Comprehensive Long-Term Environmental Action Navy

CLEAN

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DRAFT SITE INSPECTION (SI) REPORT

FOR

NAVAL AIR FACILITY (NAF)

MIDWAY ISLAND

VOLUME II: APPENDICES
PART 1 OF 3

Prepared for:

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Appendix A

APPENDIX A

SITE SPECIFIC SPECIES CHECKLIST

Table A-1
Plant Species Identified on each Site

Scientific Name	Common Name	1	2	3	4	5	7	8	9	10	11	12	13	23
MONOCOTYLEDONAE														
CYPERACEAE (Sedge family)														
Cyperus rotundus	nutgrass	x	x	x										
Fimbristylis pycnocephala	button sedge	x	x											
POACEAE (Grass family)														
Cenchrus echinatus	sandbur		x											
Chloris barbata	swollen fingergrass		x											
Cynodon dactylon	Bermuda Grass	x	x	x	x	x	x	x	x			x		
Dactyloctenium aegyptium	beach wiregrass	x	x	x	x	x	x			x				
Digitaria adscendens	Henry's crabgrass		x				x		x					
Eleusine indica	goosegrass	x	x		x			x						
Eragrostis tenella	Japanese lovegrass	x	x				x	x						
Paspalum urvillei	Vasey grass	x												
Stenotaphrum secundatum	buffalo grass	x												
DICOTYLEDONAE														
APIACEAE (Carrot family)														
Ciclospermum leptophyllum	fine-leaved celery										x			
ASTERACEAE (Composite family)														
Bidens alba	beggar's tick	x			x									
Bidens pilosa	Spanish needles			x				x						
Conyza bonariensis	ilioha	x	x	x	x						x			
Gnaphalium purpureum	cudweed	x	x			x								
Gnaphalium sandwicensium var. *sandwicensium*	'ena'ena							x						
Pluchea symphytifolia	sourbush	x	x		x			x						
Verbesina encelioides	golden crown-beard	x	x	x	x	x	x	x	x	x	x	x	x	x
BORAGINACEAE (Heliotrope family)														
Heliotropium procumbens var. *depressum*		x	x			x								
Tournefortia argentea	tree heliotrope	x		x			x			x	x			
BRASSICACEAE (Mustard family)														
Brassica nigra	black mustard													
Lobularia maritima	sweet alyssum	x	x	x			x	x	x	x	x	x	x	

Table A-1
Plant Species Identified on each Site

Scientific Name	Common Name	1	2	3	4	5	7	8	9	10	11	12	13	23
CONVOLVULACEAE (Morning-glory family)														
Ipomoea pes-caprae subsp. brasiliensis	beach morning glory	x			x					x				
CASUARINACEAE (Casuarina family)														
Casuarina equisetifolia	ironwood	x	x	x	x	x	x	x	x	x	x	x	x	x
EUPHORBIACEAE (Spurge family)														
Chamaesyce hirta	hairy spurge	x	x			x		x	x					
Chamaesyce hypericifolia					x									
Chamaesyce prostata	small ground fig	x			x	x		x	x	x				
Euphorbia cyathopora	wild poinsettia		x					x						
Euphorbia peplus	petty spurge		x											
FABACEAE (Pea family)														
Leucaena leucocephala	koa haole	x	x											
Medicago lupulina	black medic	x						x						
GOODENIACEAE (Goodenia family)														
Scaevola sericea	naupaka						x			x				
MALVACEAE (Mallow family)														
Hibiscus tiliaceus	hau													
NYCTAGINACEAE (Four o'clock family)														
Boerhavia repens	alena		x			x	x	x	x					
PLANTAGINACEAE (Plantain family)														
Plantago lanceolata	English plantain	x	x											
POLYGONACEAE (Buckwheat family)														
Coccoloba uvifera	sea grape													
PORTULACACEAE (Purslane family)														
Portulaca oleracea	common purslane	x												
SOLANACEAE (Nightshade family)														
Solanium nigrum	nightshade		x											

Table A-1
Plant Species Identified on each Site

Scientific Name	Common Name	33	54	97	98	100	SB	B1 EI	B2 EI	B3 EI	B1 SI	B2 SI	B3 SI	B4 SI
MONOCOTYLEDONAE														
CYPERACEAE (Sedge family)														
Cyperus rotundus	nutgrass											x		
Fimbristylis pycnocephala	button sedge													
POACEAE (Grass family)														
Cenchrus echinatus	sandbur													
Chloris barbata	swollen fingergrass													
Cynodon dactylon	Bermuda Grass						x						x	x
Dactyloctenium aegyptium	beach wiregrass			x										
Digitaria adscendens	Henry's crabgrass										x			
Eleusine indica	goosegrass												x	x
Eragrostis tenella	Japanese lovegrass											x		
Paspalum urvillei	Vasey grass													
Stenotaphrum secundatum	buffalo grass													
DICOTYLEDONAE														
APIACEAE (Carrot family)														
Ciclospermum leptophyllum	fine-leaved celery													
ASTERACEAE (Composite family)														
Bidens alba	beggar's tick											x		
Bidens pilosa	Spanish needles													
Conyza bonariensis	ilioha											x		
Gnaphalium purpureum	cudweed													
Gnaphalium sandwicensium var. *sandwicensium*	'ena'ena													
Pluchea symphytifolia	sourbush													
Verbesina encelioides	golden crown-beard	x	x	x	x	x	x	x	x	x	x		x	
BORAGINACEAE (Heliotrope family)														
Heliotropium procumbens var. *depressum*														
Tournefortia argentea	tree heliotrope		x						x	x				
BRASSICACEAE (Mustard family)														
Brassica nigra	black mustard		x											
Lobularia maritima	sweet alyssum		x			x	x	x	x	x	x	x		

Table A-1
Plant Species Identified on each Site

Scientific Name	Common Name	33	54	97	98	100	SB	B1 EI	B2 EI	B3 EI	B1 SI	B2 SI	B3 SI	B4 SI
CONVOLVULACEAE (Morning-glory family)														
Ipomoea pes-caprae subsp. brasiliensis	beach morning glory													
CASUARINACEAE (Casuarina family)														
Casuarina equisetifolia	ironwood				x	x	x	x			x	x	x	
EUPHORBIACEAE (Spurge family)														
Chamaesyce hirta	hairy spurge											x		
Chamaesyce hypericifolia														
Chamaesyce prostata	small ground fig													
Euphorbia cyathopora	wild poinsettia											x		
Euphorbia peplus	petty spurge													
FABACEAE (Pea family)														
Leucaena leucocephala	koa haole													
Medicago lupulina	black medic												x	x
GOODENIACEAE (Goodenia family)														
Scaevola sericea	naupaka							x	x		x			
MALVACEAE (Mallow family)														
Hibiscus tiliaceus	hau													
NYCTAGINACEAE (Four o'clock family)														
Boerhavia repens	alena		x		x			x	x		x			
PLANTAGINACEAE (Plantain family)														
Plantago lanceolata	English plantain													
POLYGONACEAE (Buckwheat family)														
Coccoloba uvifera	sea grape										x			
PORTULACACEAE (Purslane family)														
Portulaca oleracea	common purslane										x	x	x	
SOLANACEAE (Nightshade family)														
Solanium nigrum	nightshade												x	

Table A-2
Algae Present at Sampled Marine Sites

Phylum	Order	Scientific Name	M01/05-06	M01/04	M01/01-02	M02/01	M02/02	M02/04-05	M05	M08	M25/01	M25/02	M25/03-04	M25/05	M25/06	M25/07	M25/08-09	M65	M10	Total
			Site # / Sampling Location*																	
Cyanophyta																				
(Blue-green algae)		Thiobacteria	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	4
		Blue-green algal mat	1	0	1	1	1	0	1	0	0	0	0	1	0	1	1	0	0	8
Chorophyta																				
(Green algae)	Codiales	*Bryopsis* sp.	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	4
	Codiales	*Codium edule*	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	3
	Dasycladales	*Acetabularia* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Dasycladales	*Neomeris annulatus*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	3
	Siphonales	*Caulerpa peltata*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
	Siphonales	*Caulerpa racemosa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	3
	Siphonales	*Caulerpa serrulata*	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	4
	Siphonales	*Caulerpa sertularioides*	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	4
	Siphonales	*Halimeda sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Siphonales	*Halimeda discoidea*	0	1	0	1	1	1	0	0	0	1	1	1	0	1	1	1	1	11
	Siphonales	*Halimeda opuntia*	0	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	13
	Siphonocladales	*Dictyosphaeria cavernosa*	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	3
	Siphonocladales	*Dictyosphaeria versluyii*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	3
	Siphonocladales	*Valonia ventricosa*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	2
	Ulotrichales	*Ulva fasciata*	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
		Unid. filamentous green	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	4
Rhodophyta																				
(Red algae)	Ceramiales	*Laurencia nidifica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Ceramiales	*Sphyridia filamentosum*	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1	7
	Cryptonemiales	*Jania* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
	Gigartinales	*Eucheuma striatum*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Gigartinales	*Gracilaria* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2
	Gigartinales	*Hypnea cervicornis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	3
	Gigartinales	*Plocamium* sp.	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2
	Gigartinales	*Predaea weldii*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Gigartinales	*Gracilaria* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2
	Nemaliales	*Asparagopsis taxiformis*	0	1	0	0	0	0	0	1	1	0	1	1	0	0	1	0	0	6
	Nemaliales	*Liagora* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A-2
Algae Present at Sampled Marine Sites

Phylum	Order	Scientific Name	M01/05-06	M01/04	M01/01-02	M02/01	M02/02	M02/04-05	M05	M08	M25/01	M25/02	M25/03-04	M25/05	M25/06	M25/07	M25/08-09	M65	M10	Total
			Site # / Sampling Location*																	
		Encrusting coralline	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0	5
		Filamentous red turf	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Galaxaura fastigiata	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	5
		Galaxaura rugosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
		Nodular coralline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tenerea tessellatum	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Phaeophyta (Brown algae)	Chordariales	*Ralfsia pangoensis*	0	0	1	0	0	0	0	1	0	1	0	0	0	1	1	1	1	7
	Dictytales	*Dictyota* sp.	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	4
	Dictytales	*Dictyota acutiloba*	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	1	1	7
	Dictytales	*Dictyota barteyresii*	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	4
	Dictytales	*Dictyota dentata*	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	3
	Dictytales	*Dictyota divaricata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dictytales	*Padina japonica*	0	1	1	0	1	1	1	1	0	1	1	1	0	1	1	0	1	12
	Dictytales	*Padina thivyi*	0	1	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	7
	Dictytales	*Padina* sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Ectocarpales	*Giffordia breviarticulata*	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	5
	Fucales	*Turbinaria ornata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Scytosiphonales	*Colpomenia sinuosa*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
		Lobophora variegatus	0	0	0	1	1	0	0	1	1	0	1	0	0	0	1	1	1	8
		Stypopodium hawaiiensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
		Unid. filamentous brown	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	3
		Total	5	11	15	9	12	4	4	11	8	5	11	18	4	8	26	14	12	177

*Presence or absence of algae at a site is indicated by1 or 0

Table A-3
Invertebrate Abundances at Each Site

Biota	Site # / Sampling Location																							
	M01/05-06	M01/04	M01/01-02	M01/03		M02/01	M02/02	M02/03	M02/04	M02/05	M05	M08	M25/01	M25/02	M25/04	M25/03	M25/05	M25/07	M25/08	M25/-09	M65	M25/06	M10/01-02	M10/03-05
Bacteria																								
Thiobacteria					P,1		S,2					A,3												
Blue-green algae																								
Blue-green algal mat				C,4		C	C										A							
Blue-green long tufts ?																		A						
Green algae																								
Acetabularia sp.					S																			
Bryopsis sp. (green tufts)			C			S	S															C		
Caulerpa peltata																				P				
Caulerpa racemosa																	S				S			
Caulerpa serrulata												S							S	S				
Caulerpa sertularioides							S		C			C,5										C		
Codium edule		S.															S		S					
Dictyosphaeria cavernosa					S	S																S		
Dictyosphaeria versluyii																		S		P	S			
Halimeda sp.																								
Halimeda discoidea		S				S	S		S					S		S	S	S	S		S		S	
*Halimeda opuntia**		S		S	S	S	S					S,7		C		S	S	S	S	S	S		S	
Ulva fasciata																	S							
Unid. filamentous green	A	S,6									A,8		A											
Valonia ventricosa												S									S			
Red algae																								
Asparagopsis taxiformis		S?										C	C			S	C		S	P				
Encrusting coralline													C				C		S	S	C			
Eucheuma striatum			C																					
Filamentous red turf	A																							
Galaxaura fastigiata		S			C,10	S	S										S		S	S				
Galaxaura rugosa																			S					
*Giffordia breviarticulata**	A		A			C	C										A							
Hypnea cervicornis																	C			P			S	S
Jania sp.																					S		S	S
Laurencia nidifica																								
Neomeris annulatus				S		S													S	S				
Nodular coralline																								
Plocamium sandvicense																S								
Predaea weldii																								
Red puff						C	C				S,2	S												

Table A-3
Invertebrate Abundances at Each Site

Biota	M01/05-06	M01/04	M01/01-02	M01/03		M02/01	M02/02	M02/03	M02/04	M02/05	M05	M08	M25/01	M25/02	M25/04	M25/03	M25/05	M25/07	M25/08	M25/-09	M65	M25/06	M10/01-02	M10/03-05
	Site # / Sampling Location																							
Sphyridia filamentosum		S															S			S	S		S	
Tenerea tessellatum		S																						
White filamentous tuft /red tips																								
Brown algae																								
Colpomenia sinuosa							S																	
Dictyota acutiloba												A,11				S	C	A	S	S	C,8		S	
Dictyota barteyresii												S,12				S			S		C	C		
Dictyota dentata									C								C		S	S				
Dictyota sp.		S																						
Dictyota sp. (blue)																	S							
Gracilaria sp.																	C			P				
Lobophora variegatus		C				C	C					A				S			C	C	S		S	
Padina japonica		S		S	S		S		S		S,2	S		S		A	C	S	S	S			S	
Padina thivyi																	C		S	C	S		S	S
Padina sp.													S	C-A										
Ralfsia pangoensis			C									C		C				S		P	S			
Stypopodium hawaiiensis																			S					
Turbinaria ornata																								
Unid. filamentous brown alga											C,8										S		S	
Total Number of Algal Species	3	11	4	4	5	10	11	0	4	0	4	11	4	5	0	8	18	7	16	17	14	4	10	3
Marine plants																								
Halophila ovalis									C												A,13			
Number of Marine Plant Species	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Porifera																								
Cliona sp.									C									C						
Fleshy gray sponge, spiny												S												
Orange sponge																			S					
Fleshy red sponge		S											C,15	C		S	S	C			C		S	
White sponge														S,2										
Cnidaria																								
Anemone on shell debris in sand																								
Burrowing anemones				1			1																	S
Calliactis polypus																							S	S
Cyphastrea ocellina					S											S				S			S	
Leptastrea purpurea		S			S																			

Table A-3
Invertebrate Abundances at Each Site

Biota	M01/05-06	M01/04	M01/01-02	M01/03		M02/01	M02/02	M02/03	M02/04	M02/05	M05	M08	M25/01	M25/02	M25/04	M25/03	M25/05	M25/07	M25/08	M25/-09	M65	M25/06	M10/01-02	M10/03-05
	Site # / Sampling Location																							
Millepora sp.															S									
Montipora tuberculosa																S								
Montipora sp. ?																								
Plumularia sp.																								
Pocillipora damicornis		C		S	S,17	C	C		C			S	S	C	S	S	S	S	S	S	S	S	S	
Pocillopora eydouxi ?									S															
Pocillipora meandrina		C		S	S,18	C	C		C				S	S	C	S	S	S	S	S			S	
Pocillopora verrucosa										S								S						
Porites compressa									S							S								
Porites lobata		S			S,19		S		S			S		S,20		S		S	S		S			
Porites sp.																	P		P					
Platyhelminthes																								
Flatworm																								S
Annelida																								
Arenicola sp.?																								
Sabellastarte sanctijosephi									1												S			
Pseudopolydora tubicolous		C,21		C	C	C	C		C				S				C		C	C		C		S
Spirobranchus giganteus		S		S	S	S	S		S				C			S		S				S		
Bryozoa																								
Bryozoa, crimson encrusting												S												
Mollusca - Bivalvia																								
Chama iostoma					S	C	C		C			C,2	S	C				C			S	A		
Pinctada margaritifera																								
Pinctada radiata ?													1											
Pinna muricata																								S
Streptopinna saccata ?												1												
Spondylus histrix						S																		
Spondylus tenebrosus													1					S						
Mollusca -Gastropoda																								
Cellana exarata											C,22	C					S							
Conus abbreviatus		S											1			S				S	S		S	
Conus flavidus		S														S	S		S		S			
Conus leopardus																			S	S	C		S	S
Conus lividus										S			S	S		S	S		S					S
Conus sp.		S												S										
Dorid nudibranch; white s/ocelli																		1						
Hipponix sp.						S	S		S							S								

Table A-3
Invertebrate Abundances at Each Site

Biota	M01/05-06	M01/04	M01/01-02	M01/03		M02/01	M02/02	M02/03	M02/04	M02/05	M05	M08	M25/01	M25/02	M25/04	M25/03	M25/05	M25/07	M25/08	M25/-09	M65	M25/06	M10/01-02	M10/03-05
	Site # / Sampling Location																							
Littorina pintado		S										C					C				S,23			
Naticid egg cases												S						C						
Nerita picea												C									A,23			
Octopus ornatus				S	S											3								
Petaloconchus keeni ?	C	C																			C			
Plakobranchus ocellatus								S	S	S		S						1			S			
Pleurobranchus sp.??																								
Sabia sp.		S																						
Serpulorbis variabilis					S		S				S					S	C		S			S	S	
Terebra maculata																					C		S	S
Terebra sp.																					S			
Turbo sandwicensis																1								
Arthropoda																								
Alpheus deuteropus																S								
Alpheus sp.									A												S			
Barnacles						C	S				C,22	C,22				S,25	C							
Burrowing crab									C															
Calappa hepatica														1							S		S	S
Smooth green left-claw pagurid											S			S							S		S	S
Smooth purple left-claw pagurid													1											
Dardanus sp.				1			1									1				P			S	S
Hymenocera picta																					1			
Orange, hairy left clawed hermit																								
Ligia spp.												C,2												
Paguridea, unidentified spp.						S		P			S				S							C,26		
Panulirus penicillatus						C	S		S				S											
Purple & yellow shore crab												S												
Red grapsid w/ yellow spots																								
Light-colored grapsid																							1	
Stenopus hispidus		S						S	S				S			2				S		S,27	2	
Stomatopoda, unident.									S							1								
Thalamita integra ?											S			1										S
Xanthid crab																					S			
Echinodermata																								
Bohadschia obesus		S		1		C	S	S	S				S		C		S	S	S	S			S	1
Echinostrephus aciculatus					S								S			S		S			S			
Echinometra mathaei	S,10	C		S	C	C	C	S	C			C	A	A	C	A		C	C	C	S	C	S	S

Table A-3
Invertebrate Abundances at Each Site

Biota	M01/05-06	M01/04	M01/01-02	M01/03		M02/01	M02/02	M02/03	M02/04	M02/05	M05	M08	M25/01	M25/02	M25/04	M25/03	M25/05	M25/07	M25/08	M25/-09	M65	M25/06	M10/01-02	M10/03-05
	Site # / Sampling Location																							
Echinothrix diadema							1	S		S		S									S		S	
Brissus latecarinatus test																								S
Pseudoboletia indiana																							S	
Heterocentrotus mammillatus					S										C	S				P				
Holothuria sp.		C				S							C			C	S			S			A	S
Holothuria nobilis		S				S							S		S	S			S					
Holothuria atra		C											C				S	1					C	C
Ophiocoma longispina		S				S-C											C	S						
Cyrtacanthus verruculatus								S																
Echinaster sp.?																								
Total Invertebrate Species	2	20	0	9	13	15	16	7	19	4	6	16	19	12	8	25	15	17	13	12	22	8	20	17
Vertebrata																								
Green turtle				1		1		1	1						1									
Monk seak																								

Footnotes

A - abundant
C - common
S - sparse
P - present
1 - on inner, upper lip of outfall
2 - on sheet pile
3 - on upper lip, top, and inside roof of intake pipe and adjacent sheetpile
4 - Extensive mat
5 - Common on coral rubble/sand substrate, Sparse on sheet piling
6 - high intertidal
7 - some living on deflector plate at top of intake, covered w/Thiobacter
8 - on coral rubble
9 - growing on dead coral branches
10 - in patches
11 - on coral rubble/sand substrate
12 - patch living inside intake pipe
13 - extensive offshore
14 - dense bed
15 - offshore
16 - on algae
17 - <1%
18 - 1%
19 - <<1%
20 - on pipe
21 - on rocks
22 - small, on sheet pile
23 - on rip-rap
24 - 13 cm long; max length reported is 14 cm
25 - intertidal on rubble
26 - small, under rocks
27 - in outfall pipe
28 - in sand

Table A-3
Invertebrate Abundances at Each Site

Biota	Reference		Other Sites			
	M00/04	M00/01-02	Spit Island West Side	Lagoon Patch Reef	Outfall-HazMat	Rusty Bucket
Bacteria						
Thiobacteria						
Blue-green algae						
Blue-green algal mat						
Blue-green long tufts ?				C		
Green algae						
Acetabularia sp.						
Bryopsis sp. (green tufts)						
Caulerpa peltata						
Caulerpa racemosa						
Caulerpa serrulata						
Caulerpa sertularioides						
Codium edule						
Dictyosphaeria cavernosa						
Dictyosphaeria versluyii		S				
Halimeda sp.						
Halimeda discoidea		S	S	C		S
*Halimeda opuntia**		C	S	C	S	
Ulva fasciata						
Unid. filamentous green		C,9				
Valonia ventricosa						
Red algae						
Asparagopsis taxiformis			C		S?	
Encrusting coralline						
Eucheuma striatum						
Filamentous red turf						
Galaxaura fastigiata						
Galaxaura rugosa						
*Giffordia breviarticulata**						
Hypnea cervicornis						
Jania sp.						
Laurencia nidifica						C
Neomeris annulatus						
Nodular coralline			C	C		
Plocamium sandvicense						
Predaea weldii		S				
Red puff						

Table A-3
Invertebrate Abundances at Each Site

Biota	Reference		Other Sites			
	M00/04	M00/01-02	Spit Island West Side	Lagoon Patch Reef	Outfall-HazMat	Rusty Bucket
Sphyridia filamentosum					S	
Tenerea tessellatum						
White filamentous tuft /red tips		C				
Brown algae						
Colpomenia sinuosa						
Dictyota acutiloba						
Dictyota barteyresii				C		C
Dictyota dentata						A
Dictyota sp.						
Dictyota sp. (blue)						
Gracilaria sp.						
Lobophora variegatus		C		C	C	
Padina japonica				C		A
Padina thivyi			S		S	C
Padina sp.						
Ralfsia pangoensis			S	C		C
Stypopodium hawaiiensis						
Turbinaria ornata		S		S		
Unid. filamentous brown alga						
Total Number of Algal Species	0	8	6	9	5	7
Marine plants						
Halophila ovalis	A,14					
Number of Marine Plant Species	1	0	0	0	0	0
Porifera						
Cliona sp.				C		C
Fleshy gray sponge, spiny						
Orange sponge						
Fleshy red sponge				C		
White sponge						
Cnidaria						
Anemone on shell debris in sand						
Burrowing anemones						
Calliactis polypus						
Cyphastrea ocellina						
Leptastrea purpurea						

Table A-3
Invertebrate Abundances at Each Site

Biota	Reference		Other Sites			
	M00/04	M00/01-02	Spit Island West Side	Lagoon Patch Reef	Outfall-HazMat	Rusty Bucket
Millepora sp.						S
Montipora tuberculosa						
Montipora sp. ?		A		S		
Plumularia sp.		S,16				
Pocillipora damicornis	S	A	S	C		
Pocillopora eydouxi ?			S			
Pocillipora meandrina				C		
Pocillopora verrucosa						
Porites compressa						
Porites lobata	S		S	C	S	
Porites sp.						
Platyhelminthes						
Flatworm						
Annelida						
Arenicola sp.?						S
Sabellastarte sanctijosephi						
Pseudopolydora tubicolous						S
Spirobranchus giganteus			S	S	S	
Bryozoa						
Bryozoa, crimson encrusting						
Mollusca - Bivalvia						
Chama iostoma			C	C		
Pinctada margaritifera				1		
Pinctada radiata ?						
Pinna muricata						
Streptopinna saccata ?						
Spondylus histrix			S			
Spondylus tenebrosus						
Mollusca -Gastropoda						
Cellana exarata						
Conus abbreviatus						
Conus flavidus						
Conus leopardus	1,24					
Conus lividus						
Conus sp.			S			
Dorid nudibranch; white s/ocelli						
Hipponix sp.						

Table A-3
Invertebrate Abundances at Each Site

Biota	Reference		Other Sites			
	M00/04	M00/01-02	Spit Island West Side	Lagoon Patch Reef	Outfall-HazMat	Rusty Bucket
Littorina pintado						
Naticid egg cases					S	
Nerita picea						
Octopus ornatus						
Petaloconchus keeni ?						
Plakobranchus ocellatus		S				
Pleurobranchus sp.??					S	
Sabia sp.						
Serpulorbis variabilis			S	C		
Terebra maculata						
Terebra sp.						
Turbo sandwicensis						
Arthropoda						
Alpheus deuteropus				C	S	
Alpheus sp.						
Barnacles						
Burrowing crab						
Calappa hepatica					S	
Smooth green left-claw pagurid			S			
Smooth purple left-claw pagurid						
Dardanus sp.						
Hymenocera picta						
Orange, hairy left clawed hermit					S	
Ligia spp.						
Paguridea, unidentified spp.						
Panulirus penicillatus				S		S
Purple & yellow shore crab						
Red grapsid w/ yellow spots						
Light-colored grapsid						
Stenopus hispidus						
Stomatopoda, unident.						
Thalamita integra ?				S,28	C	
Xanthid crab						
Echinodermata						
Bohadschia obesus			C	C		C
Echinostrephus aciculatus		S	S	S		S
Echinometra mathaei	S	A	A	A	A	A

Table A-3
Invertebrate Abundances at Each Site

Biota	Reference		Other Sites			
	M00/04	M00/01-02	Spit Island West Side	Lagoon Patch Reef	Outfall-HazMat	Rusty Bucket
Echinothrix diadema					S	
Brissus latecarinatus test			P			
Pseudoboletia indiana					S	
Heterocentrotus mammillatus		C	C	C	S	
Holothuria sp.	A	C	C	S	C	S
Holothuria nobilis	S	S	S	S	S	
Holothuria atra		S	S		C	
Ophiocoma longispina						
Cyrtacanthus verruculatus						1
Echinaster sp.?						1
Total Invertebrate Species	6	10	17	19	15	11
Vertebrata						
Green turtle						
Monk seak					P	

Footnotes

A - abundant
C - common
S - sparse
P - present
1 - on inner, upper lip of outfall
2 - on sheet pile
3 - on upper lip, top, and inside roof of intake pipe and adjacent sheetpile
4 - Extensive mat
5 - Common on coral rubble/sand substrate, Sparse on sheet piling
6 - high intertidal
7 - some living on deflector plate at top of intake, covered w/Thiobacter
8 - on coral rubble
9 - growing on dead coral branches
10 - in patches
11 - on coral rubble/sand substrate
12 - patch living inside intake pipe
13 - extensive offshore
14 - dense bed
15 - offshore
16 - on algae
17 - <1%
18 - 1%
19 - <<1%
20 - on pipe
21 - on rocks
22 - small, on sheet pile
23 - on rip-rap
24 - 13 cm long; max length reported is 14 cm
25 - intertidal on rubble
26 - small, under rocks
27 - in outfall pipe
28 - in sand

Table A-4
Fish Present at Midway Sites

Family	Scientific Name	Common Name	Site # / Sampling Location																
			M01/05-06	M01/04	M01/01-02	M01/03	M02/01	M02/02	M02/03	M02/04-05	M05	Cargo pier, night fishing	M08	M25/01	M25/02/07-09	M25/02/01-06	M25/04	M25/03	M25/05
Acanthuridae	*Acanthurus leucopareius*	Whitebar surgeonfish	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0
Acanthuridae	*Acanthurus nigroris*	Whitecheek surgeonfish	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Acanthuridae	*Acanthurus olivaceus*	Orangeband surgeonfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthuridae	*Acanthurus triostegus*	Striped convict tang	1	1	1	1	1	0	1	0	1	0	1	1	0	1	1	1	0
Acanthuridae	*Acanthurus xanthopterus*	Yellowfin surgeonfish	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Acanthuridae	*Ctenochaetus strigosus*	Goldring surgeonfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthuridae	*Naso unicornis*	Bluespine unicornfish	0	1	0	0	1	0	1	0	0	0	0	0	0	1	1	1	0
Acanthuridae	*Zebrasoma flavescens*	Yellow tang	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthuridae	*Zebrasoma veliferum*	Sailfin tang	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Antennariidae	*Antennarius commersonii*	Commerson's frogfish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Apogonidae	*Apogon maculiferus*	Spotted cardinalfish	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
Apogonidae	*Apogon* sp.	Cardinalfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aulostomidae	*Aulostomus chinensis*	Trumpetfish	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Balistidae	*Melichthys vidua*	Pinktail durgon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balistidae	*Sufflamen fraenatus*	Bridled triggerfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balistidae	*Xanthichthys mento*	Triggerfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belonidae	*Platybelone argalus*	Needlefish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beloniidae	Belonid, unident.	Needlefish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Blenniidae	brown spotted blenny	Blenny	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blenniidae	*Plagiotremus ewaensis*	Ewa blenny	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bothidae	*Bothus mancus*	Manyray flatfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bothidae	*Bothus pantherinus*	Large spotted flounder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Alectis ciliaris*	African pompano	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Carangoides ferdau*	Bar jack	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	1	0
Carangidae	*Caranx ignobilis*	White ulua, Giant trevally	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0
Carangidae	*Caranx melampygus*	Blue jack, Bluefin trevally	0	1	1	1	0	0	1	0	1	0	0	0	0	1	0	1	0
Carangidae	*Decapterus macarellus*	Mackerel shad	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Carangidae	*Pseudocaranx dentex*	Jack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Scomberoides lysan*	Leatherback	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Seriola dumerili*	Amberjack	0	0	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0
Carangidae	*Seriola rivoliana*	Almaco jack	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Carangidae	small jack	Jack	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Carcharinidae	*Carcharinus galapagensis*	Galapagos reef shark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A-4
Fish Present at Midway Sites

Family	Scientific Name	Common Name	Site # / Sampling Location																
			M01/05-06	M01/04	M01/01-02	M01/03	M02/01	M02/02	M02/03	M02/04-05	M05	Cargo pier, night fishing	M08	M25/01	M25/02/07-09	M25/02/01-06	M25/04	M25/03	M25/05
Chaetodontidae	*Chaetodon auriga*	Threadfin butterflyfish	0	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	0
Chaetodontidae	*Chaetodon fremblii*	Bluestripe butterflyfish	0	1	1	1	1	0	1	1	0	0	0	1	0	1	1	1	1
Chaetodontidae	*Chaetodon miliaris*	Milletseed butterflyfish	0	1	1	1	1	0	0	1	1	0	1	1	0	1	0	1	0
Chaetodontidae	*Chaetodon ornatissimus*	Ornate butterflyfish	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Chaetodontidae	*Forcipiger flavissimus*	Forcepsfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chanidae	*Chanos chanos*	Milkfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cheilodactylidae	*Cheilodactylus vittatus*	Hawaiian morwong	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Cirrhitidae	*Cirrhitops fasciatus*	Redbar hawkfish	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0
Cirrhitidae	*Cirrhitus pinnulatus*	Stocky hawkfish	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cirrhitidae	*Paracirrhites arcatus*	Arc-eye hawkfish	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Cirrhitidae	*Paracirrhites forsteri*	Blackside hawkfish	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	1	0
Congridae	*Conger cinereus*	Conger eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diodontidae	*Arothron hispidus*	Stripebelly puffer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diodontidae	*Arothron meleagris*	Spotted puffer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diodontidae	*Diodon holocanthus*	Spiny puffer	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Diodontidae	*Diodon hystrix*	Porcupinefish	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0
Fistulariidae	*Fistularia commersonii*	Cornetfish	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Gobiidae	*Psilogobius mainlandi*	Goby	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Hemiramphidae	*Hyporamphus* sp.	Halfbeak	0	1	1	1	0	0	0	1	1	0	1	1	0	0	0	1	0
Holocentridae	*Myripristis kuntee*	Shoulderbar soldierfish	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Holocentridae	*Myripristis* sp.	Soldierfish	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Holocentridae	*Neoniphon sammara*	Spotfin squirrelfish	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0
Holocentridae	*Sargocentron* sp.	Squirrelfish	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Holocentridae	*Sargocentron spiniferum*	Long-jawed squirrelfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kuhliidae	*Kuhlia sandvicensis*	Hawaiian flagtail	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Kyphosidae	*Kyphosus bigibbus*	Brown chub	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Kyphosidae	*Kyphosus bigibbus/vaigiensis*	Sea chub	1	1	0	0	1	0	1	0	1	0	0	1	0	0	0	1	0
Kyphosidae	*Kyphosus cinerascens*	Snubnose chub	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Kyphosidae	*Kyphosus vaigiensis*	Brassy chub	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	*Anampses cuvier*	Pearl wrasse	0	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	0
Labridae	*Bodianus bilunulatus*	Hawaiian hogfish	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0
Labridae	*Cheilio inermis*	Cigar wrasse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Labridae	*Cheilinus unifasciatus*	Ringtail wrasse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A-4
Fish Present at Midway Sites

