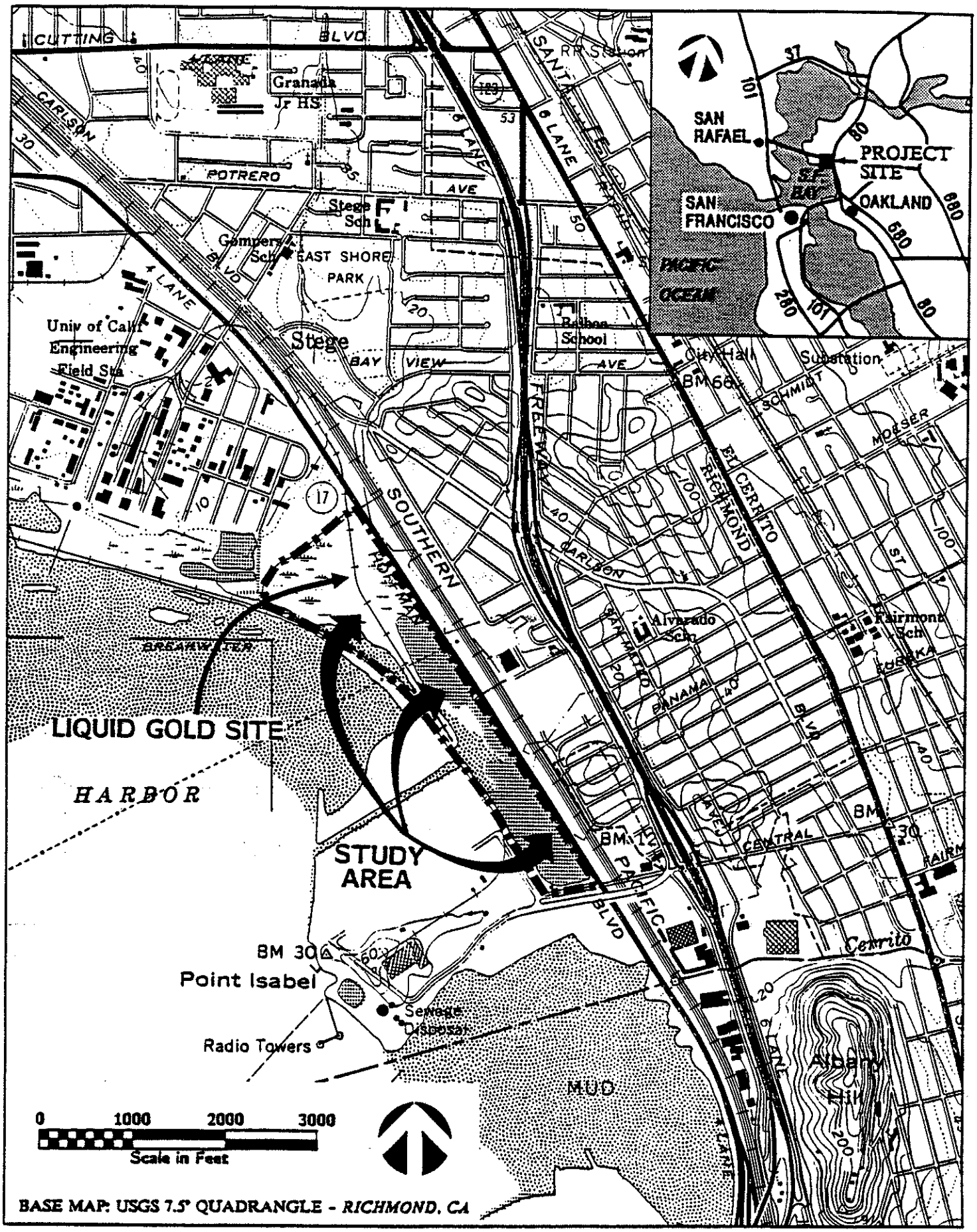

BASE MAP: USGS 7.5' QUADRANGLE - *RICHMOND, CA*

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Transportation Company
Hoffman Marsh/Liquid Gold Site

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FIGURE 1

BIOLOGICAL INVESTIGATION
STUDY AREA LOCATION

other sources may have the largest impact on Hoffman Marsh. Aside from the Liquid Gold site, chemicals could also be entering the marsh from the following:

- Stormwater runoff from Highway 580
- Urban stormwater runoff that enters through a culvert beneath Highway 580
- Adjacent hazardous waste sites such as Point Isabel
- Adjacent industrial areas
- Inflowing waters from San Francisco Bay

WESCO's study approach was designed to distinguish the Liquid Gold site's chemical contribution from the background levels of chemical concentrations across the wetlands, and to assess the potential impact of the site's chemicals upon the species of concern utilizing the marsh. The study focuses on indicator organisms within the food chain and on sediment analysis, as well as endangered species. The intent of the study was to compare chemical and biotic conditions from various portions of Hoffman Marsh. The condition of the north end of the marsh adjacent to the Liquid Gold site could be compared to the southern end which is furthest from the Liquid Gold site. If Liquid Gold's historical operations have had a significant impact on the marsh, differences in sediment chemistry, animal tissue chemistry, and benthic organism populations should be apparent.

The study approach included the following components:

- Sediment analysis for organic and inorganic chemicals
- Benthos sampling for abundance and relative composition
- Crab tissue analysis for organic and inorganic chemicals
- Vegetation mapping
- Pickleweed tissue analysis for inorganic chemicals
- Salt marsh harvest mouse live-trapping
- Small mammal live-trapping
- California clapper rail and black rail surveys

The intent of the sediment analyses was to establish the total concentrations of chemicals in the marsh potentially available for biological uptake. Plant and animal tissue analyses were included to allow assessment of the extent of biological uptake of pollutants by the test organisms. Benthos sampling was conducted to determine relative differences in species composition and density at various locations within the marsh. Vegetation mapping established the terrestrial habitat characteristics, while small mammal trapping indicated species composition and use of the Liquid Gold site. The salt marsh harvest mouse live-trapping was necessary to determine if this endangered species is present in Hoffman Marsh. The California clapper rail and black rail, two bird species of endangered and threatened status, respectively, were surveyed to determine if they use this marsh.

Recognizing that seasonal salinity variations of water in the marsh were likely to alter benthos species composition and the potential bioavailability of heavy metals in the sediment, the original study plan called for both a dry season and a wet season sampling of benthos and sediment. The dry season sampling was conducted in October of 1988. The wet season sampling was scheduled to occur in February 1989; however, drought conditions resulting in limited Delta outflows during that winter failed to create wet season conditions. After measuring February and March surface water salinities in Hoffman Marsh and monitoring the volume of Delta outflow, it was decided by

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WESCO that adequate wet season conditions had failed to materialize. With the agreement of the state and federal agencies involved on this project, the 1989 wet season sampling program was dropped from the study. A description of the methods employed and the data reviewed to reach this conclusion are provided in Attachment A.

The schedule followed for the field sampling portion of this study is shown in Figure 2.

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ACTIVITY SCHEDULE

TASKS:

	1988 MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1989 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Benthos/Sediment Sampling						---											
Benthos Tissue Sampling						---											
Mouse Trapping							---										
High Tide Rail Observations								--------									
Clapper Rail Call Survey											---------						
Veg. Community Mapping							-----										
Veg. Tissue Sampling												------					
Salinity Measurements							---			--------							

LEGEND:
MAJOR ACTIVITY PERIOD --------

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FIGURE 2
HOFFMAN MARSH BIOLOGY STUDY
SAMPLING SCHEDULE

2.0 METHODOLOGY

2.1 SEDIMENT

Field

Sediment and benthos sampling sites were established at intervals along six tidal sloughs (Figure 3). Site locations were spaced to give the entire channel representation, yet allow for the recognition of the possible contribution of chemicals from small tributary channels. Transects 1 through 4 were located in the pickleweed marsh adjacent to Highway 580, and Transects 5 and 6 were along sloughs draining the west side of the Liquid Gold site.

Most transects had four sampling stations distributed along its lengths. Transects 1 and 5 were in particularly long sloughs and received six stations each. Stations were denoted by transect number followed by the station number (e.g., Transect 2, station 3 would be T2-3).

The sediment and benthos sampling occurred at intervals along the bottom, top, and side-slopes of the six tidal sloughs. The four primary transects in the pickleweed marsh (T-1 through T-4) each consisted of three series of sample points. Transect sample points in the bottom of channels were part of the "A" series and their samples labeled with an A at the end of the sample number. Sample points midway along the side-slope of the channels are part of the "B" series and are indicated with a B. Those sample points located out of the channel and in the pickleweed were denoted by a C to indicate the "C" series. Therefore, the three component series of Transect 1, Station 3 would be referred to as T1-3A, T1-3B, and T1-3C.

Transects 5 and 6 draining the western side of the Liquid Gold site were sampled for sediment and benthos only from the A series in the bottom of the channel. The B series sampling was included in Transects 1 through 4 because shorebirds were observed to concentrate their feeding in the pickleweed marsh represented by these transects. Shorebirds probe both the bottom and the sides of the sloughs for invertebrates. A summary of the number of samples per transect and station is provided as Table 1.

Sediment sampling in the A and B series consisted of using a stainless steel Ekman dredge to collect a cube of sediment measuring approximately 15 x 15 x 15 cm. A teflon coated spatula was used to remove the outermost 1 cm of sediment from the sides of the sample where it contacted the Ekman dredge. The same spatula was then used to transfer the sample into glass jars. Series C samples were collected by inserting a 4.5 and 15 cm brass tube full length into the soil, then extruding the sample into a glass jar. Labeled jars containing the sample were then iced and stored in a cooler until delivery to the laboratory within 10 hours of sampling.

Quality Control

The equipment used to sample sediment was cleaned between samples. Initially rinsed with local bay water to remove the large pieces of mud, this was followed by a washing with a TSP solution, then a rinse with distilled water. A check list of samples was kept in the field to facilitate tracking the large number of samples being handled. As each sample was placed in the cooler, its

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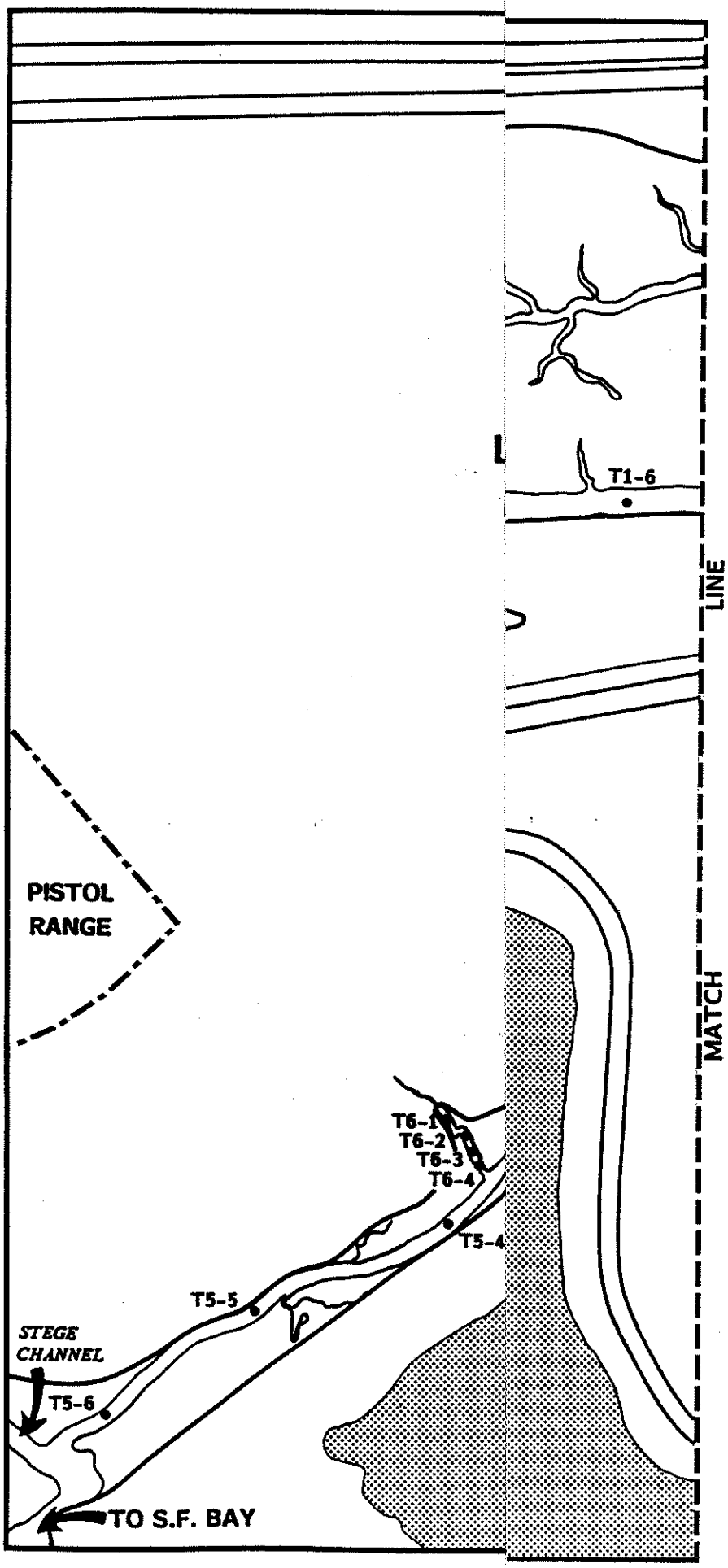

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Hoffman Marsh/Liquid Gold Site

FIGURE 3

SEDIMENT AND BENTHOS SAMPLING STATIONS IN HOFFMAN MARSH, OCTOBER 1988

LEGEND

UPPER TIDAL INUNDATION

• SAMPLING LOCATION

N

0 200 400

Scale in Feet (Approximate)

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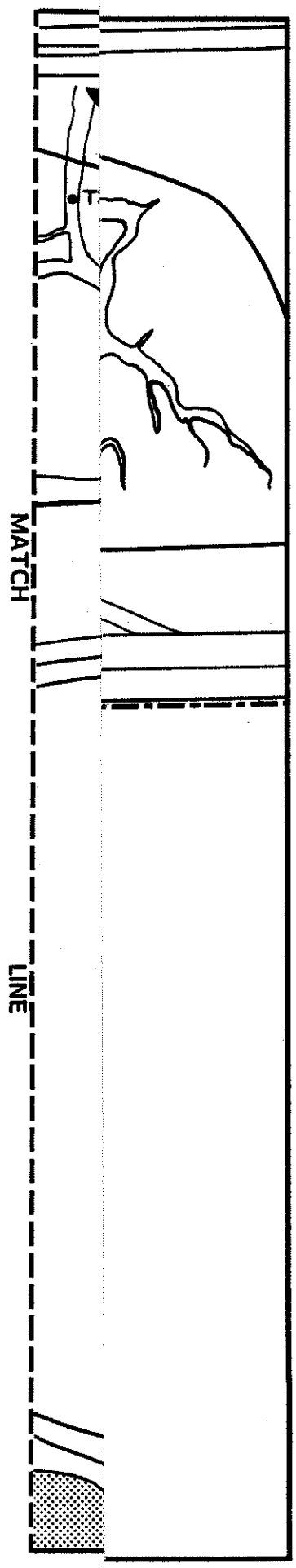

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FIGURE 3, continued

SEDIMENT AND BENTHOS
SAMPLING STATIONS IN
HOFFMAN MARSH,
OCTOBER 1988

LEGEND

UPPER
TIDAL INUNDATION

• SAMPLING LOCATION

N

0 200 400

Scale in Feet
(Approximate)

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Table 1
Number of Samples per Transect
Hoffman Marsh Biological Investigations

	#1			#2			#3			#4			#5	#6	Samplings Per Year	Total No. Samples
	A	B	C	A	B	C	A	B	C	A	B	C	A	A		
Sediment	6	6	4	4	4	4	4	4	4	4	4	4	6	4	1	62[1]
Benthos[2]	24	24		16	16		16	16		16	16		24	16	1	184
Crab Tissue	3			2			2			2			3	2	1	14
Plant Tissue			4			4			4			4			1	16

[1]Plus seven duplicate sediment samples.
[2]Four replicates per site for the A and B series.

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sample number was entered onto a chain-of-custody form. This form then accompanied the samples to the laboratory.

Prior to initiating the field sampling, a random number table was used to select six sites (10 percent of the total number of sites) from which to collect a duplicate set of sediment samples for analysis. The collection of duplicate samples was to provide an indication of chemical variability of the sediment at those sites. The sites selected for duplicate sampling are listed below by series.

A series	B Series	C Series
T6-1	T3-4	T4-3
T1-6	T2-3	
T4-4		

Laboratory

Once in the laboratory, the samples were stored at 4 degrees C and analyzed within 14 days. Sediment samples were analyzed for a variety of physical characteristics and chemical constituents. These analyses and the methods employed are presented in Table 2. Particle size determination used a series of brass Standard U.S. sieves of the following sizes: 0.063, 0.125, 0.180, 0.250, and 0.425 mm. Once these particle size ranges were determined, this data was converted by cubic interpolation to Phi values as 10 categories ranging from -6 (pebble) to 8 (clay)(Blatt 1967; Matthews 1974). The QA/QC procedures for the State Certified Laboratories that performed the analyses were provided in the *Quality Assurance Project Plan of the Remedial Investigation/Feasibility Work Plan* for the site (reissued December 1988).

2.2 BENTHOS

Field

With one exception, benthos sampling locations are the same as those described previously for sediment sampling. The exception is that no benthos samples were collected from the C series of T1 through T4. The rationale for this is that shorebird feeding on the pickleweed flats is focused on invertebrates associated with the surface vegetation rather than the underlying substrate. At each sample point on the A and B series, four replicate benthos samples were collected with the Ekman dredge described previously. Prior to removing the sample from the dredge, a measurement of sample height within the dredge was recorded in case calculations of sample volume became necessary. The sample was then deposited in a wash bucket with a 0.5 mm mesh screen, and washed in the field. Care was taken that no water entered over the top of the wash bucket as the sample within the bucket was agitated in the tidal waters. Once cleaned of fine sediments, the remaining sample was stained with Rose Bengal dye and stored in a plastic container with a 10 percent formalin solution.

Labeling of the benthos samples began with transect number, followed by sample point, then replicate number, followed by an A or B to denote the series. Sample T1-2-3B would be from Transect 1, station 2 of the B series, and be the third replicate.

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Table 2
Sediment, Plant and Crab Tissue Analytical Methods
Liquid Gold Site - Hoffman Marsh, Richmond, California

Analysis	Method	Reference
SEDIMENT:		
Metals:		
Chromium	ICAP	EPA 600/4-79-020 and SW-846
Copper	ICAP	
Lead	AA	
Mercury	Cold-vapor AA	
Nickel	ICAP	
Zinc	ICAP	
PCB	EPA 3540 (Soxhlet extraction) EPA 8080	SW-846
BNA	EPA 8270	SW-846
TPH	Hexane extraction GC/FID	RWQCB
Oil and grease	SM 503	Standard methods
TOC	EPA 9060	SW-846
Chloride	EPA 325	SW-846
Sulfide	EPA 9030	SW-846
Total Sulfur	Microcoulometric	--
Particle Size	Hydrometer	EPA Soil Test Methods
PLANT TISSUE:		
Metals:		
Chromium	ICAP	EPA 600/4-79-020 and SW-846
Copper	ICAP	
Lead	ICAP	
Nickel	ICAP	
Zinc	ICAP	

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Table 2 cont'd.

Analysis	Method	Reference
CRAB TISSUE:		
Metals:		
Copper	ICAP	EPA 600/4-79-020
Lead	ICAP	and SW-846
Mercury	Cold Vapor AA	
Nickel	ICAP	
Zinc	ICAP	
BNA	EPA 8270	SW-846

Abbreviations:
ICAP = inductively coupled argon plasma
AA = atomic absorption
PCB = polychlorinated biphenyl
BNA = base/neutral, acid extractable compounds
TPH = total petroleum hydrocarbons
GC/FID = gas chromatography, flame ionization detector
TOC = total organic carbon

References:

Standard Methods for the Examination of Water and Wasterwater, 16th edition. APHA-AWWA-WPCF, 1986.

Test Methods for Evaluating Solid Waste, 3rd ed. EPA SW-846. November 1986.

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Quality Control

Quality control during the benthos field sampling consisted of: having a checklist for noting each sample as it was collected; measuring the sample height within the dredge; taking four replicate samples; and labeling each sample jar twice (once on the outside and one label placed inside the container). A master checklist was maintained at WESCO to track the benthos samples as they were brought in each day.

Laboratory

Approximately 72-120 hours after sampling, the samples were washed in WESCO's laboratory using a 0.5 mm sieve and stored in 75 percent ethanol. Immediately before sorting, the sample was again rinsed to remove excess ethanol.

To permit the processing of the 182 benthos sample replicates to be completed in a reasonable time, most of the sieved benthos samples were split in half and only one half sorted and analyzed. The organisms for each sample were sorted into the following major taxonomical groups:

- Crustacea
- Mollusca
- Vermes (Polychaeta, Oligochaeta, and Nematoda)
- "Other"

The samples that passed quality control, along with all other sorted samples in that batch, were sent to taxonomists who then identified all the organisms to the lowest taxon readily possible, and counted them. A schematic diagram of the benthos processing procedures is provided as Figure 4.

Quality Control

To determine how representative these half-sample splits were of the whole, 10 percent of the split samples had both halves sorted separately but by the same sorter. Quality control for the sample sorting was provided by the following procedure. Ten percent of each individuals' samples were sent to quality control for resorting to insure that sorters were consistent in their effort and their ability to recognize the benthos species. The samples which failed the 95 percent detection requirement were resorted as were all others in that batch of 10 samples sorted by that individual. The benthos sorting laboratory supervisor was the only individual allowed to remove unsorted samples from storage for sorting and to distribute sorted samples to the quality control person and the taxonomists. Written records similar to a chain-of-custody form and a master list of samples were used to facilitate this process.

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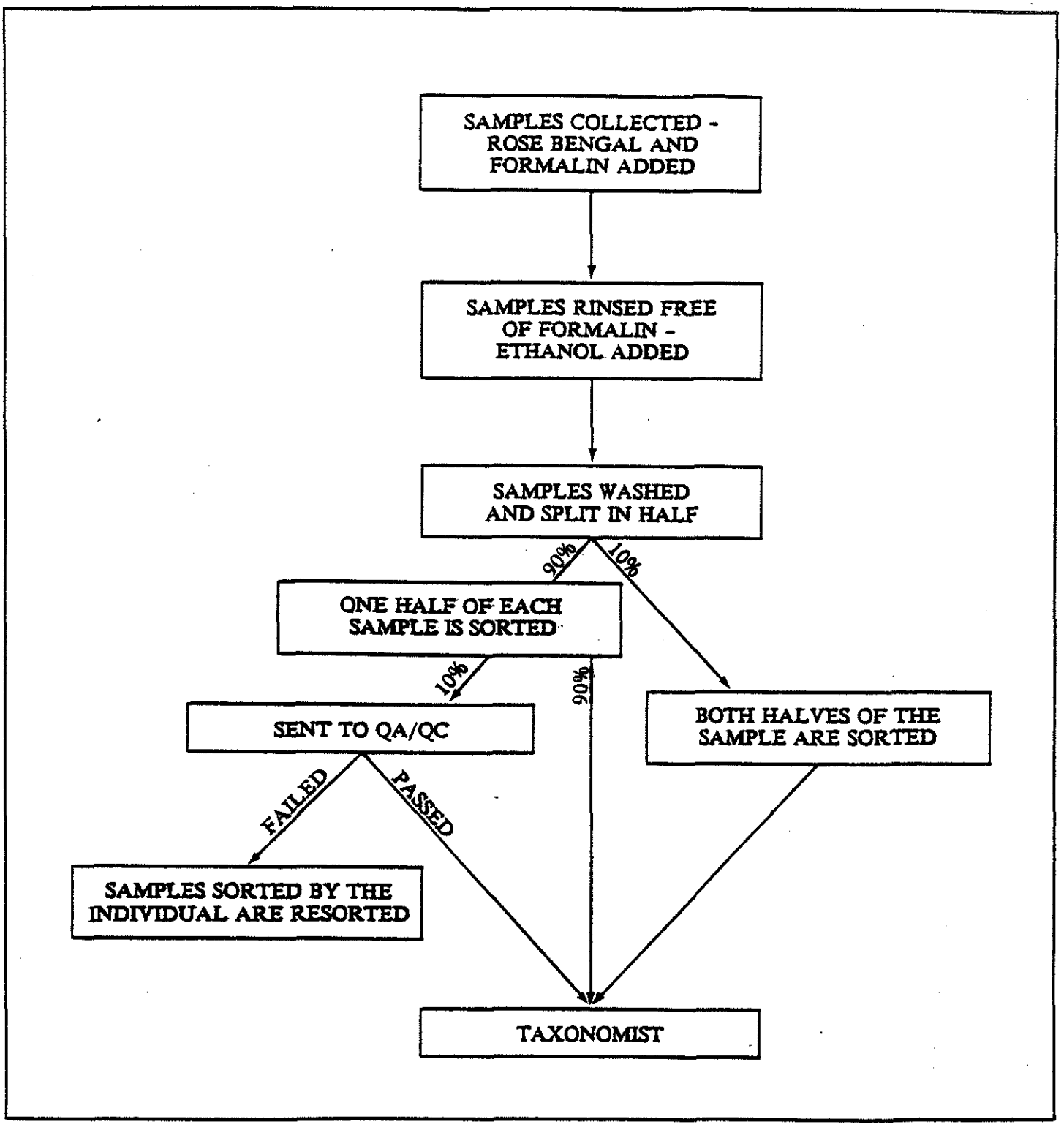

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Southern Pacific Transportation Company
Hoffman Marsh/Liquid Gold Site

FIGURE 4
BENTHOS SAMPLE PROCESSING PROCEDURES

2.3 TISSUE

Field

Plant Tissue

Bioavailable heavy metals may be taken up by a plant with other ions through the roots; however, petroleum hydrocarbons are not readily taken up by living plants in this manner (Hershner and Lake 1980). Mercury testing was included although, in reducing soils such as these of the marsh, physical and chemical forces hold the mercury in insoluble sulphides or organic complexes (National Academy of Sciences 1978). To determine the concentrations of chromium, copper, lead, nickel, and zinc available for entering the food chain through the pickleweed in the marsh, the uppermost tips (2-3 cm from the top) of pickleweed were collected during mid-April of 1989. The 16 samples were taken from sites corresponding to the C series for all the transect stations for T1 through T4 with the exception of T1-4 and T1-6. These latter two sites were omitted because it was felt that T1 was adequately represented by its other four sites and T2-4.

Pickleweed tops (*Salicornia virginica*) were removed with stainless steel scissors from plants within a 1-meter radius of the sediment sampling location for each of these sites. Only green, living tissue was sampled. Approximately 30-40 grams of tissue was collected at each site. The material was placed in a self-sealing plastic bag and stored on ice in a cooler until delivery to the laboratory within 2 hours of sampling.

Quality Control. Contamination of the samples was avoided by using clean stainless steel scissors and storing the vegetation samples in self-sealing plastic bags. The sample containers were labeled both inside and out. A chain-of-custody accompanied the chilled samples to the laboratory.

Animal Tissue

At the time of the dry season sampling in October of 1988, it soon became evident that of various candidate animal species for tissue analysis, the yellow shore crab (*Hemigrapsus oregonensus*) was abundant throughout the marsh, while clams and mussels were uncommon. Only two ribbed horse mussels (*Ischadium demissum*) were observed in the entire marsh. No mud snails (*Nassarius obsoletus*) were found in the marsh, and live clams were infrequently captured during benthos sampling. Although of low density (62 clams per square meter), the clam *Macoma balthica* was the most common bivalve in the marsh. However, its small size (20 mm) and low density made it necessary to gather 200 to 300 clams per site in order to extract the 20-30 grams of tissue needed for the full spectrum of analyses for heavy metals and organic chemicals. Large areas of the tidal sloughs of Hoffman Marsh would have to be disrupted to obtain a sufficient number of clams. For these reasons, the yellow shore crab was selected and approved by the agency representatives for tissue analysis (October 28, 1988 meeting).

Yellow shore crabs were collected in October 1988 with baited minnow traps set throughout approximately 6 hours of a high tide cycle. The collection points were the sediment and benthos sampling stations of all six transects with the following exceptions. Because of its short length (30 meters), crabs were collected from only two of the four benthos sampling stations in Transect 6. Site

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T6-2 was trapped instead of T6-1 because the uppermost site was too exposed and potentially vulnerable to vandalism during all but the highest tidal conditions.

The number of crabs captured at each station was recorded. Approximately 1 liter of live crabs was saved from the upper and lower end of each transect for tissue analysis. Transects 1 and 5, because of their greater lengths, also had crab tissue analyzed from a station near the middle of their length. A total of 14 crab samples were delivered to the laboratory for analysis.

Quality Control. The live crabs were wrapped in aluminum foil and the package labeled both inside and out. When delivered to the cooler within 60 minutes after their collection, each sample number was entered onto chain-of-custody form which accompanied the samples to the laboratory. The labeled samples were then stored with ice in a cooler and delivered to the laboratory within 2 hours.

Laboratory

Plant Tissue

Pickleweed samples delivered to the laboratory were frozen and stored at 4 degrees C. Samples were ground under liquid nitrogen and then digested with nitric acid and hydrogen peroxide to measure chromium, copper, lead, nickel, and zinc concentrations using inductively coupled argon plasma atomic emission spectroscopy. Mercury concentrations were measured using the cold-vapor flameless atomic absorption method after digestion with potassium persulfate, potassium permanganate, and aquaregia.

Animal Tissue

The crab samples were frozen at the laboratory and stored at 4 degrees C. Within 14 days of sampling, each sample was homogenized by placing the entire crab(s) into a blender and grinding the sample into a paste. Samples were then digested in concentrated nitric acid using a modified EPA Method 3050. Sample extracts were analyzed by GC-MS for organics and the heavy metals by ICP and cold-vapor AA (see Table 2).

Quality Control. Laboratory QA/QC procedures for all plant and animal tissue analyses are described in Attachment B.

2.4 VEGETATION

Existing literature pertaining to the vegetation of the Liquid Gold/Hoffman Marsh study area was reviewed. A survey of the study area was conducted by WESCO on November 7, 1988. A botanist walked the entire study area, recorded all identifiable vascular plants, and mapped vegetation types onto a 1:2400 scale air photo.

2.5 WILDLIFE

Existing literature on the local flora and fauna was reviewed to evaluate site conditions and to determine the known distribution of animal species of concern in the study area. Field surveys

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of the Liquid Gold site and adjacent Hoffman Marsh were conducted on November 7-11, 1988, and January 19 and March 6, 1989. The purpose of these surveys was to assess the existing wildlife resources and to determine the presence of any rare, threatened, or endangered animal species.

Specific surveys were conducted to determine the presence of the endangered California clapper rail (*Rallus longirostris obsoletus*) and threatened California black rail (*Laterallus jamaicencis coturniculus*) in Hoffman Marsh. Surveys were conducted during a winter flood tide event (January 19) and during the breeding season (March 30 and May 2). Procedures during the winter survey involved 3 hours of visual observations during a flood tide (6.7 feet) reported for 9:00 a.m. During such high tides, rails are usually forced to the highest exposed areas of the marsh and are more readily detected. Tape-recorded calls were broadcast from various points around the marsh to elicit a vocal response from clapper rails and black rails during breeding season surveys.

WESCO also conducted a live-trapping survey for the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*), and other small mammals, during the period of November 7-11, 1988. On November 7, nine traplines of 24 to 25 traps each were set in representative habitats (above the high water line) throughout the study area. On November 8, two additional traplines were set. Sherman live-traps, placed at 20-foot intervals, were insulated with polyester fiber bedding and baited with a mixture of rolled oats, wild bird seed, and walnut meat. Walnut extract was applied to the door of each trap as an attractant. Traplines were inspected for 3 to 4 consecutive days between 6:30 and 10:00 a.m. All traps were removed on November 11 for a trapping effort of 1,013 trap-nights. In addition to live-trapping, cover (i.e., boards and other debris) was overturned in an effort to locate salt marsh harvest mice and other species such as the salt marsh wandering shrew (*Sorex vagrans halicoetes*). Species determination for the salt marsh harvest mouse was accomplished using standard tail and body measurements. To avoid counting recaptures, captured mammals were temporarily marked with a harmless dye.

The presence of other animal species of concern, and common species typical of the region, was determined through incidental observations made during specific surveys described above and other sampling activities. To evaluate the presence of the larger and more elusive mammals, seven Have-a-Hart cage traps were distributed across the study area concurrently with the small mammal live-trapping effort. Each trap was baited with sardines and inspected for 4 consecutive days for a trapping effort of 28 trap-nights.

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3.0 METHODS FOR STATISTICAL ANALYSIS OF DATA

Of the various components of the biological investigation, only data from the following had sufficient sample sizes to warrant statistical evaluation: sediment analysis, benthos, plant and animal tissue analyses. Because Transects 5 and 6 are in a different drainage than Transects 1 through 4, and lack the almost exclusively pickleweed plant community of these latter transects, statistical evaluations were performed separately whenever possible. A description of the statistical methods employed for each of these data sets is provided in the following sections.

3.1 SEDIMENT

Star plots were used to provide a means of displaying multivariate data for the purposes of presentation of information and for visual examination of findings. For economy of presentation and analysis, the sediment analysis measurements were grouped into the following three groups:

- copper, lead, zinc, mercury, nickel, and chromium;
- chloride, TOC, Phi value (sediment particle size); and
- total sulphur, sulfide, pH and oil & grease.

Cluster analyses were performed for Transects 1 through 4 for each of the above groups of variables for each series for the purpose of statistically identifying unusual sample locations. Transects 5 and 6 were not analyzed by cluster analysis because of an insufficient number of data points. The results from these analyses provided additional information with which to evaluate and corroborate trends or findings emerging from the visual examination of the star plots. For the cluster analyses, the group of metals was divided into: 1) copper, lead, zinc, and 2) mercury, nickel, chromium. Thus, there were four groups of variables (two sets of three metals each, plus the two physical chemical groups noted above) requiring separate analysis for each sample series A through C. The reasons for these groupings of three or four variables each are: 1) it is easier to identify visually which stations are unusual; and 2) in performing a cluster analysis, it is generally advisable to have at least five times as many data points (i.e., sample stations) as variables. For the evaluation of each group, cluster analysis was performed using three different clustering algorithms to validate the robustness of the results with respect to choice of clustering method. All noteworthy cluster analysis findings reported are those that were found to be unaffected by choice of clustering linkage algorithm (i.e., centroid linkage, single linkage or nearest neighbor, and further neighbor).

Data for all variables subject to statistical characterization in star plots and cluster analysis were normalized for each series (A, B, C) and transect areas (T1-4, T5-6). This was necessary because of the differences in scale of the analysis results for the variables. Thus, a "normalized" value for a particular measure (e.g., lead concentration) and sample point was determined by subtracting the overall mean for the area and series from the observed value for the sample point, and then dividing the difference by the sample standard deviation of the measure for the area and series.

For the purpose of calculating the mean for the area and series, a value had to be assigned to those constituents having non-detectable concentrations. For heavy metals, the detection limit

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was used; for organics, a value of 0 was used. These values were chosen on the belief that heavy metals are present at background levels even if too low to be detectable. Since organics are less common in the local environment, it was felt to be reasonable to assume their absence if below detection limits.

3.2 BENTHOS

Stacked bar graphs were used to display the total abundance of the benthic organisms by site and also illustrate each site's composition by major taxa. Cluster analyses were also conducted on the benthos composition for both T1 through T4 and T1 through T6. For the A series, the cluster analysis was performed using the total number of organisms for the four major taxa of the series (i.e., oligochaetes, polychaetes, nematodes and cumaceans). For the B series, the total numbers of amphipods were used in place of the numbers of cumaceans. For the purpose of placing emphasis on identifying sample locations with unusually low numbers of organisms in one or more taxa, the cluster analysis was based on $\frac{100}{\text{natural log (number of organisms + 3.0)}}$ for each taxon included on the analysis for each site and series.

To determine if overall correlations existed between the density of certain taxa and the physical and chemical characteristics of the associated sediment, Pearson correlation coefficients (r) and associated p-value were computed. This effort was supplemented by examining individual scatter plots for high correlations and identifying possible nonlinear relationships.

The Pearson correlation coefficient is a measure of linear association between two variables. This statistic is defined from -1 (perfect inverse association) to +1 (perfect direct association), with values near zero representing no association. Significance probabilities (p-values) are a measure of the probability of a particular result being due to chance alone. Small p-values (e.g., <0.10, 0.05, 0.01) are therefore generally considered to be statistically significant because they are unlikely to occur by chance.

Because of the small number of sample locations (six) with detectable polynuclear aromatic hydrocarbons (PAH), the Pearson correlation coefficient was not computed. The Wilcoxon rank sum tests was used to determine if sample locations with detectable levels of total PAH's had significantly different benthos densities.

The evaluation of differences between the benthos sample splits was accomplished through calculation and examination of the mean Coefficient of Variation (S.D./X) and the Percent Sampling Error ($|X_1 - X_2|/X$) based on the paired split values.

3.3 TISSUE

Plant Tissue

Analyses were conducted to determine if metal concentrations in sediments correlated with those in plant tissue. All analyses consisted of computation of Pearson correlation coefficients (r) and associated p-values, and of examination of individual scatterplots for the purpose of detecting

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high correlations and identifying possible nonlinear relationships. Each sampling station contributed no more than one observation for analysis.

Animal Tissue

Crab tissue contained no detectable levels of organic pollutants, but its heavy metal concentrations were detectable and were evaluated with star plots. For the purpose of normalizing these data, a nondetectable level of a heavy metal was given a value of half the detection limit. This was because heavy metals are assumed likely to exist in crab tissue, but at lower levels than that common to the marsh sediments.

To compare the metal concentrations in crab tissue to concentrations in the sediment samples, scatter plots and correlation coefficients were computed and examined in the manner described previously for plant tissues.

LG006501

4.0 OVERVIEW OF RESULTS

The sediment chemistry, benthos results, and tissue analysis results presented in this section serve to provide a descriptive overview of these data. Detailed discussions of the interpretation of these data are provided in Section 5.0.

4.1 SEDIMENT

Chemical and Physical Characteristics

The particle sizes prevalent in the sediment samples were converted to Phi values and are provided in Attachment C. The laboratory analysis reports for particle size, plant tissue, and crab tissue, plus a summary of the associated QA/QC, is presented in Attachment B. Note that the crab tissue laboratory analysis results in Attachment B are shown as wet weight concentrations, while the body of this report expresses these results on a dry weight basis unless noted otherwise. The A series of Transects 1 through 4 ranged from very coarse sand to very fine sand. The B and C series of these transects were similar for the upper range of particle size, but progressively more coarse on the low range with the increase in elevation (fine sand and course sand, respectively). The A series of Transects 5 and 6 ranged in particle size from granule to course silt.

The results of the chloride, TOC, oil and grease, sulphide, total sulphur, and pH analyses are also included in Attachment C. However, a summary of the range of values, and the location where they occurred, is presented in Table 3.

Organics

No detectable levels of phenol (<0.330 mg/kg wet weight) or TPH (<0.1 mg/kg wet weight) were found in the sediments. PCBs were present in samples from nine of the sample sites (Table 4). The upper and lower ends of Transect 3 contained PCBs, and the remaining occurrences of PCBs were located in Transects 5 and 6. The highest reported concentration of PCBs was 0.63 mg/kg from the A series of site T5-6.

Eight BNAs were found in the study area's sediments (Table 5), all but bis(2-ethylhexyl) phthalate being PAH. The most prevalent was pyrene, which was detected in 12 samples plus a duplicate sample. With two exceptions, BNAs were at the lower end (near San Francisco Bay) of all six channels sampled. The exceptions were Transects 1 and 6. Detectable PAHs were present in the A series of T1-1, 2, and 4; the B-series of T1-2 and 3; and T1-2 of the C series. In Transect 6, PAHs occurred at T6-1 and 2.

Heavy Metals

The results of the sediment analyses for heavy metals are provided in Attachment C. A summary of these analyses is presented in Table 6.

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Table 3
Summary Statistics for Selected Chemical Analyses of Sediment Collected from Hoffman Marsh, October 1988

	Concentration in mg/kg Dry Weight						
	Chloride	Total Organic Carbon	TPH*	Oil/Grease	Sulphide	Total Sulphur	pH (units)
Transects 1 through 4							
Series A:							
Maximum (Location)	41,000 (T2-1)	34,000 (T2-1)	<1	2,800 (T1-1)	1,600 (T1-1)	1,300 (T1-1)	8 (T4-3)
Minimum (Location)	7,800 (T4-3)	3,800 (T1-2)	<1	310 (T4-3)	250 (T4-3)	97 (T4-3)	7.1 (T2-1)
Mean	19,000	19,000	<1	1,200	760	350	7.6
Series B:							
Maximum (Location)	32,000 (T1-1)	53,000 (T1-1)	<1	2,200 (T2-4)	1,800 (T2-4)	880 (T2-4)	7.8 (T1-6)
Minimum (Location)	14,000 (T3-3)	2,700 (T3-4)	<1	110 (T3-1)	38 (T3-3)	29 (T3-1)	6.8 (**)
Mean	20,000	22,000	<1	1,000	410	250	7.1
Series C:							
Maximum (Location)	50,000 (T2-1)	66,000 (T4-2)	<1	1,500 (T4-2)	4,900 (T4-2)	710 (T4-2)	7.3 (T1-5)
Minimum (Location)	21,000 (T3-2)	16,000 (T1-5)	<1	110 (T2-2)	42 (T1-2)	29 (T3-2)	6 (T3-1)
Mean	29,000	38,000	<1	760	460	120	6.7
Transects 5 and 6							
Series A:							
Maximum (Location)	31,000 (T6-2)	97,000 (T6-1)	<1	4,300 (T6-1)	3,200 (T6-3)	1,300 (T6-3)	7.9 (T5-6)
Minimum (Location)	6,300 (T5-6)	5,700 (T5-4)	<1	360 (T5-6)	150 (T6-1)	94 (T5-6)	7.4 (T6-3&4)
Mean	16,100	28,000	<1	1,700	1,200	430	7.4

*Total Petroleum Hydrocarbons.
**A pH of 6.8 occurred at T2-3 and 4, and T3-4.

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Table 4
PCB Concentrations in Hoffman Marsh Sediment
October 1988

Site	PCB's in mg/kg Dry Weight
A Series:	
T3-4	0.34
T5-3	0.28
T5-4	0.22
T5-5	0.30
T5-6	0.63
T6-1	0.35
T6-1 Duplicate	0.38
B Series:	
T3-1	0.59
T3-4	0.20
C Series:	
T3-4	0.25

Notes:

- Transects 5 and 6 were sampled only in the A series (bottom of channel).
- Only those sites with detectable concentrations of PCBs are shown (detection limit = 0.1 mg/kg).

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Table 5

Hoffman Marsh Concentrations of Base/Neutral/Acid Extractables

October 1988

SITE	Sediment and Soil Concentrations as Milligrams/Kilogram, Dry Weight							
	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Bis(2-Ethylhexyl)phthalate	Chrysene	Benzo(b)fluoranthene	Benzo(a)pyrene
T1-1A		2.42	2.03	1.90		2.12	1.30	1.00
T1-2A			1.20					
T1-4A			0.90					
T1-2B			1.17					
T1-3B			0.85					
T1-2C	2.02	1.30	5.55	0.91		1.30		
T2-4B	0.88							
T3-4A	0.62	0.74	1.72					
T3-3B			0.72					
T4-4A			0.80		2.80		0.66	
T4-4A dup.							0.54	
T4-3B							0.66	
T4-4B							0.70	
T4-3C							0.52	
T4-3C dup.							0.84	
T4-4C							0.80	
T5-6A	0.71	0.57	0.61		1.28			
T6-1A		1.43	3.78			1.08		
T6-1A dup.		1.62	2.86			1.62	1.37	
T6-2A		1.38	2.67					

Notes:
- o "A" series are mid-channel, "B" series are sideslopes, and "C" series are out-of-channel.
- o Dup. indicates a duplicate sample.
- o Of the base/neutral/acid extractables (BNAs) listed above, all but bis(2-ethylhexyl)phthalate) are polycyclic aromatic hydrocarbons (PAHs).

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Table 6
Summary Statistics for Heavy Metal Analyses of Sediment Collected from Hoffman Marsh, October 1988

	Concentration in mg/kg Dry Weight					
	Cr	Cu	Pb	Hg	Ni	Zn
Transects 1 through 4						
Series A:						
Maximum (Location)	100 (T2-1)	120 (T2-1)	240 (T1-6)	2.30 (T2-1)	88 (T204)	590 (T2-1)
Minimum (Location)	27 (T1-2)	38 (T1-2)	82 (T4-3)	0.64 (T3-4)	27 (T1-2)	27 (T1-3)
Mean	61	72	180	1.20	57	280
Series B:						
Maximum (Location)	120 (T4-1)	140 (T4-1)	360 (T1-4)	2.90 (T3-1)	83 (T2-1, T3-2)	450 (T4-1)
Minimum (Location)	54 (T3-3)	53 (T4-4)	150 (T3-3)	0.87 (T4-4)	51 (T1-2)	150 (T4-4)
Mean	79	87	240	1.50	67	270
Series C:						
Maximum (Location)	100 (T4-3)	110 (T1-3)	470 (T1-5)	1.40 (T1-3)	85 (T4-3)	310 (T1-5)
Minimum (Location)	47 (T1-2)	32 (T4-3)	220 (T3-4)	0.51 (T4-3)	44 (T1-1, T1-2)	87 (T1-1)
Mean	71	65	350	0.91	67	180
Transects 5 and 6						
Series A:						
Maximum (Location)	87 (T6-3)	180 (T5-4)	410 (T6-1)	4.50 (T6-3)	62 (T6-1)	900 (T6-3)
Minimum (Location)	43 (T5-6)	34 (T6-3)	120 (T5-1)	0.57 (T5-6)	43 (T5-3)	200 (T5-6)
Mean	62	120	210	1.80	54	460

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4.2 BENTHOS

Detailed information on the results of the benthos analyses is available in Attachment D. A list of the benthos taxa found in the sediments of the study area is shown as Table 7. Figures 5 and 6 illustrate the mean benthos composition by major taxa for the A series of Transects 1 through 4 and Transects 5 and 6, respectively. Figure 7 shows the mean benthos composition for the B series of Transects 1 through 4. Because of geographical and environmental differences between the pickleweed marsh and the channels represented by Transects 5 and 6, and results of these latter two transects should not be compared directly against the results for Transects 1 through 4.

The benthos species were grouped into the following major taxa for data evaluation: Polychaeta, Oligochaeta, Nematoda, Amphipoda, Cumacea, and other. Approximately 85 percent of the Polychaeta were *Streblospio benedicti*, 98 percent of the A series Amphipoda were *Grandidierella japonica*, and 98 percent of the B series Amphipoda were *Corophium spinicorne*. The majority of the cumaceans were *Hemileucon hinumensis* and the rest mostly *Cumella* sp. The "other" category is comprised primarily of the yellow shore crab with occasional snails and *Macoma balthica*. Brief descriptions of the organisms dominating the benthic community during this sampling are presented below.

Streblospio Benedicti

Streblospio benedicti is a small (adults are <20 mm long), free-living polychaete in the family Spionidae. It is a benthic infaunal worm often present in estuaries, beaches or where the substratum consists of fine mud with considerable organic debris (Jong 1977). This species is a common, opportunistic, and often numerically dominant member of estuarine deposit feeding communities. Surveys in San Francisco Bay have found peak abundances of *Streblospio benedicti* to occur during late winter and early spring months (June 1961; Liu, Martin and Norwood 1975; Nichols 1977).

Oligochaetes

Segmented aquatic worms of the class Oligochaeta are mostly restricted to freshwater but a few species are euryhaline and common to brackish-water sediments. The majority of oligochaetes found in San Pablo Bay, Point Richmond, and probably the Liquid Gold site as well, is the turbificid, *Peloscolex gabriellae*. These thin worms can occur in extremely high numbers where substrate conditions provide nutrient enrichment, little or no toxic chemicals, and good oxygen levels (Brinkhurst and Simmons 1968).

Grandidierella Japonica

This Japanese amphipod was introduced to central California with plantings of Japanese oyster (Chipman and Dorman 1975). It is a free-living organism that builds u-shaped tubes in mud substrate, and is often associated with the amphipod *Corophium spinicorne* and the bivalve *Macoma balthica*. Chapman and Dorman (1975) report the largest male *G. japonica* they captured to be 22 mm in length while the largest female was 13 mm.

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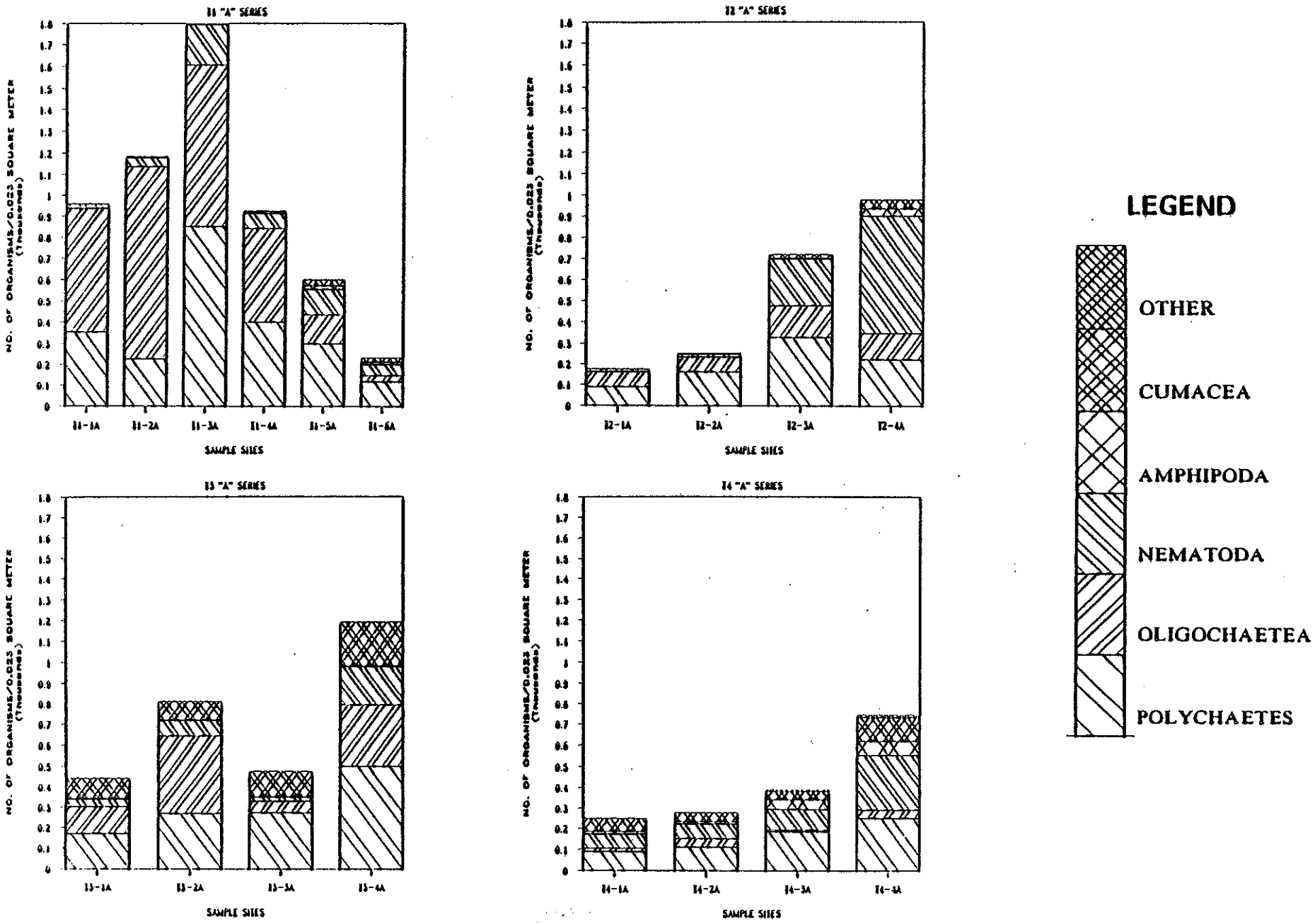


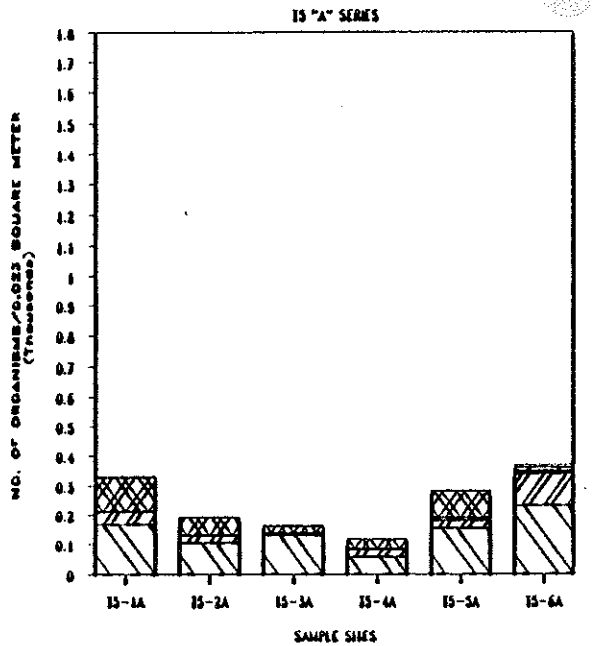
Southern Pacific Transportation Company

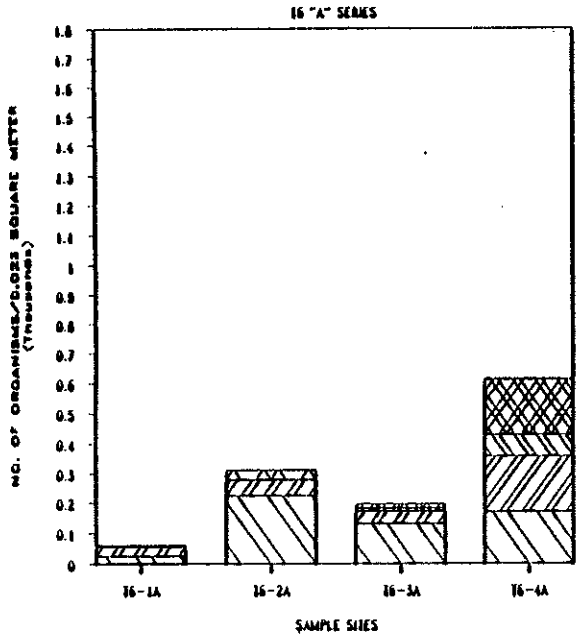
Hoffman Marsh/Liquid Gold Site

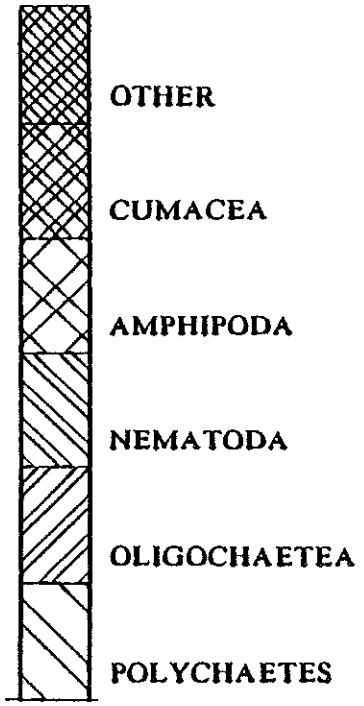
LG006508

FIGURE 5

HOFFMAN MARSH MEAN BENTHOS COMPOSITION BY MAJOR TAXA, TRANSECTS 1-4 ("A" SERIES), OCTOBER 1988







Southern Pacific
Transportation Company
Hoffman Marsh/Liquid Gold Site

FIGURE 6

HOFFMAN MARSH MEAN BENTHOS COMPOSITION
BY MAJOR TAXA, TRANSECTS 5 AND 6 ("A" SERIES), OCTOBER 1988

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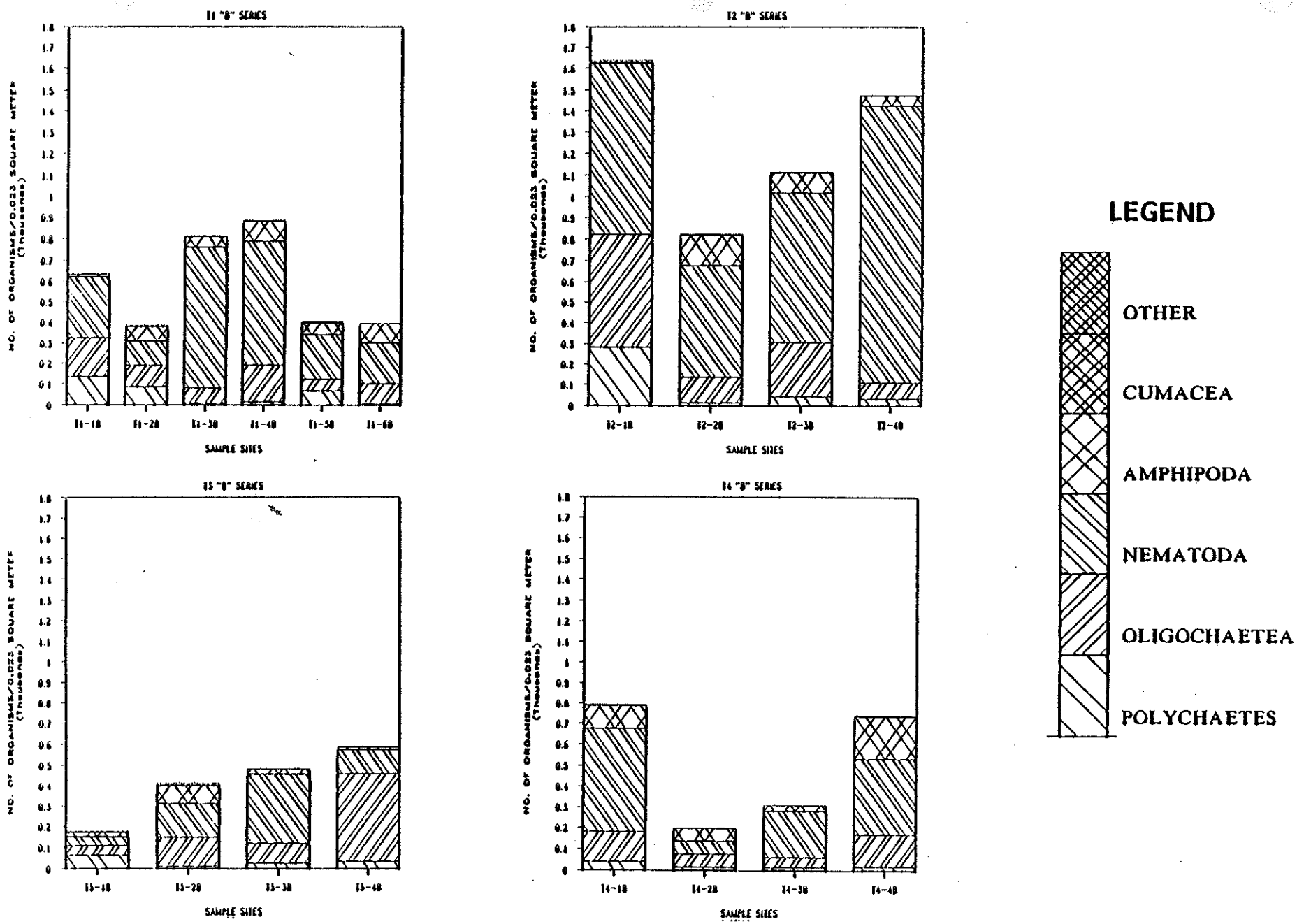

Southern Pacific Transportation Company
Hoffman Marsh/Liquid Gold Site

LG006510

FIGURE 7

HOFFMAN MARSH MEAN BENTHOS COMPOSITION BY MAJOR TAXA, TRANSECTS 1-4 ("B" SERIES), OCTOBER 1988

Table 7
Hoffman Marsh Benthos Species List
October 1988

Taxa

Polychaeta
- *Streblospio benedicti*
- *Heteromastus filiformis*
- *Polydora* spp. (nr. *lighti*)
- *Pseudopolydora kempi*
- *Pygospio elegans*
- *Capitella capitata*
- *Eteone* spp.

Cirratulidae
Nercidae
Owenidae
- *Owenia collaris*

Oligochaeta

Nematoda

Crustacea
- **Amphipoda**
  - *Grandidierella japonica*
  - *Corophium spinicorne*
  - *Ampelisca abdita*
- **Taltridae**
- **Cumacea**
  - *Hemileucon hinumensis*
  - *Cumella vulgaris*
- **Isopoda**
  - *Sphaeroma pentodon*
- **Copepoda**
  - *Harpacticoid copepod*
- **Decapoda**
  - *Hemigrapsus oregonensis*

Mollusca
- **Bivalvia**
  - *Macoma balthica*
  - *Mya arenaria*
- **Gastropoda**
  - *Assiminea californica*

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Corophium Spinicorne

An amphipod crustacean of the suborder Gammaridea, this organism lives in tubes in substrate of mud. It feeds by mechanically sorting through the grains of sand and silt. This species is tolerant of low and varying salinity, and is intolerant of exposure and wave action (Light 1970).

Cumaceans

The tiny (adults are 3-8 mm long) shrimp-like cumaceans are of the class Malacostraca and the order Cumacea. They are benthic, burrowing organisms found in mud or silt, and at least some feed by "filtering minute food particles from a current maintained by one or more of the anterior thoracic limb parts" (Gosner 1971). All cumaceans are free living, and are primarily a marine group with certain species also occurring in brackish or nearly fresh water.

4.3 TISSUE

Plant Tissue

No detectable levels of chromium and mercury were found in the pickleweed tissue (Table 8). Copper levels ranged from less than 1 to 1.6 mg/kg. Lead concentrations were frequently below the detection limit of 10 mg/kg. Nickel was not detected (<2 mg/kg detection limit) except T2-4, which had 2.5 mg/kg. Zinc was the only metal present at detectable levels in all samples, but its highest concentration was 6.8 mg/kg.

Animal Tissue

The number of yellow shore crabs captured during the typical 6-hour trapping period is shown in Table 9. Transects 1, 2, and 4 are channels that get progressively wider and deeper the closer they get to the Bay. Large numbers of yellow shore crab inhabit the upper end of these channels and their numbers decrease toward the larger end. Traps set in the lower ends of the Hoffman Marsh channels typically caught less than 50 yellow shore crabs, but would have up to 10 juvenile Dungeness crabs (*Cancer magister*).

The trapping result for Transect 6-2 is misleading. High tide conditions at the time of trapping did not result in the trap set at Transect 6-2 being fully covered by water. An extended, overnight set was then used to allow enough crabs to be captured for tissue analysis. Section 2.3 of this report explains why sites T6-1 and 3 were not trapped.

No organics were found at detectable levels in the crab tissue. Heavy metals were present at detectable levels with the exception of lead for sites T5-1 and 4 (Table 10). Relationships between crab tissue heavy metal concentrations and corresponding concentrations in the adjacent sediment were investigated.

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Table 8
Heavy Metal Concentrations in Pickleweed
Hoffman Marsh, April 1989

Site	Chromium	Copper	Lead	Mercury	Nickel	Zinc
T1-1	<1	1.3	<10	<0.02	<2	4.7
T1-2	<1	<1	<10	<0.02	<2	4.1
T1-3	<1	1.6	<10	<0.02	<2	4.5
T1-5	<1	1.3	11	<0.02	<2	5.1
T2-1	<1	<1	<10	<0.02	<2	3.1
T2-2	<1	1.2	12	<0.02	<2	4.1
T2-3	<1	1.6	13	<0.02	<2	5.3
T2-4	<1	1.5	13	<0.02	2.5	6.8
T3-1	<1	1.6	<10	<0.02	<2	5.6
T3-2	<1	1.3	11	<0.02	<2	5.8
T3-3	<1	1.3	<10	<0.02	<2	5.2
T3-4	<1	<1	<10	<0.02	<2	2.9
T4-1	<1	1.1	<10	<0.02	<2	3.2
T4-2	<1	<1	<10	0.03	<2	3.2
T4-3	<1	1.1	<10	<0.02	<2	3.5
T4-4	<1	1.2	<10	<0.02	<2	3.4
Maximum	<1	1.6	13	0.03	2.51	6.8
Minimum	<1	<1	<10	<0.02	<2	2.9
Mean*	<1	1.26	10.63	<0.02	2.03	4.41

*If value was non-detectable, the detection limit was used for calculating the mean.
Note: Only the top 2-3 cm of the pickleweed tips were sampled.

LG006513

Table 9
Yellow Shore Crab Trapping Results
Hoffman Marsh, Richmond, California

Site	Trapping Duration (hrs)	No. Yellow Shore Crabs Captured	No. Crabs per Trap Hour
T1-1	6	168	28
2	6	149	25
3	6	172	29
4	6	106	18
5	6	86	14
6	6	48	8
T2-1	6	218	36
2	6	55	9
3	6	38	6
4	6	48	8
T3-1	6	19	3
2	6	6	1
3	6	1	<1
4	6	14	2
T4-1	6.5	138	21
2	6.5	38	6
3	6.5	49	7
4	6.5	26	4
T5-1	5	106	21
2	5	96	19
35	108	22	
4	6	135	22
5	6	131	22
6	6	42*	7
T6-1	-	-	-
2	12	26**	2
3	-	-	-
4	7	146	21

*Partial malfunction of trap.
**Tide was inadequate to cover trap, so it was left overnight to include the second high tide cycle.
Note: Trapping was conducted during high tide in late October, 1988.

LG006514

Table 10
Heavy Metal Concentrations in Yellow Shore Crab Tissue
Hoffman Marsh, October 1989

Site	Chromium	Copper	Lead	Mercury	Nickel	Zinc
T1-1	1.0	37.00	1.7	0.20	1.0	41
T1-4	1.1	49.00	2.5	0.31	1.4	34
T1-6	1.2	36.00	2.6	0.22	0.93	34
T2-1	1.8	44.00	1.8	0.18	1.1	32
T2-4	0.90	33.00	2.4	0.24	0.45	33
T3-1	1.4	36.00	3.5	0.15	1.2	36
T3-4	0.85	25.00	2.8	0.17	0.71	30
T4-1	1.4	43.00	2.8	0.11	0.62	34
T4-4	1.1	32.00	3.6	0.18	1.1	38
T5-1	0.59	36.00	0.74*	0.12	0.89	31
T5-4	0.62	42.00	0.77*	0.14	0.77	38
T5-6	0.62	39.00	1.8	0.17	0.62	34
T6-2	1.0	28.00	2.9	0.13	1.0	30
T6-4	0.90	36.00	3.9	0.12	0.75	37
Maximum	1.8	44.00	3.9	0.31	1.4	41
Minimum	0.59	25.00	0.74	0.11	0.45	30
Mean	1.0	36.00	2.4	0.17	0.89	35

* These values are the dry weight equivalent of the wet weight detection level of 1 mg/kg for lead. Lead in these two samples was non-detectable. For statistical purposes, one-half of the detection level was used.

LG006515

4.4 VEGETATION

Plant communities observed in the study area are discussed below and illustrated in Figure 8 (see Map Pocket). Scientific and common names of observed plants are given in Attachment E. No state- or federally-listed rare, threatened, or endangered plant species, or candidates for listing, were observed on the site; however, the vegetation survey was only conducted on one date. This was because the California Natural Diversity Data Base (1988) has no records of any such plants in the study area, and none are expected to occur here because the pickleweed marsh is relatively new and the adjacent uplands reflect years of disturbance.

Wetland Vegetation

Coastal salt marsh vegetation generally exhibits zonation in response to elevational changes in tidal inundation and frequency. In natural salt marshes of the San Francisco Bay, the lowest vegetated zone occurs at elevations that receive frequent and prolonged tidal inundation. This "lower marsh" generally occurs below mean high water (MHW) and is dominated by cordgrass, while high marsh, above MHW, is inundated less frequently or for shorter intervals and is dominated by pickleweed (MacDonald 1977). A marsh transition zone at the upper edge of the marsh is characterized by both upland and marsh species including pickleweed, saltgrass, fat hen, gumplant, and bromes.

Hoffman Marsh is an enclosed salt marsh surrounded by earth fill, open to tidal action by a single channel to the bay. Much of the site is westward of the bay margin of the mid-1800's (Nichols and Wright 1971) and presumably was mudflat or open water historically. U.S. Geological Survey topographic quads from 1946 and 1959 show that the railroad levees on the western border were built sometime between these dates; the salt marsh in the study area has probably been in existence for 30 to 40 years. A possible exception is the small marsh at the southern end of the site (discussed below).

Because Hoffman Marsh is almost completely enclosed by fill or levees, it does not exhibit the normal gradual, bayward transition from high marsh, through low marsh, to tidal mudflat. In addition, steep slopes surrounding much of the marsh prevent the development of a significant marsh transition community.

Hoffman Marsh is drained by channels up to 15 feet wide and 5 feet deep. These channels support no vascular plants, only algae (*Enteromorpha intestinalis*) (URS 1973).

A 7.5-acre area on the southern edge of the marsh is separated from the main marsh by a sewer line levee (see the map entitled *Sampling Locations for Biological Investigations - South Study Area* in Volume I of Kennedy/Jenks/Chilton's Remedial Investigation Report). The tidal circulation of this area, which is connected to the main marsh by a culvert beneath the sewer line, was improved in 1985 as mitigation for a CALTRANS project (BCDC 1988). This area may be a portion of the original marsh that existed on the north side of Pt. Isabel, as evidenced by its higher elevation (equivalent to the open marsh south of Pt. Isabel) and its species composition (Cuneo 1987).

Wetland vegetation types found on the site are described below.

LG006516

Salt Marsh

Vegetation over most of the marsh, including the 1985 mitigation area, consists of a dense, homogeneous cover of pickleweed (primarily *Salicornia virginica*, with minor amounts of *S. subterminalis*) from 8 to 24 inches in height. Marsh areas dominated by pickleweed are labeled "Pickleweed marsh" on Figure 8. Some areas support up to 50 percent cover of cordgrass, particularly parts of the main marsh near the inlet, the small marsh to the west of the Liquid Gold site, and the banks of the channel on the northern edge of the study area. These areas are labeled "Cordgrass-Pickleweed marsh" on Figure 8. Upper portions of the marsh, such as along the natural levees of marsh channels in the California Department of Transportation's (Caltrans) 1985 mitigation area and along the marsh fringes, also support alkali heath, marsh rosemary, jaumea, saltgrass, and marsh gumplant. This last species, *Grindelia humilis*, is on List 4 of the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California (Smith and Berg 1988). Plants on this "watch list" have limited distributions, but no legally protected status. Dodder, a bright orange parasitic plant, is a common growth on pickleweed along the fringes of the marsh.

Marsh Transition

The largest area of marsh transition vegetation occurs between the Liquid Gold site and the highway (see Figure 8). Other narrow bands occur along the edge of the marsh where ice plant or concrete rip-rap does not prevent it, such as along the sewer line levee. Common constituents include marsh gumplant, ryegrass, curly dock, ripgut brome, saltgrass, and scattered pickleweed.

Brackish Marsh

An isolated and small low area and an adjacent ditch on the Liquid Gold site support brackish marsh vegetation consisting primarily of cattail, surrounded by prickly ox-tongue and saltgrass (see Figure 8).

Upland Vegetation

Because all of the upland areas within the study site consist of relatively recent fill, and because they have been subjected to repeated disturbance, upland communities in the study area are primarily weedy in nature. Some areas, mainly old unpaved roads, continue to be unvegetated. Ruderal scrub, which is found primarily along the railroad corridor and on parts of the Liquid Gold site, is dominated by an opportunistic native shrub, coyote brush, with an understory of introduced annual grasses and forbs such as wild oat, wild radish, and sow thistle. Ruderal herbaceous vegetation is composed of these grasses and forbs, plus other introduced species including bermudagrass, filaree, and Russian thistle. Native herbaceous upland plants identifiable in November were limited to California poppy, everlasting, telegraph weed, and a few others (see Attachment E).

Additionally, some upland areas have been landscaped. The slope between Highway 580 and the marsh is densely covered in ice plant, which is commonly planted by CALTRANS. The southern and southeastern edges of the site have been planted with eucalyptus, acacia, bottlebrush, and other ornamentals. Scattered eucalyptus occur on the Liquid Gold site, and pines are established around the shooting range. Additional scattered ornamentals are listed in Attachment E.

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4.5 WILDLIFE

General

Plant communities identified in the Liquid Gold Site/Hoffman Marsh study area, and illustrated in Figure 8, provide habitat for many animal species typical of the region. Described below are those species that were most well represented during WESCO surveys. A complete list of species identified in the study area, and their scientific names, is provided in Attachment E.

The salt marsh community of Hoffman Marsh is characterized by several common bird species. Most conspicuous during WESCO field surveys were the great egret, killdeer, marbled godwit, willet, common snipe, and marsh wren. Although considered common, these species did not occur in large numbers. Small mammals captured in the high marsh zone during live-trapping surveys include the house mouse and Norway rat (both naturalized exotic species) and the California vole. Trapline locations and capture data are given in Figure 8 and Table 11, respectively. Native rodent populations in the study area are evidently limited. No amphibians, reptiles, or larger mammals were noted in the salt marsh community. In addition, no larger mammals were captured in the study area during the live-trapping effort using cage traps.

The brackish marsh community, associated with the Stege drainage ditch, provides a more consistently inundated aquatic habitat with emergent vegetation growing along the banks. The ditch banks have been rip-rapped and are therefore of little habitat value. Water birds including the double-crested cormorant, black-crowned night heron, and mallard were observed foraging within the drainage ditch.