Family	Scientific Name	Common Name	Site # / Sampling Location																
			M01/05-06	M01/04	M01/01-02	M01/03	M02/01	M02/02	M02/03	M02/04-05	M05	Cargo pier, night fishing	M08	M25/01	M25/02/07-09	M25/02/01-06	M25/04	M25/03	M25/05
Labridae	*Coris ballieui*	Lined coris	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Labridae	*Coris flavovittata*	Yellowstripe coris	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0
Labridae	*Coris venusta*	Elegant coris	0	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	1
Labridae	*Cymolutes torquatus*	Finescale razorfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Labridae	*Halichoeres ornatissimus*	Ornate wrasse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Labridae	*Labroides phthirophagus*	Hawaiian cleaner wrasse	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0
Labridae	*Macropharyngodon geoffroy*	Shortnose wrasse	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
Labridae	*Stethojulis balteata*	Belted wrasse	0	1	1	0	1	0	1	1	0	0	0	1	0	1	1	1	0
Labridae	*Thalassoma ballieui*	Blacktail wrasse	1	0	1	1	1	0	1	1	0	0	0	0	0	1	0	1	0
Labridae	*Thalassoma duperrey*	Saddle wrasse	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	0
Labridae	*Thalassoma purpureum*	Surge wrasse	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Lutjanidae	*Aprion virescens*	Jobfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monacanthidae	*Pervagor spilosoma*	Fantail filefish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	1	1	1	1	1	0	0	0	0	0	0	1	0	1	0	1	0
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Mullidae	*Parupeneus multifasciatus*	Manybar goatfish	0	0	1	1	1	1	1	0	0	0	1	1	0	0	0	1	0
Mullidae	*Parupeneus pleurostigma*	Sidespot goatfish	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	1	0
Mullidae	*Parupeneus porphyreus*	Whitesaddle goatfish	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0
Mullidae	*Parupeneus* sp.	Goatfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Muraenidae	*Echidna nebulosa*	Snowflake moray	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Muraenidae	*Gymnothorax flavimarginatus*	Yellowmargin moray	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	1
Muraenidae	*Gymnothorax steindachneri*	Moray	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Muraenidae	*Gymnothorax undulatus*	Undulated moray	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Muraenidae	*Uropterygius supraforatus*	Snake moray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophidiidae	*Brotula multibarbata*	Reef cusk eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Oplegnathidae	*Oplegnathus fasciatus*	Knifejaw	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Ostrciidae	*Ostracion meleagris*	Spotted trunkfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polynemidae	*Polydactylus sexfilis*	Sixfeeler threadfin	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pomacanthidae	*Centropyge potteri*	Potter's angelfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	*Abudefduf sordidus*	Blackspot sergeant	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	*Chromis hanui*	Chocolate-dip chromis	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0
Pomacentridae	*Chromis ovalis*	Oval chromis	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Pomacentridae	*Dascyllus albisella*	Hawaiian dascyllus	0	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	0

Table A-4
Fish Present at Midway Sites

Family	Scientific Name	Common Name	Site # / Sampling Location																
			M01/05-06	M01/04	M01/01-02	M01/03	M02/01	M02/02	M02/03	M02/04-05	M05	Cargo pier, night fishing	M08	M25/01	M25/02/07-09	M25/02/01-06	M25/04	M25/03	M25/05
Pomacentridae	*Plectroglyphidodon johnstonianus*	Blue-eye damselfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0
Pomacentridae	*Stegastes fasciolatus*	Pacific gregory	0	1	1	1	1	0	1	1	0	0	1	1	0	1	1	1	0
Priacanthidae	*Heteropriacanthus cruentatus*	Glasseye	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0
Priacanthidae	*Priacanthus meeki*	Hawaiian bigeye	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
Scaridae	*Calotomus* sp.	Parrotfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaridae	*Calotomus zonarchus*	Yellowbar parrotfish	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Scaridae	*Scarus dubius*	Regal parrotfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaridae	*Scarus perspicillatus*	Spectacled parrotfish	0	1	1	1	1	0	1	0	0	0	0	0	0	1	1	1	0
Scaridae	*Scarus psittacus*	Palenose parrotfish	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Scaridae	*Scarus rubroviolaceus*	Redlip parrotfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaridae	*Scarus sordidus*	Bullethead parrotfish	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaridae	*Scarus* sp.	Parrotfish	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Scorpaenidae	*Pterois sphex*	Hawaiian turkeyfish	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Scorpaenidae	Scorpaenid, unident.	Scorpionfish	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Scorpaenidae	*Scorpaenopsis* sp.	Scorpionfish	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Scorpaenidae	*Sebastapistes ballieui*	Spotfin scorpionfish	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0
Scorpaenidae	*Sebastapistes* sp.	Scorpionfish	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Serranidae	*Epinephelus quernus*	Grouper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grammistidae	Grammistid, unident.	Soapfish	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Synodontidae	*Synodus variegatus*	Variegated lizardfish	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0
Tetraodontidae	*Canthigaster coronata*	Crown toby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraodontidae	*Canthigaster jactator*	Hawaiian whitespotted toby	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0
Zanclidae	*Zanclus cornutus*	Moorish idol	0	1	0	1	1	0	1	0	0	0	1	0	0	0	1	1	0
		Total	9	34	37	47	39	7	21	24	13	5	15	30	1	20	26	48	3

*Presence or absence at a site is indicated by 1 or 0

Table A-4
Fish Present at Midway Sites

			Site # / Sampling Location							Reference		Other Sites					
Family	Scientific Name	Common Name	M25/06	M25/07	M25/08	M25/-09	M65	M10/01-02	M10/03-05	M00/03	North Lagoon	Spit Island Reef	Eastern Island-Outside Reef	Outfall-HazMat	Boat Ramp	Rusty Bucket	Total
Acanthuridae	*Acanthurus leucopareius*	Whitebar surgeonfish	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7
Acanthuridae	*Acanthurus nigroris*	Whitecheek surgeonfish	0	0	1	1	0	0	0	0	1	1	0	0	0	0	8
Acanthuridae	*Acanthurus olivaceus*	Orangeband surgeonfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Acanthuridae	*Acanthurus triostegus*	Striped convict tang	1	1	1	1	1	1	0	1	1	1	1	0	1	1	24
Acanthuridae	*Acanthurus xanthopterus*	Yellowfin surgeonfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Acanthuridae	*Ctenochaetus strigosus*	Goldring surgeonfish	0	0	0	0	0	0	0	1	0	1	1	0	0	0	3
Acanthuridae	*Naso unicornis*	Bluespine unicornfish	0	0	0	0	0	1	0	0	1	1	1	0	0	1	11
Acanthuridae	*Zebrasoma flavescens*	Yellow tang	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Acanthuridae	*Zebrasoma veliferum*	Sailfin tang	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4
Antennariidae	*Antennarius commersonii*	Commerson's frogfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Apogonidae	*Apogon maculiferus*	Spotted cardinalfish	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Apogonidae	*Apogon* sp.	Cardinalfish	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Aulostomidae	*Aulostomus chinensis*	Trumpetfish	0	1	0	0	0	0	0	0	0	0	1	0	0	0	3
Balistidae	*Melichthys vidua*	Pinktail durgon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Balistidae	*Sufflamen fraenatus*	Bridled triggerfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Balistidae	*Xanthichthys mento*	Triggerfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Belonidae	*Platybelone argalus*	Needlefish	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Beloniidae	Belonid, unident.	Needlefish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Blenniidae	brown spotted blenny	Blenny	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Blenniidae	*Plagiotremus ewaensis*	Ewa blenny	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Bothidae	*Bothus mancus*	Manyray flatfish	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Bothidae	*Bothus pantherinus*	Large spotted flounder	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Carangidae	*Alectis ciliaris*	African pompano	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carangidae	*Carangoides ferdau*	Bar jack	1	1	0	0	1	1	1	0	0	1	0	1	0	1	13
Carangidae	*Caranx ignobilis*	White ulua, Giant trevally	0	0	1	1	0	0	0	0	0	0	1	0	0	0	7
Carangidae	*Caranx melampygus*	Blue jack, Bluefin trevally	1	1	0	1	0	0	0	0	0	1	1	0	0	0	12
Carangidae	*Decapterus macarellus*	Mackerel shad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Carangidae	*Pseudocaranx dentex*	Jack	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Carangidae	*Scomberoides lysan*	Leatherback	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Carangidae	*Seriola dumerili*	Amberjack	0	1	0	0	0	0	0	0	0	0	1	0	0	0	8
Carangidae	*Seriola rivoliana*	Almaco jack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Carangidae	small jack	Jack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Carcharinidae	*Carcharinus galapagensis*	Galapagos reef shark	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2

Table A-4
Fish Present at Midway Sites

			Site # / Sampling Location							Reference		Other Sites					
Family	Scientific Name	Common Name	M25/06	M25/07	M25/08	M25/-09	M65	M10/01-02	M10/03-05	M00/03	North Lagoon	Spit Island Reef	Eastern Island-Outside Reef	Outfall-HazMat	Boat Ramp	Rusty Bucket	Total
Chaetodontidae	*Chaetodon auriga*	Threadfin butterflyfish	1	1	1	1	0	1	0	1	1	1	1	1	0	1	23
Chaetodontidae	*Chaetodon fremblii*	Bluestripe butterflyfish	1	1	1	1	1	1	0	0	0	1	1	0	0	1	20
Chaetodontidae	*Chaetodon miliaris*	Milletseed butterflyfish	1	1	0	1	0	1	0	0	1	1	1	0	0	1	18
Chaetodontidae	*Chaetodon ornatissimus*	Ornate butterflyfish	0	0	0	0	0	0	0	0	1	0	1	0	0	0	5
Chaetodontidae	*Forcipiger flavissimus*	Forcepsfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Chanidae	*Chanos chanos*	Milkfish	0	1	0	0	0	1	1	0	0	0	0	0	0	1	5
Cheilodactylidae	*Cheilodactylus vittatus*	Hawaiian morwong	0	1	0	0	0	0	0	0	0	0	1	0	0	0	4
Cirrhitidae	*Cirrhitops fasciatus*	Redbar hawkfish	0	1	0	0	0	0	0	0	1	0	1	0	0	0	7
Cirrhitidae	*Cirrhitus pinnulatus*	Stocky hawkfish	0	0	1	1	0	0	0	0	0	1	1	0	0	0	6
Cirrhitidae	*Paracirrhites arcatus*	Arc-eye hawkfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Cirrhitidae	*Paracirrhites forsteri*	Blackside hawkfish	0	1	0	0	0	0	0	0	1	1	1	0	0	0	11
Congridae	*Conger cinereus*	Conger eel	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Diodontidae	*Arothron hispidus*	Stripebelly puffer	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Diodontidae	*Arothron meleagris*	Spotted puffer	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Diodontidae	*Diodon holocanthus*	Spiny puffer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Diodontidae	*Diodon hystrix*	Porcupinefish	1	1	0	0	0	0	0	0	0	1	0	0	1	1	9
Fistulariidae	*Fistularia commersonii*	Cornetfish	1	1	0	0	0	1	0	0	0	1	1	0	0	0	7
Gobiidae	*Psilogobius mainlandi*	Goby	0	1	0	0	1	0	0	0	0	0	0	0	0	0	4
Hemiramphidae	*Hyporamphus* sp.	Halfbeak	0	1	0	1	0	0	0	0	1	1	0	0	0	0	12
Holocentridae	*Myripristis kuntee*	Shoulderbar soldierfish	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Holocentridae	*Myripristis* sp.	Soldierfish	0	0	0	1	0	0	0	0	0	1	0	0	0	0	4
Holocentridae	*Neoniphon sammara*	Spotfin squirrelfish	0	0	0	1	0	0	0	0	1	0	1	0	0	0	8
Holocentridae	*Sargocentron* sp.	Squirrelfish	0	0	0	0	0	0	0	0	0	1	1	0	0	0	3
Holocentridae	*Sargocentron spiniferum*	Long-jawed squirrelfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Kuhliidae	*Kuhlia sandvicensis*	Hawaiian flagtail	1	0	0	0	0	0	1	0	0	0	0	1	0	1	9
Kyphosidae	*Kyphosus bigibbus*	Brown chub	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Kyphosidae	*Kyphosus bigibbus/vaigiensis*	Sea chub	0	1	0	1	0	0	1	0	1	1	1	0	0	0	13
Kyphosidae	*Kyphosus cinerascens*	Snubnose chub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Kyphosidae	*Kyphosus vaigiensis*	Brassy chub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Labridae	*Anampses cuvier*	Pearl wrasse	0	1	1	1	0	0	0	0	1	1	0	0	0	1	14
Labridae	*Bodianus bilunulatus*	Hawaiian hogfish	0	1	1	1	0	0	0	0	1	1	1	0	0	0	12
Labridae	*Cheilio inermis*	Cigar wrasse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Labridae	*Cheilinus unifasciatus*	Ringtail wrasse	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Table A-4
Fish Present at Midway Sites

			Site # / Sampling Location							Reference		Other Sites					
Family	Scientific Name	Common Name	M25/06	M25/07	M25/08	M25/-09	M65	M10/01-02	M10/03-05	M00/03	North Lagoon	Spit Island Reef	Eastern Island-Outside Reef	Outfall-HazMat	Boat Ramp	Rusty Bucket	Total
Labridae	*Coris ballieui*	Lined coris	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
Labridae	*Coris flavovittata*	Yellowstripe coris	0	1	1	1	0	1	0	0	1	1	1	0	0	0	13
Labridae	*Coris venusta*	Elegant coris	1	1	1	1	1	1	0	0	0	1	1	0	0	0	17
Labridae	*Cymolutes torquatus*	Finescale razorfish	0	0	0	0	1	1	1	0	0	0	0	0	0	0	4
Labridae	*Halichoeres ornatissimus*	Ornate wrasse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Labridae	*Labroides phthirophagus*	Hawaiian cleaner wrasse	0	0	0	1	0	0	0	0	1	1	1	0	0	0	8
Labridae	*Macropharyngodon geoffroy*	Shortnose wrasse	0	1	0	0	0	0	0	0	1	1	1	0	0	0	8
Labridae	*Stethojulis balteata*	Belted wrasse	1	1	1	1	1	0	0	0	1	1	1	0	0	1	18
Labridae	*Thalassoma ballieui*	Blacktail wrasse	0	1	1	1	0	0	0	0	1	1	1	0	0	1	15
Labridae	*Thalassoma duperrey*	Saddle wrasse	1	1	1	1	1	1	0	0	1	1	1	0	0	1	23
Labridae	*Thalassoma purpureum*	Surge wrasse	0	0	1	1	0	0	0	0	1	1	1	0	0	1	11
Lutjanidae	*Aprion virescens*	Jobfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Monacanthidae	*Pervagor spilosoma*	Fantail filefish	1	1	0	0	0	1	0	0	0	0	1	0	0	1	7
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	1	1	0	1	1	1	1	0	1	1	1	1	0	0	18
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	1	0	0	0	0	0	0	0	0	1	0	0	0	0	6
Mullidae	*Parupeneus multifasciatus*	Manybar goatfish	1	1	1	1	0	0	0	0	0	1	1	0	0	0	14
Mullidae	*Parupeneus pleurostigma*	Sidespot goatfish	1	1	0	1	0	0	0	0	0	1	0	0	0	0	10
Mullidae	*Parupeneus porphyreus*	Whitesaddle goatfish	1	1	0	1	1	0	0	0	0	1	1	0	0	0	12
Mullidae	*Parupeneus* sp.	Goatfish	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Muraenidae	*Echidna nebulosa*	Snowflake moray	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3
Muraenidae	*Gymnothorax flavimarginatus*	Yellowmargin moray	0	1	0	0	0	0	0	0	1	1	0	0	0	0	8
Muraenidae	*Gymnothorax steindachneri*	Moray	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Muraenidae	*Gymnothorax undulatus*	Undulated moray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Muraenidae	*Uropterygius supraforatus*	Snake moray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophidiidae	*Brotula multibarbata*	Reef cusk eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Oplegnathidae	*Oplegnathus fasciatus*	Knifejaw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Ostrciidae	*Ostracion meleagris*	Spotted trunkfish	0	0	1	1	0	1	0	0	0	0	0	0	0	0	3
Polynemidae	*Polydactylus sexfilis*	Sixfeeler threadfin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pomacanthidae	*Centropyge potteri*	Potter's angelfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Pomacentridae	*Abudefduf sordidus*	Blackspot sergeant	1	1	0	1	0	0	0	0	0	1	0	0	0	0	9
Pomacentridae	*Chromis hanui*	Chocolate-dip chromis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5
Pomacentridae	*Chromis ovalis*	Oval chromis	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Pomacentridae	*Dascyllus albisella*	Hawaiian dascyllus	1	1	0	1	1	1	0	1	1	1	1	1	0	1	23

Table A-4
Fish Present at Midway Sites

			Site # / Sampling Location							Reference		Other Sites					
Family	Scientific Name	Common Name	M25/06	M25/07	M25/08	M25/-09	M65	M10/01-02	M10/03-05	M00/03	North Lagoon	Spit Island Reef	Eastern Island-Outside Reef	Outfall-HazMat	Boat Ramp	Rusty Bucket	Total
Pomacentridae	*Plectroglyphidodon johnstonianus*	Blue-eye damselfish	0	0	0	0	0	0	0	0	1	0	1	0	0	0	5
Pomacentridae	*Stegastes fasciolatus*	Pacific gregory	1	1	1	1	0	1	0	0	1	1	1	1	0	1	21
Priacanthidae	*Heteropriacanthus cruentatus*	Glasseye	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
Priacanthidae	*Priacanthus meeki*	Hawaiian bigeye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Scaridae	*Calotomus* sp.	Parrotfish	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2
Scaridae	*Calotomus zonarchus*	Yellowbar parrotfish	0	0	0	0	0	0	0	0	1	0	1	0	0	0	4
Scaridae	*Scarus dubius*	Regal parrotfish	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Scaridae	*Scarus perspicillatus*	Spectacled parrotfish	1	0	0	1	0	0	0	0	1	1	1	0	0	0	13
Scaridae	*Scarus psittacus*	Palenose parrotfish	0	0	0	0	0	0	0	0	1	1	1	0	0	0	8
Scaridae	*Scarus rubroviolaceus*	Redlip parrotfish	0	0	0	0	0	0	0	0	1	1	1	0	0	0	3
Scaridae	*Scarus sordidus*	Bullethead parrotfish	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4
Scaridae	*Scarus* sp.	Parrotfish	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Scorpaenidae	*Pterois sphex*	Hawaiian turkeyfish	0	0	0	0	0	1	0	0	0	1	0	0	0	0	4
Scorpaenidae	Scorpaenid, unident.	Scorpionfish	0	1	0	1	0	1	0	0	0	0	0	0	0	0	6
Scorpaenidae	*Scorpaenopsis* sp.	Scorpionfish	0	0	0	1	0	0	0	0	0	1	1	0	0	0	4
Scorpaenidae	*Sebastapistes ballieui*	Spotfin scorpionfish	0	1	0	0	0	1	0	0	0	0	0	0	0	0	6
Scorpaenidae	*Sebastapistes* sp.	Scorpionfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Serranidae	*Epinephelus quernus*	Grouper	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Grammistidae	Grammistid, unident.	Soapfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Synodontidae	*Synodus variegatus*	Variegated lizardfish	0	1	0	0	1	0	0	0	0	1	0	0	0	0	8
Tetraodontidae	*Canthigaster coronata*	Crown toby	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Tetraodontidae	*Canthigaster jactator*	Hawaiian whitespotted toby	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5
Zanclidae	*Zanclus cornutus*	Moorish idol	0	1	0	0	0	1	0	0	1	1	1	0	0	0	12
		Total	27	39	19	33	15	24	7	5	33	47	62	7	2	21	720

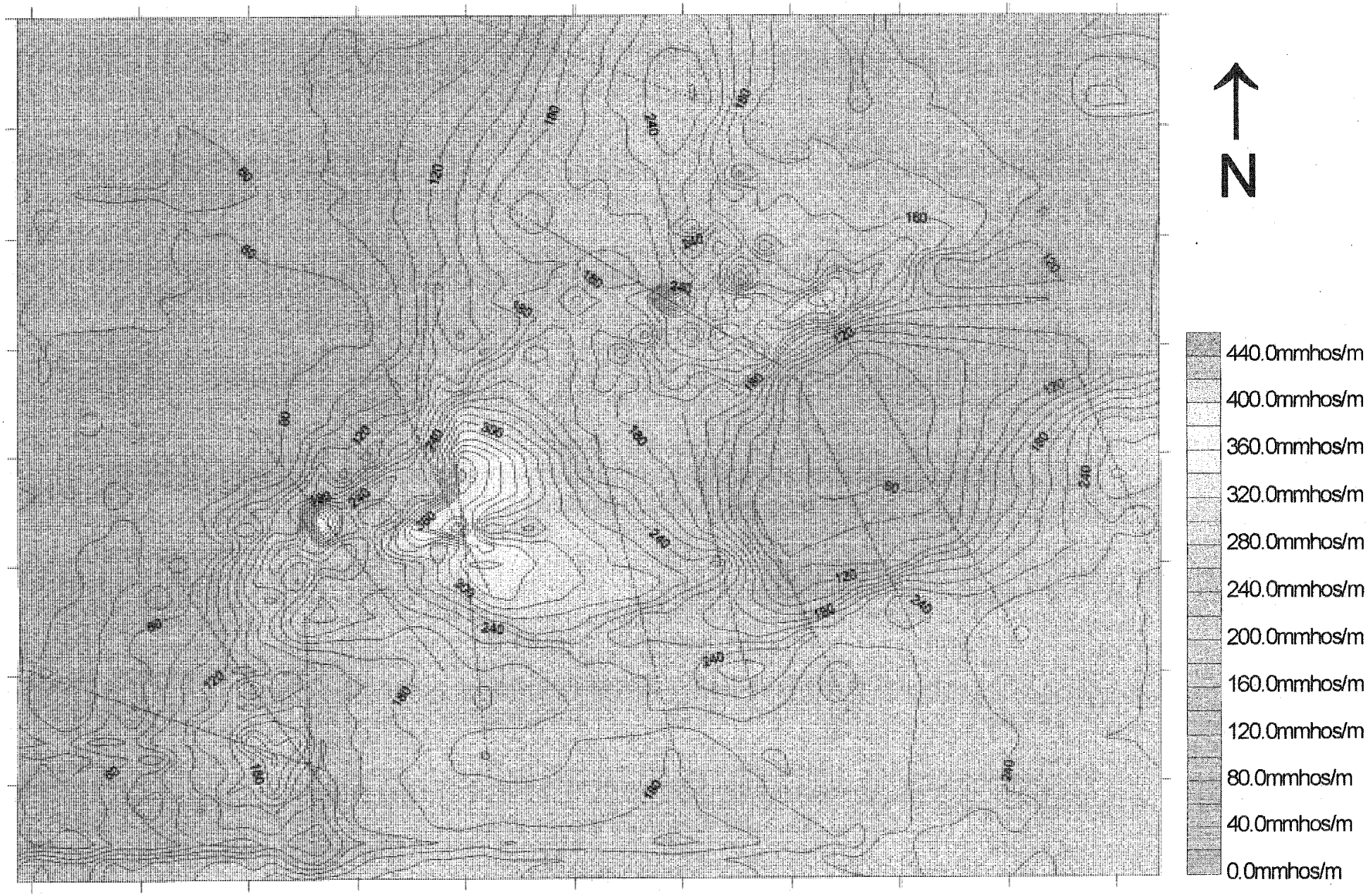
*Presence or absence at a site is indicated by 1 or 0

Appendix B

APPENDIX B

GEOPHYSICAL PLOTS

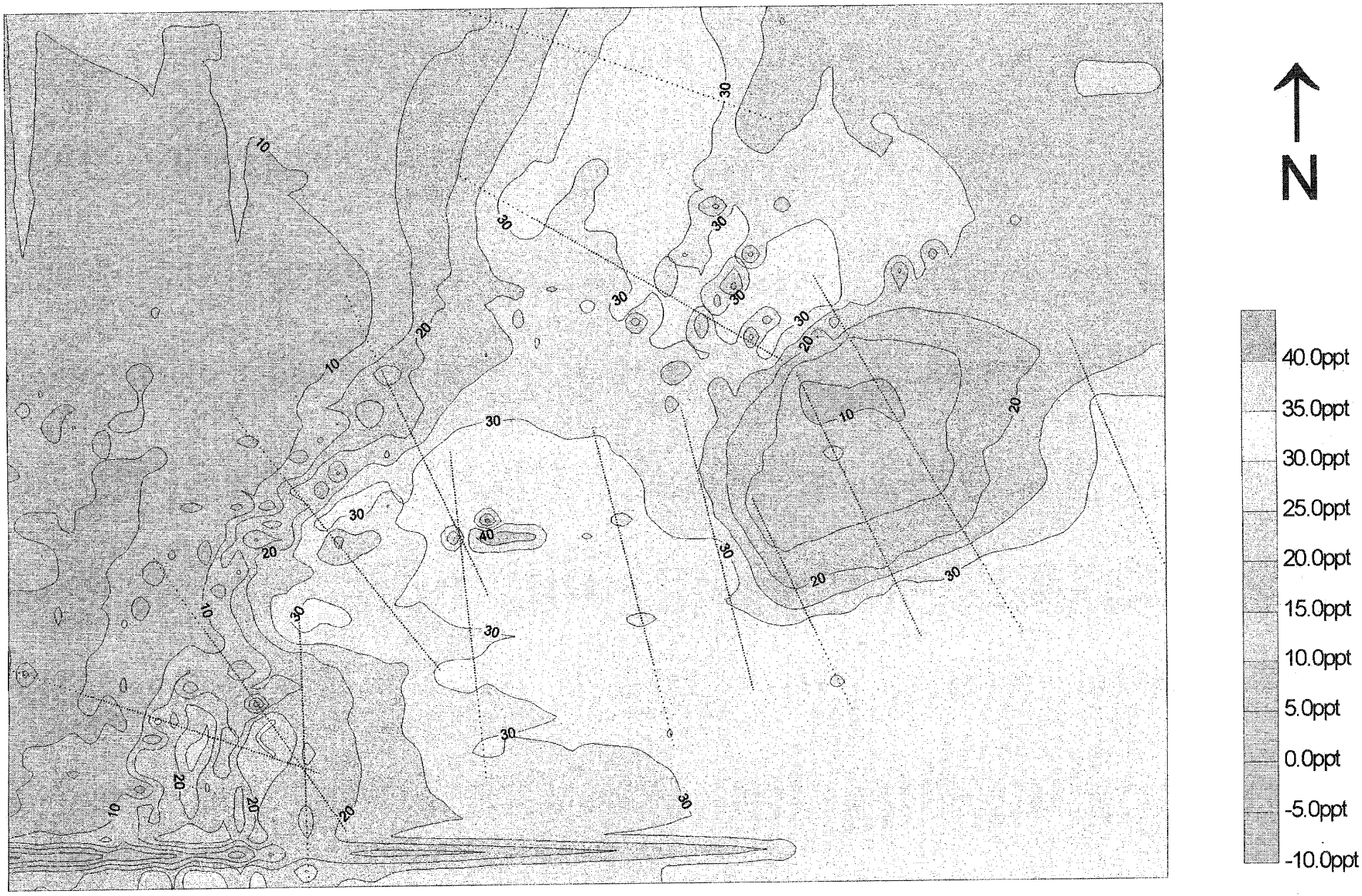
EM-31 Conductivity (mmhos/m)
Runway Landfill
Midway NAF



Scale: 1 inch = 250 feet

0ft. 250ft. 500ft. 750ft. 1000ft.

EM-31 In-Phase Component (ppt)
Runway Landfill
Midway NAF

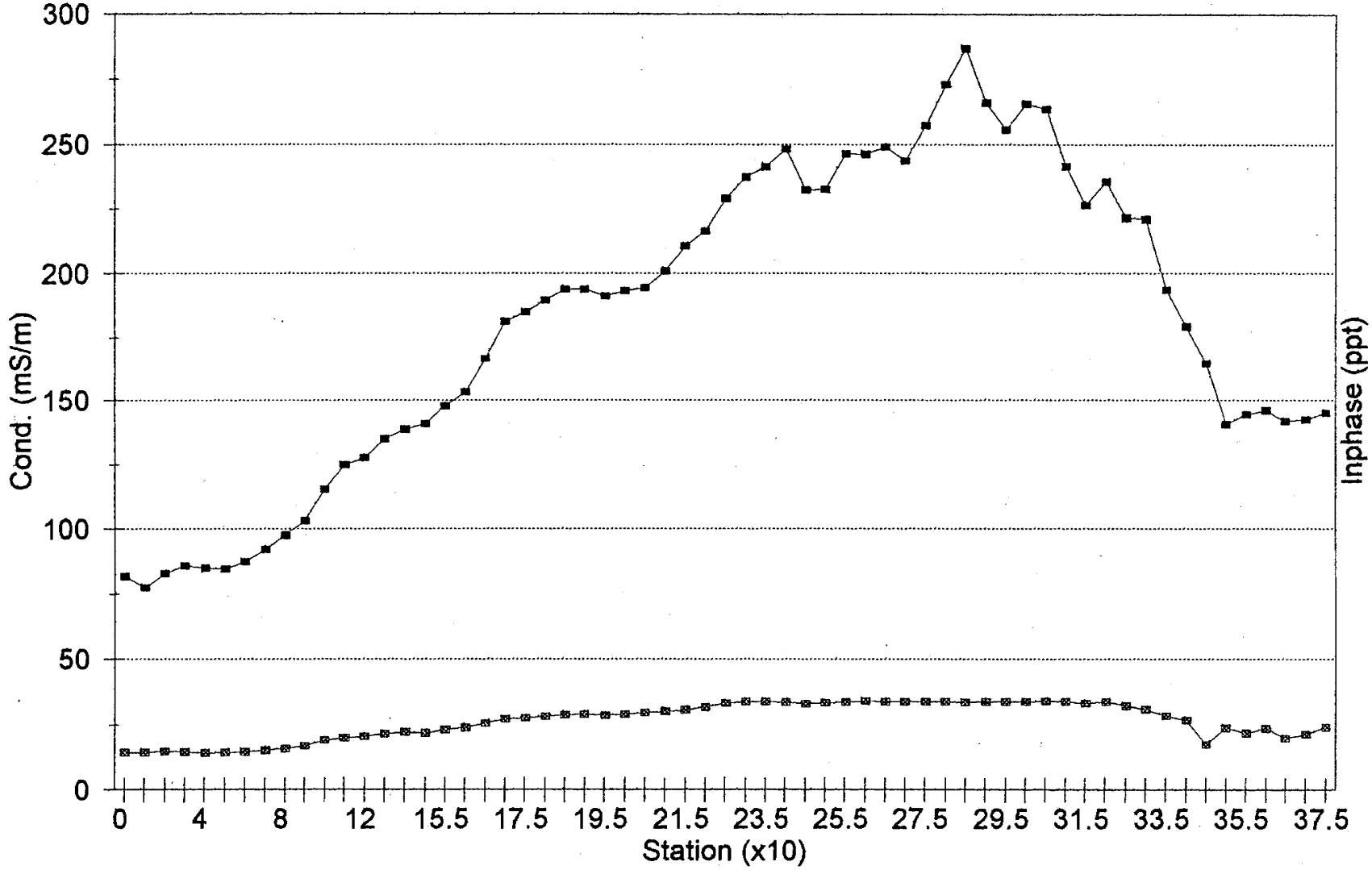


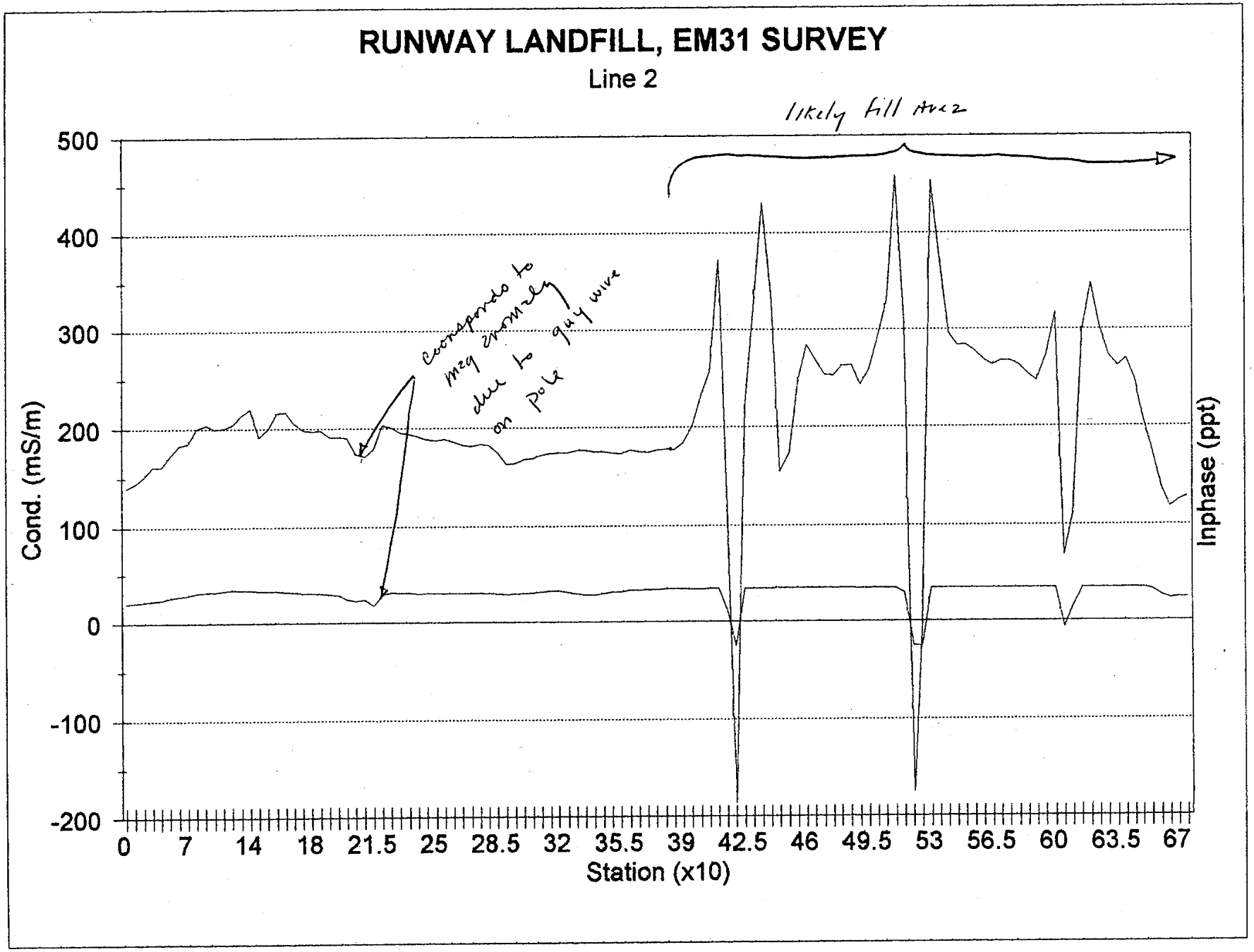
Scale: 1 inch = 250 feet

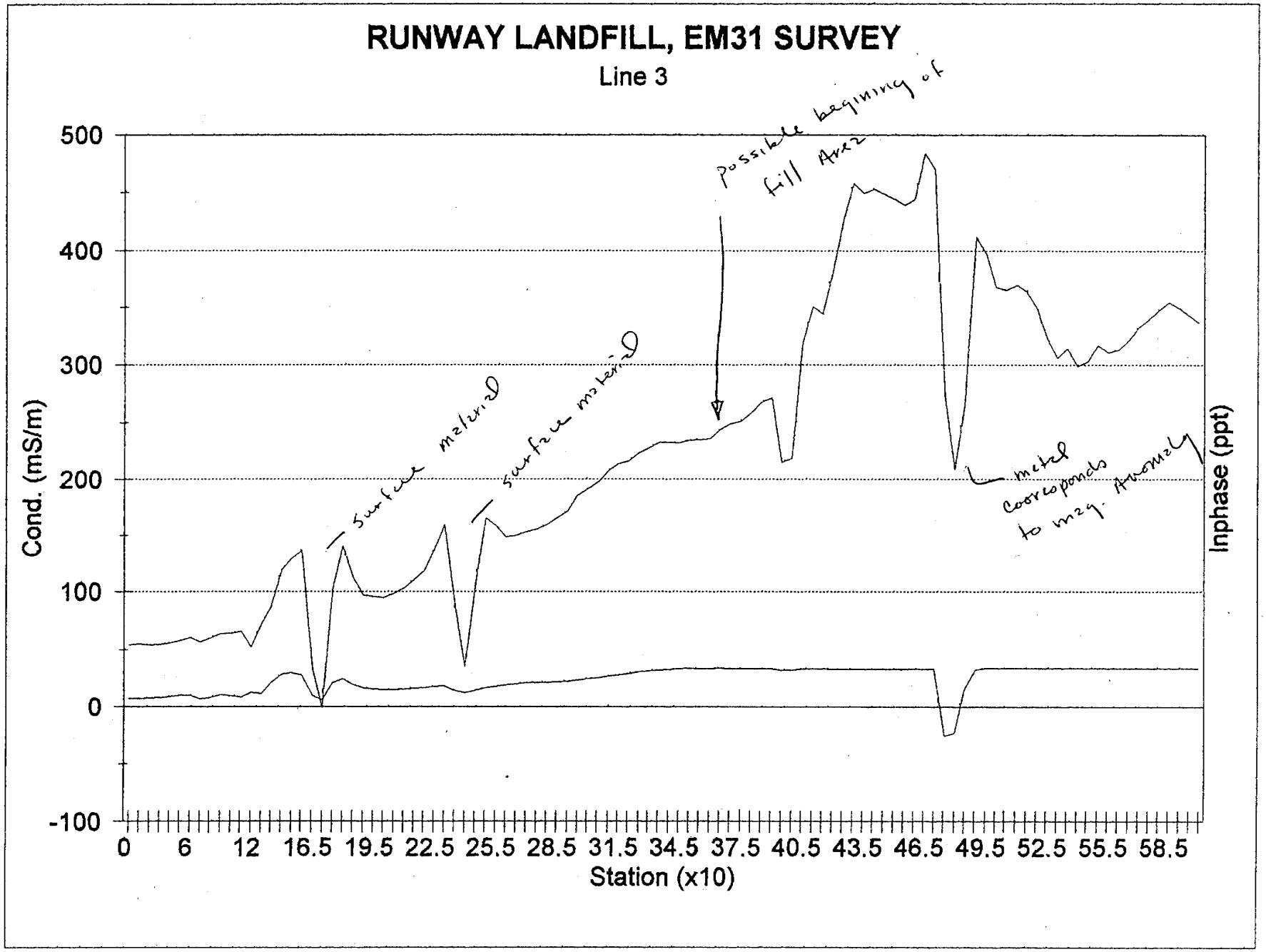
0ft 250ft 500ft. 750ft. 1000ft.

RUNWAY LANDFILL, EM31 SURVEY

Line 1

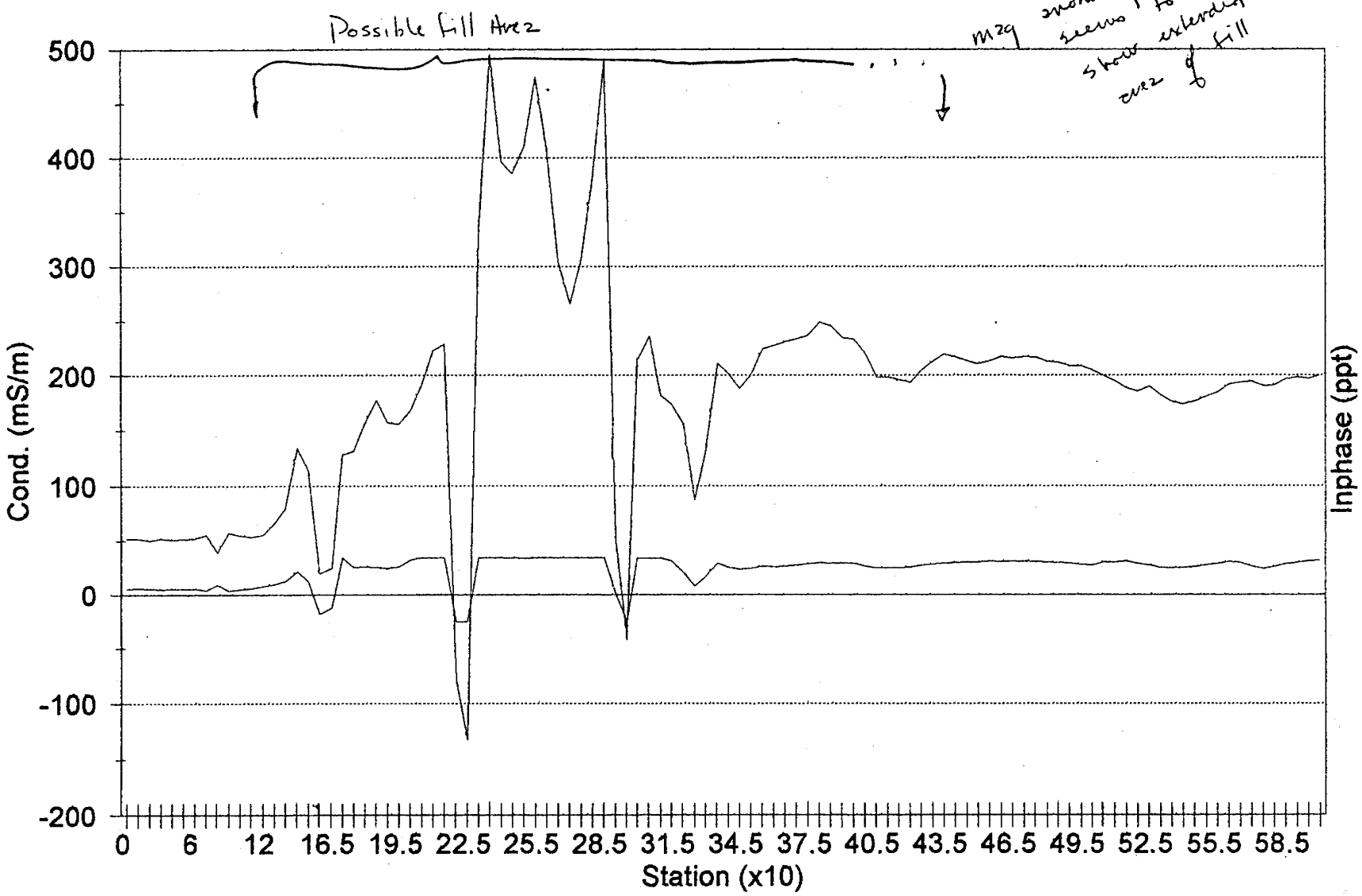



RUNWAY LANDFILL, EM31 SURVEY
Line 2
likely fill area
corresponds to mag anomaly due to guy wire on pole
500
400
300
200
100
0
-100
-200
Cond. (mS/m)
Inphase (ppt)
0
7
14
18
21.5
25
28.5
32
35.5
39
42.5
46
49.5
53
56.5
60
63.5
67
Station (x10)


RUNWAY LANDFILL, EM31 SURVEY
Line 3
Cond. (mS/m)
Inphase (ppt)
Station (x10)
500
400
300
200
100
0
-100
0
6
12
16.5
19.5
22.5
25.5
28.5
31.5
34.5
37.5
40.5
43.5
46.5
49.5
52.5
55.5
58.5
Possible beginning of fill Area
surface material
surface material
metal corresponds to mag. Anomaly

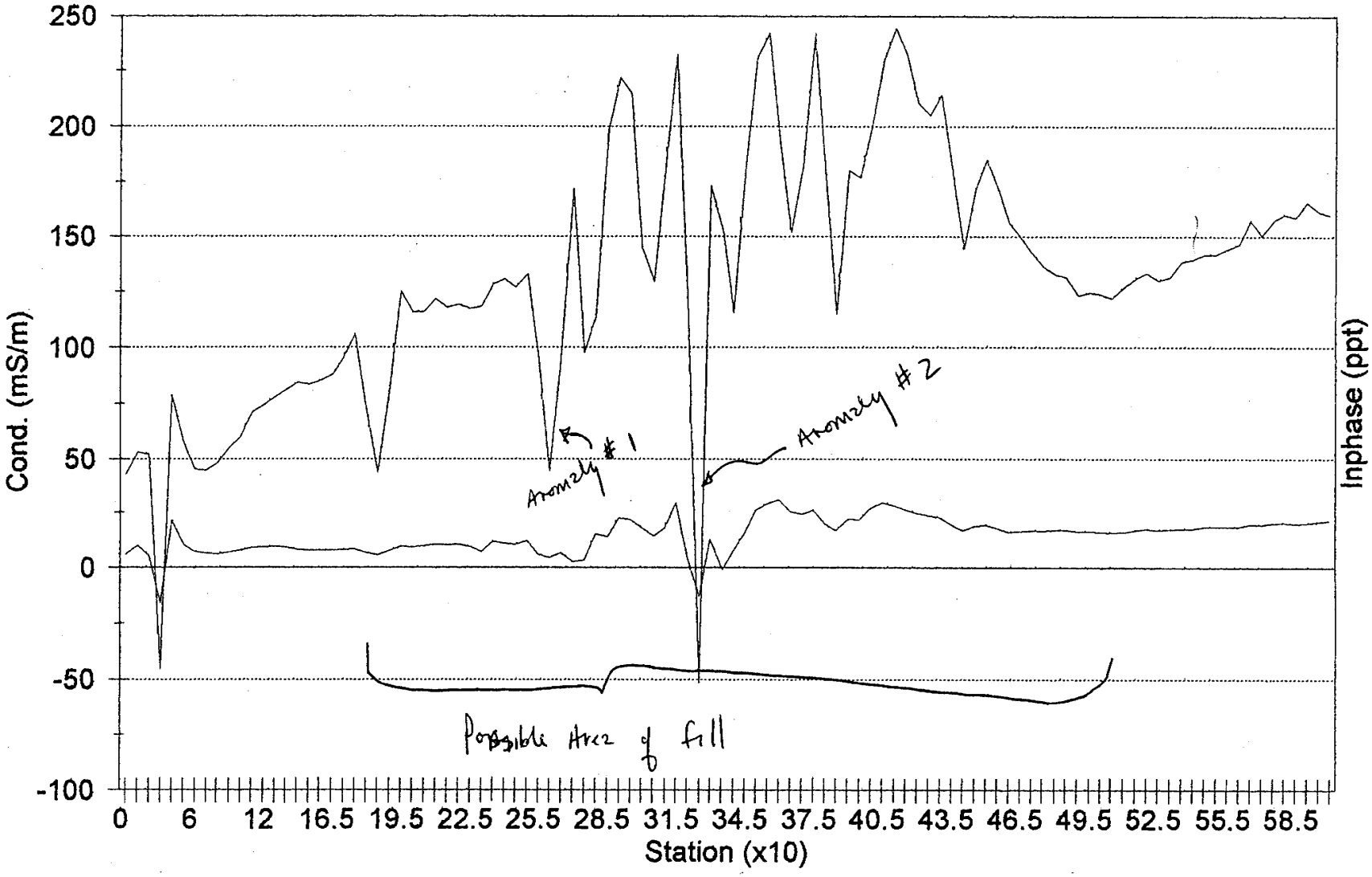
RUNWAY LANDFILL, EM31 SURVEY

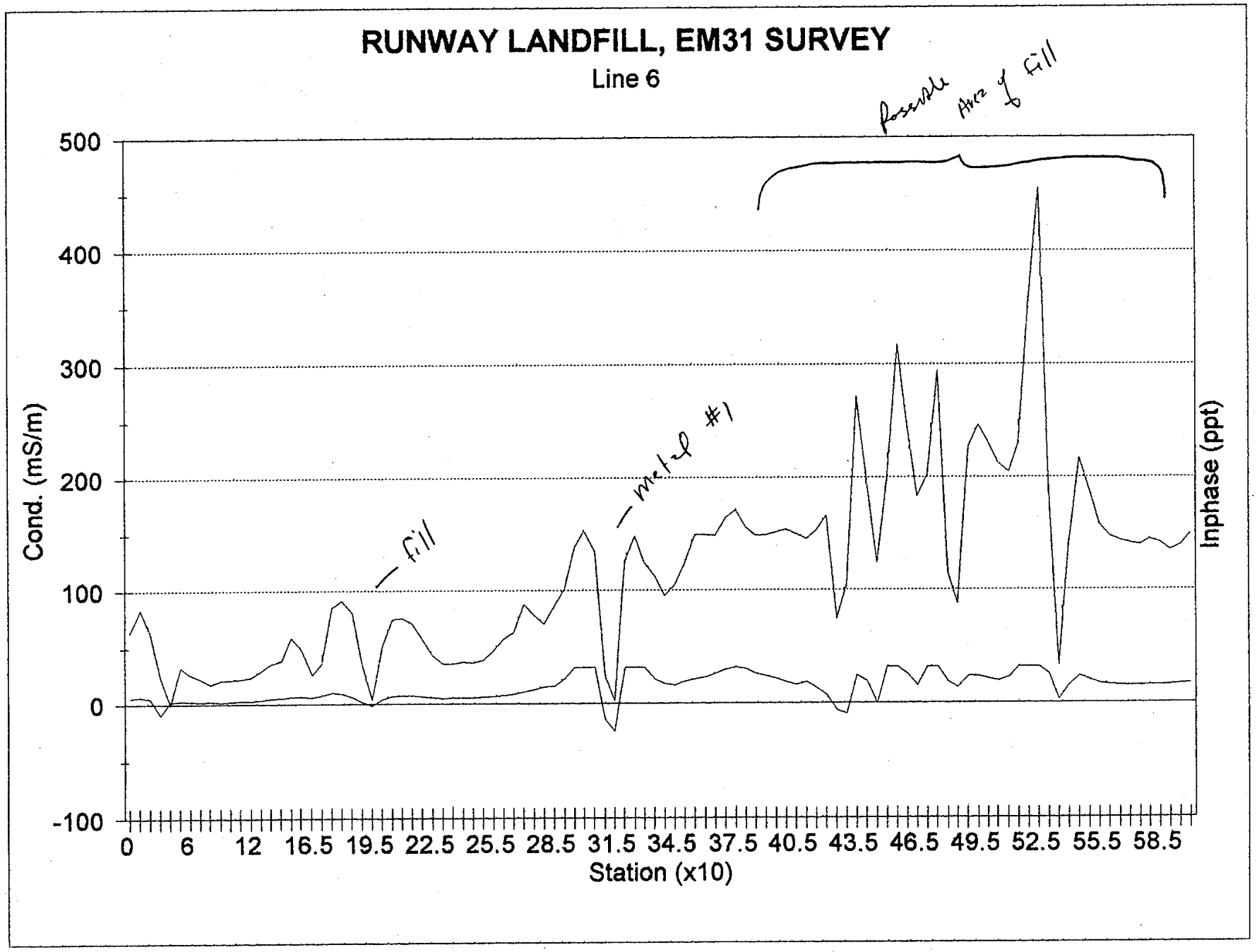
Line 4

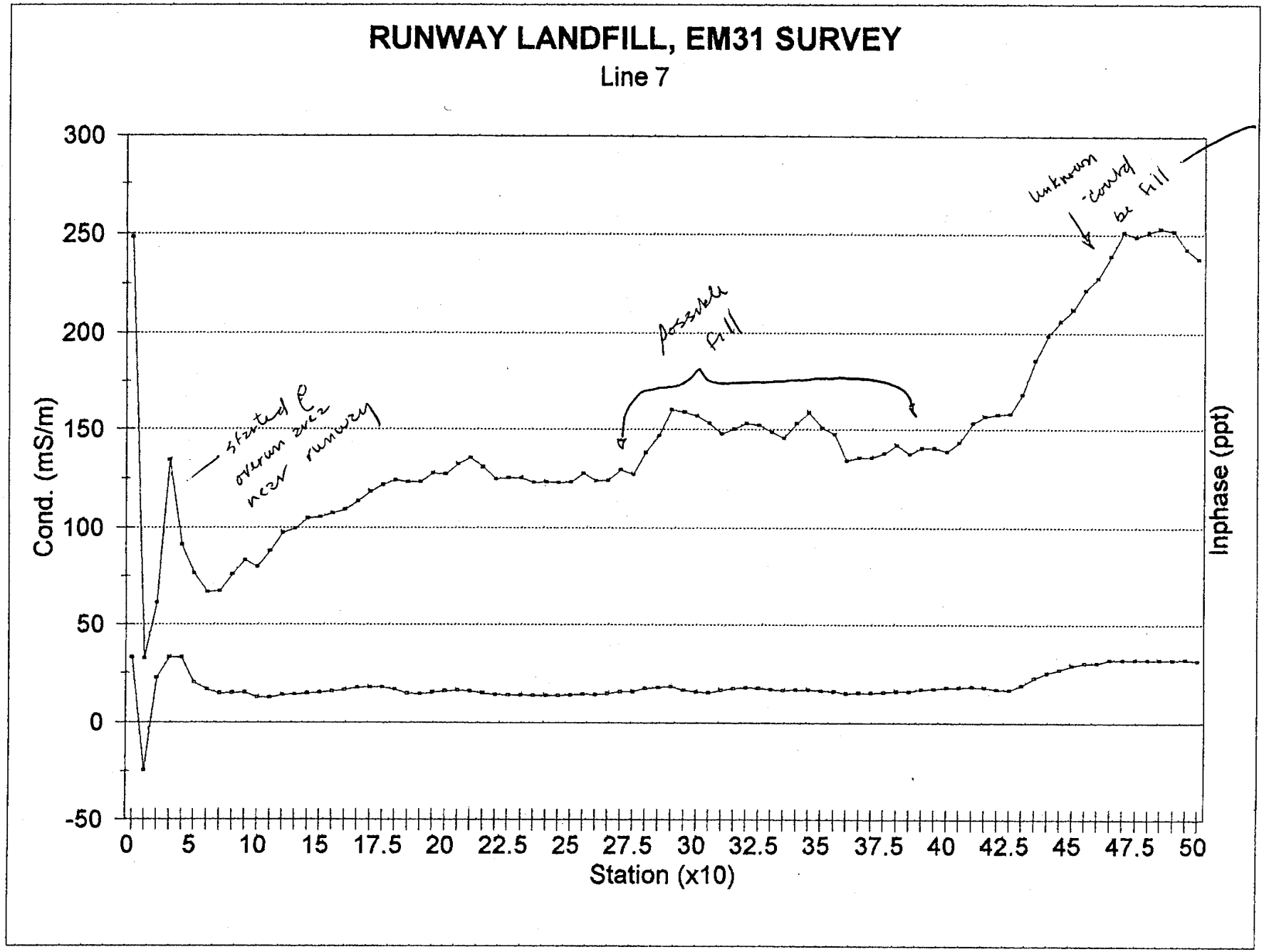


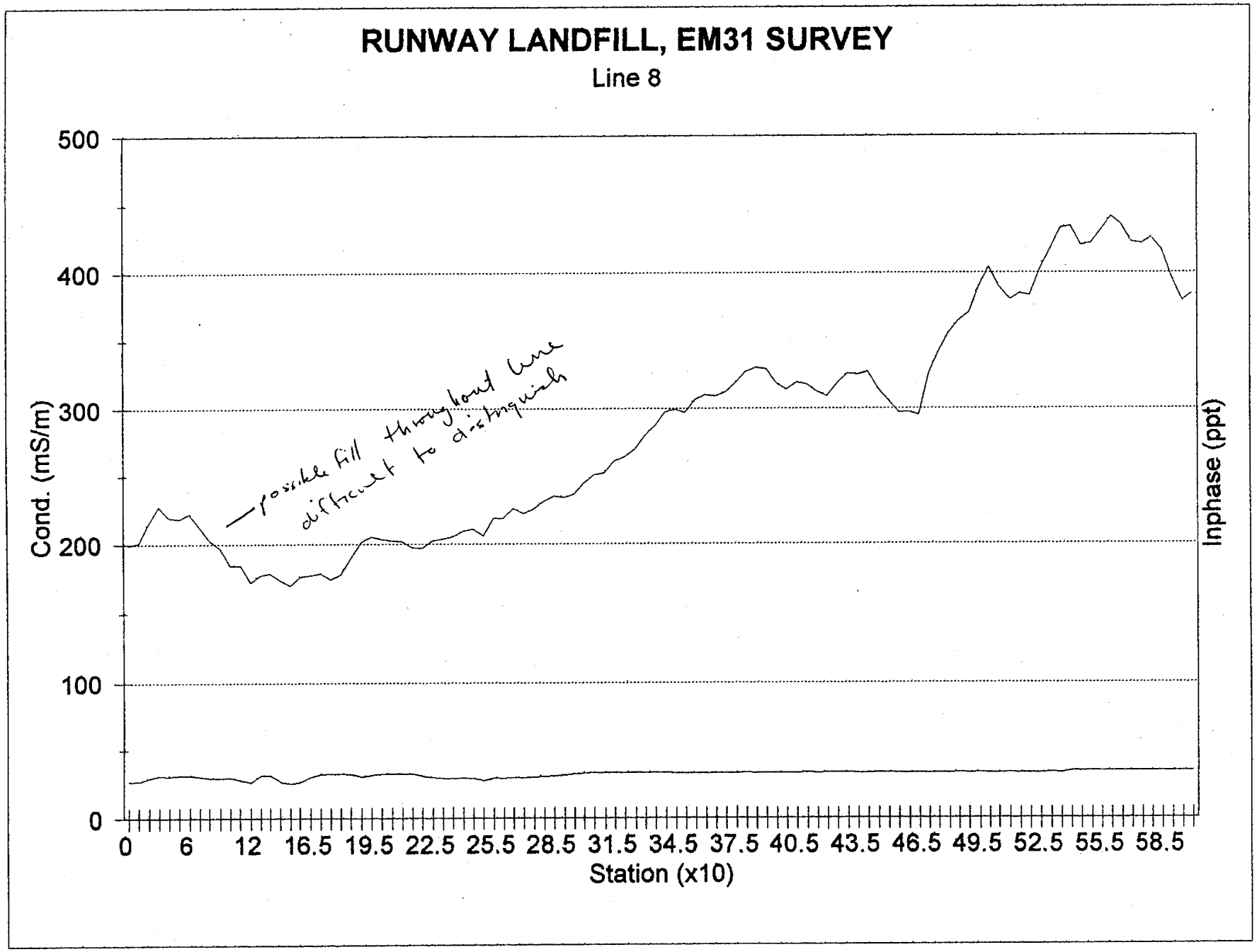
RUNWAY LANDFILL, EM31 SURVEY

Line 5



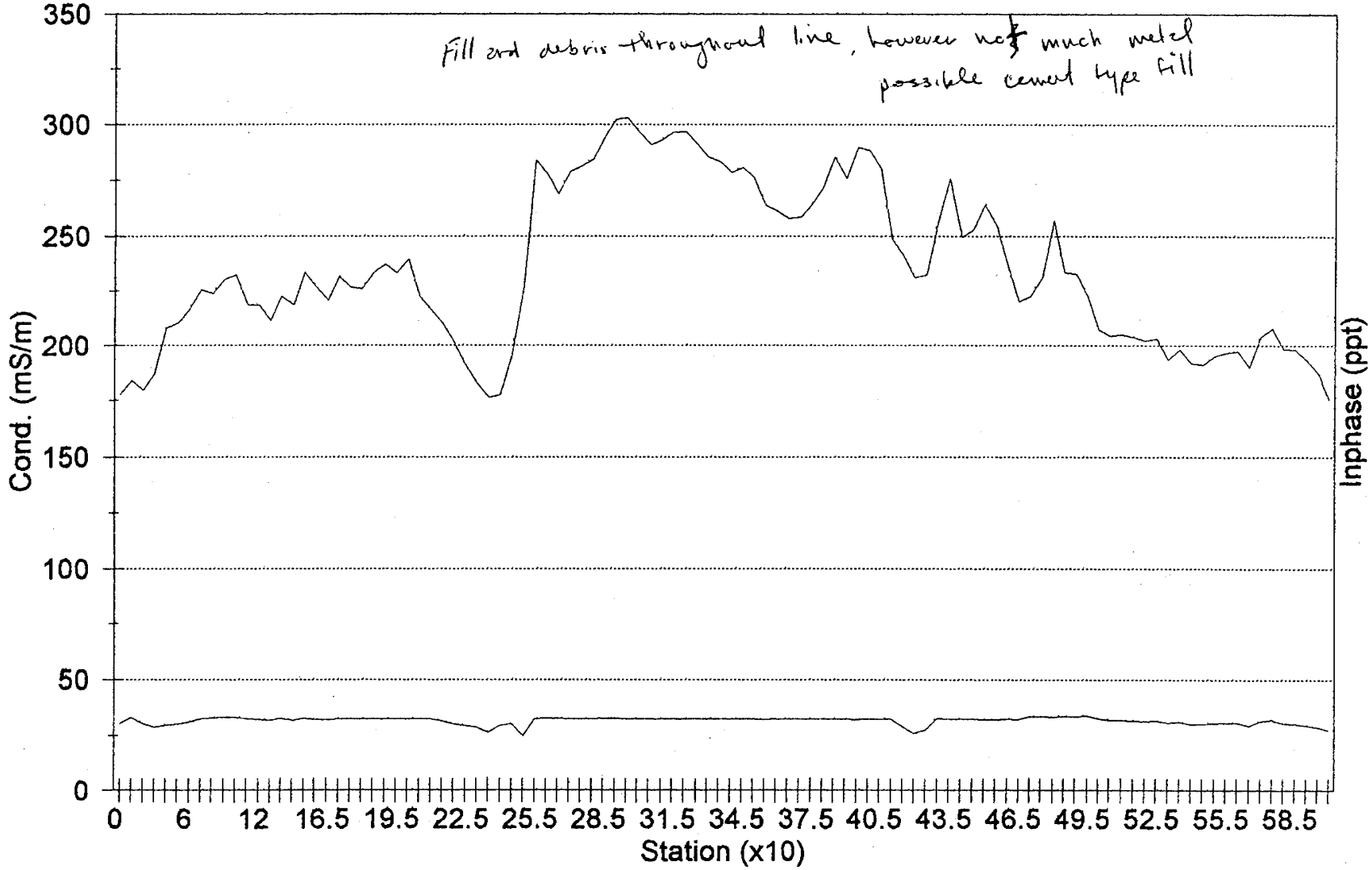

RUNWAY LANDFILL, EM31 SURVEY
Line 6
Cond. (mS/m)
Inphase (ppt)
Station (x10)
500
400
300
200
100
0
-100
0
6
12
16.5
19.5
22.5
25.5
28.5
31.5
34.5
37.5
40.5
43.5
46.5
49.5
52.5
55.5
58.5
fill
metal #1
possible area of fill