Upland portions of the study area were identified on the periphery of Hoffman Marsh and encompassed much of the Liquid Gold Site. Upland habitat, as described previously (Section 4.4 Vegetation), has been subject to at least physical disturbance as evidenced by large barren areas, railroad tracks, piles of rubbish, and ornamental plantings. Ruderal (disturbed) scrub and herbaceous areas do support several wildlife species. Small ground dwelling animals include the western fence lizard, California ground squirrel, Bottae pocket gopher, and California vole. The house mouse and Norway rat are most abundant. Common birds include the mourning dove, bushtit, dark-eyed junco, white-crowned sparrow, and house finch. Eucalyptus and pine trees scattered across the study area provide suitable perch sites and potential nesting sites for raptors (birds of prey) such as the American kestrel. Larger mammals observed include the naturalized (introduced) red fox, striped skunk, and feral cat.

Sensitive Species

Several sensitive species known to the Central San Francisco Bay region occupy habitat types identified in the study area. "Sensitive" species is a broad category of special status species and candidate special status species as defined by state and federal agencies. Table 12 provides information on the status of these species and available habitat. Their decline can be attributed to considerable habitat loss through urban development and other man-induced actions. No listed threatened or endangered species were observed during WESCO field surveys.

LG006518

Table 11
Small Mammal Capture Data for the Liquid Gold Site and Hoffman Marsh, Richmond, California

		Captures			
Trapline[1]	Trapnights	House mouse	Norway rat	California vole	California ground squirrel
A	69	8	1	1	
B	96	26	2		
C	96	10			
D	72	10	1		
E	96	11			
F	100	24			
G	96	13	1		
H	96	19	1		
I	96	4			1
J	96	15	1	2	
K	100	13	2		
Totals	1,013	153	9	3	1

[1]Trapline locations are illustrated in Figure 8 (see Map Pocket).

LG006519

Table 12
Sensitive Animals Known to the Region and Potentially Occurring in Habitat Types Identified on the Liquid Gold Site/Hoffman Marsh Study Area

Species	Status[a]	Habitat	Occurrence[b]
California clapper rail *Rallus longirostris obsoletus*	CE/FE	Tidal salt marsh	Possible
California black rail *Laterallus jamaicensis coturniculus*	CT/C2	Salt marsh	Possible
black-shouldered kite *Elanus caeruleus*	CFP	Salt marsh; ruderal scrub	Present
northern harrier *Circus cyaneus*	CSC	Salt marsh; adjacent uplands	Present
short-eared owl *Asio flammius*	CSC	Salt marsh	Present
salt marsh yellowthroat *Geothlypis trichas sinuosa*	C2	Salt marsh; adjacent uplands	Present
salt marsh wandering shrew *Sorex vagrans halicoetes*	CSC/C2	Tidal salt marsh	Not present

LG0065020

Table 12 cont'd.

Species	Status[a]	Habitat	Occurrence[b]
salt marsh harvest mouse *Reithrodontomys raviventris*	CE/FE	Salt marsh; adjacent uplands	Not present

[a]CE = California Endangered
CT = California Threatened
CFP = California Department of Fish and Game "fully protected" species
CSC = California Species of Special Concern
C2 = Category 2 Federal Candidate for listing (information to support a proposed rule is lacking)
FE = Federal Endangered
[b]Based on WESCO surveys and existing distributional information

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The California clapper rail was once widely distributed in northern California; however, breeding populations are now restricted to the greater San Francisco Bay and Elkhorn Slough (Monterey County) (CDFG 1980). The clapper rail almost exclusively inhabits tidal salt marsh habitats dominated by cordgrass and pickleweed, with cordgrass supporting highest densities. The California Natural Diversity Data Base has records for clapper rail in the remnant marshes east of Pt. Isabel. Observations of clapper rail at Hoffman Marsh were reported in March 1978 by Harvey (1980) and in March 1985 by Hay (1985). No clapper rails were detected during specific surveys conducted by WESCO. The pickleweed dominated Hoffman Marsh appears to be suitable for clapper rail, but may provide less than optimal habitat. Because much of the marsh margin, or transitional zone, has been rip-rapped and/or overtaken by ice plant, little peripheral cover is available for rails seeking refuge during high and flood tide events.

The California black rail historically occurred in coastal salt marshes from Marin County southward to Baja California, Mexico, and from inland freshwater marshes of the Colorado River and the Sacramento-San Joaquin River Delta (CDFG 1980). Its current distribution and population size are not fully known. Pickleweed dominated tidal salt marsh of the study area provides potential habitat for this species. The nearest record for black rail was reported from Wildcat Creek Marsh, north of the study area (WESCO 1986). There are no recorded observations of black rail in Hoffman Marsh and no rails were detected during specific surveys conducted by WESCO.

The black-shouldered kite, although not listed as threatened or endangered, is a California Department of Fish and Game (CDFG) "fully protected species" as described in the Fish and Game Code. The black-shouldered kite is a resident throughout the year but shifts about locally, both seasonally and from year to year, in accordance with food supply (Grinnell and Miller 1944). An essential combination of habitat conditions seems to be open grassland, meadows or marshes for foraging, and nearby isolated dense-topped trees for perching and nesting. Suitable foraging habitat and potential nesting habitat is present in the study area. Rodent populations in the study area (primarily house mice) provide a potential prey base. One black-shouldered kite was observed foraging over the Liquid Gold site during WESCO surveys (November 11, 1988).

The northern harrier is not threatened or endangered, but is listed as a California species of special concern. Species of special concern have no legal protective status. This list was prepared by CDFG to help land management agencies, developers, landowners, and the general public take action to protect declining wildlife populations before they become endangered. Species included in this category are those whose breeding populations in the state have declined severely or are otherwise so low that extirpation is a real possibility (Remsen 1978). The northern harrier typically inhabits lowland marshland, but also occurs in grassland habitats (Grinnell and Miller 1944). A fairly common migrant and winter resident in suitable habitat, relatively small numbers occur through summer and breed. Suitable foraging and potential nesting habitat for this species is present in the study area. Several observations of northern harrier were noted throughout WESCO field surveys.

The short-eared owl is also a California species of special concern, most likely to be observed during the winter months where it is found in marshy terrain (Remsen 1978). Suitable foraging habitat and potential nesting habitat is present in the study area. One short-eared owl was observed perched on the south bank of the Stege drainage ditch during a WESCO survey (March 30, 1989).

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The salt marsh yellowthroat is a rare resident bird known to breed around the San Francisco Bay and along the Pacific Coast from Tomales Bay to Pescadero Marsh. Suitable habitat includes freshwater marsh, brackish marsh, salt marsh, riparian, and adjacent upland habitats (Hobson *et al.* 1985). Marshland and adjacent uplands in the study area provide suitable habitat for this species. A 1985 breeding season survey of salt marsh yellowthroats in the San Francisco Bay Region (Hobson *et al.* 1985) reported no breeding birds in Contra Costa County. Three salt marsh yellowthroats were observed foraging at the southern end of Hoffman Marsh during a WESCO survey (March 30, 1989). No nests were found.

The salt marsh wandering shrew is known to inhabit tidal salt marshes of the south arm of San Francisco Bay (Findley 1955). Johnston and Rudd (1957) provided a detailed sketch of the habitat of this species. Shrew activity was observed in the "medium high marsh," about 6 to 8 feet above sea level, and in lower-lying marsh not regularly inundated. Suitable sites were characterized by abundant driftwood and other debris scattered among pickleweed. The extent of remaining habitat for the shrew is small, and because only a limited area within tidal salt marsh is used, there is less remaining habitat for the shrew than for the endangered salt marsh harvest mouse (Williams 1986). Hoffman Marsh provides potential habitat for the shrew; however, there are no records from this location and no shrews were observed during WESCO surveys. The nearest documented observation of the salt marsh wandering shrew is from San Pablo Marsh.

The salt marsh harvest mouse is a Bay Area endemic species. Pickleweed-dominated salt marsh (diked and tidal) is its primary habitat, although the species has been found in upland habitats adjacent to salt marsh and in other wetland communities with little or no pickleweed. Marsh habitats and adjacent uplands in the study area appear to provide suitable habitat for this species; however, for reasons described above for the clapper rail, this habitat may be less than optimal. No salt marsh harvest mice have been reported from Hoffman Marsh and none were captured during WESCO live-trapping surveys. Trapline locations and capture data are presented in Figure 8 and Table 10, respectively. The nearest documented occurrence of salt marsh harvest mouse is from Wildcat Creek Marsh in Richmond along San Pablo Bay (WESCO 1986). Hoffman Marsh is a relatively new marsh (approximately 30 years) and is isolated from marshland known to support salt marsh harvest mouse populations. Therefore, immigration of the salt marsh harvest mouse into the study area is unlikely.

LG006523

5.0 DISCUSSION OF STATISTICAL ANALYSES RESULTS

5.1 SEDIMENT

Physical and Chemical Characteristics

Two sets of star plot figures were made to depict normalized concentrations of the physical and chemical characteristics for each transect station (Attachment F). Figures F-1 through F-4 show star plots of TOC, chloride, and mean Phi values. Total sulphur, sulphide, oil and grease, and pH are illustrated in Figures F-5 through F-8. The findings of the cluster analyses for Transects 1 through 4 are provided in Table 13. Transects 5 and 6 had insufficient data points to permit a cluster analysis.

Because T5 and T6 data were normalized separately from Transects 1 through 4, one can not compare the star plots between these two groups of transects. Star plots of the A, B, or C series should not be compared outside of their respective series for the same reason.

Of the many line graphs produced to assist in the search for trends, those graphs illustrating A and B series sediment concentrations of oil and grease, oil and grease minus sulphur, chloride, TOC, Phi values (graphed as Phi value plus 4 to eliminate negative values), and elevation are included in Appendix F following the star plots. It is particularly important to note the line graphs showing both oil and grease and concentrations of oil and grease minus sulphur. This is because the gravimetric method of extracting oil and grease from the sediments also extracts the sulphur. By subtracting the total sulphur component from the oil and grease concentration (see Appendix C for analysis results), the resulting value is more indicative of the petroleum hydrocarbon portion of the oil and grease measurement.

Transects 1 Through 4

A series. The highest level of TOC and chloride occurs at T2-1 (34,000 and 41,000 mg/kg, respectively), and the lowest at T1-2 (3,800 and 7,800 mg/kg, respectively). Otherwise, all sites in this series are generally similar for these constituents. The highest levels of oil and grease (2,800 mg/kg), sulphide (1,600 mg/kg) and total sulphur (1,300 mg/kg) in this series are at T1-1, the location where petroleum discharges from the Liquid Gold site are presumed to have occurred. Transect 3, which receives urban runoff, has relatively high levels of oil and grease throughout its length, including the two highest levels of oil and grease minus sulphur (1,500 and 2,000 mg/kg). Because of the pH of the sediments has a range of only 1 pH unit within the entire marsh, the normalized values of pH depicted in the star plots should not be given excessive attention.

B series. The higher levels of TOC (53,000 and 38,000 mg/kg) and chloride (32,000 and 30,000 mg/kg) in this series occur at T1-1 and T2-3. Site T1-1 is at the upper end of the channel where tidal flushing is minimal and organic debris collects. Therefore, the high salinity and TOC at this location is not surprising. The oil and grease concentration in the B series is highest at T1-1 (2,200 mg/kg), although the T1-1 level of oil and grease minus sulphur (1,500 mg/kg) is only 100 mg/kg higher than concentrations at two sites along Transect 3.

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Table 13
Sample Locations Identified as Unusual in Cluster Analyses of Various Physical and Chemical Measures for Three Sampling Series (A, B, C*) In Hoffman Marsh

Sample Location	Chloride	TOC	PHI	Total Sulphur	Sulfide	pH	Oil & Grease
T1-1	B	B	b	A	A		A B
-2							
-3							
-4							
-5						C	C
-6						B	
T2-1	A B C	A b	a c				
-2							
-3	B	B	b				
-4				B	B	b	B
T3-1						c	C
-2							
-3							
-4							
T4-1		C	C				
-2		C	C	C	C		C
-3	C		c				
-4							

* Upper-case letters indicate relatively high values, for the sample station within the series, while lower-case letters indicate relatively low values.

Note: No C-series samples for sites T1-4 and T1-6.

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C series. Chloride (50,000 and 31,000 mg/kg) and TOC levels (62,000 and 66,000 mg/kg) in the C series are greatest at T2-1 and T4-1 and 2. The lowest values for these parameters are at T3-2 and T1-5 (21,000 mg/kg chloride and 16,000 mg/kg TOC, respectively). Oil and grease levels for this series are highest at T1-5, T3-1, and T4-2 (1,400 - 1,500 mg/kg). The latter site also has the highest concentrations of sulphur compounds. Once the sulphur values are subtracted, the remaining oil and grease levels for T1-5 and T3-1 are equal (1,400 mg/kg).

Transects 5 and 6

The A series of Transects 5 and 6 has the highest TOC levels at T6-1 (97,000 mg/kg) where splinters of deteriorating wooden boards are dispersed throughout the sediments. In general, Transect 6 sediments are more saline than Transect 5 which is lower in elevation, larger, and better flushed. While the various stations along Transect 5 range in oil and grease concentrations from 360 to 1,600 mg/kg, the highest concentrations of oil and grease for this grouping occur at T6-1 and T6-2 (4,300 and 2,600 mg/kg). The concentrations of oil and grease minus sulphur at these two sites are 4,000 and 2,000 mg/kg, respectively.

Summary

In all three series, chloride is relatively high at T2-1. This point is also relatively high in TOC for the A series, but relatively low for the B series. The C series of T4-1 and 2 are both high for TOC and Phi values. Being located near the upper end of Transect 4 channel, deposition of silt and detritus may be greater here than along downstream portions of the channel.

Three sample locations, each in different series, are relatively high in total sulphur, sulphide, and oil and grease. These locations are dispersed across the marsh: T1-1 (A series), T2-4 (B series), and T4-2 (C series). The A series of Transect 3 has relatively elevated levels of oil and grease scattered throughout its length. The highest level of oil and grease (4,300 mg/kg) occurs at site T6-1.

The star plots and cluster analysis results (see Table 13) for the physical and chemical characteristics of the pickleweed marsh are consistent with the expected association between elevated sulphur and oil and grease levels. The higher levels of oil and grease relative to the field of data are scattered throughout the marsh, but site T1-1 is unique in having elevated oil and grease concentrations in both the A and B series.

Heavy Metals

All six of the heavy metals analyzed were included in individual star plots. These star plots of the normalized values for the metals are shown as Figures F-9 through F-12 of Attachment F. Table 14 summarizes the findings of the cluster analyses for these metals.

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Table 14
Heavy Metal Concentrations in Pickleweed
Hoffman Marsh, April 1989

Site	Chromium	Copper	Lead	Mercury	Nickel	Zinc
T1-1						
-2	ab			a	ab	
-3	C	A		C		a
-4						
-5						C
-6						
T2-1	A	A	A	A	A B	A
-2						
-3						
-4					A	
T3-1				B		
-2					B	
-3						
-4						
T4-1		B				B
-2						
-3	a	a	a	a	a	
-4						

* Uppercase letters indiciate relatively high values for the sample station within the series, while lowercase letters indicate relatively low values.

Note: No C series analysis results are available for T1-4 and T1-6.

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Transects 1 through 4

A series. For the A series of sediments, T2-1 is noteworthy as being high in all of the heavy metals relative to the other sample locations. Once again in relative terms, T2-4 is high in nickel (88 mg/kg) and T1-3 and T2-1 are high in copper (100 and 120 mg/kg, respectively).

B series. The highest mercury level in the B series occurs at T3-1 (2.90 mg/kg), with relatively high copper and zinc at T4-1 (140 and 450 mg/kg, respectively).

C series. In this series the higher mercury and copper levels occur at T1-3 (1.40 and 110 mg/kg, respectively), and the highest lead and zinc at T1-5 (470 and 310 mg/kg, respectively). The duplicate sample for T4-3 is relatively high in all six metals while its companion sample reveals only lead being high relative to the study area.

Transects 5 and 6

Transect 6 is generally high in lead (410 mg/kg), mercury (4.5 mg/kg), chromium (87 mg/kg) and nickel (62 mg/kg) relative to the concentrations of these metals in Transect 5.

Summary

Site T2-1 in the A series is notable for being relatively high in all six heavy metals analyzed. This site is also high in nickel in the B series. While the middle to lower portion of Transect 1 has five instances of elevated metal concentrations in various series, the upper end of this transect contains no elevated levels of metals. Site T1-3 in the A series is notable for its elevated levels of copper, and site T1-2 for having the lowest concentrations of mercury, chromium, and nickel in the A and B series (see Table 14).

Referring to Table 6 for a comparison of actual concentrations rather than normalized values, Transects 5 and 6 tend to be higher in copper (an average of 120 mg/kg), mercury (4.5 mg/kg), and zinc (890 mg/kg) than what was typical of the Transect's 1 through 4 sediments. The highest mercury and zinc levels found during this study are from T6-3.

The results of the cluster analyses (see Table 14) do not indicate an association between heavy metal concentrations in the pickleweed marsh and a primary point source of input. Elevated levels of metals, relative to Transects 1 through 4, are scattered across the marsh with the only notable high concentration occurring at T2-1.

Variability Between Duplicate Sediment Samples

A sense of the amount of variability between duplicate sediment samples is readily provided by the star plots in Attachment F. Regarding heavy metal concentrations, the most substantial differences between duplicates occur with sample T4-3C. Moderate differences exist for sample T4-4A, and the remaining samples show only small differences.

Variability in particle size, TOC, and chloride between duplicates is substantial for C series sample T4-3 for particle size and TOC, T3-4B for TOC, T6-1A for all three characteristics, and T2-

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3B for chloride. Total sulphur, sulphide, oil and grease, and pH analyses do not indicate notable differences between the duplicates.

A review of the PAHs and BNA extractables results in Table 5 shows the duplicate A series samples for T4-4 to vary between nondetectable and 0.80 mg/kg for pyrene, and nondetectable and 2.8 mg/kg for bis(2-ethylhexyl)phthalate. The duplicate samples for T6-1 ranged between non-detectable and 1.4 mg/kg for benzo(b)fluoranthene. Otherwise, there were no notable differences between the duplicates.

5.2 BENTHOS

Cluster analyses were conducted on the benthos composition for each of the A and B series of Transects 1 through 4 and for the A series of Transects 1 through 6. For the A series, the cluster analysis was performed using the total number of organisms for the four major taxa of the series (i.e., oligochaetes, polychaetes, nematodes and cumaceans). For the B series, the total number of amphipods was used in place of the numbers of cumaceans. The A series' results for Transects 1 through 6 differed from that for Transects 1 through 4 only in that the former identified the additional points for Transects 5 and 6. For this reason, Table 15 illustrates the A series results for both sets of cluster analysis for this series. The following observations are based on the findings of the cluster analyses (Table 15) and on visual examination of the bar graphs depicting the benthos results (see Figures 5 through 7).

A Series

Cluster Analyses Observations

- None of the A series sites shows unusually high levels of any taxa relative to the study area data base.
- T1-1, 2, and 3 are relatively low in cumaceans.
- T2-1 and 2 are relatively low in polychaetes, nemotodes, and cumaceans.
- Nematodes are relatively low at T5-1, 2, and 4, and T6-1 and 2.

Bar Graph Observations

- Polychaetes, oligochaetes, and nematodes dominate the benthos community.
- In the A series, cumaceans are generally more abundant than amphipods (A series amphipods are comprised mostly of *Grandidierella japonica*).
- T1-1, 2, and 3 have no cumaceans, which are present at low levels in most of the samples of this series, and have greater numbers of oligochaetes than other sites.
- The lowest total abundance of organisms for Transect 5 occurs on either side of the point at which Transect 6 enters the Transect 5 channel.

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Table 15
Sample Locations Identified as Unusal in Cluster
Analyses of Benthos Taxa and
Two Sampling Series (A, B*)
In Hoffman Marsh

SAMPLE LOCATION	OLIGOCHAETES	POLYCHAETES	NEMATODES	("A" SERIES ONLY) CUMACEANS	("B" SERIES ONLY) AMPHIPODS
T1-1	B	B		a	b
-2				a	
-3				a	
-4					
-5					
-6					
T2-1	B	Ba	a	a	b
-2		a	a	a	
-3					
-4					
T3-1					
-2					
-3					
-4	B				b
T4-1					
-2					
-3					
-4					
"A" Series Only					
T5-1			a		
-2			a		
-3					
-4			a		
-5					
-6					
T6-1			a		
-2			a		
-3					
-4					

*Upper-case letters indicate relatively high values for the sample station within the series, while lower-case letters indicate relatively low values.

Note: The "A" series cluster analyses of T1 through T6 yielded the same results as cluster analyses for T1 through T4 except for the locations identified specifically for transects 5 and 6.

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- T6-1 has the lowest total number of organisms.

- Benthos density for T6-2 through 4 is equal to, or greater than, the benthos density in Transect 5 sites, and is similar in density to Transect 4 sites.

B series

Cluster Analyses Observations

- Relative to the entire B series, T1-1 and T2-1 are high in oligochaetes and polychaetes, and low in amphipods.

- T3-4 is relatively high in oligochaetes and relatively low in amphipods.

Bar Graph Observations

- Cumaceans are an insignificant percentage of the B series' biota.

- Amphipods are more numerous in the B series than the A series, but their dominant species is *Corophium spinicorne* rather than the *G. japonica* common to the A series.

- The B series is generally low in polychaetes relative to the A series. Polychaetes in the B series are most abundant in the head end of channels where the side slope is almost at the same elevation as the bottom of the channel.

Correlations

Numerous line graphs were made in an effort to detect any indication of positive or negative correlations between benthos density by taxa and various chemical and physical characteristics of the sediment. Because of their potential for influencing oligochaete density in the A and B series of Transects 1 through 4, the following line graphs are included in Appendix F: oil and grease, oil and grease minus sulphur, chloride, TOC, particle size, elevation, and oligochaetes. A visual inspection of the line graphs did not suggest any correlations for the A series, but did indicate four possible correlations for the B series (Table 16). These possibilities were evaluated by computing Pearson correlation coefficients (r) and associated p-values and by examining individual scatterplots. The scatterplots for these four comparisons are provided in Attachment G. Additional comparisons were investigated because the cluster analyses indicated an association between polychaetes and oligochaete densities at T1-1 with oil and grease levels at this location. No correlations were computed between heavy metals and benthos because the cluster analyses suggested no locations of elevated metals concentrations in the pickleweed marsh in the area adjacent to the Liquid Gold site (see Table 14).

The results indicate a moderately strong and statistically significant ($p<0.05$) tendency for increasing chloride levels to be associated with increasing polychaete density in the B series (Table 16). Examination of the scatterplot suggests that the significance of the correlation may be partly or largely attributable to one or two sampling stations with relatively high chloride and polychaete density (T2-1 and T1-1).

LG006531

Table 16
Correlation Statistics for Hoffman Marsh
Benthos Versus Several Physical and Chemical Characteristics of the Sediment

	A Series				B Series	
	T1-T6 (N=28)		T1-T4 (N=18)		T1-T4 (N=18)	
	r	p	r	p	r	p
Polychaete Density and Chloride Levels	0.10	0.61	-0.15	0.56	0.56	0.015
Oligochaete Density and Chloride Levels	0.20	0.32	-0.09	0.71	0.44	0.07
Polychaete Density and Oil/Grease Levels	0.04	0.86	0.32	0.20	-0.03	0.91
Oligochaete Density and Oil/Grease Levels	0.14	0.49	0.38	0.12	0.02	0.95
Polychaete Density and TOC Levels	----	----	-0.15	0.55	----	----
Oligochaete Density and TOC Levels	----	----	0.08	0.76	-0.02	0.95
Nematode Density and Particle Size*	----	----	----	----	0.05	0.83
Amphipod Density and Particle Size*	----	----	----	----	0.12	0.62

*Particle size as indicated by Phi values

Notes:
1) The Pearson correlation coefficient is "r"; the "p" is the p-value.
2) Polychaete density and chloride levels for the B series are significant at $p<0.05$.
3) Oligochaete density and chloride levels for the B series are significant at $p<0.10$.
4) A "dash" indicates that analysis was not performed.

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Although statistically less significant ($p<0.10$) than above, the scatterplot suggest that the density of oligochaetes in the B series also appears to be directly associated with chloride levels.

The results provide no evidence that either nematode or amphipod density is associated with Phi values.

Oil and Grease Versus Oligochaete and Polychaete Density

Indications of past petroleum discharges from the Liquid Gold site to the north end of Hoffman Marsh is provided by the presence at T1-1 of six PAHs (see Table 5) and elevated levels of oil and grease relative to other sample sites within the pickleweed marsh (see Table 3). Transect 3, which receives urban runoff with its associated load of petroleum residue, has A series oil and grease levels along its length that are similar to that found in the A series of Transect 1 (see Figure F-5 and the oil and grease minus sulphur line graphs in Appendix F). The A series benthos of Transect 3 has the highest density of oligochaetes second only to Transect 1 (see Figure 5).

An association of oligochaetes with higher levels of oil and grease was reported by CH_2M Hill (1981) in their study of Castro Creek and marsh near the Chevron refinery. They found that the polychaete, *Streblospio benedicti*, and oligochaetes thrived in the more industrialized portions of their study area that typically had more than 1,000 mg/kg oil and grease. Eadie *et al.* (1982) reported oligochaetes to maintain extremely low tissue concentrations of PAHs despite high levels of PAHs in the surrounding sediments. They suggested that oligochaetes may have an enhanced ability to metabolize certain PAHs.

Despite the cluster analyses results indicating an association in the B series between elevated levels of oil and grease and higher oligochaetes densities at T1-1 and T2-1 (see Tables 13 and 15), no significant overall correlation was found between either oligochaetes or polychaetes and the level of oil and grease present. The correlation between oligochaete density and oil and grease level for Transects 1 through 4 in the A series approaches significance at $p = 0.10$. However, two particular sample sites in Transect 1 are not consistent with a possible correlation. Sites T1-2 and 3 have the highest density of oligochaetes in the A series, but have only moderate to moderately low levels of oil and grease relative to other sites on Hoffman Marsh. Because oligochaetes are generally prolific in organically enriched environments (Brinkhurst and Simmons 1968), a possible correlation with TOC levels was examined. The line graph of TOC and oligochaete numbers in the B series of Transect 1 show a possible positive relationship (see Appendix F). However, this apparent association was not evident in the A series of this transect. Sites T1-2 and 3 were found to have among the lowest TOC concentrations in the A series of Transects 1 through 4, and no overall correlation with oligochaete numbers was evident (see Table 16). A similar pattern was observed for oligochaete numbers and chloride levels (see Table 16 and the line graphs in Appendix F). Chloride levels and oligactaete numbers appear to be well correlated in the B series (significant at $p<0.10$), but not in the A series.

Because of the small number of sample stations with detectable PAHs, the statistical technique utilized above is not appropriate for assessing a relationship between polychaete and oligochaetes densities and levels of total PAHs. Therefore these data were first examined by graphing total PAH concentrations with polychaete and oligochaete densities for the 18 sites of Transects 1 through 4, A and B series (Figures 9 and 10). Similar graphs were prepared using the combined percent

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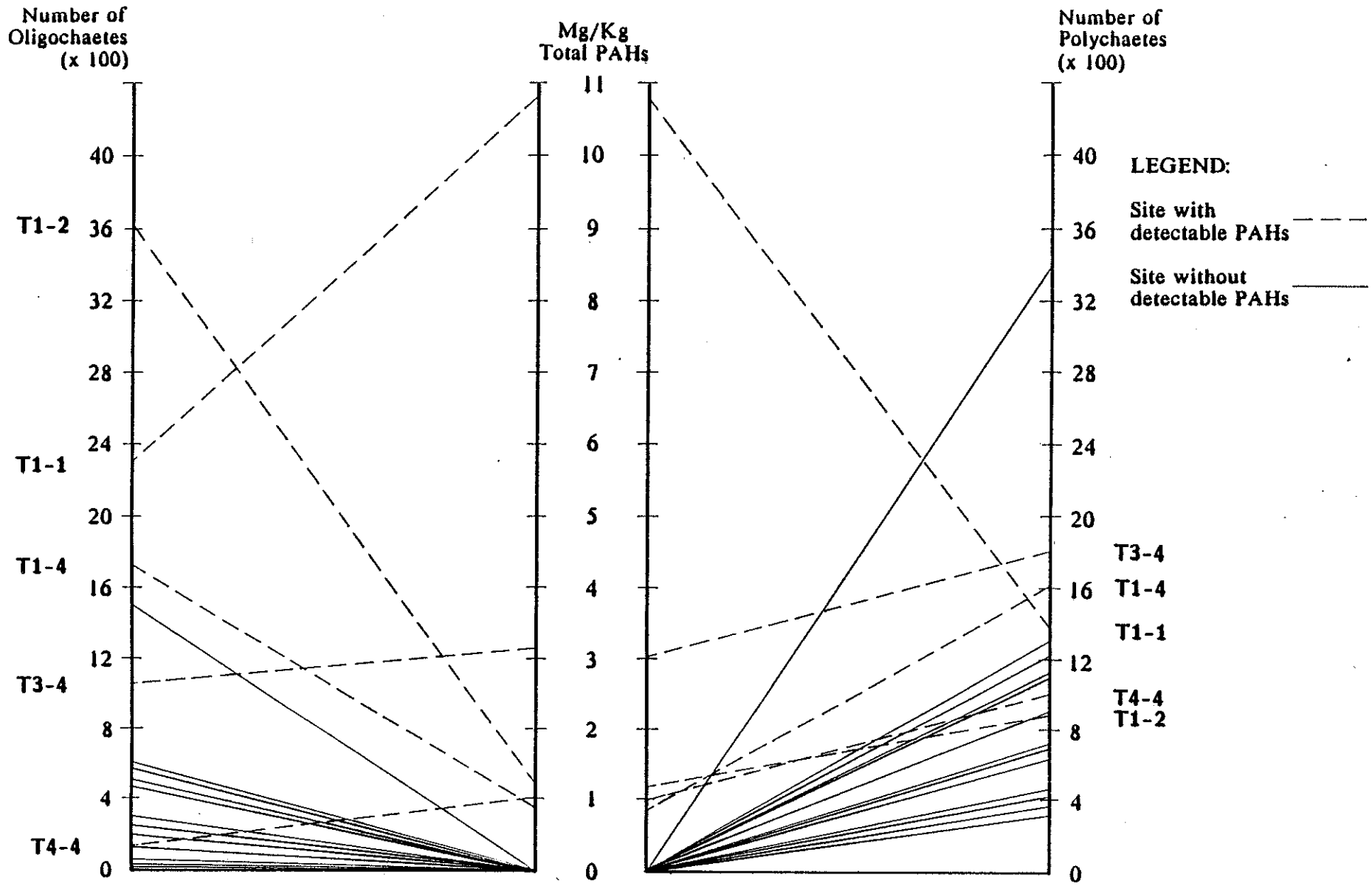

Southern Pacific Transportation Company

Hoffman Marsh/Liquid Gold Site

FIGURE 9

TOTAL PAH LEVELS VERSUS OLIGOCHAETE AND POLYCHAETE DENSITIES, HOFFMAN MARSH TRANSECTS 1-4 ("A" SERIES), OCTOBER 1988

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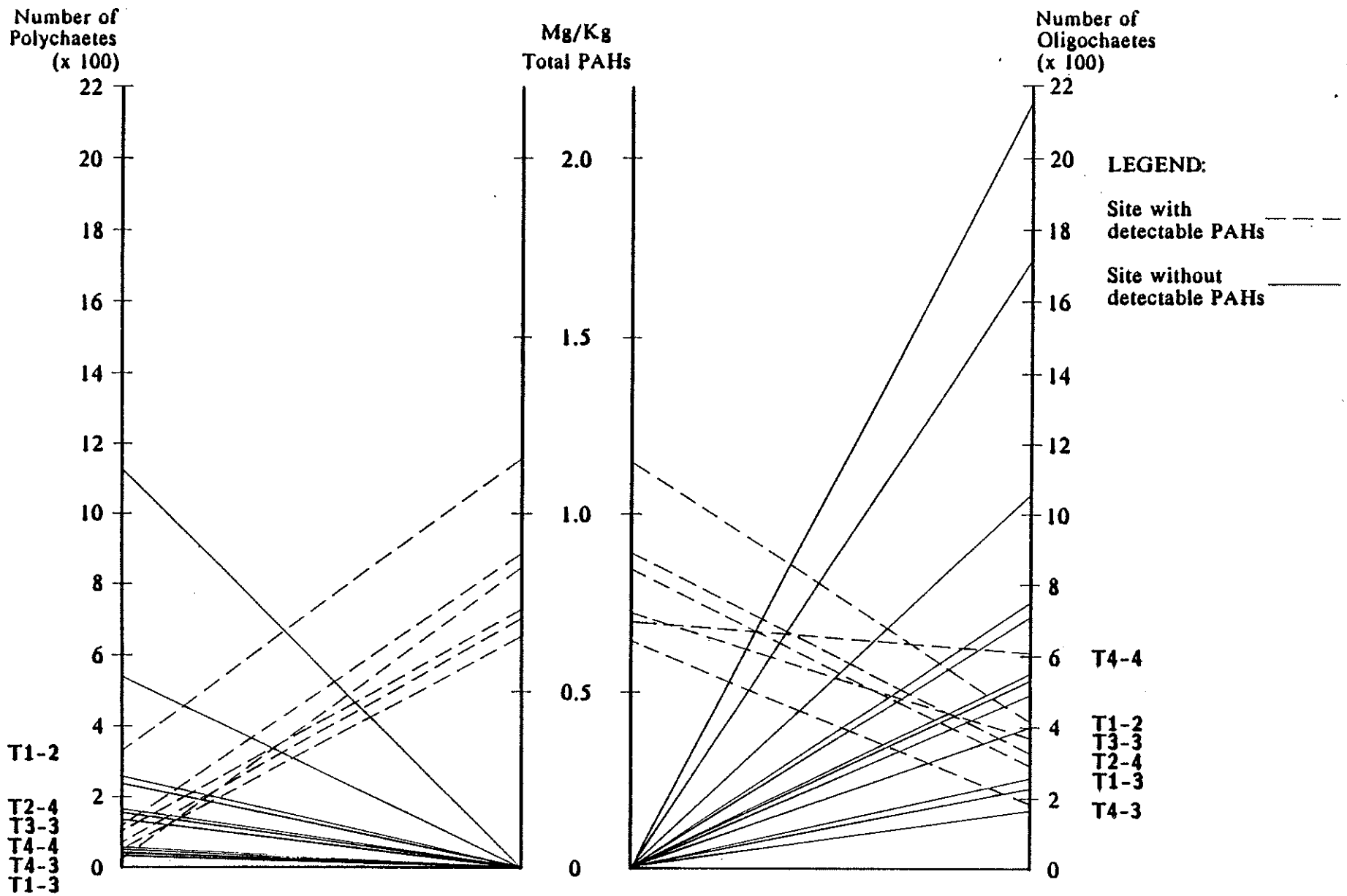

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FIGURE 10

TOTAL PAH LEVELS VERSUS OLIGOCHAETE AND POLYCHAETE DENSITIES, HOFFMAN MARSH TRANSECTS 1-4 ("B" SERIES), OCTOBER 1988

LG006535

polychaetes and oligochaetes instead of their density (Figure 11). None of these three figures reveal a relationship between these two taxa of opportunistic, industrialized benthos (CH_2M Hill 1981) and total PAH concentrations. Should a positive relationship exist, the lines in these graphs would appear as a series of parallel or similar lines with a tendency for the sites with higher total PAH concentrations to occupy the upper portions of the graph.

The Wilcoxon rank sum test was employed to determine if locations with detectable PAH levels tended to have higher densities of polychaetes and/or oligochaetes. Polychaete density was not found to be significantly different between sample stations with detectable PAH levels (n_1=6) and those sample sites with no detectable levels (n_2=12) of PAH (k=52, Z= -0.42, p=0.68, two-tailed). Similarly, no significant difference was found for oligochaete density (Wilcoxon rank sum test, K=43, Z=-1.26, p=0.20, two-tailed).

Additional Observations Regarding Transects 5 and 6

The middle of the Liquid Gold site uplands drains into the tidal slough containing Transect 6. The upper end of this narrow channel is marked by a large stack of wooden boards and other debris. The sediments in the upper end of Transect 6 have elevated levels of oil and grease (see Figure F-6) and the presence of four PAHs (see Table 5). Site T6-1 at the upper end of this channel also had a confirmed reading of 0.35 to 0.38 mg/kg of PCBs (see Table 4). Elevated levels of heavy metals relative to the study area are found in most of the four sample sites located along the length of this 30-meter channel (see Figure F-10).

Because the limited number of data points in Transect 6 restrict statistical interpretation of these data, chemical concentrations for six heavy metals, oil and grease, and total PAHs were plotted as bar graphs in a search for visually apparent trends. Apparent trends were observed for lead, oil and grease, and total PAHs These bar graphs and others depicting total benthos density, sample station elevations, chloride levels, TOC levels, and particle size, are illustrated in Figures 12 and 13. While these graphs show a visually apparent trend of increasing chemical levels the nearer a station is to the Liquid Gold site, bear in mind that one out of 10 bar graphs of this type would be expected to show an apparent trend just by chance alone. This is analogous to the common multiple comparison problem in statistical inference.

Assuming that these apparent trends are accurate, the bar graph for station elevation in Figure 12 suggests that the lower benthos density at T6-1 may be a reflection of a harsher environment than other sites. The higher elevation of T6-1 (1.2 feet National Geodetic Vertical Datum [NGVD]) subjects this location to greater desiccation than most other sites. (T2-1 is higher at 1.5 feet NGVD and T1-1 though 3 are 1.1 to 0.3 feet, all other A series sites are below 0.0 feet NGVD.).

Another consideration is that T6-1 has a slight hydraulic control at its lower end that causes water to pool in the small basin in which this site is located. During the winter months, benthos at this site are subjected to freshwater runoff that collect in the basin. These seasonal fluctuations in salinity may be more drastic that at other sites and result in a greater impact to this site's benthic community.

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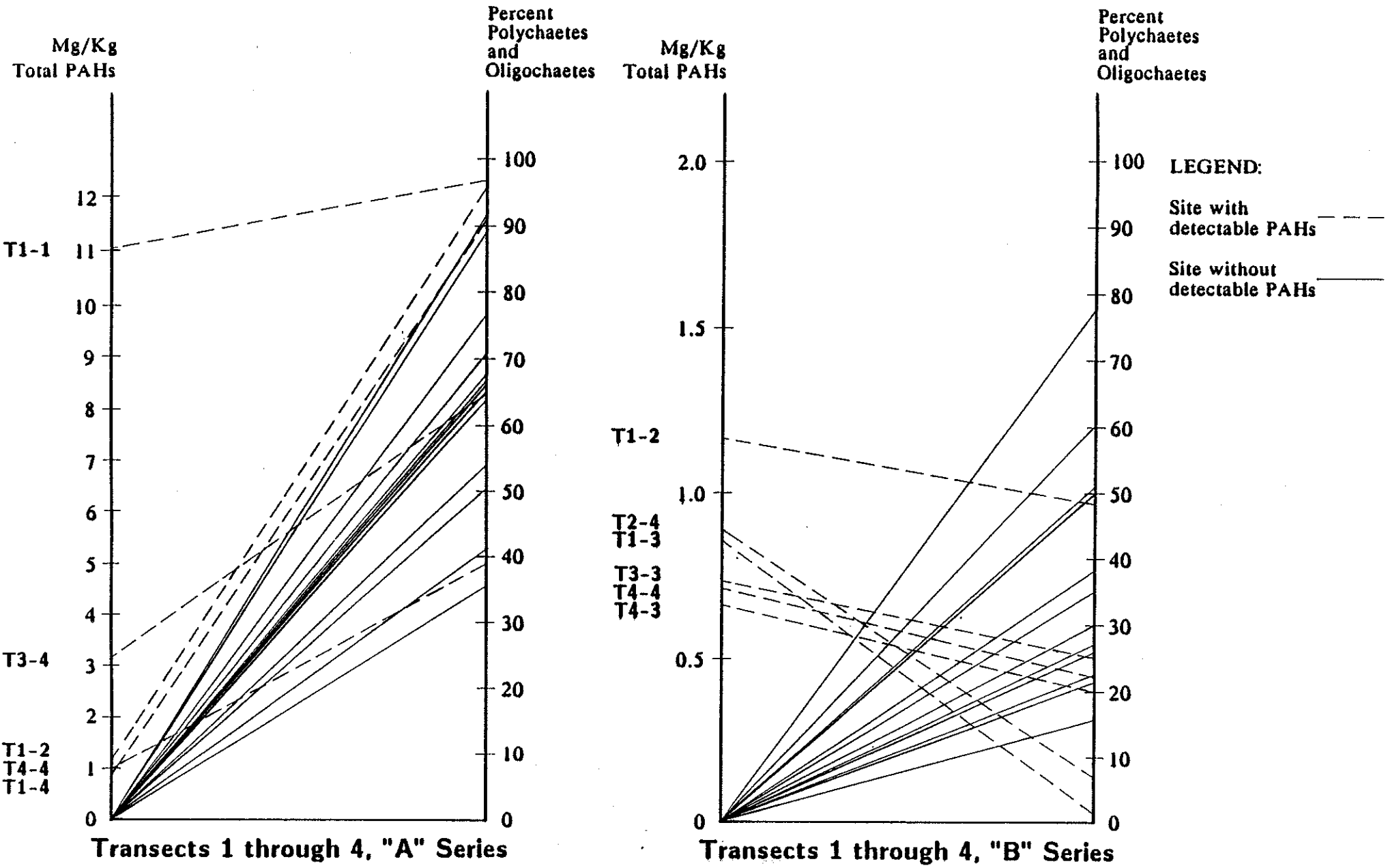

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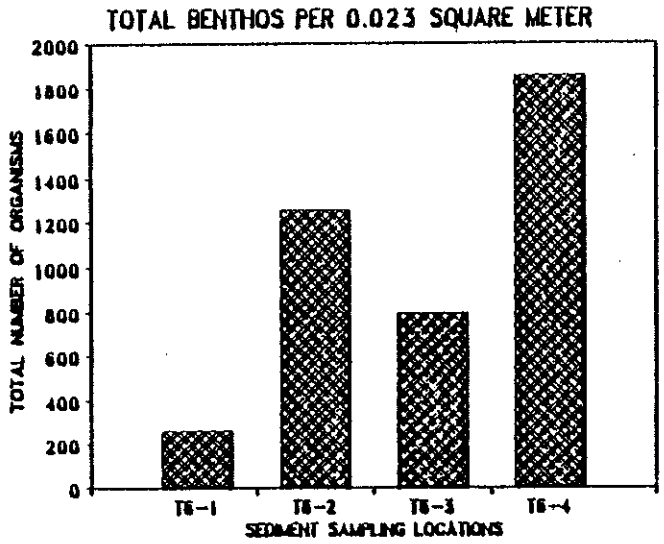
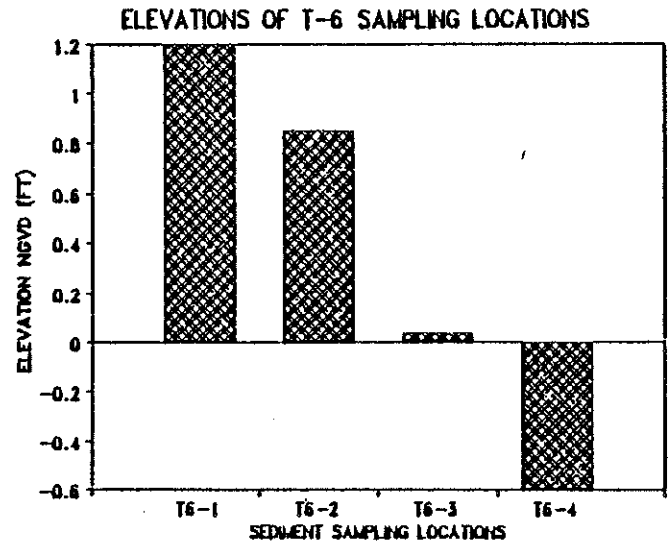
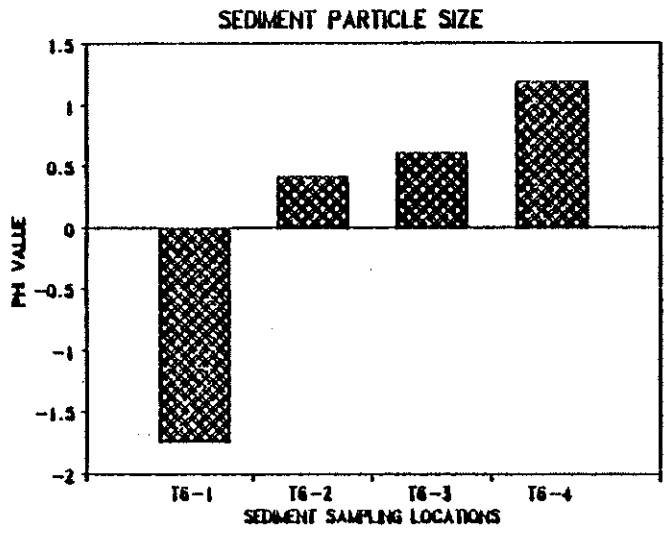
FIGURE 11

TOTAL PAH LEVELS VERSUS PERCENT POLYCHAETE AND OLIGOCHAETE PER SITE, HOFFMAN MARSH TRANSECTS 1-4 ("A" AND "B" SERIES), OCTOBER 1988







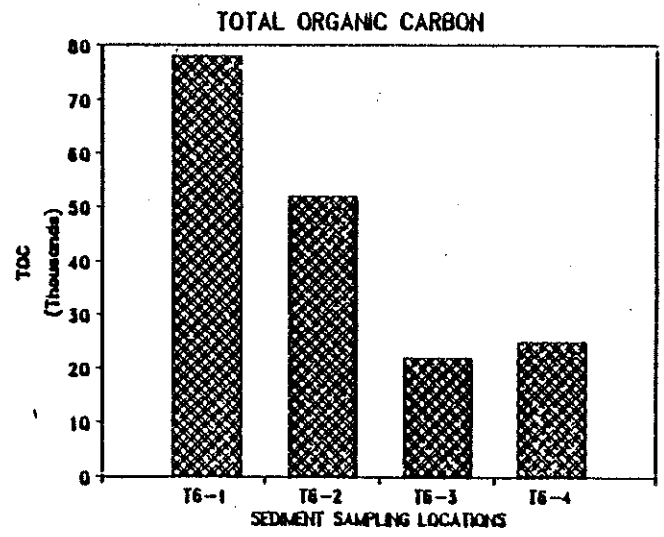


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FIGURE 12

APPARENT TRENDS OF BENTHOS AND SEDIMENT PHYSICAL CHARACTERISTICS AT TRANSECT 6 ("A" SERIES), OCTOBER 1988

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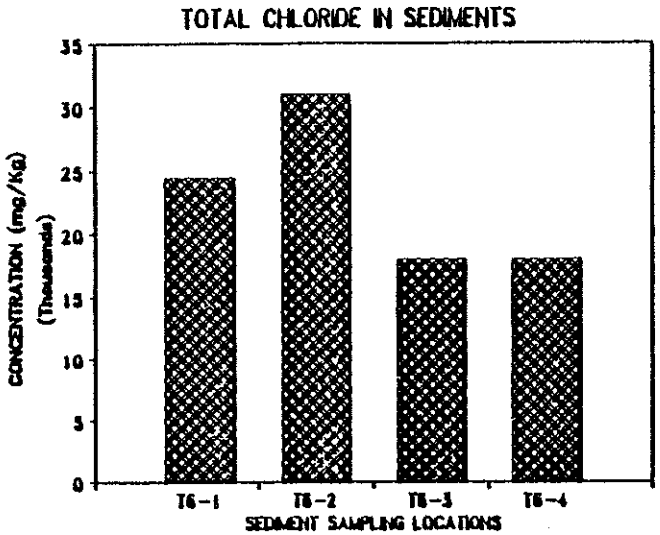

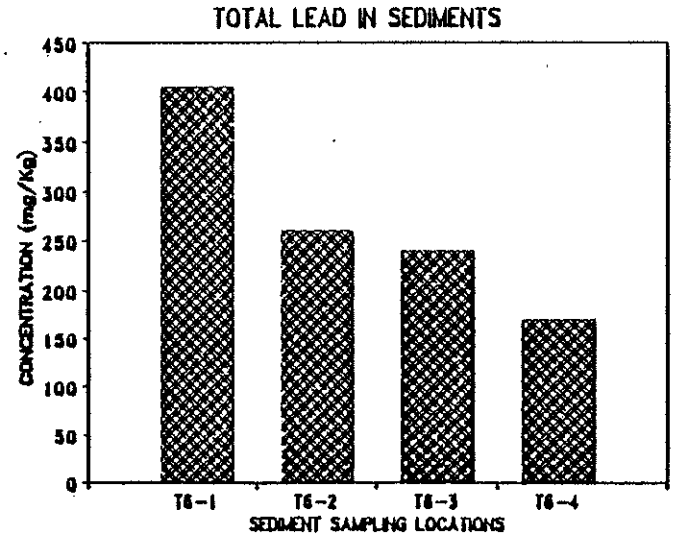

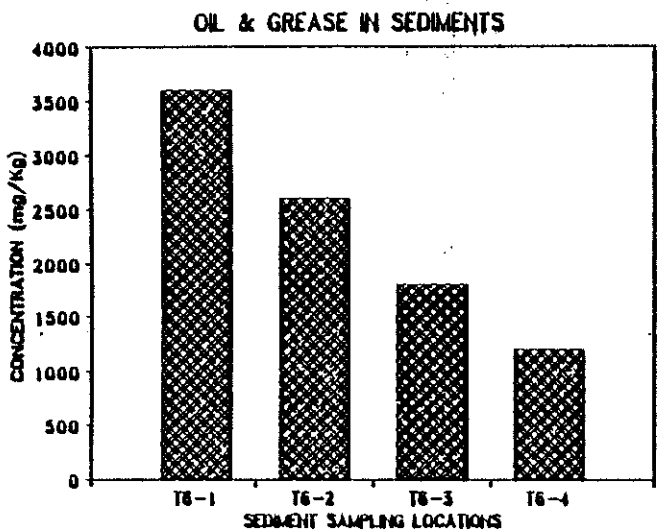

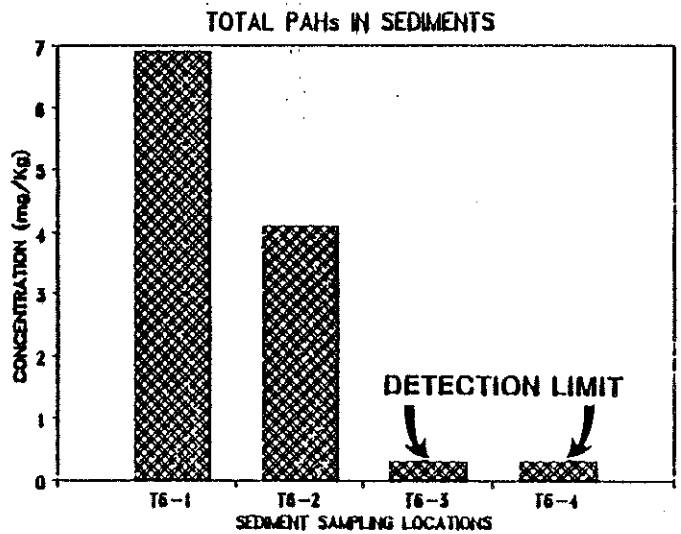

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FIGURE 13

APPARENT TRENDS OF SEDIMENT CHEMISTRY
AT TRANSECT 6 ("A" SERIES), OCTOBER 1988

LG006539

The particle size graph in Figure 12 indicates that the sediments at Site T6-1 have significantly larger particles than occurs at the other sites in this transect. The largest mesh screen used in the particle size determination was 0.425 mm, and withheld 71.4 and 90.2 percent of the sediment sample and its duplicate from T6-1. The remaining three sample sites in this transect had, in ascending order from T6-2, 62.8, 60.0, and 52.4 percent of the sample withheld by the 0.425 mm screen. However, these values do not tell how much larger than 0.425 mm were the particles screened from the sample.

To answer this question, the four benthos samples from this site were re-examined (four grabs per sample). All of the benthos samples had been washed in a 0.5 mm diameter screen at the time of field collection. Anything retained by this screen had been placed in a sample jar and preserved to be inspected later for benthic organisms. The inspection of these samples revealed that almost all of the inorganic sediments were finer than 0.5 mm and not present in the sample jar, and the organic sediment retained consists of small pieces (1 x 2 mm) of vegetative matter. This high percent of organic matter is also evident in the graph depicting TOC levels along this transect (Figure 12).

Therefore, the particle size graph in Figure 12 is somewhat misleading relative to the difference between T6-1 and the other sites in this transect. T6-1 has sufficiently small inorganic particles and a high level of TOC to satisfy oligochaete habitat requirements, so particle size is not seen as a factor limiting oligochaete numbers at this site.

Another observation is that the benthos density for T5-4 is the lowest of the six sites in Transect 5. Station T5-4 is located a short distance downstream of the mouth of the Transect 6 channel. Station T5-3, located a similar distance upstream of Transect 6, has the second lowest density in Transect 5 (see Figure 6). However, this evidence of a possible impact of Transect 6 outflow on benthos is tempered by the benthos densities for the three lower stations in Transect 6, all of which are similar to or surpass the Transect 5 benthos densities.

The existing data base fails to satisfactorily attribute the low numbers of benthos for T6-1 to environmental factors, nor does it provide conclusive evidence that this is a result of sediment chemical concentrations. Oil and grease and lead are the only two chemicals found in higher concentrations at T6-1 than at other sites in the study area supporting higher numbers of benthos. Site T6-1 oil and grease levels, and oil and grease minus sulphur levels, are 4,300 (duplicate - 2,900) mg/kg and 4,000 (duplicate - 2,600), respectively. By comparison, T1-1 has oil and grease, and oil and grease minus sulphur, of 2,800 and 1,500 mg/kg, respectively. Yet T1-1 has ten times the number of benthos found at T6-1.

This may mean that oligochaete and polychaete tolerance levels for these two chemicals lie between these values (2,800 versus 4,300/2,900 mg/kg oil and grease; 260 versus 400/410 mg/kg lead), or the T6-1 benthos numbers may be a result of the synergistic effect of these two chemicals plus harsh environmental conditions. With the existing data base, either of the above two possibilities appear slightly more likely than attributing the depressed benthos numbers at T6-1 to environmental factors alone. Chapman *et al.* (1987) reported significant biological effects in San Francisco Bay subtidal sediments for lead and PAHs of 130 parts per million (ppm) and 9.5 ppm, respectively. If chemicals are impacting T6-1, there also exists a possibility that the same chemicals at other sampling locations are affecting the benthos of lower Transect 6, but this is not clear from the benthos data for this slough.

LG006540

PCBs

The levels of PCBs where present in the study area did not exceed 0.63 mg/kg (see Table 4). Although not directly comparable with sediment, the U.S. Environmental Protection Agency action level for PCBs in soil is 1 mg/kg. However, Chapman *et al.* (1987) reported significant biological effects in San Francisco Bay subtidal sediments from PCB levels of 0.16 ppm and greater. The source of the PCBs entering the pickleweed marsh adjacent to Highway 580 appears to be the urban runoff carried by the Transect 3 channel. The more prevalent presence of PCBs in the lower half of Transect 5 and the uppermost site of Transect 6 may be from two different sources. Previous soil samples from the ditch draining into the Transect 6 slough have contained PCBs, so this is the likely source of this chemical for T6-1. The lack of PCB detection in the lower three sites in Transect 6, and the consistent presence of PCBs in the lower four sites of Transect 5, suggest that the Stege drainage channel is a possible source of this chemical in Transect 5. The single occurrence and relatively low concentration of PCBs (0.38 mg/kg) associated with Transect 6 and the lack of PCBs in Transect 1 suggests that PCB input to the wetlands from the Liquid Gold site is not a problem.

Comparison of Benthos Sample Splits

Statistical features of the benthos sample splits are provided in Table 17. The statistical measures characterizing the comparison of the splits were the Coefficient of Variation (S.D./X) and the Percent Absolute Sampling Error ($|X_1 - X_2|/X$).

Five of the 17 splits had differences of greater than 20 percent of their mean. However, the differences in the total numbers of organisms between the split samples are generally much smaller than the differences among replicates for a sampling station. Noting this, together with the observation that most replicates in the study included at least 100 organisms, it is reasonable to assume that the split samples adequately characterize the benthos data.

5.3 TISSUE

Plant Tissue

A comparison of the actual copper, lead and zinc concentrations in pickleweed tips (the other three metals were not present in detectable levels) versus the concentrations associated sediment from the same sample station was made by computing the Pearson correlation coefficients (r) and associated p-values, and by examining individual scatterplots. The scatterplots are provided in Attachment G, and the correlation statistics are summarized in Table 18.

Although the correlation results for copper concentrations in pickleweed and sediment do not achieve statistical significance, its relatively low p-value (p=0.14) and modest correlation (r=0.38) does suggest that concentrations of copper in sediment samples may be associated with concentrations in the corresponding vegetation sample.

There is no statistical evidence that pickleweed concentrations of lead and zinc are correlated with sediment concentrations of these two heavy metals.

LG006541

Table 17
Comparison of Hoffman Marsh Benthos Sample Splits
October 1988

Sample I.D.	Total # of Organisms	Mean	S.D.	Coefficient of Variation	$[X_1 - X_2]$	Difference of Splits (Expressed as % of Mean)
T1-2-4A	1139					
	949	1044	134.35	0.13	190	18
T1-3-1A	382					
	393	387.5	7.78	0.02	11	3
T1-4-3B	279					
	250	264.5	20.51	0.08	29	11
T1-6-4B	501					
	423	462	55.15	0.12	78	17
T2-2-2A	147					
	146	146.5	0.71	0.01	1	0.7
T2-3-4A	703					
	722	712.5	13.44	0.02	19	3
T2-1-2B	750					
	752	751	1.41	0.00	2	3
T2-4-4B	746					
	1074	910	231.9	0.25	328	36

LG006542

Table 17, Cont'd

Sample I.D.	Total # of Organisms	Mean	S.D.	Coefficient of Variation	$[X_1 - X_2]$	Difference of Splits (Expressed as % of Mean)
T3-2-1A	240					
	241	240.5	0.71	0.00	1	0.4
T3-4-3A	382					
	216	299	117.38	0.39	166	56
T3-3-2B	44					
	96	70	36.77	0.52	52	74
T4-3-2A	92					
	120	106	19.80	0.02	28	26
T4-2-4B	131					
	119	125	8.48	0.07	12	10
T5-4-2A	63					
	109	86	32.53	0.38	46	54
T5-6-4A	266					
	359	312.5	65.76	0.21	93	30
T6-3-3A	104					
	107	105.5	2.12	0.02	3	3
T6-4-4A	218					
	205	211.5	9.19	0.04	13	6

LG006543

Table 18
Sample Correlation Statistics for Hoffman Marsh Pickleweed Tissue Versus Sediment Concentrations for Copper, Lead, and Zinc

	Transect Series C (N=17)	
	r	p
Copper	0.38	0.14
Lead	0.22	0.39
Zinc	0.01	0.96

Note: The Pearson correlation coefficient is "r," the "p" is the p-value.

LG006544

Animal Tissue

Pearson correlation coefficients and associated p-values were computed for yellow shore crab tissue versus sediment concentrations of six heavy metals. Individual scatterplots were also prepared and examined for identifying possible linear or nonlinear relationships. The resulting scatterplots are provided in Attachment G, and the correlation statistics are included in Table 19.

Of the six heavy metal concentrations examined for each of the A and B series of sediment results, only chromium showed a statistically significant positive correlation ($p<0.01$, $r=0.68$), but only with the A series sediment. The high chromium level in the A series of site T2-1 is largely responsible for the significance of this correlation. Eliminating this site from the computation yields a correlation of 0.43 ($p=0.14$) and reduces the amount of variation explained from 46.2 percent to 18.5 percent.

LG006545

Table 19
Sample Correlation Statistics for Hoffman Marsh Crab Tissue Versus Sediment Concentrations for Heavy Metals

	Transect Series			
	A (N=14)		B (N=9)	
	r	p	r	p
Chromium	0.68	<0.01	-0.12	0.77
Copper	0.20	0.50	-0.50	0.17
Lead	0.33	0.25	0.25	0.52
Mercury	-0.13	0.66	0.10	0.80
Nickel	-0.20	0.50	-0.28	0.46
Zinc	0.04	0.88	0.49	0.18

Notes: - The Pearson's correlation coefficient is "r," the "p" is the p-value.
- Chromium shows a significant correlation ($p<0.05$) in the A series.

LG006546

6.0 CONCLUSIONS

6.1 CHEMICAL MOVEMENT THROUGH THE FOOD WEB

Sediments act as natural sorbents capable of binding a wide range of organic and inorganic compounds. Because each type of sediment has its own binding affinities, each sediment type has different sorption properties which release trapped chemicals at varying rates under varying conditions. The release of metals from sediment for biological uptake is influenced by particle size, salinity, pH, the redox potential, presence of chelating agents, and the metal content of the substrate (Olsen 1984). Regarding the binding of petroleum PAHs to the sediments, there is a tendency for greater binding to sediments of smaller particle size and higher organic carbon content (Varanosi 1989). Because of the hydrophobic nature of PAHs, they tend to stay bound to the sediment. PAHs also gradually break down from weathering (e.g. sunlight and oxidation) and microbial action (Olsen 1984; Thomson and Webb 1984).

There are three primary routes by which toxic materials bound to sediments may enter biological systems (Samoiloff 1989).

1) Physical contact between the organism and the sediment resulting in the absorption of the chemical directly through the organism's body wall.

2) Ingestion by the organism, desorption of the chemical in the gut, and absorption of the chemical through the digestive system.

3) Desorption of the chemical from the sediment to the water column, and the organism uptake of the chemical via the water.

The compounds associated with the sediment particles are less available for biological uptake than the fraction released to the interstitial waters (Roesijadi *et al.* 1978; Neff *et al.* 1978). Of those compounds ingested, the availability of metals is greatly influenced by the acidity of the organism gut (Olsen 1984). In general, the accumulation rates of metals by fish and benthic organisms vary over a wide range of parameters including type of organism, exposure time and concentrations, salinity, and temperature (Leland *et al.* 1978; Engler 1979; Laube *et al.* 1979).

<u>Vegetation</u>

Marsh vegetation may retain organic and inorganic chemicals while either living or dead. Petroleum hydrocarbons are not readily taken in to the live plant, but have been found in the roots and rhizomes of *Spartina alterniflora* under conditions suggesting the entrance to those tissues occurred primarily after the plant died (Hershner and Lake 1980). Metals in the sediments are much more readily taken into vegetation, but once again, dead plant tissue of pickleweed and other marsh plants has a greater concentration of most heavy metals than occurs in the live plant tissue (Williams and Murdoch 1969; Gallagher and Kibby 1980).

The reason for this may be one or a combination of factors (Gallagher and Kibby 1980). First of all, dead tissues are more porous and the tissues' interstitial spaces may be more readily contaminated with sediment. Second, this porous structure may provide surfaces for sorption of salts.

LG006547

Third, decomposition may be selectively removing other components and causing a decreased total biomass of plant material. Fourth, microbes associated with the dead plant tissue may be causing the precipitation of metals. Although the dead plant tissue releases metals back to the marsh through fragmentation, leaching, and excretion by organisms associated with the breakdown of the tissue, the possibility of the significant uptake of metals by higher organisms as they ingest vegetation is the focus of this study, and these higher organisms do not feed on the dead plant tissue.

An elevated level of metals in marsh soil does not necessarily result in the associated marsh vegetation having levels of metals higher than would occur in soil with low levels of metals. Gallagher and Kibby (1980) grew salt grass and pickleweed in natural Oregon marsh soil and in contaminated dredged material containing metals several orders of magnitude higher than the natural soil. Copper was the only metal found to be accumulated from the contaminated soils. Even then, while the difference in copper content between the two soils was 86.9 versus 4,720 mg/kg dry weight, the pickleweed tissue concentration differences were only 7.9 versus 34.7 mg/kg dry weight.

The examination of possible correlations between the Hoffman Marsh sediment metal concentrations and those of the pickleweed tissue also suggested that copper levels in pickleweed may be positively correlated between the pickleweed and its associated soil (see Attachment G). Otherwise, none of the other five metals showed any association between marsh soil and pickleweed tissue concentrations. In view of the overall correlation results suggesting an association for copper, it is worth noting that the highest copper concentration found in the Transects 1 through 4 pickleweed marsh sediments was 110 mg/kg, and the cluster analysis for Transects 1 through 4 identified no locations with elevated copper levels associated with those sites nearest the Liquid Gold property. Based on these findings and the low levels of heavy metals found in the pickleweed tissue, the Liquid Gold site does not appear to be a significant contributor of chemicals to the food web through the marsh vegetation. (Petroleum hydrocarbons are not readily taken into live plants.)

Animal

Benthic organisms accumulate and depurate contaminants at various rates depending on species and environmental factors. Certain species, such as the polychaete *Capitella capitata*, have enzymes that enable them to metabolize hydrocarbons (Lee 1977). The only benthic organism present in Hoffman marsh with sufficient size and numbers to make the analysis of its tissue feasible was the yellow shore crab. This species served as the study's only indicator of toxic compounds passing up the food web to the shore birds that feed in Hoffman marsh.

First of all, it should be noted that the yellow shore crab is an important prey item for the California clapper rail, black rail, egret, heron, willet and other large wading birds (Morris *et al.* 1980; Josselyn 1983). This species is very abundant throughout most of the tidal sloughs of the marsh. During the October sampling activities in the marsh, wading birds were frequently observed feeding on yellow shore crab.

The yellow shore crab feeds mainly at night, primarily on diatoms and green algae, but also on dead or wounded animal life (Morris *et al.* 1980). They are good diggers and can rapidly bury themselves into the soil sediments when exposed at low tide. Their digging capacity also permits them to construct burrows in the firmer sediments along the side slopes of the tidal sloughs.

LG006548

Although no previous PAH toxicity research on the yellow shore crab is available, studies have been conducted on the effect of contaminants on fiddler crabs (*Uca pughax*), a species of similar size and habits. Krebs and Burns (1977) found the fiddler crab, when exposed to sediment with high petroleum hydrocarbon concentrations (No. 2 fuel oil), suffered heavy overwintering mortality, incorporation of the hydrocarbons into their body tissue, and experienced behavioral disorders such as locomotor impairment and abnormal burrow construction. The crab's exposure to contaminated sediment included the physical contact occurring when molting and remaining in their burrows until the shell hardened. Krebs and Burns (1977) also reported that the population density of the fiddler crab was reduced when TPH concentrations in the sediment exceeded 200 mg/kg and that sediment concentrations in excess of 100-200 mg/kg TPH were toxic to overwintering juvenile crabs. The authors' suspected that only the aromatic fractions (mostly naphthalenes in this particular oil) were primarily responsible for the long-term toxic effects observed. Unfortunately, there is no way to translate these TPH concentrations reliably into PAH values for comparison with this study's sediment analysis results, and no detectable levels of TPH (<1.0 mg/kg) were found in the Hoffman Marsh sediments (Attachment C). The Krebs and Burns study does show that high levels of petroleum hydrocarbons will reduce crab populations and can affect crab behavior. Because this study reported finding crab tissue with up to 280 mg/kg of hydrocarbons, it demonstrates that, if the study area's sediments contain high levels of petroleum hydrocarbons and it is passed up the food chain, it should be evident in the yellow shore crab tissue.

Trapping of yellow shore crab for tissue analysis revealed no abnormalities among the captured crabs. The highest numbers of captured crabs were associated with the upper and middle portions of Transects 1 and 5, the upper end of Transects 2 and 4, and the lower end of Transect 6 (see Table 9). Crab data for the upper end of Transect 6 is relatively meaningless because tidal conditions did not allow the trap to be submerged for a sufficient time. Other than upper Transect 6, the lowest crab capture rate occurred at the lowermost ends of Transects 1 through 4 where the larger channels are more heavily scoured, and Transect 3. Transect 3 is the largest channel of those sampled and is 12-18 feet wide throughout its length. The greatest numbers of crabs captured were from the upper half of Transect 1.

Analysis of the crab tissue revealed no detectable levels (usually <0.044 mg/kg wet weight) of PCBs, phenols, or petroleum hydrocarbons. Of the six heavy metals of concern, only chromium concentrations were significantly correlated between crab tissue and sediment in the A series (see Attachment G). The strength of this correlation rests largely on a single point, a high chromium level in the sediment at T2-1 accompanied by a high crab tissue level. However, the maximum chromium concentration found in the crab tissue (T2-1) was only 1.2 mg/kg wet weight (1.8 mg/kg dry weight) and the mean was 0.7 mg/kg wet weight (1.0 mg/kg dry weight).

6.2 RARE AND ENDANGERED SPECIES

There are no reports from the study area of any state- or federally-listed or candidate rare, threatened, or endangered plant species from either the reviewed literature or the California Natural Diversity Data Base (1988). Nor were any such species observed during WESCO's November survey. One sensitive species, marsh gum plant, is scattered throughout the site in areas of marsh transition. However, there is no evidence that past toxic discharges have affected this species' vigor or distribution within the study area. This plant has no legally protected status, but is on the California Native Plant Society's List 4, a watch list of plants of limited distribution.

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No state- or federally-listed threatened or endangered animal species were encountered during WESCO surveys. However, potential habitat was identified for the California clapper rail, California black rail, and salt marsh harvest mouse.

The California clapper rail has been reported from Hoffman Marsh, with the most recent recorded observation in 1985 (Hay 1986). Existing tidal salt marsh apparently provides suitable habitat for both the California clapper rail and California black rail; however, conditions are less than optimal. Much of the marsh margin, or transitional zone, has been rip-rapped and/or overtaken by iceplant and little peripheral cover is available for rails seeking refuge during high and flood tide events. Because the rails are secretive and difficult to detect, they may frequent Hoffman Marsh on an occasional basis, yet remain unnoticed.

There are no records of salt marsh harvest mouse in the study area and none were captured during live-trapping surveys. Because Hoffman Marsh is not contiguous to other marshland supporting populations of this species, immigration into the study area is unlikely. Similar to the reasons discussed above for the clapper rail, the limited extent and quality of peripheral high tide refugia, combined with the relatively low elevation of the marsh zone and frequent total inundation of the marsh vegetation, Hoffman Marsh provides poor quality habitat for the salt marsh harvest mouse. Given the poor quality of the habitat, in combination with the area's isolation from existing salt marsh harvest mouse population, and the lack of current and historic records, Hoffman Marsh is unlikely to support this species.

Other sensitive species known to the region, and potentially occurring in habitat types of the study area, are the salt marsh yellowthroat (federal candidate, Category 2), northern harrier, short-eared owl, salt marsh wandering shrew (California species of special concern), and black-shouldered kite (CDFG fully protected species). All but the shrew were observed in the study area during WESCO surveys. Those observations were of foraging birds, with no evidence of nesting onsite.

6.3 IMPACT TO BIOTA

Aquatic

The higher number of oligochaetes at the upper end of Transect 1 may be a reflection of the presence of PAHs and the greater levels of oil and grease existing in the sediments of this area, or it may be a result of elevated levels of TOC or chloride at these sites. However, no general trends for the entire area were found to be statistically significant. *Streblospio benedicti*, an opportunistic polychaete (Jong 1977) with an apparent tolerance of petroleum hydrocarbons (Felice 1954, 1958, and 1959; CH_2M Hill 1981), is also prevalent in Transect 1 but, with the possible exception of T1-3, not particularly more than at other transects in Hoffman Marsh. This apparent overall lack of an association between polychaete densities and oil and grease levels was supported by the statistical analyses. The benthic fauna of Transect 1 are not depressed in numbers relative to the rest of Hoffman Marsh, but the upper three or four sites do exhibit slightly less diversity (little or no cumaceans and amphipods) than is typical of most other sample sites. Because of the small size of these organisms, it would be both difficult and disruptive to the marsh to collect enough of these organisms to analyze their tissue for organic chemicals. For this reason, the study used the yellow shore crab for an assessment of the upward passage of chemicals through the food chain.

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None of the yellow shore crab tissue collected from within the study area had detectable levels of PAHs (typically <0.044 mg/kg wet weight). The greatest number of crabs captured within the study area came from the upper end of Transect 1, a location with relatively elevated levels of oil and grease and PAHs. None of the crabs collected in the study area show signs of discoloration, missing limbs, or abnormal behavior. Discounting the upper Transect 6 and trapping data because of physical trapping difficulties, and using the crab capture data from the lower end of this 30-meter channel, Transect 6 is similar to Transect 5 in the number of crabs captured. None of the crabs captured in upper or lower Transect 6 showed any signs of discoloration, missing limbs, or abnormal behavior.

Other than chromium, no metal concentrations in crab tissue were correlated with the concentration of similar metals in the sediments. Cluster analysis have not indicated that heavy metal levels in the sediments of the pickleweed marsh suggest a point source in a specific portion of the marsh (see Table 14). Based on these data in this study, it is concluded that: 1) there is no evidence that the Liquid Gold site and its past operations is a point source contributor of heavy metals to the pickleweed marsh; 2) the yellow shore crabs densities in the vicinity of the Liquid Gold site show no indication of being depressed relative to the rest of the marsh, nor does their health show signs of being impaired; and 3) there is no indication that the yellow shore crab, a major prey species for shorebirds, is a significant pathway of the Liquid Gold Site's chemicals into the food web.

The benthos density of upper Transect 6 is depressed and appears to be impacted by either desiccation (because of the sites elevation), salinity fluctuations, oil and grease and/or heavy metals, or a combination of these conditions. The available data do not permit a clear distinction between the individual effect of these factors. The remaining portion of Transect 6 has a benthos density similar to most other sites in the study area, and does not appear to be significantly impacted.

Vegetation

Although no quantitative sampling of species abundance and total plant cover was conducted, the vegetation structure and species composition of the wetlands of the study area do not differ significantly from other marshes in the Central San Francisco Bay region (WESCO observations; Cuneo 1987). The vegetation of these wetlands show no visual signs of adverse effects of past discharges from the Liquid Gold operations, nor is this evidenced in the heavy metal content of the pickleweed tissue. Further observations made in the spring of 1989 revealed no visually detectable differences in plant health or vigor between the marsh area immediately adjacent to the Liquid Gold site and other portions of the marsh. Upland areas support vegetation of a quality and composition typical of areas that have never supported a natural (pristine) plant community and that have been subjected to physical disturbance.