RUNWAY LANDFILL, EM31 SURVEY
Line 7
Cond. (mS/m)
Inphase (ppt)
Station (x10)
300
250
200
150
100
50
0
-50
0
5
10
15
17.5
20
22.5
25
27.5
30
32.5
35
37.5
40
42.5
45
47.5
50
started @ overrun area near runway
possible fill
unknown - could be fill
should be checked visually


RUNWAY LANDFILL, EM31 SURVEY
Line 8
Cond. (mS/m)
500
400
300
200
100
0
Inphase (ppt)
0
6
12
16.5
19.5
22.5
25.5
28.5
31.5
34.5
37.5
40.5
43.5
46.5
49.5
52.5
55.5
58.5
Station (x10)
possible fill throughout line
difficult to distinguish

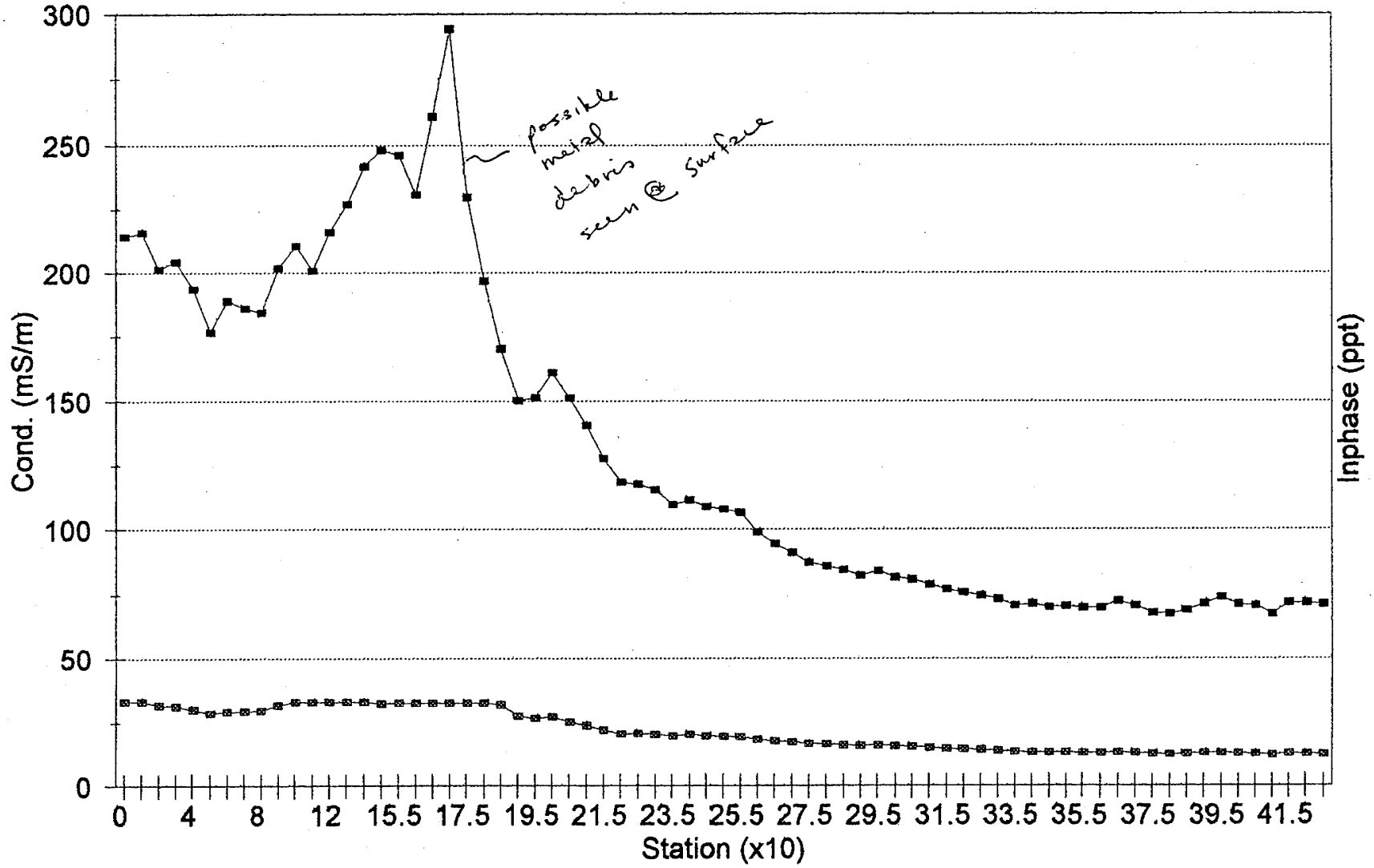
RUNWAY LANDFILL, EM31 SURVEY

Line 9



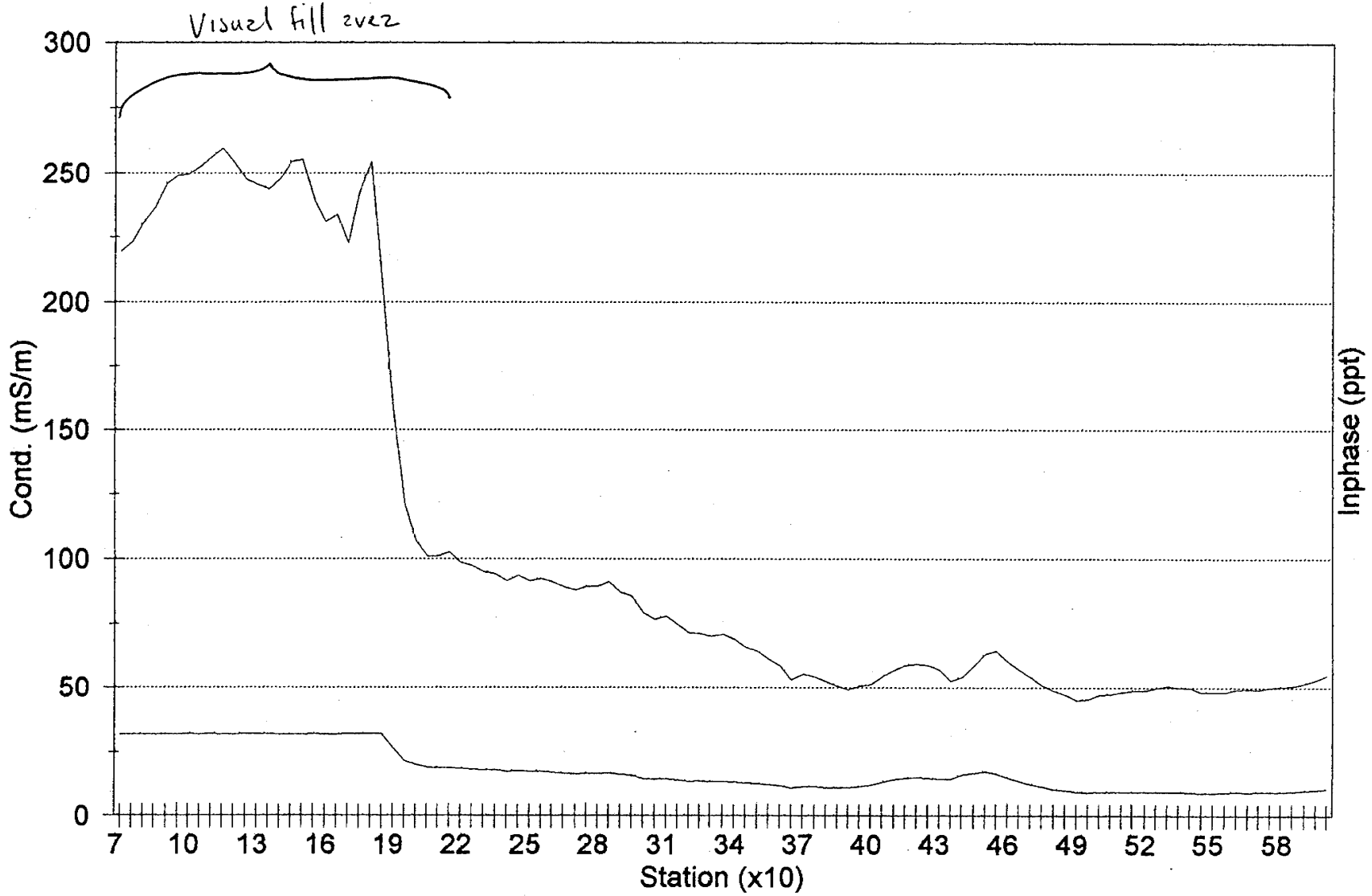
RUNWAY LANDFILL, EM31 SURVEY

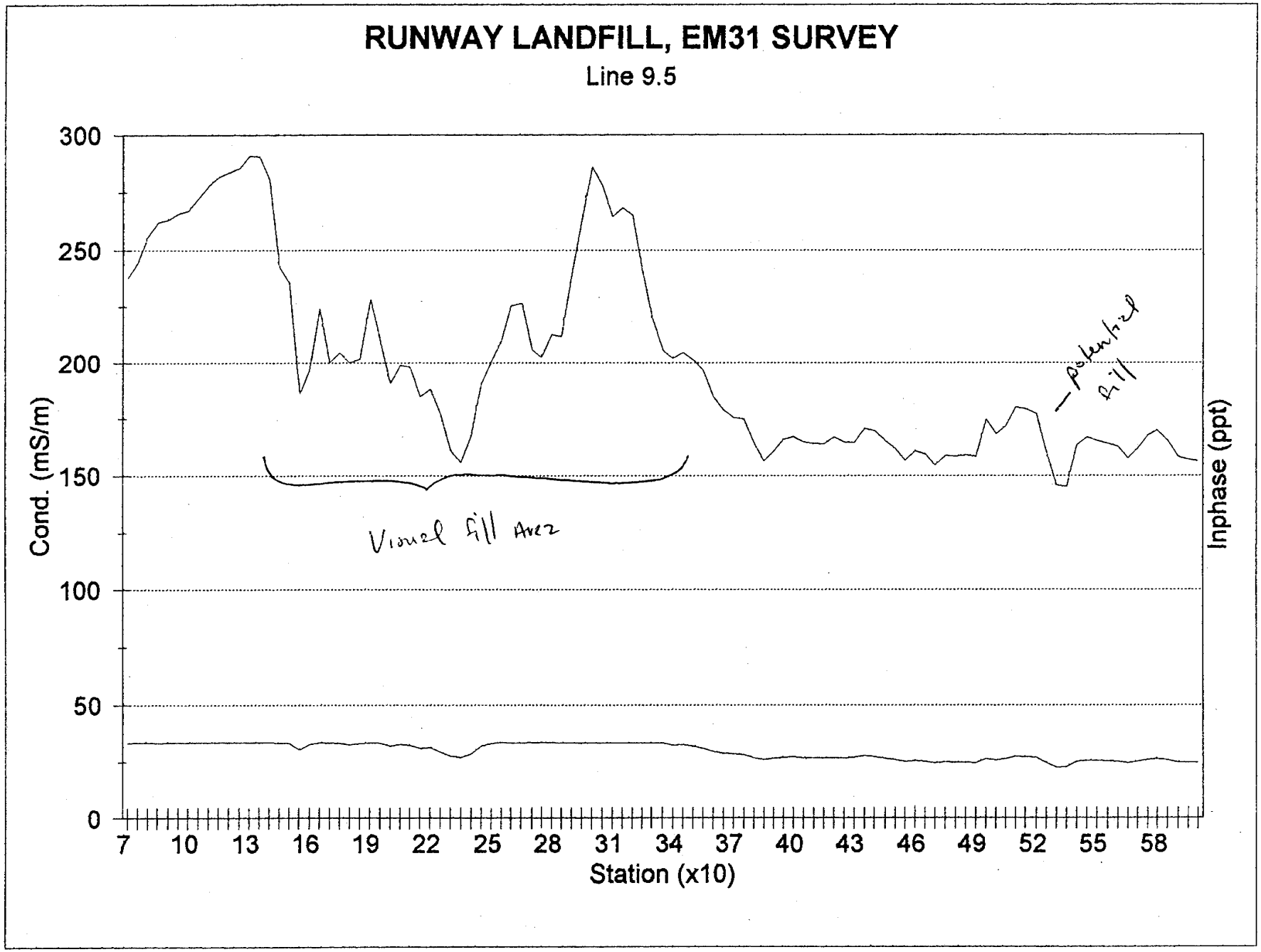
Line 10



RUNWAY LANDFILL, EM31 SURVEY

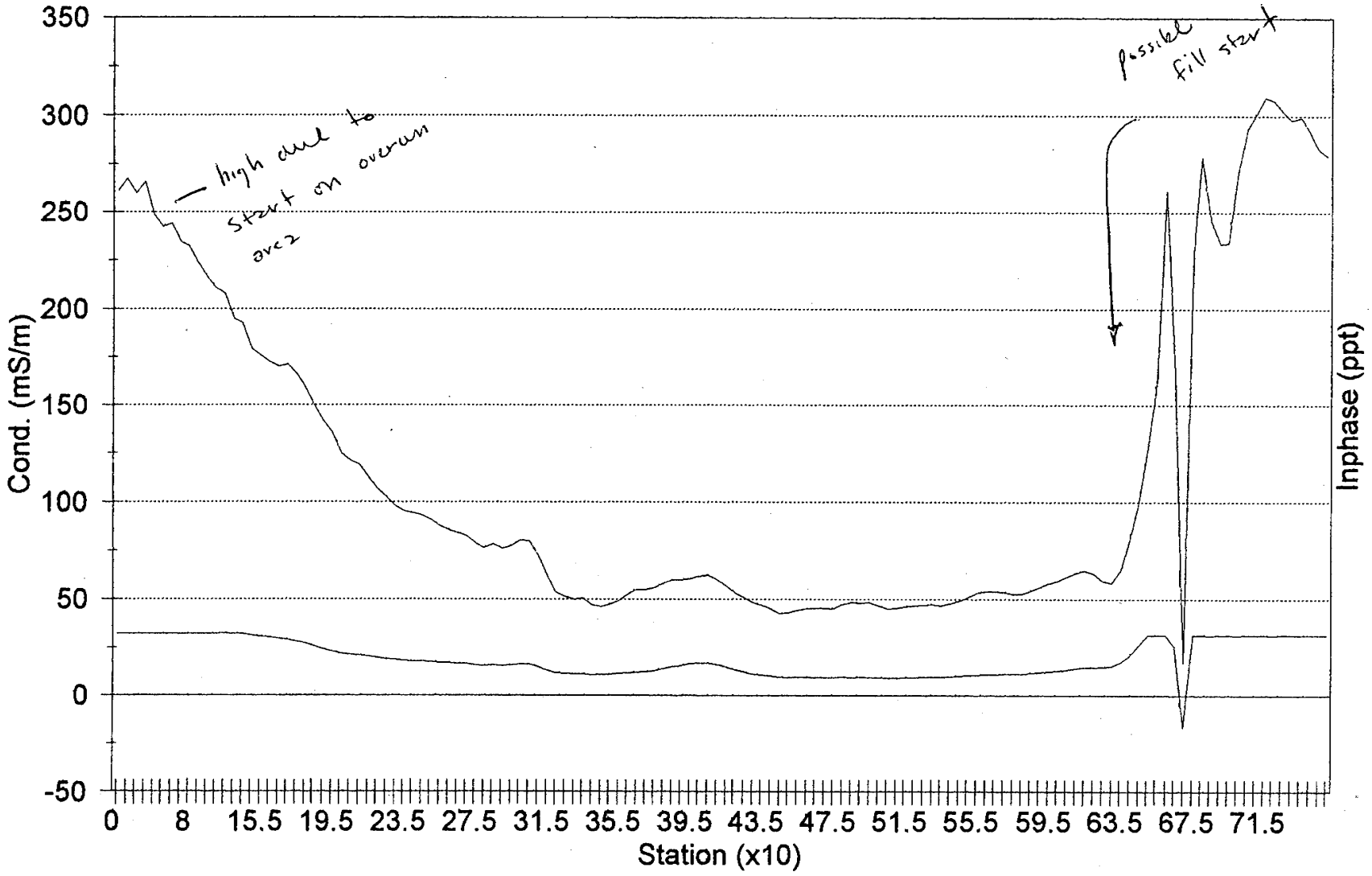
Line 10.5

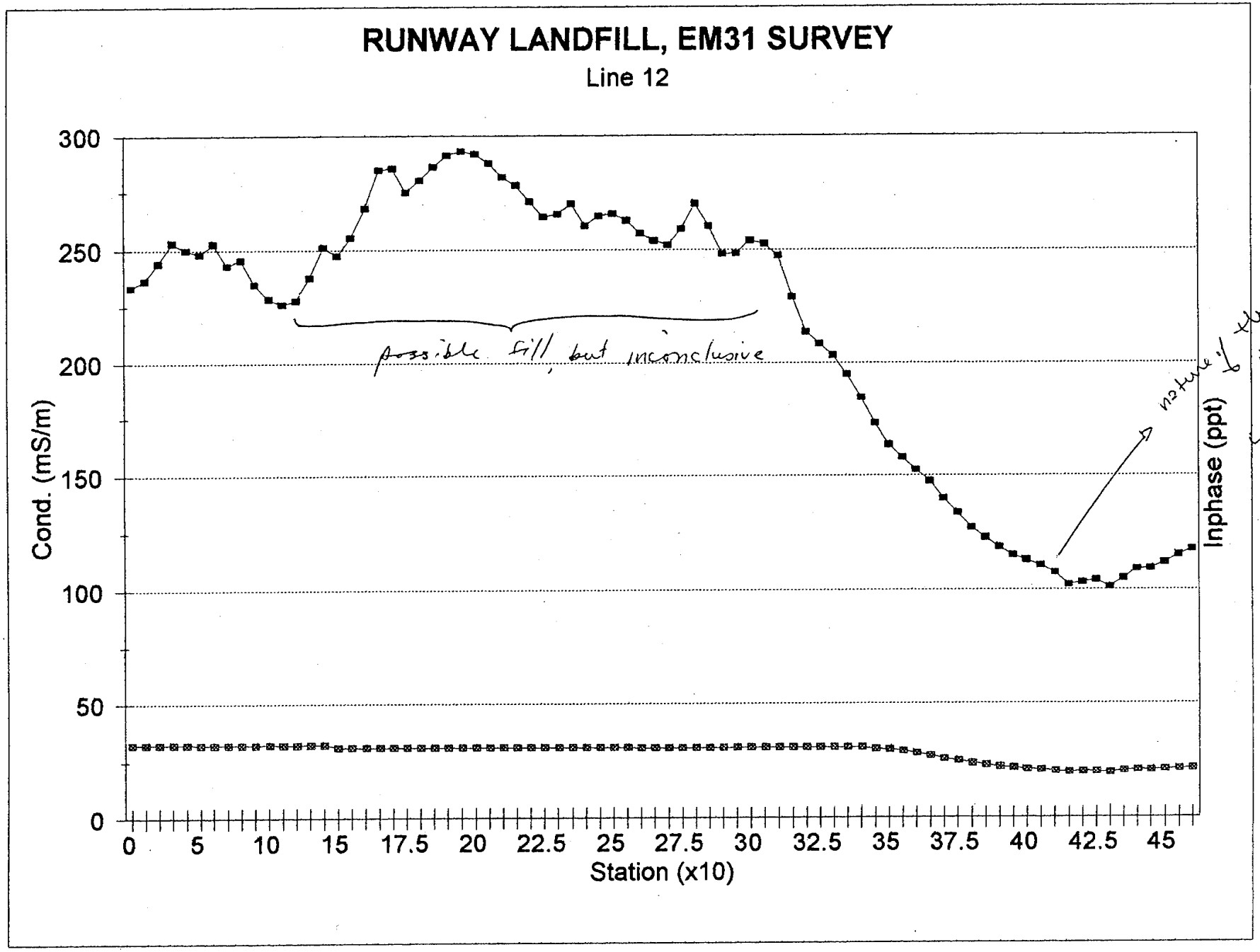



RUNWAY LANDFILL, EM31 SURVEY
Line 9.5
Cond. (mS/m)
Inphase (ppt)
Station (x10)
300
250
200
150
100
50
0
7
10
13
16
19
22
25
28
31
34
37
40
43
46
49
52
55
58
Visual fill Area
potential fill

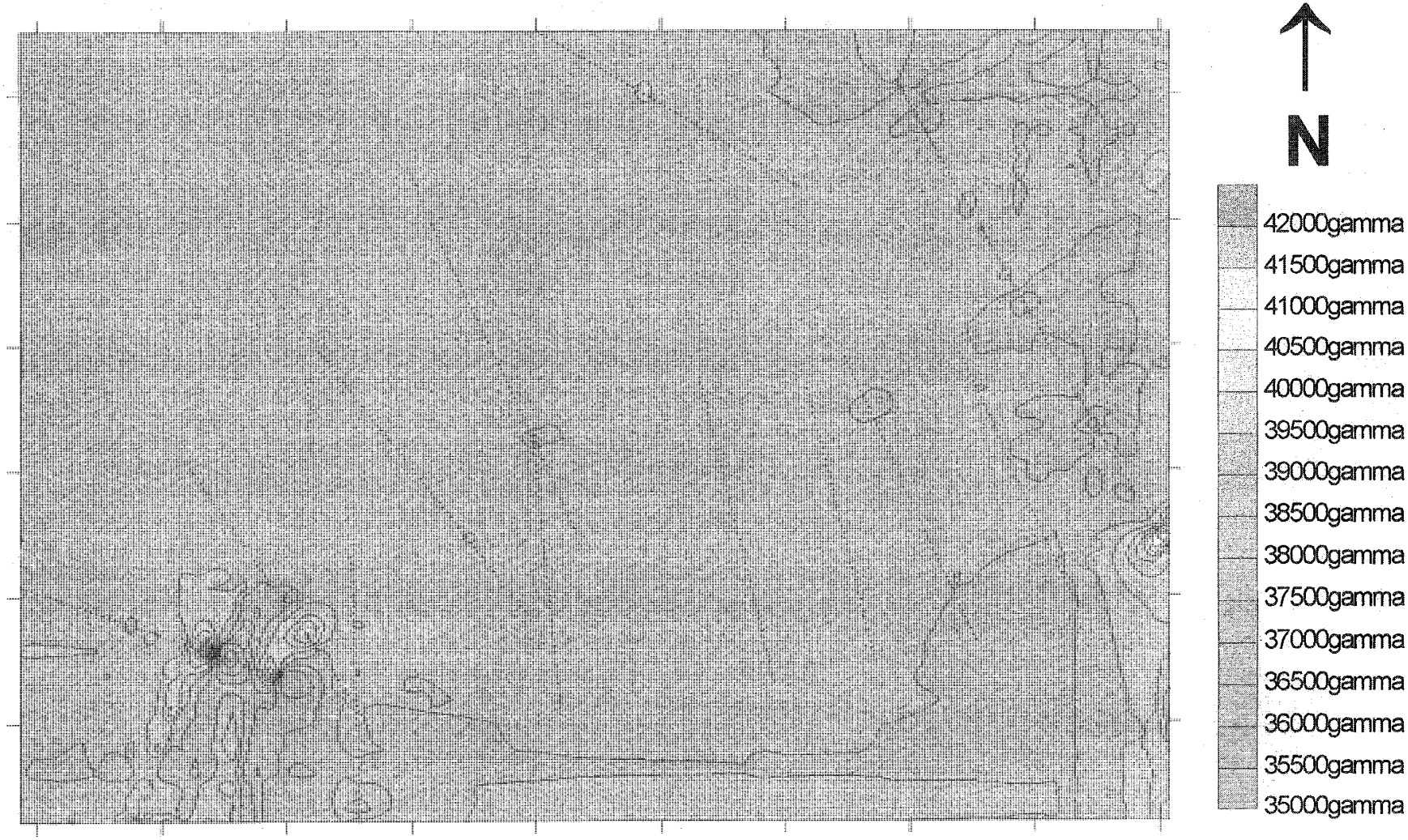
RUNWAY LANDFILL, EM31 SURVEY

Line 11




RUNWAY LANDFILL, EM31 SURVEY
Line 12
Cond. (mS/m)
Inphase (ppt)
Station (x10)
300
250
200
150
100
50
0
0
5
10
15
17.5
20
22.5
25
27.5
30
32.5
35
37.5
40
42.5
45
possible fill, but inconclusive
nature of this low is indeterminate
could be due to proximity to active fill or road.

Total Field Magnetometer Data
Runway Landfill
Sand Island
Midway NAF



Scale: 1 inch = 250 feet

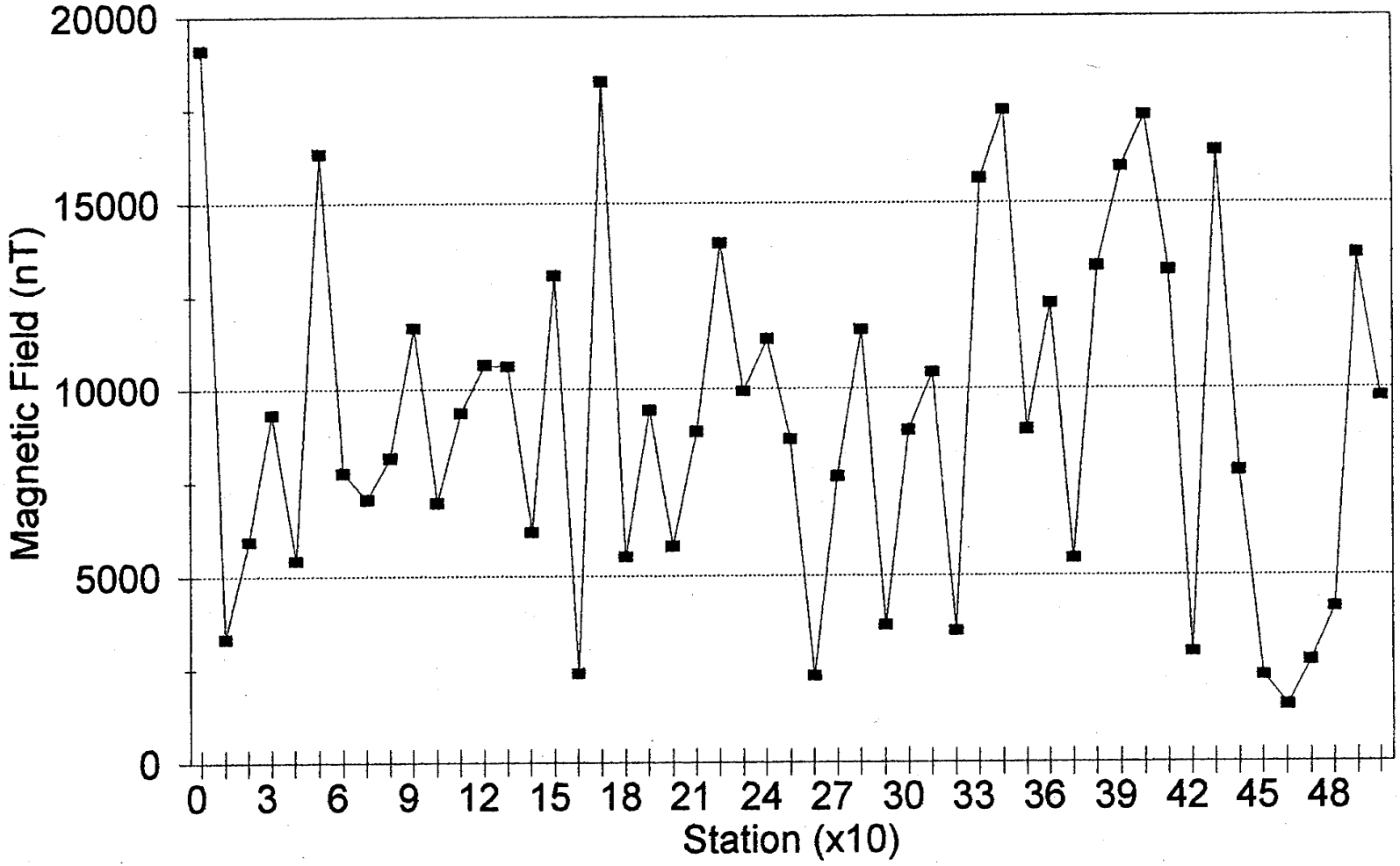
0ft. 250ft. 500ft. 750ft. 1000ft.

Note: Line 1 removed due to metallic seawall signal
Stations 0.0 and 50 ft. in line 7 removed due to
anomalously high reading caused by known
feature (metallic sign).

Variation due to metal piling in Sez well

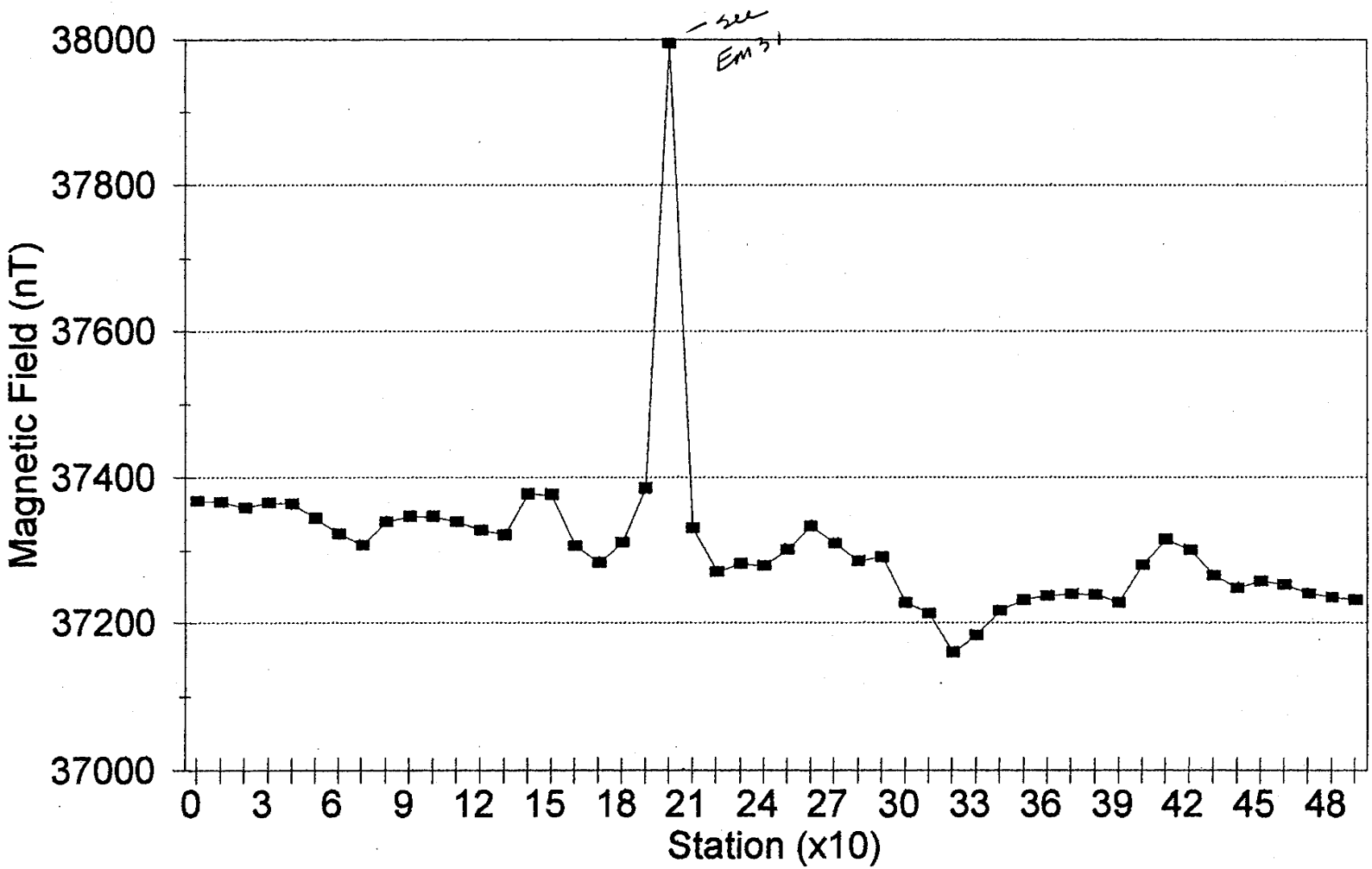
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 1



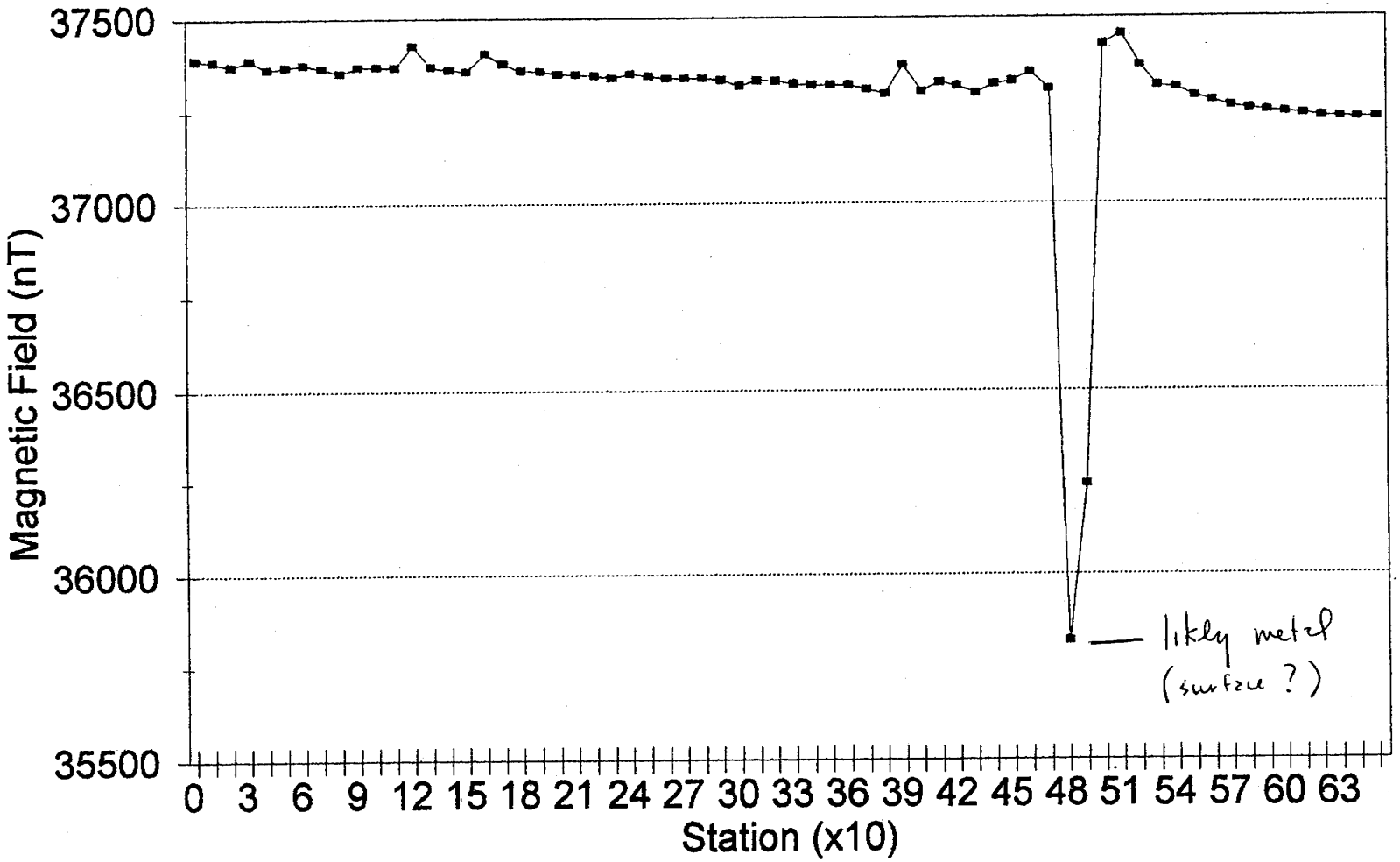
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 2



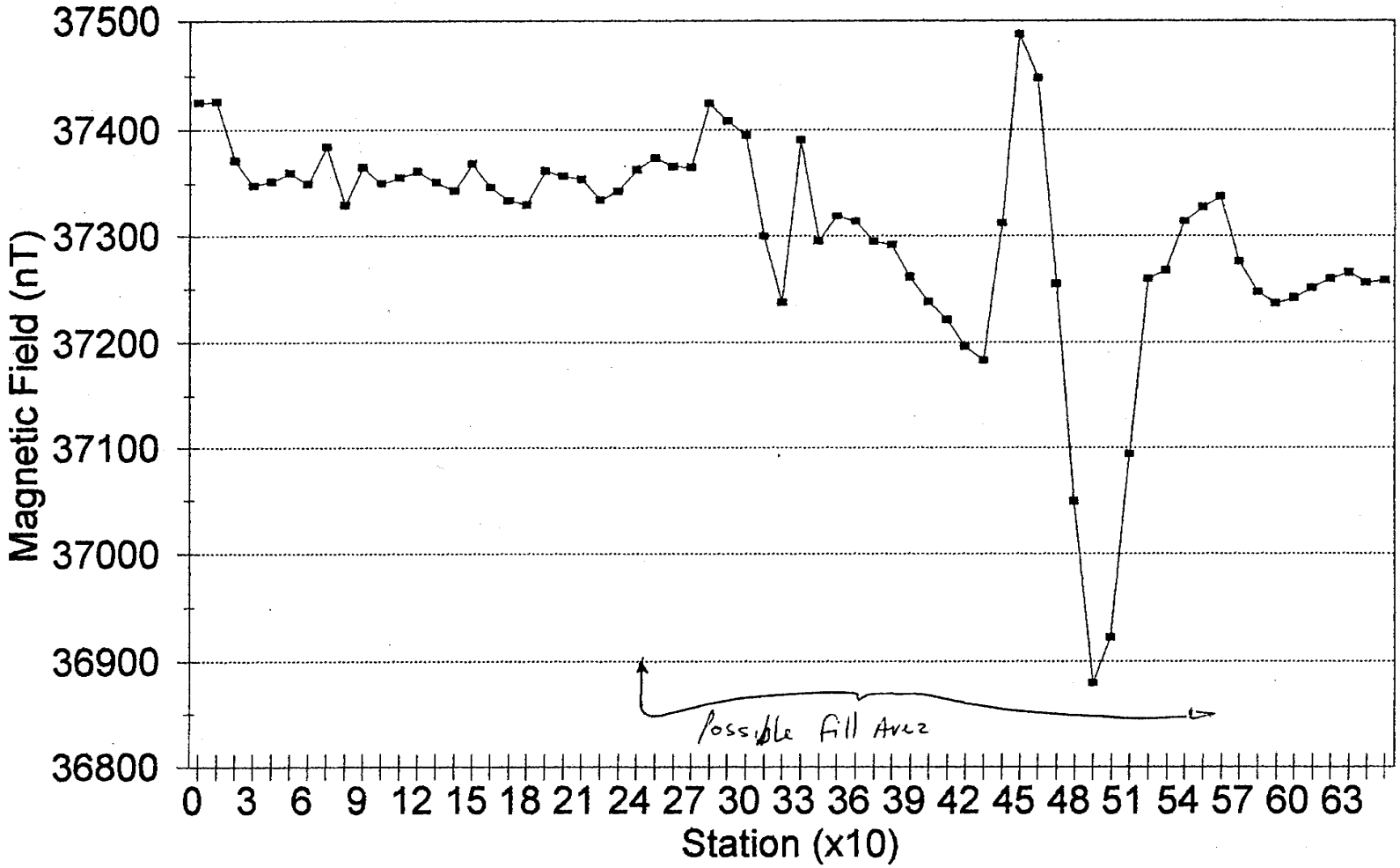
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 3



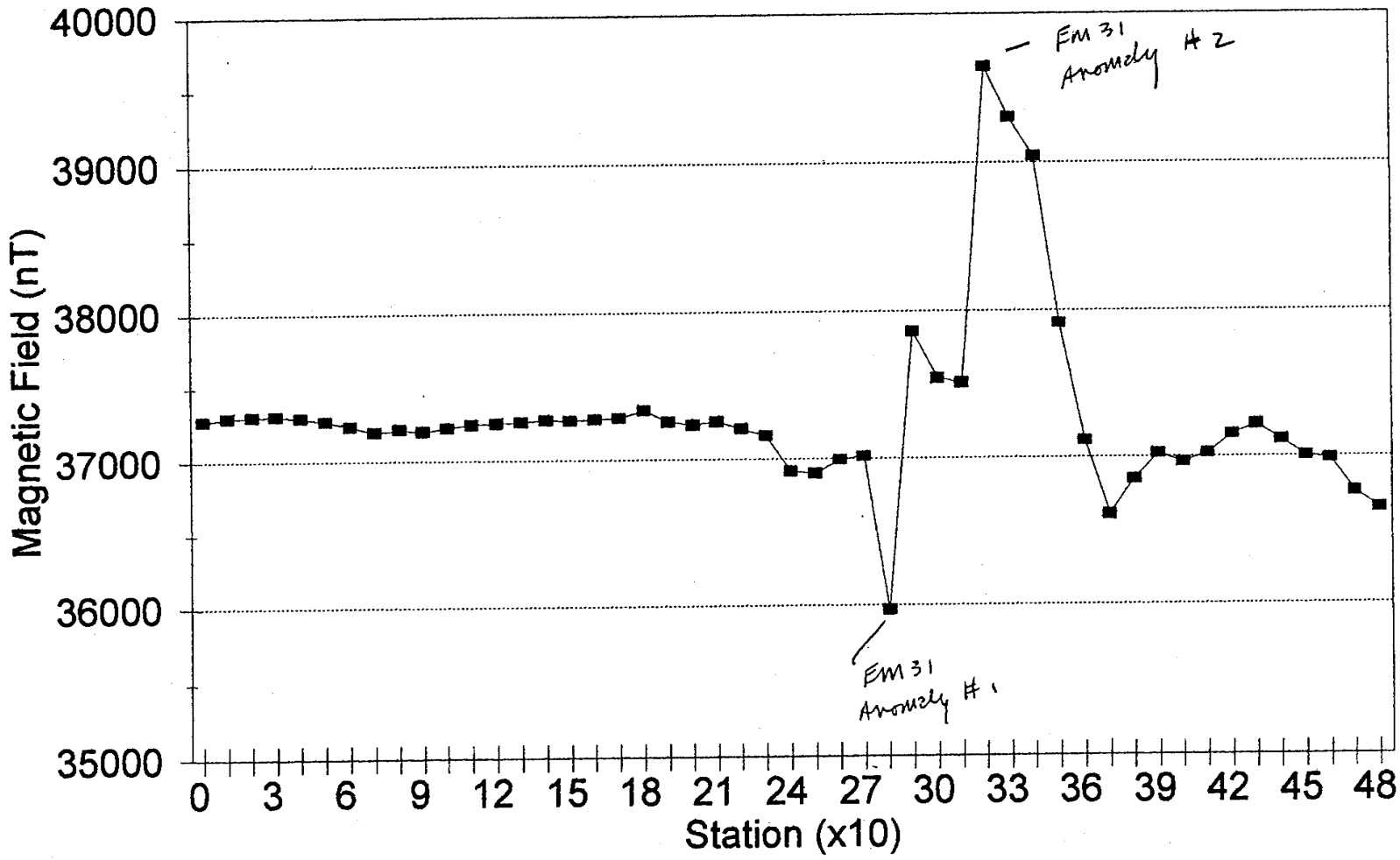
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 4



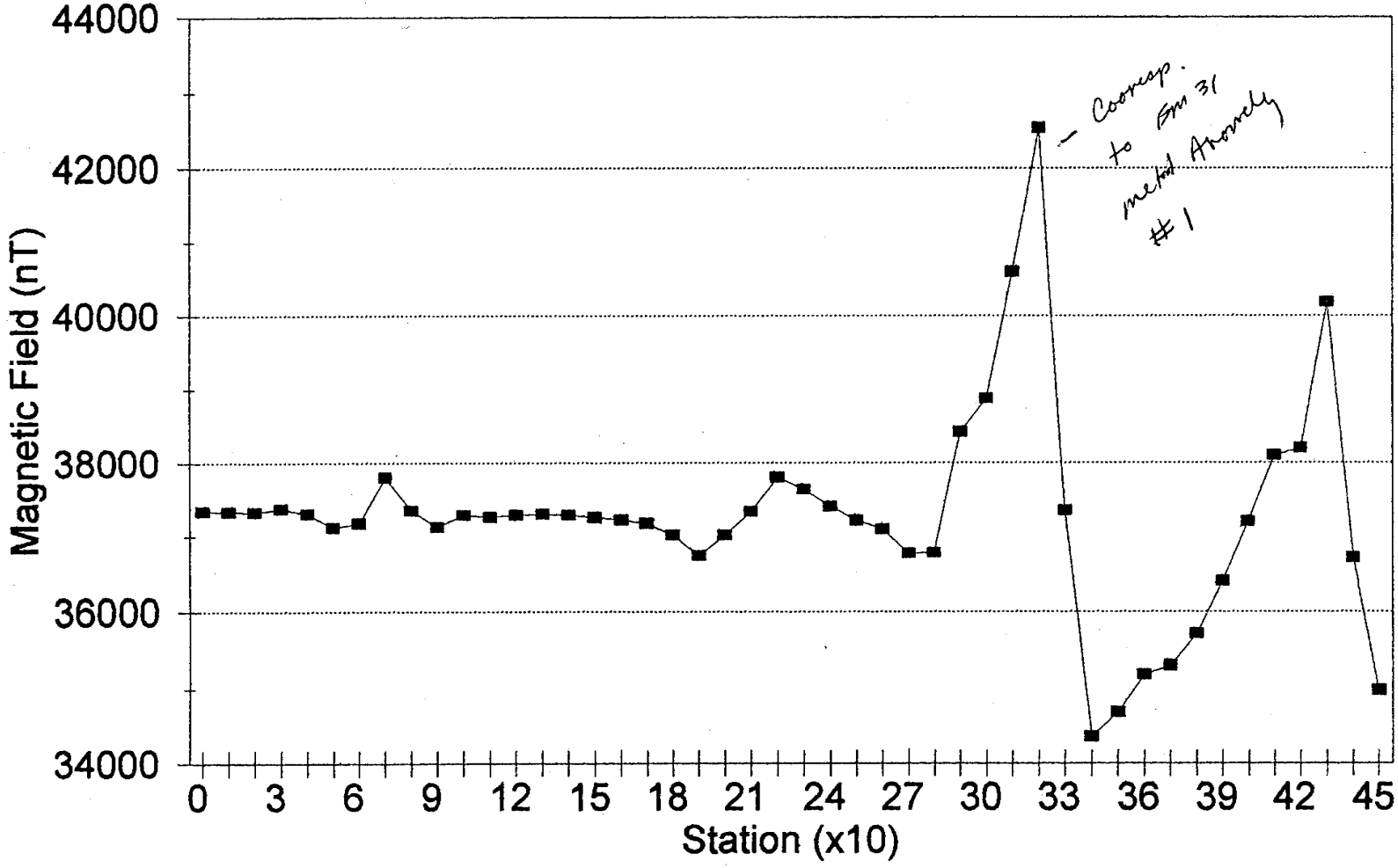
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 5



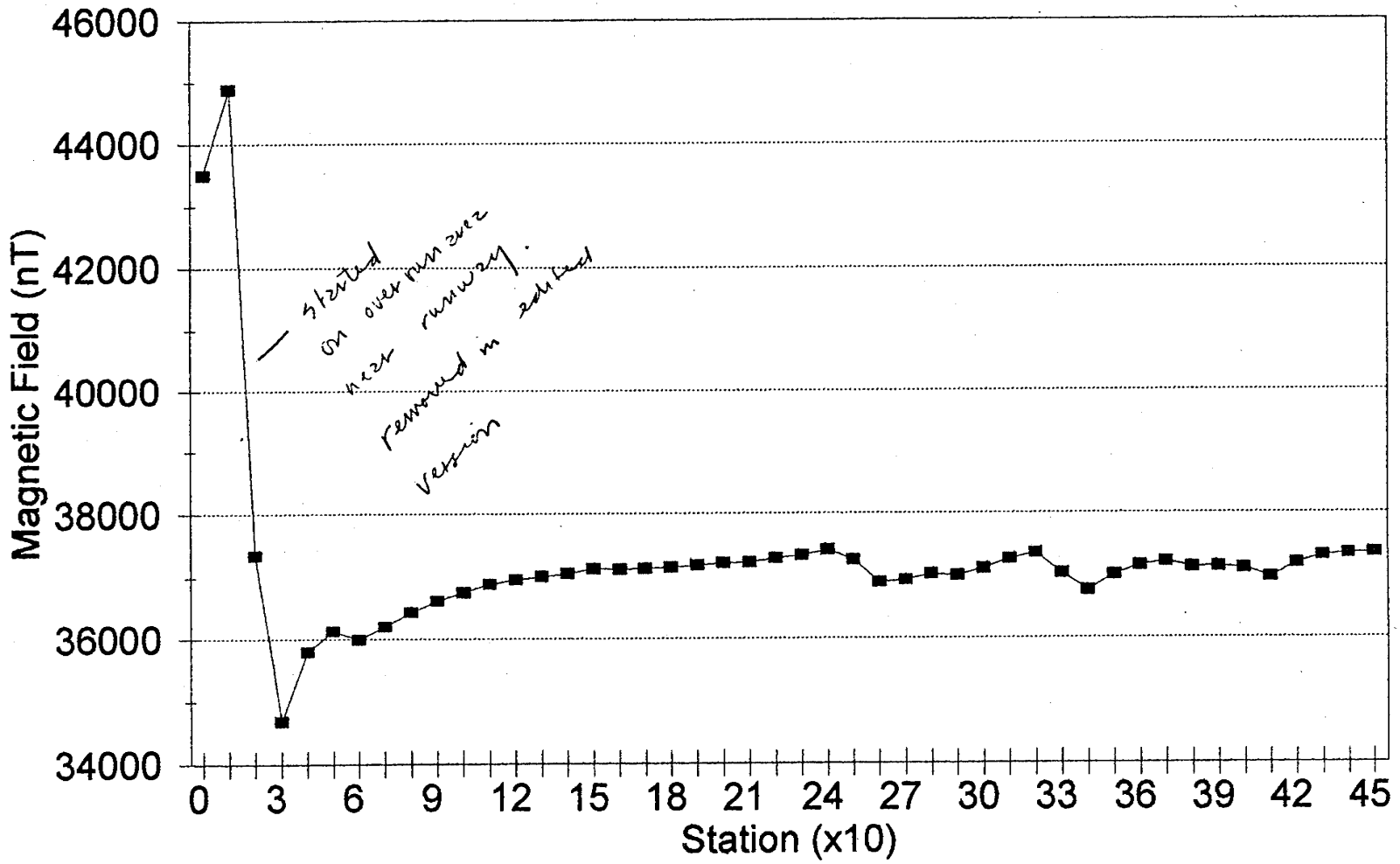
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 6



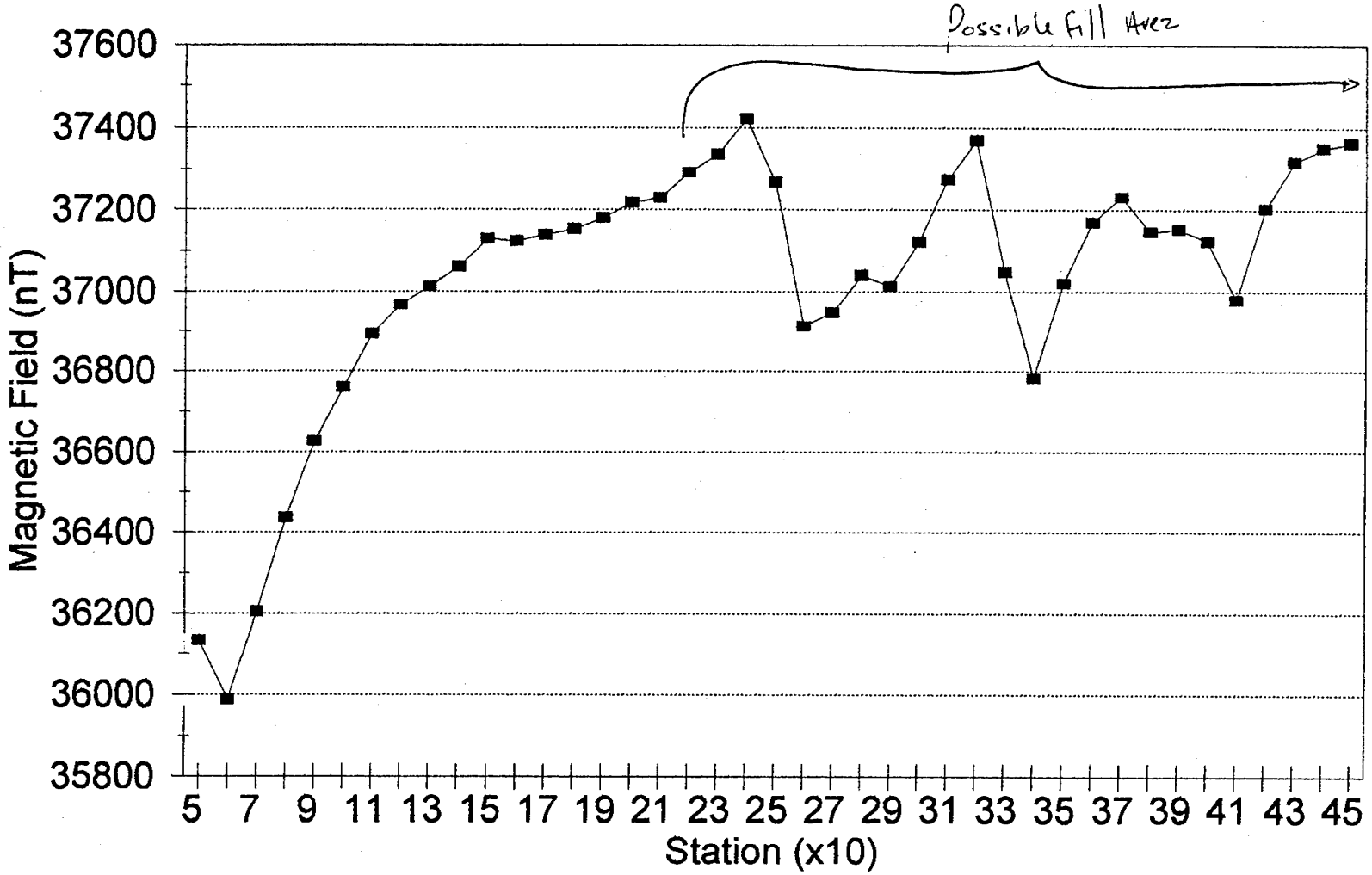
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 7



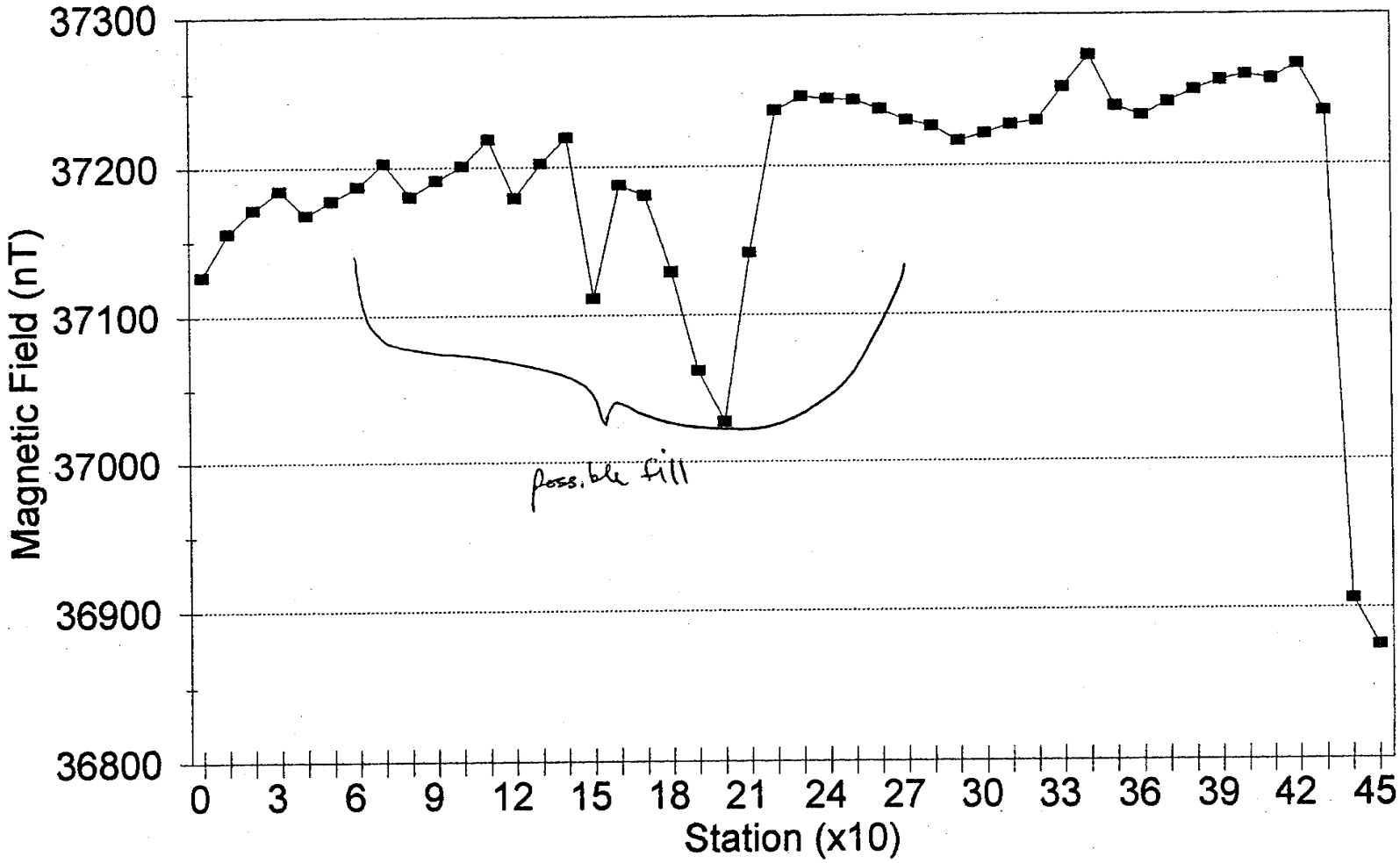
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 7 (edited)



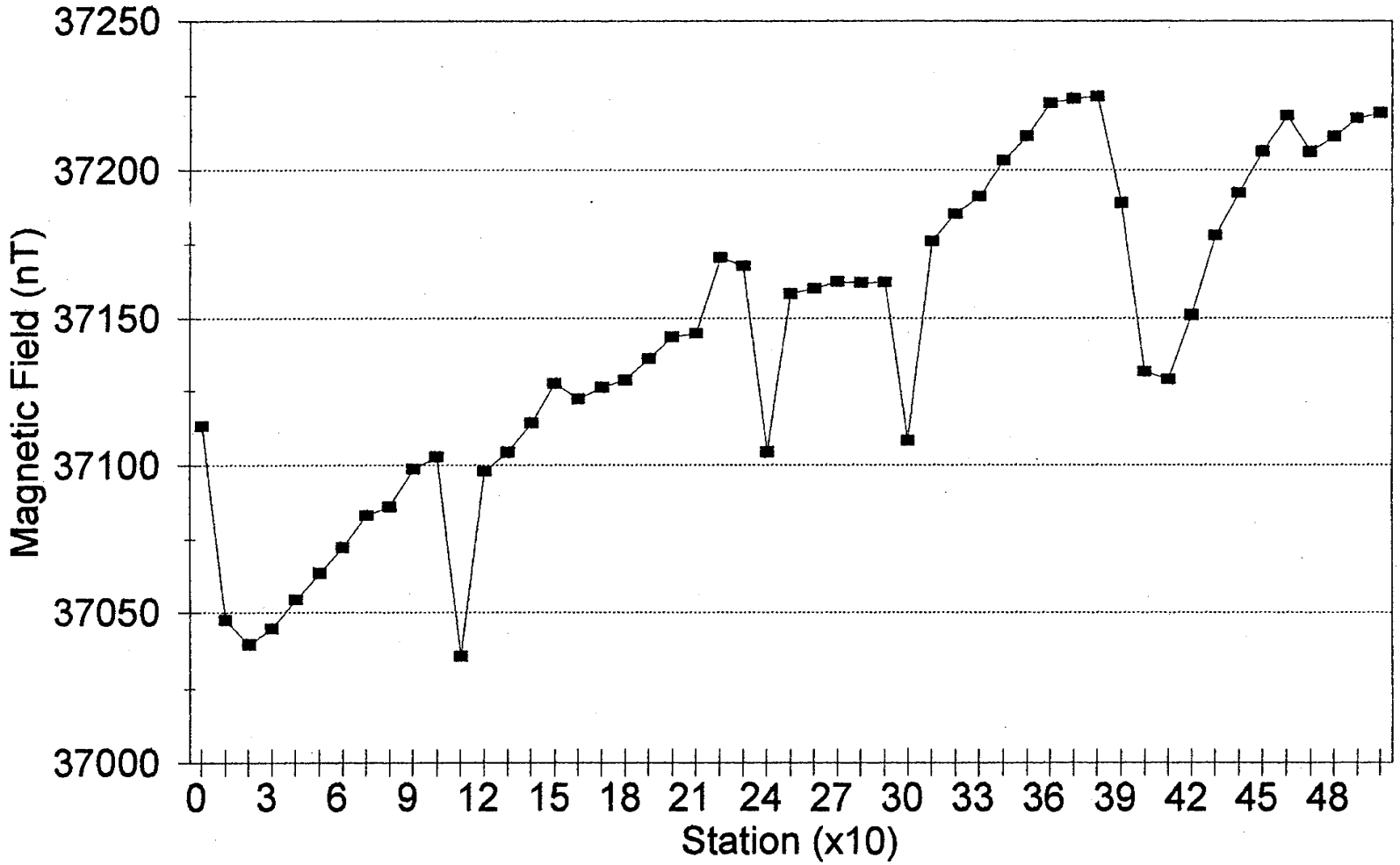
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 8



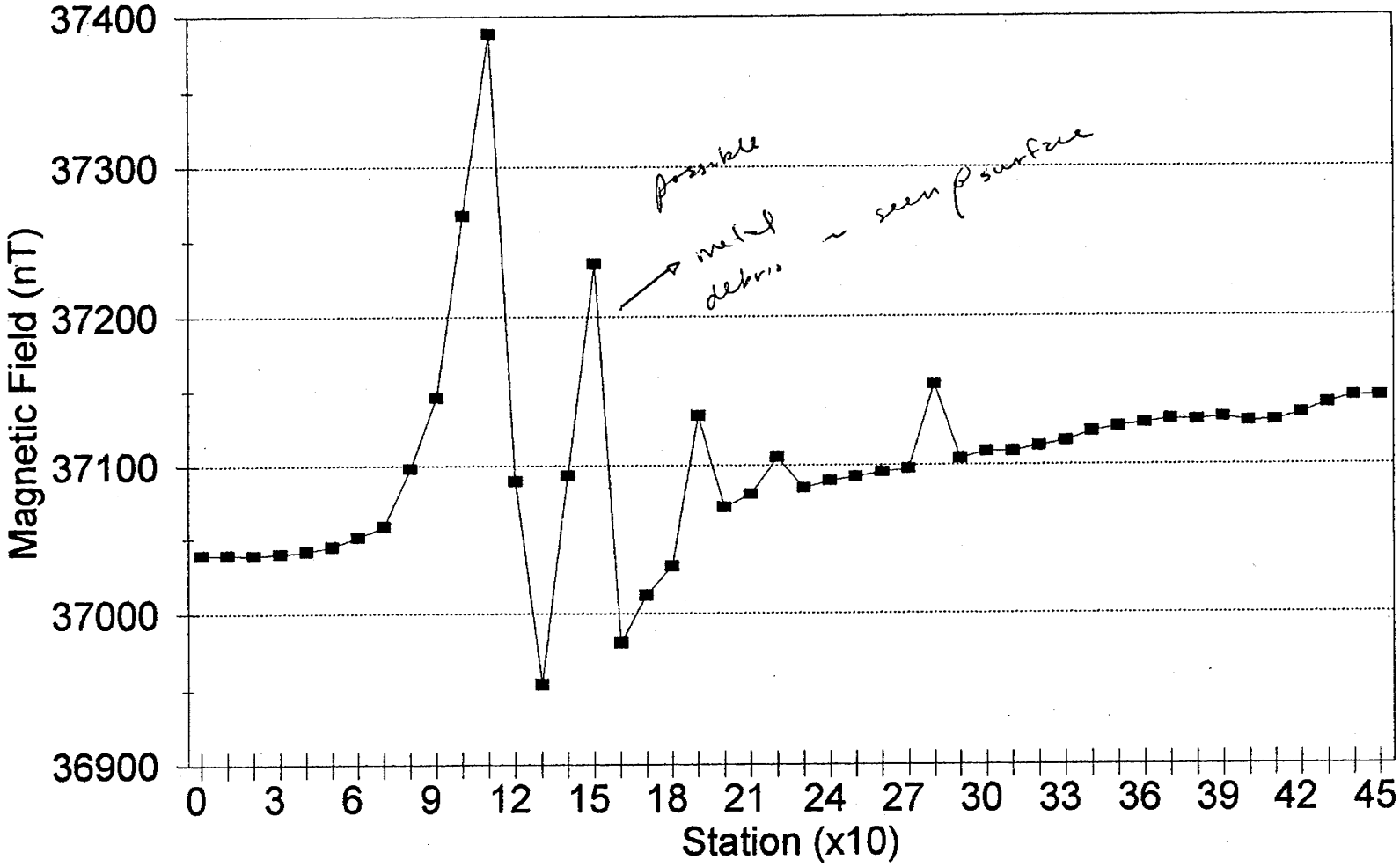
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 9