Waterbirds

Based on qualitative field observations by WESCO biologists, waterbird species composition in the study area does not differ significantly from other tidal marshlands in the Central San Francisco Bay area. In addition, waterbirds were distributed fairly evenly across Hoffman Marsh. No conclusions can be made regarding relative abundance because other marshes were not surveyed.

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The yellow shore crab is a common prey species utilized by many of the waterbirds that feed in Hoffman marsh. No organic contaminants were present at detectable levels in the tissue of these crabs and heavy metal concentrations were not notably high. In the one case where an overall positive correlation was found between the sediment levels of chromium (100 mg/kg) and that in crab tissue (1.8 mg/kg), the site with the highest chromium level (T2-1) was not associated with the Liquid Gold drainage channels. None of the data developed for this study indicates that the Liquid Gold site is impacting waterbirds through the food web.

Small Mammals

Small mammals are abundant throughout the Liquid Gold site/Hoffman Marsh study area; however, species composition is indicative of a disturbed setting in proximity to urban environments. Native populations of small mammals such as the western harvest mouse (*Reithrodontomys megalotus*), California vole, and California ground squirrel are either lacking (in the case of the western harvest mouse) or very limited. The salt marsh harvest mouse is also apparently absent. Exotic species such as the house mouse and Norway rat are abundant. Factors potentially contributing to the existing small mammal populations include the relatively recent establishment of Hoffman Marsh (approximately 30 years), considerable physical disturbance of existing habitats, potential historic toxic disturbance that could have resulted in the colonization of the site by exotic species from adjacent habitats, proximity to urban development, and isolation from other marsh habitats supporting small mammal populations. The analysis of Hoffman Marsh pickleweed tissue showed no notably elevated levels of heavy metals and no indication of the Liquid Gold site contributing contaminants to the food web through the pickleweed.

6.4 SUMMARY OF CONCLUSIONS

The biological investigation of the Liquid Gold Site/Hoffman Marsh was designed with the premise that, if the Liquid Gold site and its past operations are adversely affecting the biota of the marsh, it should be evident in its greater impact to adjacent wetlands than in those portions of the wetland further away. Sampling stations were therefore spread across the marsh so that comparisons could be made for locations at different distances and directions from the Liquid Gold site.

Upper Transect 1 adjacent to the Liquid Gold site was not found to have unusually high concentrations of heavy metals relative to the entire pickleweed marsh (Transects 1 through 4). Although not analyzed by cluster analysis because of a small number of data points, sample site T6-3 had the highest levels of mercury (4.50 mg/kg) and zinc (900 mg/kg) relative to all other transects in the study area but there was no decreasing trend with increasing distance from the site.

Using cluster analyses to assess Transects 1 through 4 and comparative line graphs for the remaining transects, the higher levels of oil and grease (2,800-4,300 mg/kg) and total PAHs (11 and 7 mg/kg) were found at upper Transects 1 and 6. Of the other organics analyzed, TPH was nondetectable (<1.0 mg/kg), as was phenol (<0.330 mg/kg wet weight). PCB's were present at concentrations up to 0.71 mg/kg in eight sites located at Transects 3 and 5, and at one site in Transect 6.

With two exceptions, the benthos community showed little difference among transects. Upper Transect 1 was relatively higher in numbers of oligochaetes, an opportunistic taxa with an apparent

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tolerance of petroleum hydrocarbons. However, no statistically significant overall correlation was found between oligochaete density and either oil and grease concentrations or the presence of total PAHs. Although there exists a possibility that oil and grease concentrations are impacting benthos in upper Transect 1, the higher number of oligochaetes can as easily be attributed to elevated levels of TOC or chloride as to oil and grease. Site T6-1 of Transect 6 was notable for having the lowest benthos density. This appears to be a result of either elevation, salinity fluctuation, the levels of oil and grease and/or other chemicals, or a combination of these conditions. The remaining sites on this 30-meter channel had benthos density and diversity similar to most other transects.

The highest crab capture rate occurred in upper Transect 1 near the Liquid Gold site. Insufficient tides reduced the effectiveness of the crab trapping at upper Transect 6, but the lower end of that transect produced crab numbers similar to other transects. None of the captured crabs showed signs of discoloration, missing limbs, or abnormal behavior.

Crab tissue was found not to contain detectable levels of PAHs. Heavy metals were present in the tissue but not at levels that appear particularly elevated. Of the six metals for which the crab tissue was analyzed, only chromium showed a significant correlation with levels of chromium in the sediments near the crab sample capture site. This finding is largely attributable to an elevated chromium level in both crab tissue and sediment at the upper end of Transect 2 (T2-1). The cluster analyses of sediment metal concentrations for Transects 1 through 4 identified no unusual locations of elevated metals near the Liquid Gold site.

There were no significant overall correlations between pickleweed tissue concentrations and soil concentrations for copper, lead, and zinc, the only heavy metals found in detectable levels in the pickleweed. Cluster analyses of metals in the pickleweed marsh failed to identify locations with unusually high copper levels near the Liquid Gold site.

The vegetation of the marsh was found to be similar to other San Francisco Bay wetlands of similar elevation and age. The pickleweed has good vigor, and the wetland vegetation shows no sign of being adversely affected by chemicals from the Liquid Gold site.

Trapping studies to determine presence or absence on the site of the endangered salt marsh harvest mouse concluded that it is not present. However, potentially suitable habitat is present for this species, the California clapper rail (endangered), and California black rail (threatened). Waterbird use of the wetlands is distributed fairly evenly across Hoffman Marsh, and shows no sign of impact by the Liquid Gold site.

Analyses of data generated by this investigation lead to the following conclusions:

1) The data for Transects 1 through 4 show no elevated concentrations of heavy metals in the sediment, pickleweed, and crab tissue of the pickleweed marsh adjacent to the Liquid Gold site. For this reason, it is concluded that the Liquid Gold site is not a point source contributor of heavy metals to the pickleweed marsh.

2) Relatively higher oil and grease levels in both the A and B series of T1-1, the presence of detectable PAHs, and slightly less benthos diversity than the rest of the pickleweed marsh (Transects 2 through 4) suggest the influence of the Liquid Gold

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site on the upper end of Transect 1. However, no significant overall associations were found between the oligochaete and polychaete densities and either oil and grease or total PAHs. Chloride and TOC levels showed an association with high oligochaete numbers similar to that observed for oil and grease. Additionally, the concentrations of oil and grease minus sulphur at upper Transect 1 sites are similar to those found in the other transects in the pickleweed marsh. This information, plus the similarities in the benthos fauna for most of the Transect 1 sites to the other pickleweed marsh sites, lead to the conclusion that the Liquid Gold site is not significantly affecting the benthic fauna of the pickleweed marsh (Transects 1 through 4).

3) The uppermost end of Transect 6 (T6-1) supports the lowest benthos density of all six transects. Site T6-1 also has the highest concentration of oil and grease and lead found in the study area sediments, and is subjected to more desiccation and salinity fluctuations than other locations. The benthos of T6-1 may be impacted by environmental factors, chemicals in the sediment, or a combination of these conditions; however, the latter two possibilities appear to be slightly more likely than attributing it to environmental factors alone.

   This impact appears to be limited to the upper end of Transect 6. The lower three sample sites in Transect 6 have higher benthos densities than most of the sites in Transect 5 and are similar to the benthos densities of Transect 4, the transect furthest from the Liquid Gold site.

4) The prevalence of PCBs throughout the lower two thirds of Transect 5, although not notably high in concentration, suggests that incoming tides have carried PCBs into this slough from a source other than the Liquid Gold site's Transect 6 drainage. (PCBs were found at T6-1 but not at other sites within this transect.) There is no indication of the Liquid Gold site's Transect 1 drainage contributing PCBs to the pickleweed marsh.

5) An absence of detectable PAHs and elevated heavy metals in the tissue of yellow shore crab in Transect 6 and upper Transect 1 relative to other study area sites, and the health of the crab populations at these sites does not suggest that the Liquid Gold property is affecting this crab species.

6) A general lack of correlation between metal concentrations in sediment with those in pickleweed and crab tissue, plus a failure to find elevated levels of metals or PAHs in prey species near the Liquid Gold site, leads to the conclusion that pickleweed and yellow shore crab, a major prey species for shorebirds, are not significant pathways into the food web for chemicals originating on the Liquid Gold site.

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7.0 PREPARATION STAFF

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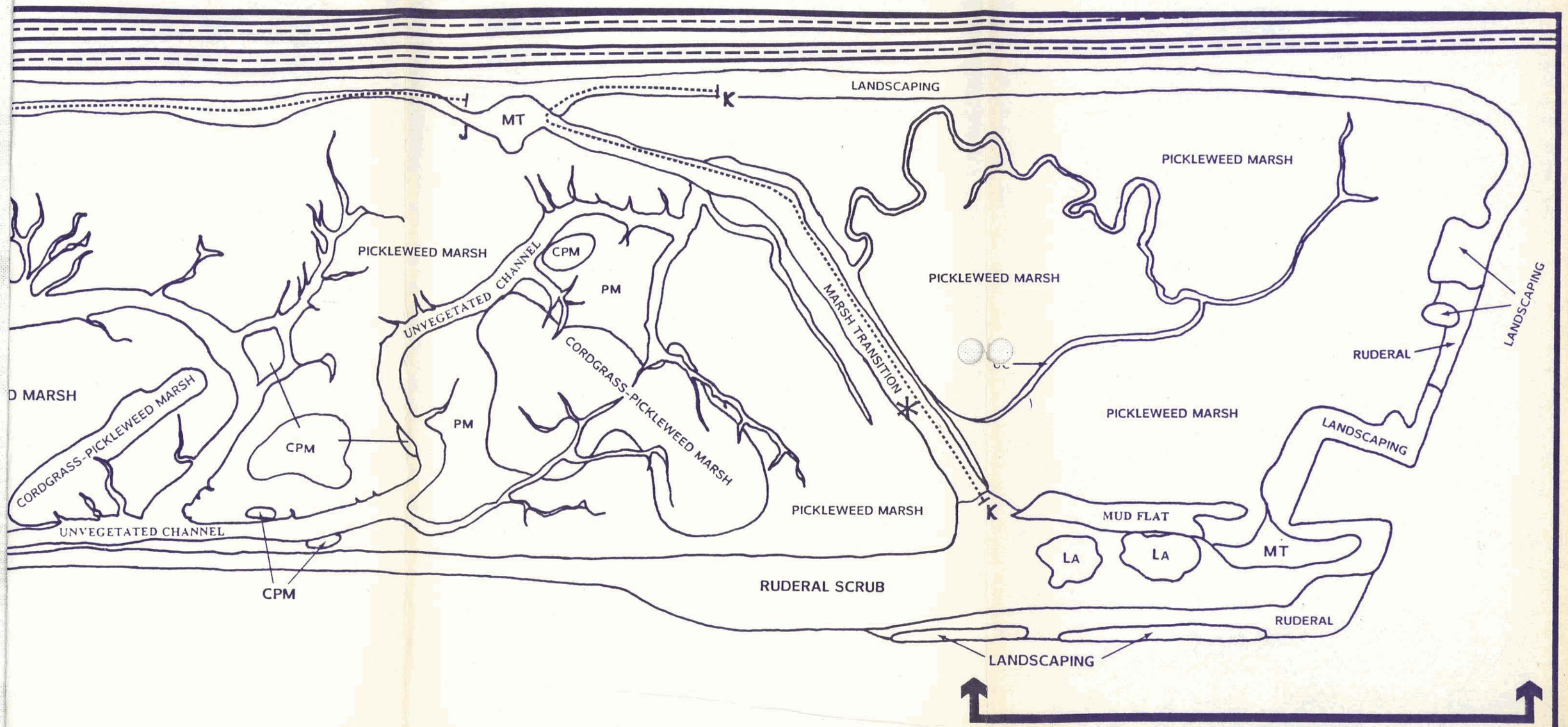
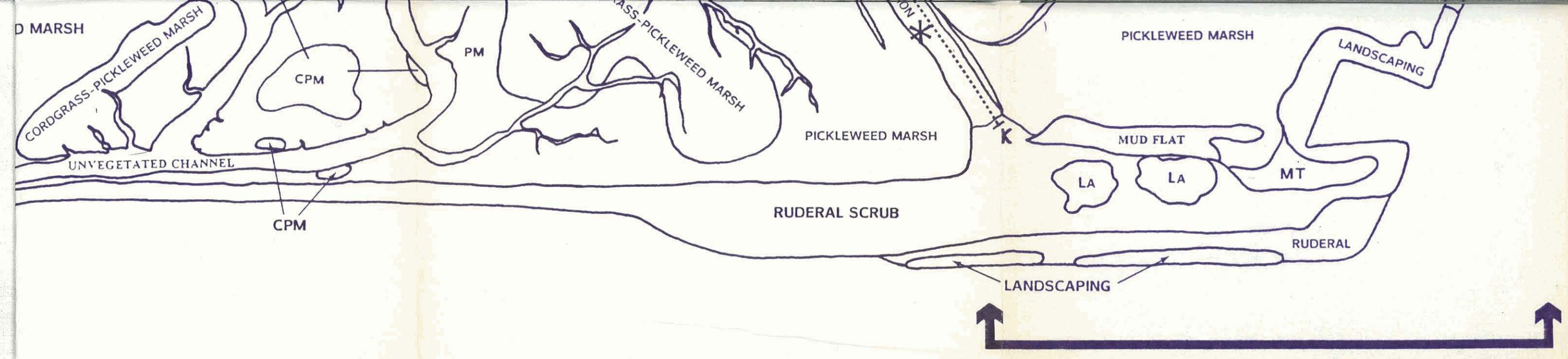


CALTRANS MITIGATION AREA
(Southeast of marsh transition berm)

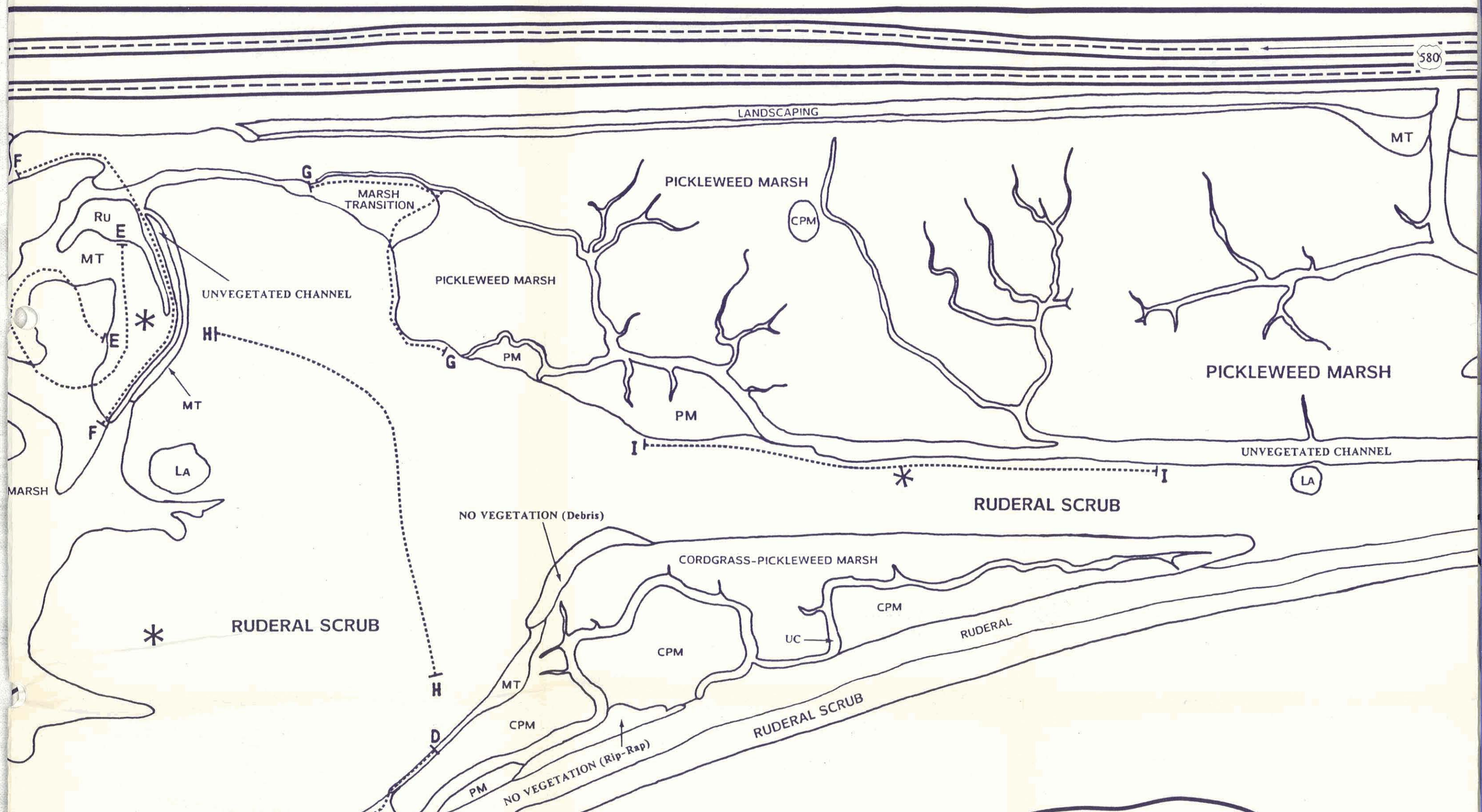


CALTRANS MITIGATION AREA
(Southeast of marsh transition berm)

BULK MAIL CENTER

LEGEND

CPM	CORDGRASS-PICKLEWEED MARSH
PM	PICKLEWEED MARSH
MT	MARSH TRANSITION
LA	LANDSCAPING
RU	RUDERAL
UC	UNVEGETATED CHANNEL
⊢----⊣	SMALL MAMMAL TRAP-LINE LOCATIONS


580
LANDSCAPING
MT
F
G
MARSH TRANSITION
PICKLEWEED MARSH
CPM
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E
MT
UNVEGETATED CHANNEL
PICKLEWEED MARSH
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PM
PICKLEWEED MARSH
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F
PM
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UNVEGETATED CHANNEL
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RUDERAL SCRUB
NO VEGETATION (Debris)
CORDGRASS-PICKLEWEED MARSH
CPM
UC
RUDERAL
*
RUDERAL SCRUB
CPM
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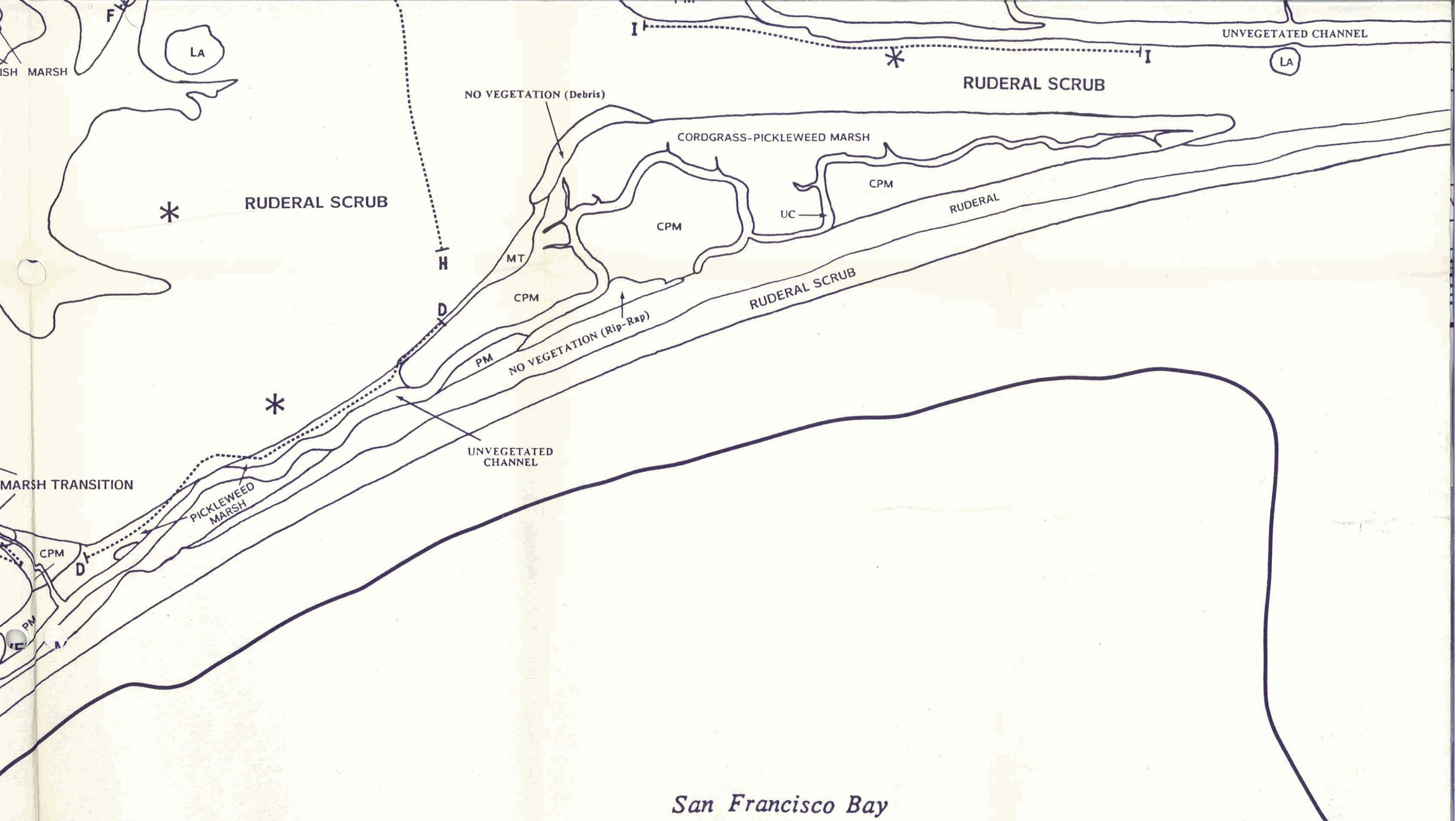
MT
CPM
D
RUDERAL SCRUB
NO VEGETATION (Rip-Rap)
PM


F
ISH MARSH
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RUDERAL SCRUB
NO VEGETATION (Debris)
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CORDGRASS-PICKLEWEED MARSH
CPM
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MT
CPM
D
PM
NO VEGETATION (Rip-Rap)
UNVEGETATED CHANNEL
MARSH TRANSITION
PICKLEWEED MARSH
CPM
D
PM
San Francisco Bay

ATTACHMENTS

ATTACHMENT A

HOFFMAN MARSH WET SEASON SALINITY ASSESSMENT

ATTACHMENT A

HOFFMAN MARSH WET SEASON SALINITY

INTRODUCTION

WESCO's original program for the biological investigations of Hoffman Marsh called for both dry and wet season benthos sampling. The dry season sampling was conducted in October of 1988, and the wet season sampling was scheduled for February of 1989. Unfortunately, local precipitation and Delta outflow during the winter failed to significantly lower the salinity of Central San Francisco Bay waters near Hoffman Marsh. Salinity measurements last fall at the marsh's point of inflow/outflow to the Bay were 33-35 parts per thousand (ppt). The salinity readings at this same site on two occasions in February were 30 ppt.

Because wet season conditions failed to occur by late February, the state and federal agencies reviewing this investigation agreed in a 27 February 1989 meeting that conditions were unsuitable for the wet season benthos sampling. Consideration was to be given to alternative approaches to assessing the potential impacts to aquatic biota from the possibly increased bioavailability of heavy metals during wet season conditions. The possibility of wet season benthos sampling during this winter or spring required extensive rainfall during the month of March. For this reason, surface water salinities in Hoffman Marsh were measured frequently during March. A description of the methods employed, results, and conclusions follow.

METHODOLOGY

Surface water salinities for Hoffman Marsh were measured with a portable refractometer salinity meter. The initial salinity measurements were made in October 1988 at the pickleweed marsh's point of inflow/outflow to Central San Francisco Bay (the old railroad trestle near Transect 4-4). Further readings were made at this site in February 1989. In March of 1989, salinity measurements were extended to the various tidal sloughs within the study area.

March began with some of the heaviest rainfall the San Francisco Bay area had received all winter. The salinity of Hoffman Marsh surface waters at the upper and lower ends of each transect, plus the inflow/outflow channel, was recorded under various tidal conditions, typically 1 to 4 days after a rainstorm. The following dates and tidal conditions were measured for salinity:

March 9	incoming to nearly high tide
March 14	low tide
March 16	outgoing to nearly low tide
March 17	high tide, outgoing
March 22	high tide
March 30	outgoing to nearly low tide

No attempt was made to synchronize our measurements to sequentially collect from the same location for similar portions of the tide cycle. We instead tried to obtain salinity readings from the upper and lower ends of our transect channels for high and low tide conditions. Outgoing and low tide conditions were assumed to best represent the effect of local runoff on the marsh's salinity. High tide and incoming tides were believed to be indicative of the effect of the Bay water's salinity on the marsh.

Quality Control

Quality control was maintained by rinsing the refractometer before and after sampling until the instrument zeroed out. Then it was dried with a paper towel prior to depositing a drop of the next water sample on the instrument lens.

RESULTS AND DISCUSSIONS

The low end of winter and spring salinity ranges in Hoffman Marsh are controlled by local precipitation and the size of the watershed draining into individual channels. The high end of the wet season salinity is largely controlled by the ambient salinity of Central San Francisco Bay, which is in turn determined by the volume of freshwater outflow from the Delta. The ambient salinity of the Central San Francisco Bay was found to drop from 30 ppt on March 9th to the low to mid 20's ppt by the end of March (Table A-1, inflow channel site). This apparent drop in ambient salinity may be influenced by the dilution of local runoff as it first mixes with Bay waters.

The low end of our measured salinities varied by channel and by the size of the channel's upland drainage. Transect 3 is a channel that drains urban runoff from Richmond Annex on the east side of Hwy 580. It carries the greatest volume of fresh water and its upper sample site had salinities of 0.0 to 5.0 ppt for five of the six sampling periods and 9.5 ppt at high tide. The transects with the next lowest salinities are the upper ends of transects 1 and 6. Both receive local runoff from the Liquid Gold site uplands and had salinities typically in the range of 5 to 8 ppt throughout most of the month. Transect 5 was the next most saline with readings that probably reflected the freshwater inflow from Stege channel. The two most saline were transects 2 and 4 which had no significant upland runoff and had surface water salinities of 17.5 to 30.0 ppt in their upper ends.

CONCLUSIONS

Delta outflow greatly affects the salinity of Central San Francisco Bay waters, particularly the east side of the Bay where incoming tides tend to direct the fresh water leaving San Pablo Bay. An example of this effect is shown in Table A-2 where winter/spring salinities at Alameda are correlated to Delta outflow. Table A-3 and Figure A-1 illustrate the degree to which Delta outflow during the 1989 Water Year winter study period was below average.

Salinities are assumed to be lowest for most transects at low tide when freshwater runoff or seepage can exert its greatest influence. The confluence of transects 1 through 4 near the old railroad trestle (inflow/outflow channel) at low tide and the beginning of the incoming tide is a mixing zone of freshwater inflow from Transect 3 and the waters of Central San Francisco Bay. The incoming tide pushes this mixed water back up the various tidal sloughs. This is part of the reason that the lower ends of transects 2 and 4 frequently have lower salinities than their upper ends. The other reason is that the upper ends of transects 2 and 4 are 0.2 to 0.3 feet lower in elevation than the mid-portion of the marsh. Salt water collects and evaporates on the pickleweed flats of the upper ends of these transects, resulting in a higher soil salinity. This greater salinity is reflected in the tidal runoff from these sites.

Extensive rainfall during the month of March produced partial wet season conditions in Hoffman Marsh as a result of local precipitation and runoff. Salinities in channels draining significant upland areas dropped to levels estimated to approximate normal wet season conditions. Salinity levels in the upper ends of transects 1, 3, and 6 were sufficiently lowered to the 15 ppt or

less, which may contribute to mobilizing heavy metals in the sediments (E.V.S. Consultants 1989). However, because the ambient salinity of Central San Francisco Bay wasn't as low as would be expected during a normal water year, the upper salinity range was believed to be higher than normal for most of the marsh. Those transects and portions of transects exposed to salinities of 0 to 8 ppt because of upland runoff would have a benthos population more stressed from the extremes in salinity fluctuation than the benthos of transects 2 and 4 where only moderate salinity fluctuation occurred. If the benthos had been sampled at that time, any comparison of benthos numbers and taxa composition between the upper end of transects 1 and 6 versus most of the other transect sites would require distinguishing between salinity impacts and heavy metal impacts. This would have been an extremely difficult task requiring a detailed knowledge of the salinity tolerance of the major benthic taxa present. For this reason, there was no compelling rationale to change the decision not to conduct a wet season field study of Hoffman Marsh.

Table A-1

Hoffman Marsh Surface Water Salinities, March 1989

	March 9			March 14		
SITE:	Salinity (ppt)	Tide	Time	Salinity (ppt)	Tide	Time
Inflow Channel	17.5/30.0	in	0855/1115	25.0	out	0915
T1-1	14.0	out	1000	8.0	low	1240
T1-6	24.0	in	0912	20.0	low	1115
T2-1	30.0	low	1005	30.0	low	1150
T2-4	22.5	out	0925	27.0	low	1140
T3-1	3.5	in	1021	5.0	low	1200
T1 & T3 Jxn	11.5	low	0903	15.0	low	1030
T4-1	30.0	low	0849	30.0	low	0940
T4-4	26.5	low	0835	27.0	low	1000
T5-1	15.0	in	1035	15.0	low	1250
T5-6	30.0	high	1100	13.0	low	1345
T6-1	12.0	out	1045	7.0	low	1330
T6-4	28.0	in	1047	10.0	low	1320

	March 16			March 17		
SITE:	Salinity (ppt)	Tide	Time	Salinity (ppt)	Tide	Time
Inflow Channel	4.5	out	1340	----		
T1-1	5.5	out	1230	5.5	out	1035
T1-6	11.5	out	1335	20.0	out	0905
T2-1	20.0	out	1245	22.5	out	1045
T2-4	14.0	out	1255	18.0	out	0915
T3-1	0.0	out	1310	0.5	out	1050
T3-4	0.5	out	1320	22.0	out	0900
T4-1	28.0	out	1410	17.5	out	1020
T4-4	15.0	out	1345	23.0	out	0855
T5-1	13.5	out	1215	12.5	out	0935
T5-6	1.0	out	1155	15.5	out	0950
T6-1	1.5	out	1145	5.0	out	1000
T6-4	2.0	out	1130	11.0	out	0942

	March 22			March 30		
SITE:	Salinity (ppt)	Tide	Time	Salinity (ppt)	Tide	Time
Inflow Channel	18.5/20.5	high/out	1215/1325	14.5/20.5	out	0830/1015
T1-1	6.0	high	1150	7.5	out	0935
T1-6	19.0	in	1220	14.0	out	0840
T2-1	14.5	in	1157	13.0	low	1030
T2-4	19.0	in	1238	20.0	out	0850
T3-1	9.5	in	1202	3.0	out	1045
T1 & T3 Jxn	17.0	in	1217	5.0	out	0835
T4-1	17.5	out	1350	24.0	out	0815
T4-4	20.0	out	1340	16.5	out	0820
T5-1	18.5	out	1245	9.5	out	0905
T5-6	18.5	out	1307	7.5	out	0925
T6-1	5.5	out	1300	6.5	low	0915
T6-4	17.0	out	1253	7.0	out	0920
Jxn. of Outflow Channel & Bay	21.5	out	1335	14.5	out	1005

Notes: 1) "In" = incoming; "out" = outgoing.
2) "Inflow channel" is the railroad trestle near T4-4.
3) "Jxn. of Outflow Channel and Bay" = the mouth of the inflow/outflow channel at Point Isabel.

Table A-2
Variations in Salinity at Alameda Relative to Delta Outflow

Water Year	Winter/Spring Delta Outflow (cfs)	Winter & Spring Salinity (PPT) @ Alameda
1969	106,000	12-15
1970	106,000	10-15
1971	80,000	20-22
1972	35,000	24
1973	100,000	17-18
1974	106,000	14
1975	60,000	18-20
1976	17,000	30-31

SOURCE: Conomos, T.J. ed. 1979. San Francisco Bay: the Urbanized Estuary. Pacific Division of AAAS. San Francisco. Page 58 of 493 pp.

Table A-3
Sacramento - San Joaquin Delta Outflow,
1982-1989 Water Years, October-March

Water Year	Mean Delta Outflow Minus Bypass in Thousands of cfs					
	October	November	December	January	February	March
1982	3.2	31.2	86.2	83.4	88.7	65.9
1983	20.3	30.7	79.8	76.1	176.5	250.6
1984	29.5	59.5	137.2	90.2	37.1	31.5
1985*	12	11.5	23	33	17	17.5
1986	2.2	3.6	8.4	12.9	170.7	148.4
1987	11.7	9.2	11.3	12.3	17.0	19.7
1988	3.3	3.5	8.7	17.6	4.6	5.5
1989**	3.2	5.6	6.8	5.3	5.9	34.5
1982-1988 Avg.	11.7	21.3	50.6	46.5	73.1	77.0

* The 1985 Water Year outflow record was missing from the package sent to WESCO by the Department of Water Resources. Therefore, the 1985 Water Year flows are approximated from a graph depicting average monthly outflow at Chipps Island 1980-85 (California Department of Fish and Game. 1987. Exhibit 60, submitted to the Bay/Delta water rights hearings).

** The Hoffman Marsh wet season sampling was scheduled to occur in February of the 1989 water year (October 1, 1988-September 30, 1989).

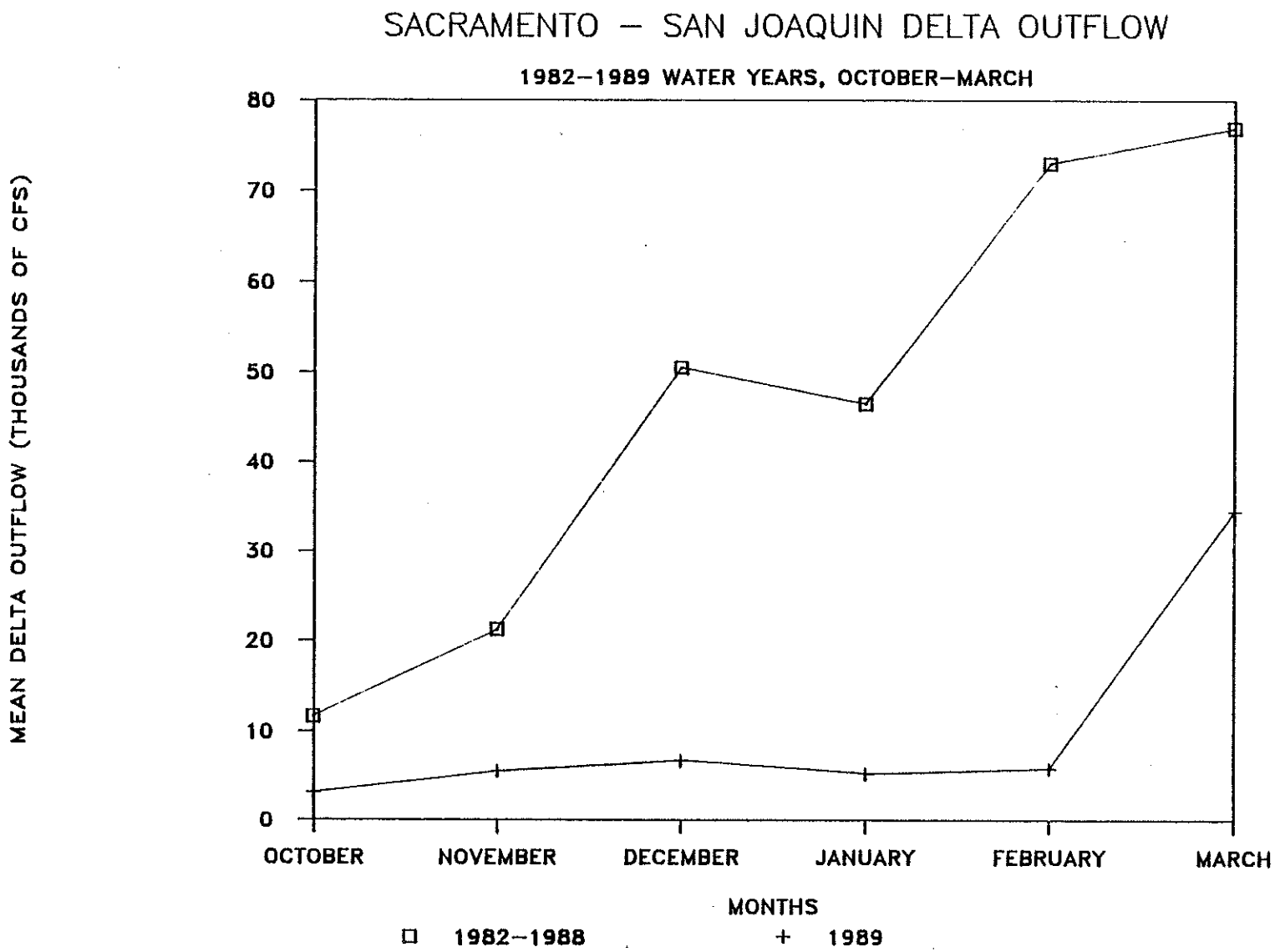

Figure A-1. Sacramento-San Joaquin Delta Outflow to San Francisco Bay, October through March, 1982-88 Water Year Average and 1989 Water Year.

L00065370

ATTACHMENT B

PACE LABORATORIES DATA AND QA/QC RESULTS -
PARTICLE SIZE AND TISSUE ANALYSES

ATTACHMENT B

TISSUE SAMPLE QUALITY ASSURANCE RESULTS

CRAB TISSUE

Fourteen yellow shore crabs were collected from Hoffman Marsh in the late fall of 1988. These samples were analyzed by PACE Laboratories of Novato, California using methods described in Section 2.3 of this report. Two quality assurance (QA) samples accompanied these 14 tissue samples throughout the analysis process (Table B-1). Each inorganic QA sample preparation consisted of the following:

- Preparation blank (de-ionized water w/reagents)
- Lab control sample (spiked blank)
- Four aliquots of the sample:
  - Two aliquots received normal analysis preparation (yield percent precision)
  - Two aliquots were spiked (yield percent spike duplication)

The organic QA sample preparation was similar to that described above except that surrogate spikes were added to the sample.

The results of the inorganic and organic QA sample analyses for the crab tissue are shown on tables B-2 and B-3, respectively. Regarding the inorganic QA results, most of the Relative Percent Differences (RPD) between the duplicates (DUP) were outside of the normal control limit of 20 percent. However, this was offset by good results for the spiked duplicate RPD. As such, these results are considered acceptable relative to the difficulty of the matrix involved.

PACE Laboratories checks calibration of its instruments after each run of 10 samples. Following the run of 10 lead samples, the calibration check found that the instrument had drifted 4 percent out of the standard range of 90 to 110 percent. Because the levels of lead in the QA samples are close to the method detection limit (MDL), this is not seen to be a significant problem.

The QA results for the organic analyses (Table A-3) show no problems. The precision and recoveries for both the methods 8270 and 8080 are within control limits. However, a review of the surrogate recovery data for the 8270 analyses for sample T 1-6 (see pages 2 and 3 of lab data sheets) indicate low recovery (12 to 15 percent) compared to other samples. Because, with the exception of sample contamination, no detectable levels of base/neutral, acid extractables were found in any of the crab tissue tested, it is unlikely that this is a significant problem for the study.

Regarding sample contamination, the results for the 8270 analyses show detectable levels of phthalates in over 90 percent of the samples, yet none was found in the sample blanks. Phthalates are common plastisizers found in most rubber and plastic products. As such, the phthalates found in the QA samples are believed to have resulted from accidental field or processing contamination of the samples.

PICKLEWEED TISSUE

The 16 pickleweed samples were only tested for heavy metal content. The QA sample procedures were the same as that described previously for the inorganic analyses of crab tissue. The number of QA samples used for these 16 samples is shown on Table B-4.

The results of the QA analyses are summarized in Table B-5. All of the QA results show good precision and recovery well within the 20 percent control limits.

Table B-1
Number of QA Crab Tissue Samples Analyzed by PACE Laboratories
December 1988 and January 1989, Hoffman Marsh/Liquid Gold Site

(mical	Number of Spike Samples Analyzed	Approximate Percentage of Spike Samples Analyzed	Number of Duplicate Samples Analyzed	Approximate Percentage of Duplicate Samples Analyzed
l organics:				
Chromium	2	14%	2	14%
Copper	2	14%	2	14%
Lead	2	14%	2	14%
Mercury	2	14%	2	14%
Nickel	2	14%	2	14%
Zinc	2	14%	2	14%
Organics:				
EPA Method 8080	1	7%	1	7%
PA Method 8270	1	7%	1	7%

Table B-2
Crab Tissue Samples QA Inorganic Results, PACE Laboratories, December 1988 and January 1989, Hoffman Marsh/Liquid Gold Site

Analysis Results in Milligrams per Kilogram Wet Weight

Parameter	Prep Blank	LCS Rec	Sample Result	Dup Result	RPD Dup	Sample Result	Spike Result	Spike Added	Spike Rec	Spike Dup	Spike Dup Rec	Spike Dup RPD	MDL
Chromium	ND	103%	0.55	0.52	5.6%	0.55	111	100	110%	106	105%	4.6%	0.2
Copper	ND	101%	24	37	43%	24	136	100	112%	130	106%	4.5%	0.2
Lead*	ND	94%	3.9	3.2	20%	3.9	47	40	108%	46	105%	2.2%	1.0
Mercury	0.02	95%	0.06	0.10	50%	0.06	0.83	1	77%	0.90	84%	8.1%	0.02
Nickel	ND	107%	0.50	1.2	82%	0.50	111	100	110%	109	108%	1.8%	0.2
Zinc	ND	98%	25	35	33%	25	133	100	108%	124	99%	7.0%	0.2

* QC results are from a run where the calibration drifted slightly out of control.

Notes:
Prep. Blank = Preparation blank (de-ionized water w/reagent)
LCS Rec = Laboratoray control sample recovery
Dup Rec = Duplicate recovery
RPD Dup = Relative percent difference ($\frac{\text{difference absolute value}}{}$) x 100 = %

MDL = Method detection limit

Table 3-3
Crab Tissue Samples QA Organic Results, PACE Laboratories, December 1988 and January 1989, Hoffman Marsh/Liquid Gold Site

Analysis Results in Milligrams per Kilogram Wet Weight

Parameter	Prep Blank	Sample Result	Spike Result	Spike Added	Spike Rec	Spike Dup	Spike Dup Rec	Spike Dup RPD	MDL
EPA Method 8270:									
1,4-dichlorobenzene	ND	ND	0.0074	0.0100	74%	0.0071	71%	4%	--
Acenapthene	ND	ND	0.0070	0.0100	70%	0.0069	69%	1%	--
2,4-dinitrotoluene	ND	ND	0.0055	0.0100	55%	0.0043	43%	24%	--
Pyrene	ND	ND	0.0059	0.0100	59%	0.0053	53%	11%	--
Phenol	ND	ND	0.0156	0.0200	78%	0.0154	77%	1%	--
4-chloro-3-methylphenol	ND	ND	0.0088	0.0200	44%	0.0104	52%	17%	--
4-nitrophenol	ND	ND	0.0148	0.0200	74%	0.0094	47%	45%	--
Pentachlorophenol	ND	ND	0.0158	0.0200	79%	0.0140	70%	12%	--
EPA Method 8080:									
Lindane	ND	ND	0.028	0.06	47%	0.022	37%	24%	0.0001
Heptachlor	ND	ND	0.029	0.064	46%	0.026	41%	11%	0.0001
Aldrin	ND	ND	0.013	0.062	21%	0.017	18%	15%	0.0001

Notes:
Prep. Blank = Preparation blank (de-ionized water w/reagent)
Dup Rec = Duplicate recovery
RPD Dup = Relative percent difference $\left(\frac{\text{difference absolute value}}{\text{mean}}\right) \times 100 = \%$
MDL = Method detection limit

Table B-4
Number of QA Pickleweed Tissue Samples Analyzed by PACE Laboratories
May 1989, Hoffman Marsh/Liquid Gold Site

Chemical	Number of Spike Samples Analyzed	Approximate Percentage of Spike Samples Analyzed	Number of Duplicate Samples Analyzed	Approximate Percentage of Duplicate Samples Analyzed
Inorganics:				
Chromium	2	12%	2	12%
Copper	2	12%	2	12%
Lead	2	12%	2	12%
Mercury	2	12%	2	12%
Nickel	2	12%	2	12%
Zinc	2	12%	2	12%

Table B-5
Pickleweed Tissue Samples QA Inorganic Results, PACE Laboratories
May 1989, Hoffman Marsh/Liquid Gold Site

Analysis Results in Milligrams per Kilogram Wet Weight

Parameter	Prep Blank	LCS Rec	Sample Result	Dup Result	RPD Dup	Sample Result	Spike Result	Spike Added	Spike Rec	Spike Dup	Spike Dup Rec	Spike Dup RPD	MDL
Chromium	ND	98%	ND	ND	0%	ND	95.3	100	95%	96.8	97%	1.6%	1
Copper	ND	120%	1.3	1.2	8.0%	1.3	99.9	100	99%	103	102%	3.1%	1
Lead	ND	102%	ND	ND	0%	ND	197	200	98%	192	96%	2.6%	10
Mercury	ND	103%	0.02	0.02	0%	0.02	0.92	1.0	90%	0.90	88%	2.5%	0.02
Nickel	ND	93%	ND	ND	0%	ND	92.6	100	93%	96.7	97%	4.3%	2
Zinc	ND	109%	4.7	4.4	6.6%	4.7	494	500	98%	484	96%	2.0%	1

Notes:

Prep. Blank = Preparation blank (de-ionized water w/reagent)
LCS Rec = Laboratoray control sample recovery
Dup Rec = Duplicate recovery
RPD Dup = Relative percent difference $\left(\frac{\text{difference absolute value}}{\text{mean}}\right) \times 100 = \%$

MDL = Method detection limit

LG006578

pace laboratories, inc.
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report Date: 20-Jan-89
PACE JOB #: WES 0817.5-L

Completion Date: 17-Jan-89
Reported by: J.L.HARWOOD

MATRIX: CRAB TISSUE

LAB #	CLIENT ID	Chromium (Cr) (mg/kg)	Copper (Cu) (mg/kg)	Lead (Pb) (mg/kg)	Mercury (Hg) (mg/kg)	Nickel (Ni) (mg/kg)	Zinc (Zn) (mg/kg)
8-1454	T1-1T	0.6	22	1.0	0.08	0.6	24
8-1455	T1-4T	0.7	25	1.6	0.11	0.9	22
8-1456	T1-6T	0.8	23	1.7	0.08	0.6	22
8-1457	T2-1T	1.2	29	1.2	0.06	0.7	21
8-1458	T2-4T	0.6	22	1.6	0.08	0.3	22
8-1459	T3-1T	0.9	24	2.3	0.05	0.8	24
8-1460	T3-4T	0.6	18	2.0	0.05	0.5	21
8-1461	T4-1T	0.9	28	1.8	0.04	0.4	22
8-1462	T4-4T	0.7	21	2.4	0.06	0.7	25
8-1463	T5-1T	0.4	24	ND	0.04	0.6	21
8-1464	T5-4T	0.4	27	ND	0.05	0.5	25
8-1465	T5-6T	0.4	25	1.2	0.06	0.4	22
8-1466	T6-2T	0.7	19	2.0	0.04	0.7	21
8-1467	T6-4T	0.6	24	2.6	0.04	0.5	25
Detection limit		0.2	0.2	1	0.02	0.2	0.2
Method number		EPA 6010	EPA 6010	EPA 7420	EPA 7471	EPA 6010	EPA 6010

ND: Not Detected

Analytical Supervisor

LG006579

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report Date: 20-Jan-89
PACE JOB #: WES 0817.5-L
MATRIX: CRABS

Completion date: 20-Dec-88
Reported by: J.L.HARWOOD
Analyst: R.AYZENBERG

LAB #	CLIENT ID	% MOISTURE	DETECTION LIMIT
8-1454	T1-1T	41.0	0.5
8-1455	T1-4T	36.0	0.5
8-1456	T1-6T	35.6	0.5
8-1457	T2-1T	34.2	0.5
8-1458	T2-4T	33.6	0.5
8-1459	T3-1T	34.0	0.5
8-1460	T3-4T	29.1	0.5
8-1461	T4-1T	35.0	0.5
8-1462	T4-4T	34.0	0.5
8-1463	T5-1T	32.5	0.5
8-1464	T5-4T	35.0	0.5
8-1465	T5-6T	35.2	0.5
8-1466	T6-2T	31.0	0.5
8-1467	T6-4T	33.2	0.5

N.D.: Not Detected

Steve Mackenzie
Analytical Supervisor

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REPORT OF LABORATORY ANALYSIS

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Report Date: 24-Jan-89
PACE JOB #: WES 0817.5-L
Analytical Method: EPA 8270
MATRIX: CRAB TISSUE

Extract/Purge Date: 12-Dec-88
Completion Date: 16-Dec-88
Analyst: R.SIEGMUND
Reported by: J.L.HARWOOD

LAB #:	8-1454	8-1455	8-1456	8-1457	8-1458	
CLIENT'S ID:	T1-1T	T1-4T	T1-6T	T2-1T	T2-4T	
BASE NEUTRALS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
N-Nitrosodimethylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Aniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Bis(2-chloroethyl) ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,3-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,4-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroisopropyl)ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
N-Nitroso-di-N-propylamine	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	44
Nitrobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Isophorone	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroethoxy)methane	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2,4-Trichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Naphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobutadiene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorocyclopentadiene	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dimethylphthalate	N.D.	N.D.	N.D.	N.D.	N.D.	44
Acenaphthylene	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,6-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Acenaphthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dibenzofuran	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Diethyl phthalate	96	N.D.	N.D.	162	N.D.	44
Fluorene	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Chlorophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
N-Nitrosodiphenyl amine	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2-Diphenylhydrazine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Bromophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Di-n-butyl phthalate	728	N.D.	90	N.D.	599	44
Fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzidine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Butylbenzyl phthalate	N.D.	1160	N.D.	N.D.	N.D.	44

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BASE NEUTRALS (cont)
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1454	8-1455	8-1456	8-1457	8-1458	
CLIENT'S ID:	T1-1T	T1-4T	T1-6T	T2-1T	T2-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Benzo(a)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
3,3'-Dichlorobenzidine	N.D.	N.D.	N.D.	N.D.	N.D.	87
Chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-ethylhexyl) phthalate	1860	3850	596	1900	1040	44
Di-n-octyl phthalate	915	1430	142	770	146	44
Benzo(b)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Indeno(1,2,3-cd)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dibenzo(a,h)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(g,h,i)perylene	N.D.	N.D.	N.D.	N.D.	N.D.	44
QUALITY CONTROL DATA	Base/Neutral Surrogate Spike Recovery					
Nitrobenzene-d5	127%	132%	14%	99%	91%	
2-Fluorobiphenyl	134%	113%	15%	97%	91%	
Terphenyl-d14	106%	98%	12%	81%	71%	

ACID COMPOUNDS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Phenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Chlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Nitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dimethylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzoic Acid	N.D.	N.D.	N.D.	N.D.	N.D.	220
2,4-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Chloro-3-methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	87
2,4,6-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4,5-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
4-Nitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
2-Methyl-4,6-dinitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
QUALITY CONTROL DATA						
2-Fluorophenol	122%	114%	43%	122%	105%	
Phenol-d5	105%	101%	38%	106%	92%	
2,4,6-Tribromophenol	100%	94%	38%	93%	89%	

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PESTICIDE COMPOUNDS
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1454	8-1455	8-1456	8-1457	8-1458	
CLIENT'S ID:	T1-1T	T1-4T	T1-6T	T2-1T	T2-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
alpha-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
beta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
gamma-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
delta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan I	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDE	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dieldrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan II	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDD	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Aldehyde	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan Sulfate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

QUALITY CONTROL DATA	Pesticide Surrogate Spike Recovery				
Nitrobenzene-d5	127%	132%	14%	99%	91%
2-Fluorobiphenyl	134%	113%	15%	97%	91%
Terphenyl-d14	106%	98%	12%	81%	71%

OTHER EXTRACTABLES	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit(ug/kg)
Acetophenone	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Aminobiphenyl	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Arochlors	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Benzyl Alcohol	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Chloroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenz(a,j)acridine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2,6-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
p-Dimethylaminoazobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
7,12-Dimethylbenz(a)-anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
alpha,alpha-Dimethylphen-ethylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Ketone	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Ethylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Methoxychlor	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

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OTHER EXTRACTABLES
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1454	8-1455	8-1456	8-1457	8-1458	
CLIENT'S ID:	T1-1T	T1-4T	T1-6T	T2-1T	T2-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
3-Methylchloranthene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Methylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Methylnaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
3-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosophenylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosopiperidine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachloronitrobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Picoline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pronamide	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1,2,4,5-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2,3,4,6-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Toxaphene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Biphenyl	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Diphenylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
beta-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenzothiophene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

N.D.: Not Detected n.d.: not determined
N.A.: Not Applicable

NOTE: Detection Limits are 3 times higher than normal.
1,4-Cyclooctadiene was tentatively identified in all of the samples, but is concluded to be a lab contaminant.

Analytical Supervisor

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Report Date: 24-Jan-89
PACE JOB #: WES 0817.5-L
Analytical Method: EPA 8270

Extract/Purge Date: 12-Dec-88
Completion Date: 16-Dec-88
Analyst: R.SIEGMUND
Reported by: J.L.HARWOOD

MATRIX: CRAB TISSUE

LAB #:	8-1459	8-1460	8-1461	8-1462	8-1463*	
CLIENT'S ID:	T3-1T	T3-4T	T4-1T	T4-4T	T5-1T	
BASE NEUTRALS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
N-Nitrosodimethylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Aniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Bis(2-chloroethyl) ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,3-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,4-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroisopropyl)ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
N-Nitroso-di-N-propylamine	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachloroethane	N.D.	N.D.	N.D.	N.D.	N.D.	44
Nitrobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Isophorone	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroethoxy)methane	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2,4-Trichlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Naphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobutadiene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorocyclopentadiene	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dimethylphthalate	N.D.	N.D.	N.D.	N.D.	N.D.	44
Acenaphthylene	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,6-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Acenaphthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dibenzofuran	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Diethyl phthalate	N.D.	166	N.D.	N.D.	262	44
Fluorene	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Chlorophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
N-Nitrosodiphenyl amine	N.D.	N.D.	N.D.	N.D.	N.D.	44
1,2-Diphenylhydrazine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Bromophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Phenanthrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Di-n-butyl phthalate	868	505	339	233	561	44
Fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzidine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Butylbenzyl phthalate	N.D.	327	N.D.	217	N.D.	44

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BASE NEUTRALS (cont)
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1459	8-1460	8-1461	8-1462	8-1463*	
CLIENT'S ID:	T3-1T	T3-4T	T4-1T	T4-4T	T5-1T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Benzo(a)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
3,3'-Dichlorobenzidine	N.D.	N.D.	N.D.	N.D.	N.D.	87
Chrysene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Bis(2-ethylhexyl) phthalate	1200	1674	534	933	6525	44
Di-n-octyl phthalate	725	572	N.D.	320	N.D.	44
Benzo(b)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Indeno(1,2,3-cd)pyrene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Dibenzo(a,h)anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzo(g,h,i)perylene	N.D.	N.D.	N.D.	N.D.	N.D.	44
QUALITY CONTROL DATA	Base/Neutral Surrogate Spike Recovery					
Nitrobenzene-d5	105%	77%	78%	85%	73%	
2-Fluorobiphenyl	104%	89%	95%	93%	79%	
Terphenyl-d14	82%	72%	69%	71%	83%	

ACID COMPOUNDS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Phenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Chlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2-Nitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dimethylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
Benzoic Acid	N.D.	N.D.	N.D.	N.D.	N.D.	220
2,4-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
4-Chloro-3-methylphenol	N.D.	N.D.	N.D.	N.D.	N.D.	87
2,4,6-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4,5-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
4-Nitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
2-Methyl-4,6-dinitrophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	220
QUALITY CONTROL DATA						
2-Fluorophenol	117%	81%	97%	100%	98%	
Phenol-d5	103%	74%	81%	82%	89%	
2,4,6-Tribromophenol	104%	76%	92%	87%	88%	

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PESTICIDE COMPOUNDS
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1459	8-1460	8-1461	8-1462	8-1463*	
CLIENT'S ID:	T3-1T	T3-4T	T4-1T	T4-4T	T5-1T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
alpha-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
beta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
gamma-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
delta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan I	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDE	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dieldrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan II	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDD	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Aldehyde	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan Sulfate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

QUALITY CONTROL DATA	Pesticide Surrogate Spike Recovery				
Nitrobenzene-d5	105%	77%	78%	85%	73%
2-Fluorobiphenyl	104%	89%	95%	93%	79%
Terphenyl-d14	82%	72%	69%	71%	83%

OTHER EXTRACTABLES	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit(ug/kg)
Acetophenone	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Aminobiphenyl	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Arochlors	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Benzyl Alcohol	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Chloroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenz(a,j)acridine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2,6-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
p-Dimethylaminoazobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
7,12-Dimethylbenz(a)-anthracene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
alpha,alpha-Dimethylphen-ethylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Ketone	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Ethylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Methoxychlor	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

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OTHER EXTRACTABLES
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1459	8-1460	8-1461	8-1462	8-1463*	
CLIENT'S ID:	T3-1T	T3-4T	T4-1T	T4-4T	T5-1T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
3-Methylchloranthene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Methylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Methylnaphthalene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
3-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
4-Nitroaniline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosophenylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosopiperidine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachloronitrobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2-Picoline	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Pronamide	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
1,2,4,5-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
2,3,4,6-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Toxaphene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Biphenyl	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Diphenylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
beta-Naphthylamine	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenzothiophene	N.D.	N.D.	N.D.	N.D.	N.D.	n.d.

NO EXTRA PEAKS

N.D.: Not Detected n.d.: not determined
N.A.: Not Applicable
*: Completion Date for Lab # 8-1463 is 19-Dec-88.

NOTE: Detection Limits are 3 times higher than normal.
1.4-Cyclooctadiene was tentatively identified in all of the samples, but is concluded to be a lab contaminant.

Analytical Supervisor

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Report Date: 24-Jan-89
PACE JOB #: WES 0817.5-L
Analytical Method: EPA 8270
MATRIX: CRAB TISSUE

Extract/Purge Date: 12-Dec-88
Completion Date: 19-Dec-88
Analyst: R.SIEGMUND
Reported by: J.L.HARWOOD

LAB #:	8-1464	8-1465	8-1466	8-1467	
CLIENT'S ID:	T5-4T	T5-6T	T6-2T	T6-4T	
BASE NEUTRALS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
N-Nitrosodimethylamine	N.D.	N.D.	N.D.	N.D.	n.d.
Aniline	N.D.	N.D.	N.D.	N.D.	n.d.
Bis(2-chloroethyl) ether	N.D.	N.D.	N.D.	N.D.	44
1,3-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	44
1,4-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	44
1,2-Dichlorobenzene	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroisopropyl)ether	N.D.	N.D.	N.D.	N.D.	44
N-Nitroso-di-N-propylamine	N.D.	N.D.	N.D.	N.D.	44
Hexachloroethane	N.D.	N.D.	N.D.	N.D.	44
Nitrobenzene	N.D.	N.D.	N.D.	N.D.	44
Isophorone	N.D.	N.D.	N.D.	N.D.	44
Bis(2-chloroethoxy)methane	N.D.	N.D.	N.D.	N.D.	44
1,2,4-Trichlorobenzene	N.D.	N.D.	N.D.	N.D.	44
Naphthalene	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobutadiene	N.D.	N.D.	N.D.	N.D.	44
Hexachlorocyclopentadiene	N.D.	N.D.	N.D.	N.D.	44
2-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	44
Dimethylphthalate	N.D.	N.D.	N.D.	N.D.	44
Acenaphthylene	N.D.	N.D.	N.D.	N.D.	44
2,6-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	44
Acenaphthene	N.D.	N.D.	N.D.	N.D.	44
Dibenzofuran	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrotoluene	N.D.	N.D.	N.D.	N.D.	44
Diethyl phthalate	309	220	250	315	44
Fluorene	N.D.	N.D.	N.D.	N.D.	44
4-Chlorophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	44
N-Nitrosodiphenyl amine	N.D.	N.D.	N.D.	N.D.	44
1,2-Diphenylhydrazine	N.D.	N.D.	N.D.	N.D.	n.d.
4-Bromophenylphenyl ether	N.D.	N.D.	N.D.	N.D.	44
Hexachlorobenzene	N.D.	N.D.	N.D.	N.D.	44
Phenanthrene	N.D.	N.D.	N.D.	N.D.	44
Anthracene	N.D.	N.D.	N.D.	N.D.	44
Di-n-butyl phthalate	321	429	316	373	44
Fluoranthene	N.D.	N.D.	N.D.	N.D.	44
Benzidine	N.D.	N.D.	N.D.	N.D.	n.d.
Pyrene	N.D.	N.D.	N.D.	N.D.	44
Butylbenzyl phthalate	N.D.	N.D.	N.D.	N.D.	44

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BASE NEUTRALS (cont)
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1464	8-1465	8-1466	8-1467	
CLIENT'S ID:	T5-4T	T5-6T	T6-2T	T6-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Benzo(a)anthracene	N.D.	N.D.	N.D.	N.D.	44
3,3'-Dichlorobenzidine	N.D.	N.D.	N.D.	N.D.	87
Chrysene	N.D.	N.D.	N.D.	N.D.	44
Bis(2-ethylhexyl) phthalate	10500	5570	26500	2280	44
Di-n-octyl phthalate	N.D.	N.D.	N.D.	N.D.	44
Benzo(b)fluoranthene	N.D.	N.D.	N.D.	N.D.	44
Benzo(k)fluoranthene	N.D.	N.D.	N.D.	N.D.	44
Benzo(a)pyrene	N.D.	N.D.	N.D.	N.D.	44
Indeno(1,2,3-cd)pyrene	N.D.	N.D.	N.D.	N.D.	44
Dibenzo(a,h)anthracene	N.D.	N.D.	N.D.	N.D.	44
Benzo(g,h,i)perylene	N.D.	N.D.	N.D.	N.D.	44
QUALITY CONTROL DATA	Base/Neutral Surrogate Spike Recovery				
Nitrobenzene-d5	87%	84%	91%	96%	
2-Fluorobiphenyl	87%	82%	79%	86%	
Terphenyl-d14	96%	103%	85%	94%	

ACID COMPOUNDS	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Phenol	N.D.	N.D.	N.D.	N.D.	44
2-Chlorophenol	N.D.	N.D.	N.D.	N.D.	44
2-Methylphenol	N.D.	N.D.	N.D.	N.D.	44
4-Methylphenol	N.D.	N.D.	N.D.	N.D.	44
2-Nitrophenol	N.D.	N.D.	N.D.	N.D.	44
2,4-Dimethylphenol	N.D.	N.D.	N.D.	N.D.	44
Benzoic Acid	N.D.	N.D.	N.D.	N.D.	220
2,4-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	44
4-Chloro-3-methylphenol	N.D.	N.D.	N.D.	N.D.	87
2,4,6-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	44
2,4,5-Trichlorophenol	N.D.	N.D.	N.D.	N.D.	44
2,4-Dinitrophenol	N.D.	N.D.	N.D.	N.D.	220
4-Nitrophenol	N.D.	N.D.	N.D.	N.D.	220
2-Methyl-4,6-dinitrophenol	N.D.	N.D.	N.D.	N.D.	220
Pentachlorophenol	N.D.	N.D.	N.D.	N.D.	220
QUALITY CONTROL DATA					
2-Fluorophenol	109%	97%	96%	104%	
Phenol-d5	95%	88%	88%	97%	
2,4,6-Tribromophenol	86%	86%	79%	89%	

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PESTICIDE COMPOUNDS
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1464	8-1465	8-1466	8-1467	
CLIENT'S ID:	T5-4T	T5-6T	T6-2T	T6-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
alpha-BHC	N.D.	N.D.	N.D.	N.D.	n.d.
beta-BHC	N.D.	N.D.	N.D.	N.D.	n.d.
gamma-BHC	N.D.	N.D.	N.D.	N.D.	n.d.
delta-BHC	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor	N.D.	N.D.	N.D.	N.D.	n.d.
Aldrin	N.D.	N.D.	N.D.	N.D.	n.d.
Heptachlor epoxide	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan I	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDE	N.D.	N.D.	N.D.	N.D.	n.d.
Dieldrin	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan II	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDD	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Aldehyde	N.D.	N.D.	N.D.	N.D.	n.d.
4,4'-DDT	N.D.	N.D.	N.D.	N.D.	n.d.
Endosulfan Sulfate	N.D.	N.D.	N.D.	N.D.	n.d.

QUALITY CONTROL DATA	Pesticide Surrogate Spike Recovery			
Nitrobenzene-d5	87%	84%	91%	96%
2-Fluorobiphenyl	87%	82%	79%	86%
Terphenyl-d14	96%	103%	85%	94%

OTHER EXTRACTABLES	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit(ug/kg)
Acetophenone	N.D.	N.D.	N.D.	N.D.	n.d.
4-Aminobiphenyl	N.D.	N.D.	N.D.	N.D.	n.d.
Arochlors	N.D.	N.D.	N.D.	N.D.	n.d.
Benzyl Alcohol	N.D.	N.D.	N.D.	N.D.	n.d.
Chlordane	N.D.	N.D.	N.D.	N.D.	n.d.
4-Chloroaniline	N.D.	N.D.	N.D.	N.D.	n.d.
1-Chloronaphthalene	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenz(a,j)acridine	N.D.	N.D.	N.D.	N.D.	n.d.
2,6-Dichlorophenol	N.D.	N.D.	N.D.	N.D.	n.d.
p-Dimethylaminoazobenzene	N.D.	N.D.	N.D.	N.D.	n.d.
7,12-Dimethylbenz(a)-anthracene	N.D.	N.D.	N.D.	N.D.	n.d.
alpha,alpha-Dimethylphen-ethylamine	N.D.	N.D.	N.D.	N.D.	n.d.
Endrin Ketone	N.D.	N.D.	N.D.	N.D.	n.d.
Ethylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	n.d.
Methoxychlor	N.D.	N.D.	N.D.	N.D.	n.d.

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OTHER EXTRACTABLES
PACE JOB#: WES 0817.5-L Analytical Method: EPA 8270

LAB #:	8-1464	8-1465	8-1466	8-1467	
CLIENT'S ID:	T5-4T	T5-6T	T6-2T	T6-4T	
	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
3-Methylchloranthene	N.D.	N.D.	N.D.	N.D.	n.d.
Methylmethane sulfonate	N.D.	N.D.	N.D.	N.D.	n.d.
2-Methylnaphthalene	N.D.	N.D.	N.D.	N.D.	n.d.
1-Naphthylamine	N.D.	N.D.	N.D.	N.D.	n.d.
2-Naphthylamine	N.D.	N.D.	N.D.	N.D.	n.d.
2-Nitroaniline	N.D.	N.D.	N.D.	N.D.	n.d.
3-Nitroaniline	N.D.	N.D.	N.D.	N.D.	n.d.
4-Nitroaniline	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosophenylamine	N.D.	N.D.	N.D.	N.D.	n.d.
N-Nitrosopiperidine	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachlorobenzene	N.D.	N.D.	N.D.	N.D.	n.d.
Pentachloronitrobenzene	N.D.	N.D.	N.D.	N.D.	n.d.
2-Picoline	N.D.	N.D.	N.D.	N.D.	n.d.
Pronamide	N.D.	N.D.	N.D.	N.D.	n.d.
1,2,4,5-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	n.d.
2,3,4,6-Tetrachlorobenzene	N.D.	N.D.	N.D.	N.D.	n.d.
Toxaphene	N.D.	N.D.	N.D.	N.D.	n.d.
Biphenyl	N.D.	N.D.	N.D.	N.D.	n.d.
Diphenylamine	N.D.	N.D.	N.D.	N.D.	n.d.
beta-Naphthylamine	N.D.	N.D.	N.D.	N.D.	n.d.
Dibenzothiophene	N.D.	N.D.	N.D.	N.D.	n.d.

NO EXTRA PEAKS

N.D.: Not Detected n.d.: not determined
N.A.: Not Applicable

NOTE: Detection Limits are 3 times higher than normal.
1,4-Cyclooctadiene was tentatively identified in all of the samples, but is concluded to be a lab contaminant.

Analytical Supervisor

LG006592

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
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Tampa, Florida
Coralville, Iowa
Novato, California

QUALITY CONTROL DATA
METHOD EPA 8270 PACE JOB#: WES 0817.5-L

COMPOUND	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
BASE NEUTRAL COMPOUNDS			
N-Nitrosodimethylamine	N.D.	n.s.	n.s.
Aniline	N.D.	n.s.	n.s.
Bis(2-chloroethyl) ether	N.D.	n.s.	n.s.
1,3-Dichlorobenzene	N.D.	n.s.	n.s.
1,4-Dichlorobenzene (MS)	N.D.	4	74
1,2-Dichlorobenzene	N.D.	n.s.	n.s.
Bis(2-chloroisopropyl)ether	N.D.	n.s.	n.s.
N-Nitroso-di-N-propylamine	N.D.	n.s.	n.s.
Hexachloroethane	N.D.	n.s.	n.s.
Nitrobenzene-d5 (SS)	N.A.	17	98
Nitrobenzene	N.D.	n.s.	n.s.
Isophorone	N.D.	n.s.	n.s.
Bis(2-chloroethoxy)methane	N.D.	n.s.	n.s.
1,2,4-Trichlorobenzene	N.D.	n.s.	n.s.
Naphthalene	N.D.	n.s.	n.s.
Hexachlorobutadiene	N.D.	n.s.	n.s.
Hexachlorocyclopentadiene	N.D.	n.s.	n.s.
2-Fluorobiphenyl (SS)	N.A.	9	93
2-Chloronaphthalene	N.D.	n.s.	n.s.
Dimethylphthalate	N.D.	n.s.	n.s.
Acenaphthylene	N.D.	n.s.	n.s.
2,6-Dinitrotoluene	N.D.	n.s.	n.s.
Acenaphthene (MS)	N.D.	1	70
Dibenzofuran	N.D.	n.s.	n.s.
2,4-Dinitrotoluene (MS)	N.D.	24	55
Diethyl phthalate	N.D.	n.s.	n.s.
Fluorene	N.D.	n.s.	n.s.
4-Chlorophenylphenyl ether	N.D.	n.s.	n.s.
N-Nitrosodiphenyl amine	N.D.	n.s.	n.s.
1,2-Diphenylhydrazine	N.D.	n.s.	n.s.
4-Bromophenylphenyl ether	N.D.	n.s.	n.s.
Hexachlorobenzene	N.D.	n.s.	n.s.
Phenanthrene	N.D.	n.s.	n.s.
Anthracene	N.D.	n.s.	n.s.
Di-n-butyl phthalate	N.D.	n.s.	n.s.
Fluoranthene	N.D.	n.s.	n.s.
Benzidine	N.D.	n.s.	n.s.
Pyrene (MS)	N.D.	11	59
Terphenyl-d12 (SS)	N.A.	13	84
Butylbenzyl phthalate	N.D.	n.s.	n.s.
Benzo(a)anthracene	N.D.	n.s.	n.s.
3,3'-Dichlorobenzidine	N.D.	n.s.	n.s.

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Novato, California

COMPOUND
PACE JOB #: WES 0817.5-L METHOD: EPA 8270

	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
Chrysene	N.D.	n.s.	n.s.
Bis(2-ethylhexyl) phthalate	N.D.	n.s.	n.s.
Di-n-octyl phthalate	N.D.	n.s.	n.s.
Benzo(b)fluoranthene	N.D.	n.s.	n.s.
Benzo(k)fluoranthene	N.D.	n.s.	n.s.
Benzo(a)pyrene	N.D.	n.s.	n.s.
Indeno(1,2,3-cd)pyrene	N.D.	n.s.	n.s.
Dibenzo(a,h)anthracene	N.D.	n.s.	n.s.
Benzo(g,h,i)perylene	N.D.	n.s.	n.s.
ACID COMPOUNDS			
2-Fluorophenol (SS)	N.A.	1	104
Phenol-d5 (SS)	N.A.	6	98
Phenol (MS)	N.D.	1	78
2-Chlorophenol	N.D.	n.s.	n.s.
2-Methylphenol	N.D.	n.s.	n.s.
4-Methylphenol	N.D.	n.s.	n.s.
2-Nitrophenol	N.D.	n.s.	n.s.
2,4-Dimethylphenol	N.D.	n.s.	n.s.
Benzoic Acid	N.D.	n.s.	n.s.
2,4-Dichlorophenol	N.D.	n.s.	n.s.
4-Chloro-3-methylphenol (MS)	N.D.	17	44
2,4,6-Trichlorophenol	N.D.	n.s.	n.s.
2,4,5-Trichlorophenol	N.D.	n.s.	n.s.
2,4-Dinitrophenol	N.D.	n.s.	n.s.
4-Nitrophenol	N.D.	45	74
2-Methyl-4,6-dinitrophenol	N.D.	n.s.	n.s.
2,4,6-Tribromophenol (SS)	N.A.	4	96
Pentachlorophenol (MS)	N.D.	12	79
PESTICIDES			
alpha-BHC	N.D.	n.s.	n.s.
beta-BHC	N.D.	n.s.	n.s.
gamma-BHC	N.D.	n.s.	n.s.
delta-BHC	N.D.	n.s.	n.s.
Heptachlor	N.D.	n.s.	n.s.
Aldrin	N.D.	n.s.	n.s.
Heptachlor epoxide	N.D.	n.s.	n.s.

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REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
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Novato, California

QUALITY CONTROL DATA
METHOD EPA 8270 PACE JOB#: WES 0817.5-L

COMPOUND	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
Endosulfan I	N.D.	n.s.	n.s.
4,4'-DDE	N.D.	n.s.	n.s.
4-Terphenyl-d14 (SS)	N.A.	n.s.	n.s.
Dieldrin	N.D.	n.s.	n.s.
Endrin	N.D.	n.s.	n.s.
Endosulfan II	N.D.	n.s.	n.s.
4,4'-DDD	N.D.	n.s.	n.s.
Endrin Aldehyde	N.D.	n.s.	n.s.
4,4'-DDT	N.D.	n.s.	n.s.
Endosulfan Sulfate	N.D.	n.s.	n.s.

QUALITY CONTROL DATA

Base/Neutral Blank S. S. Recovery		Acid Blank S. S. Recover	percent
Nitrobenzene-d5	80 %	2-Fluorophenol	97%
2-Fluorobiphenyl	94 %	Phenol-d5	90%
Terphenyl-d14	97 %	2,4,6-Tribromophenol	82%

N.D.: Not Detected (SS): Surrogate Spike
N.R.: Not Recovered (MS): Matrix Spike
n.s.: not spiked N.A.: Not Applicable

Analytical Supervisor

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
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Novato, California

QUALITY CONTROL DATA
METHOD EPA 8270 PACE JOB#: WES 0817.5-L

COMPOUND	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
BASE NEUTRAL COMPOUNDS			
N-Nitrosodimethylamine	N.D.	n.s.	n.s.
Aniline	N.D.	n.s.	n.s.
Bis(2-chloroethyl) ether	N.D.	n.s.	n.s.
1,3-Dichlorobenzene	N.D.	n.s.	n.s.
1,4-Dichlorobenzene (MS)	N.D.	4	74
1,2-Dichlorobenzene	N.D.	n.s.	n.s.
Bis(2-chloroisopropyl)ether	N.D.	n.s.	n.s.
N-Nitroso-di-N-propylamine	N.D.	n.s.	n.s.
Hexachloroethane	N.D.	n.s.	n.s.
Nitrobenzene-d5 (SS)	N.A.	17	98
Nitrobenzene	N.D.	n.s.	n.s.
Isophorone	N.D.	n.s.	n.s.
Bis(2-chloroethoxy)methane	N.D.	n.s.	n.s.
1,2,4-Trichlorobenzene	N.D.	n.s.	n.s.
Naphthalene	N.D.	n.s.	n.s.
Hexachlorobutadiene	N.D.	n.s.	n.s.
Hexachlorocyclopentadiene	N.D.	n.s.	n.s.
2-Fluorobiphenyl (SS)	N.A.	9	93
2-Chloronaphthalene	N.D.	n.s.	n.s.
Dimethylphthalate	N.D.	n.s.	n.s.
Acenaphthylene	N.D.	n.s.	n.s.
2,6-Dinitrotoluene	N.D.	n.s.	n.s.
Acenaphthene (MS)	N.D.	1	70
Dibenzofuran	N.D.	n.s.	n.s.
2,4-Dinitrotoluene (MS)	N.D.	24	55
Diethyl phthalate	N.D.	n.s.	n.s.
Fluorene	N.D.	n.s.	n.s.
4-Chlorophenylphenyl ether	N.D.	n.s.	n.s.
N-Nitrosodiphenyl amine	N.D.	n.s.	n.s.
1,2-Diphenylhydrazine	N.D.	n.s.	n.s.
4-Bromophenylphenyl ether	N.D.	n.s.	n.s.
Hexachlorobenzene	N.D.	n.s.	n.s.
Phenanthrene	N.D.	n.s.	n.s.
Anthracene	N.D.	n.s.	n.s.
Di-n-butyl phthalate	N.D.	n.s.	n.s.
Fluoranthene	N.D.	n.s.	n.s.
Benzidine	N.D.	n.s.	n.s.
Pyrene (MS)	N.D.	11	59
Terphenyl-d12 (SS)	N.A.	13	84
Butylbenzyl phthalate	N.D.	n.s.	n.s.
Benzo(a)anthracene	N.D.	n.s.	n.s.
3,3'-Dichlorobenzidine	N.D.	n.s.	n.s.

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REPORT OF LABORATORY ANALYSIS

Offices:
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COMPOUND
PACE JOB #: WES 0817.5-L METHOD: EPA 8270

	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
Chrysene	N.D.	n.s.	n.s.
Bis(2-ethylhexyl) phthalate	N.D.	n.s.	n.s.
Di-n-octyl phthalate	N.D.	n.s.	n.s.
Benzo(b)fluoranthene	N.D.	n.s.	n.s.
Benzo(k)fluoranthene	N.D.	n.s.	n.s.
Benzo(a)pyrene	N.D.	n.s.	n.s.
Indeno(1,2,3-cd)pyrene	N.D.	n.s.	n.s.
Dibenzo(a,h)anthracene	N.D.	n.s.	n.s.
Benzo(g,h,i)perylene	N.D.	n.s.	n.s.
ACID COMPOUNDS			
2-Fluorophenol (SS)	N.A.	1	104
Phenol-d5 (SS)	N.A.	6	98
Phenol (MS)	N.D.	1	78
2-Chlorophenol	N.D.	n.s.	n.s.
2-Methylphenol	N.D.	n.s.	n.s.
4-Methylphenol	N.D.	n.s.	n.s.
2-Nitrophenol	N.D.	n.s.	n.s.
2,4-Dimethylphenol	N.D.	n.s.	n.s.
Benzoic Acid	N.D.	n.s.	n.s.
2,4-Dichlorophenol	N.D.	n.s.	n.s.
4-Chloro-3-methylphenol (MS)	N.D.	17	44
2,4,6-Trichlorophenol	N.D.	n.s.	n.s.
2,4,5-Trichlorophenol	N.D.	n.s.	n.s.
2,4-Dinitrophenol	N.D.	n.s.	n.s.
4-Nitrophenol	N.D.	45	74
2-Methyl-4,6-dinitrophenol	N.D.	n.s.	n.s.
2,4,6-Tribromophenol (SS)	N.A.	4	96
Pentachlorophenol (MS)	N.D.	12	79
PESTICIDES			
alpha-BHC	N.D.	n.s.	n.s.
beta-BHC	N.D.	n.s.	n.s.
gamma-BHC	N.D.	n.s.	n.s.
delta-BHC	N.D.	n.s.	n.s.
Heptachlor	N.D.	n.s.	n.s.
Aldrin	N.D.	n.s.	n.s.
Heptachlor epoxide	N.D.	n.s.	n.s.

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
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QUALITY CONTROL DATA
METHOD EPA 8270 PACE JOB#: WES 0817.5-L

COMPOUND	Blank (ug/l)	Spike Duplicate % Deviation	% Spike Recovery
Endosulfan I	N.D.	n.s.	n.s.
4,4'-DDE	N.D.	n.s.	n.s.
4-Terphenyl-d14 (SS)	N.A.	n.s.	n.s.
Dieldrin	N.D.	n.s.	n.s.
Endrin	N.D.	n.s.	n.s.
Endosulfan II	N.D.	n.s.	n.s.
4,4'-DDD	N.D.	n.s.	n.s.
Endrin Aldehyde	N.D.	n.s.	n.s.
4,4'-DDT	N.D.	n.s.	n.s.
Endosulfan Sulfate	N.D.	n.s.	n.s.

QUALITY CONTROL DATA

Base/Neutral Blank S. S. Recovery		Acid Blank S. S. Recover	percent
Nitrobenzene-d5	80 %	2-Fluorophenol	97%
2-Fluorobiphenyl	94 %	Phenol-d5	90%
Terphenyl-d14	97 %	2,4,6-Tribromophenol	82%

N.D.: Not Detected (SS): Surrogate Spike
N.R.: Not Recovered (MS): Matrix Spike
n.s.: not spiked N.A.: Not Applicable

Analytical Supervisor

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
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Report Date: 06-Feb-89
PACE JOB #: WES 0817.5-L
Analytical Method: EPA 8080
MATRIX: CRAB

Completion Date: 12-Dec-88
Reported by: J.L.HARWOOD
Analyst: A.POWELL
Instrument I.D.: 3700-GAMMA

LAB #:	8-1454	8-1455	8-1456	8-1457	
CLIENT'S ID:	T1-1T	T1-4T	T1-6T	T2-1T	
COMPOUND	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Aroclor 1016	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1221	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1232	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1242	N.D.	N.D.	N.D.	N.D.	40
Aroclor 1248	N.D.	N.D.	N.D.	N.D.	40
Aroclor 1254	N.D.	N.D.	N.D.	N.D.	100
Aroclor 1260	N.D.	N.D.	N.D.	N.D.	100
QUALITY CONTROL DATA					
Surrogate Spike % Recovery					
2,4,5,6-TCMX	57%	43 %	49%	40%	

LAB #:	8-1458	8-1459	8-1460	8-1461	
CLIENT'S ID:	T2-4T	T3-1T	T3-4T	T4-1T	
COMPOUND	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Aroclor 1016	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1221	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1232	N.D.	N.D.	N.D.	N.D.	60
Aroclor 1242	N.D.	N.D.	N.D.	N.D.	40
Aroclor 1248	N.D.	N.D.	N.D.	N.D.	40
Aroclor 1254	N.D.	N.D.	N.D.	N.D.	100
Aroclor 1260	N.D.	N.D.	N.D.	N.D.	100
QUALITY CONTROL DATA					
Surrogate Spike % Recovery					
2,4,5,6-TCMX	40%	70 %	60%	42%	

N.D.: Not Detected
n.d.: not determined

Analytical Supervisor

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
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Novato, California

Report Date: 06-Feb-89
PACE JOB #: WES 0817.5-L
Analytical Method: EPA 8080
MATRIX: CRAB

Completion Date: 12-Dec-88
Reported by: J.L.HARWOOD
Analyst: A.POWELL
Instrument I.D.: 3700-GAMMA

LAB #:	8-1462	8-1463	8-1464	
CLIENT'S ID:	T4-4T	T5-1T	T5-4T	
COMPOUND	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Aroclor 1016	N.D.	N.D.	N.D.	60
Aroclor 1221	N.D.	N.D.	N.D.	60
Aroclor 1232	N.D.	N.D.	N.D.	60
Aroclor 1242	N.D.	N.D.	N.D.	40
Aroclor 1248	N.D.	N.D.	N.D.	40
Aroclor 1254	N.D.	N.D.	N.D.	100
Aroclor 1260	N.D.	N.D.	N.D.	100
QUALITY CONTROL DATA				
Surrogate Spike % Recovery				
2,4,5,6-TCMX	92%	79 %	72%	

LAB #:	8-1465	8-1466	8-1467	
CLIENT'S ID:	T5-6T	T6-2T	T6-4T	
COMPOUND	RESULT (ug/kg)	RESULT (ug/kg)	RESULT (ug/kg)	Detection Limit (ug/kg)
Aroclor 1016	N.D.	N.D.	N.D.	60
Aroclor 1221	N.D.	N.D.	N.D.	60
Aroclor 1232	N.D.	N.D.	N.D.	60
Aroclor 1242	N.D.	N.D.	N.D.	40
Aroclor 1248	N.D.	N.D.	N.D.	40
Aroclor 1254	N.D.	N.D.	N.D.	100
Aroclor 1260	N.D.	N.D.	N.D.	100
QUALITY CONTROL DATA				
Surrogate Spike % Recovery				
2,4,5,6-TCMX	52%	52 %	146%*	

N.D.: Not Detected
n.d.: not determined
*: Matrix Interference with solvent front.

Analytical Supervisor

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REPORT OF LABORATORY ANALYSIS

Offices:
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QUALITY CONTROL DATA
METHOD: EPA 8080 PACE JOB #: WES 0817.5-L

COMPOUND	Blank (ug/l)	Spike Duplicate % deviation	Spike % recovery
Lindane	N.D.	23	47
Heptachlor	N.D.	11	46
Aldrin	N.D.	15	21
QUALITY CONTROL DATA Surrogate Spike % Recovery			
2,4,5,6-TCMX	78 %	69 %	69 %

N.D.: Not Detected

Analytical Supervisor

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REPORT OF LABORATORY ANALYSIS

Offices:
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Novato, California

PACE Project Number: 490419501
PACE WP Number: WPPLAB #733

May 26, 1989

Mr. Scott Cressey
WESCO, Inc.
14 Galli Drive
Novato, CA 94949

Dear Mr. Cressey:

Enclosed is the Report of Laboratory Analyses for samples received 04/19/89.

Samples were ground under liquid nitrogen and then digested with nitric acid and hydrogen peroxide to measure chromium, copper, lead, nickel, and zinc concentrations using inductively coupled argon plasma atomic emission spectroscopy. Mercury concentrations were measured using the cold-vapor flameless atomic absorption method after digestion with potassium persulfate, potassium permanganate, and aquaregia.

If you have any questions concerning this report, please feel free to contact us.

Sincerely,

Stephen Nackord

Stephen F. Nackord
Director, Sampling and Analytical Services

Enclosures

LG006602

pace laboratories, inc.

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

:sco, Inc.
14 Galli Dr.
Novato, CA 94949

May 26, 1989
PACE Project Number: 490419501

Attn: Mr. Scott Cressey

KJC 8802

Date Sample(s) Collected: 04/19/89
Date Sample(s) Received: 04/19/89

PACE Sample Number: Parameter	Units	MDL	724070 T1-1	724080 T1-2	724090 T1-3
INORGANIC ANALYSIS					
INDIVIDUAL PARAMETERS					
Chromium	mg/kg wet	1	ND	ND	ND
Copper	mg/kg wet	1	1.3	ND	1.6
Lead	mg/kg wet	10	ND	ND	ND
Mercury	mg/kg wet	0.020	0.02	0.02	0.02
Nickel	mg/kg wet	2	ND	ND	ND
Zinc	mg/kg wet	1	4.7	4.1	4.5

) Not detected at or above the MDL.
MDL Method Detection Limit

L6906603

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REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

. Scott Cressey

May 26, 1989
PACE Project Number: 490419501

PACE Sample Number: Parameter	Units	MDL	724100 T1-5	724110 T2-1	724120 T2-2
INORGANIC ANALYSIS					
INDIVIDUAL PARAMETERS					
Chromium	mg/kg wet	1	ND	ND	ND
Copper	mg/kg wet	1	1.3	1.0	1.2
Lead	mg/kg wet	10	11	ND	12
Mercury	mg/kg wet	0.020	0.02	0.02	0.02
Nickel	mg/kg wet	2	ND	ND	ND
Zinc	mg/kg wet	1	5.1	3.1	4.1

ND Not detected at or above the MDL.
MDL Method Detection Limit

LG006604

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REPORT OF LABORATORY ANALYSIS

Offices:
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Novato, California

May 26, 1989
PACE Project Number: 490419501

PACE Sample Number: Parameter	Units	MDL	724130 T2-3	724140 T2-4	724150 T3-1
INORGANIC ANALYSIS					
INDIVIDUAL PARAMETERS					
Chromium	mg/kg wet	1	ND	ND	ND
Copper	mg/kg wet	1	1.6	1.5	1.6
Lead	mg/kg wet	10	13	13	ND
Mercury	mg/kg wet	0.020	ND	ND	0.02
Nickel	mg/kg wet	2	ND	2.5	ND
Zinc	mg/kg wet	1	5.3	6.8	5.6

ND Not detected at or above the MDL.
MDL Method Detection Limit

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REPORT OF LABORATORY ANALYSIS

Offices:
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. Scott Cressey

May 26, 1989
PACE Project Number: 490419501

PACE Sample Number: Parameter	Units	MDL	724160 T3-2	724170 T3-3	724180 T3-4
INORGANIC ANALYSIS					
INDIVIDUAL PARAMETERS					
Chromium	mg/kg wet	1	ND	ND	ND
Copper	mg/kg wet	1	1.3	1.3	ND
Lead	mg/kg wet	10	11	ND	ND
Mercury	mg/kg wet	0.020	0.02	0.02	0.02
Nickel	mg/kg wet	2	ND	ND	ND
Zinc	mg/kg wet	1	5.8	5.2	2.9

ND Not detected at or above the MDL.
MDL Method Detection Limit

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REPORT OF LABORATORY ANALYSIS

Offices:
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Coralville, Iowa
Novato, California

r. Scott Cressey
rage 5

May 26, 1989
PACE Project Number: 490419501

PACE Sample Number: Parameter	Units	MDL	724190 T4-1	724200 T4-2	724210 T4-3
INORGANIC ANALYSIS					
INDIVIDUAL PARAMETERS					
Chromium	mg/kg wet	1	ND	ND	ND
Copper	mg/kg wet	1	1.1	ND	1.1
Lead	mg/kg wet	10	ND	ND	ND
Mercury	mg/kg wet	0.020	0.02	0.03	0.02
Nickel	mg/kg wet	2	ND	ND	ND
Zinc	mg/kg wet	1	3.2	3.8	3.5

ND Not detected at or above the MDL.
MDL Method Detection Limit

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REPORT OF LABORATORY ANALYSIS

Offices:
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May 26, 1989
PACE Project Number: 490419501

PACE Sample Number:			724220
Parameter	Units	MDL	T4-4
INORGANIC ANALYSIS			
INDIVIDUAL PARAMETERS			
Chromium	mg/kg wet	1	ND
Copper	mg/kg wet	1	1.2
Lead	mg/kg wet	10	ND
Mercury	mg/kg wet	0.020	0.02
Nickel	mg/kg wet	2	ND
Zinc	mg/kg wet	1	3.4

ND Not detected at or above the MDL.
MDL Method Detection Limit

The data contained in this report were obtained using EPA or other approved methodologies. All analyses were performed by me or under my direct supervision.

Stephen Nackord
Stephen F. Nackord
Director, Sampling and Analytical Services

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report Date: 24-Jan-89 Completion date: 07-Dec-88
PACE JOB #: WES 0816-L Reported by: J.L.HARWOOD
MATRIX: SOIL Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1098	T1-1A-S3	57.28	25.13	5.55	3.04	5.13	3.87
8-1099	T1-1B-S3	68.65	12.54	4.42	3.49	5.76	5.14
8-1100	T1-2A-S3	70.31	14.33	4.23	3.40	4.95	2.78
8-1101	T1-2B-S3	72.23	14.63	5.49	3.20	2.74	1.71
8-1102	T1-3A-S3	73.73	13.03	3.67	2.34	4.07	3.16
8-1103	T1-3B-S3	69.15	20.36	3.23	1.92	3.02	2.32
8-1104	T1-4A-S3	50.91	12.04	4.96	5.87	15.08	11.13
8-1105	T1-4B-S3	65.46	10.86	5.07	3.83	7.45	7.34
8-1106	T1-5A-S3	37.18	16.34	8.17	8.27	20.63	9.40
8-1107	T1-5B-S3	71.27	10.28	4.54	3.83	5.65	4.44
8-1108	T1-6A-S3	45.78	14.44	7.43	6.92	18.72	6.71
8-1221	T1-6A-S3 DUP	38.08	14.46	7.12	7.43	22.19	10.42
8-1109	T1-6B-S3	68.49	10.84	4.46	4.26	6.08	5.88
8-1396	T1-1C-S3	65.95	21.50	5.76	2.57	2.98	1.23
8-1397	T1-2C-S3	73.03	15.66	3.22	1.76	3.11	3.22
8-1398	T1-3C-S3	72.66	14.55	4.47	2.91	3.22	2.18
8-1399	T1-4C-S3	67.56	12.64	5.18	3.83	5.28	5.49
8-1400	T1-4C-S3 DUP	83.05	10.88	2.62	1.36	1.67	0.42
8-1401	T1-5C-S3	65.58	13.32	5.53	4.30	5.64	5.33
8-1402	T1-6C-S3	70.79	11.43	4.68	3.64	5.00	4.47

Steve Moeckel
Analytical Supervisor

LG006609

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REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report Date: 24-Jan-89
PACE JOB #: WES 0817-L
MATRIX: SOIL

Completion date: 07-Dec-88
Reported by: J.L.HARWOOD
Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1181	T5-1A-S3	59.29	11.73	5.71	5.51	10.51	7.24
8-1183	T5-2A-S3	50.56	13.20	6.60	6.00	16.45	7.21
8-1195	T5-3A-S3	32.28	13.48	9.40	11.75	24.51	8.58
8-1188	T5-4A-S3	68.98	9.08	3.88	4.29	8.78	5.00
8-1197	T5-5A-S3	34.38	13.73	9.64	10.90	23.17	8.18
8-1186	T5-6A-S3	7.84	28.76	31.86	16.29	12.68	2.58

Steve Mackurd
Analytical Supervisor

LG006610

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report Date: 24-Jan-89
PACE JOB #: WES 0817.1-L
MATRIX: SOIL

Completion date: 07-Dec-88
Reported by: J.L.HARWOOD
Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1222	T2-1A-S3	83.21	13.18	1.13	1.03	1.24	0.21
8-1223	T2-1B-S3	67.28	14.20	5.86	4.32	4.63	3.70
8-1214	T2-2A-S3	62.18	16.17	5.18	3.42	7.15	5.91
8-1215	T2-2~~A~~B-S3	67.16	11.12	5.04	3.57	6.40	6.72
8-1216	T2-3A-S3	69.09	10.55	3.69	3.16	7.49	6.01
8-1217	T2-3B-S3	70.56	12.76	4.36	3.27	4.91	4.14
8-1218	T2-3B-S3 DUP	68.98	10.37	4.46	3.42	6.02	6.74
8-1219	T2-4A-S3	60.54	12.46	5.92	4.98	9.03	7.06
8-1220	T2-4B-S3	48.42	13.46	7.03	7.44	12.95	10.70
8-1403	T2-1C-S3	83.02	10.39	2.78	1.54	1.65	0.62
8-1404	T2-2C-S3	69.85	17.75	4.31	2.31	3.99	1.79
8-1405	T2-3C-S3	79.44	11.84	3.12	2.08	2.49	1.04
8-1406	T2-4C-S3	65.65	13.44	5.57	5.15	5.46	4.73

Steve Mackenzie
Analytical Supervisor

LG006611

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REPORT OF LABORATORY ANALYSIS

Offices:
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Novato, California

Report Date: 24-Jan-89
PACE JOB #: WES 0817.2-L
MATRIX: SOIL

Completion date: 07-Dec-88
Reported by: J.L.HARWOOD
Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1378	T3-1A-S3	58.59	21.02	7.04	5.23	6.30	1.81
8-1379	T3-1B-S3	48.44	13.17	7.26	6.33	12.86	11.93
8-1380	T3-2A-S3	62.71	17.98	5.79	4.34	5.68	3.51
8-1381	T3-2B-S3	58.59	11.49	5.38	5.28	9.73	9.52
8-1382	T3-3A-S3	63.33	13.22	5.89	5.17	6.92	5.48
8-1383	T3-3B-S3	66.56	13.90	5.85	4.70	6.79	2.19
8-1384	T3-4A-S3	18.35	40.77	18.45	7.85	10.30	4.28
8-1385	T3-4B-S3	60.87	13.11	5.20	4.68	9.26	6.87
8-1386	T3-4B-S3 DUP	59.59	11.55	5.05	4.95	9.48	9.38
8-1407	T3-1C-S3	62.97	10.13	4.43	5.06	9.07	8.33
8-1408	T3-2C-S3	67.29	10.18	5.19	4.88	6.02	6.44
8-1409	T3-3C-S3	62.80	13.58	6.11	4.87	6.53	6.11
8-1410	T3-4C-S3	67.09	15.77	4.73	3.79	5.05	3.60

Steve Moeckerd
Analytical Supervisor

LG006612

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
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Novato, California

Report Date: 24-Jan-89 Completion date: 07-Dec-88
PACE JOB #: WES 0817.3-L Reported by: J.L.HARWOOD
MATRIX: SOIL Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1387	T4-1A-S3	47.29	11.85	5.00	5.52	17.36	12.97
8-1388	T4-1B-S3	58.70	14.24	4.89	4.35	8.70	9.13
8-1389	T4-2A-S3	39.27	16.67	6.77	5.83	19.06	12.40
8-1390	T4-2B-S3	58.85	13.89	6.07	5.04	12.35	3.81
8-1391	T4-3A-S3	17.19	20.25	4.43	4.75	40.19	13.19
8-1392	T4-3B-S3	48.25	13.85	6.02	5.69	14.33	12.86
8-1393	T4-4A-S3	50.00	14.15	6.28	5.43	14.04	10.11
8-1394	T4-4A-S3 DUP	43.16	14.12	7.00	6.80	15.79	13.18
8-1395	T4-4B-S3	55.04	14.23	6.13	4.98	11.01	8.62
8-1411	T4-1C-S3	73.00	21.32	1.58	1.68	2.00	0.42
8-1412	T4-2C-S3	67.16	16.31	4.99	3.18	4.87	3.50
8-1413	T4-3C-S3	76.26	9.97	3.80	3.08	3.39	3.49
8-1414	T4-3C-S3 DUP	66.52	12.12	5.36	4.61	5.79	5.58
8-1415	T4-4C-S3	69.96	13.23	4.52	3.26	5.15	3.89

Steve Mackerel
Analytical Supervisor

LG006613

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REPORT OF LABORATORY ANALYSIS

Offices:
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Report Date: 24-Jan-89
PACE JOB #: WES 0817.4-L
MATRIX: SOIL

Completion date: 07-Dec-88
Reported by: J.L.HARWOOD
Analyst: R.AYZENBERG

LAB #	CLIENT ID	Particle Size by Sieve 0.425mm %	0.250mm %	0.180mm %	0.125mm %	0.063mm %	Bottom of pan %
8-1424	T6-1A-S3	71.40	11.57	4.00	4.21	5.05	3.79
8-1190	T6-1A-S3	90.19	7.14	0.53	0.32	0.96	0.85
8-1198	T6-2A-S3	62.81	13.01	5.94	4.92	7.17	6.15
8-1194	T6-3A-S3	60.04	11.07	3.69	4.78	13.46	6.95
8-1192	T6-4A-S3	52.45	13.43	4.48	5.44	16.10	8.10

Steve Mackerel
Analytical Supervisor

LG006614

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REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0816 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: S. Cressey

Date sampled: October 20, 1988 Site: SPT Co. Liquid Gold Richmond CA
Sampled by: R. H.

Date received: October 20, 1988 P.O.: verbal
Submitted by: R.H.

Lab #	Client ID	Matrix	Analysis
8- 1098	T1-1A-S3	soil	Particle size by sieve
8- 1099	T1-1B-S3	soil	Particle size by sieve
8- 1100	T1-2A-S3	soil	Particle size by sieve
8- 1101	T1-2B-S3	soil	Particle size by sieve
8- 1102	T1-3A-S3	soil	Particle size by sieve
8- 1103	T1-3B-S3	soil	Particle size by sieve
8- 1104	T1-4A-S3	soil	Particle size by sieve
8- 1105	T1-4B-S3	soil	Particle size by sieve
8- 1106	T1-5A-S3	soil	Particle size by sieve
8- 1107	T1-5B-S3	soil	Particle size by sieve
8- 1108	T1-6A-S3	soil	Particle size by sieve
8- 1109	T1-6B-S3	soil	Particle size by sieve

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REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
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Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0816 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: S. Cressey

Date sampled: October 20, 1988 Site: SPT Co. Liquid Gold Richmond CA
Sampled by: R. H.

Date received: October 20, 1988 P.O.: verbal
Submitted by: R.H.

Lab #	Client ID	Matrix	Analysis

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Sontag
Sample Controller

LG006616

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 21, 1988 Site: SPT Co. Liquid Gold
Sampled by: R.H. / S.C.

Date received: October 24, 1988 P.O.: Verbal
Submitted by: R. Hartwell

Lab #	Client ID	Matrix	Analysis
8- 1181	T5-1A-S3	soil	Particle size by sieve
8- 1182	T5-1B-S3	soil	ON HOLD
8- 1183	T5-2A-S3	soil	Particle size by sieve
8- 1184	T5-2B-S3	soil	ON HOLD
8- 1195	T5-3A-S3	soil	Particle size by sieve
8- 1196	T5-3B-S3	soil	ON HOLD
8- 1188	T5-4A-S3	soil	Particle size by sieve
8- 1189	T5-4B-S3	soil	ON HOLD
8- 1197	T5-5A-S3	soil	Particle size by sieve
8- 1185	T5-5B-S3	soil	ON HOLD
8- 1186	T5-6A-S3	soil	Particle size by sieve
8- 1187	T5-6B-S3	soil	ON HOLD
8- 1190	T6-1A-S3	soil	Particle size by sieve
8- 1198	T6-2A-S3	soil	Particle size by sieve
8- 1194	T6-3A-S3	soil	Particle size by sieve
8- 1191	T6-3B-S3	soil	ON HOLD
8- 1192	T6-4A-S3	soil	Particle size by sieve
8- 1193	T6-4B-S3	soil	ON HOLD

LG006617

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 21, 1988 Site: SPT Co. Liquid Gold
Sampled by: R.H. / S.C.

Date received: October 24, 1988 P.O.: Verbal
Submitted by: R. Hartwell

Lab #	Client ID	Matrix	Analysis

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Sontag
Sample Controller

LG006618

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FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.1 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: S. Cressey

Date sampled: October 24, 1988 Site: SPC Co. Liquid Gold
Sampled by: KAW

Date received: October 25, 1988 P.O.: 855018.05
Submitted by: R. Hartwell

Lab #	Client ID	Matrix	Analysis
8- 1221	T1-6A-S3 DUP	soil	Particle size by sieve
8- 1222	T2-1A-S3	soil	Particle size by sieve
8- 1223	T2-1B-S3	soil	Particle size by sieve
8- 1214	T2-2A-S3	soil	Particle size by sieve
8- 1215	T2-2B-S3	soil	Particle size by sieve
8- 1216	T2-3A-S3	soil	Particle size by sieve
8- 1217	T2-3B-S3	soil	Particle size by sieve
8- 1218	T2-3B-S3 DUP	soil	Particle size by sieve
8- 1219	T2-4A-S3	soil	Particle size by sieve
8- 1220	T2-4B-S3	soil	Particle size by sieve

LG006619

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.1 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: S. Cressey

Date sampled: October 24, 1988 Site: SPC Co. Liquid Gold
Sampled by: KAW

Date received: October 25, 1988 P.O.: 855018.05
Submitted by: R. Hartwell

Lab #	Client ID	Matrix	Analysis

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Dontag
Sample Controller

LG006620

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.2 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 28, 1988 Site: SPT Co. Liquid Gold
Sampled by: Roger Hartwell

Date received: October 28, 1988 P.O.: 855018.05
Submitted by: Roger Hartwell

Lab #	Client ID	Matrix	Analysis
8- 1378	T3-1A-S3	soil	Particle size by sieve
8- 1379	T3-1B-S3	soil	Particle size by sieve
8- 1380	T3-2A-S3	soil	Particle size by sieve
8- 1381	T3-2B-S3	soil	Particle size by sieve
8- 1382	T3-3A-S3	soil	Particle size by sieve
8- 1383	T3-3B-S3	soil	Particle size by sieve
8- 1384	T3-4A-S3	soil	Particle size by sieve
8- 1385	T3-4B-S3	soil	Particle size by sieve
8- 1386	T3-4B-S3 dup	soil	Particle size by sieve
8- 1387	T4-1A-S3	soil	Particle size by sieve
8- 1388	T4-1B-S3	soil	Particle size by sieve
8- 1389	T4-2A-S3	soil	Particle size by sieve
8- 1390	T4-2B-S3	soil	Particle size by sieve
8- 1391	T4-3A-S3	soil	Particle size by sieve
8- 1392	T4-3B-S3	soil	Particle size by sieve
8- 1393	T4-4A-S3	soil	Particle size by sieve
8- 1394	T4-4A-S3 dup	soil	Particle size by sieve
8- 1395	T4-4B-S3	soil	Particle size by sieve

LG006621

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.2 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 28, 1988 Site: SPT Co. Liquid Gold
Sampled by: Roger Hartwell

Date received: October 28, 1988 P.O.: 855018.05
Submitted by: Roger Hartwell

Lab #	Client ID	Matrix	Analysis

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Sontag
Sample Controller

LG006622

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.3 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 31, 1988 Site: Southern Pacific, Liquid Gold
Sampled by: Walsh, Cressey

Date received: October 31, 1988 P.O.: 855018.05
Submitted by: Scott Cressey

Lab #	Client ID	Matrix	Analysis
8- 1396	T1-1C-S3	soil	Particle size by sieve
8- 1397	T1-2C-S3	soil	Particle size by sieve
8- 1398	T1-3C-S3	soil	Particle size by sieve
8- 1399	T1-4C-S3	soil	Particle size by sieve
8- 1400	T1-4C-S3 dup	soil	Particle size by sieve
8- 1401	T1-5C-S3	soil	Particle size by sieve
8- 1402	T1-6C-S3	soil	Particle size by sieve
8- 1403	T2-1C-S3	soil	Particle size by sieve
8- 1404	T2-2C-S3	soil	Particle size by sieve
8- 1405	T2-3C-S3	soil	Particle size by sieve
8- 1406	T2-4C-S3	soil	Particle size by sieve
8- 1407	T3-1C-S3	soil	Particle size by sieve
8- 1408	T3-2C-S3	soil	Particle size by sieve
8- 1409	T3-3C-S3	soil	Particle size by sieve
8- 1410	T3-4C-S3	soil	Particle size by sieve
8- 1411	T4-1C-S3	soil	Particle size by sieve
8- 1412	T4-2C-S3	soil	Particle size by sieve
8- 1413	T4-3C-S3	soil	Particle size by sieve

LG006623

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.3 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Scott Cressey

Date sampled: October 31, 1988 Site: Southern Pacific, Liquid Gold
Sampled by: Walsh, Cressey

Date received: October 31, 1988 P.O.: 855018.05
Submitted by: Scott Cressey

Lab #	Client ID	Matrix	Analysis
8- 1414	T4-3C-S3 dup	soil	Particle size by sieve
8- 1415	T4-4C-S3	soil	Particle size by sieve

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Sontag
Sample Controller

LG006624

pace laboratories, inc
FORMERLY WESCO LABORATORIES

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa
Novato, California

Report date: January 25, 1989 Pace job #: WES 0817.4 -L
Client: WESCO
14 Galli Drive
Novato, CA 94949
Attn.: Kim Walsh

Date sampled: October 31, 1988 Site: So. Pacific / Liquid Gold
Sampled by: Walsh / Cressey

Date received: November 1, 1988 P.O.: 855018.05
Submitted by: S. Cressey

Lab #	Client ID	Matrix	Analysis
8- 1424	T6-1A-S3	soil	Particle size by sieve

Dear Client,

No problems were encountered with the analysis of your samples. We will store samples for 14 days after the report date. The samples will be returned to the client after the 14-day period, unless other arrangements are made.
If you have any questions, please feel free to call Lisa Petersen, our Client Services Coordinator at (415)883-6100.

C. Sontag
Sample Controller

LG006625

ATTACHMENT C

SEDIMENT ANALYSES RESULTS

ATTACHMENT C

Hoffman Marsh Sediment Analysis Results (mg/kg - Dry Weight)
October 1988

TRANSECT	OILGREASE	SULFIDE	T SULFUR	0&G - S	TOTAL PAH	pH	TPH GASOLINE	TPH DIESEL
T1-1A-S1	2800	1600	1300	1500	11	7.5	-1	-1
T1-2A-S1	980	570	440	540	1.2	7.8	-1	-1
T1-3A-S1	1300	690	390	880		7.6	-1	-1
T1-4A-S1	1500	390	460	1000	0.9	7.9	-1	-1
T1-5A-S1	750	680	320	430		7.8	-1	-1
T1-6A-S1	1300	290	140	1100		7.8	-1	-1
T1-6A-S1D	750	530	240	510		7.6	-1	-1
T2-1A-S1	1100	1300	450	690		7.1	-1	-1
T2-2A-S1	870	1300	370	500		7.4	-1	-1
T2-3A-S1	1200	370	320	1200		7.4	-1	-1
T2-4A-S1	710	620	240	470		7.6	-1	-1
T3-1A-S1	1800	950	370	1400		7.8	-1	-1
T3-2A-S1	1800	430	270	1500		7.2	-1	-1
T3-3A-S1	1500	340	390	1100		7.2	-1	-1
T3-4A-S1	2200	900	280	2000	3.1	7.9	-1	-1
T4-1A-S1	870	1300	360	510		7.7	-1	-1
T4-2A-S1	1100	480	210	920		7.8	-1	-1
T4-3A-S1	310	250	97	220		8.0	-1	-1
T4-4A-S1	820	1100	240	580	1.5	7.5	-1	-1
T4-4A-S1D	1200	850	150	1100	0.5	7.4	-1	-1
T1-1B-S1	2100	560	530	1500		6.9	-1	-1
T1-2B-S1	760	120	33	720	1.2	7.2	-1	-1
T1-3B-S1	450	230	300	150	0.9	7.4	-1	-1
T1-4B-S1	1500	73	200	1300		7.3	-1	-1
T1-5B-S1	1300	96	280	1000		7.4	-1	-1
T1-6B-S1	820	820	160	650		7.8	-1	-1
T2-1B-S1	600	600	400	190		7.0	-1	-1
T2-2B-S1	690	120	170	520		6.9	-1	-1
T2-3B-S1	1300	1200	300	1100		6.8	-1	-1
T2-3B-S1D	620	310	210	410		6.8	-1	-1
T2-4B-S1	2200	1800	880	1400	0.9	6.8	-1	-1
T3-1B-S1	110	130	29	85		7.3	-1	-1
T3-2B-S1	1200	440	170	1000		7.2	-1	-1
T3-3B-S1	1500	38	130	1400	0.7	6.9	-1	-1
T3-4B-S1	1100	220	220	860		6.8	-1	-1
T3-4B-S1D	960	310	310	640		6.9	-1	-1
T4-1B-S1	980	240	290	690		7.5	-1	-1
T4-2B-S1	840	310	190	660		7.1	-1	-1
T4-3B-S1	660	340	130	530	0.7	7.2	-1	-1
T4-4B-S1	830	260	32	800	0.7	7.3	-1	-1

NOTE: Minus sign indicates non-detectable. Number shown after minus sign indicates detection limit.

TRANSECT	OILGREASE	SULFIDE	T SULFUR	0&G - S	TOTAL PAH	pH	TPH GASOLINE	TPH DIESEL
T1-2C-S1	260	-42	42	220	11	6.6	-1	-1
T1-3C-S1	600	-33	33	570		6.5	-1	-1
T1-5C-S1	1400	-33	33	1400		7.3	-1	-1
T2-1C-S1	920	710	300	620		6.7	-1	-1
T2-2C-S1	-110	83	42	69		6.7	-1	-1
T2-3C-S1	200	320	140	68		7.0	-1	-1
T2-4C-S1	870	740	78	790		6.8	-1	-1
T3-1C-S1	1400	48	36	1400		6.0	-1	-1
T3-2C-S1	790	33	29	760		6.5	-1	-1
T3-3C-S1	560	-31	31	530		6.4	-1	-1
T3-4C-S1	700	-38	38	660		6.6	-1	-1
T4-1C-S1	720	-47	170	550		7.1	-1	-1
T4-2C-S1	1500	4900	710	740		6.8	-1	-1
T4-3C-S1	510	380	38	480	0.5	6.6	-1	-1
T4-3C-S1	710	190	110	600	0.8	6.4	-1	-1
T4-4C-S1	1000	370	130	900	0.8	7.0	-1	-1
T5-1A-S1	1400	1400	440	970		7.7	-1	-1
T5-2A-S1	1100	350	180	900		7.6	-1	-1
T5-3A-S1	380	170	170	210		7.6	-1	-1
T5-4A-S1	1500	870	360	1100		7.7	-1	-1
T5-5A-S1	1600	580	400	1200		7.5	-1	-1
T5-6A-S1	360	340	94	260	1.9	7.9	-1	-1
T6-1A-S1	4300	150	340	4000	6.3	6.9	-1	-1
T6-1A-S1D	2900	480	330	2600	7.5	6.8	-1	-1
T6-2A-S1	2600	1900	610	2000	4.1	6.9	-1	-1
T6-3A-S1	1800	4200	1300	550		7.4	-1	-1
T6-4A-S1	1200	2700	570	590		7.4	-1	-1

NOTE: Minus sign indicates non-detectable. Number shown after minus sign indicates detection limit.

	CHLORIDE	TOC	PHI (value)*
T1-1A-S1	24,000	23,000	0.98
T1-2A-S1	—	3,800	0.07
T1-3A-S1	16,000	11,000	-0.25
T1-4A-S1	28,000	18,000	1.23
T1-5A-S1	18,000	11,000	1.9
T1-6A-S1	12,000	17,000	1.49
T1-6A-S1D	15,000	21,000	1.87
T2-1A-S1	41,000	34,000	-0.8
T2-2A-S1	26,000	26,000	0.6
T2-3A-S1	22,000	26,000	-0.23
T2-4A-S1	12,000	12,000	0.62
T3-1A-S1	22,000	26,000	0.88
T3-2A-S1	18,000	25,000	0.64
T3-3A-S1	25,000	32,000	0.41
T3-4A-S1	11,000	19,000	2.22
T4-1A-S1	18,000	11,000	1.43
T4-2A-S1	16,000	22,000	1.87
T4-3A-S1	7,800	7,900	2.72
T4-4A-S1	18,000	18,000	1.34
T4-4A-S1D	9,700	26,000	1.68
T1-1B-S1	32,000	53,000	0.02
T1-2B-S1	18,000	16,000	-0.01
T1-3B-S1	15,000	18,000	0.44
T1-4B-S1	20,000	27,000	0.08
T1-5B-S1	18,000	15,000	-0.43
T1-6B-S1	15,000	7,600	-0.15
T2-1B-S1	28,000	7,400	0.23
T2-2B-S1	23,000	31,000	-0.02
T2-3B-S1	30,000	38,000	-0.08
T2-3B-S1D	18,000	31,000	-0.24
T2-4B-S1	21,000	23,000	1.38
T3-1B-S1	15,000	15,000	1.4
T3-2B-S1	20,000	27,000	0.72
T3-3B-S1	14,000	26,000	0.26
T3-4B-S1	15,000	22,000	0.66
T3-4B-S1D	18,000	2,700	0.67
T4-1B-S1	21,000	17,000	0.9
T4-2B-S1	18,000	22,000	0.8
T4-3B-S1	16,000	22,000	1.44
T4-4B-S1	17,000	26,000	1.07
T1-1C-S1	31,000	28,000	0.6
T1-2C-S1	39,000	31,000	0.03
T1-3C-S1	29,000	21,000	-0.04

*Sediment Description by PHI Value: -6 Pebble; -2 Granual; -1 Very Coarse Sand; 0 Coarse Sand; 1 Medium Sand; 2 Fine Sand; 3 Very Fine Sand; 4 Coarse Silt; 5 Fine Silt; 8 Clay.

	CHLORIDE	TOC	PHI (value)*
T1-5C-S1	27,000	16,000	-1.2
T2-1C-S1	50,000	54,000	-1.31
T2-2C-S1	28,000	33,000	0.3
T2-3C-S1	32,000	27,000	-0.77
T2-4C-S1	24,000	35,000	0.28
T3-1C-S1	36,000	40,000	0.28
T3-1C-S1	21,000	50,000	-0.14
T3-3C-S1	23,000	35,000	0.46
T3-4C-S1	25,000	22,000	0.34
T4-1C-S1	28,000	62,000	0.33
T4-2C-S1	31,000	66,000	0.36
T4-3C-S1	24,000	56,000	-0.88
T4-3C-S1	24,000	27,000	0.12
T4-4C-S1	21,000	39,000	0
T5-1A-S1	12,000	9,100	0.66
T5-2A-S1	13,000	8,000	1.24
T5-3A-S1	9,300	11,000	2.08
T5-4A-S1	12,000	5,700	-0.44
T5-5A-S1	8,400	11,000	1.98
T5-6A-S1	6,300	5,900	3.6
T6-1A-S1	22,000	59,000	-3.21
T6-1A-S1D	27,000	97,000	-0.26
T6-2A-S1	31,000	52,000	0.42
T6-3A-S1	18,000	22,000	0.61
T6-4A-S1	18,000	25,000	1.19

*Sediment Description by PHI Value: -6 Pebble; -2 Granual; -1 Very Coarse Sand; 0 Coarse Sand; 1 Medium Sand; 2 Fine Sand; 3 Very Fine Sand; 4 Coarse Silt; 5 Fine Silt; 8 Clay.

	CR	CU	PB	HG	NI	ZN
T1-1A-S1	61	70	180	1.40	55	460
T1-2A-S1	27	38	150	0.76	27	210
T1-3A-S1	51	100	170	1.40	43	27
T1-4A-S1	66	89	230	1.60	57	340
T1-5A-S1	66	84	210	1.40	57	520
T1-6A-S1	58	75	180	1.10	50	290
T1-6A-S1D	57	72	240	1.20	51	210
T2-1A-S1	100	120	220	1.30	79	590
T2-2A-S1	76	97	200	1.70	66	260
T2-3A-S1	72	86	180	1.50	65	260
T2-4A-S1	78	67	140	1.10	88	240
T3-1A-S1	63	56	170	0.67	60	200
T3-2A-S1	64	64	180	0.80	64	210
T3-3A-S1	66	66	140	1.10	63	200
T3-4A-S1	50	48	210	0.64	57	260
T4-1A-S1	73	80	210	1.20	64	310
T4-2A-S1	67	70	160	1.20	63	260
T4-3A-S1	30	42	82	0.70	30	190
T4-4A-S1	58	74	220	0.98	62	340
T4-4A-S1D	43	44	150	0.74	46	210
T1-1B-S1	82	79	320	1.50	71	260
T1-2B-S1	60	62	210	2.30	51	180
T1-3B-S1	74	83	230	1.40	62	280
T1-4B-S1	75	84	360	1.30	61	270
T1-5B-S1	98	110	280	1.80	72	350
T1-6B-S1	59	69	200	1.00	53	310
T2-1B-S1	91	83	240	1.30	83	290
T2-2B-S1	100	100	260	1.50	74	170
T2-3B-S1	84	92	320	1.70	73	250
T2-3B-S1D	80	87	240	1.60	67	220
T2-4B-S1	86	100	240	1.40	67	310
T3-1B-S1	71	110	180	2.90	65	350
T3-2B-S1	85	85	240	1.50	83	290
T3-3B-S1	54	56	150	1.00	54	180
T3-4B-S1	75	96	310	1.20	71	330
T3-4B-S1D	69	75	190	1.00	67	270
T4-1B-S1	120	140	210	2.20	76	450
T4-2B-S1	89	98	310	1.40	71	330
T4-3B-S1	74	78	170	1.30	60	220
T4-4B-S1	57	53	170	0.87	57	150
T1-1C-S1	49	49	280	1.00	44	87
T1-2C-S1	47	56	260	0.83	44	170
T1-3C-S1	98	110	330	1.40	76	200
T1-5C-S1	78	73	470	1.00	78	310
T2-1C-S1	75	88	320	0.70	75	250

	CR	CU	PB	HG	NI	ZN
T2-2C-S1	69	61	220	1.20	64	140
T2-3C-S1	94	77	360	1.10	74	170
T2-4C-S1	74	61	460	1.00	67	160
T3-1C-S1	67	55	480	0.83	76	190
T3-2C-S1	63	56	360	0.71	63	180
T3-3C-S1	56	75	350	0.88	56	150
T3-4C-S1	65	53	220	0.60	65	140
T4-1C-S1	69	56	380	0.72	63	160
T4-2C-S1	69	51	270	0.74	69	160
T4-3C-S1	57	32	410	0.51	57	94
T4-3C-S1D	100	100	410	1.10	85	250
T4-4C-S1	78	61	420	1.00	76	180
T5-1A-S1	57	160	120	1.90	55	400
T5-2A-S1	61	160	160	2.00	51	490
T5-3A-S1	48	140	130	1.40	43	380
T5-4A-S1	63	180	180	2.00	59	500
T5-5A-S1	51	100	140	1.40	49	260
T5-6A-S1	43	43	130	0.57	44	200
T6-1A-S1	70	120	400	1.30	62	460
T6-1A-S1D	69	120	410	1.30	62	520
T6-2A-S1	71	140	260	1.50	61	520
T6-3A-S1	87	34	240	4.50	58	900
T6-4A-S1	66	170	170	2.00	52	430

ATTACHMENT D

BENTHOS DATA

ATTACHMENT D

HOFFMAN MARSH BENTHOS SUMMARY FOR OCT.
"A" SERIES CORRECTED TO REPRESENT WHOLE SAMPLES

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-1-1A	5		686		144	480	54	4		4	686
2	5		1244		494	722	24			4	1244
3	3		1288		592	694	2				1288
4	4		626		180	440	4	2			626
SUM			3844		1410	2336	84	6	0	8	3844
		4.25		961							
STD		0.829156		306.1323							
PERCENT					0.366805	0.607700	0.021852	0.001560		0.002081	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-2-1A	4		1250		406	840		4			1250
2	2		430		168	262					430
3	4		966		188	762	14			2	966
4	6		2088		140	1774	154	19		1	2088
SUM			4734		902	3638	168	23	0	3	4734
MEAN		4		1183.5							
STD		1.414213		599.5020							
PERCENT					0.190536	0.768483	0.035487	0.004858		0.000633	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-3-1A	6		775		349	144	275	2		5	775
2	3		2404		712	1654	38				2404
3	2		62		40	22					62
4	6		3950		2296	1206	440	2		6	3950
SUM			7191		3397	3026	753	4	0	11	7191
MEAN		4.25		1797.75							
STD		1.785357		1504.872							
PERCENT					0.472396	0.420803	0.104714	0.000556	0	0.001529	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-4-1A	5		660		286	342	22	2	8		660
2	6		766		264	386	94	16	4	2	766
3	7		632		332	234	48	10	4	4	632
4	6		1658		718	804	124	2	2	8	1658
SUM			3716		1600	1766	288	30	18	14	3716
MEAN		6		929							
STD		0.707106		423.8454							
PERCENT					0.430570	0.475242	0.077502	0.008073	0.004843	0.003767	1

LG006634

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-5-1A	6		996		422	320	230	6	12	6	996
2	7		516		270	68	74	30	66	8	516
3	5		362		232	42	44	4	36	4	362
4	5		548		274	110	138	22		4	548
SUM			2422		1198	540	486	62	114	22	2422
MEAN		5.75		605.5							
STD		0.829156		236.1667							
PERCENT					0.494632	0.222956	0.200660	0.025598	0.047068	0.009083	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-6-1A	5		68		22	12	2	12	20		68
2	6		380		242	66	50	10	8	4	380
3	6		202		100	24	54	18	4	2	202
4	4		292		112	22	104		54		292
SUM			942		476	124	210	40	86	6	942
MEAN		5.25		235.5							
STD		0.829156		115.3808							
PERCENT					0.505307	0.131634	0.222929	0.042462	0.091295	0.006369	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-1-1A	3		54		16	32	6				54
2	3		62		18	18	26				62
3	6		358		238	88	22	4	2	4	358
4	3		238		86	148	4				238
SUM			712		358	286	58	4	2	4	712
MEAN		3.75		178							
STD		1.299038		127.3106							
PERCENT					0.502808	0.401685	0.081460	0.005617	0.002808	0.005617	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-2-1A	4		460		308	116	22	12		2	460
2	5		293		194	84	12	1	2		293
3	4		32		14	10		6		2	32
4	6		238		134	80	14	4	2	4	238
SUM			1023		650	290	48	23	4	8	1023
MEAN		4.75		255.75							
STD		0.829156		152.8763							
PERCENT					0.635386	0.283479	0.04692	0.022482	0.00391	0.00782	1

LG006635

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-3-1A	5		122		56	20	20	4	22		122
2	6		532		252	140	98	2	38	2	532
3	6		810		344	182	262	10	8	4	810
4	5		1425		653	254	512		1	5	1425
SUM			2889		1305	596	892	16	69	11	2889
MEAN		5.5		722.25							
STD		0.5		473.8282							
PERCENT					0.451713	0.206299	0.308757	0.005538	0.023883	0.003807	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-4-1A	5		424		78	22	296	2	26		424
2	6		1868		346	334	1140	12	36		1868
3	6		1052		294	76	464	114	102	2	1052
4	6		574		172	68	316	6	10	2	574
SUM			3918		890	500	2216	134	174	4	3918
MEAN		5.75		979.5							
STD		0.433012		562.9607							
PERCENT					0.227156	0.127616	0.565594	0.034201	0.044410	0.001020	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-1-1A	6		400		140	80	44	12	120	4	400
2	5		136		70	20	2	6	38		136
3	5		832		252	368	18	8	186		832
4	4		418		224	54	80		60		418
SUM			1786		686	522	144	26	404	4	1786
MEAN		5		446.5							
STD		0.707106		248.9954							
PERCENT					0.384098	0.292273	0.080627	0.014557	0.226203	0.002239	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-2-1A	5		481		170	237	30	1	43		481
2	6		538		208	154	4	8	162	2	538
3	6		1626		442	848	258	6	72		1626
4	5		602		266	238	10		88		602
SUM			3247		1086	1477	302	15	365	2	3247
MEAN		5.5		811.75							
STD		0.5		472.0521							
PERCENT					0.334462	0.454881	0.093008	0.004619	0.112411	0.000615	1

LG006636

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-3-1A	5		101		8	7		8	77	1	101
2	6		172		10	6	11	13	132		172
3	5		1002		790	58	56	10	88		1002
4	6		636		286	154	10	4	182		636
SUM			1911		1094	225	77	35	479	1	1911
MEAN		5.5		477.75							
STD		0.5		365.8226							
PERCENT					0.572475	0.117739	0.040293	0.018315	0.250654	0.000523	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-4-1A	6		1128		462	428	160	2	70	6	1128
2	6		1176		330	234	260	4	342	6	1176
3	9		598		345	72	38	8	131	4	598
4	8		1600		664	386	290	8	246	6	1600
SUM			4502		1801	1120	748	22	789	22	4502
MEAN		7.25		1125.5							
STD		1.299038		355.6553							
PERCENT					0.400044	0.248778	0.166148	0.004886	0.175255	0.004886	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-1-1A	6		206		48	8	30	26	92	2	206
2	4		186		82	4	32		68		186
3	6		392		128	30	180	8	46		392
4	5		218		106	18	32	12	50		218
SUM			1002		364	60	274	46	256	2	1002
MEAN		5.25		250.5							
STD		0.829156		82.49090							
PERCENT					0.363273	0.059880	0.273453	0.045908	0.255489	0.001996	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-2-1A	5		302		142	16	76	16	52		302
2	6		216		94	22	46	6	48		216
3	6		314		112	84	94	12	8	4	314
4	7		288		106	38	58	12	70	4	288
SUM			1120		454	160	274	46	178	8	1120
MEAN		6		280							
STD		0.707106		38.07886							
PERCENT					0.405357	0.142857	0.244642	0.041071	0.158928	0.007142	1

LG006637

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-3-1A	6		490		302	6	70	72	38	2	490
2	7		212		81		50	71	5	5	212
3	6		136		42	12	18	4	56	4	136
4	7		726		322	16	260	38	76	14	726
SUM			1564		747	34	398	185	175	25	1564
MEAN		6.5		391							
STD		0.5		234.0363							
PERCENT					0.477621	0.021739	0.254475	0.118286	0.111892	0.015984	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-4-1A	6		210		82	4	38	8	76	2	210
2	10		1054		432	40	226	212	92	52	1054
3	6		678		300	34	124	8	210	2	678
4	6		1050		194	88	666	26	74	2	1050
SUM			2992		1008	166	1054	254	452	58	2992
MEAN		7		748							
STD		1.732050		346.1155							
PERCENT					0.336898	0.055481	0.352272	0.084893	0.151069	0.019385	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-1-1A	4		344		186	14	2		140	2	344
2	4		302		80	20			198	4	302
3	5		546		322	122			98	4	546
4	4		136		86	16			26	8	136
SUM			1328		674	172	2	0	462	18	1328
MEAN		4.25		332							
STD		0.433012		145.9931							
PERCENT					0.507530	0.129518	0.001506	0	0.347891	0.013554	1

LG006638

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-2-1A	7		172		70	12	6	2	76	6	172
2	6		68		34	10		4	16	4	68
3	5		252		122	22			100	8	252
4	5		302		196	58			48		302
SUM			794		422	102	6	6	240	18	794
MEAN		5.75		198.5							
STD		0.829156		88.46892							
PERCENT					0.531486	0.128463	0.007556	0.007556	0.302267	0.022670	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-3-1A	6		122		84		8	2	18	10	122
2	6		204		144	6	4	2	42	6	204
3	5		214		180	4	4		18	8	214
4	7		138		116	6	2		8	6	138
SUM			678		524	16	18	4	86	30	678
MEAN		6		169.5							
STD		0.707106		40.05933							
PERCENT					0.772861	0.023598	0.026548	0.005899	0.126843	0.044247	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-4-1A	6		136		28	54		6	42	6	136
2	5		172		76	39	4	1	47	5	172
3	4		40		14			2	22	2	40
4	4		142		110	12			18	2	142
SUM			490		228	105	4	9	129	15	490
MEAN		4.75		122.5							
STD		0.829156		49.54543							
PERCENT					0.465306	0.214285	0.008163	0.018367	0.263265	0.030612	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-5-1A	7		512		190	50	24	2	238	8	512
2	4		232		140	10	2		74	6	232
3	4		234		182	10	8		30	4	234
4	5		170		110	38	2		16	4	170
SUM			1148		622	108	36	2	358	22	1148
MEAN		5		287							
STD		1.224744		132.4273							
PERCENT					0.541811	0.094076	0.031358	0.001742	0.311846	0.019163	1

LG006639

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T5-6-1A	5		332		292	6	10	22		2	332
2	4		224		180	32	4	8			224
3	5		302		220	24	6	18	34		302
4	4		625		242	363	19			1	625
SUM			1483		934	425	39	48	34	3	1483
MEAN		4.5		370.75							
STD		0.5		151.7923							
PERCENT					0.629804	0.286581	0.026298	0.032366	0.022926	0.002022	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T6-1-1A	4		126		76	38	4	3			126
2	4		18		2	8	6			2	18
3	4		88		12	70				6	88
4	4		30		10	4	6		10		30
SUM			262		100	120	16	8	10	8	262
MEAN		4		65.5							
STD		0		43.82636							
PERCENT					0.381679	0.458015	0.061068	0.030534	0.038167	0.030534	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T6-2-1A	5		114		72	22	4	10		6	114
2	5		382		308	24	2	48			382
3	5		646		430	148	4	54	8	2	646
4	4		118		86	20	2	10			118
SUM			1260		896	214	12	122	8	8	1260
MEAN		4.75		315							
STD		0.433012		219.8067							
PERCENT					0.711111	0.169841	0.009523	0.096825	0.006349	0.006349	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T6-3-1A	4		166		104	42		2	18		166
2	7		282		204	44	16	2	10	6	282
3	5		211		146	37	2	10	16		211
4	5		136		76	46	8		6		136
SUM			795		530	169	26	14	50	6	795
MEAN		5.25		198.75							
STD		1.089724		54.97897							
PERCENT					0.666666	0.212578	0.032704	0.017610	0.062893	0.007547	1

LG006640

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T6-4-1A	6		532		202	154	52	2	114	8	532
3	5		900		170	372	148		206	4	900
4	6		423		138	39	15	4	220	7	423
SUM			1855		510	565	215	6	540	19	1855
MEAN		5.666666		618.3333							
STD		0.471404		204.0789							
PERCENT					0.274932	0.304582	0.115902	0.003234	0.291105	0.010242	1

NOTE: T6-4-2A REJECTED BECAUSE OF DATA ABNOMALITY

HOFFMAN MARSH BENTHOS SUMMARY FOR OCT.
"B" SERIES CORRECTED TO REPRESENT WHOLE SAMPLES

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-1-18	5		76		26	42	4	2	2		76
2	4		782		242	148	390			2	782
3	6		328		14	106	184	12		12	328
4	6		1370		264	464	608	22		12	1370
SUM			2556		546	760	1186	36	2	26	2556
MEAN		5.25		639							
STD		0.829156		492.0619							
PERCENT					0.213615	0.297339	0.464006	0.014084	0.000782	0.010172	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-2-18	5		190		48	20	74	46		2	190
2	7		456		160	82	140	60		14	456
3	6		454		116	190	72	70		6	454
4	6		456		22	120	190	110		14	456
SUM			1556		346	412	476	286	0	36	1556
MEAN		6		389							
STD		0.707106		114.8956							
PERCENT					0.222365	0.264781	0.305912	0.183804	0	0.023136	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-3-18	7		938		30	100	734	66		8	938
2	4		932			80	792	56		4	932
3	6		1162		4	92	1006	56		4	1162
4	4		218		2	20	178	18			218
SUM			3250		36	292	2710	196	0	16	3250
MEAN		5.25		812.5							
STD		1.299038		355.5316							
PERCENT					0.011076	0.089846	0.833846	0.060307	0	0.004923	1

LG006641

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-4-18	5		724		2	210	412	98		2	724
2	7		366		8	94	162	96	2	4	366
3	6		529		1	64	350	108		6	529
4	7		1932		48	340	1454	76		14	1932
SUM			3551		59	708	2378	378	2	26	3551
MEAN		6.25		887.75							
STD		0.829156		616.0756							
PERCENT					0.016615	0.199380	0.669670	0.106448	0.000563	0.007321	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-5-1B	7		600		128	96	320	40	12	4	600
2	7		258		4	32	98	116	2	6	258
3	5		144		46	16	60	14	8		144
4	7		624		88	80	392	54	8	2	624
SUM			1626		266	224	870	224	30	12	1626
MEAN		6.5		406.5							
STD		0.866025		209.5870							
PERCENT					0.163591	0.137761	0.535055	0.137761	0.018450	0.007380	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T1-6-1B	6		124		2	48	48	22		4	124
2	5		374		20	46	214	92		2	374
3	7		160		2	20	20	114		4	160
4	6		924			266	522	136			924
SUM			1582		24	380	804	364	0	10	1582
MEAN		6		395.5							
STD		0.707106		319.7448							
PERCENT					0.015170	0.240202	0.508217	0.230088	0	0.006321	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-1-1B	5		2464		590	930	940	2		2	2464
2	6		1502		274	499	699	13	1	16	1502
3	5		1278		248	456	556	8		10	1278
4	4		1322		16	264	1032	6		4	1322
SUM			6566		1128	2149	3227	29	1	32	6566
MEAN		5		1641.5							
STD		0.707106		482.2289							
PERCENT					0.171794	0.327292	0.491471	0.004416	0.000152	0.004873	1

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SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-2-1B	4		1160		4	74	906	172		4	1160
2	4		784		14	68	484	210		8	784
3	5		866		28	144	624	64		6	866
4	6		484		4	208	160	108		4	484
SUM			3294		50	494	2174	554	0	22	3294
MEAN		4.75		823.5							
STD		0.829156		240.7586							
PERCENT					0.015179	0.149969	0.659987	0.168184	0	0.006678	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-3-1B	5		286		4	160	88	32	2		286
2	7		1532		68	314	1018	114		18	1532
3	4		640		2	12	426	192		8	640
4	4		2008		92	564	1316	36			2008
SUM			4466		166	1050	2848	374	2	26	4466
MEAN		5		1116.5							
STD		1.224744		686.3299							
PERCENT					0.037169	0.235109	0.637707	0.083743	0.000447	0.005821	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T2-4-1B	6		880		6	44	812	16	2		880
2	7		1544		30	80	1406	22	4	2	1544
3	6		1658		80	120	1396	58	2	2	1658
4	5		1820		11	66	1651	87		5	1820
SUM			5902		127	310	5265	183	8	9	5902
MEAN		6		1475.5							
STD		0.707106		357.5258							
PERCENT					0.021518	0.052524	0.892070	0.031006	0.001355	0.001524	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-1-1B	5		441		248	73	77	41	2		441
2	6		47		2	26	12	6	1		47
3	6		196		4	72	76	24		20	196
4	5		41			9	3	22	7		41
SUM			725		254	180	168	93	10	20	725
MEAN		5.5		181.25							
STD		0.5		162.3120							
PERCENT					0.350344	0.248275	0.231724	0.128275	0.013793	0.027586	1

LG006643

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-2-1B	7		552		6	182	260	82		22	552
2	5		254			82	90	62		20	254
3	7		612		8	200	236	160		8	612
4	5		246		26	90	72	57		1	246
SUM			1664		40	554	658	361	0	51	1664
MEAN		6		416							
STD		1		167.3738							
PERCENT					0.024038	0.332932	0.395432	0.216947	0	0.030649	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-3-18	5		1201		14	142	976	67	2		1201
2	6		140		8	63	37	27	5		140
3	6		399		44	169	183	1		2	399
4	5		201		34	11	150	4	1	1	201
SUM			1941		100	385	1346	99	8	3	1941
MEAN		5.5		485.25							
STD		0.5		424.1853							
PERCENT					0.051519	0.198351	0.693456	0.051004	0.004121	0.001545	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T3-4-18	6		575		73	255	213	24	4	6	575
2	9		273		15	152	90	11	1	4	273
3	6		821		15	687	106	5	1	7	821
4	6		692		32	608	47	3	1	1	692
SUM			2361		135	1702	456	43	7	18	2361
MEAN		6.75		590.25							
STD		1.299038		202.7798							
PERCENT					0.057179	0.720880	0.193138	0.018212	0.002964	0.007623	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-1-18	5		678		136	16	464	38	24		678
2	6		442		4	90	170	174	2	2	442
3	6		440			138	192	108	2		440
4	4		1620		20	318	1162	120			1620
SUM			3180		160	562	1988	440	28	2	3180
MEAN		5.25		795							
STD		0.829156		486.0421							
PERCENT					0.050314	0.176729	0.625157	0.138364	0.008805	0.000628	1

LG006644

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-2-18	4		232			100	106	24		2	232
2	5		190		20	88	36	44		2	190
3	4		128		18	14	18	78			128
4	5		250		23	50	78	96		3	250
SUM			800		61	252	233	242	0	7	800
MEAN		4.5		200							
STD		0.5		46.92547							
PERCENT					0.07625	0.315	0.2975	0.3025	0	0.00875	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-3-18	5		300		26	34	222	16		2	300
2	4		50		2	16	22	10			50
3	5		620		10	86	476	44		4	620
4	4		274		24	56	150	44			274
SUM			1244		62	192	870	114	0	6	1244
MEAN		4.5		311							
STD		0.5		203.1575							
PERCENT					0.049839	0.154340	0.699356	0.091639	0	0.004823	1

SAMPLE NUMBER	TOTAL # TAXA	MEAN TOTAL # TAXA	TOTAL # ORGANS.	MEAN TOTAL # ORGANS	NUMBER ORGANISMS BY MAJOR TAXA POLY.	OLIGO.	NEMATODE	AMPHIPOD	CUMACEA	OTHER	
T4-4-18	4		1474		54	402	766	252			1474
2	6		388		8	76	198	96		10	388
3	7		774		18	82	456	208		10	774
4	6		342			42	38	254		8	342
SUM			2978		80	602	1458	810	0	28	2978
MEAN		5.75		744.5							
STD		1.089724		453.3594							
PERCENT					0.026863	0.202149	0.489590	0.271994	0	0.009402	1

ATTACHMENT E

SPECIES LIST - VEGETATION AND WILDLIFE

ATTACHMENT E

Table E - 1

Plant Species Observed at the Hoffman Marsh Site during WESCO Field Surveys in November 1988.

COMMON NAME	SCIENTIFIC NAME
Native and naturalized exotic species	
fat hen	*Atriplex patula* var. *hastata*
Australian saltbush	*Atriplex semibaccata*
wild oat	*Avena fatua*
baccharis	*Baccharis douglasii*
coyote brush	*Baccharis pilularis* ssp. *consanguinea*
wild mustard	*Brassica* sp.
ripgut brome	*Bromus diandrus*
soft chess	*Bromus mollis*
red brome	*Bromus rubens*
Italian thistle	*Carduus pycnocephala*
ice plant	*Carpobrotus edulis*
bindweed	*Convolvulus arvensis*
horseweed	*Conyza* sp.
pampas grass	*Cortaderia jubata*
dodder	*Cuscuta salina* var. *major*
artichoke thistle	*Cynara cardunculus*
bermudagrass	*Cynodon dactylon*
French broom	*Cytisus monspessulanus*
saltgrass	*Distichlis spicata*
creeping wildrye	*Elymus triticoides*
willow-herb	*Epilobium* sp.
red-stem filaree	*Erodium cicutarium*
California poppy	*Eschscholzia californica*
wild fennel	*Foeniculum vulgare*
alkali heath	*Frankenia grandifolia*
green everlasting	*Gnaphalium* sp.
everlasting	*Gnaphalium* sp.
marsh gumplant	*Grindelia humilis*
telegraph weed	*Heterotheca grandiflora*
Mediterranean barley	*Hordeum geniculatum*
jaumea	*Jaumea carnosa*
prickly lettuce	*Lactuca serriola*
marsh rosemary	*Limonium californicum*
sweet alyssum	*Lobularia maritima*
ryegrass	*Lolium* sp.
white sweet-clover	*Melilotus albus*
sour grass	*Oxalis pes-caprae*
prickly ox-tongue	*Picris echioides*
ribgrass	*Plantago major* var. *scopularum*
rabbit'sfoot grass	*Polypogon monspeliensis*
wild radish	*Raphanus sativus*
coffeeberry	*Rhamnus californica*
blackberry	*Rubus ursinus*

(CONTINUED)

Table E - 1 (Continued)

COMMON NAME	SCIENTIFIC NAME
Native and naturalized exotic species (Continued)	
curly dock	*Rumex crispus*
pickleweed	*Salicornia subterminalis*
pickleweed	*Salicornia virginica*
Russian thistle	*Salsola kali*
elderberry	*Sambucus mexicanus*
bulrush	*Scirpus* sp.
milk thistle	*Silybum marianum*
nightshade	*Solanum nodiflorum*
sow-thistle	*Sonchus asper*
cordgrass	*Spartina foliosa*
spurrey	*Spergularia arvense*
stephanomeria	*Stephanomeria* sp.
poison oak	*Toxicodendron diversilobum*
cattail	*Typha* sp.
Landscape plants and isolated ornamentals	
green wattle	*Acacia decurrens*
golden wattle	*Acacia longiflora*
century plant	*Agave* sp.
belladonna lilies	*Amaryllis belladonna*
bottlebrush	*Callistemon* sp.
cotoneaster	*Cotoneaster* sp.
Monterey cypress	*Cupressus macrocarpa*
eucalyptus	*Eucalyptus* sp.
cultivated iris	*Iris* sp.
opuntia cactus	*Opuntia* sp.
Monterey pine	*Pinus radiata*
fireberry	*Pyracantha* sp.
yucca	*Yucca* sp.

Table E - 2

Wildlife Species Observed at the Liquid Gold Site and Hoffman Marsh, Richmond, California[1]

Reptiles	
western fence lizard	*Sceloporus occidentalis*
Birds	
double-crested cormorant	*Phalacrocorax auritus*
black-crowned night heron	*Nycticorax nycticorax*
great egret	*Casmerodias albus*
great blue heron	*Ardea herodias*
mallard	*Anas platyrynchos*
scaup	*Athya* sp.
common goldeneye	*Bucephala islandica*
bufflehead	*Bucephala albeola*
killdeer	*Charadrius vociferus*
marbled godwit	*Limosa fedoa*
willet	*Catoptrophorus semipalmatus*
greater yellowlegs	*Tringa melanoleuca*
dowitcher	*Limnodromus* sp.
common snipe	*Gallinago gallinago*
turkey vulture	*Cathartes aura*
black-shouldered kite	*Elanus caeruleus*
northern harrier	*Circus cyaneus*
American kestrel	*Falco sparverius*
rock dove	*Columba livia*
mourning dove	*Zenaida macroura*
short-eared owl	*Asio flammeus*
Anna's hummingbird	*Calypte anna*
northern flicker	*Colaptes auratus*
black phoebe	*Sayornis nigricans*
bushtit	*Psaltriparus minimus*
marsh wren	*Cistothorus palustris*
American robin	*Turdus migratorius*
northern mockingbird	*Mimus polyglottos*
European starling	*Sturnus vulgaris*
salt marsh yellowthroat	*Geothlypis trichas sinuosa*
song sparrow	*Melospiza melodia*
dark-eyed junco	*Junco hyemalis*
white-crowned sparrow	*Zonotrichia albicollis*
Brewer's blackbird	*Euphagus cyanocephalus*
house sparrow	*Passer domesticus*
lesser goldfinch	*Carduelis psaltria*
house finch	*Carpodacus mexicanus*

(CONTINUED)

Table E - 2 (Continued)

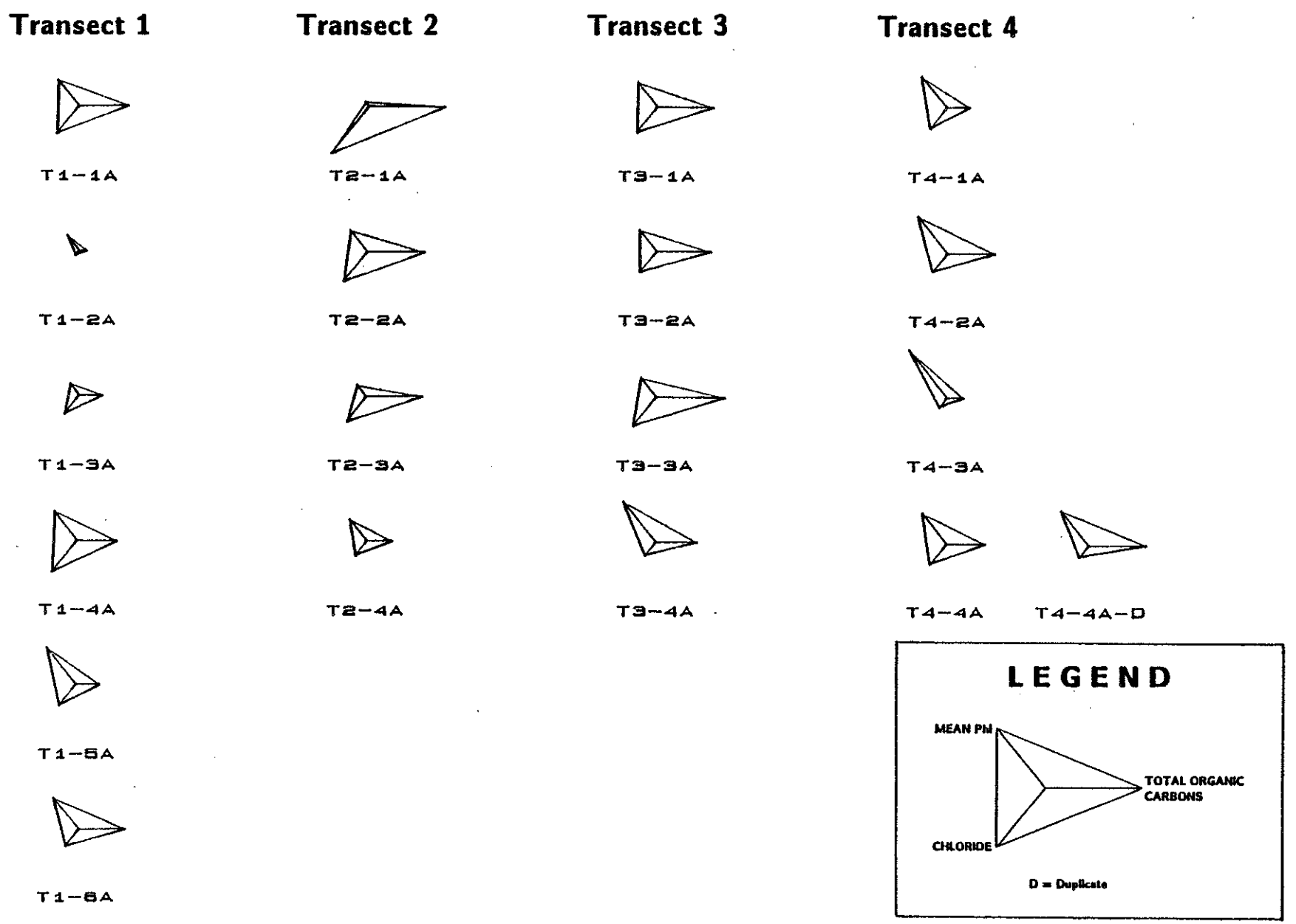
Mammals	
striped skunk	*Mephitis mephitis*
red fox	*Vulpes vulpes*
feral cat	*Felis catus*
California ground squirrel	*Spermophilus beecheyi*
Botta pocket gopher	*Thomomys bottae*
California vole	*Microtus californicus*
house mouse	*Mus musculus*
Norway rat	*Rattus norvegicus*

[1]Source: WESCO field survey, conducted November 1988, and January, March, and May 1989. Kennedy/Jenks/Chilton observations January 1989.