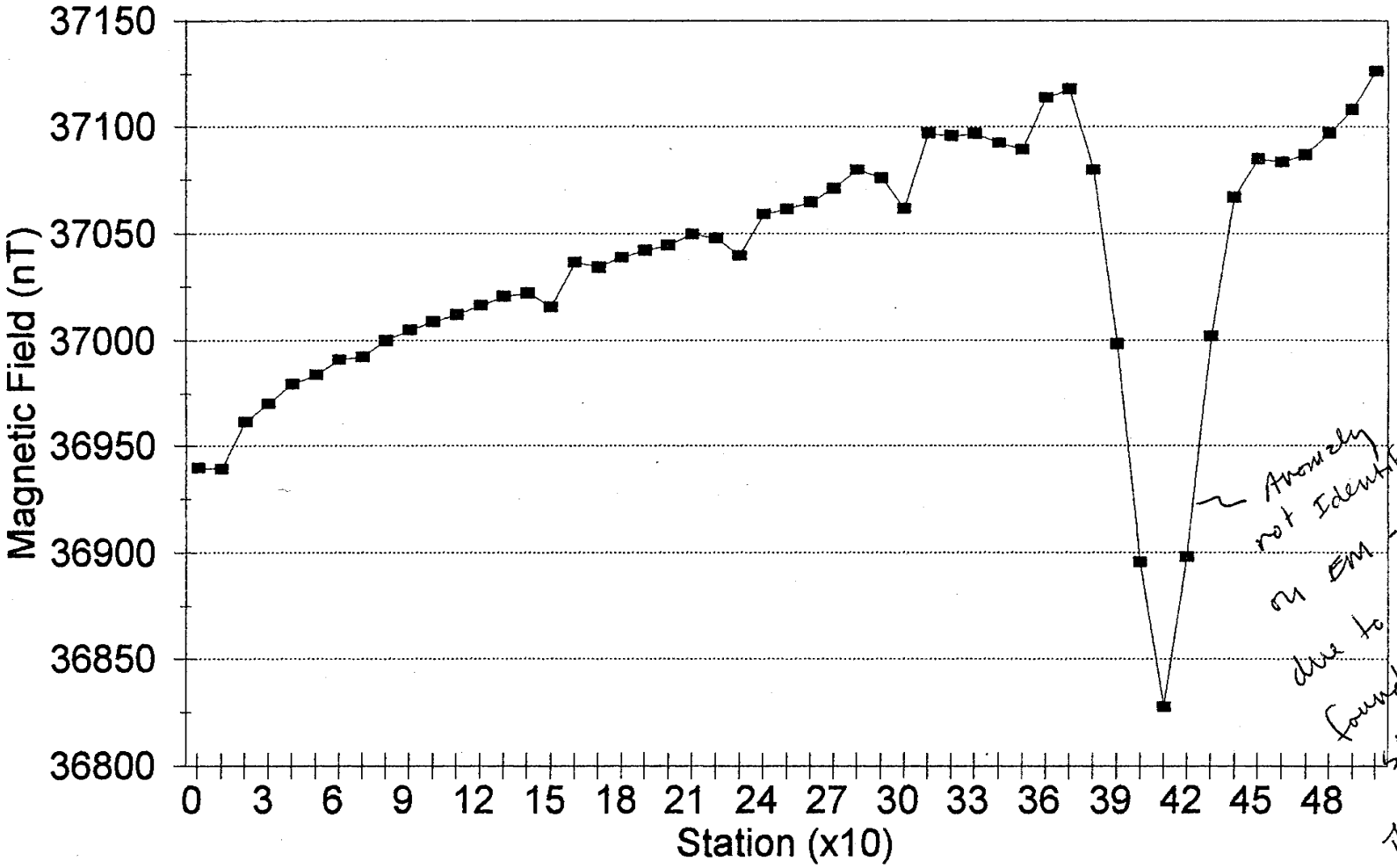
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 10



RUNWAY LANDFILL, MAGNETIC SURVEY

Line 11

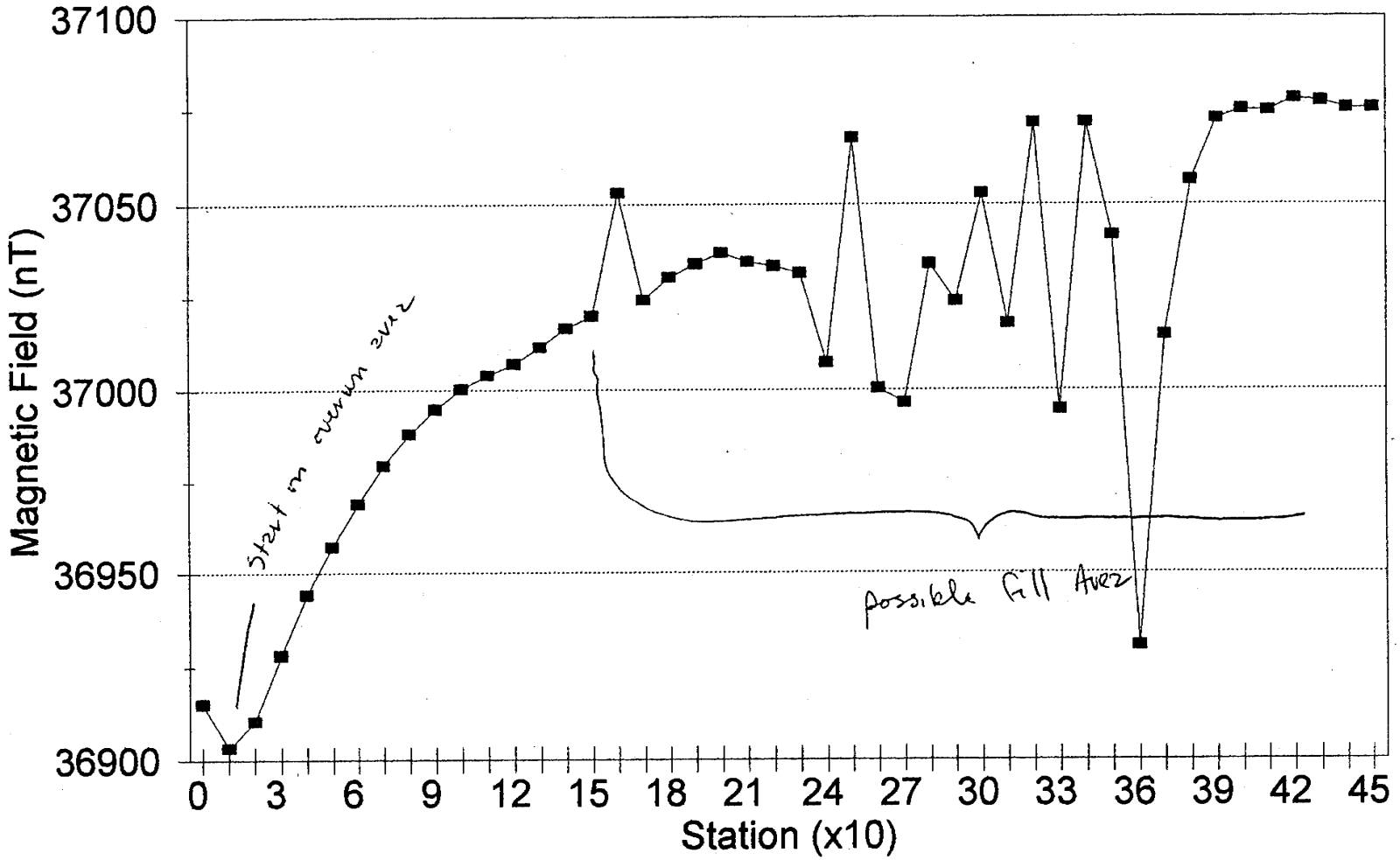


Anomaly not Identified on EM - possibly due to high level anomaly found on EM @ station 67.5

The anomaly could be high enough to "hide" this mag anomaly in the data.

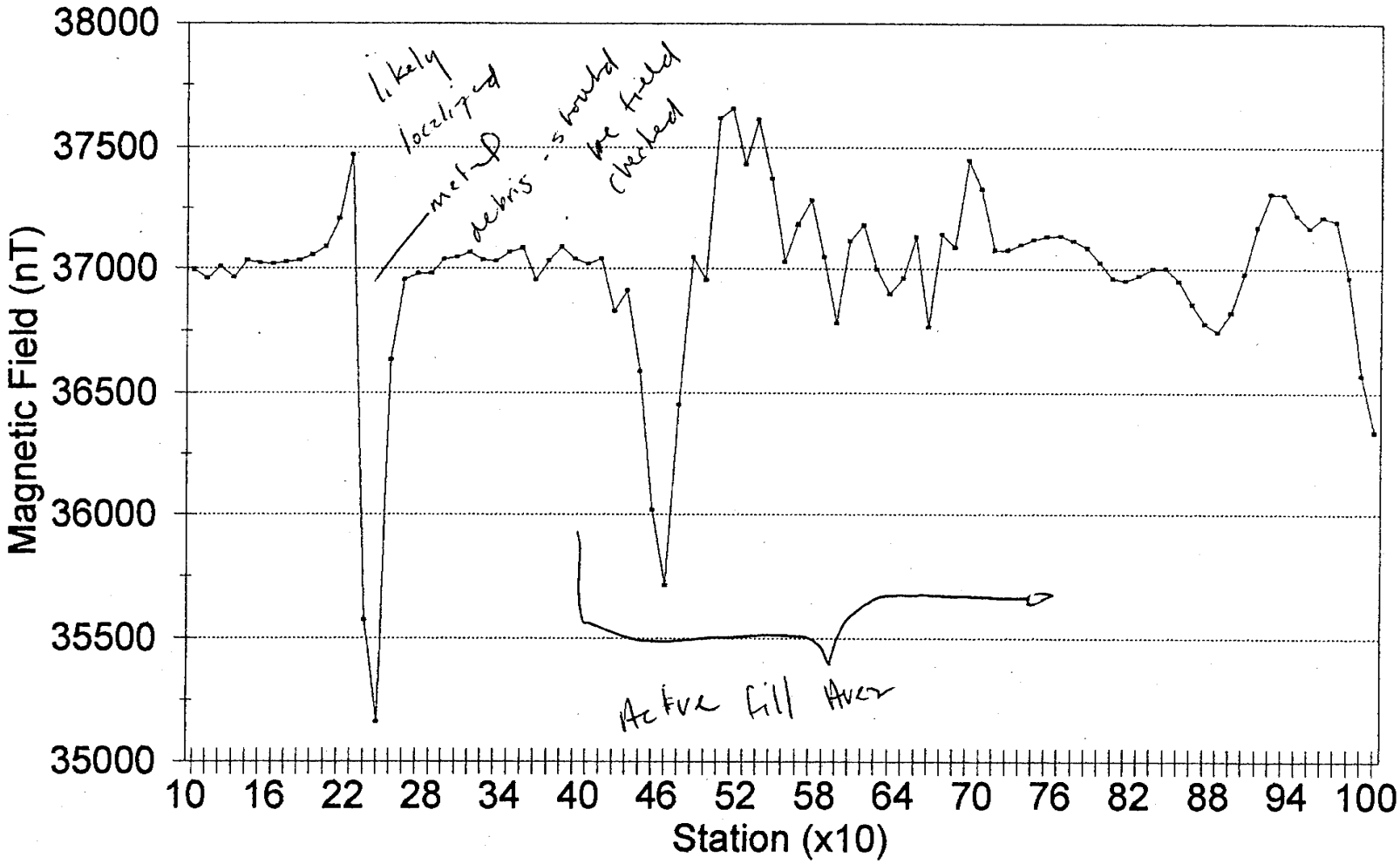
RUNWAY LANDFILL, MAGNETIC SURVEY

Line 12



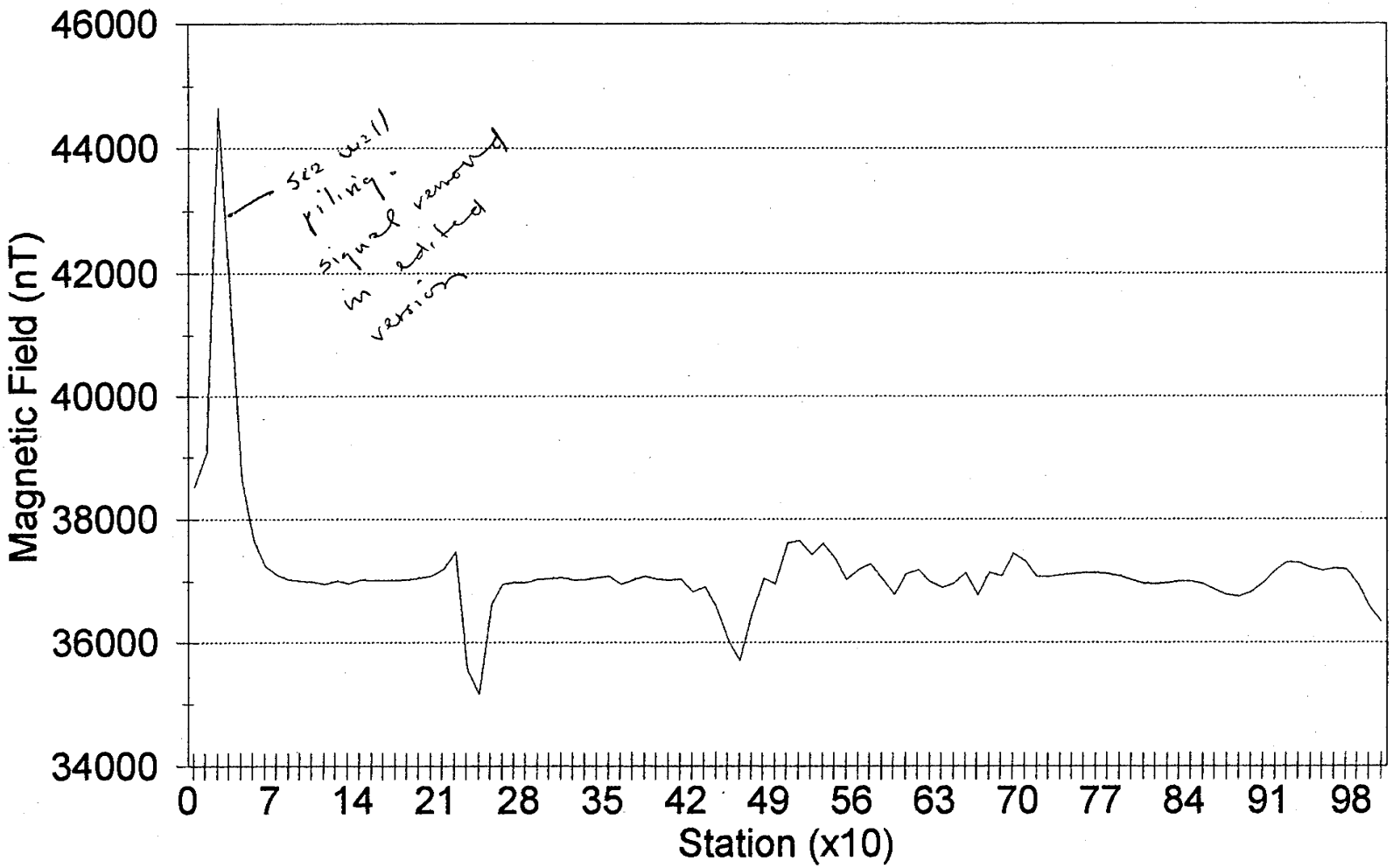
RUNWAY LANDFILL, MAGNETIC SURVEY

Transect Across Active Fill (edited)

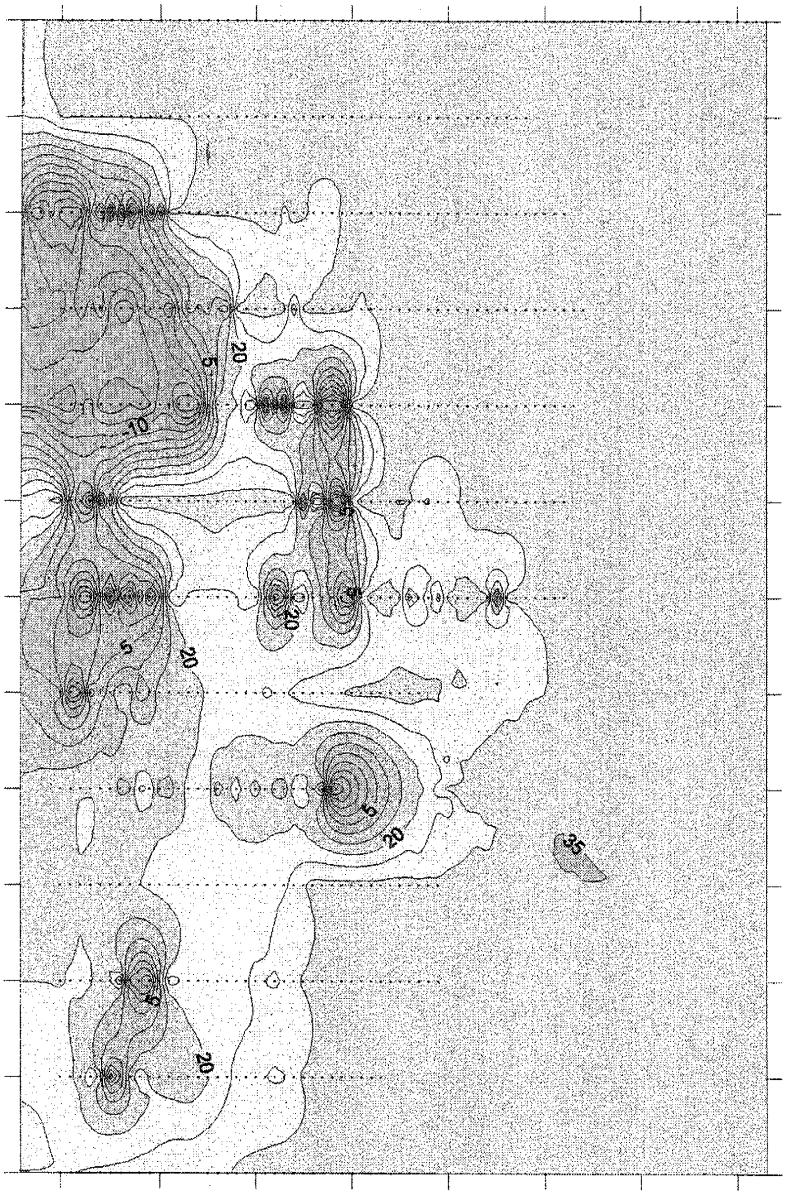


RUNWAY LANDFILL, MAGNETIC SURVEY

Transect Across Active Fill



EM-31 In-Phase Data
North East Disposal Area
Eastern Island
Midway NAF



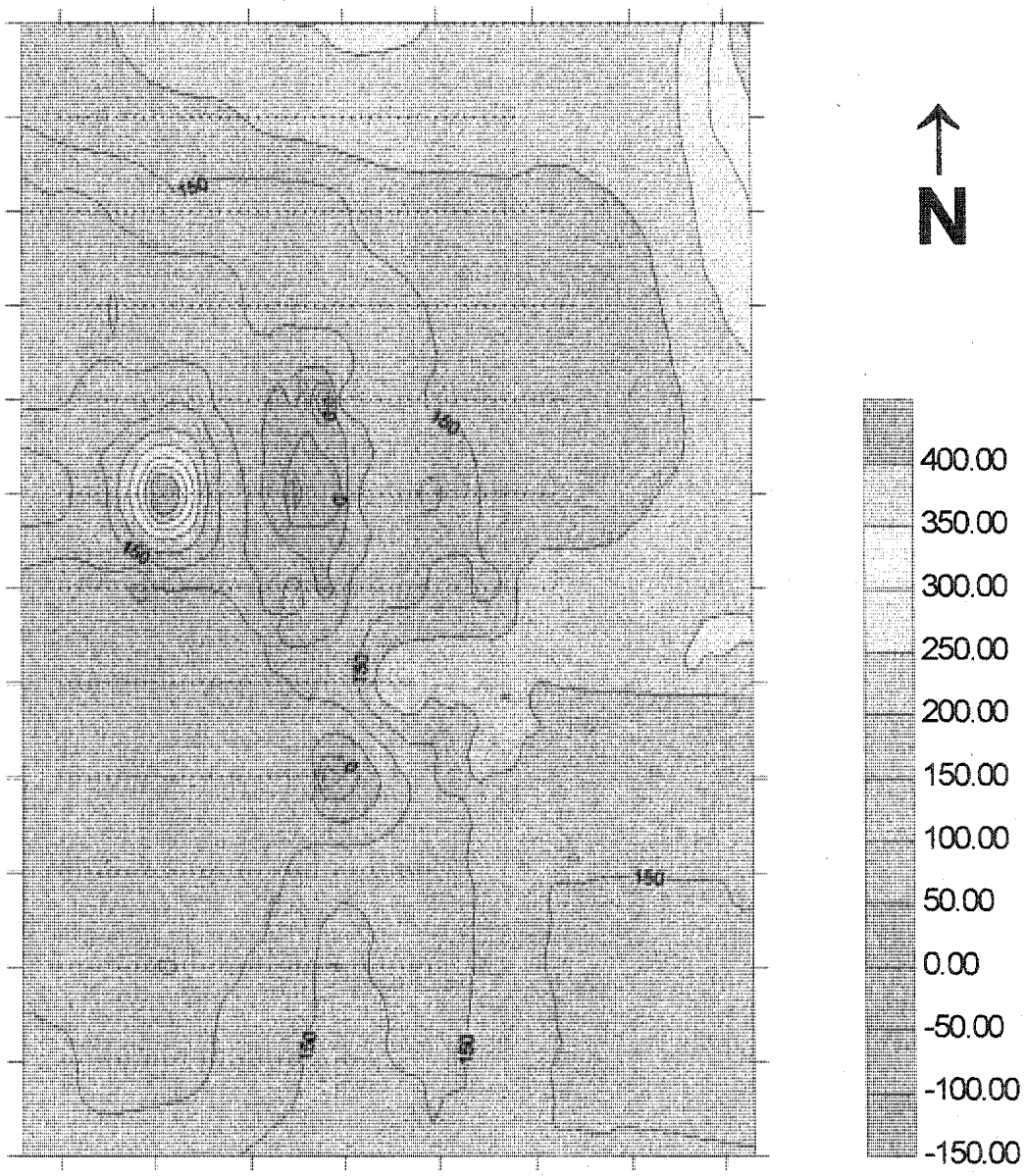
N

35ppt.
30ppt.
25ppt.
20ppt.
15ppt.
10ppt.
5ppt.
0ppt.
-5ppt.
-10ppt.
-15ppt.
-20ppt.
-25ppt.

Scale: 1 inch = 100 feet

0ft. 100ft. 200ft. 300ft. 400ft.

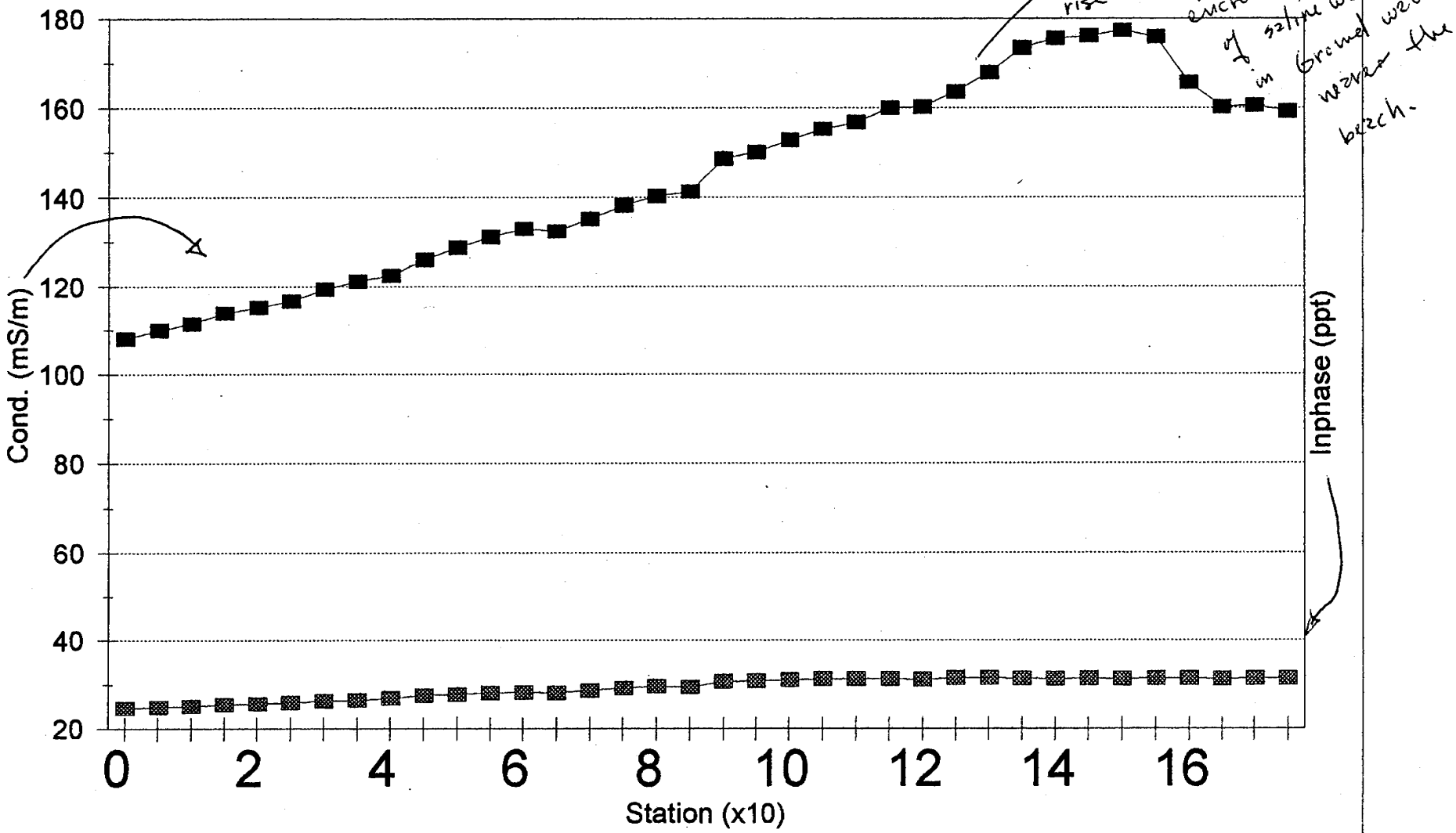
EM-31 Conductivity Data
North East Disposal Area
Eastern Island
Midway NAF