ATTACHMENT F

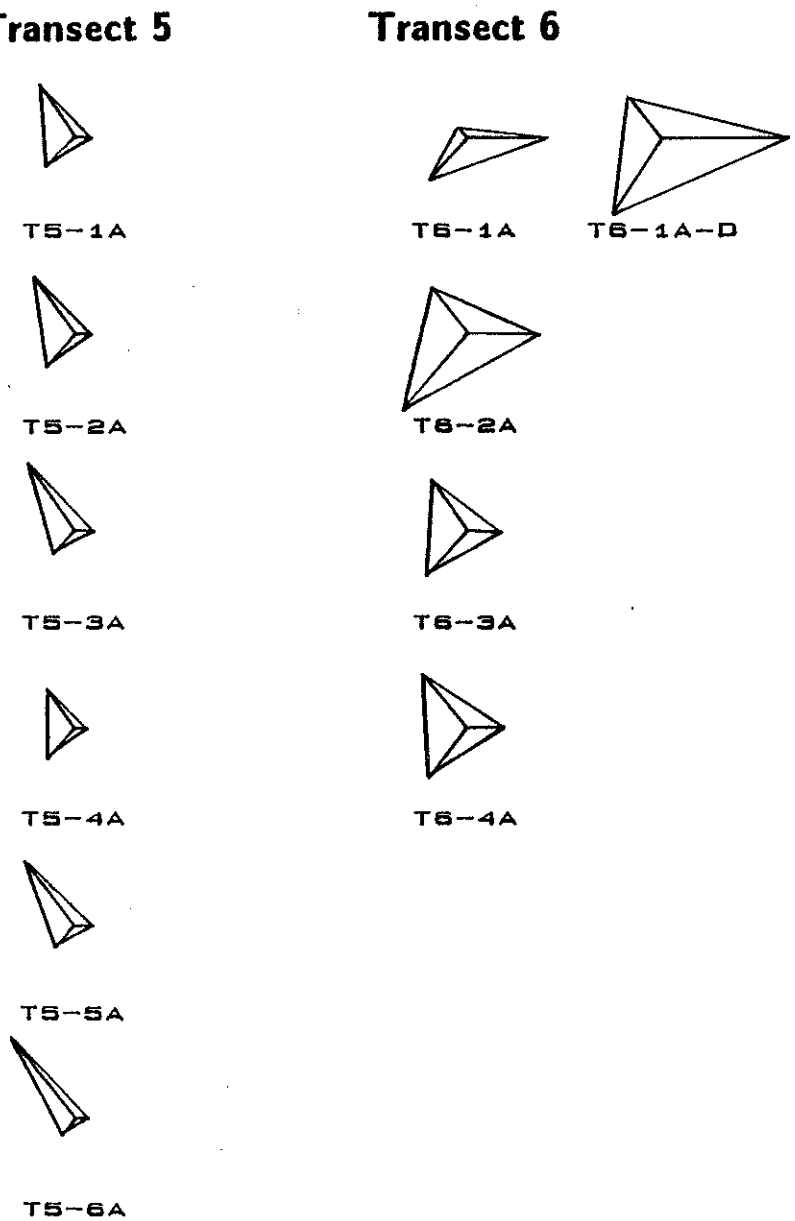
STAR PLOTS AND LINE GRAPHS

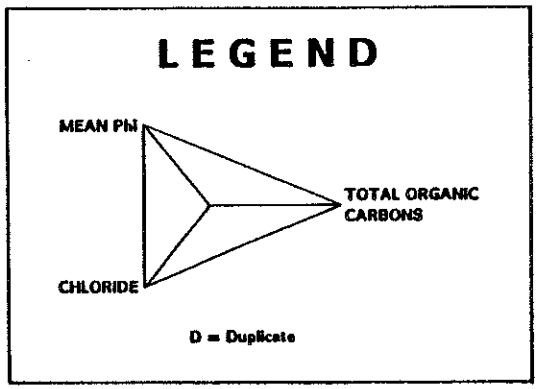
ATTACHMENT F



LG006652

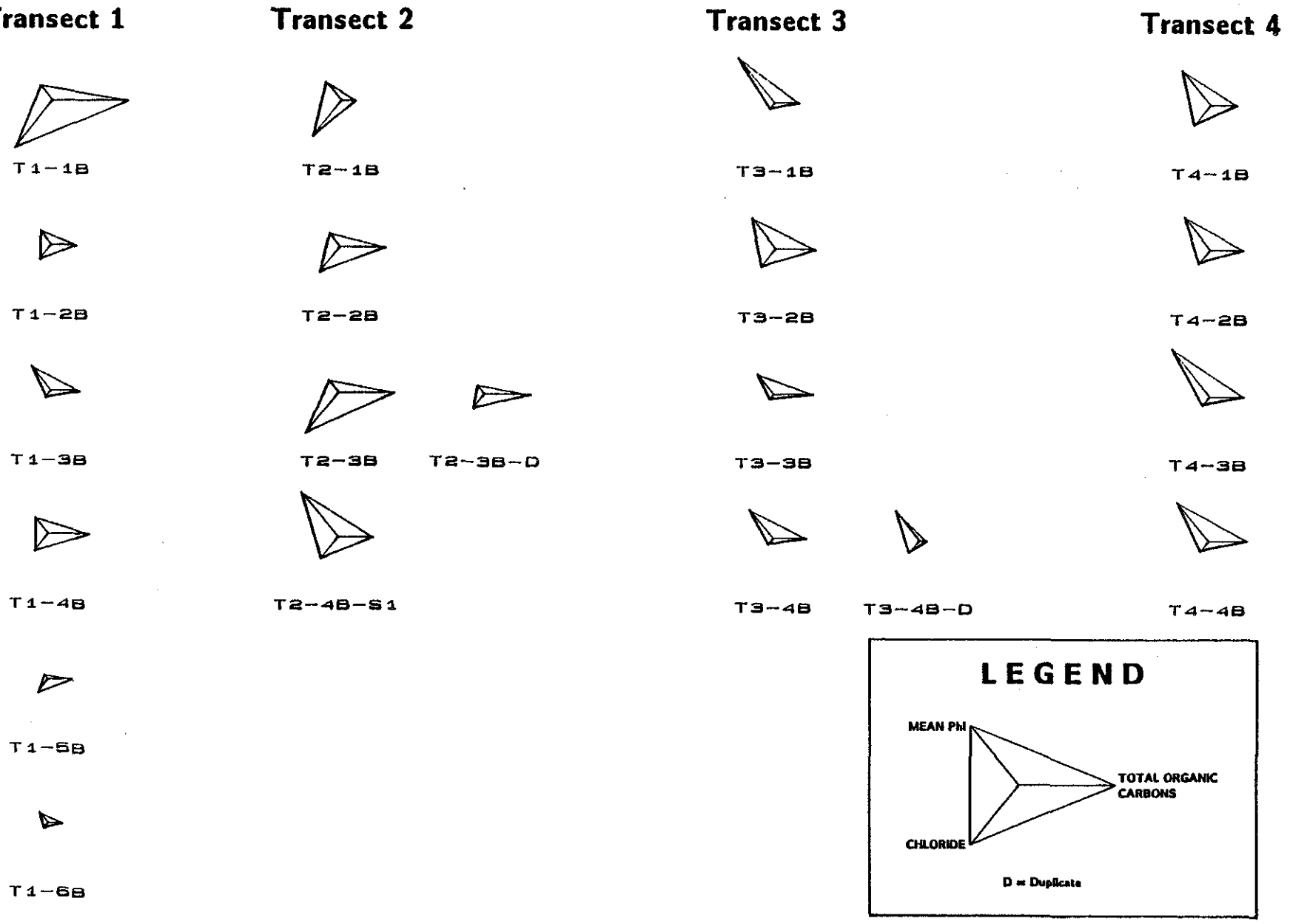
LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-1.** Plots of Normalized Values for TOC, Chloride, and Mean Phi (Sediment Particle Size) in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 1 through 4, October 1988.	WESCO





LG006653

LIQUID GOLD SITE SOUTHERN PACIFIC TRANSPORTATION COMPANY	Figure F-2. Plots of Normalized Values for TOC, Chloride, and Mean Phi (Sediment Particle Size) in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 5 and 6, October 1988.	WESCO



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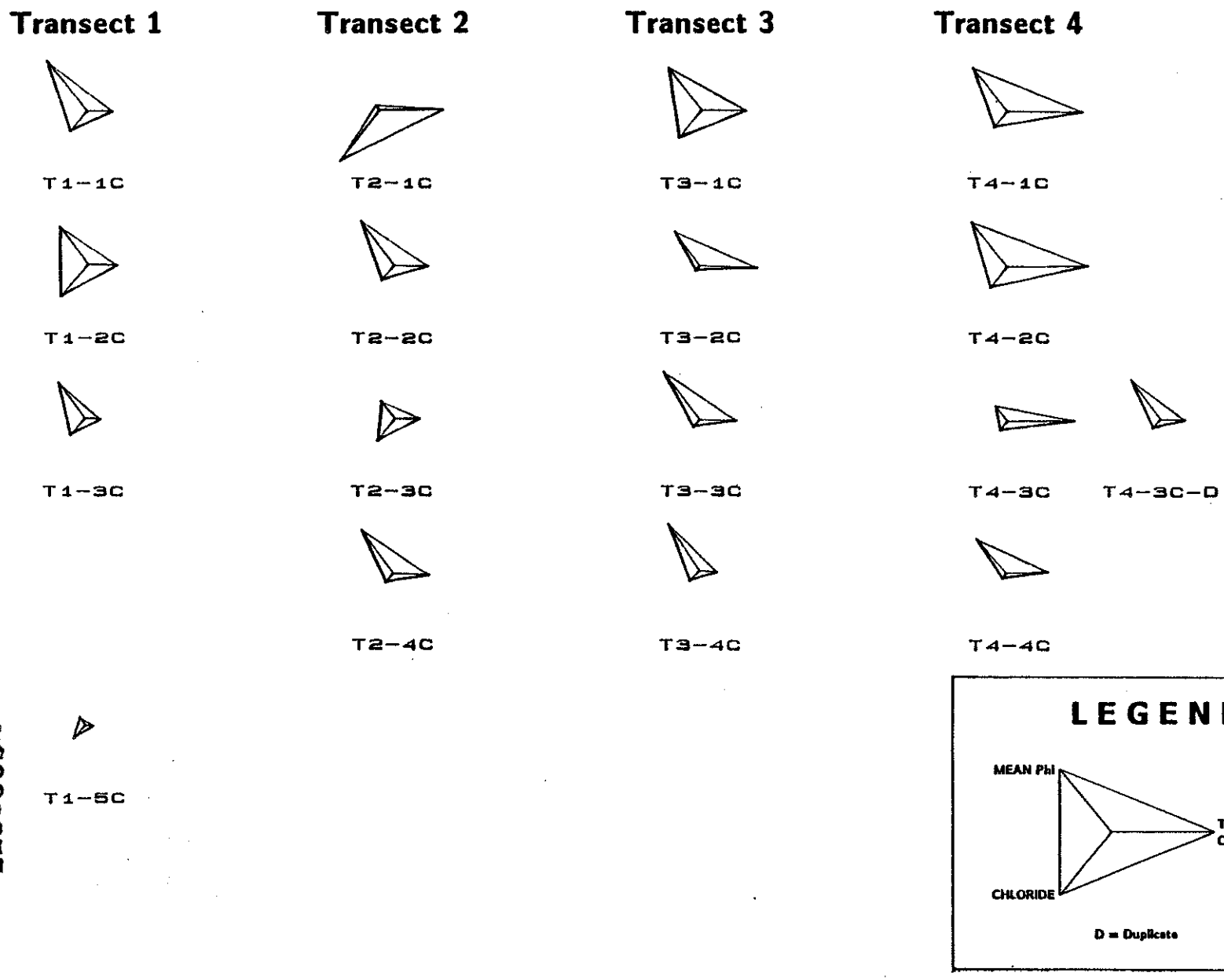
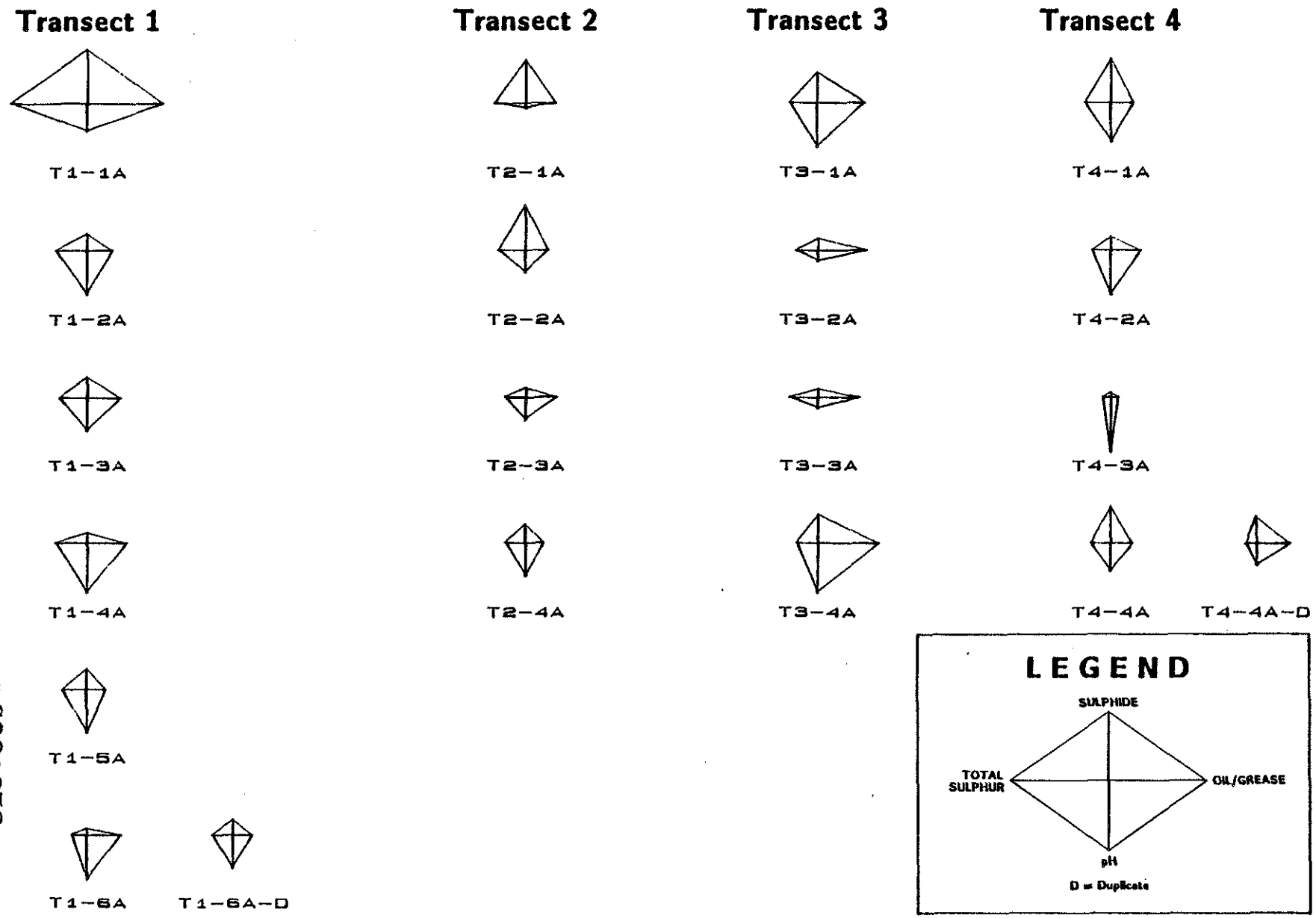
LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-3.** Plots of Normalized Values for TOC, Chloride, and Mean Phi (Sediment Particle Size) in Hoffman Marsh Channel Sideslope ("B" Series) Sediment Samples, Transects 1 through 4, October 1988.	WESCO



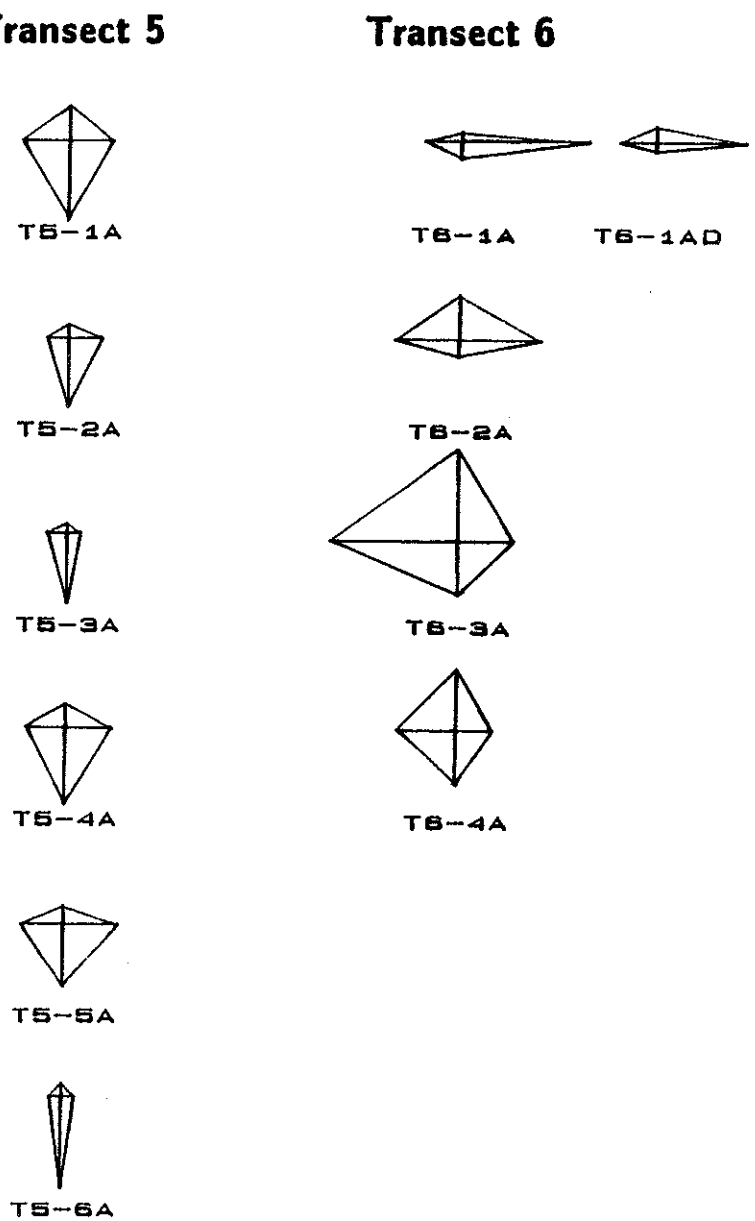
LG006655

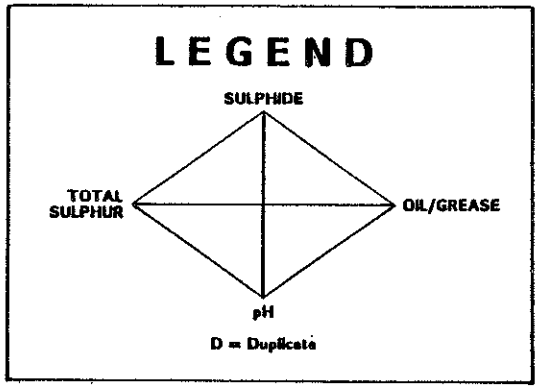
LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-4.** Plots of Normalized Values for TOC, Chloride, and Mean Phi (Sediment Particle Size) in Hoffman Marsh Out-of-Channel ("C" Series) Sediment Samples, Transects 1 through 4, October 1988.	WESCO



LG006656

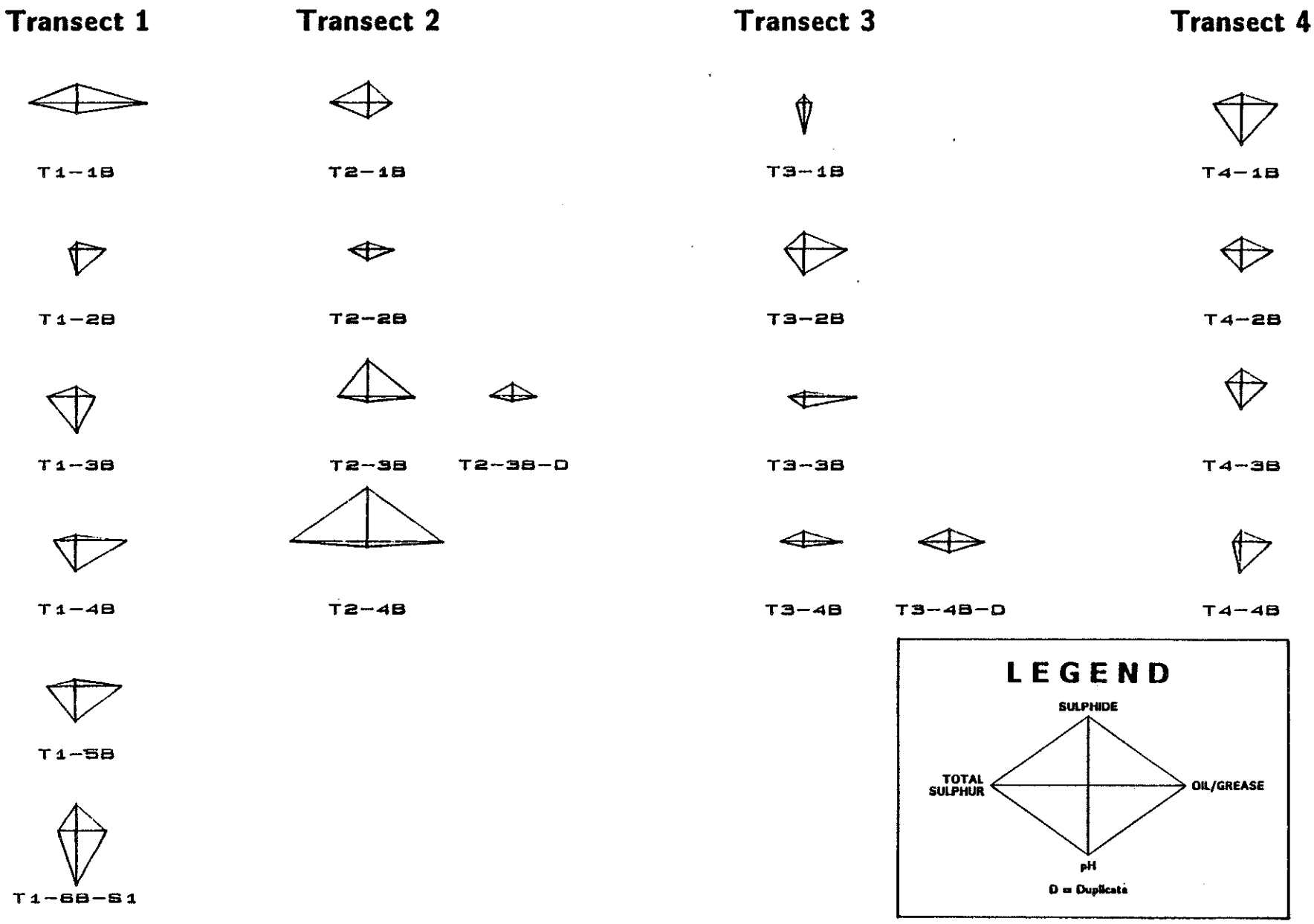
LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-5.** **Plots of Normalized Values for Total Sulphur, Sulphide, Oil and Grease, and pH in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 1 through 4, October 1988.**	WESCO





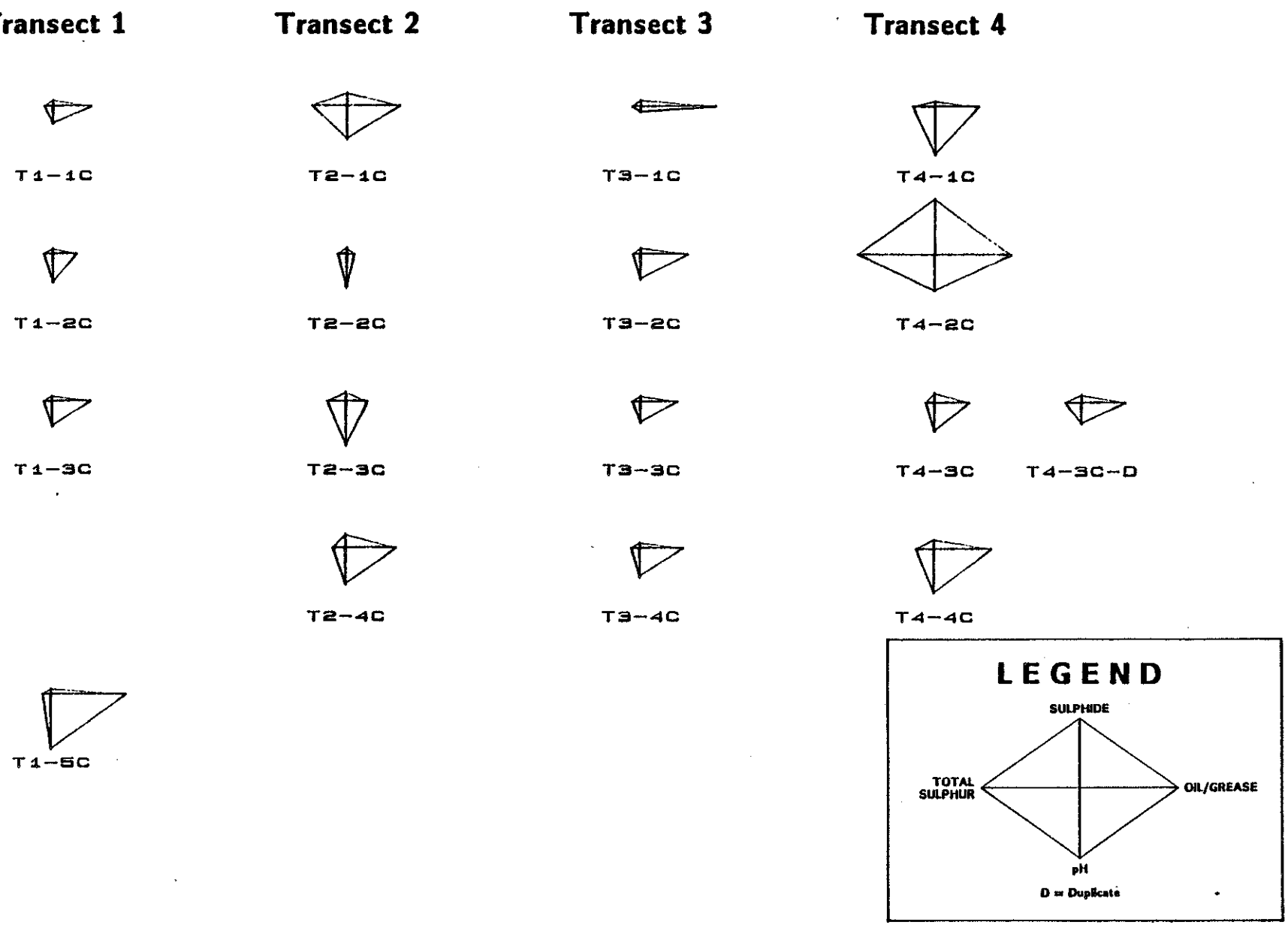
LG006657

LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-6.** Plots of Normalized Values for Total Sulphur, Sulphide Oil and Grease, and pH in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 5 and 6, October 1988.	WESCO



LG006658

LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-7.** Plots of Normalized Values for Total Sulphur, Sulphide Oil and Grease, and pH in Hoffman Marsh Channel Sideslope ("B" Series) Sediment Samples, Transects 1 through 4, October 1988.	WESCO



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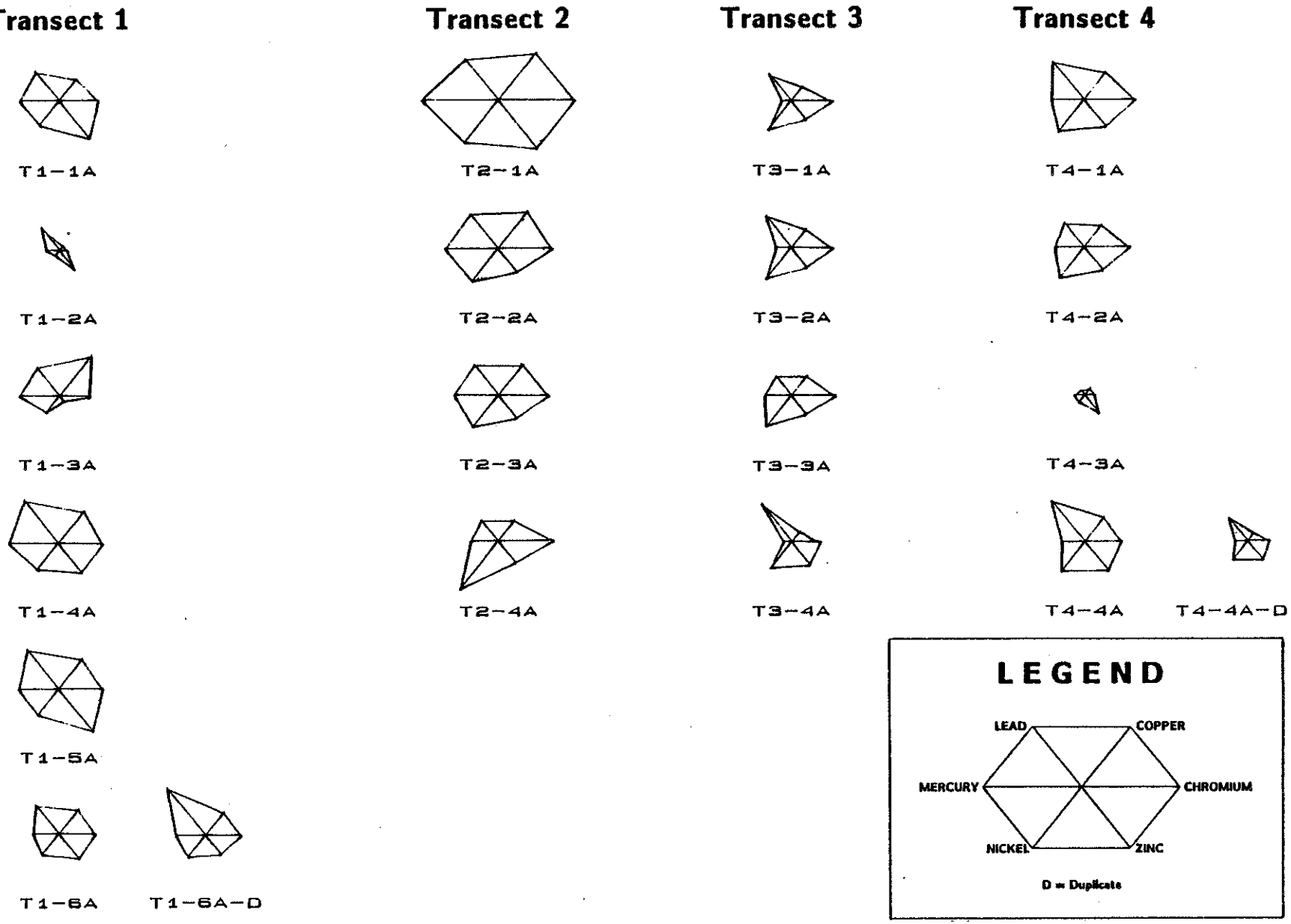
LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-8.** Plots of Normalized Values for Total Sulphur, Sulphide, Oil and Grease, and pH in Hoffman Marsh Out-of-Channel ("C" Series) Sediment Samples, Transects 1 through 4, October 1988.	WESCO



LIQUID GOLD SITE

SOUTHERN PACIFIC TRANSPORTATION COMPANY

Figure F-9. Plots of Normalized Heavy Metal Values in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 1 through 4, October 1988.

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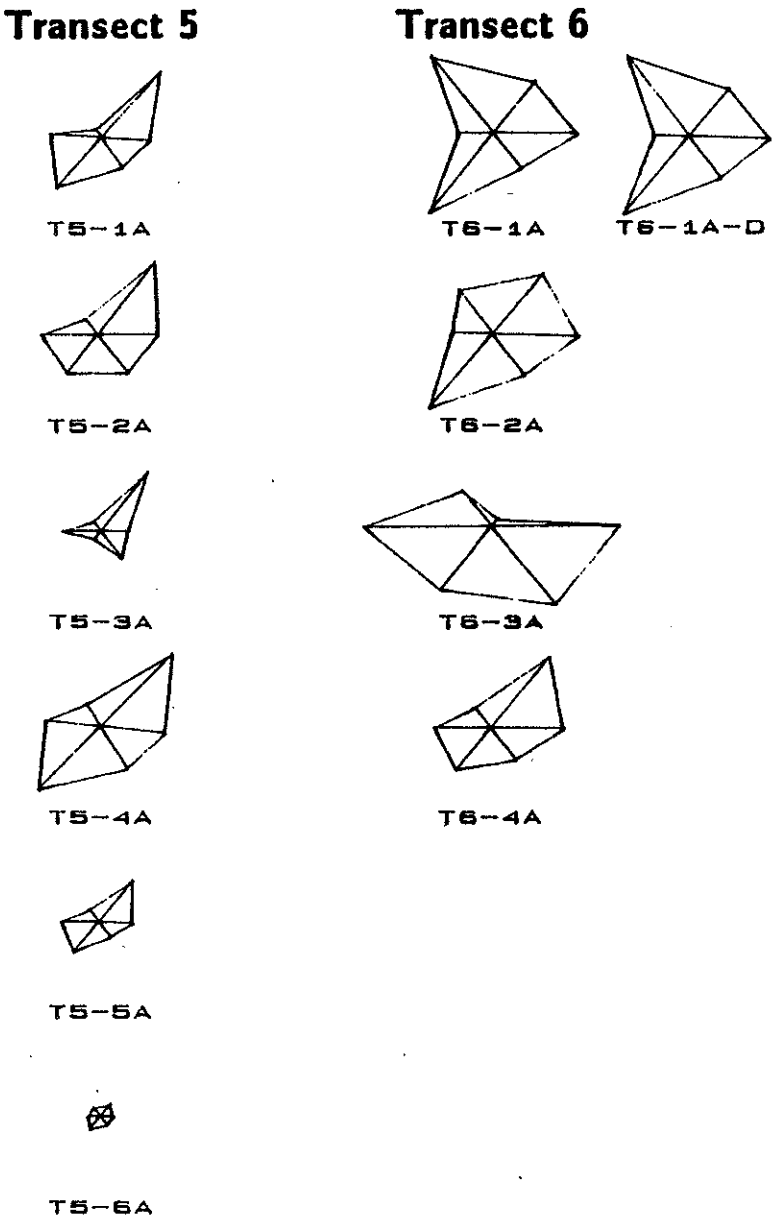
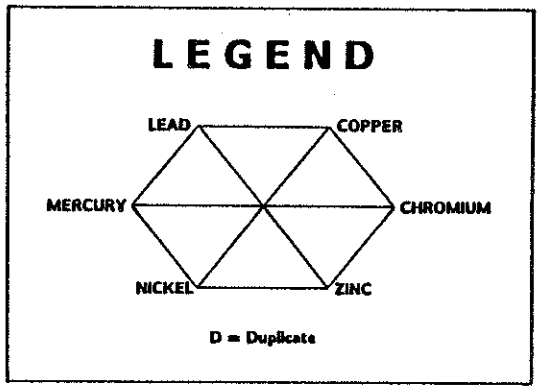




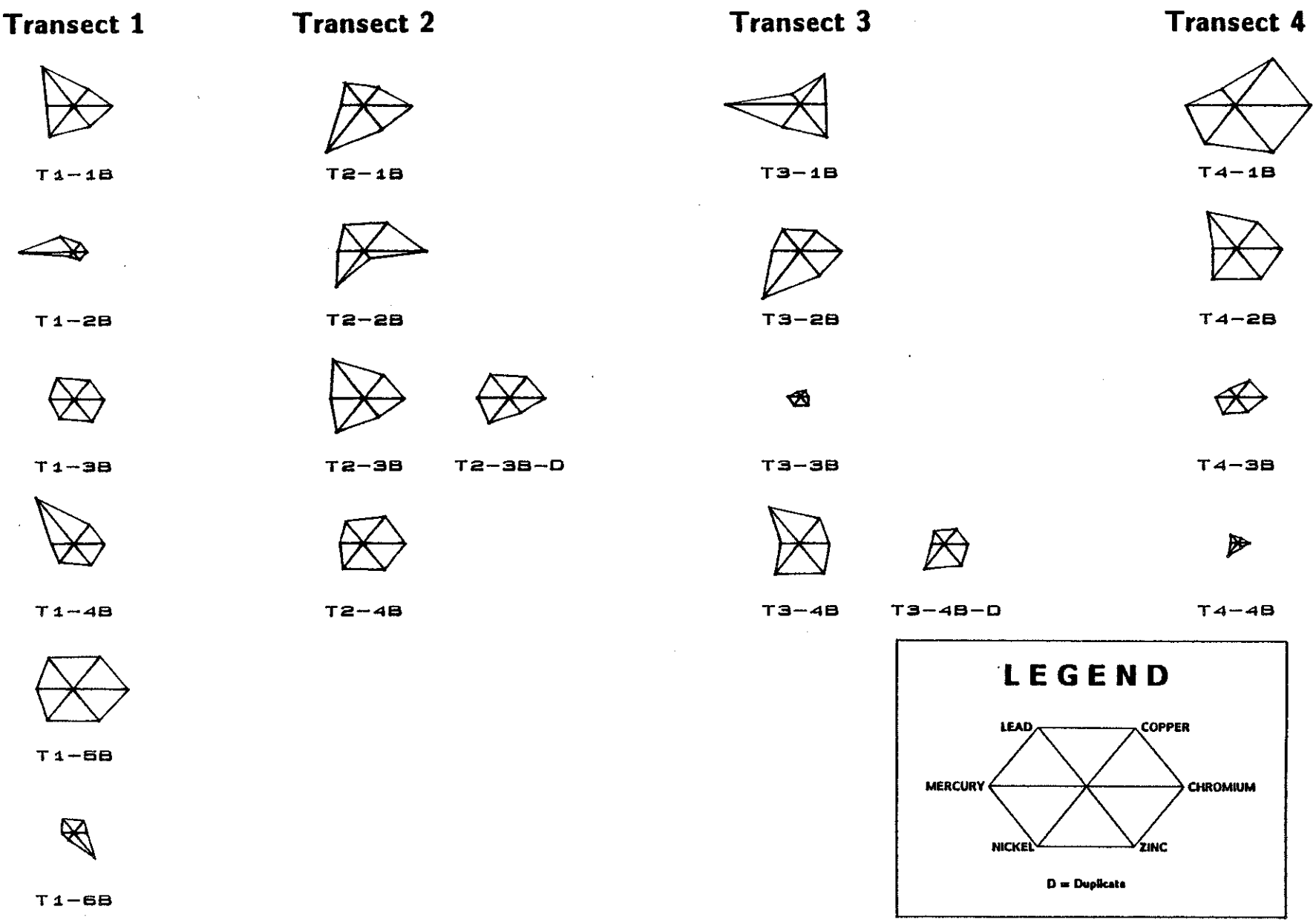
LIQUID GOLD SITE

SOUTHERN PACIFIC TRANSPORTATION COMPANY

Figure F-10. Plots of Normalized Heavy Metal Values in Hoffman Marsh Mid-Channel ("A" Series) Sediment Samples, Transects 5 and 6, October 1988.

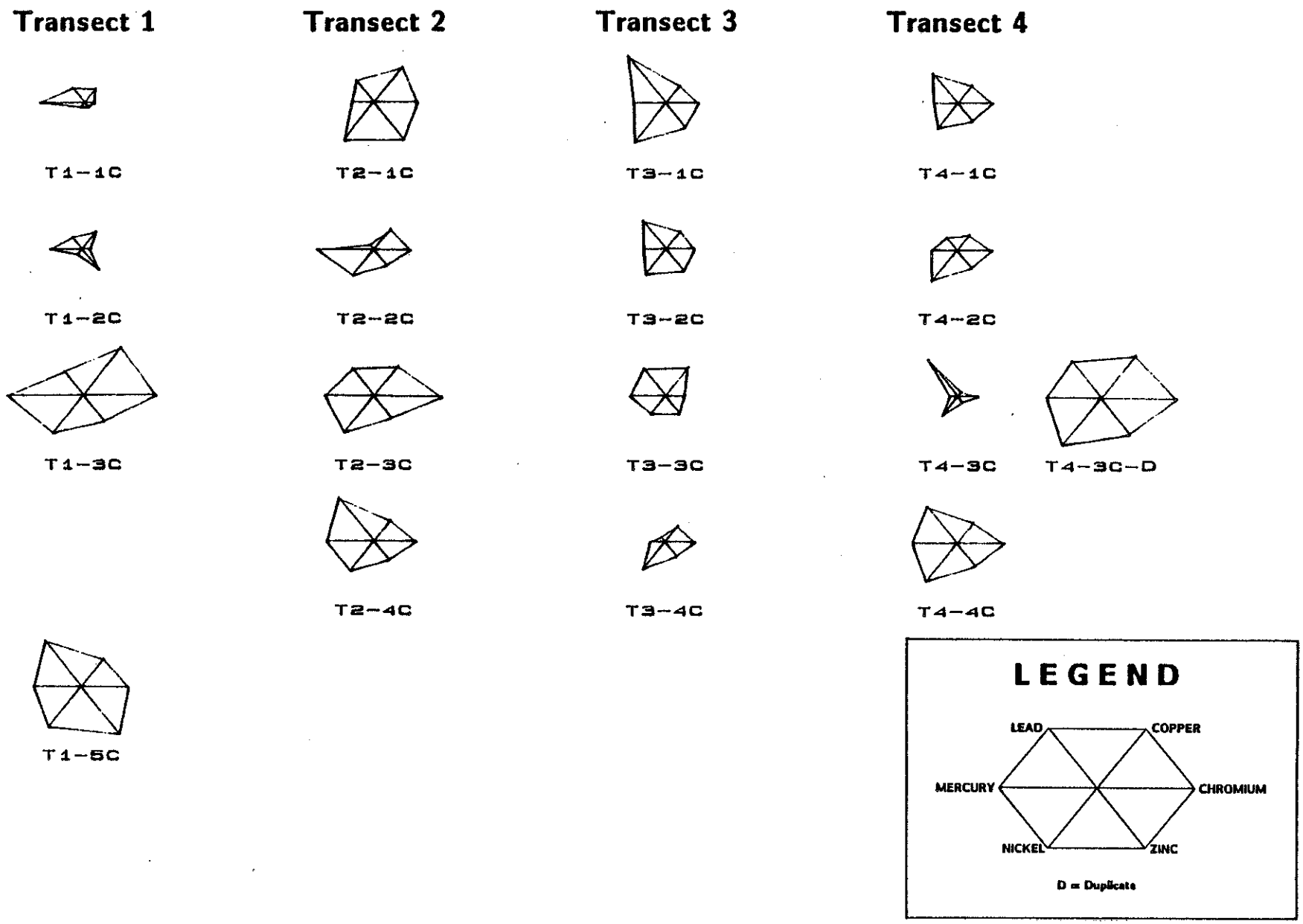
WESCO

L0006661



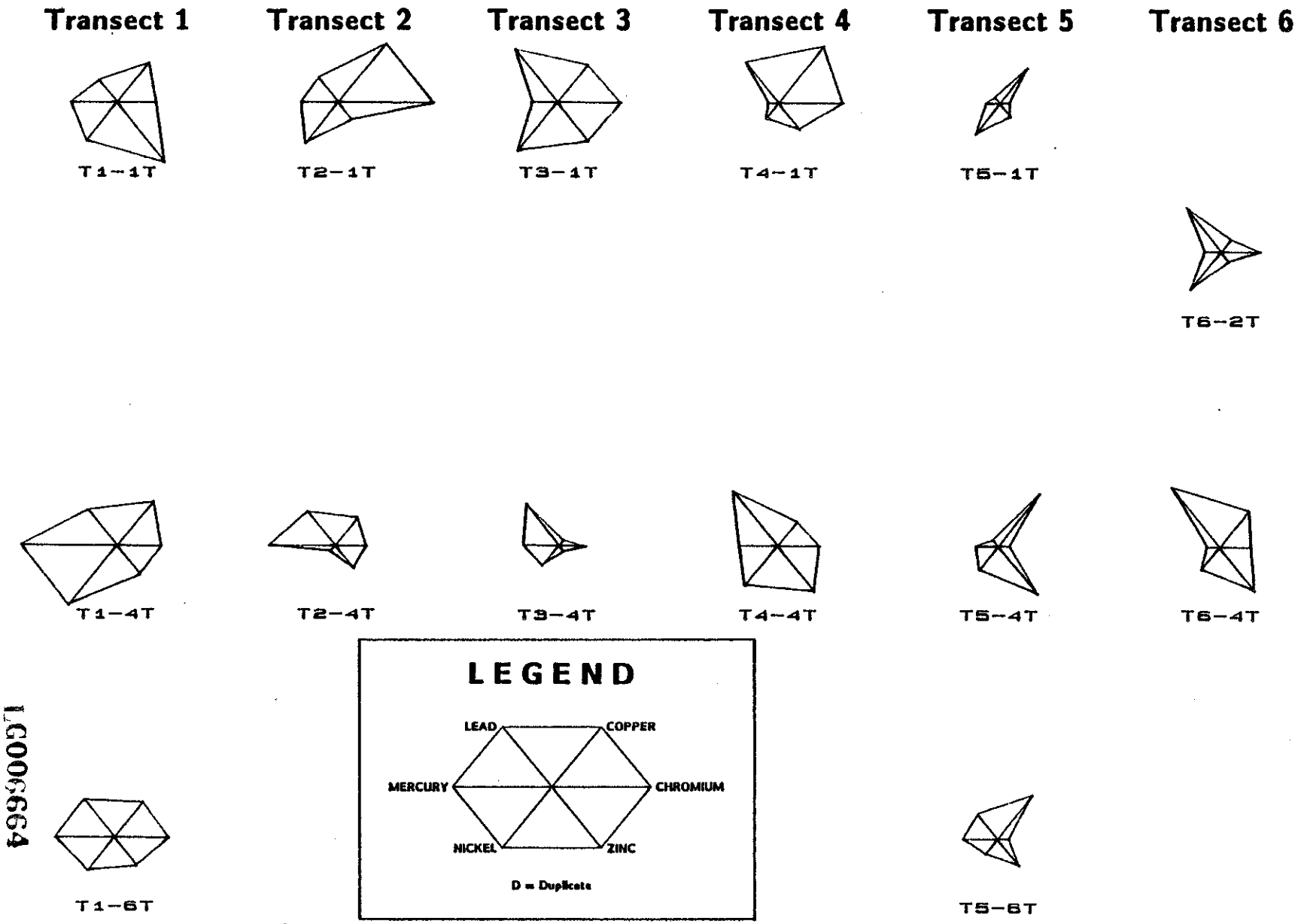
LG006662

LIQUID GOLD SITE SOUTHERN PACIFIC TRANSPORTATION COMPANY	Figure F-11. Plots of Normalized Heavy Metal Values in Hoffman Marsh Channel Sideslope ("B" Series), Sediment Samples, Transects 1 through 4, October 1988.	WESCO



LG006663

LIQUID GOLD SITE **SOUTHERN PACIFIC TRANSPORTATION COMPANY**	**Figure F-12. Plots of Normalized Heavy Metal Values in Hoffman Marsh Out-of Channel ("C" Series) Sediment Samples, Transects 1 through 4, October 1988.**	WESCO



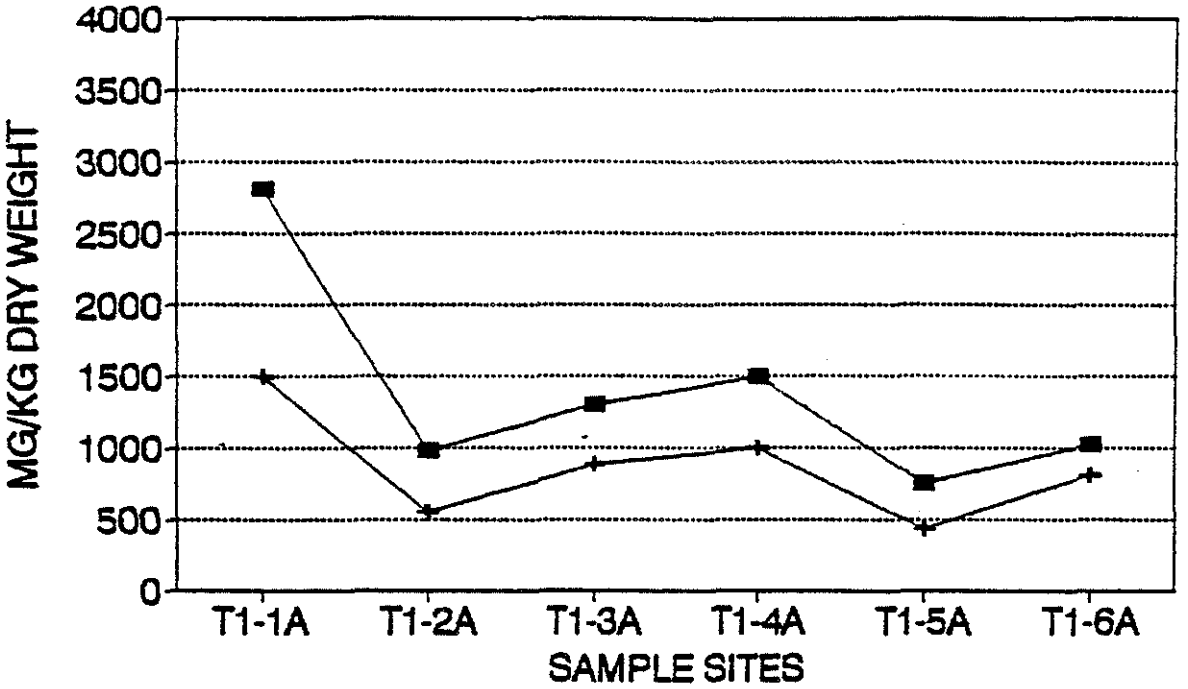
LG006664

LIQUID GOLD SITE SOUTHERN PACIFIC TRANSPORTATION COMPANY	Figure F-13. Plots of Normalized Heavy Metal Values in Yellow Shorecrab from Hoffman Marsh, Transects 1 through 6, October 1988.	WESCO

SERIES A

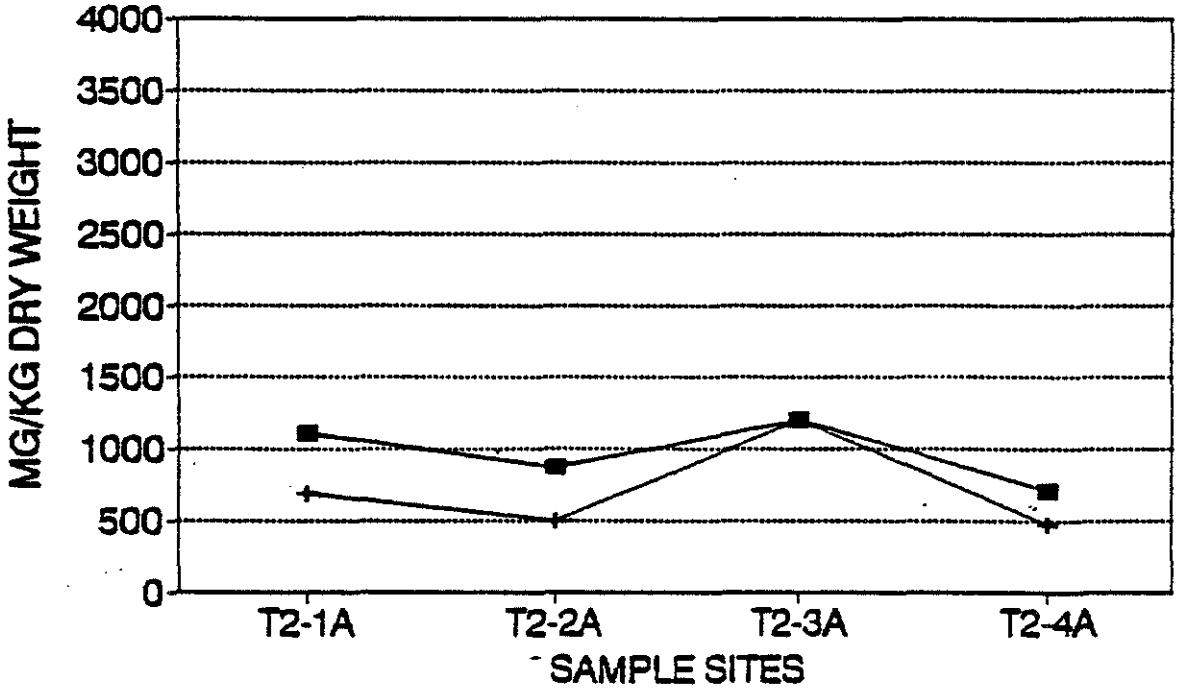
LG006665

HOFFMAN MARSH SEDIMENT
TRANSECT 1, OIL & GREASE AND O&G-S



SERIES A

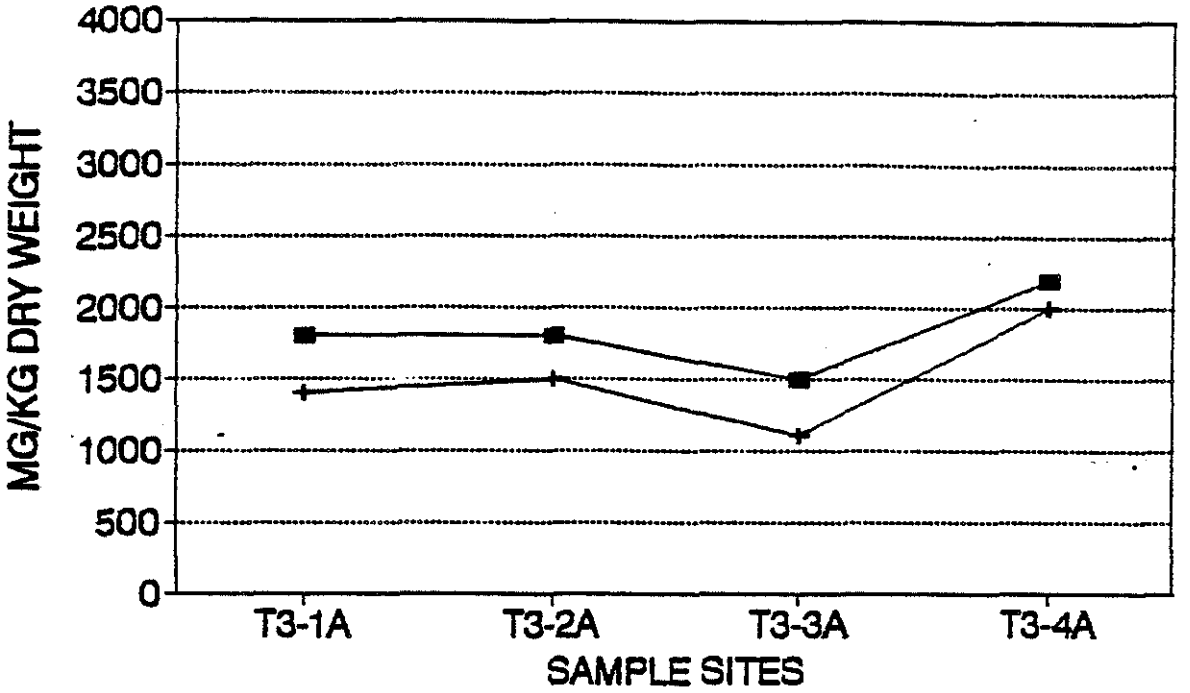
HOFFMAN MARSH SEDIMENT
TRANSECT 2, OIL & GREASE AND O&G-S



O&G O&G-SULFUR

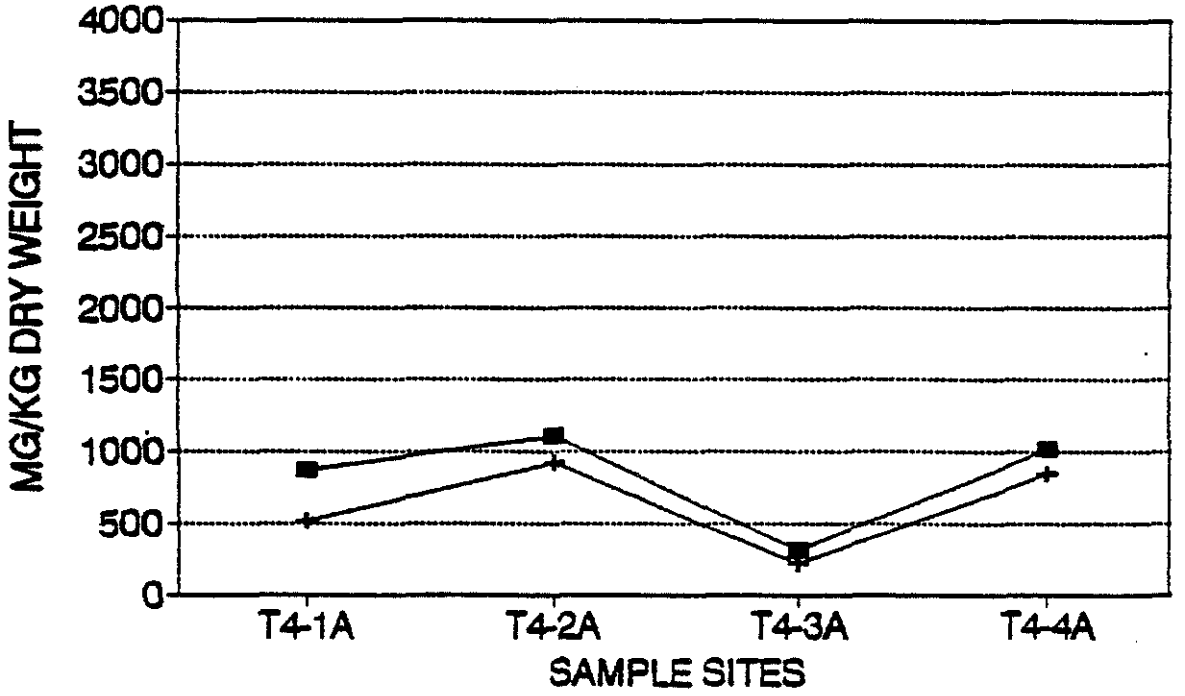
LG006666

HOFFMAN MARSH SEDIMENT
TRANSECT 3, OIL & GREASE AND O&G-S



SERIES A

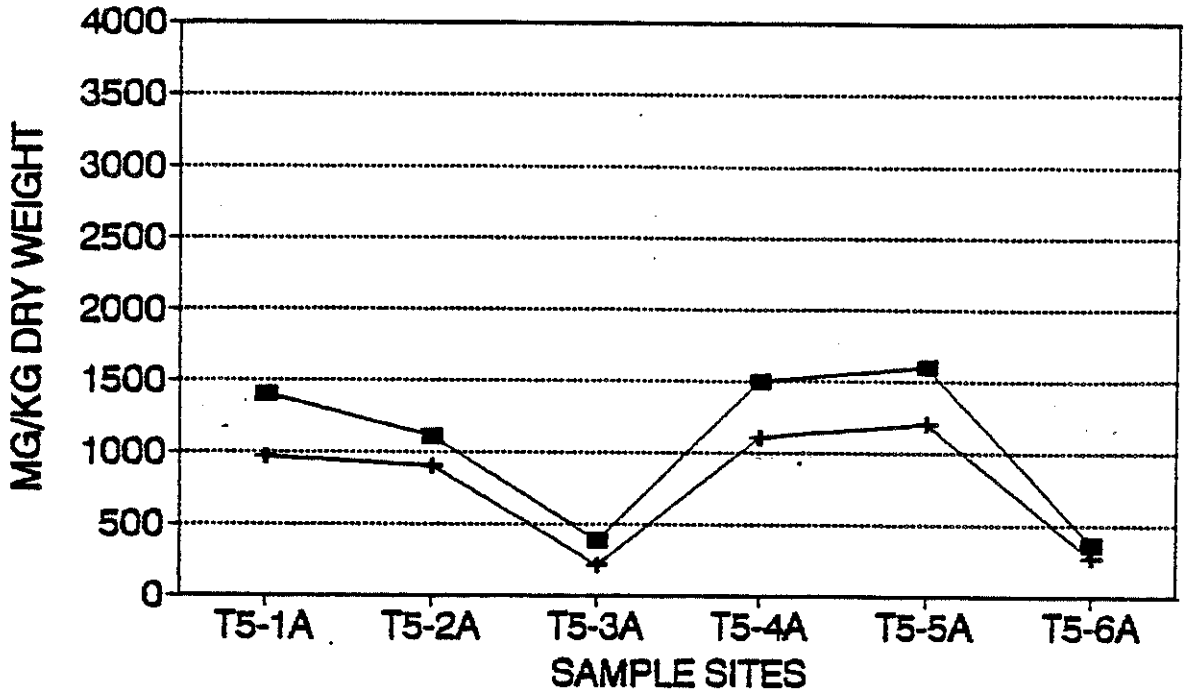
HOFFMAN MARSH SEDIMENT
TRANSECT 4, OIL & GREASE AND O&G-S



O&G — O&G-SULFUR

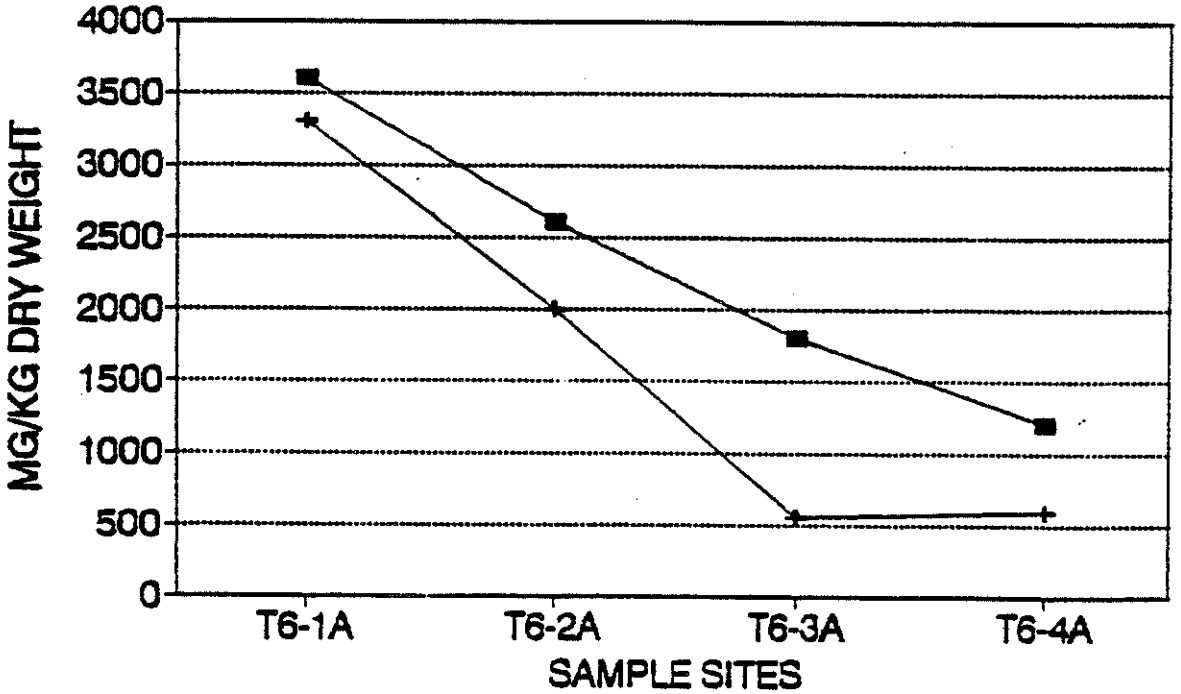
LG006667

HOFFMAN MARSH SEDIMENT
TRANSECT 5, OIL & GREASE AND O&G-S



SERIES A

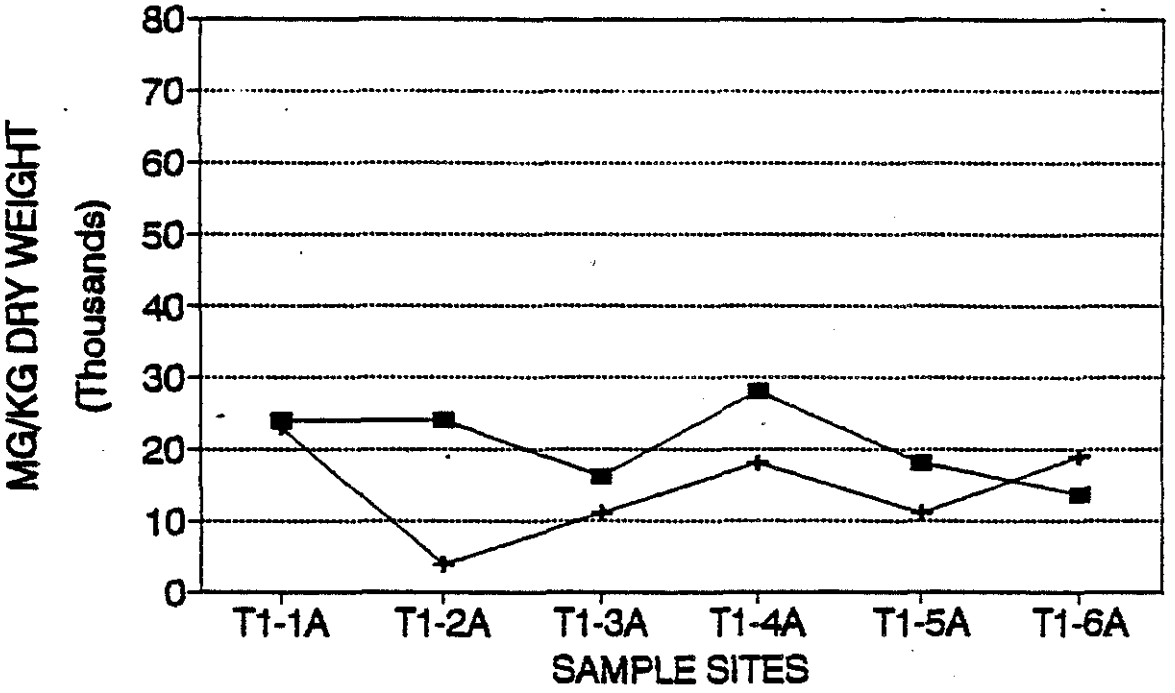
HOFFMAN MARSH SEDIMENT
TRANSECT 6, OIL & GREASE AND O&G-S



O&G — O&G-SULFUR

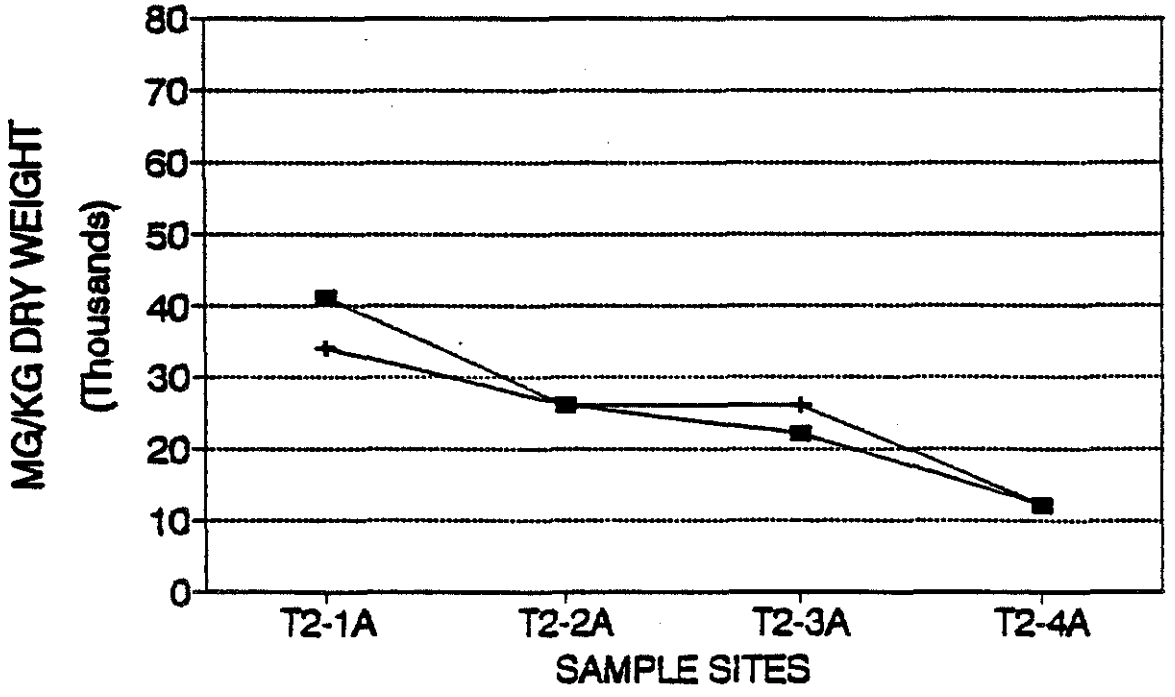
LG006668

HOFFMAN MARSH SEDIMENT
TRANSECT 1, CHLORIDE AND TOC



SERIES A

HOFFMAN MARSH SEDIMENT
TRANSECT 2, CHLORIDE AND TOC

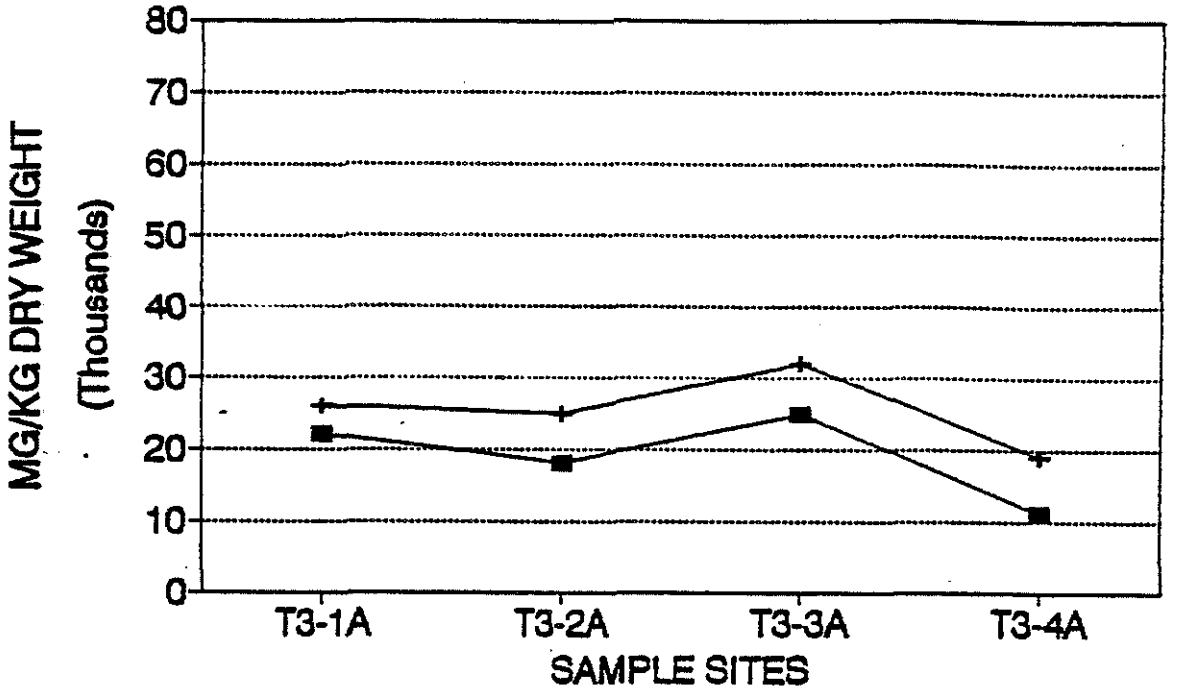


LG006669

CHLORIDE TOC

HOFFMAN MARSH SEDIMENT

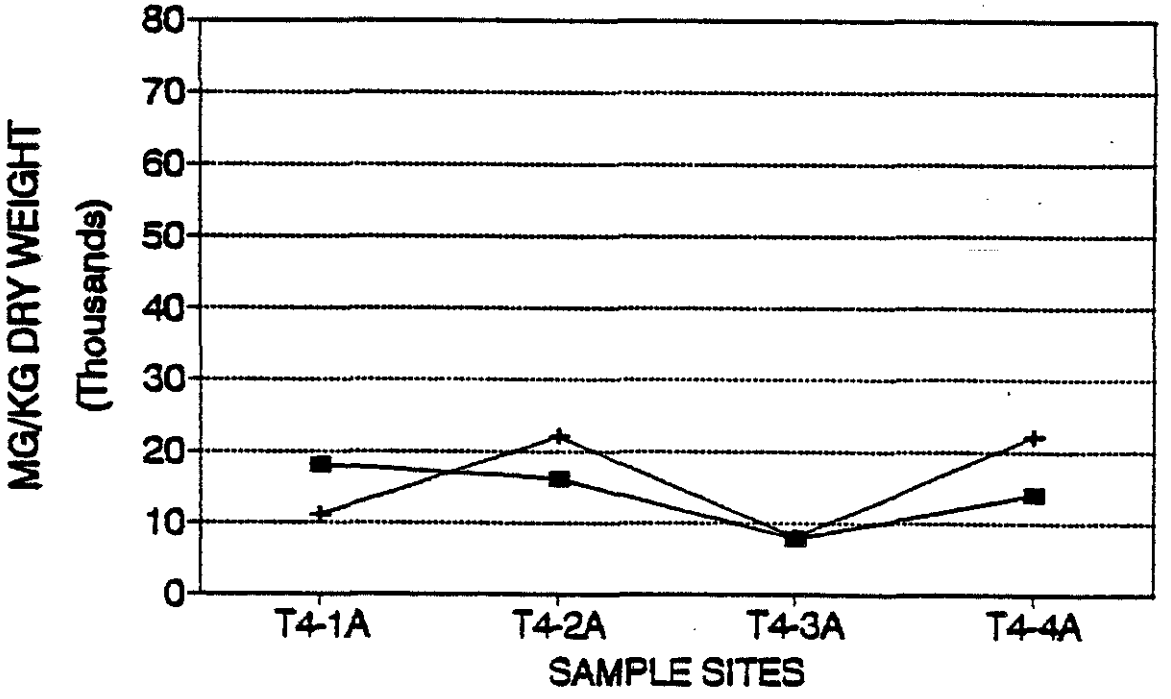
TRANSECT 3, CHLORIDE AND TOC



SERIES A

HOFFMAN MARSH SEDIMENT

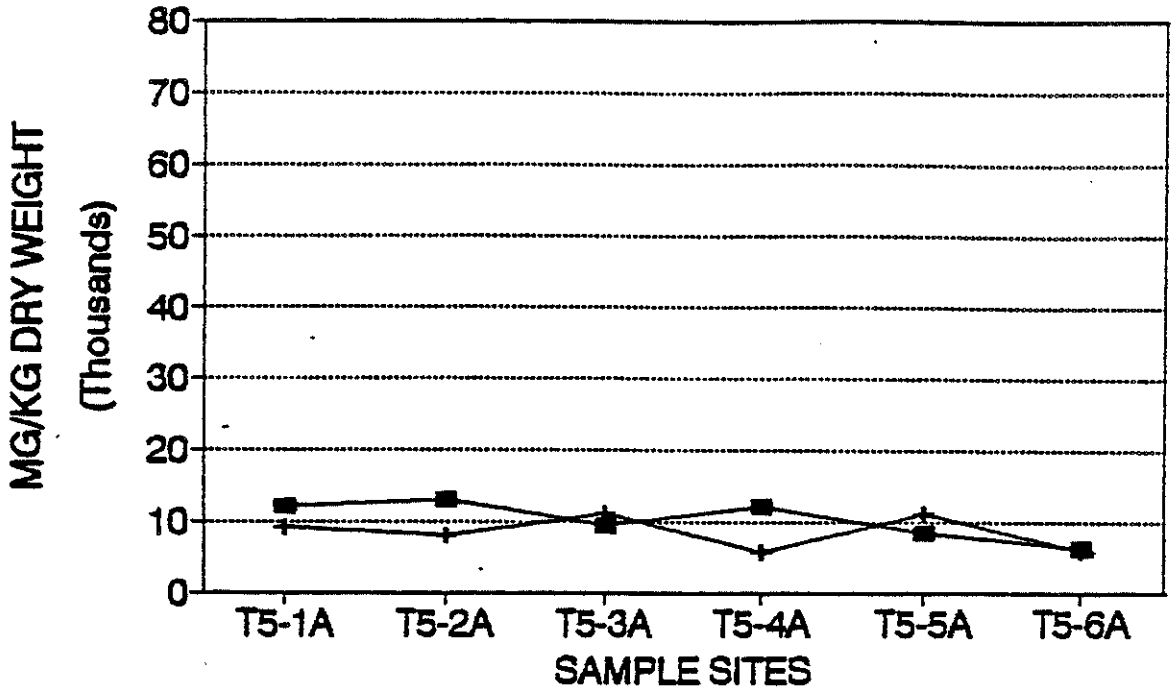
TRANSECT 4, CHLORIDE AND TOC



CHLORIDE TOC

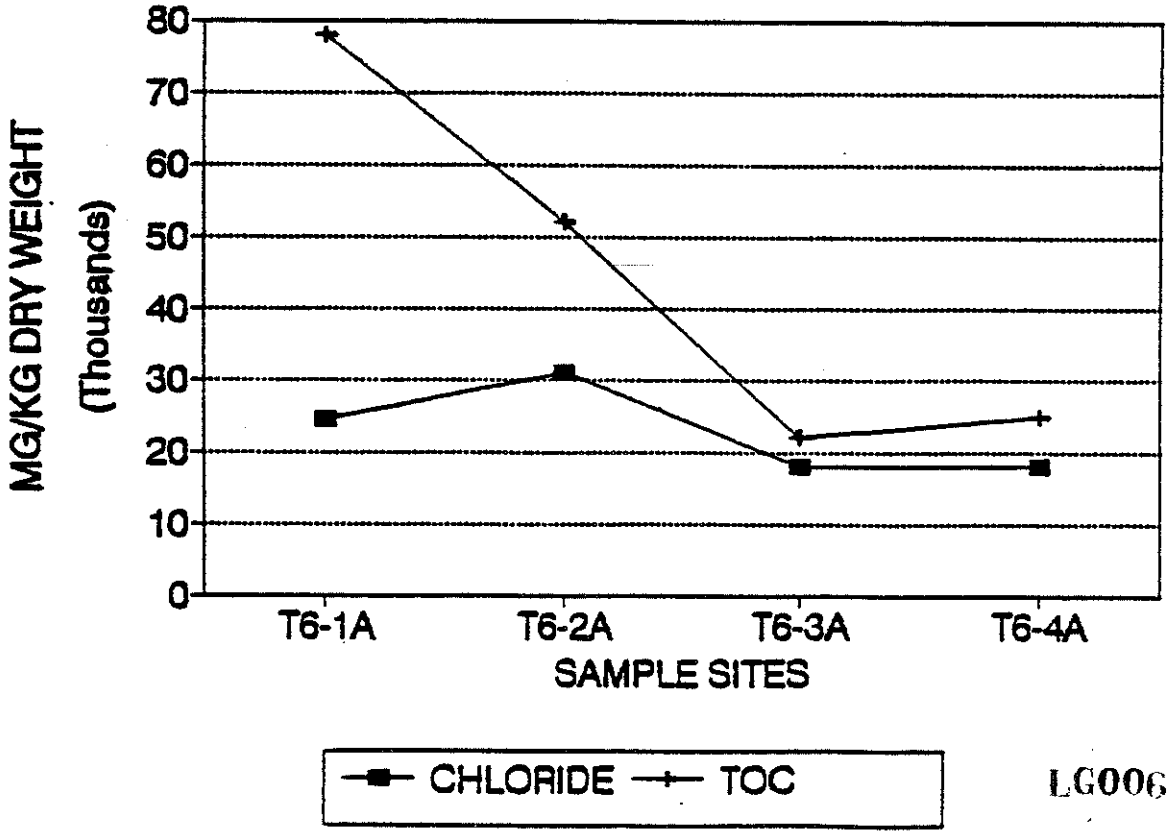
LG006670

HOFFMAN MARSH SEDIMENT
TRANSECT 5, CHLORIDE AND TOC



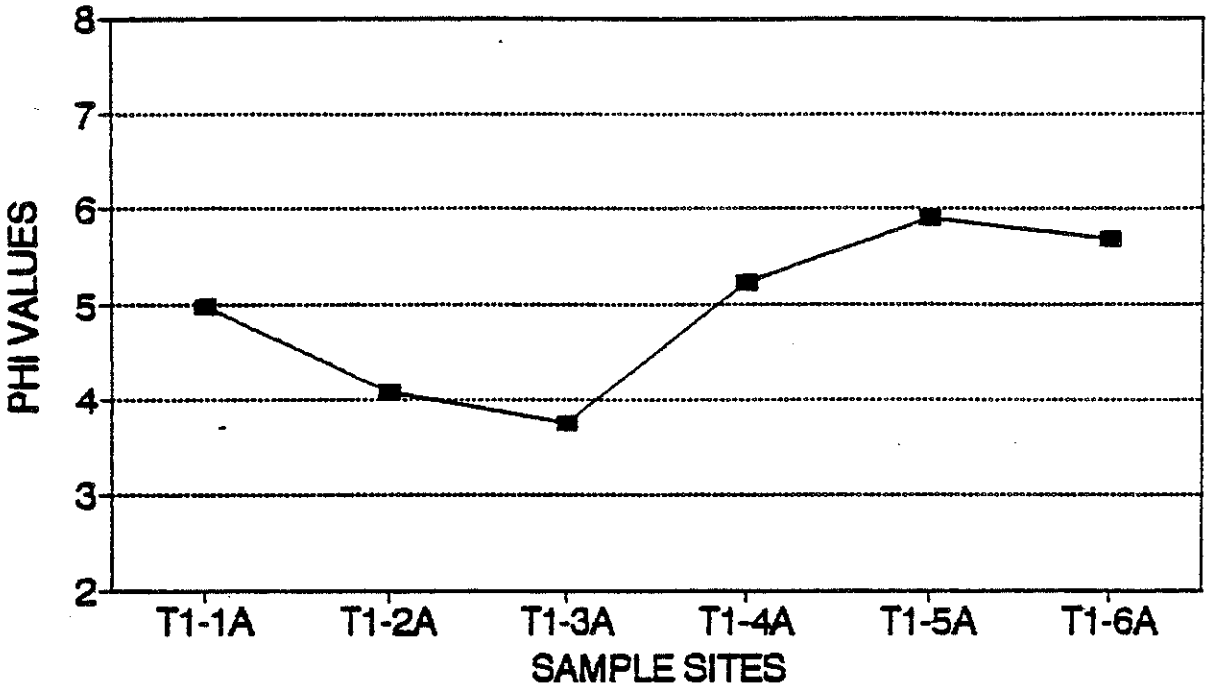
SERIES A

HOFFMAN MARSH SEDIMENT
TRANSECT 6, CHLORIDE AND TOC



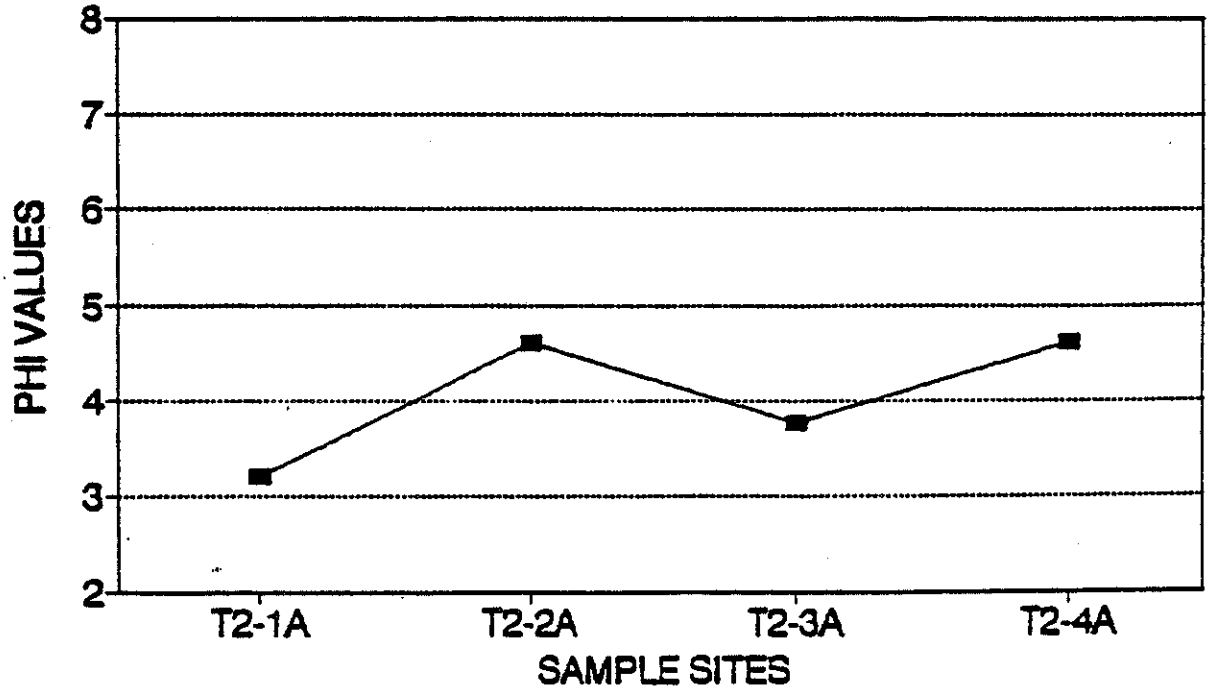
LG006671

HOFFMAN MARSH SEDIMENT
TRANSECT 1, PARTICLE SIZE AS PHI VALUES



SERIES A

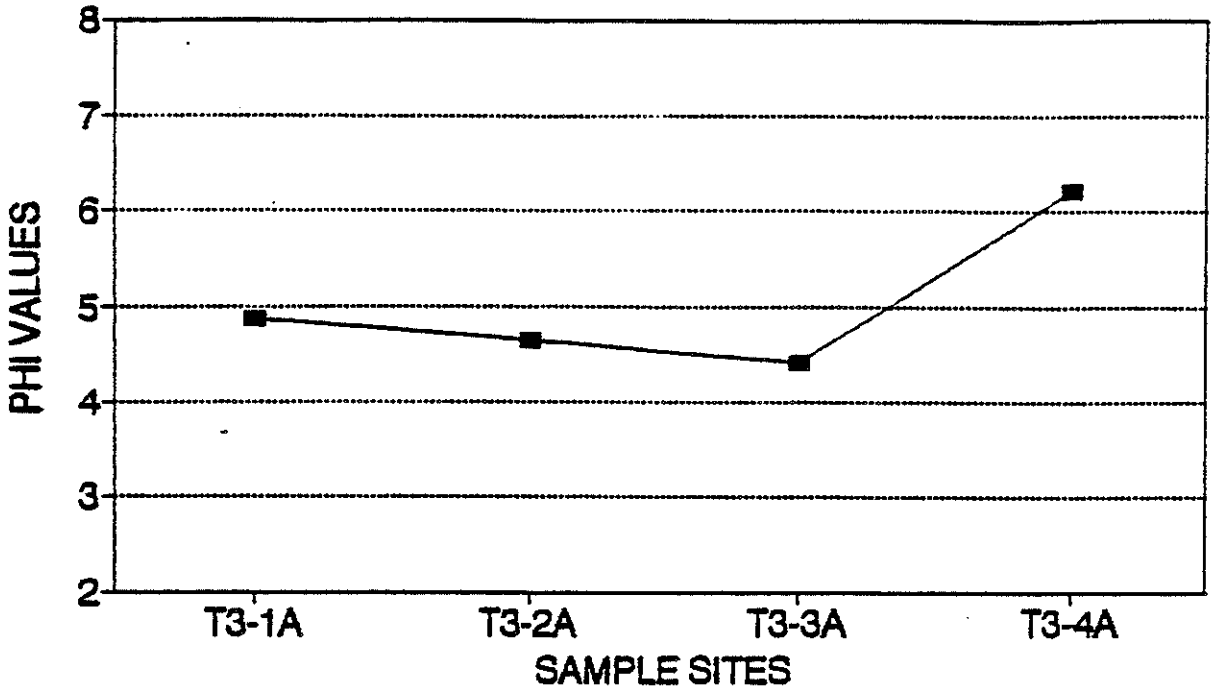
HOFFMAN MARSH SEDIMENT
TRANSECT 2, PARTICLE SIZE AS PHI VALUES



PHI VALUE PLUS 4

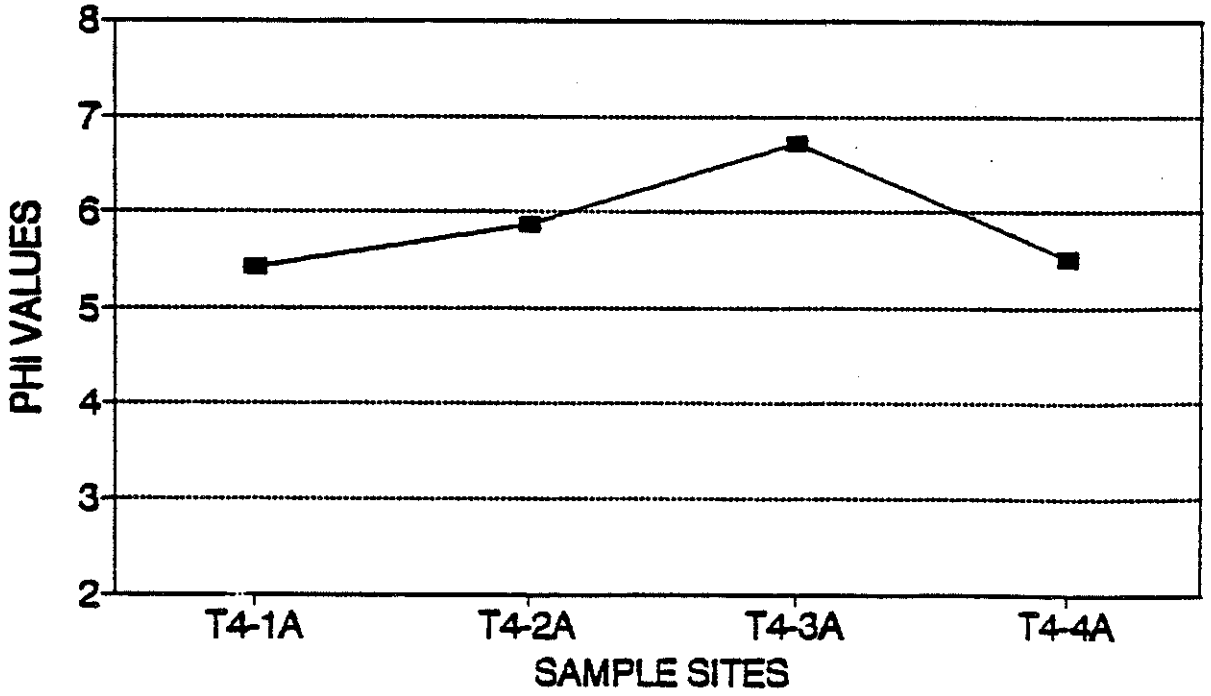
LG006672

HOFFMAN MARSH SEDIMENT
TRANSECT 3, PARTICLE SIZE AS PHI VALUES



SERIES A

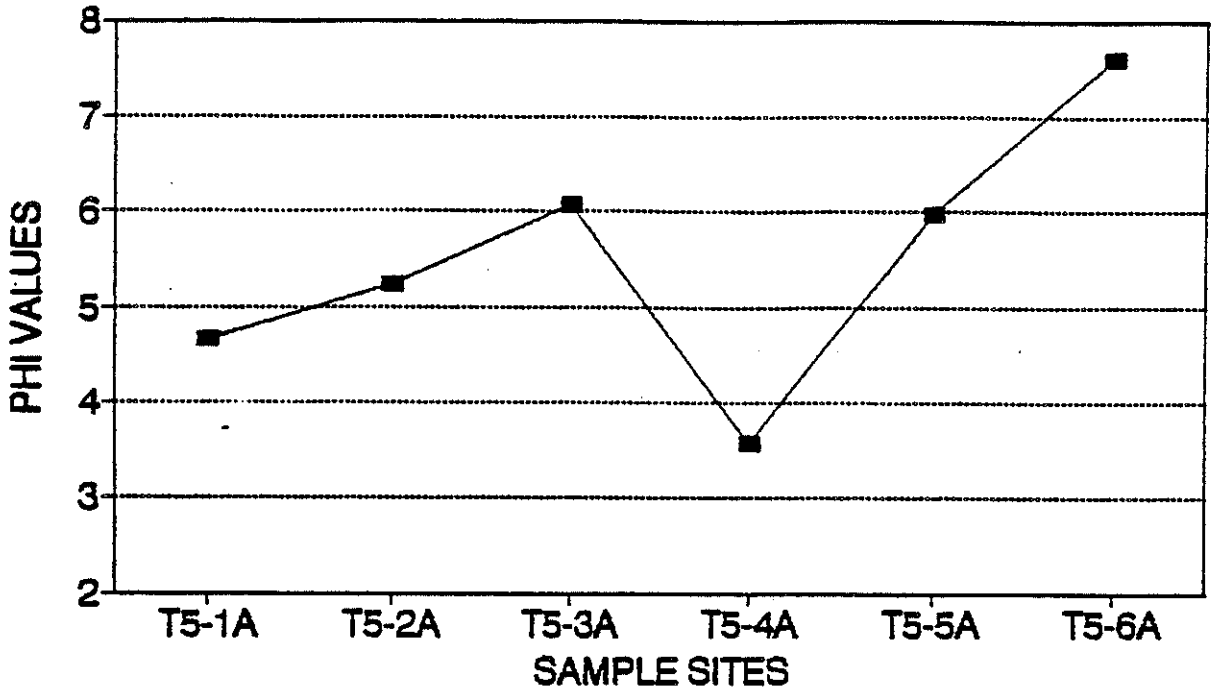
HOFFMAN MARSH SEDIMENT
TRANSECT 4, PARTICLE SIZE AS PHI VALUES



PHI VALUE PLUS 4

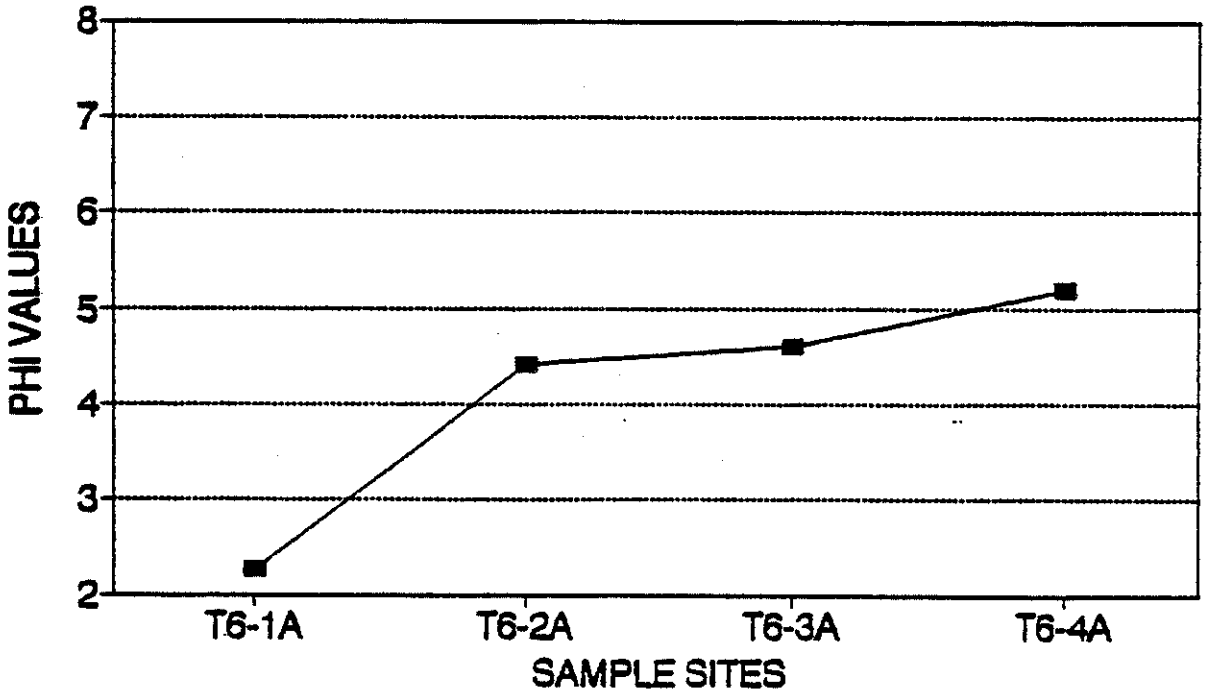
LG006673

HOFFMAN MARSH SEDIMENT
TRANSECT 5, PARTICLE SIZE AS PHI VALUES



SERIES A

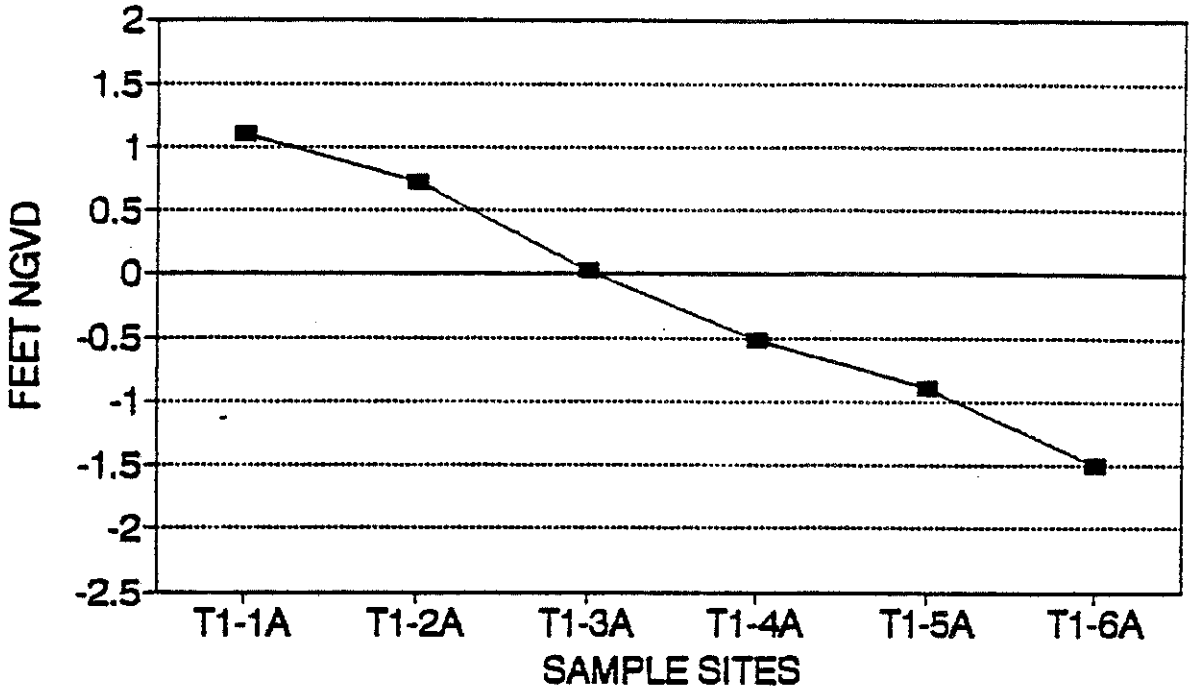
HOFFMAN MARSH SEDIMENT
TRANSECT 6, PARTICLE SIZE AS PHI VALUES



PHI VALUE PLUS 4

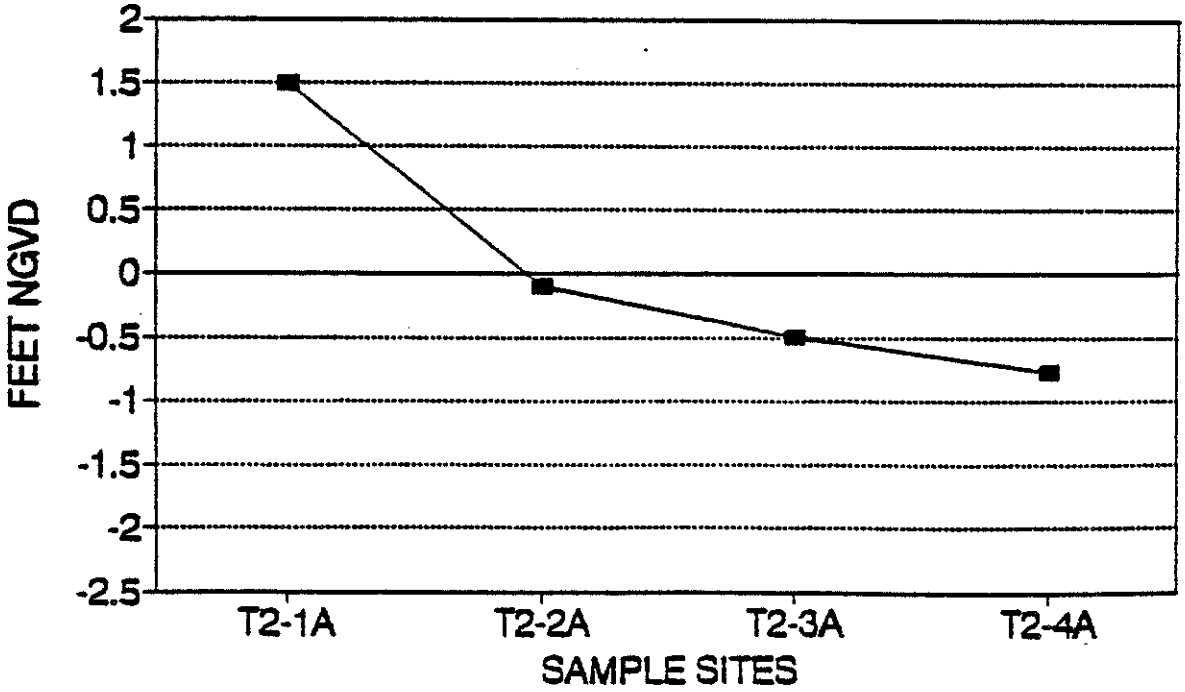
LG006674

HOFFMAN MARSH SEDIMENT
TRANSECT 1, ELEVATION



SERIES A

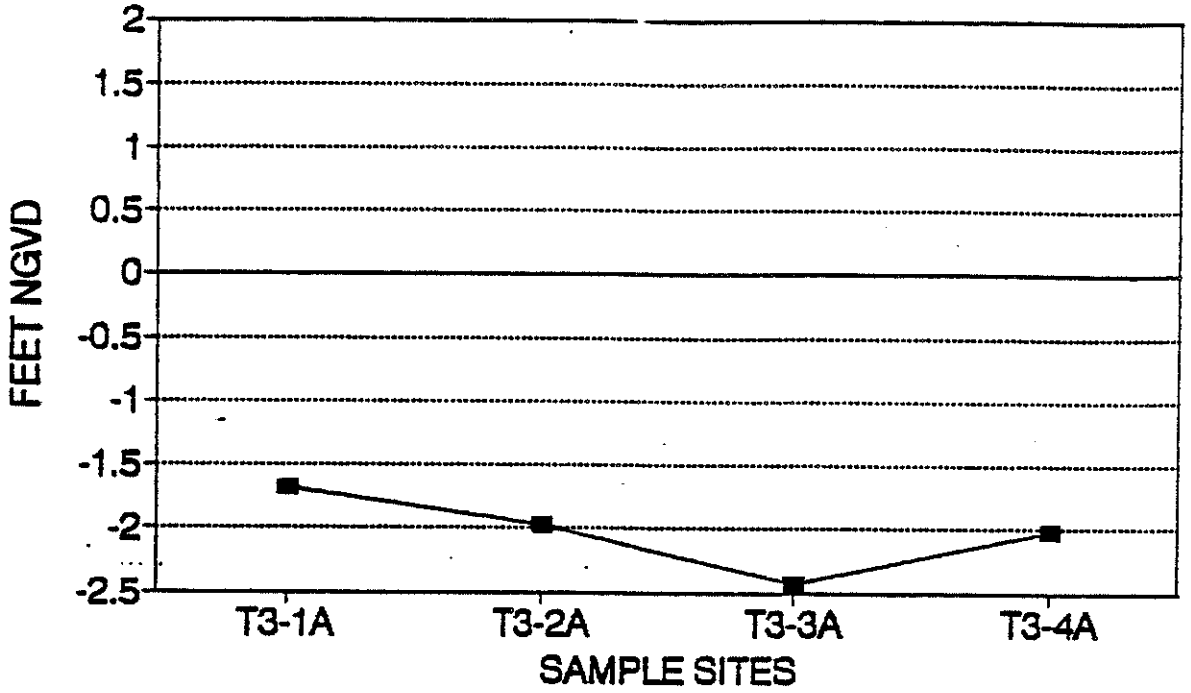
HOFFMAN MARSH SEDIMENT
TRANSECT 2, ELEVATION



LG006675

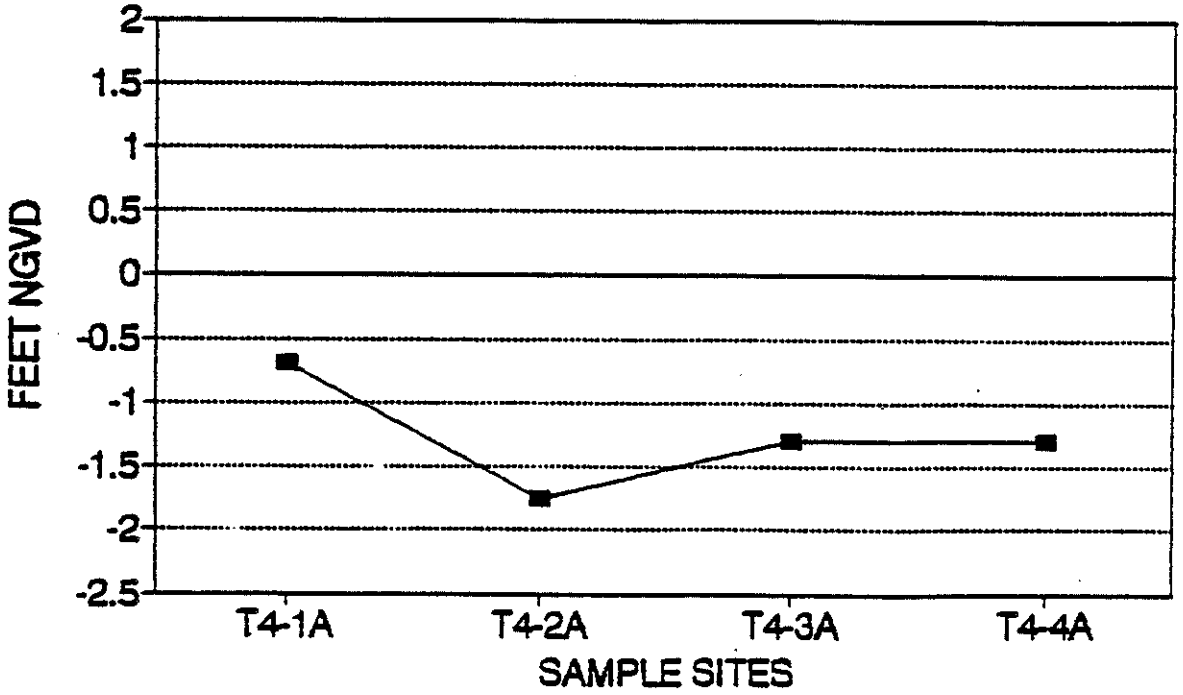
ELEVATION

HOFFMAN MARSH SEDIMENT
TRANSECT 3, ELEVATION



SERIES A

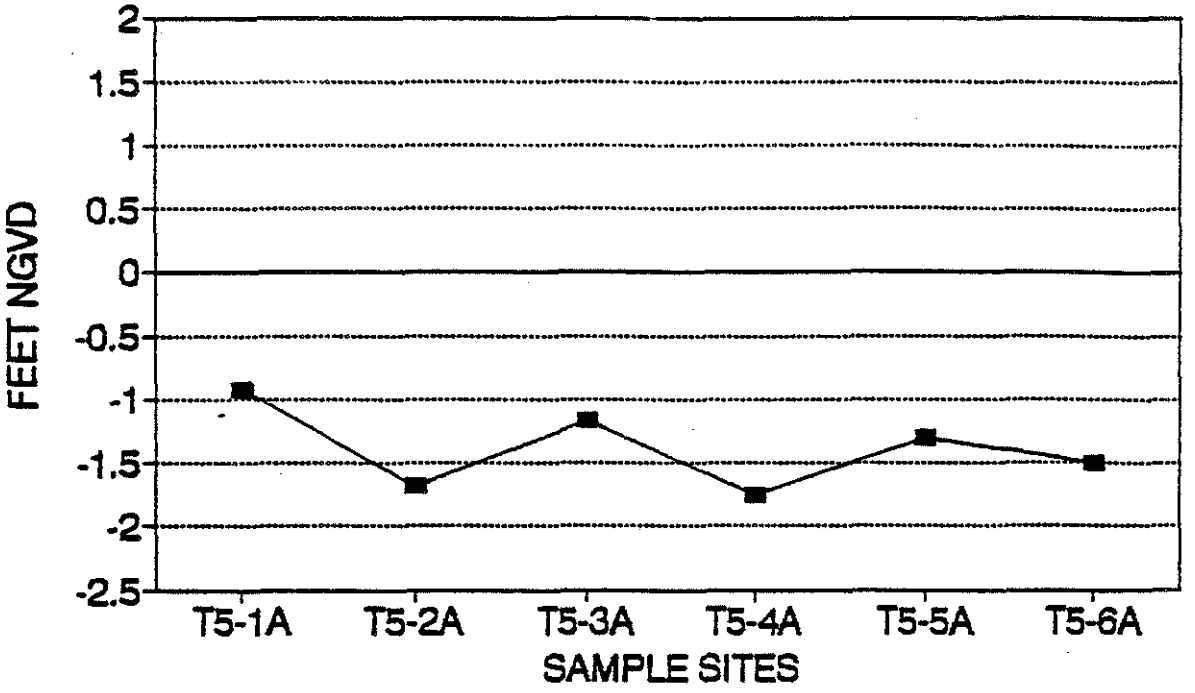
HOFFMAN MARSH SEDIMENT
TRANSECT 4, ELEVATION