Scale: 1 inch = 100 feet

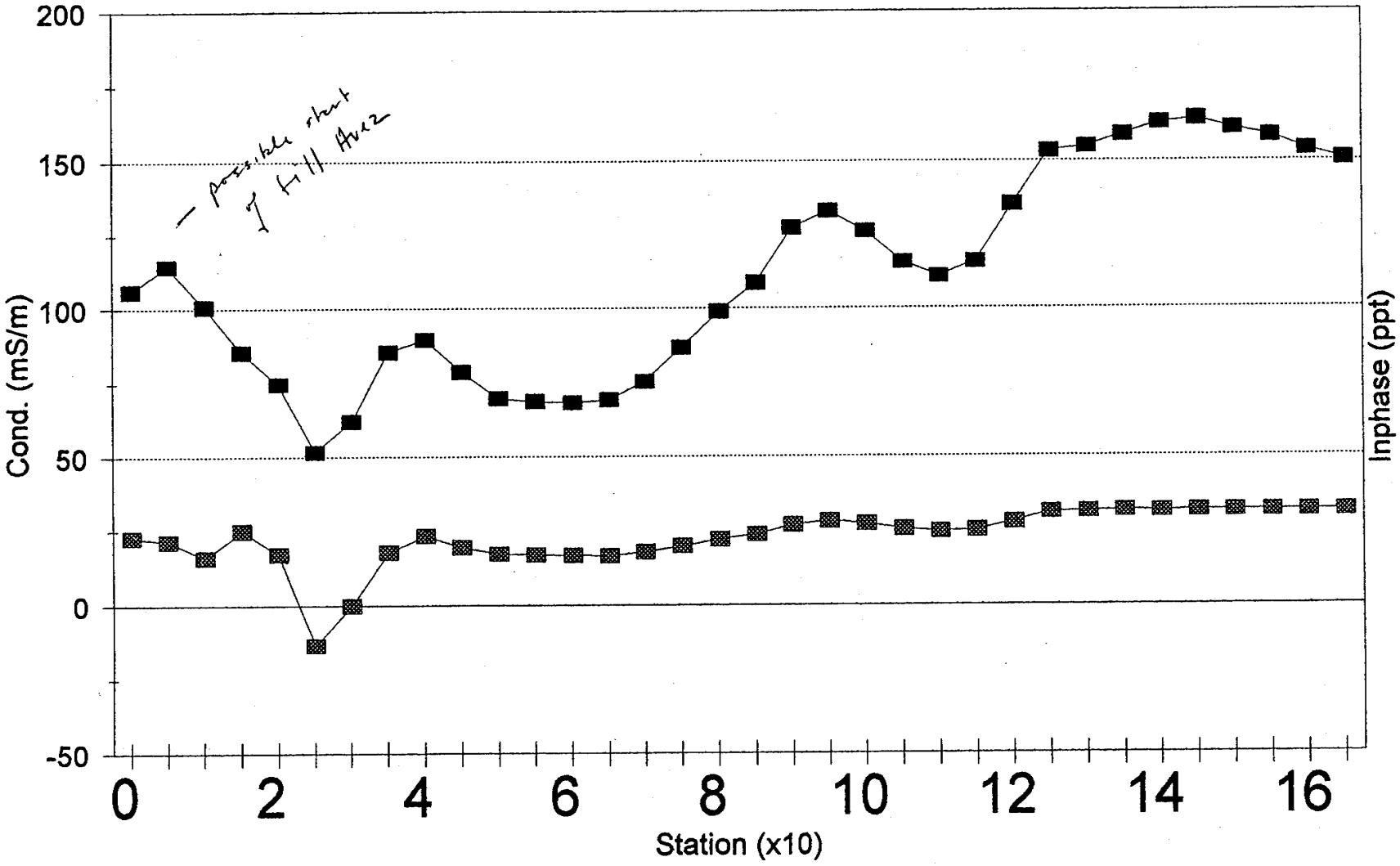
NE DISPOSAL AREA, EM31 SURVEY

Line 1



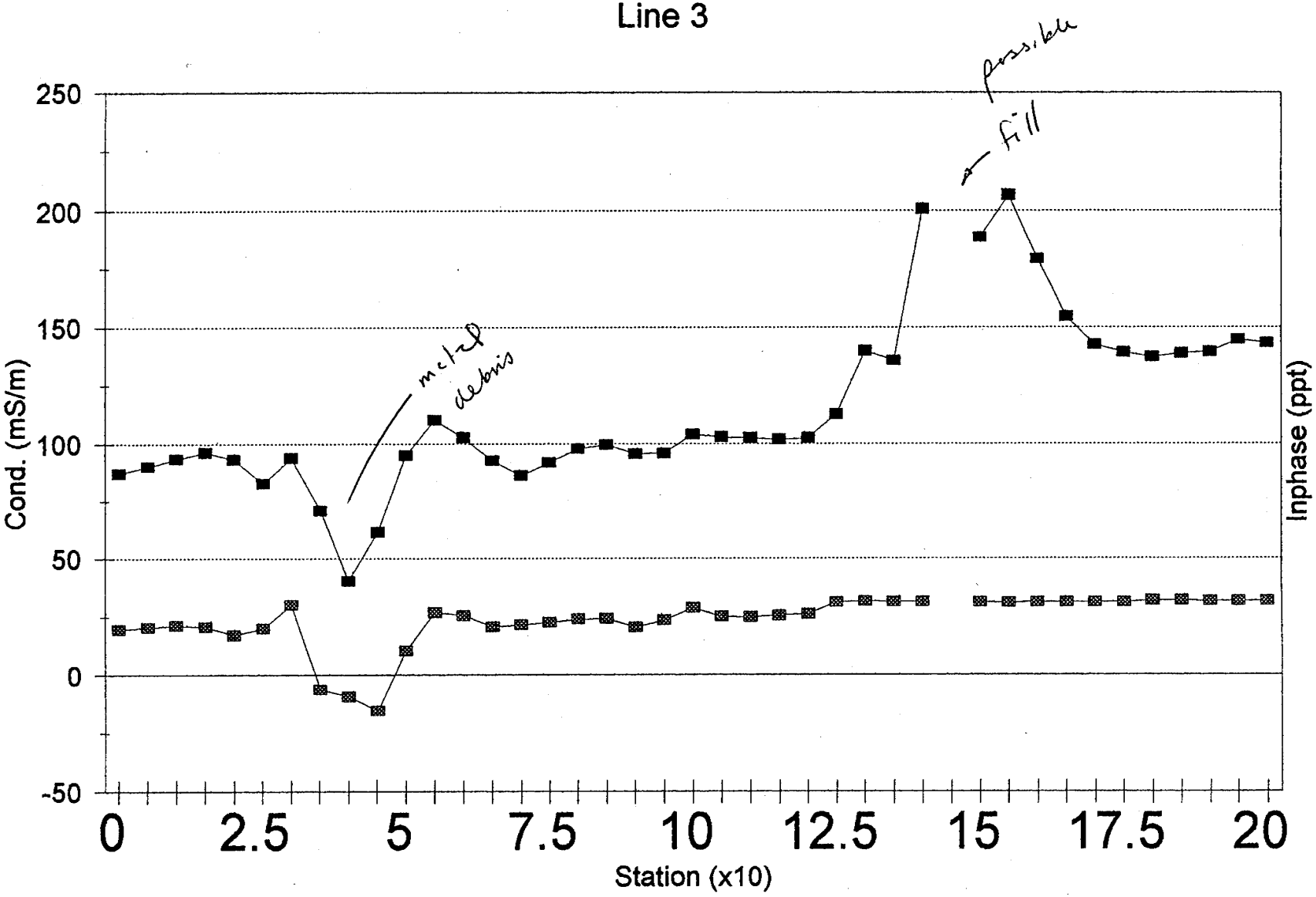
NE DISPOSAL AREA, EM31 SURVEY

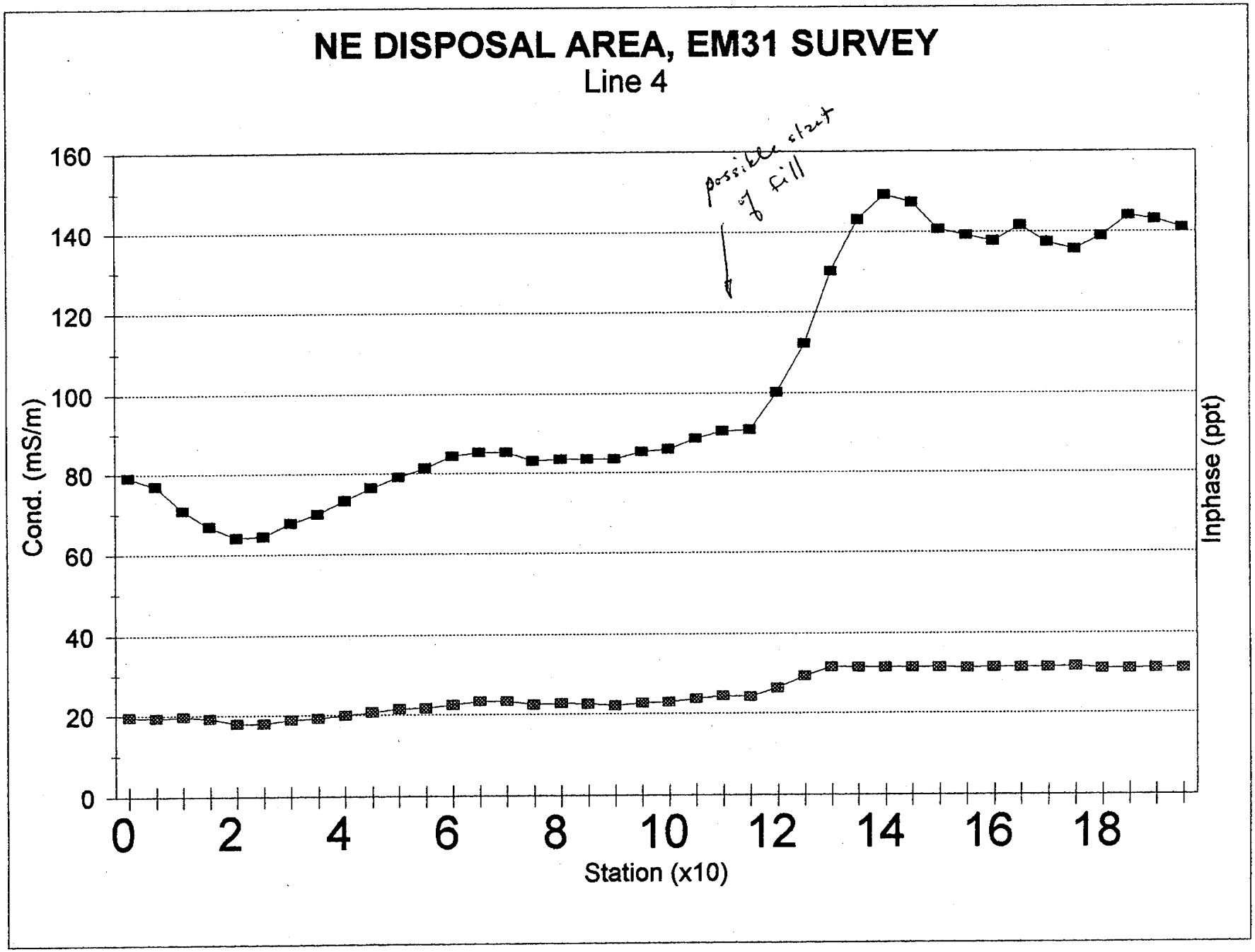
Line 2

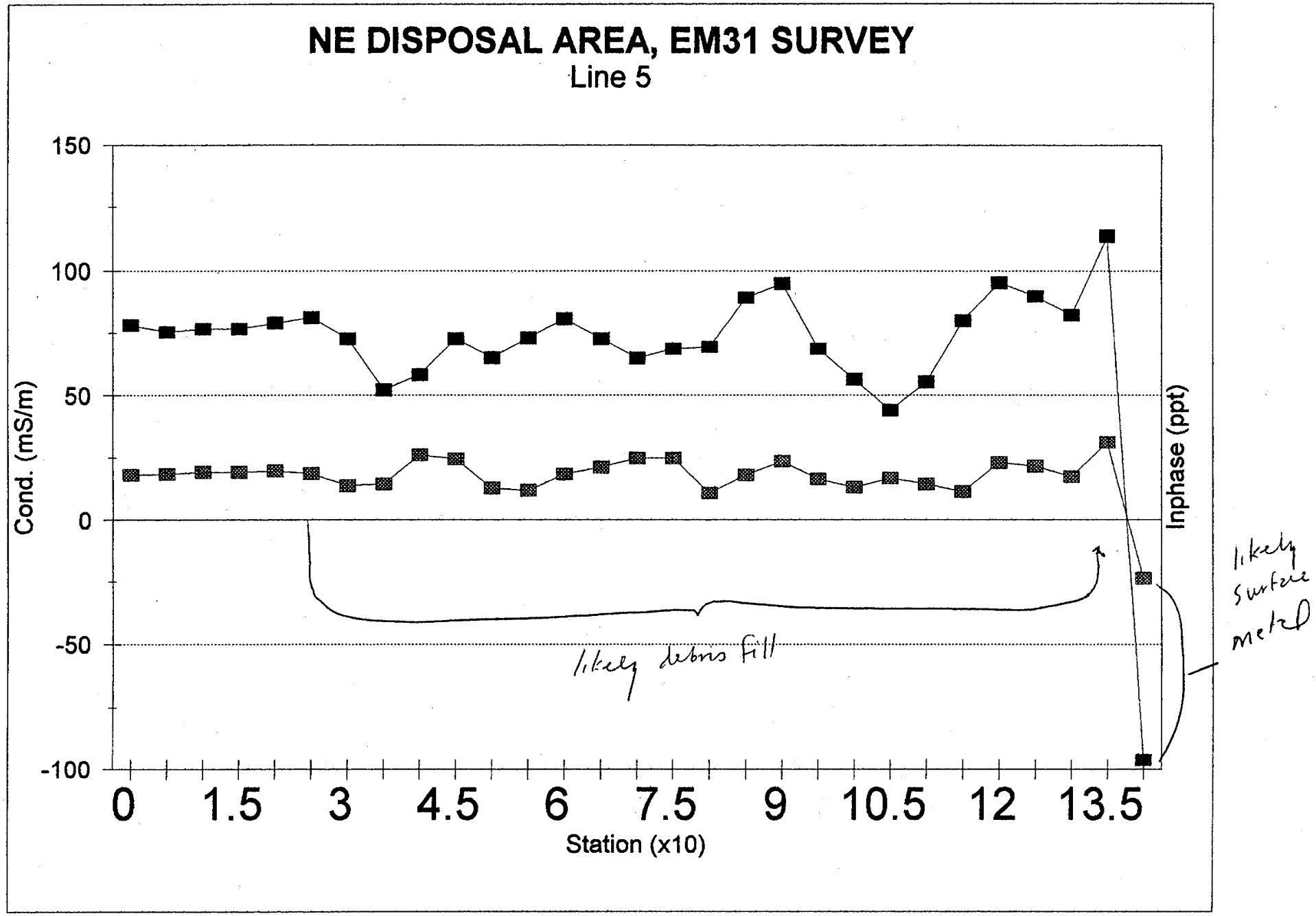


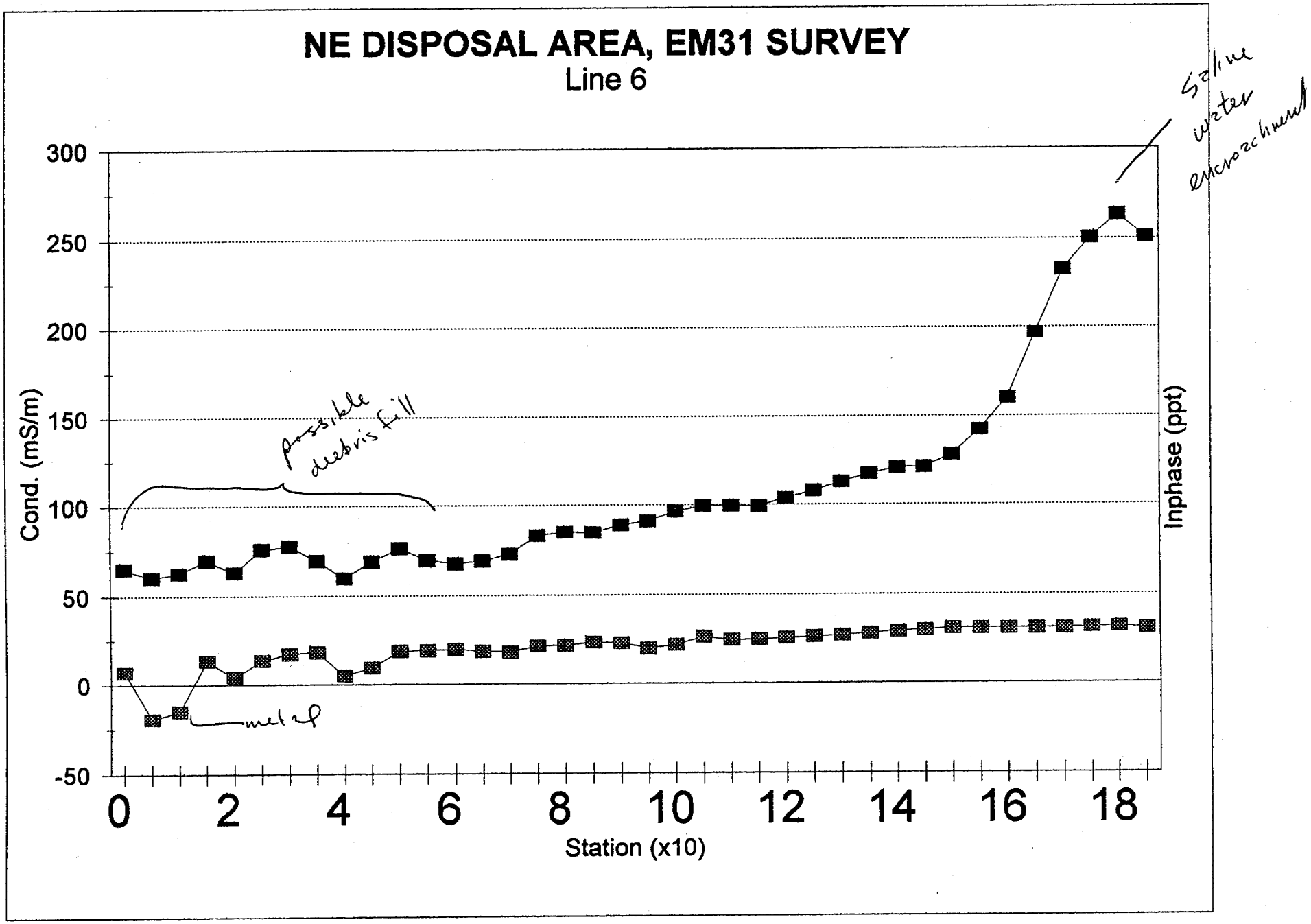
NE DISPOSAL AREA, EM31 SURVEY

Line 3



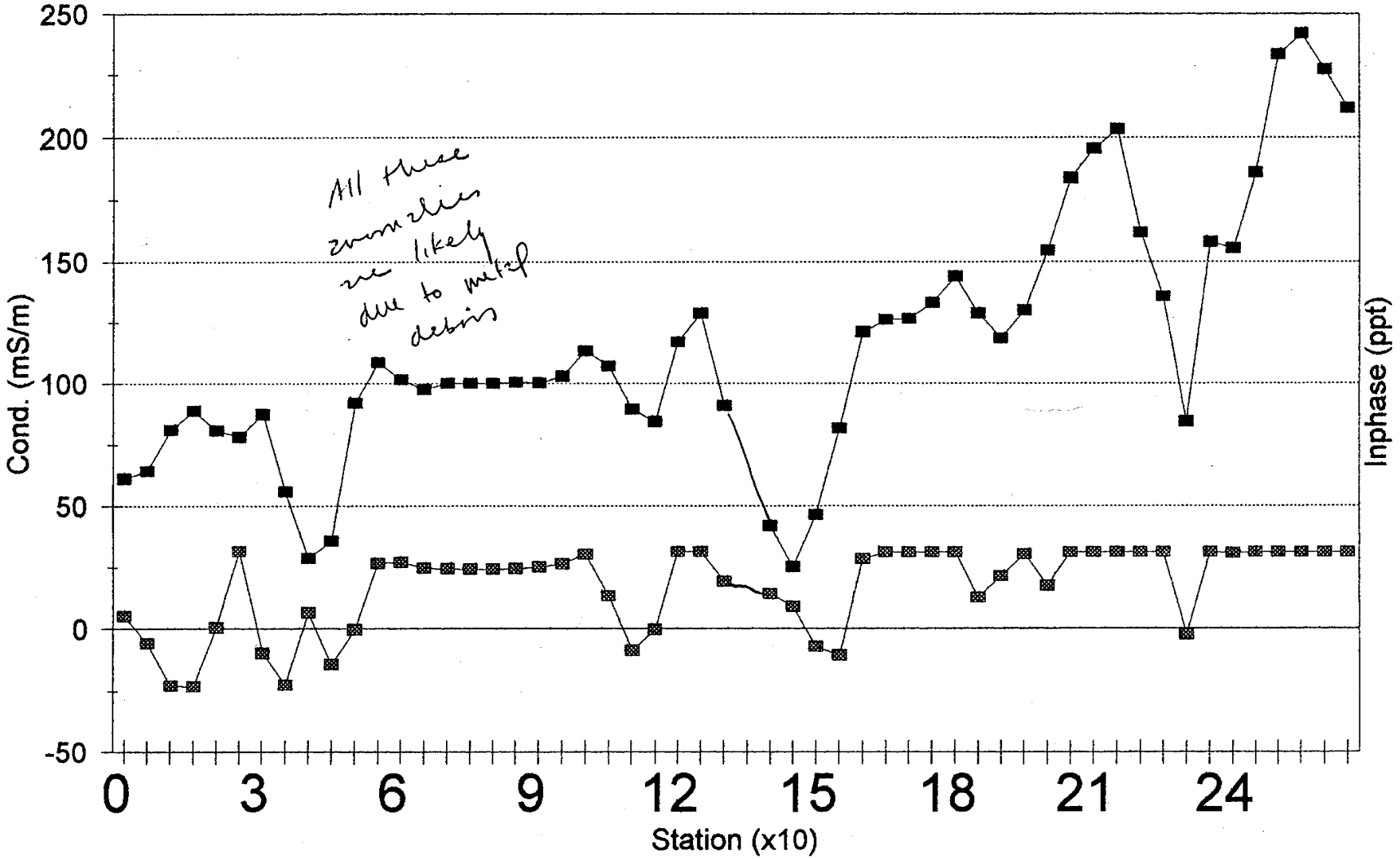

NE DISPOSAL AREA, EM31 SURVEY
Line 4
possible start of fill
Cond. (mS/m)
Inphase (ppt)
Station (x10)
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
12
14
16
18


NE DISPOSAL AREA, EM31 SURVEY
Line 5
150
100
50
0
-50
-100
Cond. (mS/m)
Inphase (ppt)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
Station (x10)
likely debris fill
likely surface metal


NE DISPOSAL AREA, EM31 SURVEY
Line 6
Cond. (mS/m)
Inphase (ppt)
Station (x10)
300
250
200
150
100
50
0
-50
0
2
4
6
8
10
12
14
16
18
possible debris fill
metal
saline water encroachment