LG006676

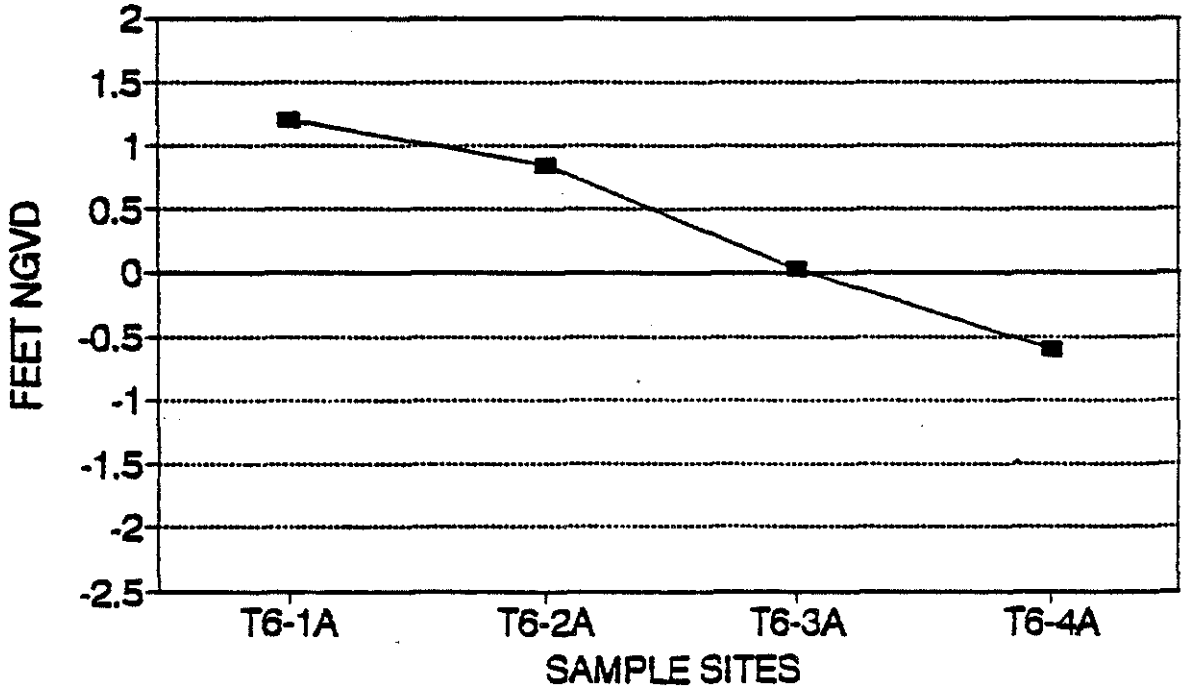
ELEVATION

HOFFMAN MARSH SEDIMENT
TRANSECT 5, ELEVATION



SERIES A

HOFFMAN MARSH SEDIMENT
TRANSECT 6, ELEVATION

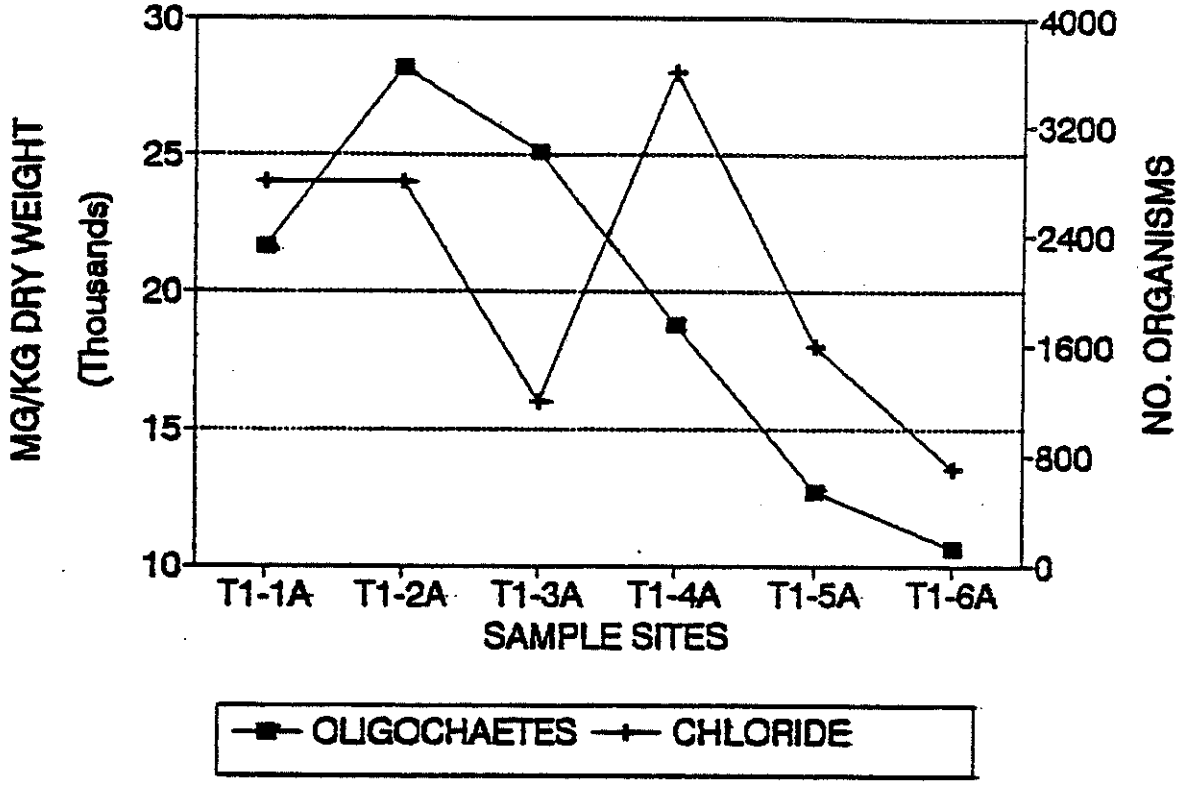


ELEVATION

LG006677

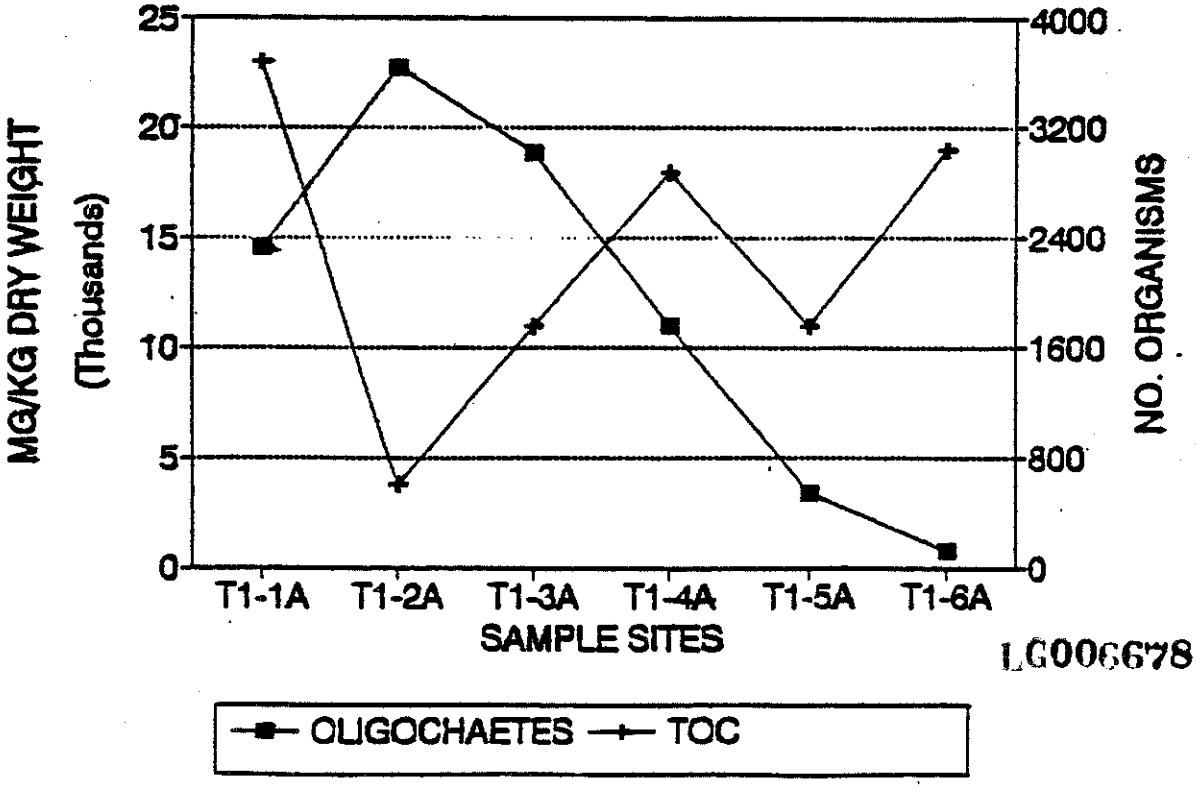
HOFFMAN MARSH SEDIMENT,SERIES A

TRANSECT 1, OLIGOCHAETES & CHLORIDE



HOFFMAN MARSH SEDIMENT,SERIES A

TRANSECT 1, OLIGOCHAETES & TOC

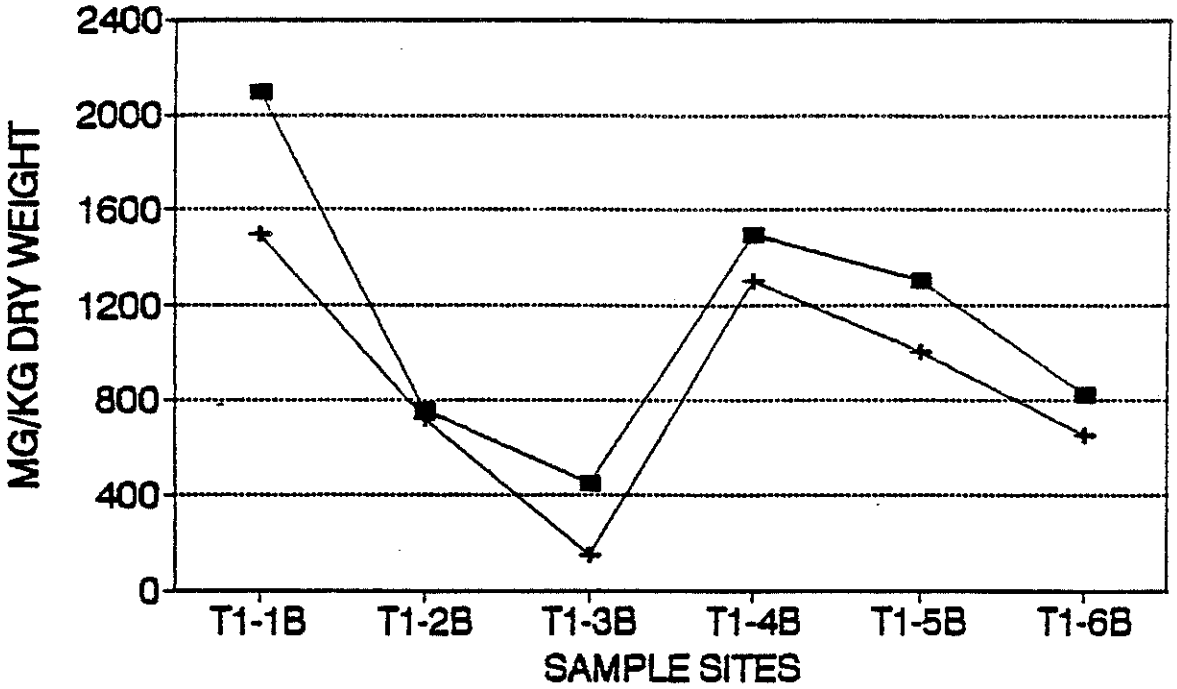


LG006678

SERIES B

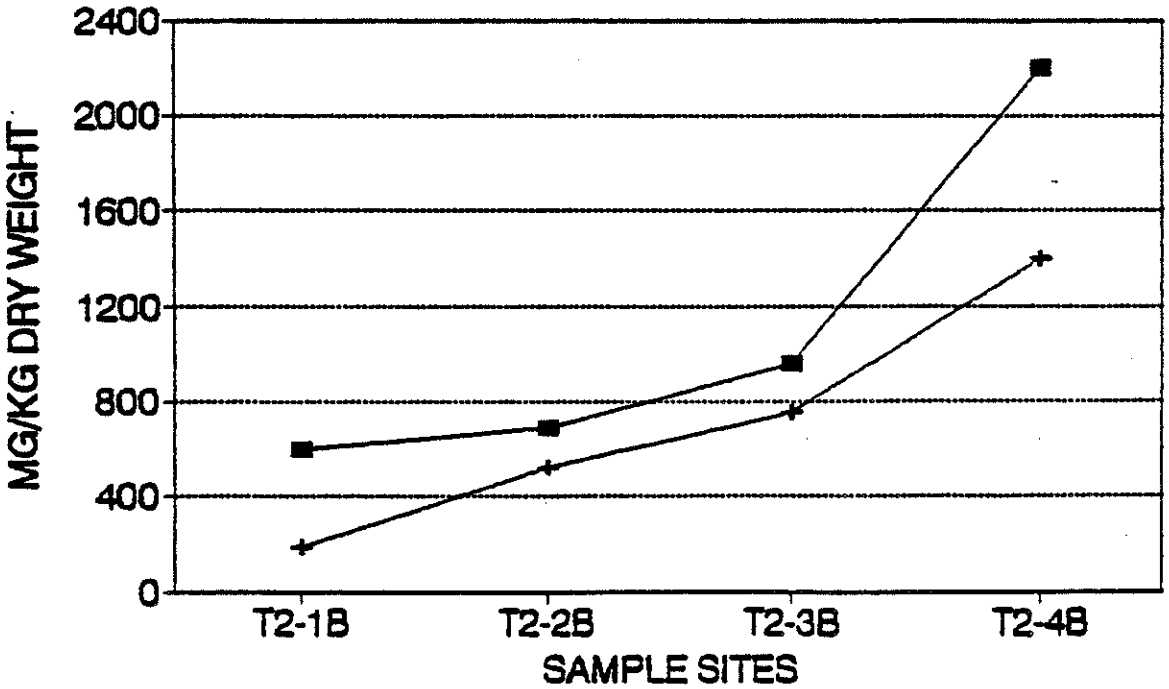
LG006679

HOFFMAN MARSH SEDIMENT
TRANSECT 1, OIL & GREASE AND O&G-S



SERIES B

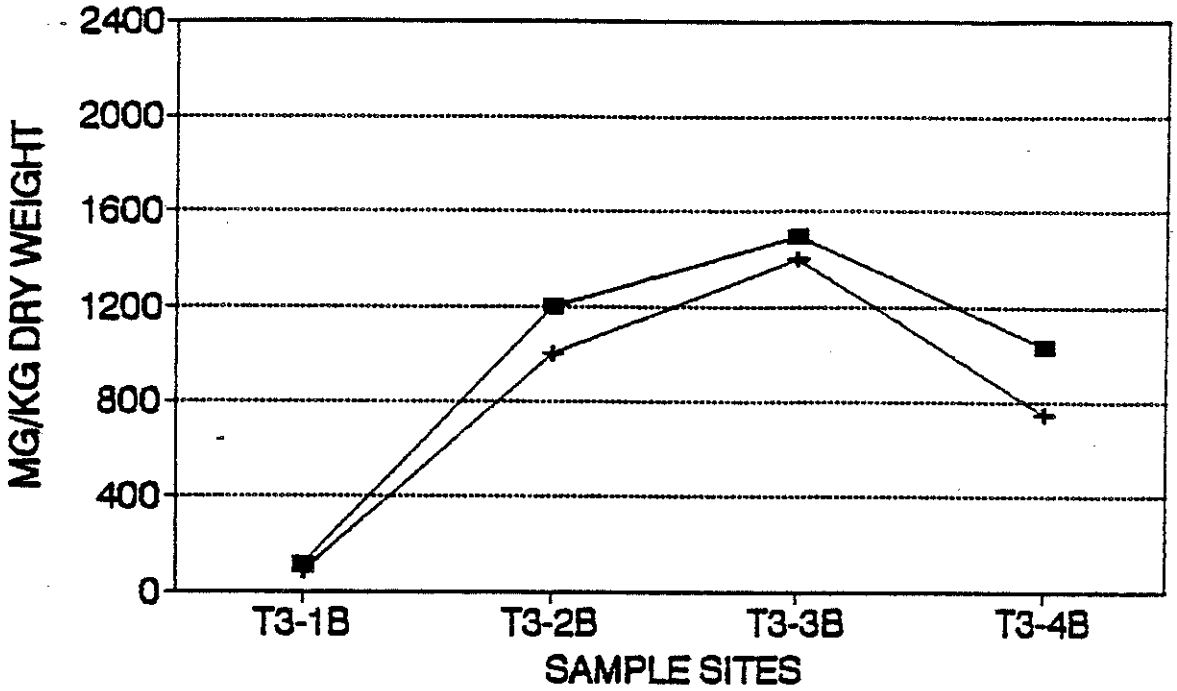
HOFFMAN MARSH SEDIMENT
TRANSECT 2, OIL & GREASE AND O&G-S



LG006680

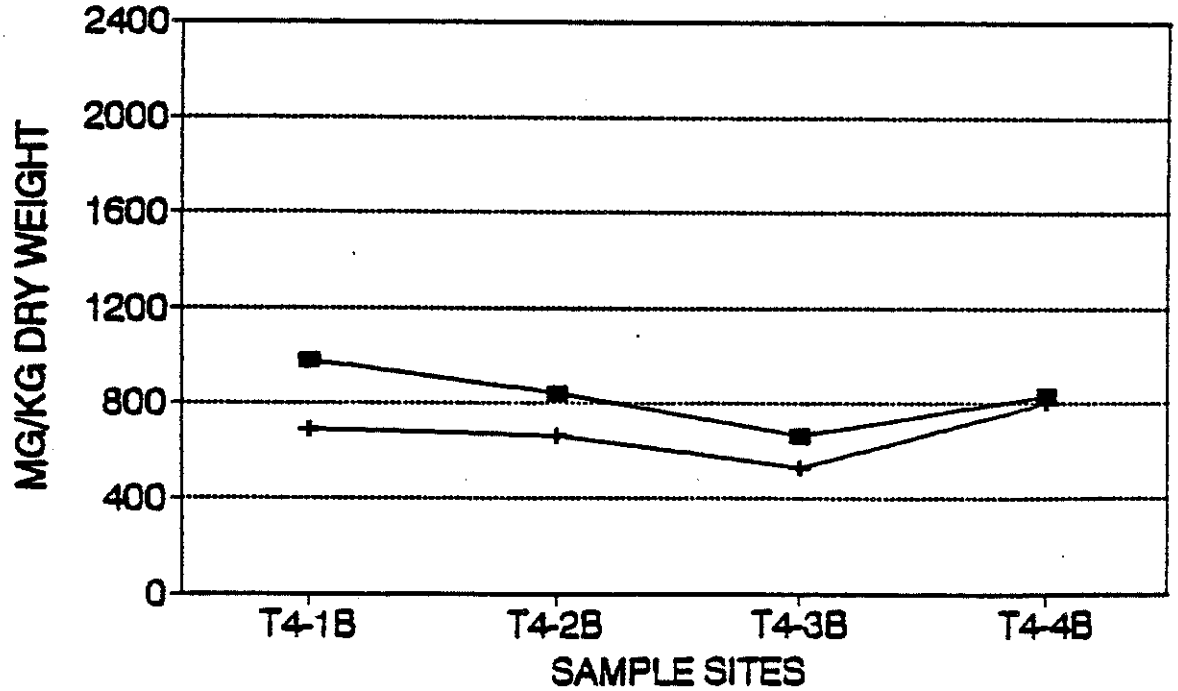
O&G O&G-SULFUR

HOFFMAN MARSH SEDIMENT
TRANSECT 3, OIL & GREASE AND O&G-S



SERIES B

HOFFMAN MARSH SEDIMENT
TRANSECT 4, OIL & GREASE AND O&G-S

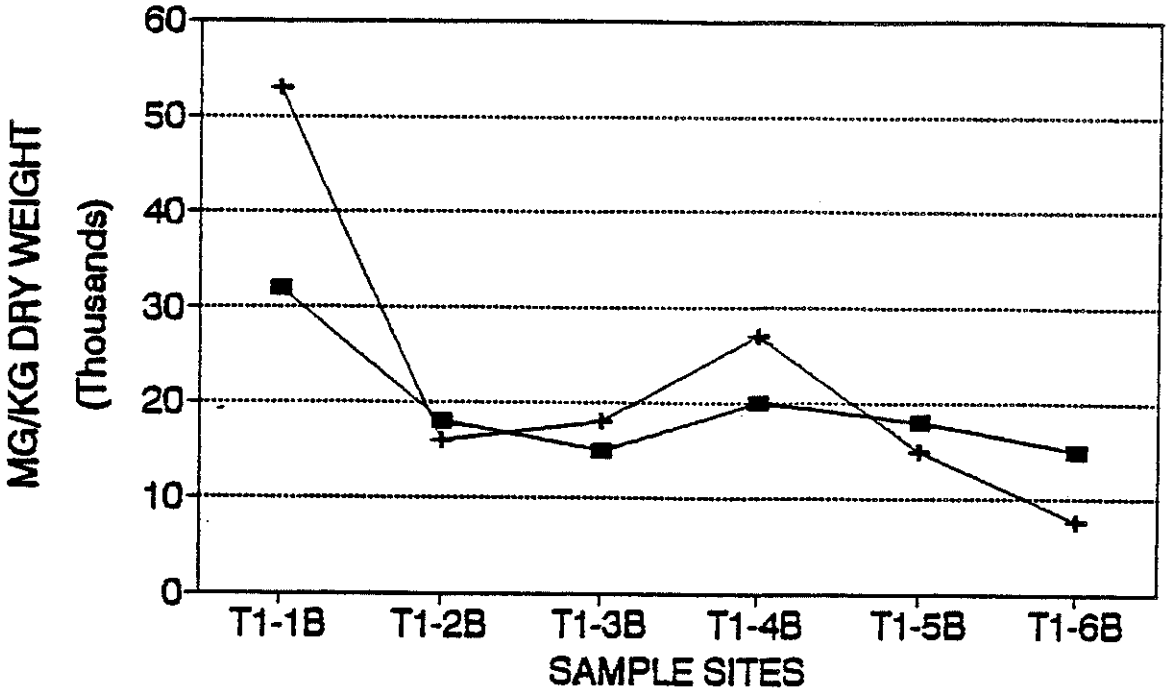


O&G — O&G-SULFUR

LG006681

HOFFMAN MARSH SEDIMENT

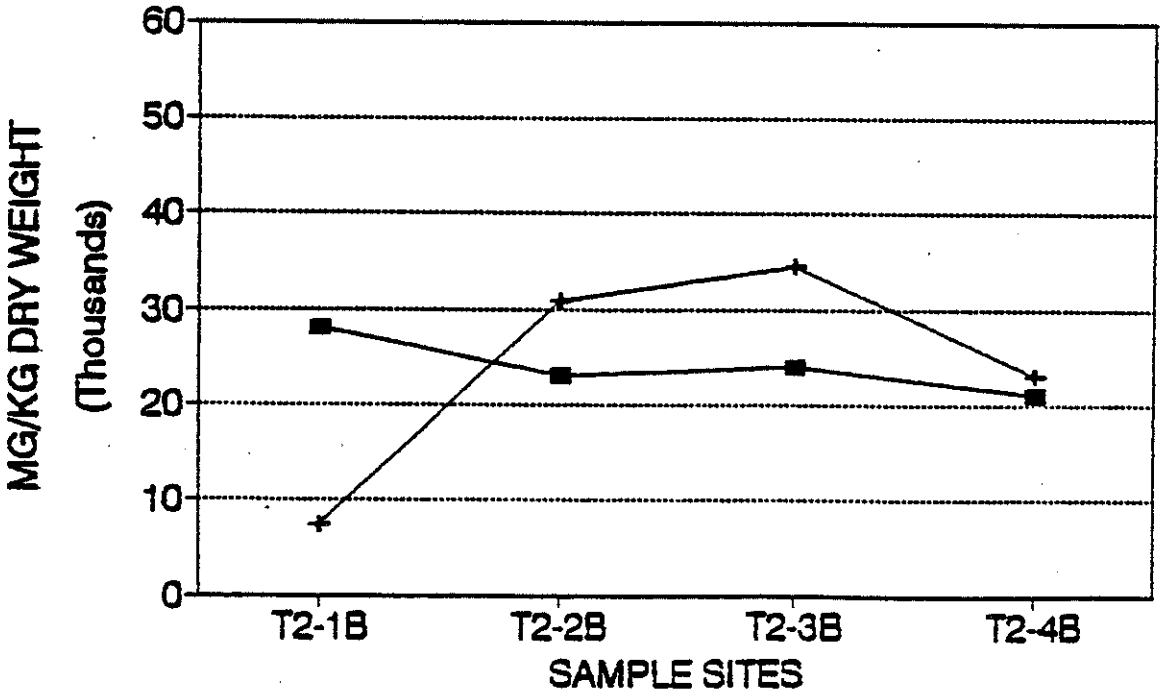
TRANSECT 1, CHLORIDE AND TOC



SERIES B

HOFFMAN MARSH SEDIMENT

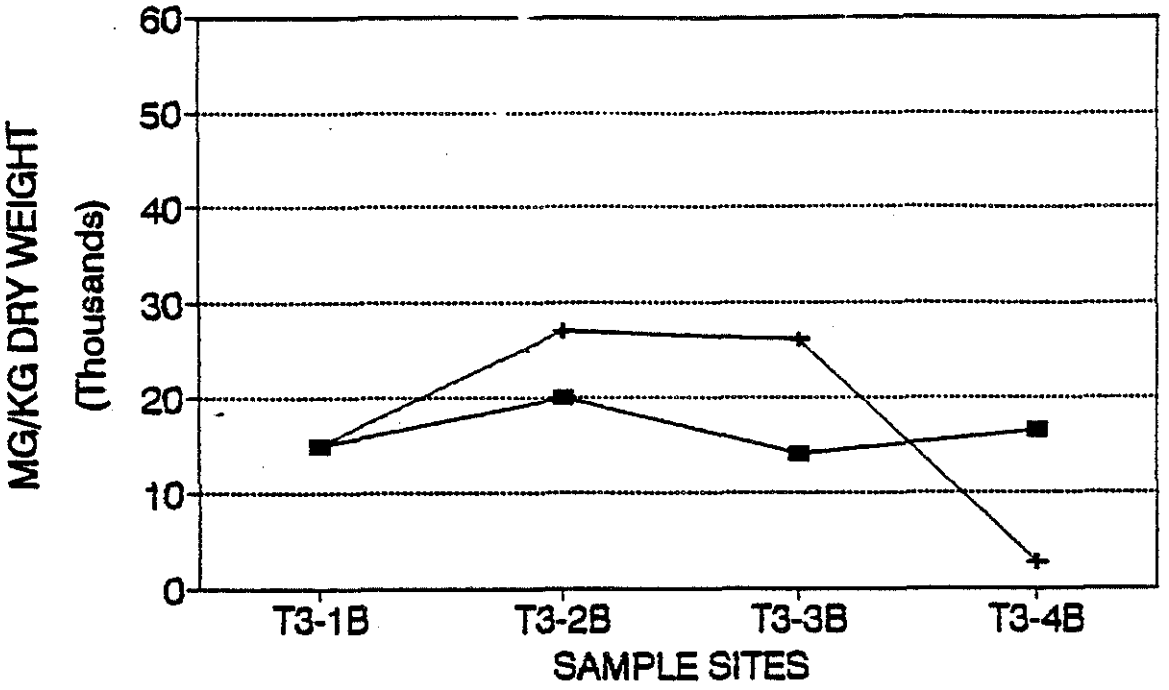
TRANSECT 2, CHLORIDE AND TOC



LG006682

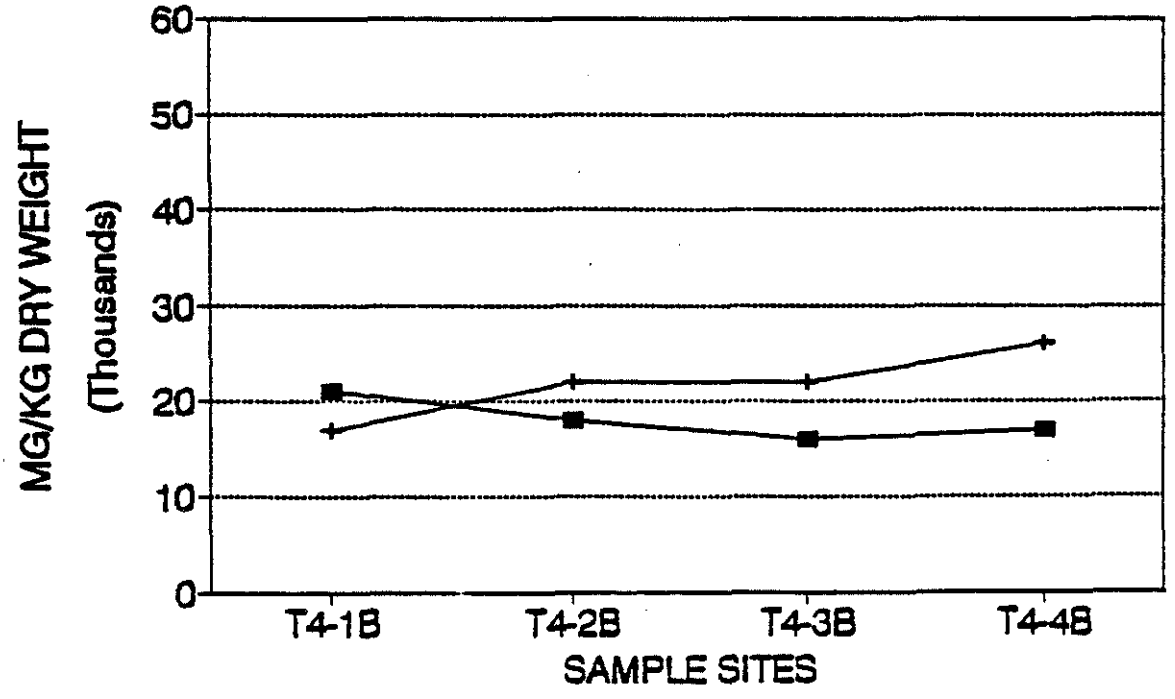
CHLORIDE TOC

HOFFMAN MARSH SEDIMENT
TRANSECT 3, CHLORIDE AND TOC



SERIES B

HOFFMAN MARSH SEDIMENT
TRANSECT 4, CHLORIDE AND TOC

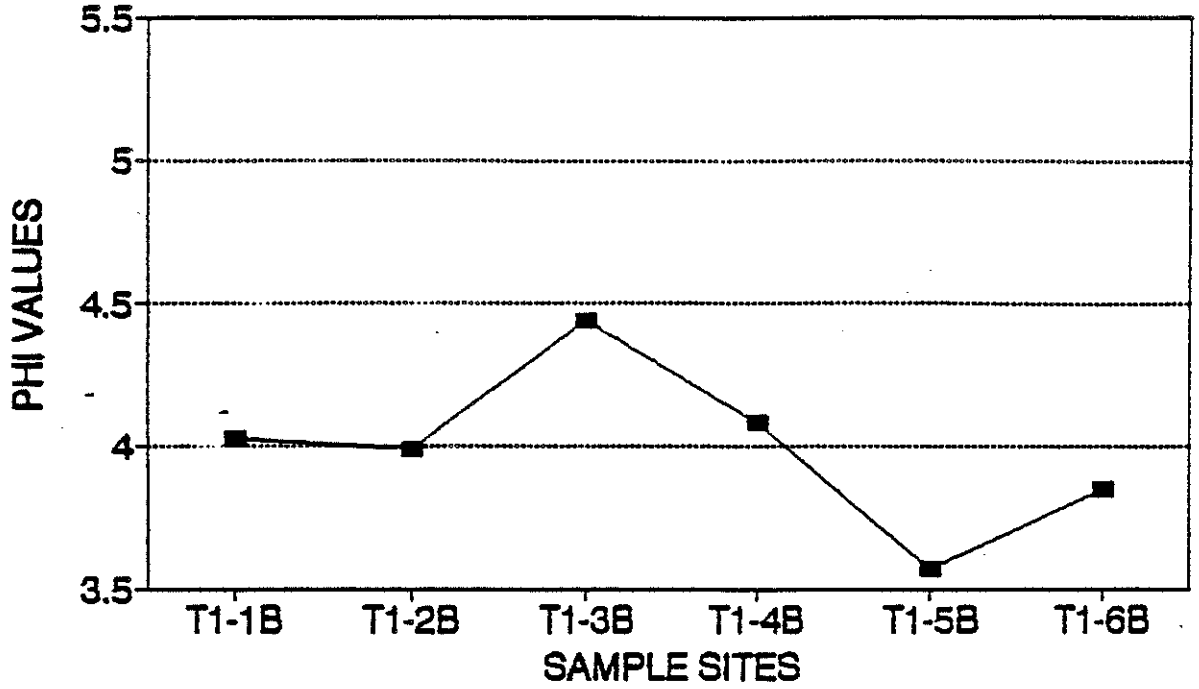


CHLORIDE TOC

LG006683

HOFFMAN MARSH SEDIMENT

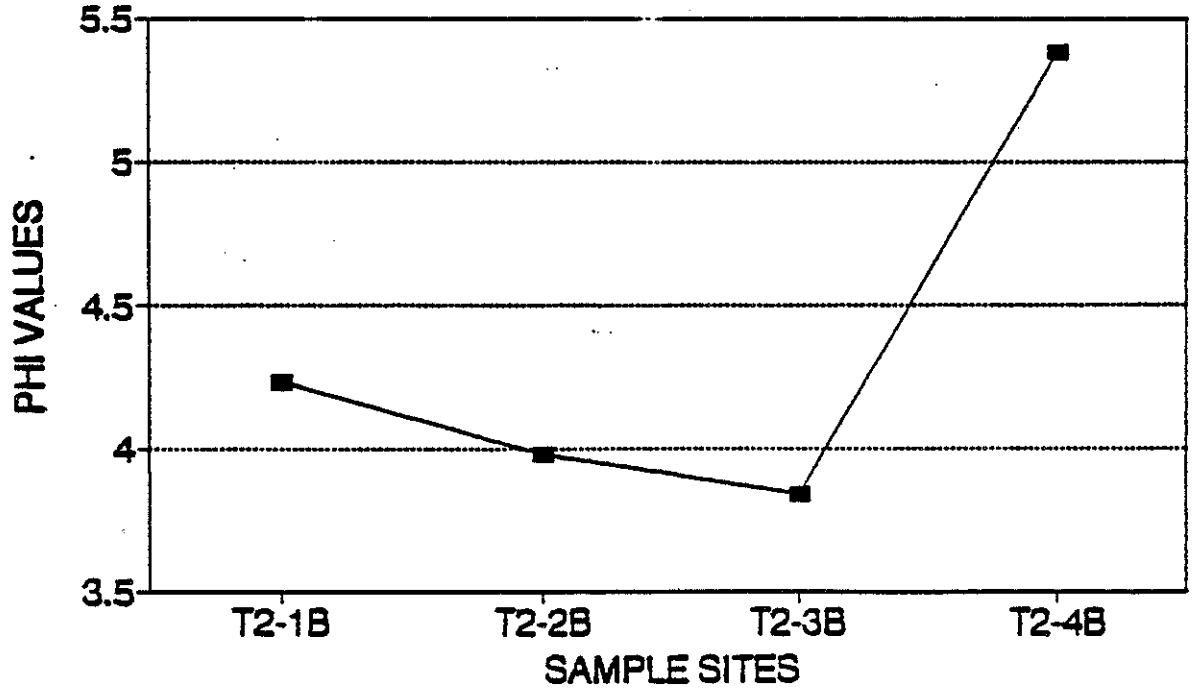
TRANSECT 1, B SERIES PARTICLE SIZE



SERIES B

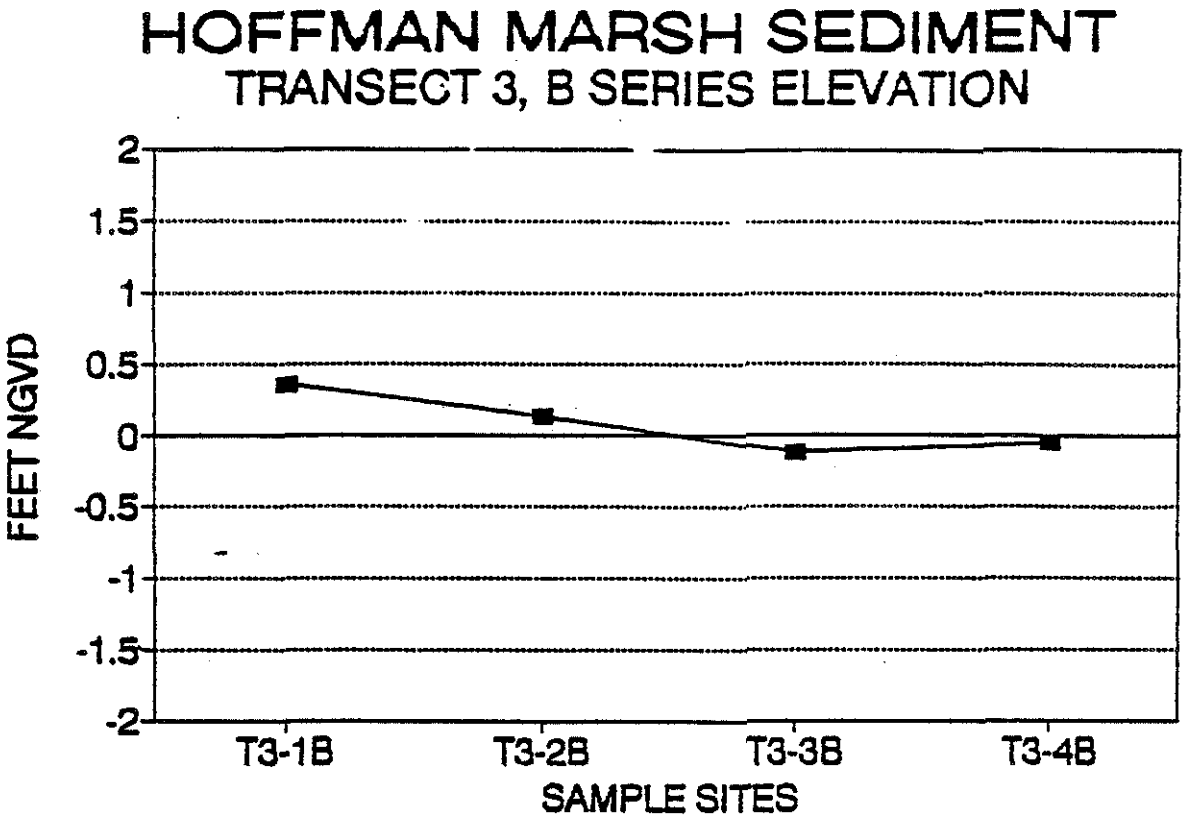
HOFFMAN MARSH SEDIMENT

TRANSECT 2, B SERIES PARTICLE SIZE

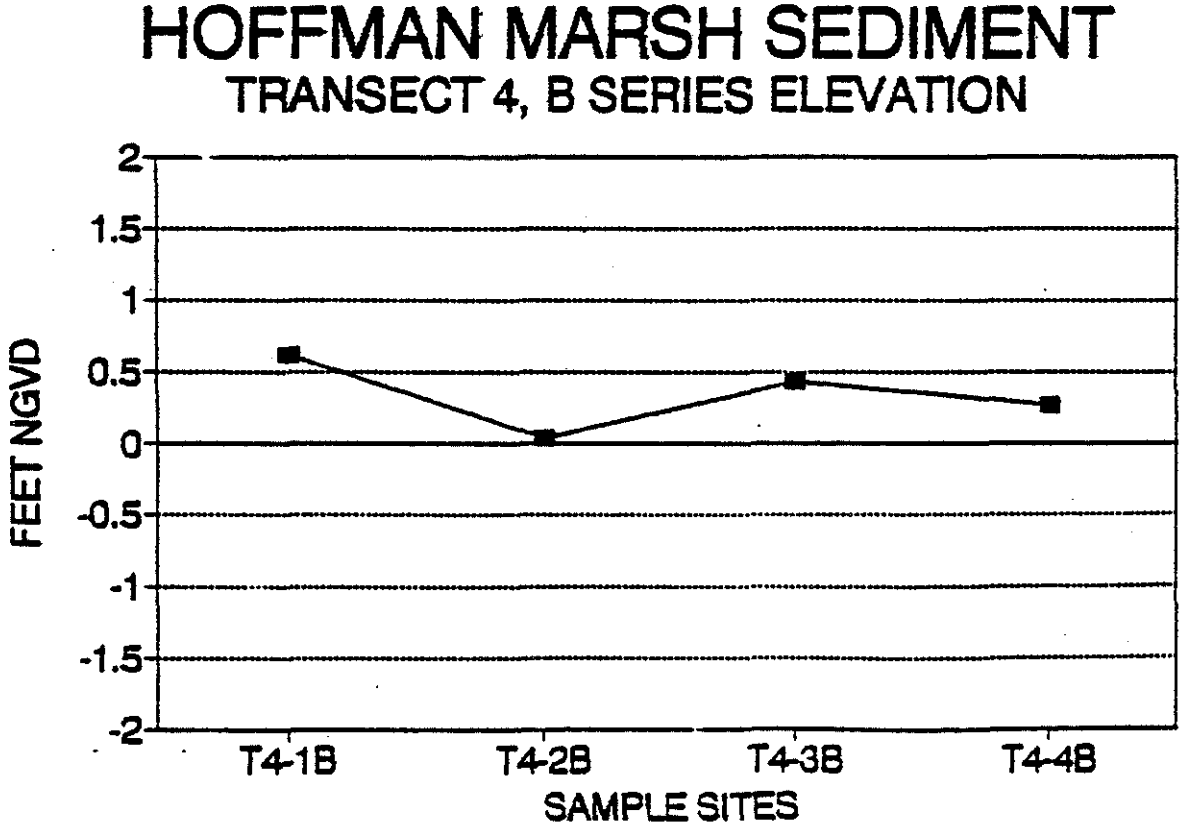


LG006684

PHI VALUE PLUS 4



SERIES B

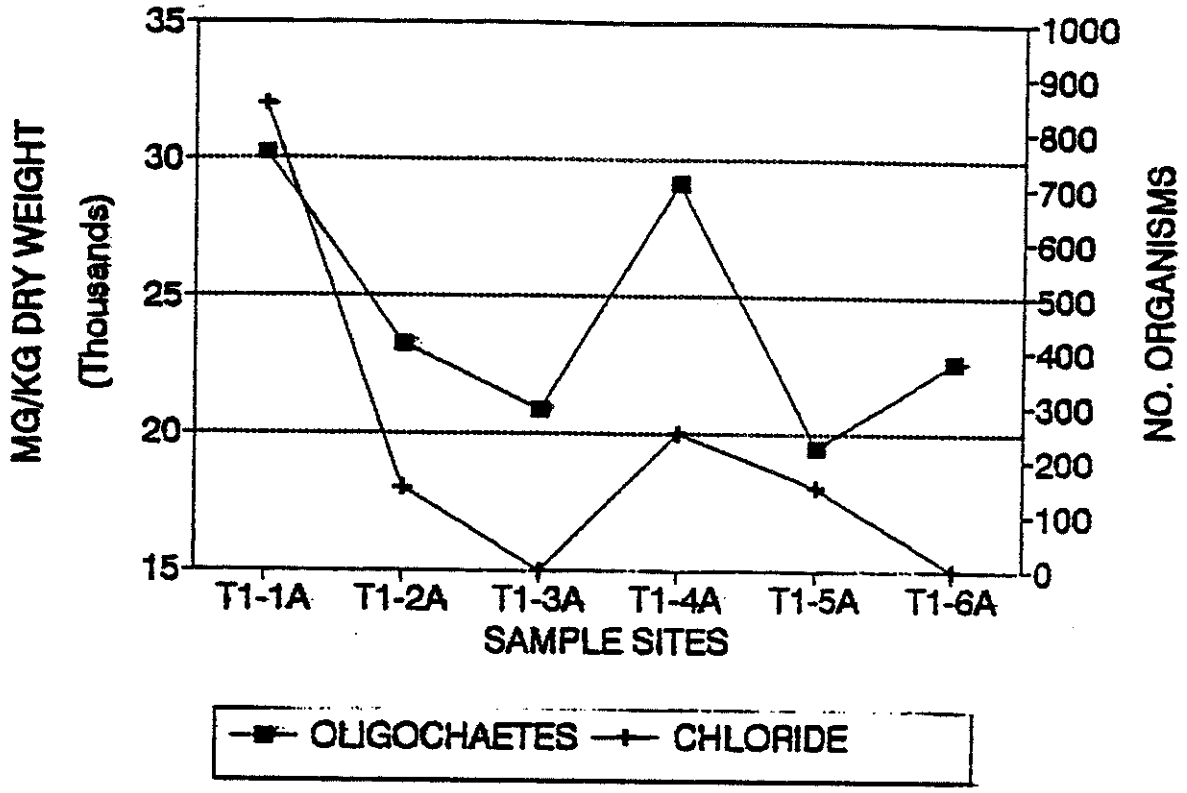


LG006685

ELEVATION

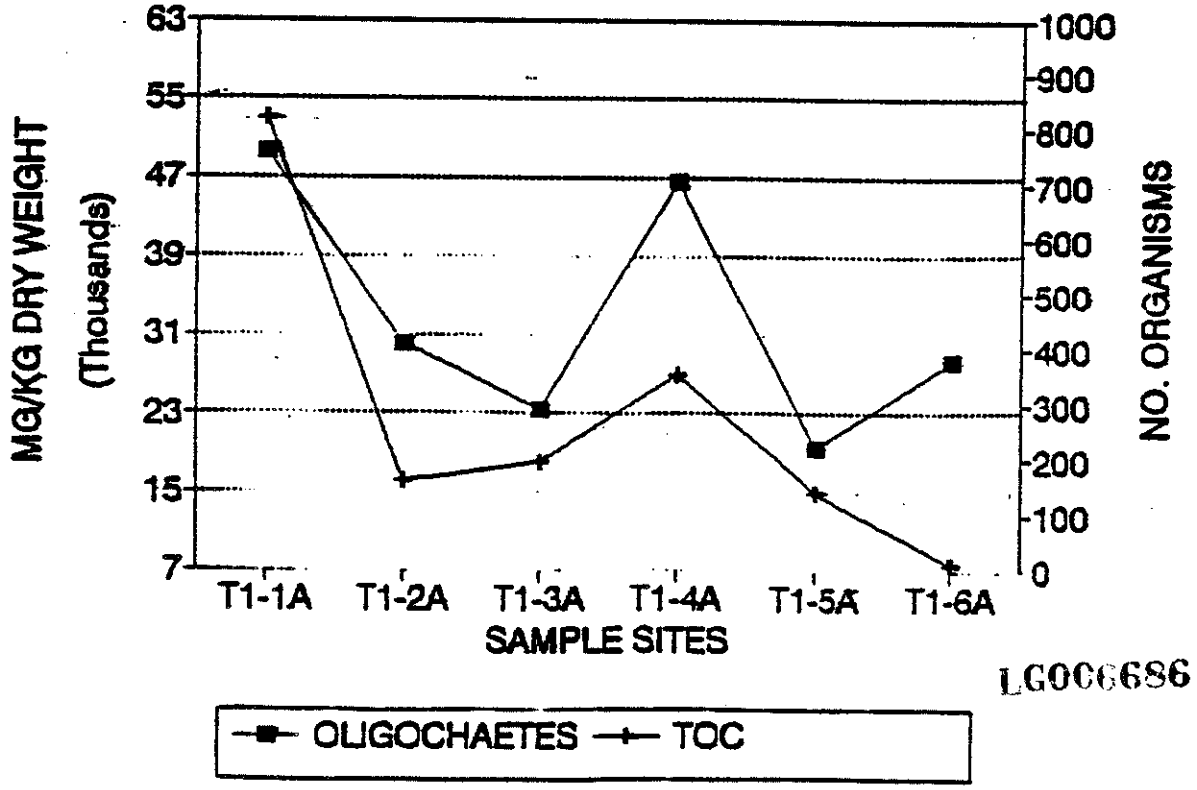
HOFFMAN MARSH SEDIMENT,SERIES B

TRANSECT 1, OLIGOCHAETES & CHLORIDE



HOFFMAN MARSH SEDIMENT,SERIES B

TRANSECT 1, OLIGOCHAETES & TOC

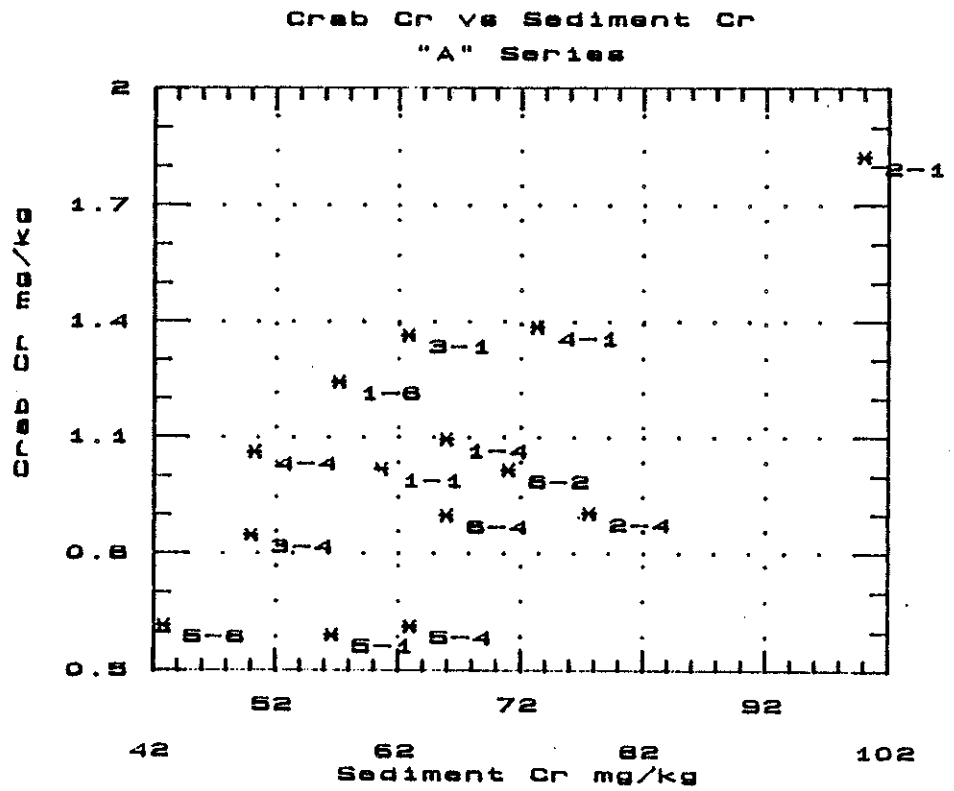


LG006686

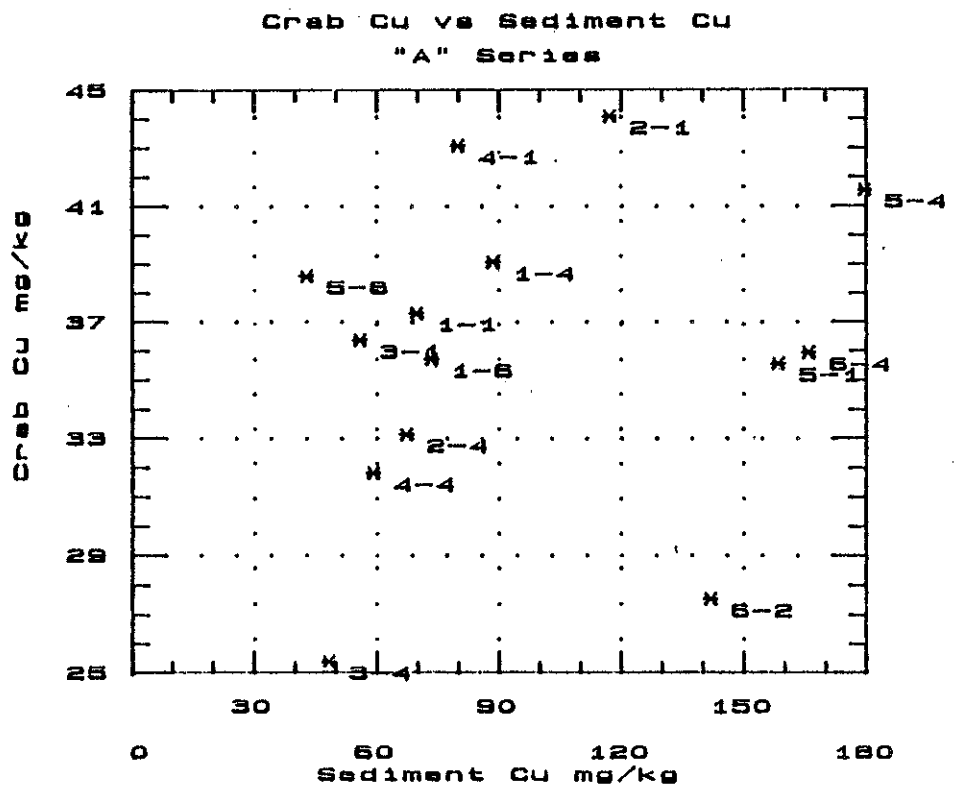
ATTACHMENT G

SCATTER PLOTS

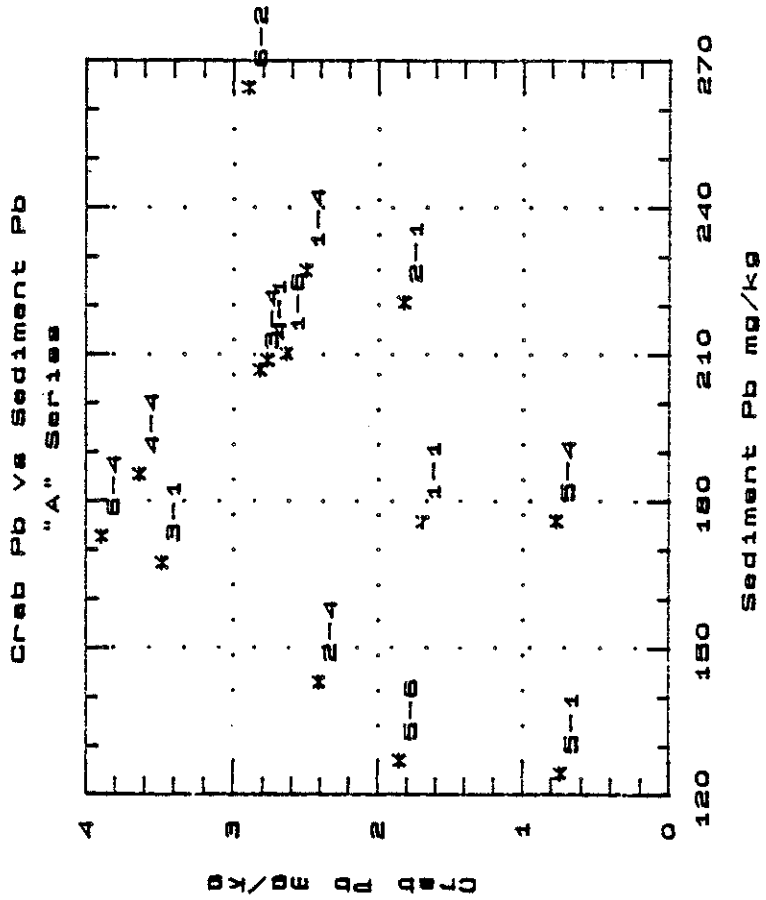
ATTACHMENT G


Crab Cr vs Sediment Cr
"A" Series
Crab Cr mg/kg
2
1.7
1.4
1.1
0.8
0.5
42
52
62
72
82
92
102
Sediment Cr mg/kg
2-1
3-1
4-1
1-6
1-4
4-4
1-1
6-2
6-4
2-4
3-4
5-6
5-1
5-4

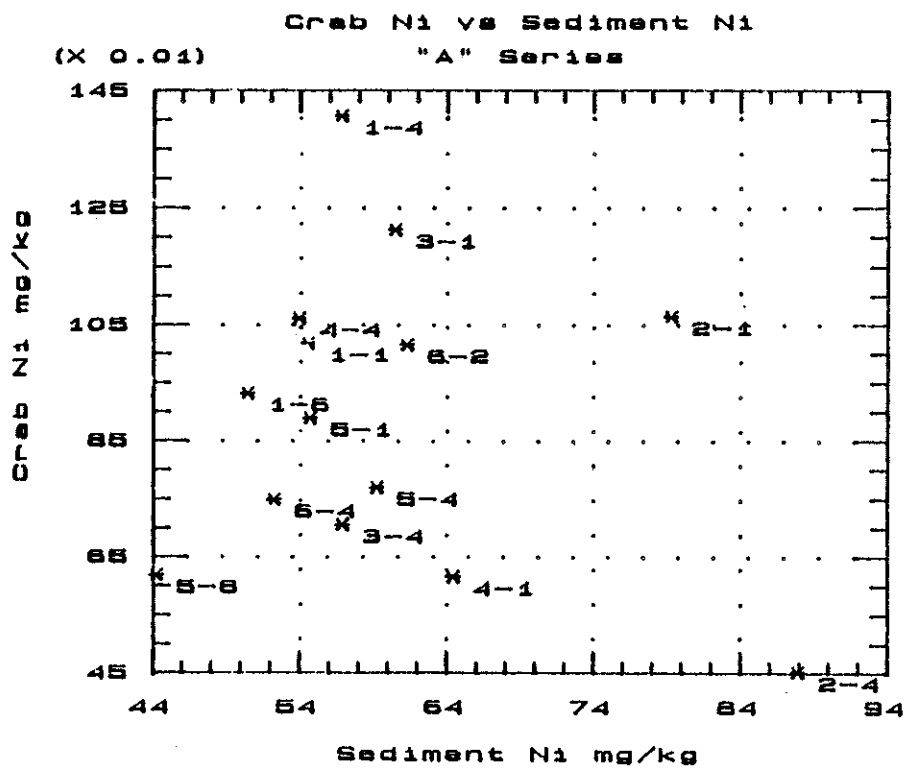
LG006688


Crab Cu vs Sediment Cu
"A" Series
Crab Cu mg/kg
45
41
37
33
29
25
30
90
150
0
60
120
180
Sediment Cu mg/kg
2-1
4-1
5-4
1-4
5-8
1-1
3-4
1-8
6-4
5-1
2-4
4-4
6-2
3-4

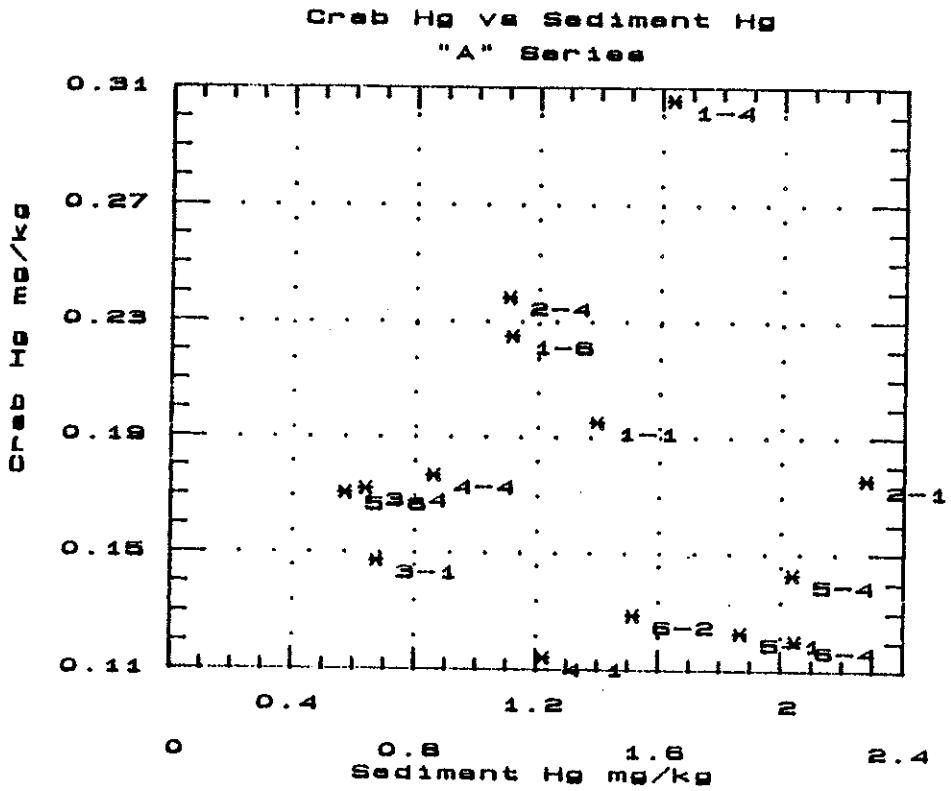
L0006689


Crab Pb vs Sediment Pb
"A" Series
Crab Pb mg/kg
Sediment Pb mg/kg
0
1
2
3
4
120
150
180
210
240
270
6-2
1-4
1-6
3-1
2-1
4-4
6-4
3-4
1-1
5-4
2-4
5-6
5-1

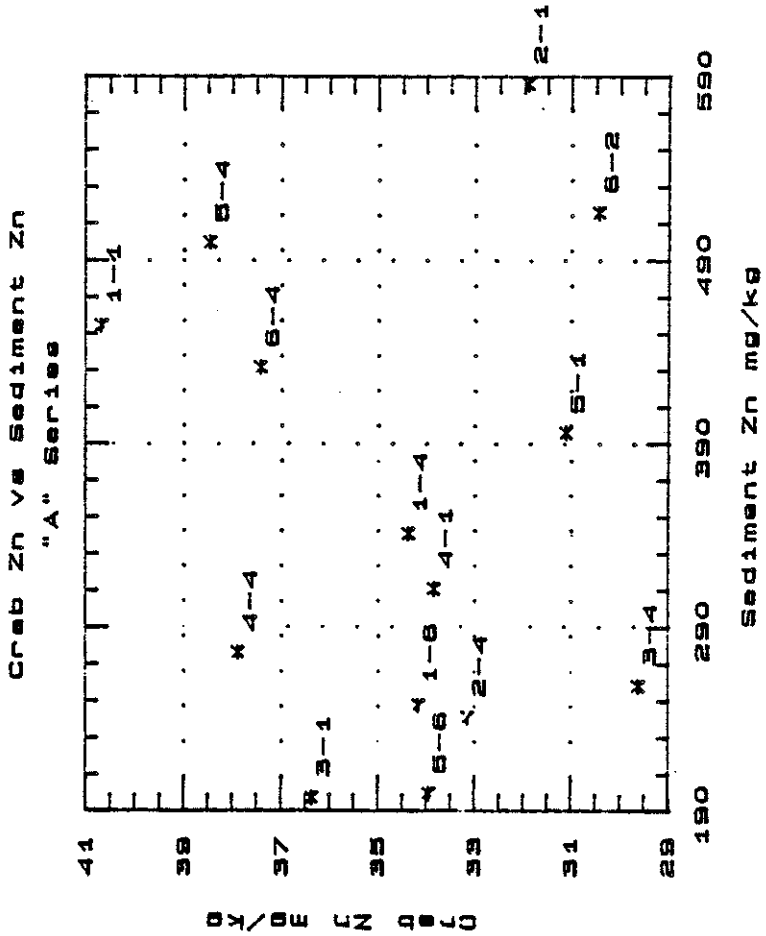
LG006690


Crab Ni vs Sediment Ni
(X 0.01)
"A" Series
Crab Ni mg/kg
145
125
105
85
65
45
44
54
64
74
84
94
Sediment Ni mg/kg
1-4
3-1
4-4
1-1
6-2
2-1
1-5
5-1
5-4
6-4
3-4
5-6
4-1
2-4

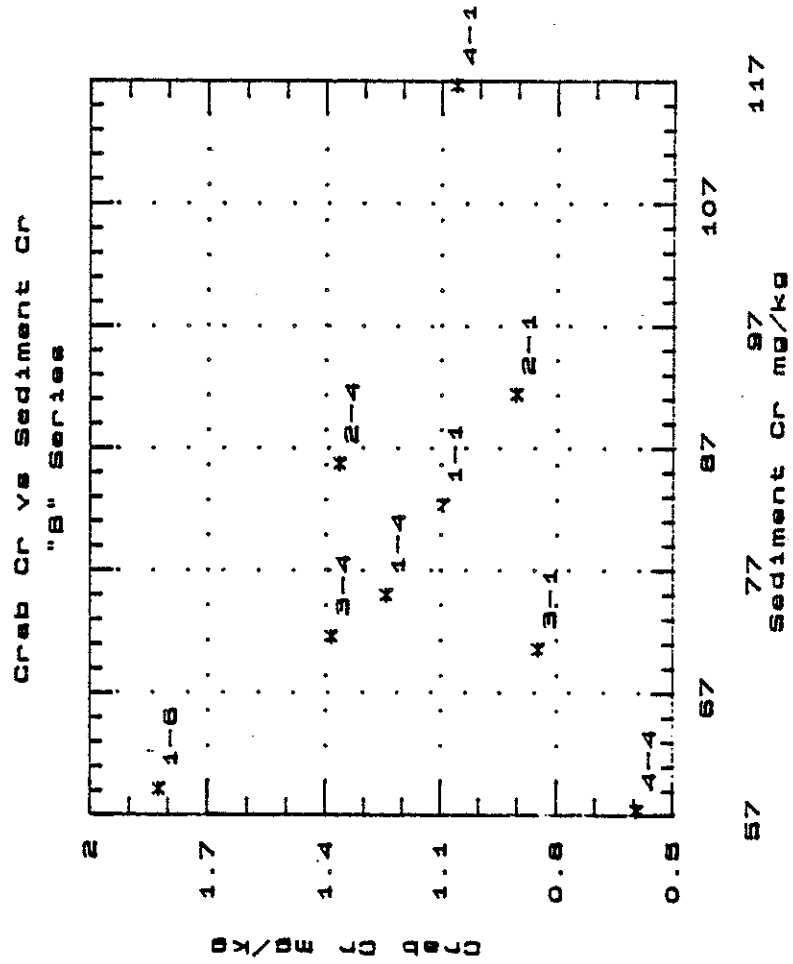
LG006691


Crab Hg vs Sediment Hg
"A" Series
Crab Hg mg/kg
0.31
0.27
0.23
0.19
0.15
0.11
0
0.4
0.8
1.2
1.6
2
2.4
Sediment Hg mg/kg
1-4
2-4
1-6
1-1
4-4
2-1
3-1
5-4
6-2
6-4

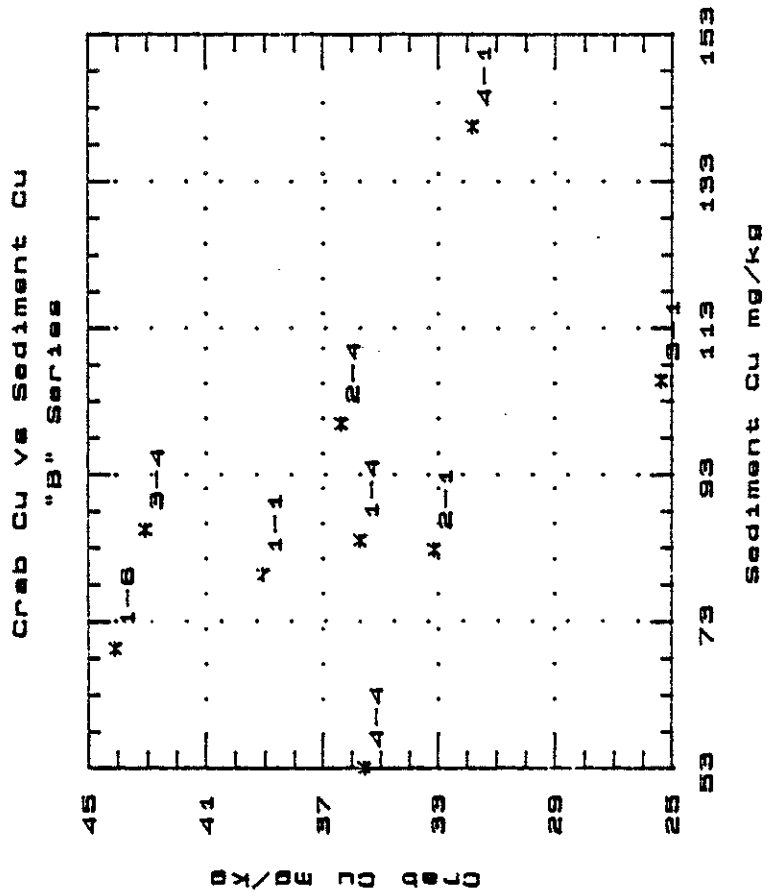
LG006692


Crab Zn Vs Sediment Zn
"A" Series
Crab Zn mg/kg
Sediment Zn mg/kg
41
39
37
35
33
31
29
190
290
390
490
590
1-1
5-4
6-4
4-4
3-1
5-6
1-6
2-4
1-4
4-1
3-4
5-1
6-2
2-1

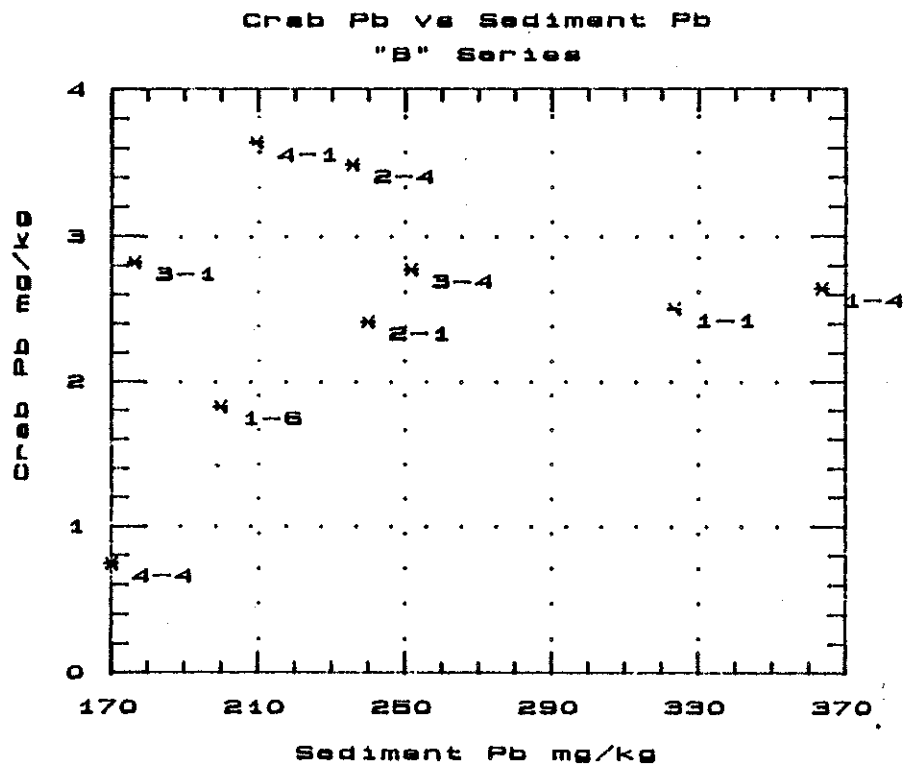
LG006693


Crab Cr Vs Sediment Cr
"B" Series
Crab Cr mg/kg
2
1.7
1.4
1.1
0.8
0.5
57
67
77
87
97
107
117
Sediment Cr mg/kg
1-6
3-4
1-4
2-4
1-1
2-1
3-1
4-4
4-1

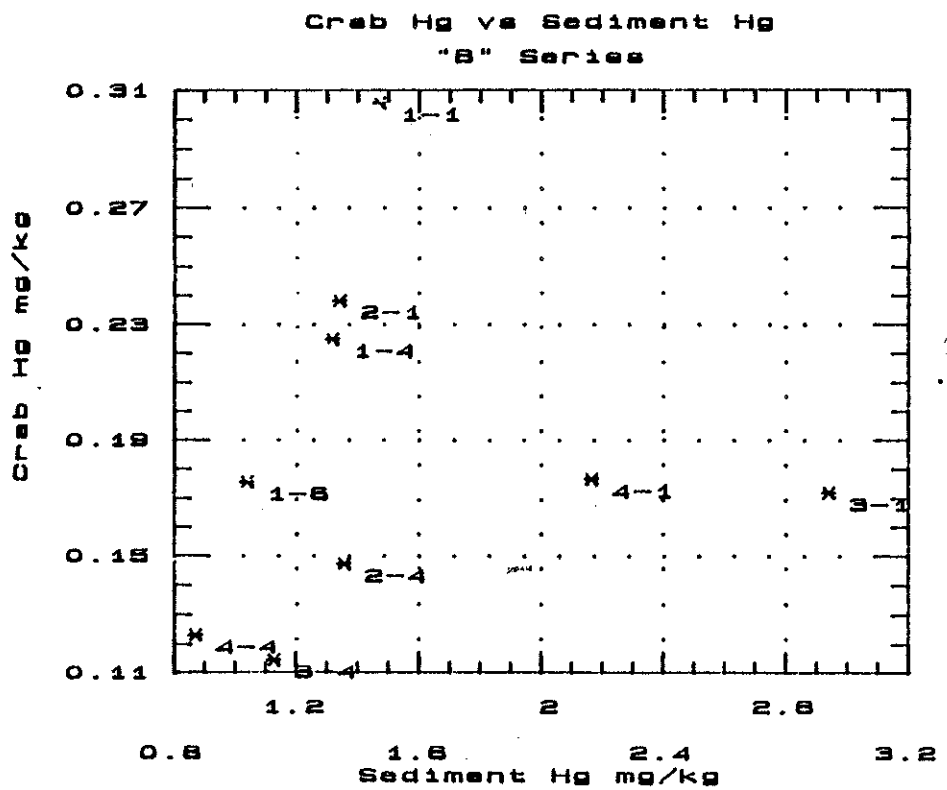
LG006694


Crab Cu Vs Sediment Cu
"B" Series
Crab Cu mg/kg
Sediment Cu mg/kg
45
41
37
33
29
25
53
73
93
113
133
153
1-6
3-4
1-1
1-4
4-4
2-4
2-1
4-1

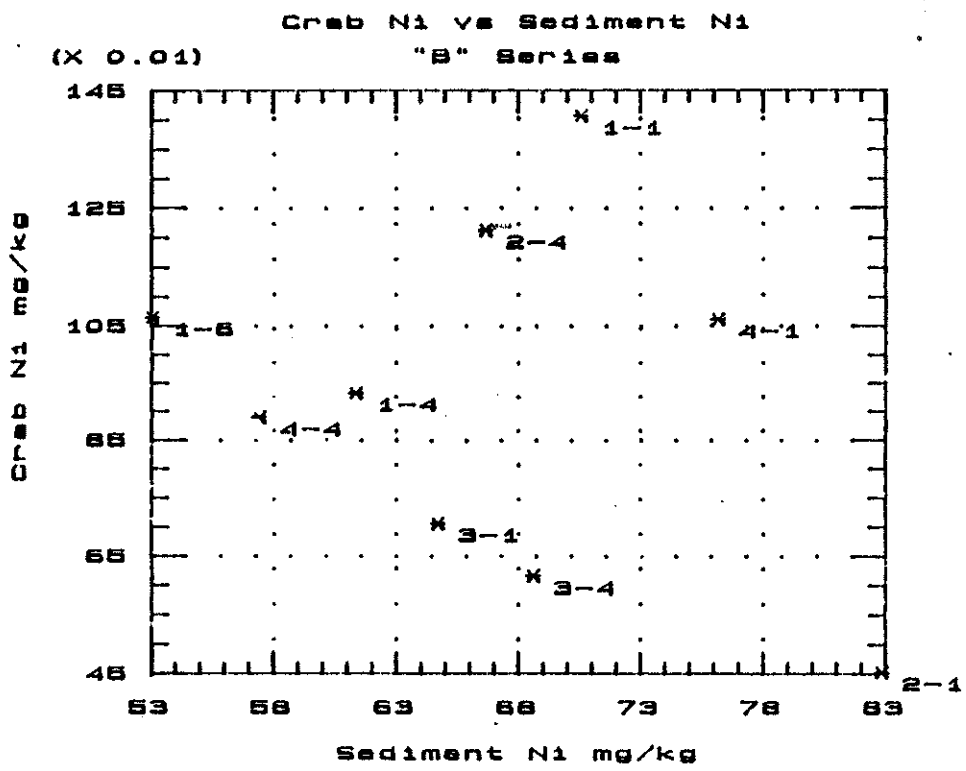
LG006695


Crab Pb vs Sediment Pb
"B" Series
Crab Pb mg/kg
Sediment Pb mg/kg
0
1
2
3
4
170
210
250
290
330
370
4-1
2-4
3-1
3-4
2-1
1-1
1-4
1-6
4-4

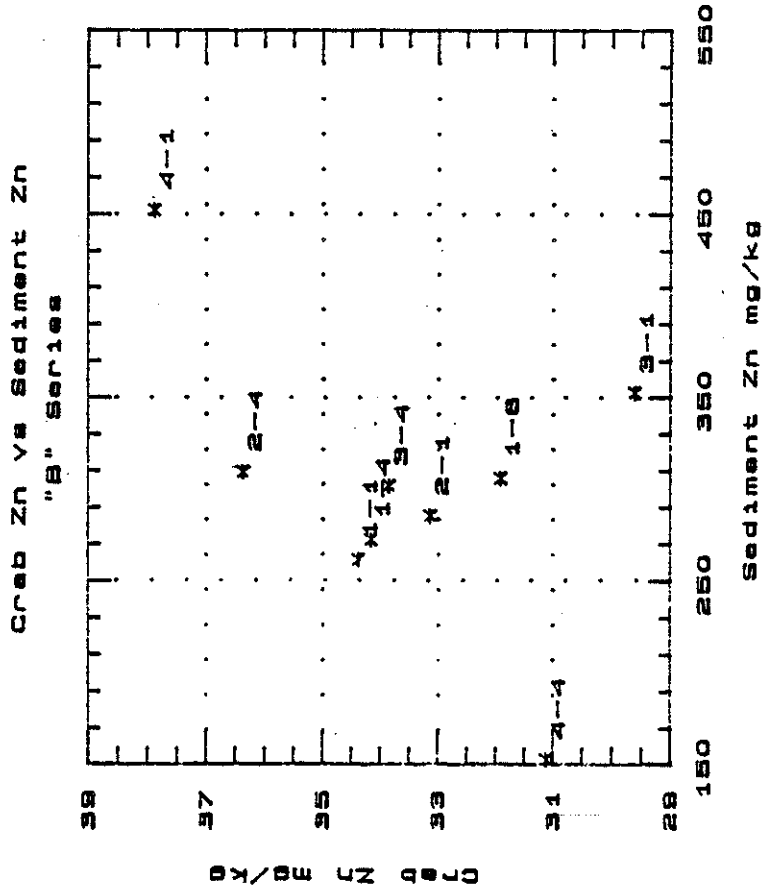
LG006696


Crab Hg vs Sediment Hg
"B" Series
Crab Hg mg/kg
0.31
0.27
0.23
0.19
0.15
0.11
1.2
2
2.8
0.8
1.6
2.4
3.2
Sediment Hg mg/kg
1-1
2-1
1-4
1-6
4-1
3-1
2-4
4-4
3-4

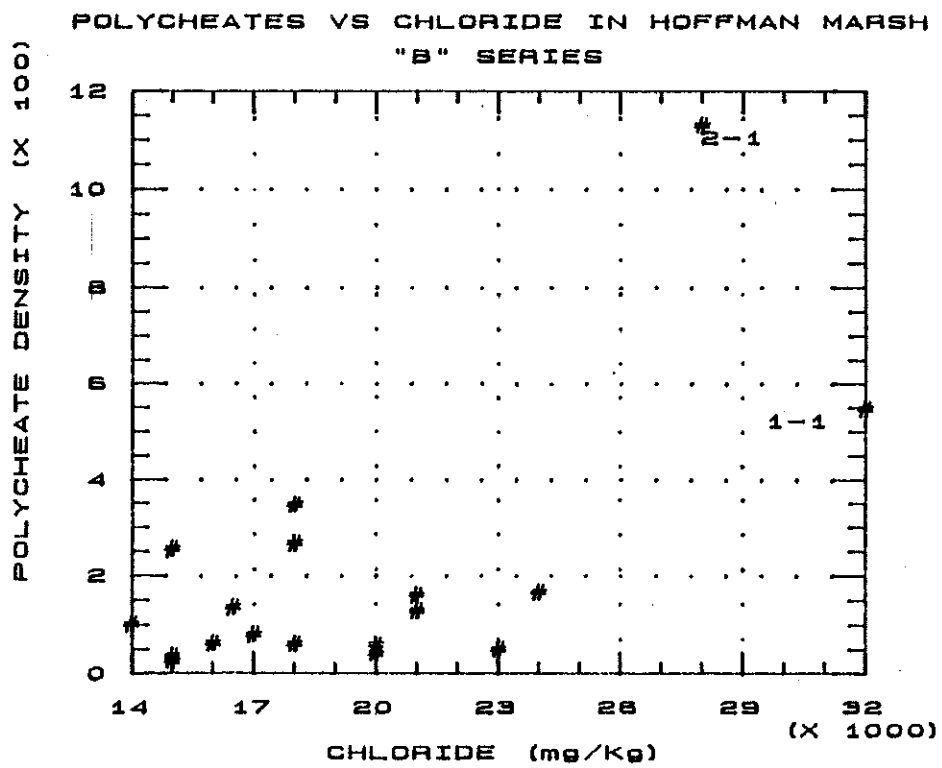
LG006697


Crab Ni vs Sediment Ni
"B" Series
(X 0.01)
Crab Ni mg/kg
Sediment Ni mg/kg
145
125
105
85
65
45
53
58
63
68
73
78
83
1-1
2-4
1-6
4-1
1-4
4-4
3-1
3-4
2-1

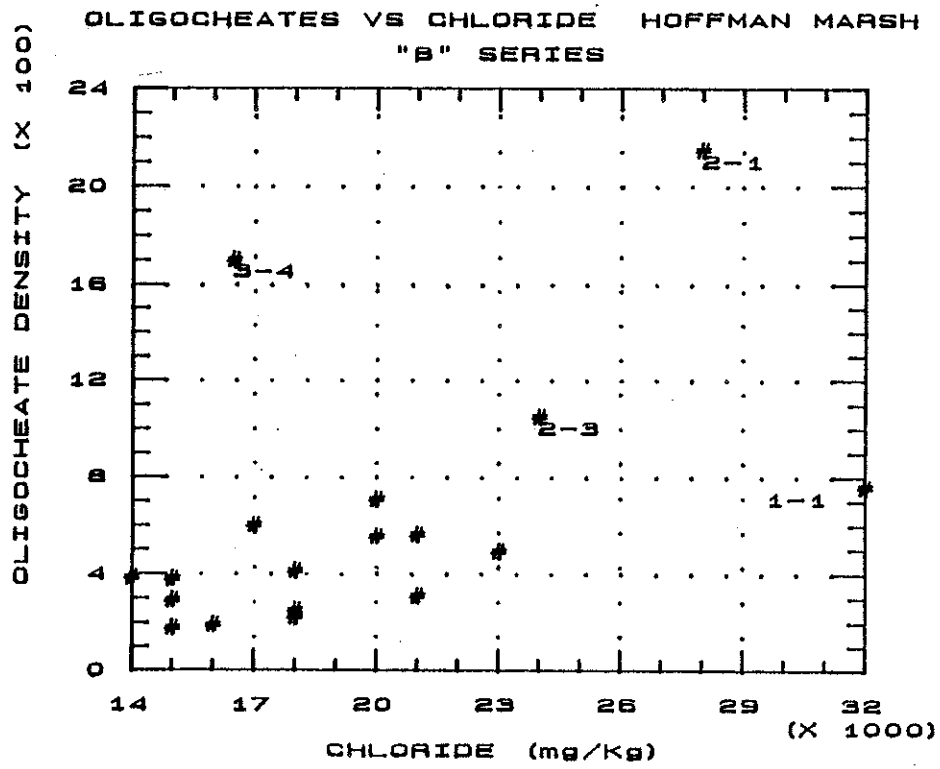
LG006698

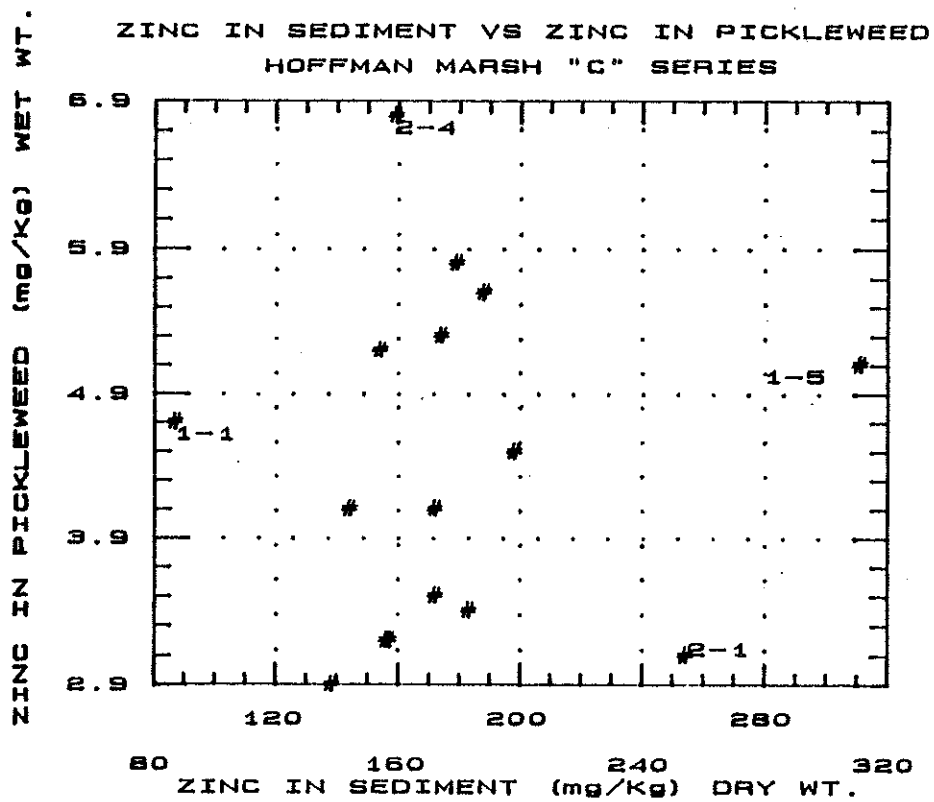

Crab Zn vs Sediment Zn
"B" Series
Crab Zn mg/kg
Sediment Zn mg/kg
39
37
35
33
31
29
150
250
350
450
550
4-1
2-4
1-1
3-4
2-1
1-8
3-1
4-4

LG006699

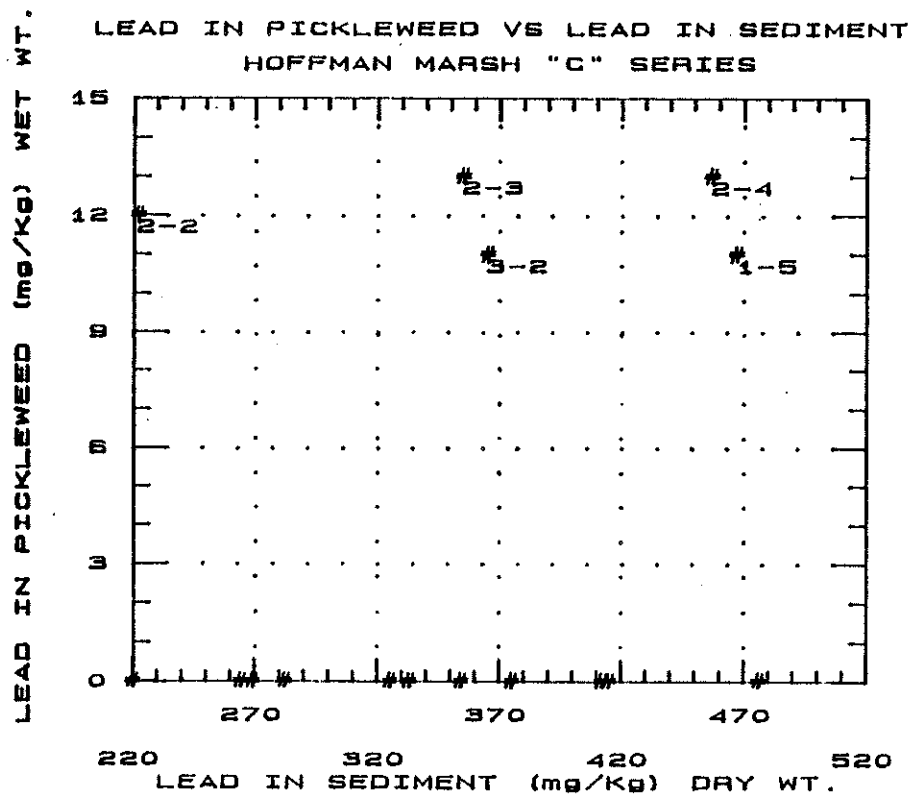

POLYCHEATES VS CHLORIDE IN HOFFMAN MARSH
"B" SERIES
POLYCHEATE DENSITY (X 100)
12
10
8
6
4
2
0
14
17
20
23
26
29
32
(X 1000)
CHLORIDE (mg/Kg)
2-1
1-1

LC006700

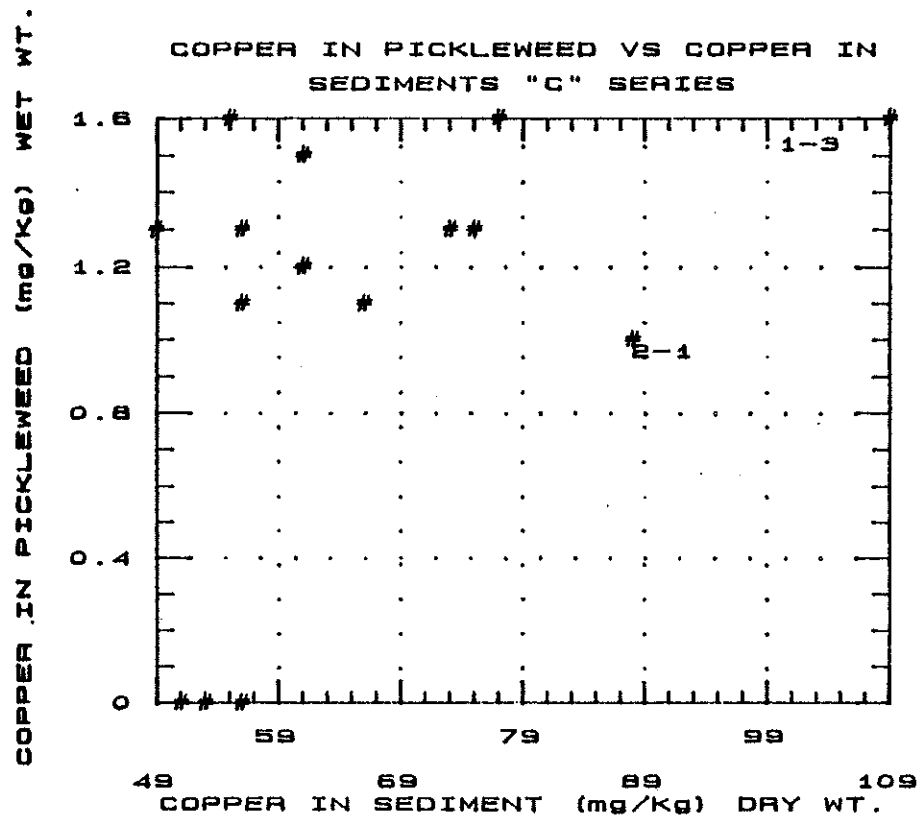

OLIGOCHEATES VS CHLORIDE HOFFMAN MARSH
"B" SERIES
OLIGOCHEATE DENSITY (X 100)
24
20
16
12
8
4
0
14
17
20
23
26
29
32
(X 1000)
CHLORIDE (mg/Kg)
2-1
3-4
2-3
1-1


ZINC IN SEDIMENT VS ZINC IN PICKLEWEED
HOFFMAN MARSH "C" SERIES
ZINC IN PICKLEWEED (mg/Kg) WET WT.
6.9
5.9
4.9
3.9
2.9
2-4
1-5
1-1
2-1
120
200
280
80
160
240
320
ZINC IN SEDIMENT (mg/Kg) DRY WT.

LG006702


LEAD IN PICKLEWEED VS LEAD IN SEDIMENT
HOFFMAN MARSH "C" SERIES
LEAD IN PICKLEWEED (mg/Kg) WET WT.
15
12
9
6
3
0
#2-3
#2-4
#2-2
#3-2
#1-5
220
270
320
370
420
470
520
LEAD IN SEDIMENT (mg/Kg) DRY WT.

LG00703


COPPER IN PICKLEWEED VS COPPER IN
SEDIMENTS "C" SERIES
COPPER IN PICKLEWEED (mg/Kg) WET WT.
1.6
1.2
0.8
0.4
0
1-3
2-1
49
59
69
79
89
99
109
COPPER IN SEDIMENT (mg/Kg) DRY WT.

LG006704

APPENDIX D

Bioassay Study

LG006705

APPENDIX D

BIOASSAY STUDY

This appendix consists of documents related to the soil elutriate bioassay study. Provided first is the initial bioassay results report submitted in November 1989, which includes the approved bioassay workplan as an attachment. Agency comment letters are included next, along with Kennedy/Jenks/Chilton response letters, and a summary of a meeting held with the agencies on 22 January 1990 to discuss the results of the bioassay study. Finally, the results of the agreed-to confirmation bioassay study are presented in a new report by E.V.S. Consultants. A table of contents for the appendix is provided on the following page.

LG066706

APPENDIX D

TABLE OF CONTENTS

Kennedy/Jenks/Chilton letter report to Department of Health Services dated 10 November 1989. Soil Elutriate Bioassay Results.

Attachment A Laboratory Report Sheets for Soil Analyses (Omitted)

Attachment B Results of Bioassay Testing and Chemical Characterization of Elutriates from Surface and Subsurface Soils From The Liquid Gold Site. E.V.S. Consultants. Appendix B - Raw Bioassay Data (omitted).

Attachment C Revised Bioassay Workplan

Department of Health Services letter to Southern Pacific Transportation Company dated 14 December 1989. Agency Comments on Soil Elutriate Bioassay Results.

Kennedy/Jenks/Chilton letter to Department of Health Services dated 12 January 1990. Response to Comments on Soil Elutriate Bioassay Results.

Regional Water Quality Control Board letter to Southern Pacific Transportation Company dated 8 January 1990. Preliminary Development of Remedial Alternatives and Soil Elutriate Bioassay Report for the Liquid Gold Site in Richmond.

Department of Fish and Game memorandum to Department of Health Services dated 8 January 1990. Comments and Recommendations on Results of Soil Elutriate Bioassay - November 1989.

Kennedy/Jenks/Chilton letter to Department of Health Services dated 25 January 1990. Meeting Regarding Soil Elutriate Bioassay Results.

Kennedy/Jenks/Chilton letter to Department of Health Services dated 8 February 1990. Response to RWQCB Comments on Soil Elutriates Bioassay Results.

Kennedy/Jenks/Chilton letter to Department of Health Services dated 9 February 1990. Response to DFG Comments on Soil Elutriate Bioassay Results.

E.V.S. Consultants. Results of Bioassay Testing and Chemical Characterization of Elutriates from Resampled Surface and Subsurface Soils from The Liquid Gold Site. March 1990.

LG006707

Kennedy/Jenks/Chilton

Consulting Engineers

Marathon Plaza, Tenth Floor North
303 Second Street
San Francisco, California 94107
415-362-6065

10 November 1989

Mr. Howard Hatayama
Department of Health Services
Toxic Substances Control Division
700 Heinz Street
Building F, Second Floor
Berkeley, California 94710

Subject: Soil Elutriate Bioassay Results
Liquid Gold Site, Richmond, California
(K/J/C 855018.05-G-01)

Dear Mr. Hatayama:

The bioassay workplan was finalized in a letter to the Department of Health Services (DHS) dated 24 August 1989 for work at Southern Pacific Transportation Company's (SPT Co) Liquid Gold site in Richmond, California. The results of the sampling and analysis effort are summarized in this letter report.

Sample Collection

Soil samples were collected on 28 August 1989. The sample locations are shown on Figure 1. The subsurface samples (MO series) were collected to a depth of approximately 6 feet by continuous sampling using 2-inch brass liners. The ends of the liners were covered with Teflon and capped. Samples were labeled and chain of custody forms were completed. Location MO-2 was drilled twice to complete the sample throughout the entire depth. At MO-4 an oily layer was observed at approximately 3 feet.

Surface samples were collected from 0 to 1 inch using a clean metal trowel. Samples were placed in labeled glass jars with Teflon lined lids. Subsurface and surface samples were delivered the same day to K/J/C Laboratory Division for compositing. Part of each composite was kept for chemical analysis, and the remainder was delivered to E.V.S Consultants laboratory for the elutriate and bioassay portions of the study.

In shipment of the soil composites for bioassay, jars with samples from surface locations M6-1 and M6-2 were broken. These locations were resampled on 5 September 1989. The new samples were composited and then split for chemical and bioassay analyses as before.

Mr. Howard Hatayama
Department of Health Services
10 November 1989

Soil Chemical Analysis Results

Chemical analysis results on soil samples are summarized in Table 1 for metals and Table 2 for organics. Laboratory report sheets are included as Attachment A.

Bioassay Results

The revised bioassay workplan is included for completeness as Attachment C. The results of the elutriate bioassays by E.V.S. Consultants are given in Attachment B. The conclusion was that no toxicity was observed that is clearly attributable to chemicals in the soil samples. On the basis of these results, we do not recommend any additional bioassay testing at the site. Specifically, Phase II testing of burrowing amphipods is not recommended.

If you have any questions regarding the information presented in this report, please contact us.

Very truly yours,

KENNEDY/JENKS/CHILTON, INC

Michael T Poulsen

Michael T. Poulsen
Project Manager

Thomas J. Belick

Thomas J. Belick, P.E.
Supervising Project Engineer

MTP/TJB:mbWPC5

Attachments

Attachment to Kennedy/Jenks/Chilton
Letter to DHS dated 10 November 1989

cc: Mr. Steven Ritchie
Executive Officer
California Regional Water Quality Control Board
San Francisco Bay Region
1111 Jackson Street, Room 6040
Oakland, CA 94607

Ms. Carolyn Thompson (T-4-4)
U.S. Environmental Protection Agency
215 Fremont Street
San Francisco, CA 94105

Mr. Michael Rugg
Department of Fish and Game
P.O. Box 47
Yountville, CA 94599

Mr. Chip Demerest (T-6)
National Oceanic and Atmospheric Administration
c/o U.S. Environmental Protection Agency
215 Fremont Street
San Francisco, CA 94105

Mr. William Allan
Department of Interior
450 Golden Gate
P.O. Box 36098
San Francisco, CA 94102

Mr. Mark Ransom
Southern Pacific Transportation Company
Southern Pacific Building, Room 1004
One Market Plaza
San Francisco, CA 94105

Attachment to Kennedy/Jenks/Chilton
Letter to DHS dated 10 November 1989

TABLE 1

METAL CONCENTRATIONS IN SOIL SAMPLES COLLECTED FOR BIOASSAY
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.05-G-01)

	METAL CONCENTRATION IN MG/KG										
METAL	M0-1	M0-2	M0-3	M0-4	M0-5	M1-1	M1-2	M1-3	M6-1	M6-2	M6-3
Chromium (Total)	24	19	30	31	26	30	22	21	29	32	24
Copper	35	210	120	18	76	27	18	30	32	66	57
Lead	54	370	280	10	61	83	62	56	96	150	94
Mercury	0.07	0.38	0.06	0.07	0.18	0.57	0.09	0.22	0.37	0.21	0.24
Nickel	26	31	28	34	26	36	30	25	29	34	29
Zinc	54	200	200	29	260	140	77	55	70	140	79

LG008711

Attachment to Kennedy/Jenks/Chilton
Letter to DHS dated 10 November 1989

TABLE 2

ORGANIC COMPOUND CONCENTRATIONS IN SOIL SAMPLES COLLECTED FOR BIOASSAY
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.05-G-01)

	CHEMICAL CONCENTRATION IN MG/KG										
CHEMICAL	MO-1	MO-2	MO-3	MO-4	MO-5	M1-1	M1-2	M1-3	M6-1	M6-2	M6-3
Base/Neutral/Acid Extractable											
Phenol	ND[1]	ND	0.78	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	0.35	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	1.5	1.9	ND	ND	ND	ND	ND	0.78	ND	ND
Benz[a]anthracene	ND	0.92	0.77	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	0.75	0.46	1.5	ND	0.49	ND	0.59	ND	0.36	ND	ND
Chrysene	ND	1.0	1.3	ND	ND	ND	ND	ND	0.33	ND	ND
Benzo[k]fluoranthene	ND	2.0	2.1	ND	ND	ND	ND	ND	0.47	ND	ND
Benzo[a]pyrene	ND	0.93	0.96	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	ND	1.1	2.0	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h]anthracene	ND	0.48	0.96	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	1.6	3.3	ND	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	ND	ND	3.5	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	ND	ND	0.61	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	0.62	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oil and Grease	2200	1600	6200	920	390	670	520	740	900	930	150
PCB	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

LG006712

Note: [1]ND = Not Detected. Detection limit = 0.33 mg/kg, except for sample MO-4, which had detection limits of 10 mg/kg due to interferences from aliphatic hydrocarbons.

0 125 250

Scale in Feet
(Approx)

Basemap Reference

Hammon, Jensen, Wallen & Associates.
Job number 5841. Flown 26 November 1984.
Airphoto negative scale 1 inch = 300 feet.

Legend

- Drainage area boundary
- IX Drainage area designated number
- Area of ponding
- M1-1 △ Surface Soil Sample Location
- M0-1 ▲ Subsurface Soil Sample Location

Notes:

1. All boundaries shown are approximate. Boundaries are based on features shown on topographic map and on field observation by K/J/C in November 1987.

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Soil Sampling Locations

K/J/C 855018.05
November 1989

LG006713

Figure 1

ATTACHMENT A

Laboratory Report Sheets
For Soil Analyses

ATTACHMENT B

Results Of Bioassay Testing
And Chemical Characterization
Of Elutriates From Surface
And Subsurface Soils
From The Liquid Gold Site

FINAL REPORT

RESULTS OF BIOASSAY TESTING AND CHEMICAL CHARACTERIZATION OF ELUTRIATES FROM SURFACE AND SUBSURFACE SOILS FROM THE LIQUID GOLD SITE

For:

Kennedy/Jenks/Chilton

E.V.S. Project No. 4/420-01

November 1989

LG006716

FINAL REPORT

RESULTS OF BIOASSAY TESTING AND CHEMICAL CHARACTERIZATION OF ELUTRIATES FROM SURFACE AND SUBSURFACE SOILS FROM THE LIQUID GOLD SITE

Prepared For

Kennedy/Jenks/Chilton
Marathon Plaza, 10 North
303 Second Street
San Francisco, California 94107

Attention: Mr. Michael Poulsen

Prepared by

E.V.S. Consultants, Inc.
475 Gate Five Road, Suite 102
Sausalito, California

E.V.S. Project No.4/420-01

November 1989

LG006717

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LG006719

ACKNOWLEDGEMENTS

E.V.S. acknowledges the help in developing the conceptual framework for this study provided by Kim Walsh and additional guidance provided by Michael Poulsen of Kennedy, Jenks & Chilton. The elutriates and bioassay work was performed by Dana Watts of EVS Consultants. Chemical analyses were performed by Analytical Services Laboratories (ASL) under the supervision of Robert Deverall with assistance from Doreen Cheng. This report was prepared by Barbara Smith and James Cronin of EVS and wordprocessed by Ms. Regina Burgio and Mr. Andre Vanderbraak. Peer review of the report was provided by Peter Chapman.

LG006720

1.0 INTRODUCTION

Hoffman Marsh, located between San Francisco Bay and the urban areas of Richmond, California, receives run-off from industrialized and urban areas of South Richmond. In addition, this marsh receives run-off and there is some potential for ground water migrating from the north and east of the marsh. Concern about impacts to the marsh by industrial run-off from historical industrial sites to the northwest has prompted chemical and biological studies by Kennedy/Jenks/Chilton to determine if chemicals from the Liquid Gold site are impacting the organisms in the marsh adjacent to the site.

Somewhat elevated levels of the metals copper, lead, zinc and mercury had been observed in the marsh in comparison with values found in Richmond Inner Harbor, approximately one and one-half miles to the west (EVS Consultants, 1988a,b). Benthic studies did not indicate major impacts due to run-off, but more subtle effects may be indicated (Scott Cressey, WESCO, pers. comm.).

It was not possible to perform a wet-weather ecological field study in order to evaluate the potential affects of wet weather run-off from the Liquid Gold site because of the abnormally low rainfall and limited outflow from the delta during the 1988-89 season. In order to evaluate the potential effects of surface and ground water migration from the site into Hoffman Marsh, it was suggested by the California Department of Fish and Game that elutriate bioassays be conducted on a sensitive species, using soils from the site. This project developed from these concerns. It provided an experimental approach, at an initial screening level, to evaluate the potential for leaching of chemicals from soils on the Liquid Gold Site and the potential toxicity of the leach water from the surface and subsurface soils. The bioassay testing evaluated potential toxic effects on the alga, *Selenastrum capricornutum*, and the invertebrate, *Ceriodaphnia dubia*, while chemical analyses of the elutriate samples provided the opportunity to determine the potential extent of leaching of toxic metals and organics from the selected soil samples. These short-term, relatively inexpensive bioassays were used rather than other tests such as fathead minnow partial life-cycle tests, because of the screening nature of this study.

The work performed for this project consisted of the following:

1) The preparation of 30 elutriate samples.

   a. One deionized water (DI) elutriate of each of 11 sediment samples (11 elutriates). In addition, because of high salinities in two of the original sample elutriates, a second and then third elutriate were prepared, successively, in order to evaluate the effects of salinity on the bioassay results. Thus 15 deionized water elutriates were produced.

   b. One dilute mineral water (DMW) elutriate of each of 11 sediment samples. In addition, because of high salinities in two of the original sample elutriates, a second and then third elutriate were prepared, successively, in order to evaluate the effects of salinity on the bioassay results. Thus 15 dilute mineral water elutriates were produced.

2) Bioassay 48 h acute toxicity tests of the daphnid crustacean, *Ceriodaphnia dubia*, exposed to 28 of the above 30 sediment elutriates.

3) Bioassay 96 h toxicity tests of the alga *Selenastrum capricornutum*, exposed to 14 of the above 15 sediment elutriates made with deionized water.

4) Determination of chemical parameters in the 22 elutriate samples used for final bioassay testing and 4 control samples including: pH, salinity, alkalinity, copper, lead, zinc, mercury, nickel, chromium, PCB's, polynuclear aromatic hydrocarbons (PAH) and oil and grease.

2.0 METHODS

2.1 Sediment Sampling

Sediment sampling was performed by Kennedy/Jenks/Chilton under the supervision of Mr. Michael Poulsen. Details of this sampling are not provided in this report.

2.2 Chemical Analyses

2.2.1 Water Quality Parameters

Water quality parameters were analyzed in accordance with "Standard Methods for the Examination of Water and Wastewater" (APHA, 1985).

Salinity

Salinity was determined using a Reichart Refractometer at the E.V.S. Laboratories. Salinity values were also determined by the chemical analytical laboratory using a YSI Salinometer based on conductivity. Salinity is expressed as parts per thousand (ppt) total dissolved salts.

Hardness

Total hardness is defined as the sum of the calcium and magnesium concentrations in a sample expressed as calcium carbonate equivalents. The test is a colorimetric titration of the sample with Na_2EDTA using the indicator calmagite. The end point is a color change from magenta to light blue. Hardness is expressed in mg/L.

Alkalinity

The alkalinity of water is defined as its quantitative capacity to react with a strong acid to a designated pH. Because the alkalinity of many surface waters is primarily a function of carbonate, bicarbonate and hydroxide content, it is taken as an indication of the concentration of these constituents. This test is a titration of the sample from its initial pH, measured with a pH probe, to a final pH of 4.5. Alkalinity is expressed in mg/L.

2.2.2 Metals

The sample elutriates were analyzed for metals after passing through a 0.45 μm membrane filter to remove particles that would interfere with analyses. Filtering was performed because of an uneven distribution of particulates that could influence the apparent total concentration of metals. Because dissolved metals are a better indicator of the bioavailability of metals from solution, this procedure was adopted. Metals were analyzed as follows:

Cu, Cr, Pb and Ni: Analyzed by Graphite Furnace Atomic Absorption Spectrophotometry equipped with Zeeman background correction.

Zn: Analyzed by Direct Flame Atomic Absorption Spectrophotometry.

Hg: Analyzed by Cold Vapor Atomic Absorption Spectrophotometry after a suitable acid/permanganate digestion of the sample.

Element	Instrument Detection Mode
Trace Metals	Initial metal screen was performed using Perkin Elmer inductively coupled argon plasma emission spectrometer Model 40, coupled to an Epson Equity III plus 286 Microcomputer.
Cu, Cr, Pb & Ni	Varian Spectrometer Model AA-300 Zeeman coupled with a Zeeman Graphite Tube Atomizer and equipped with an IBM Model 30 PS2 data station.
Zn:	Perkin Elmer Model 2380 dual beam spectrophotometer equipped with automatic background correction.
Hg:	Pharmacia Model U.V. mercury monitor equipped with a 30 cm absorption cell.

2.2.3 Organic Parameters

Oil and Grease

The samples were extracted with Freon-113. The extracts thus produced were evaporated to dryness and the residue weighed to determine gravimetric oil and grease.

Polynuclear Aromatic Hydrocarbons (PAH)

The samples were analyzed in accordance with U.S. Environmental Protection Agency Method 610. This method involves the extraction of the sample with dichloromethane followed by column chromatography clean-up. The resulting extract was analyzed by capillary column gas chromatography with mass spectrometry detection.

Polychlorinated Biphenyls (PCB)

The samples were analyzed in accordance with USEPA Method 608. This procedure involves the extraction of the sample with dichloromethane followed by column chromatography cleanup. The concentrated extract was analyzed using a gas chromatograph equipped with an electron capture detector.

Element	Instrument Detection Mode
PAH	Hewlett Packard 5890 Gas Chromatograph with dual column/dual electron capture detector capabilities for simultaneous analysis and confirmation of halogenated organic compounds. Hewlett Packard MSD Gas Chromatograph/Mass Spectrometer with - Full Wiley/NBS library of 130,000 mass spectra - Full HP-UX Software for EPA Methodology
PCB	Hewlett Packard 5830 Gas Chromatograph with Electron Capture Detector.

2.3 Bioassays

2.3.1 Sediment Elutriate Preparation

Surface soil samples

For each of the six surface sediment samples (M1-1, M1-2, M1-3, M6-1, M6-2, M6-3), 800 ml of sediment was added to 3200 ml deionized water (DI) in a sterile 4 L glass jar. To each jar, 1 drop concentrated sulfuric acid was added. The jars were sealed and placed on a rolling mill for 24 h. After 24 h, all jars were removed and placed, upright, to settle at 4 °C. After 17 h, the elutriate was still cloudy, so that settling time was increased to 48 h. After 48 h, the elutriates were decanted and the salinity of the samples was measured. Only two elutriates, those from samples M1-2 and M6-2, had salinities greater than 3 ppt. These samples were eluted a second time, as indicated above. The secondary elutriates from samples M1-2 and M6-2 were found to have salinities in the range of less than 3 ppt. A third set of elutriates was prepared from samples M1-2 and M6-2 as above then filtered as follows: three grams of diatomaceous earth (Manville aquacel) was washed with 100 ml DI water on a glass fiber filter prior to filtering the DI elutriates of the above samples. The diatomaceous earth filter was replaced for each solution filtered. The elutriates were then passed through a 0.45 μm membrane filter. Elutriate not used for bioassay testing was stored in glass jars at 4 °C in the dark prior to shipment to the chemistry lab.

Another set of elutriates from the surface sediment samples was prepared using dilute mineral water (DMW) composed of 10 % (Perrier) mineral water in DI water. Samples were not acidified. Secondary DMW elutriates of surface sediment samples M1-2 and M6-2 were also prepared. After initial bioassay testing, a third set of DMW elutriates of samples M1-2 and M6-2 was prepared, as indicated above. Sediment mixing and settling times, and other elutriate preparation procedures, were the same as outlined above.

Subsurface soil samples

Five subsurface samples (M0-1, M0-2, M0-3, M0-4, M0-5) were eluted with DI water that had been sparged with gaseous nitrogen for one hour. One drop of 1 N sulfuric acid was added to each jar. Prior to mixing, the sediment/water suspension was sparged with nitrogen for 45 min. After the 48 h settling period, the jars were opened under a nitrogen atmosphere and the elutriate passed through 105 μm (Spectra Mesh) screen. Salinities of all subsurface DI elutriates were <2 ppt measured by refractometer.

A second set of DMW elutriates was prepared from the subsurface sediments. Samples were not acidified. Sediment mixing and settling times, and other elutriate preparation procedures, were the same as outlined above. Salinities measured by refractometer of all DMW were <2 ppt.

2.3.2 Crustacean Bioassays

Forty-eight hour acute bioassays were performed on juveniles of the daphnid crustacean, *Ceriodaphnia dubia*, exposed to DI and DMW elutriates of surface and subsurface sample sediments (ASTM, 1984; U.S. EPA, 1985, 1989). For each set of elutriates, 450 ml of test solution was used to expose 30 juvenile *Ceriodaphnia*. Initial water quality parameters were measured including temperature, salinity, pH and dissolved oxygen (D.O.).

Two larval daphnids were placed in each of 15 plastic vials into which 15 ml of temperature-equilibrated (21 $\pm$ 2 °C) elutriate sample had been pipetted. Bioassay vials were not aerated during the test, but were maintained in a temperature controlled water bath (21 $\pm$ 2 °C) for the duration of testing. At the termination of testing, daphnids were visually examined and scored for mortality (lack of motility). Elutriate from individual vials was pooled as directed in the protocol and terminal values of water quality parameters were determined (temperature, pH, D.O., alkalinity and hardness).

2.3.3 Algal Bioassays

Ninety-six hour algal toxicity bioassays were conducted on *Selenastrum capricornutum*, exposed to DI elutriates of surface and subsurface sediment samples. Tests were performed in accordance with the methods and

procedures outlined by the U.S. EPA (1985).

Three hundred milliliters of each elutriate were placed in a clean 1 L flask and inoculated with nutrients for algal growth (v/v: 5 mL/L, see Appendix B for final nutrient concentrations). The sample was divided into three 100 ml aliquots that were placed in sterile 250 ml Ehrlinmeyer flasks. One mL of *Selenastrum capricornutum* stock inoculum was added to each of the three replicate flasks.

Three types of controls were prepared for each test. The first contained DI water and algal growth nutrients. The second contained acidified DI water (v/v: one drop of concentrated sulfuric acid in 3200 mL DI water) that had been permitted to stand for 24 hr before the nutrients had been added to model pH effects comparable to those associated with sediment acidification. The third control contained DMW and algal growth nutrients. Control flasks were inoculated with *Selenastrum* stock solution as above.

Control and test flasks were illuminated with cool-white fluorescent lights. The flasks were manually shaken once per day and the relative positions of the flasks altered daily, to reduce variations in the light field intercepted by the individual flasks.

After 96 h, the number of cells per mL in the test flasks was determined and compared to the controls. Cell numbers were determined by counting the number of cells observed in a given part of the field of a hemocytometer (400 small squares). The mean of two counts of each replicate flask was taken as the estimate of cell concentration in that flask. The mean of the cell concentrations for the three replicate flasks was taken as the estimate of cell concentration for the test sample.

2.4 Quality Assurance/Quality Control (QA/QC)

2.4.1 QA/QC - Chemical Analyses

Extensive quality assurance measures were taken to ensure that the highest level of precision and accuracy were maintained. All analyses were performed using accepted procedures and included the concurrent analysis of reagent blanks, sample duplicates and certified reference materials (where available).

Quality control samples analyzed with the submitted samples were:

Metals- Reagent Blanks (n=2), sample duplicates (n=1) and certified reference material (CRM) [n=3 : 1 each of National Research Council (NRC) MESS, BCSS (both marine sediments) and 1 National Bureau of Standards (NBS) 1646 (estuarine sediment).

Organics- Reagent (extraction) blank (n=2), sample duplicate (n=1), certified reference material(n=1) if available and sample spikes if certified reference material not available.

2.4.2 QA/QC - Toxicity Testing

The following QA/QC guidelines were followed for all bioassays:

1. All testing was conducted using well-established negative (clean) controls consisting of DI or DMW, as appropriate. The complete bioassay series was repeated if more than 10 percent mortalities were observed in the control animals. Repeat sets of tests were also required to adhere to this standard.

2. Only healthy organisms of similar size and life history stage were used.

3. All bioassay containers were randomized such that laboratory personnel had no knowledge of sample identities (blind testing).

4. Proper water quality and other conditions necessary for the survival of the organisms were maintained and documented.

5. Standard laboratory procedures were followed, including proper documentation, cleaning methods and avoidance of contamination, maintenance of proper environmental conditions, and reporting of unusual observations or deviations from established procedures.

3.0 RESULTS AND DISCUSSION

3.1 Chemical Analyses

Chemical analyses were performed for PCB's, PAH, oil and grease, pH, alkalinity, conductivity and the metals chromium, copper, lead, mercury, nickel, and zinc in all sample elutriates except elutriates from samples M1-2 and M6-2, for which only the third elutriates were analyzed. In addition, four blanks were run for each treatment of the surface and subsurface soils to determine any general contamination from the testing process itself.

3.1.1 Metals

The results of the metal analyses are shown in Table 1 for deionized water elutriates of surface soils, Table 2 for dilute mineral water elutriates of surface soil, and Table 3 and 4 for elutriates made from subsurface soils with DI and DMW respectively. The results in Table 1 represent leaching by deionized water that had been adjusted to a pH of approximately 3.4 by the addition of one drop of concentrated sulfuric acid, prior to addition to the sediment. In all cases, the elutriation process with soils increased the final pH to neutral or above, probably due to soil alkalinity.

Final pH values for elutriates of surface soils, where the initial pH of the DI water was below 4, resulted in final pH levels in the elutriates comparable to those produced with the dilute mineral water.

The results presented in Table 3 for deionized water elutriates of subsurface soils demonstrate this same process, but with an initial pH of 6.16 as a result of the pH of adjustment with 1N sulfuric acid. The pH of the DMW prior to extraction was 6.87-6.92. The final pH of subsurface soil elutriates indicates that the initial pH of the elutriate water was not the determining factor with respect to elutriate pH.

Elutriates from several surface soils exhibited higher levels of metals. Sample M1-1 produced the highest copper levels in both the DI and DMW elutriates. In addition, nickel was relatively elevated in the elutriates from this soil sample. Copper levels in elutriates from samples M6-2 and M6-3 were also elevated. Nickel concentration was relatively elevated in several of the surface soil elutriates, e.g. M1-1 and M1-3 in both DI and DMW elutriates, while M1-2 demonstrated elevated nickel in the DMW elutriate only. Lead detected in the blanks may be due to low level contamination as indicated by lead in the blank samples. The lead value for the DMW elutriate of M6-1 was elevated while the DI water elutriate of this sample was not.

The general metal levels in the subsurface soil elutriates were somewhat lower than those found for the surface soil elutriates with the exception of lead in MO-3 and MO-5 DI water elutriates, and nickel in the MO-3 DMW elutriate. Copper was somewhat elevated in both DI and DMW elutriates from MO-1, MO-2, and MO-3.

3.1.2 Organics

The results of the analyses of organic contaminant content for DI and DMW elutriates of surface sediment and DI and DMW elutriates of subsurface sediments are presented in Tables 1, 2, 3, and 4, respectively. None of the DI and DMW elutriates of surface and subsurface sediment samples exhibited detectable levels of PCB's or PAHs.

Samples M1-3 and M6-1 exhibited some limited combined oil and grease presence in both the DI (9.0, 6.2 mg/L, respectively, Table 1) and the DMW (4.0, 7.4 mg/L, respectively, Table 2) elutriates.

Analyses of the DI and DMW elutriates of subsurface sediments exhibited detectable levels of oil and grease in blanks as well as elutriate samples (Tables 3 and 4, respectively). These detectable levels may have be due to the inadvertent introduction of oil from the apparatus used to nitrogen-sparge the samples.

Table 1 Summary of chemical analyses of deionized water (DI) elutriates of surface soil samples

		Surface DI Blank	Surface DI m1-1	Surface DI m1-2 (1)	Surface DI m1-3	Surface DI m6-1	Surface DI m6-2 (1)	Surface DI m5-3
pH		3.41	7.28	7.51	6.99	6.96	7.14	6.93
Conductivity		130	1190	1402	2290	1060	3200	964
Alkalinity CaCO3		-	244	309	281	112	174	127
Oil & Grease		<1.0	4.0	<1.0	9.0	6.2	<1.0	3.0
Metals								
Chromium	D Cr	<0.001	0.004	0.002	0.005	0.003	0.003	0.001
Copper	D Cu	0.001	0.056	0.005	0.003	0.016	0.032	0.023
Lead	D Pb	0.003	0.010	0.005	0.015	0.005	0.003	<0.001
Mercury	D Hg	<0.00005	0.00021	0.00008	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	D Ni	<0.001	0.044	<0.001	0.042	0.015	<0.001	0.010
Zinc	D Zn	<0.001	0.016	0.005	0.014	0.001	0.010	<0.001
Polychlorinated Biphenyl								
PCB'S		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Polynuclear Aromatic Hydrocarbons								
Acenaphthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acenaphthylene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Anthracene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Benzo(a)anthracene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(a)pyrene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(b)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(ghi)perylene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Benzo(k)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Chrysene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dibenzo(ah)anthracene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoranthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fluorene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Indeno(1,2,3-cd)pyrene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Naphthalene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phenanthrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pyrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

< = Less than
Results expressed as milligrams per litre except for pH and Conductivity (µmhos/cm).

(1) Analyses performed on third elutriates of these soil samples

Table 2 Summary of chemical analyses of dilute mineral water (DMW) elutriates of surface soil samples

		Surface DMW Blank	Surface DMW m1-1	Surface DMW m1-2 (1)	Surface DMW m1-3	Surface DMW m6-1	Surface DMW m6-2 (1)	Surface DMW m6-3
pH		6.87	7.43	7.29	6.97	6.98	7.30	7.11
Conductivity		99.8	1410	3750	702	1160	2450	1160
Alkalinity CaCO3		39.0	356	509	352	137	310	232
Oil & Grease		3.1	3.0	<1.0	4.0	7.4	<1.0	3.2
Metals								
Chromium	D Cr	<0.001	0.003	<0.001	0.002	0.003	0.002	0.001
Copper	D Cu	<0.001	0.039	0.007	0.003	0.018	0.024	0.020
Lead	D Pb	0.003	<0.001	0.017	<0.001	0.037	0.002	0.005
Mercury	D Hg	<0.00005	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	D Ni	<0.001	0.028	0.034	0.032	0.015	0.020	0.008
Zinc	D Zn	<0.001	0.009	0.002	0.001	0.001	<0.001	<0.001
Polychlorinated Biphenyl								
PCB's		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Polynuclear Aromatic Hydrocarbons								
Acenaphthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acenaphthylene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Anthracene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Benzo(a)anthracene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(a)pyrene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(b)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(ghi)perylene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Benzo(k)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Chrysene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dibenzo(ah)anthracene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoranthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fluorene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Indeno(1,2,3-cd)pyrene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Naphthalene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phenanthrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pyrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

< = Less than
Results expressed as milligrams per litre except for pH and Conductivity (µmhos/cm).

(1) Analyses performed on third elutriates of these soil samples

Table 3 Summary of chemical analyses of deionized water (DI) elutriates of subsurface soil samples

		Subsurface DI Blank	Subsurface DI m-1	Subsurface DI m-2	Subsurface DI m-3	Subsurface DI m-4	Subsurface DI m-5
pH		6.15	7.34	7.43	6.84	6.73	7.24
Conductivity		7.4	2060	1820	405	907	NB
Alkalinity CaCO3		2.9	85.9	105	79.4	54.4	65.7
Oil & Grease		17.0	38.0	33.5	18.5	28.8	41.7
Metals							
Chromium	D Cr	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Copper	D Cu	<0.001	0.025	0.018	0.012	0.035	0.006
Lead	D Pb	0.003	0.004	0.003	0.044	0.046	0.052
Mercury	D Hg	<0.00005	0.00029	0.00016	<0.00005	<0.00005	0.00081
Nickel	D Ni	<0.001	0.013	0.008	0.012	0.003	<0.001
Zinc	D Zn	<0.001	<0.001	0.001	0.023	<0.001	0.012
Polychlorinated Biphenyl							
PCB'S		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Polynuclear Aromatic Hydrocarbons							
Acenaphthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acenaphthylene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Anthracene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Benzo(a)anthracene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(a)pyrene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(b)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(ghi)perylene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Benzo(k)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Chrysene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dibenzo(ah)anthracene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoranthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fluorene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Indeno(1,2,3-cd)pyrene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Naphthalene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phenanthrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pyrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

< = Less than
Results expressed as milligrams per litre except for pH and Conductivity (μmhos/cm).

Table 4 Summary of chemical analysis of dilute mineral water (DMW) elutriates of subsurface soil samples

		Subsurface DMW Blank	Subsurface DMW m-1	Subsurface DMW m-2	Subsurface DMW m-3	Subsurface DMW m-4	Subsurface DMW m-5
pH		6.92	7.24	7.42	7.34	7.37	7.03
Conductivity		94.7	2380	1990	495	860	2550
Alkalinity CaCO3		30.9	120	147	161	77.0	90.2
Oil & Grease		14.5	33.0	26.0	23.5	20.7	14.0
Metals							
Chromium	D Cr	<0.001	0.005	<0.001	0.001	<0.001	<0.001
Copper	D Cu	0.002	0.023	0.015	0.029	0.003	0.005
Lead	D Pb	<0.001	0.004	0.007	<0.001	<0.001	<0.001
Mercury	D Hg	<0.00005	0.00034	0.00039	<0.00005	0.00006	0.00025
Nickel	D Ni	<0.001	0.002	0.008	0.19	0.002	0.005
Zinc	D Zn	0.004	0.007	<0.001	0.027	<0.001	0.007
Polychlorinated Biphenyl							
PCB'S		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Polynuclear Aromatic Hydrocarbons							
Acenaphthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Acenaphthylene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Anthracene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Benzo(a)anthracene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(a)pyrene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(b)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Benzo(ghi)perylene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Benzo(k)fluoranthene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Chrysene		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dibenzo(ah)anthracene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoranthene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fluorene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Indeno(1,2,3-cd)pyrene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Naphthalene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phenanthrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pyrene		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

< = Less than
Results expressed as milligrams per litre except for pH and Conductivity (μmhos/cm).

3.1.3 Water Quality Parameters

Water quality parameters, pH, alkalinity, and salinity (or conductivity) were measured on sediment sample elutriates by both the bioassay and chemistry laboratories. The pH values reported by the latter (Tables 1-4) were consistently lower than those reported by the former (Tables 5-8). These differences may be attributed to the fact that elutriate samples were stored for some period before arrival at the chemical laboratory.

Conductivities reported by the chemical laboratory for the final elutriate samples analyzed were more precise than the salinity values reported by the bioassay laboratory. Conductivities were converted to approximate equivalents of salinity using the calibration curves provided with the YSI conductivity meter. Conductivities ranged from 954 to 3200 μ mhos/cm (approximately equivalent to 0.6 to 1.8 ppt salinity, at 20 °C) in DI elutriates of surface sediments (Table 2). Conductivities ranged from 7.4 to 2080 μmhos/cm (approximately 0.25 to 1.15 ppt, at 20 °C) in DI elutriates of subsurface sediments. Some error in estimation of salinity with the use of the refractometer method is associated with suspended particulates in the elutriate samples. Thus conductivities provide better estimates of total dissolved salts than the refractometer estimates.

Estimates of alkalinity in DI and DMW elutriates of all surface and subsurface samples showed similar trends (Tables 1-4). The chemical laboratory estimates were slightly higher than the bioassay laboratory estimates in the DI and DMW elutriates of surface sediments, and the DI elutriates of subsurface samples. The chemical laboratory estimates were slightly lower in the DMW elutriates of subsurface samples. However, these differences were too small (in the range of $\pm$ 10%) to be significant.

Dissolved oxygen (D.O.) in all the terminal pooled elutriates but one (DMW elutriate of subsurface sediment M1-3, Appendix B), exceeded bioassay test minimum standards of 5.0 mg/L (US EPA, 1985). (This sample exhibited no toxicity to test organisms, however; cf. Section 3.2.1).

3.2 Bioassays

3.2.1 Crustacean Tests

Results of the *Ceriodaphnia* bioassay tests of the surface and subsurface sediments are presented in Tables 5 and 6. Detailed results and raw data are included in Appendix B. The toxicity is expressed as the percentage of surviving (mobile) *Ceriodaphnia dubia* juveniles (30 individuals) after a 48 h exposure to each of the test solutions. Water quality parameters measured at the termination of the bioassays ranged as follows: temperature, 21-23 °C; alkalinity 27-588 mg/ml; pH, 7.1-8.5; D.O., greater than 8.0 mg/L.

Two series of tests were performed for the surface sediment samples. Sediment from two samples, M1-2 and M6-2, eluted with either deionized water (DI) or dilute mineral water (DMW) exhibited significant toxicity to the daphnids (Table 5). Elutriate preparations from surface samples M1-2 and M6-2 used to perform these bioassays were secondary elutriates prepared because the primary elutriate exhibited an elevated salinity content. It is known that the 24 hr LC50 for *Ceriodaphnia* (a fresh water daphnid), exposed to Cl^- is 2 g/L (~ 2 ppt). (Arthur, 1989). Thus, elutriates of estuarine sediments must exhibit salinities of less than 2 ppt in order to distinguish toxic effects of contaminants from those due to salinity alone. The secondary elutriates from samples M1-2 and M6-2 also demonstrated elevated salinities that could have accounted for their toxicity to the test animals. Therefore, a third series of DMW and DI water elutriates from surface samples M1-2 and M1-6 was prepared. In the subsequent bioassay series, toxicity to the daphnids was exhibited only by the DMW elutriate of surface sample M1-2 (Table 6). Although the salinity, as measured by the refractometer method, was believed to be less than 1 ppt (Table 6), the estimated conductivity of the sample was quite high (3750 μmhos/cm, Table 2, representing a salinity equivalent to 2.15 ppt), suggesting the presence of high levels of dissolved salts. Elevated salinity alone could have accounted for the toxicity of this sample to the daphnids.

None of the subsurface sample DI water elutriates exhibited a significant level of toxicity to *Ceriodaphnia* (Table 5). The DMW elutriate of subsurface sample M0-1 did exhibit toxicity. Elevated conductivity (2380 μmhos/cm approximately 1.35 ppt) may have accounted for the toxicity of this sample. In addition, the high levels of suspended solids as detected in this sample are also known to be detrimental to *Ceriodaphnia* (Arthur, 1989).

Table 5 Summarized data for survival of Ceriodaphnia exposed to surface and subsurface soil elutriates

mple	Percent Survival		Salinity (2)	pH	Alkalinity (3)	Hardness (4)
rface sediments						
DI Water elutriates						
1-1	100		0	8.0 - 8.2	232	146
1-2	90	(*)	1	8.1 - 8.1	263	652
M1-3	100		1	7.9 - 7.8	247	279
6-1	100		1	7.9 - 7.9	107	333
6-2	0	(*)	5	8.3 - 7.9	149	1238
M6-3	100		1	8.1 - 7.9	90	350
MW elutriates						
M1-1	100		1	7.1 - 8.5	345	215
1-2	13	(*)	2	7.3 - 8.2	588	NA
M1-3	100		1	7.2 - 8.0	336	235
M6-1	100		1	8.5 - 7.8	127	367
6-2	0	(*)	9	7.1 - 8.2	370	564
M6-3	100		1	7.7 - 8.3	222	445
face sediments						
DI Water elutriates						
01	93		0	8.2 - 7.8	84	123
M02	97		0	8.3 - 8.1	109	185
03	100		0	8.0 - 7.9	71	128
04	100		0	8.1 - 7.8	56	166
M05	100		0	8.3 - 7.3	64	178
MW elutriates						
M01	53	(1)	0	8.0 - 8.2	134.5	160 - 168
02	97		0	8.3 - 8.2	161	272
03	100		0	7.8 - 8.3	184	195
M04	100		0	8.2 - 8.1	94.5	176
05	100		0	8.2 - 8.0	103.5	188.5

(*) Mortality was associated with salinity. Testing of a third extract was conducted (cf. Table 6).
(1) High suspended particulates probably resulted in the observed toxicity
(2) Salinity = ppt, as measured by refractometer (cf. Tables 1-4 for conductivities of these samples)
(3) Alkalinity = mg/L
(4) Hardness = mg/L

Table 6 Summarized data for survival of Ceriodaphnia exposed to third elutriates of surface soils

Sample	Percent Survival	Salinity (1)	pH	Alkalinity (2)	Hardness (3)
Surface sediments					
DI Water elutriates					
M1-2	100	0	8.2 - 8.1	263	230
M6-2	100	1	7.9 - 8.1	151	379
DMW elutriates					
M1-2	47	<1	8.0 - 8.5	377	NA
M6-2	100	2	8.0 - 8.5	260	326

1 Salinity = ppt, as measured by refractometer (cf. Tables 1-4 for conductivities of these samples)
2 Alkalinity = mg/L
3 Hardness = mg/L

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3.2.2 Algal Tests

Results of the *Selanastrum capricornutum* 96 h growth bioassay test of surface and subsurface sediments are presented in Tables 7 and 8. Detailed results and raw data are included in Appendix B. The results are expressed as percent inhibition or percent stimulation of growth, as determined by cell counts, compared to a control.

Three surface sediment elutriates, M1-3, M6-1, and M6-3 stimulated growth in *Selenastrum*. Algal growth stimulation is not considered a toxic response (Walsh and Merrill, 1984). Three surface samples showed significant algal growth inhibition: M1-1, M1-2 and M6-2. However, samples M1-1 and M1-2 had high suspended solids and the elutriate from sample M6-2 exhibited elevated salinity. These are factors that may have contributed to the algal growth inhibition exhibited in the samples. As indicated above, a third DI water elutriate (filtered through diatomaceous earth) of surface samples M1-2 and M6-2 was prepared. Both of these samples showed stimulation of algal growth upon bioassay testing (Table 8).

The subsurface sediment elutriates of samples M0-2, M0-3 and M0-5 stimulated growth of *Selenastrum*. The subsurface sediment elutriates from sites M0-1 and M0-4 inhibited algal growth. However, elutriates from these two samples had high suspended solids that may have contributed to the observed levels of algal growth inhibition. In addition, sample M0-1 also exhibited the presence of small motile organisms that may have contributed to the reduction in algal biomass observed in this sample (USEPA, 1989). Because the elutriate samples were not filtered before testing, the unidentified organisms may have been introduced from the sediment samples during the elutriate process. These organisms may have been grazers that could reduce the algal biomass, or other species of algae that could out-compete the test alga for growth nutrients (USEPA, 1989).

3.2.3 Combined Toxicity Test Results

The range in pH (7.1 to 8.5, Tables 5, 6, 7, and 8) observed in the DI and DMW elutriate samples, was not considered detrimental to the health of the test daphnids nor to the alga, and probably did not contribute to the toxic responses, where observed. The differences in alkalinities and hardness, in DI and DMW elutriates of the same sediment sample, were attributable to the chemical contents of the 10% mineral water component of the elutriate. In general, the DMW elutriates of sediment samples were expected to be less toxic to the bioassay organisms than DI elutriates because the toxicity of most metals (except Hg) decreases with increasing water hardness (Chapman et al., 1982). Because neither PCB's nor PAH were detected in any elutriates of any sediment samples, organic contamination by these parameters can be ruled out as a toxicity factor to the test organisms.

Combined bioassay results suggest that the elutriates of only two samples, M1-2 and M0-1, exhibited significant toxicity to the bioassay organisms. The DMW elutriate of subsurface sample M0-1 exhibited a slightly elevated copper concentration relative to other subsurface sediment samples, but this value was lower than that reported for DI elutriate of M0-1 in which no toxicity was observed. The toxic response of the daphnids to this sample was probably due, in part, to the high level of suspended solids, as reported above. Examination of the results of the chemical analyses indicate that none of the chemical parameters including pH, salinity (measured by refractometer) and heavy metal concentrations were observed at sufficient levels to have influenced the toxicity of the DMW elutriate of sample M1-2 to the daphnids. However, examination of the conductivity measurements of the DMW elutriates of both of these samples reveal high values that suggest elevated total dissolved salts in the elutriates. Taken together, these results suggest that the toxic response observed in bioassays of these two elutriates was associated with the dissolved salts in the elutriates, rather than the tested metals and organic parameters. Thus, the results of this study indicate no toxicity that is clearly attributable to the chemical parameters analyzed.

Table 7 Summarized data for growth response of Selenastrum exposed to deionized water (DI) elutriates of surface and subsurface soil samples

Sample	Percent Growth Inhibition	Percent Growth Stimulation	Salinity (4)	pH	Alkalinity (5)	Hardness (6)
Surface sediments						
M1-1	49 (1,2)	--	0	8.0 - 8.2	232	146
M1-2	52 (1)	--	1	8.1 - 8.1	263	652
M1-3	--	64	1	7.9 - 7.8	247	279
M6-1	--	96	1	7.9 - 7.9	107	333
M6-2	68 (2,3,4)	--	5	8.3 - 7.9	149	1238
M6-3		102 (2)	1	8.1 - 7.9	90	350
Subsurface sediments						
M0-1	36 (1,2)	--				
M0-2	--	56 (1,2)	0	8.2 - 7.8	84	123
M0-3	--	86 (1,2)	0	8.3 - 8.1	109	185
M0-4	66 (1)	--	0	8.0 - 7.9	71	128
M0-5	--	29 (1,2)	0	8.1 - 7.8	56	166
			0	8.3 - 7.7	64	178

1 High suspended particulates probably contributed to effects.
2 Many small motile organisms present, probably contributed to effects.
3 Paramecium-like organism present, probably contributed to effects.
4 Salinity = 5 ppt, as measured by refractometer (cf. Tables 1-4 for conductivities of these samples)
5 Alkalinity = mg/L
6 Hardness = mg/L

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Table 8 Summarized data for growth response of Selanastrum exposed to third deionized water (DI) elutriates of surface soils filtered through diatomaceous earth

Sample	*Percent Growth Inhibition*	*Percent Growth Stimulation*	*Salinity (2)*	*pH*	*Alkalinity (3)*	*Hardness (4)*
Surface sediments						
M1-2	--	108 (1)	0	8.2 - 8.1	263	230
M6-2	--	236 (1)	1	7.9 - 8.1	151	379

1 Motile organisms present, probably contributed to effects.
2 Salinity = ppt, as measured by refractometer (cf. Tables 1-4 for conductivities of these samples)
3 Alkalinity = mg/L
4 Hardness = mg/L

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APPENDIX A

CHEMICAL DATA

RESULTS OF ANALYSIS - Hoffman Marsh
- Quality Assurance Data

File No. 9033A
Page 8 of 8

		Reagent Blank	Reagent Blank	EPA STANDARD FOUND VALUE	EPA STANDARD FOUND VALUE	EPA STANDARD CERTIFIED VALUE	% RECOVERY SPIKE	% RECOVERY SPIKE	KCl STANDARD @ 1413.	Na_2CO_3 STANDARD @ 0.05 N
pH		-	-	-	-	-	-	-	-	-
Conductivity		-	-	-	-	-	-	-	1412.	-
Alkalinity $CaCO_3$		-	-	-	-	-	-	-	-	0.050
Oil & Grease		1.2	1.2	6.1	4.6	5.0	-	-	-	-
Metals										
Cadmium	D Cd	<0.0002	<0.0002	0.010	0.010	0.010	-	-	-	-
Chromium	D Cr	<0.001	<0.001	0.010	0.011	0.010	-	-	-	-
Copper	D Cu	<0.001	<0.001	0.011	0.009	0.010	-	-	-	-
Lead	D Pb	<0.001	<0.001	0.010	0.011	0.010	-	-	-	-
Mercury	D Hg	<0.00005	<0.00005	0.0050	0.0049	0.0049	-	-	-	-
Nickel	D Ni	<0.001	<0.001	0.013	0.010	0.010	-	-	-	-
Zinc	D Zn	<0.001	<0.001	0.011	0.010	0.010	-	-	-	-
Polychlorinated Biphenyl										
PCB'S		<0.005	<0.005	-	-	-	117	68	-	-
Polynuclear Aromatic Hydrocarbons										
Acenaphthene		<0.002	<0.002	0.036	0.026	D-0.11	-	-	-	-
Acenaphthylene		<0.002	<0.002	-	-	-	-	-	-	-
Anthracene		<0.002	<0.002	-	0.084	0.011-0.11	-	-	-	-
Benzo(a)anthracene		<0.004	<0.004	0.004	-	0.003-0.012	-	-	-	-
Benzo(a)pyrene		<0.004	<0.004	0.007	-	0-0.011	-	-	-	-
[illegible](b)fluoranthene		<0.004	<0.004	0.007	-	0.002-0.014	-	-	-	-
Benzo(ghi)perylene		<0.005	<0.005	0.007	-	D-0.010	-	-	-	-
Benzo(k)fluoranthene		<0.004	<0.004	-	0.005	-	-	-	-	-
Chrysene		<0.004	<0.004	0.007	0.011	D-0.018	-	-	-	-
Dibenzo(ah)anthracene		<0.005	<0.005	-	-	-	-	-	-	-
Fluoranthene		<0.002	<0.002	-	-	0.003-0.011	-	-	-	-
Fluorene		<0.002	<0.002	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene		<0.005	<0.005	-	0.005	0.001-0.01	-	-	-	-
Naphthalene		<0.005	<0.005	-	0.002	0.022-0.10	-	-	-	-
Phenanthrene		<0.002	<0.002	0.028	-	0.008-0.013	-	-	-	-
Pyrene		<0.002	<0.002	-	0.009	0.001-0.012	-	-	-	-

< = Less than
Results expressed as milligrams per litre except for pH and Conductivity (µmhos/cm).

LG006739

U.S. Environmental Protection Agency
Environmental Monitoring and Support Laboratory - Cincinnati

WATER POLLUTION QUALITY CONTROL SAMPLES

TRUE VALUES

POLYNUCLEAR AROMATICS - II

When diluted to volume according to instructions, the sample contain the following compounds at these concentrations expressed as ug/liter.

Parameter	True Value ug/L	Limit for S ug/L	Range for $\bar{X}$ ug/L	Range for P,Ps %
Acenaphthylene	100	45.1	2.1 - 112.1	0-139
Phenanthrene	100	37.7	8.4 - 133.7	0-155
Fluoranthene	10.0	3.0	2.7 - 11.1	14-123
Benzo(a)Anthracene	10.0	4.0	3.1 - 11.6	12-135
Benzo(a)Pyrene	10.0	4.0	0.2 - 11.0	0-128
Benzo(b)Fluoranthene	10.0	3.1	1.8 - 13.8	6-150
Dibenzo(a,h)Anthracene	10.0	2.0	0.3 - 10.0	0-110
Benzo(g,h,i)Perylene	10.0	2.3	0 - 10.7	0-116

S = Standard deviation of four recovery measurements: (Section 8.2.4.)
$\bar{X}$ = Average recovery of four measurements: (Section 8.2.4.)
P,Ps = Percent recovery measured: (Section 8.3.2 and Section 8.4.2.)
D = Detected; result must be greater than zero

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APPENDIX B

RAW BIOASSAY DATA

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

SAMPLE Hoffman Marsh with DI water

DATE COLLECTED Surface

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm) 0	96		ALK mg/L 0	48	H m 48
	Sept 20/89	1/15 ml	Control DMW							100					8.6			23		22					7.5							33	39
			DI Control							57			9.4		8.4			23		22			5.7		7.2								
			DI Control w/ H_2SO_4							0			9.3		8.4			23		22			3.5		3.4							—	—
			M6-1							100			8.0		8.3			23		22			7.9		7.9							107	333
			M6-3							100			8.9		8.3			23		22			8.1		7.9							90	350
			M1-3							100			8.0		3.6			23		22			7.9		7.8							247	279
			M1-1							100			8.8		6.8			23		22			8.0		8.2							232	146

SAMPLE DESCRIPTION

COMMENTS

LG006742

(g) _____ RANGE _____

_____ RANGE _____

DATA VERIFIED BY _____ E.V.S. CONSULTANTS

DATE _____

E.V.S. CONSULTANTS

SAMPLE Hoffman Marsh with DMW

DATE COLLECTED Surface

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours)									DISSOLVED OXYGEN (mg/L)					TEMPERATURE (°C)					pH					CONDUCTIVITY (umhos/cm)			ALK mg/L	
				1	2	4	8	18	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96		48	
	Sept 23/89	1/15ml	DMW Control							100			9.0		9.0			23		23			6.1		7.2						35	
			M1-1							100			9.0		8.3			23		23			7.8		8.5						345	
			M1-3							100			9.3		2.0			23		23			7.2		8.0						336	
			M6-1							100			9.4		7.4			23		23			8.5		7.8						127	
			M6-3							100			9.4		7.9			23		23			7.7		8.3						222	

SAMPLE DESCRIPTION

COMMENTS

RANGE

RANGE

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE

LG006743

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

AMPLE Hoffman Marsh - DMW

ATE COLLECTED Surface

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm) 0	96	—		ALK mg/L 48	H. m 48
	Sept 28/89	1/15 ml	DMW Control							100			9.0		8.7			23		22			7.2		6.4							30	42
			M1-Z							13			4.0		0.4			22		22			7.3		8.2							588	—
			M6-Z							0			6.7		5.8			22		22			7.1		8.2							370	541

SAMPLE DESCRIPTION

COMMENTS

RANGE

RANGE

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE

LG006744

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

AMPLE Hoffman Marsh with D.I. water

DATE COLLECTED Surface

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm) 0	96		ALK mg/L 0	48	H. m 48
	Oct 7 1989	1/15ml	DI Control w/ H_2SO_4							0			8.4		8.6			22		21			3.9		3.9								—	2
			M1-2							90			8.4		5.4			22		21			8.1		8.1								263	652
			M6-2							0			8.4		7.2			22		21			8.3		7.9								149	123
			Control DMW							100			8.7		8.6			22		21			8.0		6.9								27	41

SAMPLE DESCRIPTION

COMMENTS

RANGE

RANGE

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE

LG006745

E.V.S. CONSULTANTS

SAMPLE Hoffman Marsh - DI water

DATE COLLECTED Subsurface

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm)			ALK mg/L		
	Oct 7, 1989	1/15ml	DI Control w/ H_2SO_4							57			8.4		8.6			21		21			58		5.4						—		11
			mØ1							93			8.6		7.8			21		21			8.2		7.8						84		10
			mØ2							97			8.6		8.4			21		21			8.3		8.1						109		18
			mØ3							100			9.1		8.0			21		21			8.0		7.9						71		18
			mØ4							100			8.9		6.9			21		21			8.1		7.8						56		16
			mØ5							100			9.0		7.4			21		21			8.3		7.7						64		17
			DMW Control							100			8.7		8.6			21		21			8.0		6.9						27		4

SAMPLE DESCRIPTION

COMMENTS

RANGE

RANGE

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE

LG006746

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

SAMPLE Hoffman Marsh

DATE COLLECTED Subsurface

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm) 0	96	ALK mg/L 0	96
	Oct 11/89	2/30ml	Nitrogen Control							100			9.3		8.9			18		21			7.7		7.2						
			mØ1							53			8.7		8.4			20		21			8.2		8.0						
			mØ2							97			8.7		8.8			20		21			8.3		8.2						
			mØ4							100			8.9		8.9			20		21			8.2		8.1						
			mØ5							100			8.9		8.9			20		21			8.2		8.0						
	Oct. 14/89	2/30ml	Control							100			9.8		9.1			20		21			7.6		7.5						
			mØ3							100			9.9		9.1			20		21			7.8		8.3						

SAMPLE DESCRIPTION

COMMENTS All salinities are 0-1 ‰
Nitrogen control means that the sample was treated with nitroge gas in the same manner as all others.

RANGE

RANGE

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE

LG006747

E.V.S. CONSULTANTS

SAMPLE Hoffman Marsh

DATE COLLECTED

ACUTE LETHALITY BIOASSAY DATA

Ceriodaphnia

E.V.S. PROJECT NO. 9/420-02

WORK ORDER NO.

LAB NO.	TEST DATE & TIME	NO. VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours) 1	2	4	8	18	24	48	72	96	DISSOLVED OXYGEN (mg/L) 0	24	48	72	96	TEMPERATURE (°C) 0	24	48	72	96	pH 0	24	48	72	96	CONDUCTIVITY (umhos/cm) 0	96		ALK mg/L	
	Oct 21 1989	2/30ml	D1 Control							0			8.9		8.1			22					5.6		6.2						4.5	
			DMW Control							100			8.8		8.0			22		23			5.9		7.6						34	
			Control w/ 1N H_2SO_4							57			9.4		8.1			22		23			5.0		5.8						0	
			Control w/ [H_2SO_4]							0			9.5		8.1			22		23			3.8		3.7						—	
			D1 w/ D.E.							83			8.9		8.2			22		23			5.8		6.3						3.5	
			DMW w/ D.E.							100			9.5		8.2			22		23			6.3		7.6						37	
			M1-2 D1							100			8.9		5.5			22		23.5			8.2		8.1						263	
3rd			M1-2 DMW							47			9.1		6.7			22		23.5			8.0		8.5						377	
Elutriates			M16-2 D1							100			9.0		7.1			22		23.5			7.9		8.1						151	
			M16-2 DMW							100			9.0		7.5			22		23.5			8.0		8.5						260	

SAMPLE DESCRIPTION D.E. = Diatomatious Earth.

COMMENTS Salinity after filtration w/ diatomatious earth and 0.45 μm filter: M1-2 D1 = 0, M1-2 DMW = <1, M16-2 D1 = 1, M16-2 DMW = 2, all other are zero. (Using EVS Reichert Refractometer)

DATA VERIFIED BY _____ E.V.S. CONSULTANTS

DATE _____

LG006748

Surface

TABLE 1

Elutriate % (v/v)[a] a	Growth Response: Cells/mL 1000[a]	Cells/mL 1000 (Log 10)[a]	Percent Inhibition of Growth I%[a] b	Percent Stimulation of Growth S%[a] c
Control without H_2SO_4	250	2.3979		
	210	2.3222		
	255	2.4065		
	$\bar{X}$ = 240	2.3755		
Control with H_2SO_4 [Conc]	25	1.3979		
	25	1.3979		
	5	0.6990	93	
	$\bar{X}$ = 18	1.1649		
M1-1	130	2.1139		
	70	1.8451	49	(583)
	170	2.2304		
	$\bar{X}$ = 123	2.0631		
M1-3	510	2.7076		
	330	2.5185		
	340	2.5315		64 (2083)
	$\bar{X}$ = 393	2.5859		
M6-1	415	2.6180		
	585	2.7672		96 (2511)
	410	2.6128		
	$\bar{X}$ = 470	2.6660		
M6-3	505	2.7033		
	315	2.4983		102 (2594)
	635	2.8028		
	$\bar{X}$ = 485	2.6681		
	$\bar{X}$ =			
	$\bar{X}$ =			

( ) Brackets denote Inhibition and Stimulation values determined relative to H_2SO_4 controls.

LG006749

Seleniastrum

Surface

TABLE 2

Elutriate % (v/v)# a	Growth Response: Cells/mL 1000#	Cells/mL 1000 (Log 10)#	Percent Inhibition of Growth I%# b	Percent Stimulation of Growth S%# c
Control without H_2SO_4	175	2.2430		
	170	2.2304		
	125	2.0969		
	$\bar{X}$ = 157	2.1901		
Control with H_2SO_4 [conc]	200	2.3010		
	225	2.3522		
	120	2.0792		
	$\bar{X}$ = 182	2.2441		
M1-2	15	1.1761		
	95	1.9777		
	115	2.0607	52(59)	
	$\bar{X}$ = 75	1.7382		
M6-2	75	1.8751		
	35	1.5441		
	40	1.6021	68(73)	
	$\bar{X}$ = 50	1.6938		
	$\bar{X}$ =			
	$\bar{X}$ =			
	$\bar{X}$ =			
	$\bar{X}$ =			

( ) Brackets denote Inhibition and Stimulation values determined relative to H_2SO_4 controls

Selenastrum

LG006750

Sub-surface

TABLE 3

Elutriate % (v/v)* a	Growth Response: Cells/mL 1000*	Cells/mL 1000 (Log 10)*	Percent Inhibition of Growth 1%* b	Percent Stimulation of Growth 5%* c
Control without H_2SO_4 (No Nitrogen)	175	2.2430		
	170	2.2304		
	125	2.0969		
	$\bar{X}$ = 157	2.1901		
Control with H_2SO_4 1N	210	2.3222		
	245	2.3892		
	365	2.5623		
	$\bar{X}$ = 273	2.4246		
mØ1	95	1.9777		
	135	2.1303		
	70	1.8451	36 (63)	
	$\bar{X}$ = 100	1.9844		
mØ2	295	2.4698		
	185	2.2672		
	255	2.4065	(10)	56
	$\bar{X}$ = 245	2.3812		
mØ3	390	2.5911		
	240	2.3802		
	245	2.3892		86 (7)
	$\bar{X}$ = 292	2.4535		
mØ4	35	1.5441		
	60	1.7782		
	65	1.8129	66 (81)	
	$\bar{X}$ = 53	1.7117		
mØ5	240	2.3802		
	130	2.1139		
	240	2.3802	(26)	29
	$\bar{X}$ = 203	2.2914		
	$\bar{X}$ =			

(*) Brackets denote inhibition and Stimulation values determined relative to H_2SO_4 controls

Selenastrum

LG006751

9/420-02
Hoffman Marsh

Sample	#	Counts 1	2	$\bar{x}$	Comments
DI Control	A	20	25	22.5	Some debris
	B	32	26	29	
	C	20	22	21	
DI Control w/ 1N H_2SO_4	A	82	68	75	Small motile organisms, debris
	B	57	80	68.5	enlarged + straightened cells
	C	71	73	71	ie
DI Control w/ conc. H_2SO_4 = $[H_2SO_4]$	A	33	47	40	Some debris
	B	32	40	36	motile organisms
	C	38	44	41	straightened cells
Control w/ Diatamatious Earth	A	42	36	39	very small motile organisms
	B	45	58	51.5	
	C	37	41	39	
M1-2	A	68	72	70	debris, small motile organisms
	B	79	99	89	enlarged cells, clumping
	C	109	113	111	many cells shaped:
M6-2	A	147	121	134	clumping, enlarged cells
	B	173	151	162	straightening of cells.
	C	120	159	139.5	small motile organisms

LG006752

Selenastrum

Also: - round spheres
- motile
- ~ 3x Selenastrum in size

FINAL CONCENTRATION OF MACRONUTRIENTS AND MICRONUTRIENTS IN THE CULTURE MEDIUM

Macronutrient	Concentration (mg/L)	Element	Concentration (mg/L)
$NaNO_3$	25.5	N	4.20
$MgCl_2 \cdot 6H_2O$	12.2	Mg	2.90
$CaCl_2 \cdot 2H_2O$	4.41	Ca	1.20
$MgSO_4 \cdot 7H_2O$	14.7	S	1.91
K_2HPO_4	1.04	P	0.186
$NaHCO_3$	15.0	Na	11.0
		K	0.469
		C	2.14

Micronutrient	Concentration (ug/L)	Element	Concentration (ug/L)
H_3BO_3	185	B	32.5
$MnCl_2 \cdot 4H_2O$	416	Mn	115
$ZnCl_2$	3.27	Zn	1.57
$CoCl_2 \cdot 6H_2O$	1.43	Co	0.354
$CuCl_2 \cdot 2H_2O$	0.012	Cu	0.004
$Na_2MoO_4 \cdot 2H_2O$	7.26	Mo	2.88
$FeCl_3 \cdot 6H_2O$	160	Fe	33.1
$Na_2EDTA \cdot 2H_2O$	300	--	----

Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, Second Edition, EPA/600/4-89/001

LG006753

ATTACHMENT C

Revised Bioassay Workplan

Kennedy/Jenks/Chilton

Consulting Engineers

Marathon Plaza, Tenth Floor North
303 Second Street
San Francisco, California 94107
415-362-6065

24 August 1989

Mr. Rick Robison
Department of Health Services
Toxic Substances Control Division
2151 Berkeley Way, Annex 7
Berkeley, California 94704

Subject: Proposed Bioassay Workplan
Liquid Gold Site, Richmond, California
(K/J/C 855018.05-G-01)

Dear Mr. Robison:

Agency comments on the revised bioassay workplan submitted 31 July 1989 for Southern Pacific Transportation Company's (SPT Co.) Liquid Gold site in Richmond, California were discussed with you last week. Written comments to the Department of Health Services (DHS) from the National Oceanic and Atmospheric Administration (NOAA), the Department of Fish and Game (DFG), and the Regional Water Quality Control Board (RWQCB) were also provided to us. Clarifications and modifications of the bioassay workplan were agreed to orally, and approval was given by you in a letter to SPT Co. dated 17 August 1989. On behalf of SPT Co., in this letter we are providing further documentation of the agreed to revisions to the bioassay workplan.

Sample Locations

The DHS, NOAA, and DFG wanted clarification of the choice of the subsurface soil sampling locations in the former activity area, and the DFG also requested locations at the periphery of the site. The subsurface soil locations were chosen near previous locations that showed potentially high subsurface chemical concentrations, primarily metals. As discussed during our telephone conversations, sample location MO-2 was moved to the southern end of the former activity area near previous locations showing elevated metal concentrations at the 5 to 6.5 foot level so that the subsurface samples would be more representative of potentially elevated metal concentrations over a larger site area.

Two additional subsurface soil locations have also been added in response to DFG comments. Subsurface soil sample location MO-4 was added at surface soil sample location M6-3, which is located outside of the former activity area and closer to the marsh. Subsurface metal concentrations at potentially elevated levels were previously found at this location. Subsurface soil sample location MO-5 was added near surface soil sample location M6-2 at the upper

end of the southwestern drainage channel. The reasons for choosing the five subsurface soil sampling locations are summarized below:

MO-1 -- Located in the former activity area near previous location 26. Data from 1983 showed possibly elevated levels of zinc and lead at 0 to 1.5 feet. Relatively high levels of oil and grease may be present.

MO-2 -- Located at the southern end of the former activity area near previous locations 8 and 116. Data from 1983 showed possibly elevated levels of lead at 5 to 6.5 feet at location 8. Data from 1988 showed possibly elevated levels of lead, mercury and zinc at 5.5 feet at location 116. Oil and grease may also be present at this location.

MO-3 -- Located in the former activity area near previous locations 35 and 122. These locations are immediately south of the area excavated during interim remedial action. Data from 1983 showed possibly elevated levels of lead at 5 to 6.5 feet at location 35. Data from 1988 showed possibly elevated levels of lead and zinc at 2 feet, and lead at 5.5 feet at location 122.

MO-4 -- Located outside of the former activity area near previous location 51. This location is closer to the marsh than the former activity area. Data from 1983 showed possibly elevated levels of zinc at 5 to 6.5 feet at location 51.

MO-5 -- Located near the upper end of the southwest drainage channel.

The revised sampling locations are shown on Figure 1. Data on samples from the previous borings are provided in the Scoping Document (June 1988) for the October 1983 data and the Soil Sampling Report (1 December 1988) for the September 1988 data. Samples will be collected in four 1.5 foot cores, to a total depth of approximately 6 feet. Sampling will be to this depth because higher levels of metals may be associated with the fill layer at approximately 5 to 6.5 feet.

Adjustment of pH

The DFG commented on the method of lowering the pH of the water to be used in the soil elutriation, and suggested using sulfuric or nitric acid. Exposing deionized water to air was chosen in an attempt to simulate natural rainwater. Pure water in equilibrium with air has a pH of approximately 5.7 due to the presence of dissolved carbon dioxide. Our experience with deionized water exposed to air is that a pH of approximately 5.9 will be achieved. However, we agree to lower the pH of deionized water to this level using sulfuric acid

to incorporate the DFG's comment. This approach will attempt to simulate rainwater slightly acidified from sources other than carbon dioxide.

Interpretation of Results

NOAA commented on the interpretation of bioassay test results, and stated that the possibility of harm to marsh organisms must be evaluated using all of the available data. We agree with this comment, and did not intend to imply that bioassay results alone would be used in evaluating the potential for harm to the marsh. Negative bioassay results will serve as an indication of lack of harm to marsh organisms. The complete evaluation will include additional information obtained during the remedial investigation, such as results of the dry season ecological field study, chemical concentrations in samples, and characteristics of groundwater flow. Conclusions will be based on an evaluation of all these data.

We hope that these responses satisfactorily document our revisions agreed to with the DHS. If you have any questions regarding this matter, please call us.

Very truly yours,

KENNEDY/JENKS/CHILTON, INC.

Michael T Poulsen

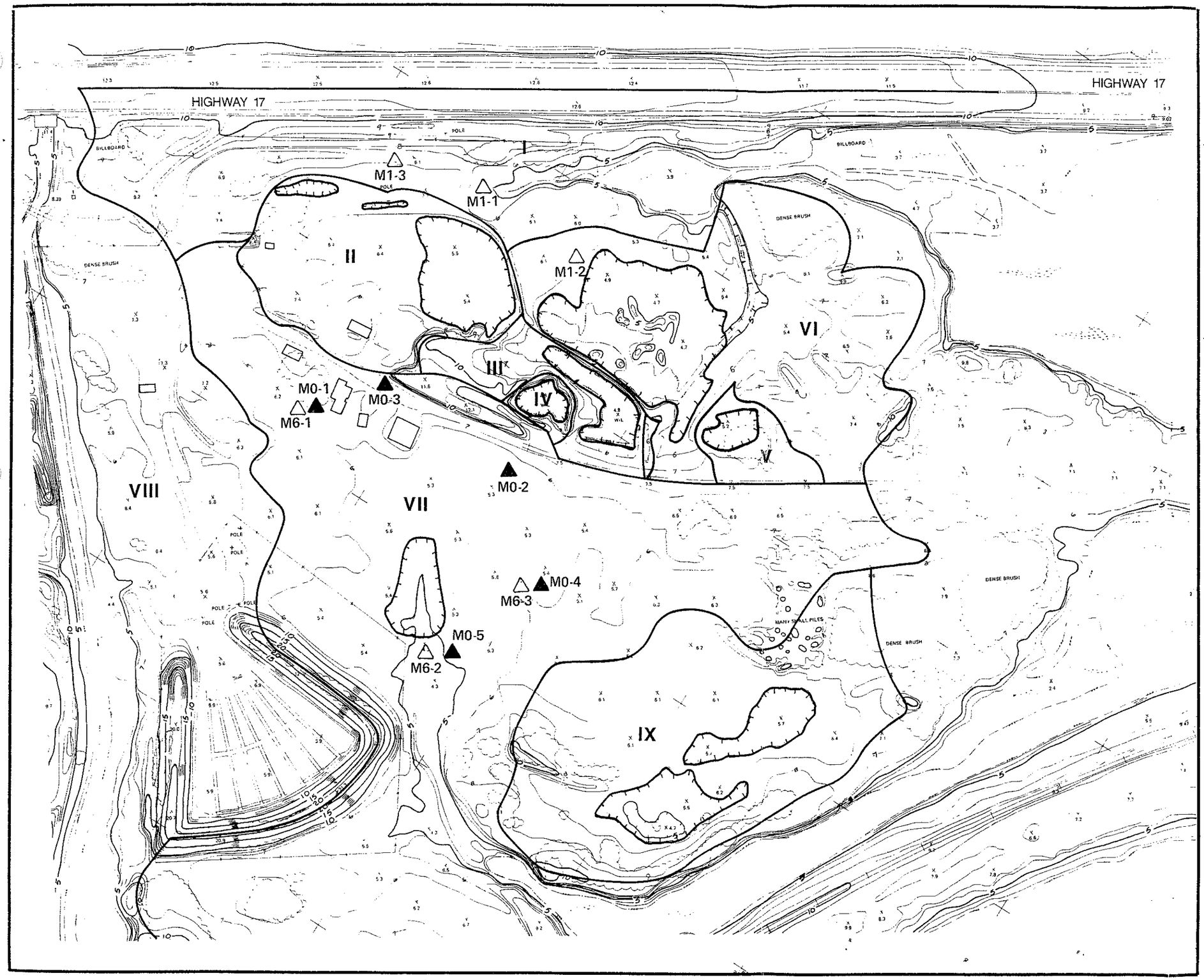
Michael T. Poulsen
Project Scientist

Aniko R. Molnar

Aniko R. Molnar
Project Manager

MTP/ARM:jtwWPC5

Attachment



0 125 250

Scale in Feet
(Approx)

Basemap Reference

Hammon, Jensen, Wallen & Associates.
Job number 5841. Flown 26 November 1984.
Airphoto negative scale 1 inch = 300 feet.

Legend

Drainage area boundary

IX Drainage area designated number

Area of ponding

M1-1 △ Surface Soil Sample Location

M0-1 ▲ Subsurface Soil Sample Location

Notes:

1. All boundaries shown are approximate. Boundaries are based on features shown on topographic map and on field observation by K/J/C in November 1987.

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Soil Sampling Locations

LG006758

K/J/C 855018.05
August 1989

Figure 1

Attachment to Kennedy/Jenks/Chilton's
letter to Department of Health Services
dated 24 August 1989

cc: Mr. Steven Ritchie
Executive Officer
California Regional Water Quality Control Board
San Francisco Bay Region
1111 Jackson Street Room 6040
Oakland, CA 94607

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U.S. Environmental Protection Agency
215 Fremont Street
San Francisco, CA 94105

Mr. Michael Rugg
Department of Fish and Game
P.O. Box 47
Yountville, CA 94599

Mr. Chip Demerset (T-6)
National Oceanic and Atmospheric Administration
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Mr. Mark Ransom
Southern Pacific Transportation Company
Southern Pacific Building, Room 1004
One Market Plaza
San Francisco, CA 94105

Kennedy/Jenks/Chilton

Consulting Engineers

Marathon Plaza, Tenth Floor North
303 Second Street
San Francisco, California 94107
415-362-6065

31 July 1989

Mr. Howard Hatayama
California Department of Health Services
Toxic Substances Control Division
2151 Berkeley Way, Annex 7
Berkeley, CA 94704

Subject: Revised Bioassay Workplan
Liquid Gold Site, Richmond, California
(K/J/C 855018.05-G-01)

Dear Mr. Hatayama:

On behalf of Southern Pacific Transportation Company (SPT Co.), we are transmitting a revised workplan for a bioassay on elutriates of soil samples from SPT Co.'s Liquid Gold site in Richmond, California.

BACKGROUND

The bioassay workplan was originally proposed in a letter from Kennedy/Jenks/Chilton (K/J/C) to the Department of Health Services (DHS) dated 19 April 1989. The DHS transmitted comments from the interested agencies on the workplan to SPT Co. in a letter dated 16 May 1989. K/J/C responded to these comments in a letter to DHS dated 22 June 1989. A meeting was held on 7 July 1989 between K/J/C and representatives of DHS and the Department of Fish and Game (DFG) to discuss K/J/C's proposed revisions to the workplan and responses to agency comments. Written comments from the DFG were distributed at the meeting. Additional written comments from the agencies were transmitted to SPT Co. by DHS in a letter dated 17 July 1989. The attached revised bioassay workplan (Attachment A) is intended to address the remaining agency concerns. The most significant changes are discussed herein.

DISCUSSION OF ISSUES

The major concern expressed by the agencies is the effect on aquatic organisms of chemicals in shallow groundwater flowing into the marsh during the wet season. The agencies suggested a bioassay on elutriates of subsurface soil samples to address this concern. The original response to this comment (presented in K/J/C's 22 June 1989 letter to DHS) was that a bioassay on groundwater would be more appropriate than a bioassay on subsurface soil elutriates because groundwater is the actual transport medium. It was recommended that the need for a bioassay on groundwater be evaluated in the Remedial Investigation (RI) report in the context of the other data from the site. The reasons given for why a bioassay on groundwater would be inappropriate at this time were:

- Although indications of a tidal influence were found, the magnitude is still being evaluated and may be small.
- Groundwater flow is probably slow, and may occur only during a limited part of the year.
- Dilution of groundwater in surface water has not been characterized.
- There are no strong indications that groundwater will have acute toxicity.
- Groundwater is saline, and therefore not appropriate for an evaluation of effects on freshwater species.

The two agencies represented at the 7 July 1989 meeting continued to request that subsurface soils be tested for toxicity. Therefore, in the interest of proceeding with the remedial investigation, we are proposing a bioassay on elutriates of subsurface soil samples which we think satisfies the concerns expressed by DFG and DHS.

At the 7 July 1989 meeting it was agreed to conduct the surface soil elutriate test starting with lower pH water (e.g. pH 6.0 to 6.5). In addition, a concurrent bioassay will be performed using water starting at a higher pH, approximately 7.6 for the Ceriodaphnia test.

LIMITATIONS OF ELUTRIATE BIOASSAY TEST

Testing of normal wet season groundwater, the actual medium in which chemicals will be transported, would be preferable to testing elutriates of subsurface soils. However, there are currently dry season conditions at the site, and the groundwater has different characteristics than wet season groundwater, most noteably a higher salinity. The first clear indications of groundwater flow during a wet season were seen in an evaluation of the Winter 1989 groundwater measurement data, and it is not yet known if groundwater samples collected during the past winter would be indicative of normal wet season conditions. Indications are that local rainfall amounts may have been normal during the past winter despite regional drought conditions. It is not feasible to simulate wet season groundwater conditions using dry season groundwater, primarily because salinity cannot be reduced without reducing dissolved chemical concentrations.

The testing of subsurface soil elutriates is not expected to duplicate groundwater entering the marsh during actual wet season conditions. During a storm event, most of the rainwater will infiltrate the soil, and a smaller percentage will run off the site (Scoping Document, June 1988). The rainwater

will leach down to groundwater, and then the groundwater will slowly move in the direction of the South Drainage channel. Based on a preliminary evaluation of the data, groundwater is expected to be flowing only during the wet season for a period of 3 to 4 months. The rate of groundwater flow, on an annual basis, is estimated to range from 0.6 m/yr to 20 m/yr. The areas of past activity on the site are over 100 meters from the drainage channel in the direction of groundwater flow, so groundwater from these areas is expected to take from 5 to 150 years to move to surface water. During this travel time, the groundwater will be interacting with soils of potentially variable chemical composition. The changes to chemical concentrations in groundwater that occur spatially and over time cannot be realistically duplicated. In addition, given the maximum estimated groundwater flow rate of 20 m/yr, the contribution of groundwater entering surface water in the drainage channel is expected to be less than 0.5 percent of the average volume of water in the drainage channel.

For these reasons, a soil elutriate does not duplicate conditions resulting from groundwater flow to the marsh that aquatic organisms will be exposed to during a wet season, and the results will need to be cautiously interpreted. Because of the limitations of a soil elutriate bioassay in simulating wet season marsh conditions, bioassay results showing toxicity will be difficult to interpret. Indications of toxicity in this screening study may result in the recommendation for an additional bioassay on wet season groundwater. The study has been designed using a conservative approach, so interpretation of negative toxicity results will be more straightforward. The conservative features of the study include:

- collection of samples in the old activity areas
- preparation of elutriates of soil instead of leachates
- testing of an expected low salinity elutriate rather than a sample at the salinity expected in the drainage channel
- filtering elutriate water through a 100 micon filter although site soils may be a more effective filter
- not incorporating attenuation effects of groundwater movement
- not incorporating dilution effects of groundwater entering surface water.

Given the conservative situation being tested, bioassay results showing a lack of toxicity may be included in the remedial investigation report as an indication of the lack of harm from groundwater discharges to surface water during a wet season.

We have discussed the proposed changes to the bioassay workplan with the interested agencies and hope that documented revisions will be acceptable. If you have any questions regarding this matter, please contact us.

Very truly yours,

KENNEDY/JENKS/CHILTON, INC.

William R Mohay / for

Aniko R. Molnar
Project Manager

Michael T Poulsen / for

Kimberly A. Walsh
Project Biologist

Michael T Poulsen

Michael T. Poulsen
Project Scientist

ARM/KAW/MTP:jtw33D
Attachment

Attachment to Kennedy/Jenks/Chilton's
letter to Department of Health Services
dated 31 July 1989

cc: Mr. Steven Ritchie
Executive Officer
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1111 Jackson Street, Room 6040
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San Francisco, CA 94105

Attachment to Kennedy/Jenks/Chilton's
letter to Department of Health Services
dated 31 July 1989

PROPOSED BIOASSAY WORKPLAN
REVISED 31 JULY 1989

LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.05-G-01)

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LG006766

LIST OF TABLES

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PROPOSED BIOASSAY WORKPLAN FOR LIQUID GOLD SITE

1. INTRODUCTION

This report provides a workplan for bioassay studies proposed as part of the remedial investigation (RI) for Southern Pacific Transportation Company's (STP Co.) Liquid Gold site in Richmond, California.

1.1 Background

As part of the RI, an ecological study of marsh areas adjacent to the site is currently being conducted. The ecological study was to consist of various tasks including two benthos sampling efforts; the first effort scheduled to occur during dry season conditions, and the second effort scheduled to occur during wet season conditions. Dry season sampling was conducted in October 1988.

A meeting with the agencies was held on 27 February 1988 to present the preliminary results of the dry season sampling, and to discuss the consequences of the continuing low delta outflows to the bay. It was decided that unless the situation changed significantly, wet season sampling should not be performed. As a followup to a suggestion by the Department of Fish and Game at this meeting, it was proposed in a letter from Kennedy/Jenks/Chilton (K/J/C) to Department of Health Services (DHS) dated 14 April 1989 that further work to evaluate potential environmental effects due to the site be focused on the issue of site surface runoff to the marsh during storm events. The potential toxicity of site surface soil elutriate and therefore site runoff will be investigated using the bioassay techniques presented herein.

A proposed workplan was submitted to the agencies on 19 April 1989. In response to comments from the agencies transmitted by DHS to SPT Co. in a letter dated 16 May 1989, revisions to the workplan were submitted to the DHS on 22 June 1989. On the basis of subsequent discussions with the agencies, further revisions were incorporated into the workplan, primarily to address subsurface soils. This revised workplan incorporates all the changes discussed with the agencies.

1.2 Objective

The objective of the study is to evaluate potential acute effects of storm water runoff and wet season groundwater on aquatic organisms in the adjacent marsh. The proposed bioassay study will be a screen of surface soil and subsurface soil elutriates for acute toxicity to freshwater organisms. The bioassay cannot be performed on organisms taken from the marsh because wet season conditions have not occurred this year and it is questionable whether the dominant dry season species would be viable under low salinity conditions. Also, organisms endemic to the marsh may have adapted to the chemical concentrations present in the study area. However, the proposed bioassays using freshwater species are designed to be sensitive enough to serve as indicators of potential risk to resident marsh species.

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1.3 Approach

Two types of soil elutriate tests will be performed:

Test A - using surface soil elutriates to evaluate storm water runoff

Test B - using subsurface soil elutriates to evaluate wet season groundwater

Differences in the tests were designed in an attempt to better represent the conditions being evaluated.

For Test A, a phased approach will be used to evaluate potential toxicity of elutriates of both types of site soil. Phase I is designed to screen soil elutriates for acute toxicity. Phase I tests and sampling are discussed in detail in this workplan. Phase II may be conducted if toxic responses are indicated during Phase I. If Phase II is conducted, an addendum to this workplan will be prepared detailing the testing and reporting planned for Phase II.

Surface soil from areas of the site potentially draining to the marsh will be collected for Test A (Phase I), and subsurface soil samples from the former activity areas will be collected for Test B. Elutriates of the soil will be prepared and potential acute toxicity of the elutriates will be tested using accepted bioassay techniques. An algae growth test and an invertebrate survival test will be used for initial screening. An overall summary of the Phase I bioassay tests is given in Table 1.

The approach for Phase II of Test A, if it is warranted, will be to evaluate toxicity of site soil elutriates using a burrowing amphipod test. The amphipod test will be conducted under conditions that more closely simulate the environment of the marsh. Elutriates will be tested over a range of salinities. The burrowing amphipod more closely represents the benthos indigenous to the marsh. Additionally, if Phase II is conducted, chemical analyses will be done on site soil and on the elutriates tested. Because of the importance of using the same soil samples for both Phase I and Phase II, results from Phase I will be obtained and interpreted so that Phase II, if necessary, can be started within six weeks of sample collection.

Test B results will be evaluated, and recommendations will be included in the RI report if additional testing, such as a bioassay on wet season groundwater, appears warranted.

2. SOIL SAMPLE COLLECTION AND PREPARATION

The rationale for the locations chosen for soil sampling and the field methods to be used in collecting the samples are discussed below.

2.1 Locations

Surface and subsurface soil sampling locations are shown on Figure 1. Sampling locations were designated on the basis of the surface drainage analysis and subsurface soil sampling results presented in the Scoping Document (K/J/C 1988a) and on the basis of the results of chemicals analysis of surface soil samples collected in September 1988 (K/J/C 1988b).

Surface Soil Samples:

At each surface sample location designated on Figure 1, surface soil samples will be collected from three subsites, located at the corners of a triangle with sides 10 feet long. The subsamples will be composited to form one surface soil sample from each sample location.

The three sample locations designated "M1" were chosen for potential drainage into Drainage Area I and subsequently to transect T-1. The three "M6" sample locations were chosen for potential drainage from Drainage Area VII into transect T-6. Specific sample locations were chosen for the following reasons:

- M1-1: copper concentrations found in surface samples in Area 2 during September 1988 sampling were elevated relative to other samples in the area
- M1-2: located in minor drainage channel
- M1-3: metal concentrations found in surface samples near Southeast Drainage channel during September 1988 sampling were elevated relative to other samples in the area
- M6-1: metal concentrations found in shallow soil sampling during October 1983 sampling were elevated relative to other samples in the area
- M6-2: located within upper end of drainage channel
- M6-3: located near center of runoff area

Subsurface Soil Samples:

The subsurface soil sampling locations are labeled on Figure 1 with the MO designations. The three locations were selected in the former activity area on the basis of past chemical analysis of subsurface soil samples (K/J/C 1988a).

2.2 Methods

Surface Soil Samples:

Surface soil samples will be collected by K/J/C personnel by scraping the top three inches of soil with a clean trowel. The soil will be placed in a glass jar with a Teflon lined cap and the cap sealed with plastic tape. Custody seals will be placed over the cap. The sample label will be completed as well as a chain-of-custody form.

Soil samples from each location will be stored in discrete jars. A portion of each discrete sample will be composited in the laboratory to obtain a representative sample from each location. The basis for the elutriate preparation will be the attached Army Corps of Engineers protocol (Attachment A). The protocol will be modified in two ways: the water used for the elutriation will have a pH of approximately 6, and the soil will be elutriated for 24 hours. Elutriate preparation water will be prepared by agitating deionized water in air until the pH drops to approximately 6 to 6.5. For the *Ceriodaphnia* test, the composite soil sample will be split and a separate elutriate prepared. The second elutriate will also be prepared by elutriating the soil for 24 hours, but the pH of the preparation water will be approximately 7.6. The purpose of the concurrent bioassay performed under these conditions is to evaluate potential stresses on the organisms caused by starting with a lower pH more representative of rainwater. The elutriate samples will be left undisturbed for 12 to 16 hours before decanting to obtain the test sample.

Subsurface Soil Samples:

Subsurface soil samples will be collected from continuous cores to a depth of 5 feet using 2.5 inch diameter brass liners. The ends of the brass liners will be covered with Teflon sheets and capped. The sample label will be completed as well as a chain-of-custody form.

A portion of each core sample, taken from the center of the core, will be composited in the laboratory to obtain a composite of the subsurface soil from 0 to 5 feet. Elutriates will be prepared in the same manner as elutriates of surface soil, as discussed above, except that the elutriation will take place in a nitrogen atmosphere to minimize oxidation effects. In addition, the final elutriate will be filtered through a 100 micron filter to provide a better representation of the chemical content that will be potentially mobile in groundwater.

3. BIOASSAYS

The rationale for the choice of bioassay tests, the general laboratory protocols to be used, and supplementary chemical analysis to be performed are discussed below.

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3.1 Tests Selected

The algal growth test using Selenastrum capricornutum and the Ceriodaphnia dubia survival test will be used to screen the potential toxicity of the soil elutriate samples.

Selenastrum and Ceriodaphnia were chosen after a literature review of various bioassay techniques. These species were selected on the basis of their sensitivity to the chemicals of interest at the site (Thomas et al, 1986), their applicability to the RI process (Christopherson, 1986), their pH and salinity tolerance, and the availability of subject organisms. A brief identification of the test species are given below.

Selenastrum capricornutum is a unicellular non-motile chlorophyte. It is easily maintained in laboratory cultures and is recommended for freshwater algal assays (Porcella 1983).

Ceriodaphnia dubia is a crustacean invertebrate belonging to a general group called water fleas. Daphnids are found in nearly all types of freshwater habitats and this organism has been recommended for freshwater invertebrate assays (Christopherson 1987).

3.2 Protocols

The algal growth test will be conducted in accordance with EPA protocol (EPA 1985). Although these methods are presented in the EPA manual for estimating chronic toxicity, methods presented in Porcella (1983) for estimating acute toxicity are essentially the same. Both were 96 hour static bioassay after which the response of the population is measured in terms of cell density. The Ceriodaphnia survival test will be conducted in accordance with the modified ASTM protocol for Daphnia magna (ASTM 1984). Summaries of these protocols (with modifications) are presented in Tables 2 and 3.

The soil elutriate protocol has been adopted from the EPA/Army Corps of Engineers methodology for dredged and fill material (attached). The use of overlying water has been replaced by the elutriate waters specified in Tables 2 and 3. The other modifications of the protocols are discussed above.

If the salinity of the elutriate is greater than the appropriate range for conducting the Ceriodaphnia bioassay, then a second elutriate, starting from the same conditions (Test B-1 and Test B-2) will be performed on the original composite soil sample. If elutriate salinities are still too high, the agencies will be consulted regarding continuation of the test.

3.3 Chemical Analyses

During Phase I screening tests, chemical analyses will be performed on composite soil samples and elutriate water. Analyses will be for chromium, copper, lead, mercury, nickel, zinc, oil and grease,