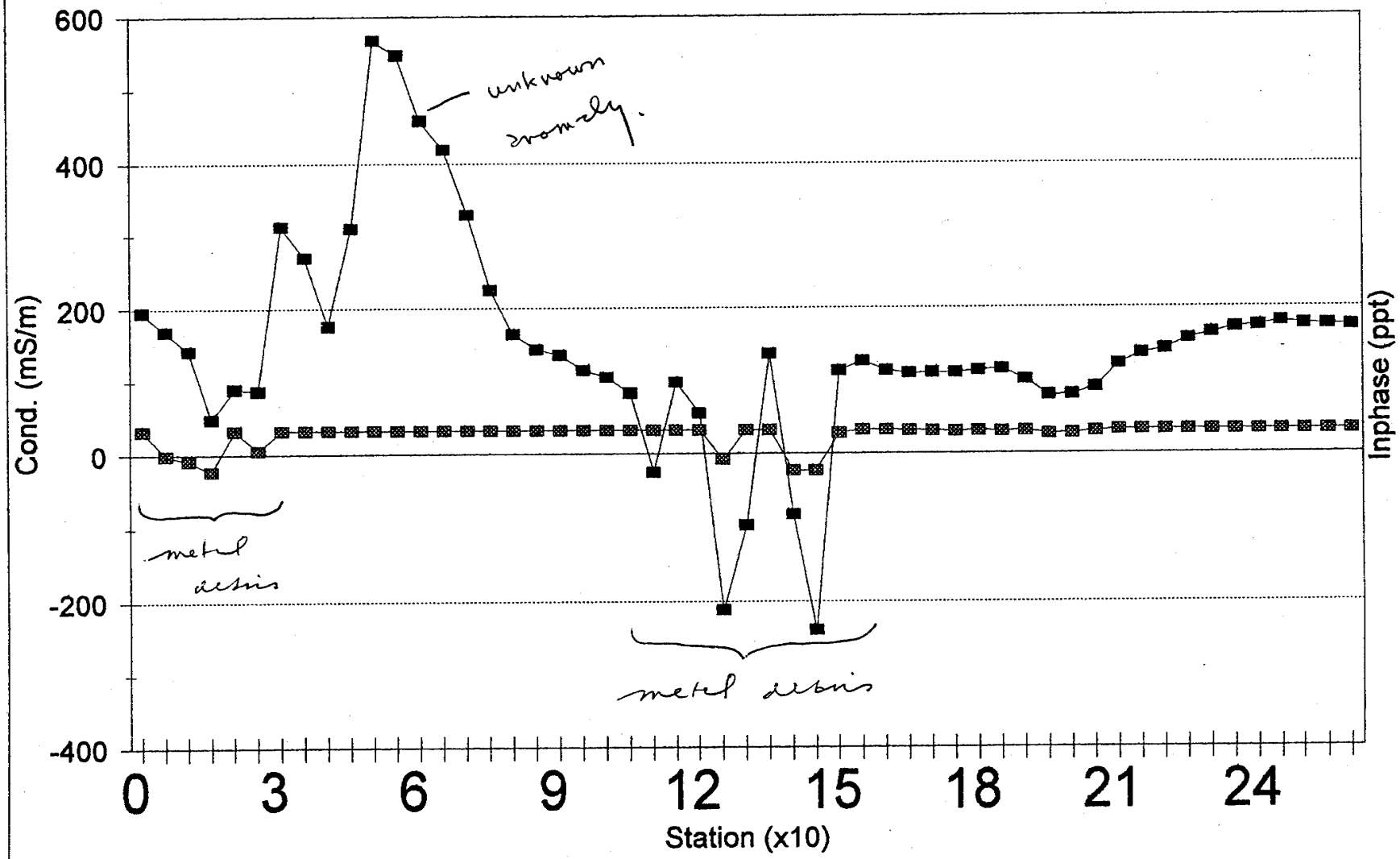
NE DISPOSAL AREA, EM31 SURVEY

Line 7



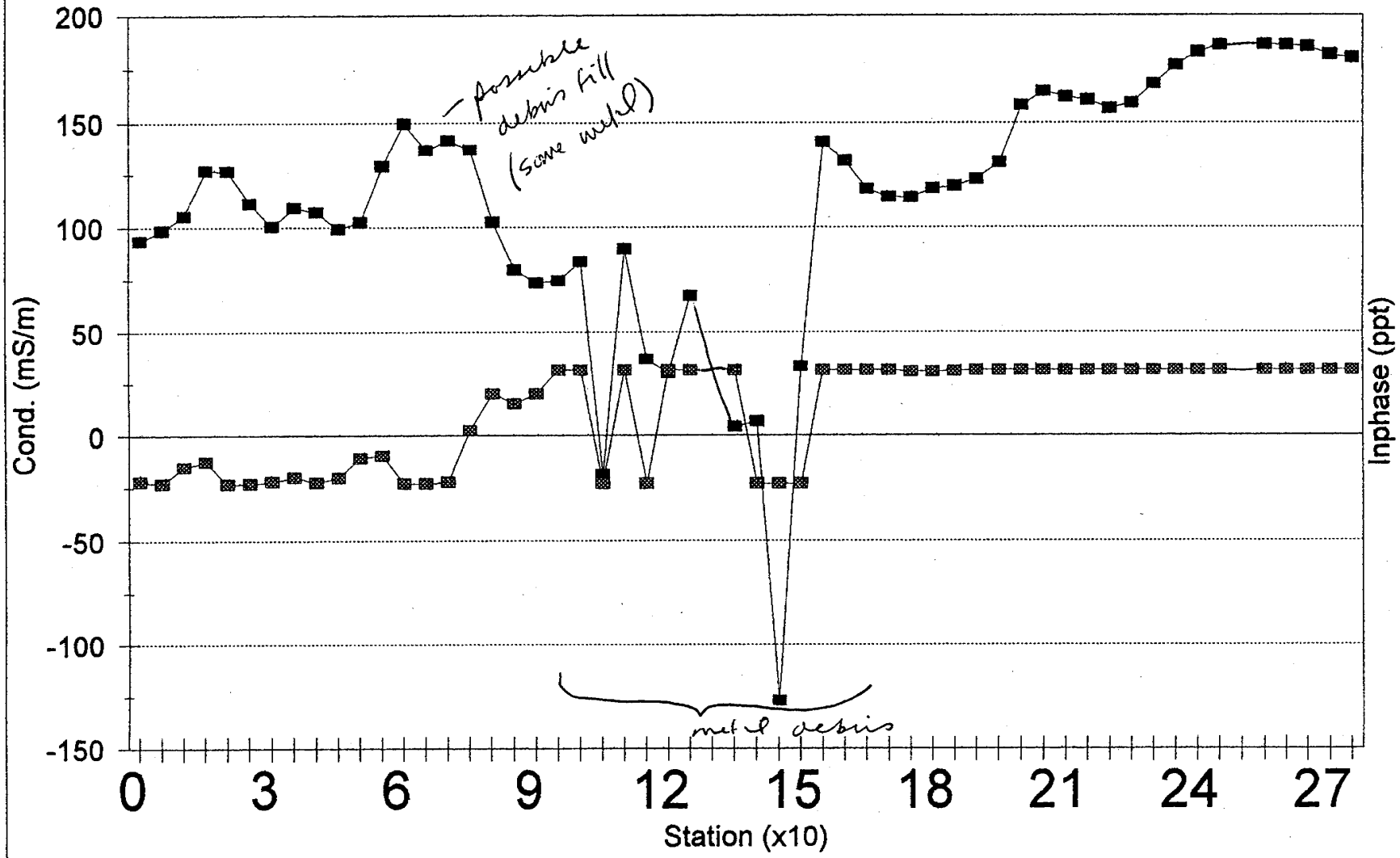
NE DISPOSAL AREA, EM31 SURVEY

Line 8



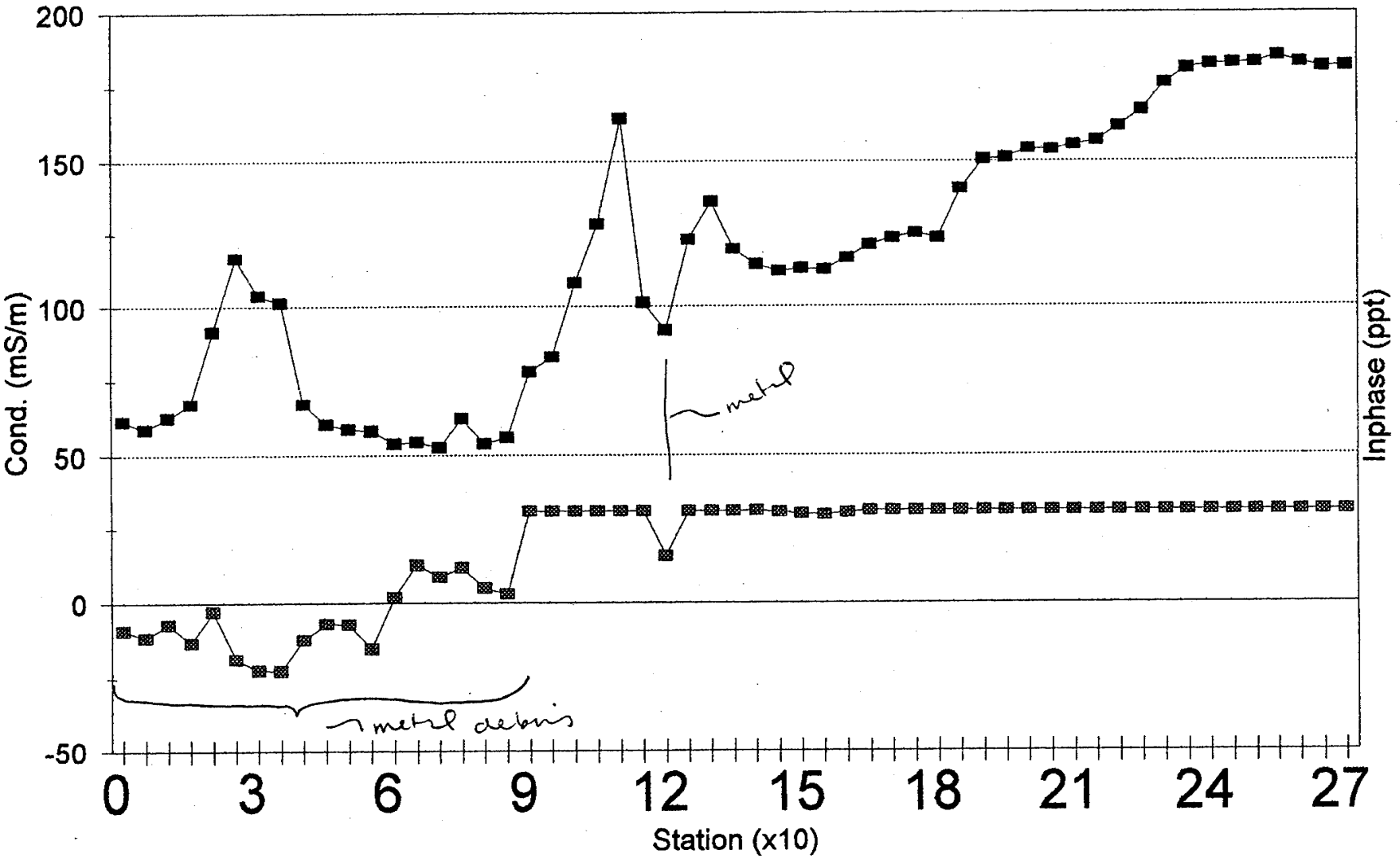
NE DISPOSAL AREA, EM31 SURVEY

Line 9



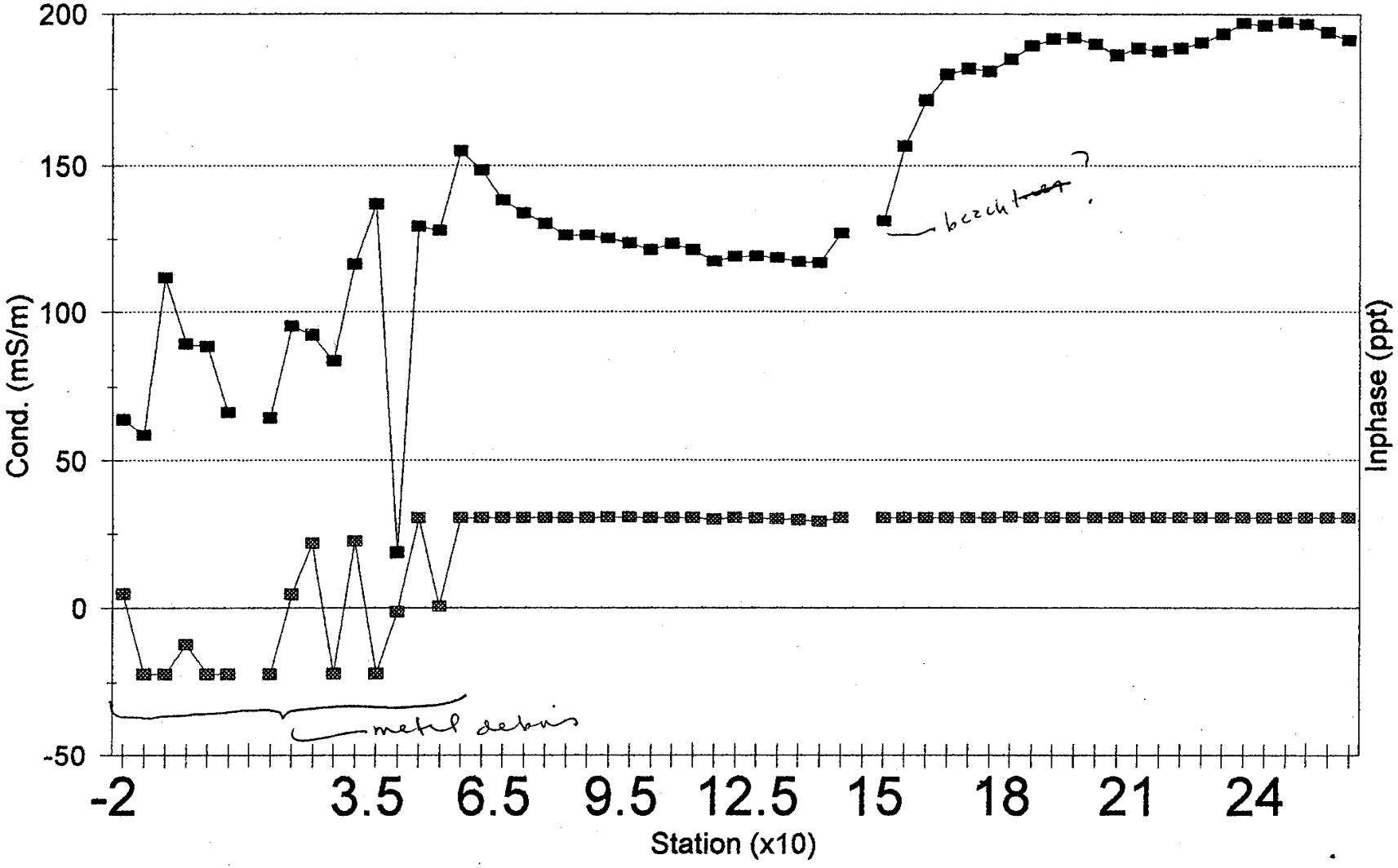
NE DISPOSAL AREA, EM31 SURVEY

Line 10



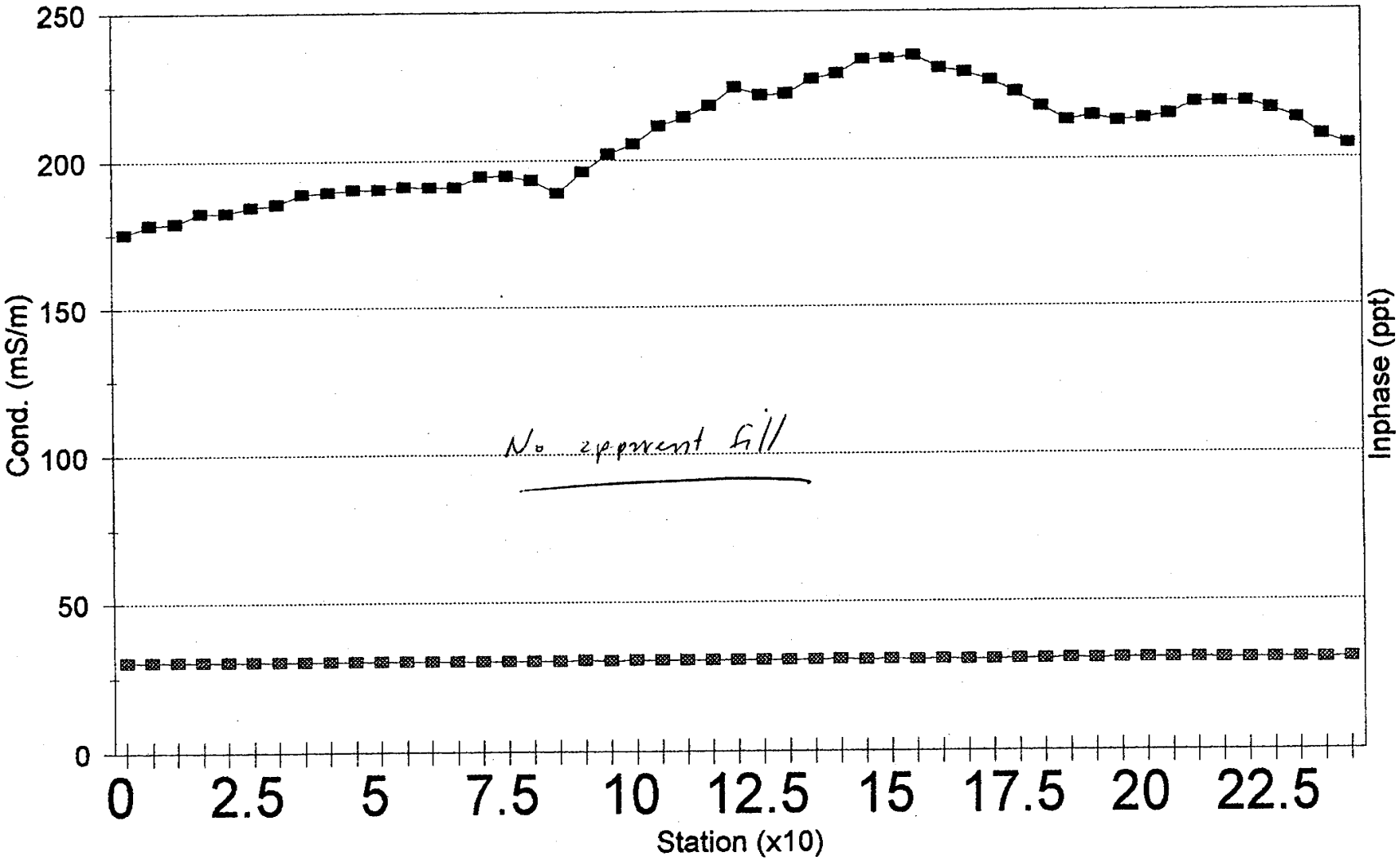
NE DISPOSAL AREA, EM31 SURVEY

Line 11



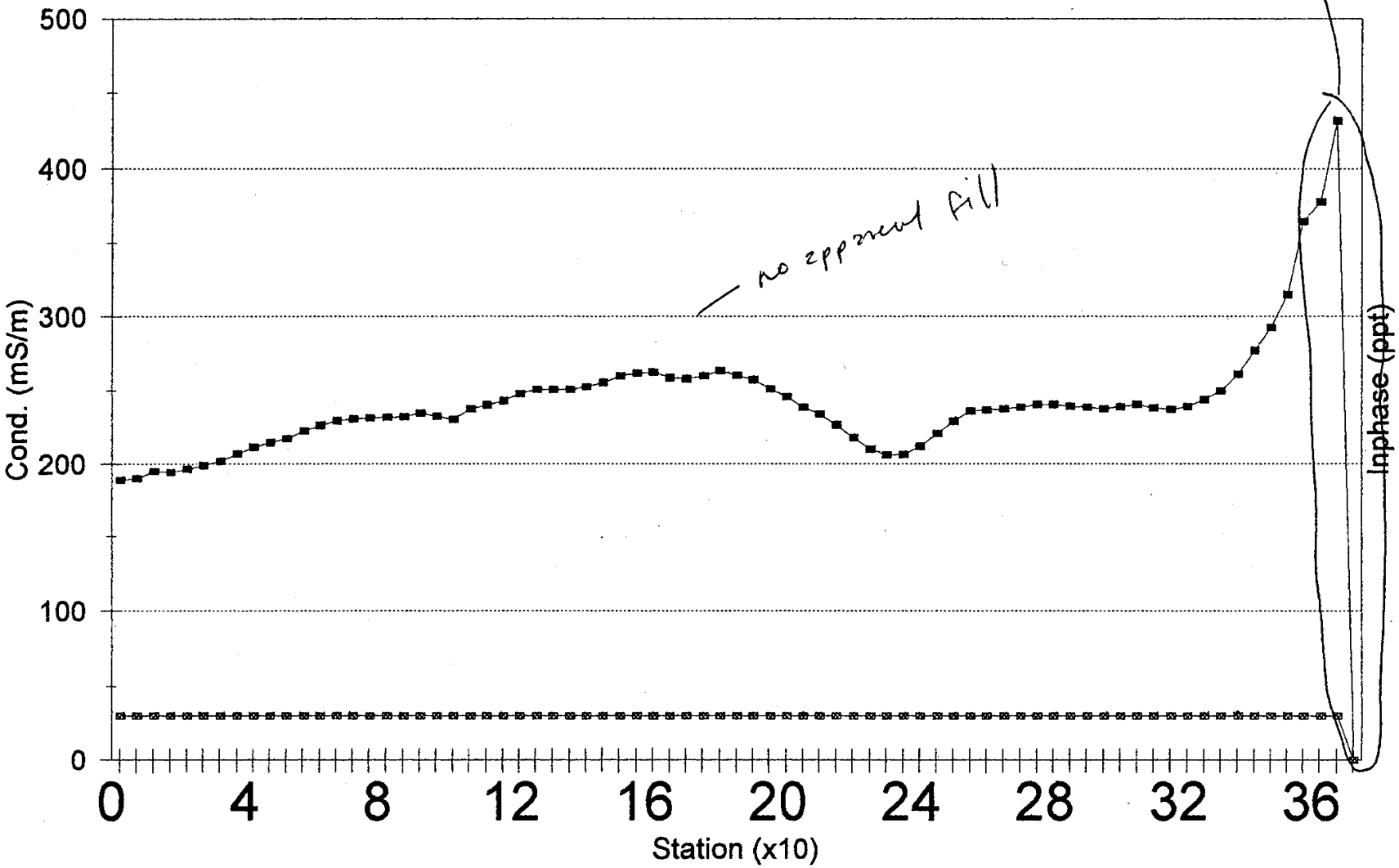
NE DISPOSAL AREA, EM31 SURVEY

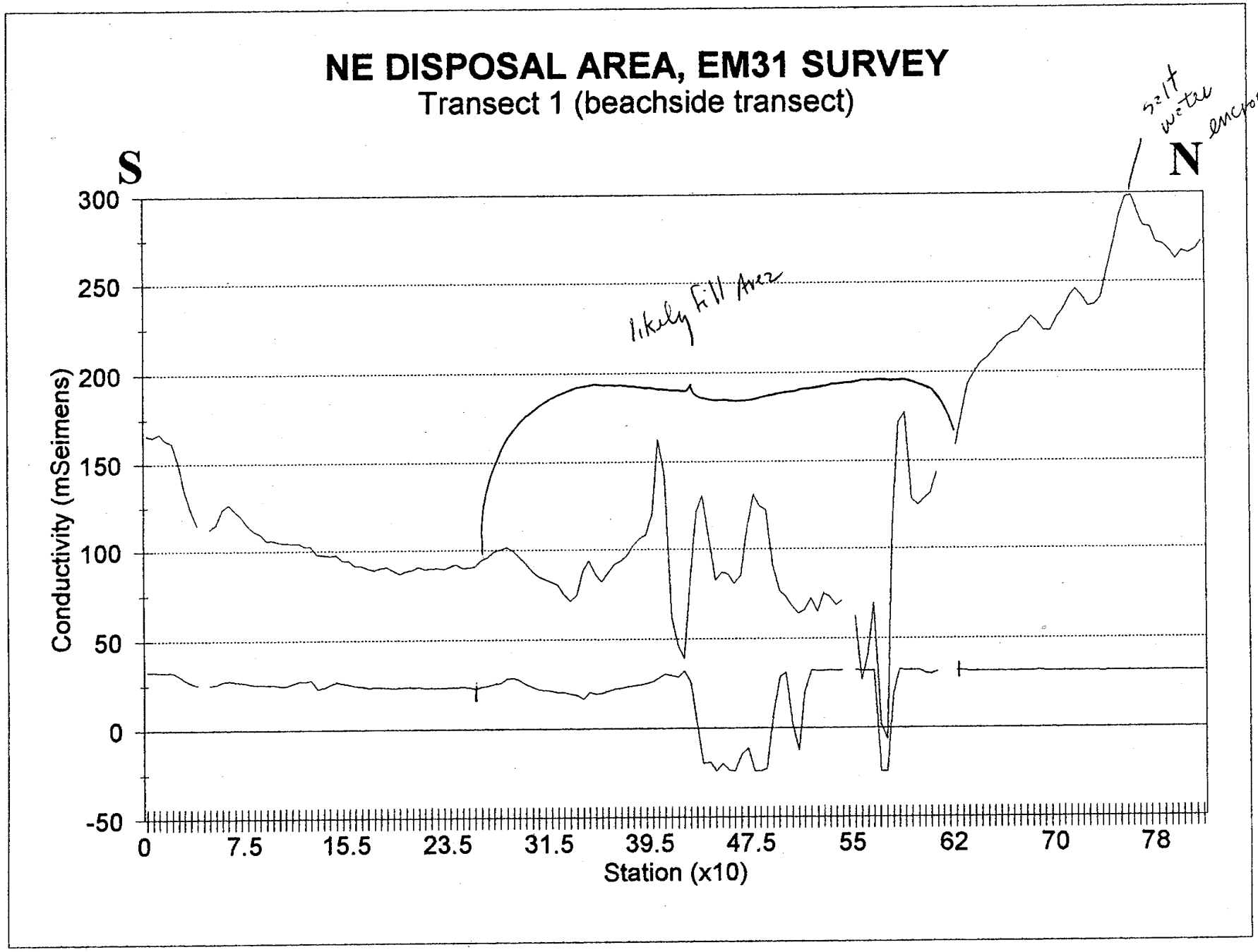
Line 12



NE DISPOSAL AREA, EM31 SURVEY

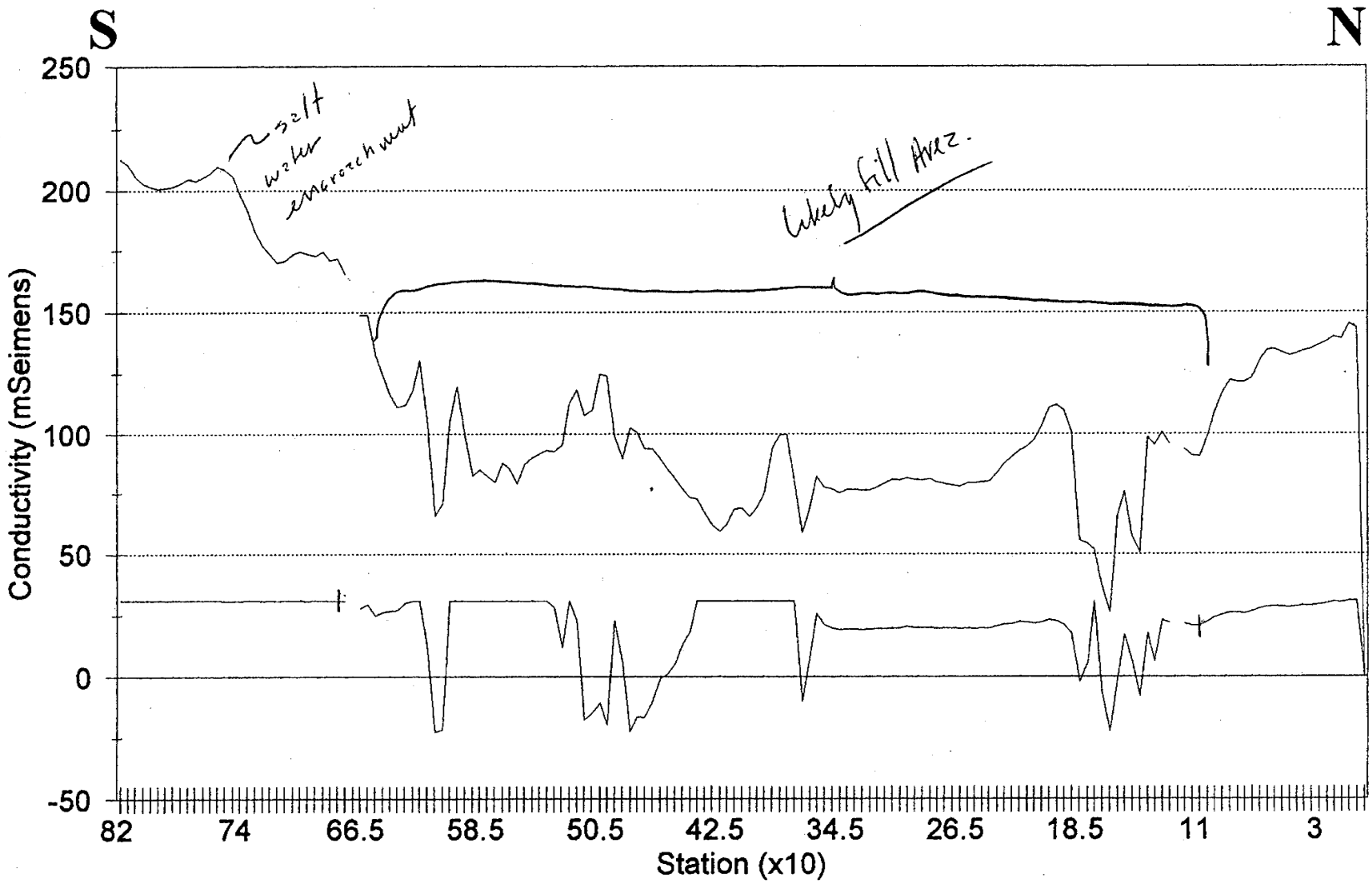
Line 13



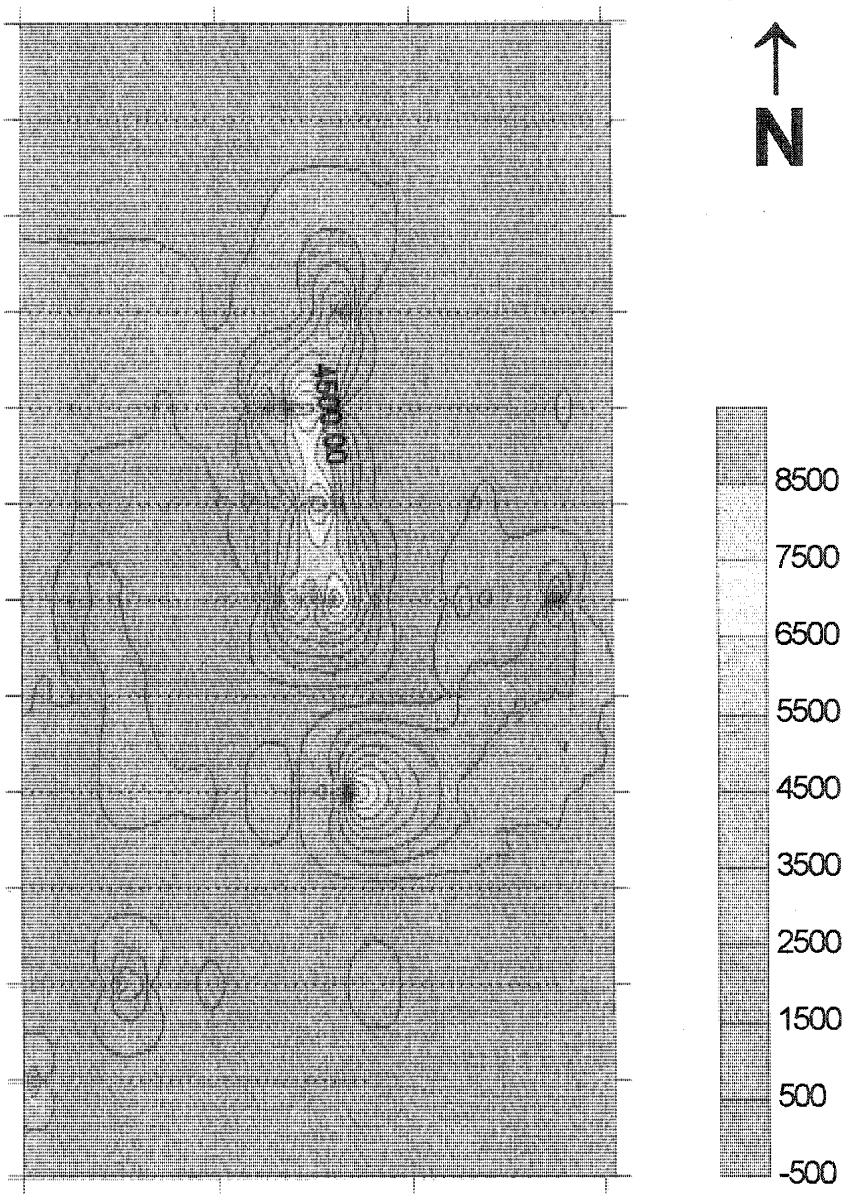

NE DISPOSAL AREA, EM31 SURVEY
Transect 1 (beachside transect)
S
N
salt water encroachment.
likely fill area
Conductivity (mSeimens)
300
250
200
150
100
50
0
-50
0
7.5
15.5
23.5
31.5
39.5
47.5
55
62
70
78
Station (x10)

NE DISPOSAL AREA, EM31 SURVEY

Transect 2 (inland transect)

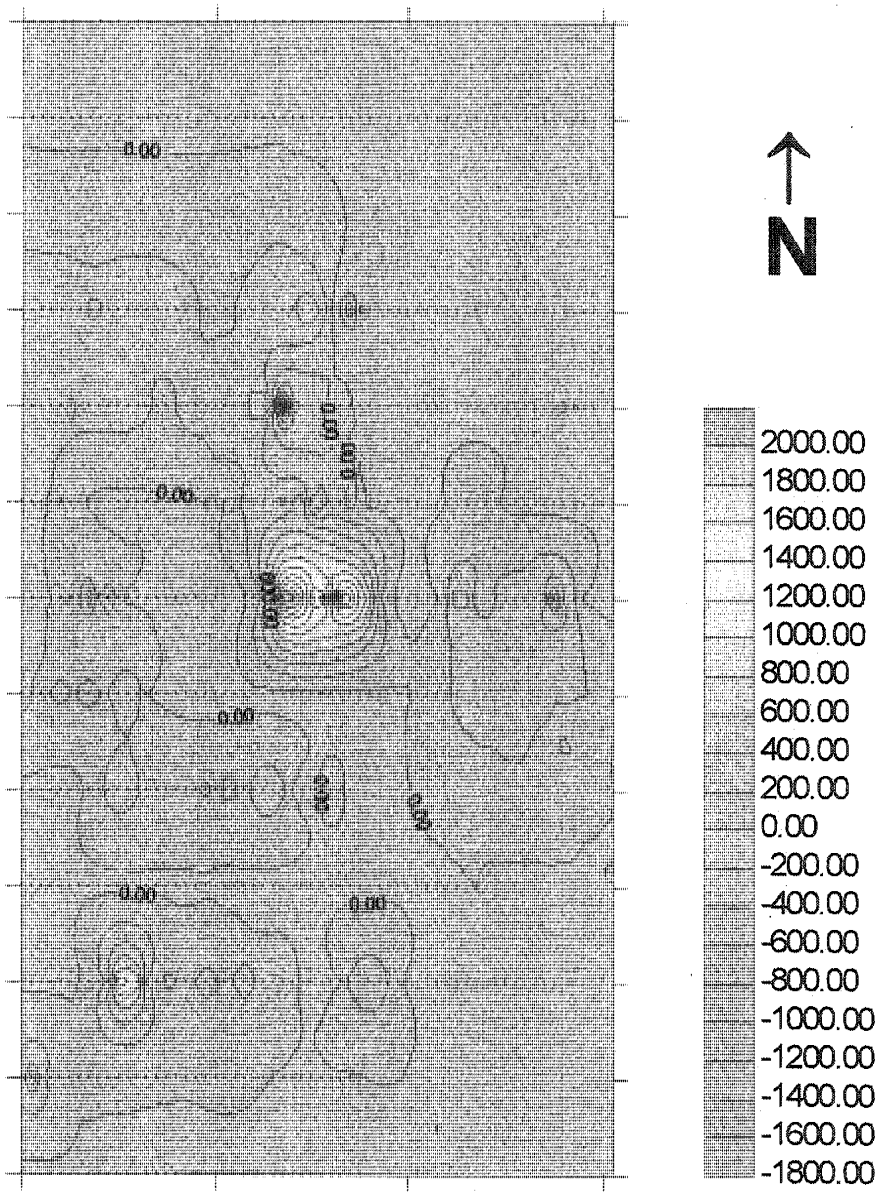


EM-61 Data
North East Disposal Area
Eastern Island
Midway NAF



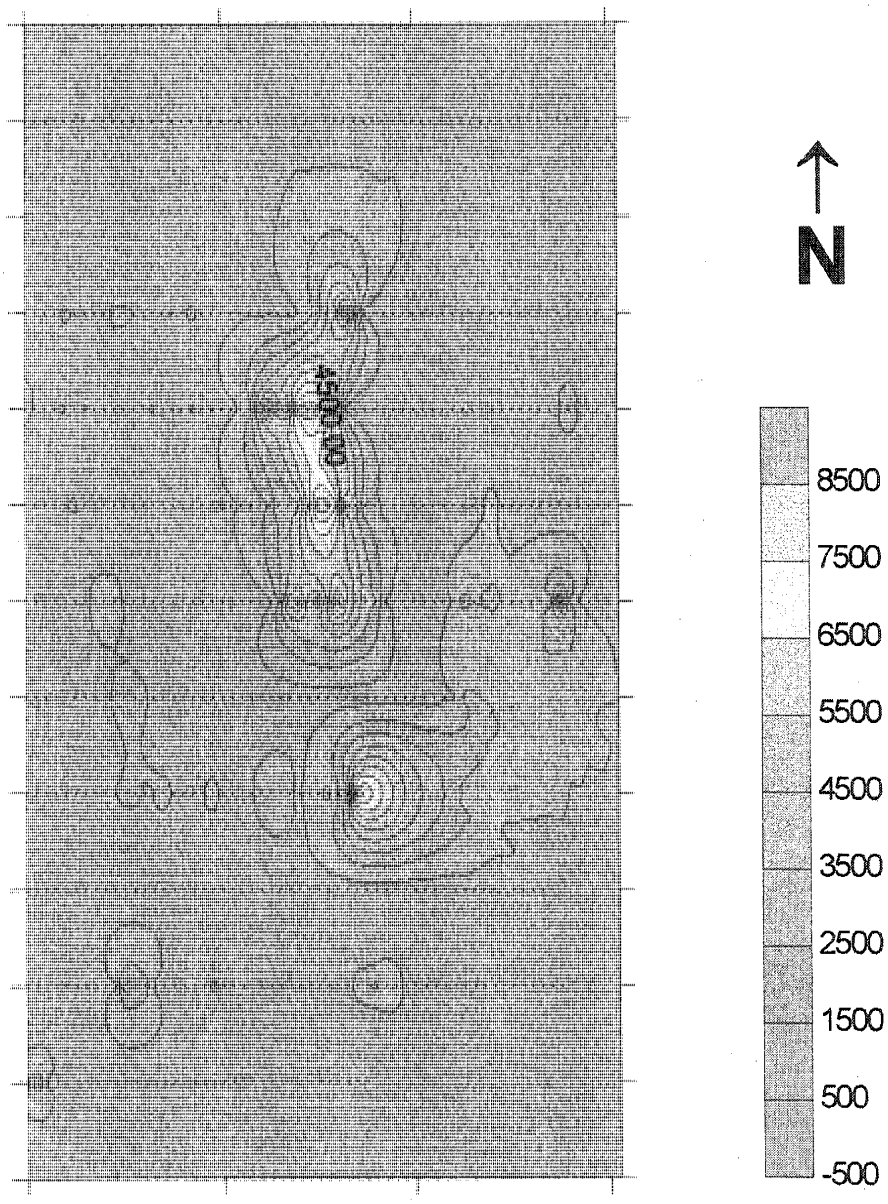
Scale: 1 inch = 100 feet

EM-61 Data (differential)
North East Disposal Area
Eastern Island
NAF Midway



Scale: 1 inch = 100 feet

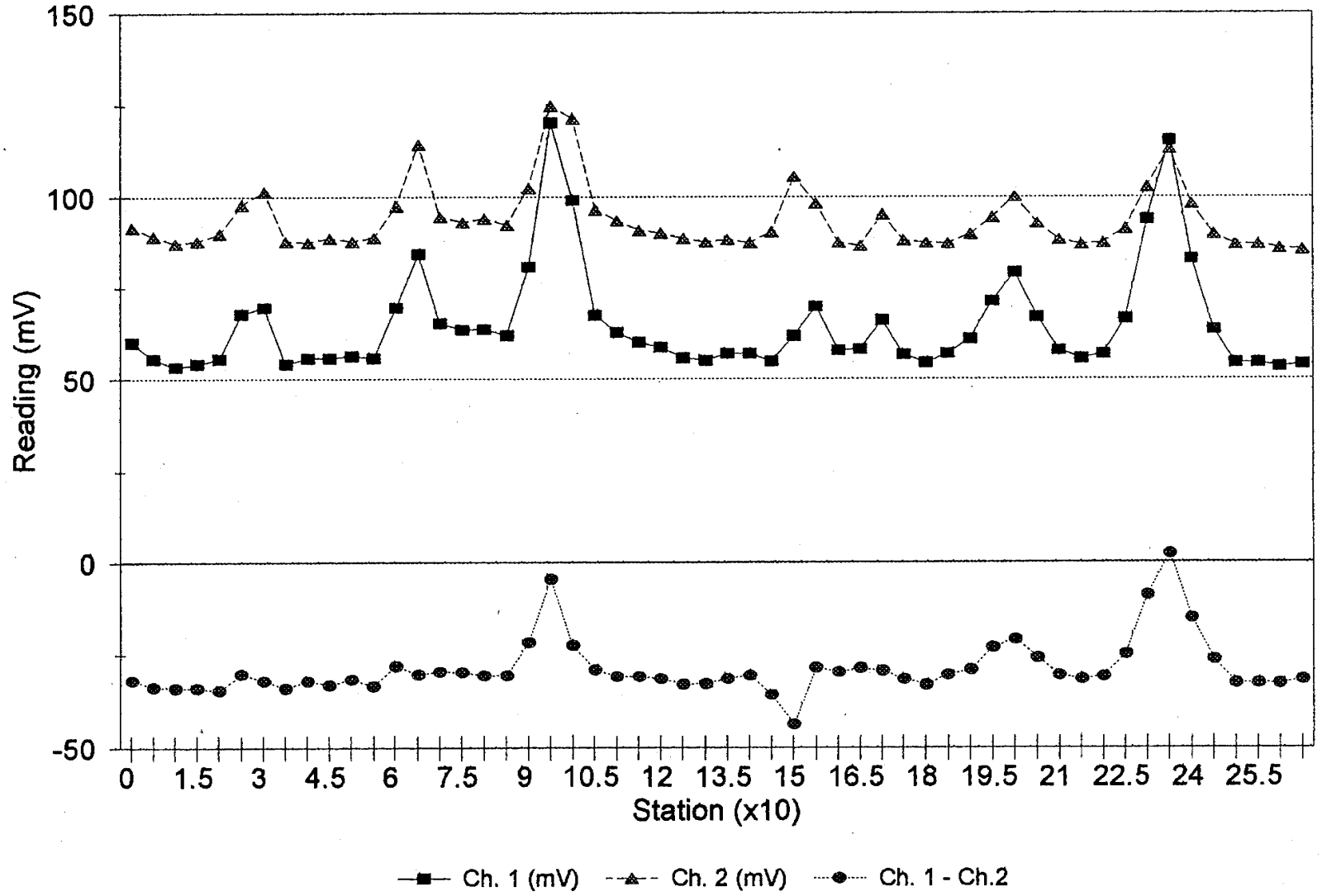
EM-61 Data (second column)
North East Disposal Area
Eastern Island
NAF Midway

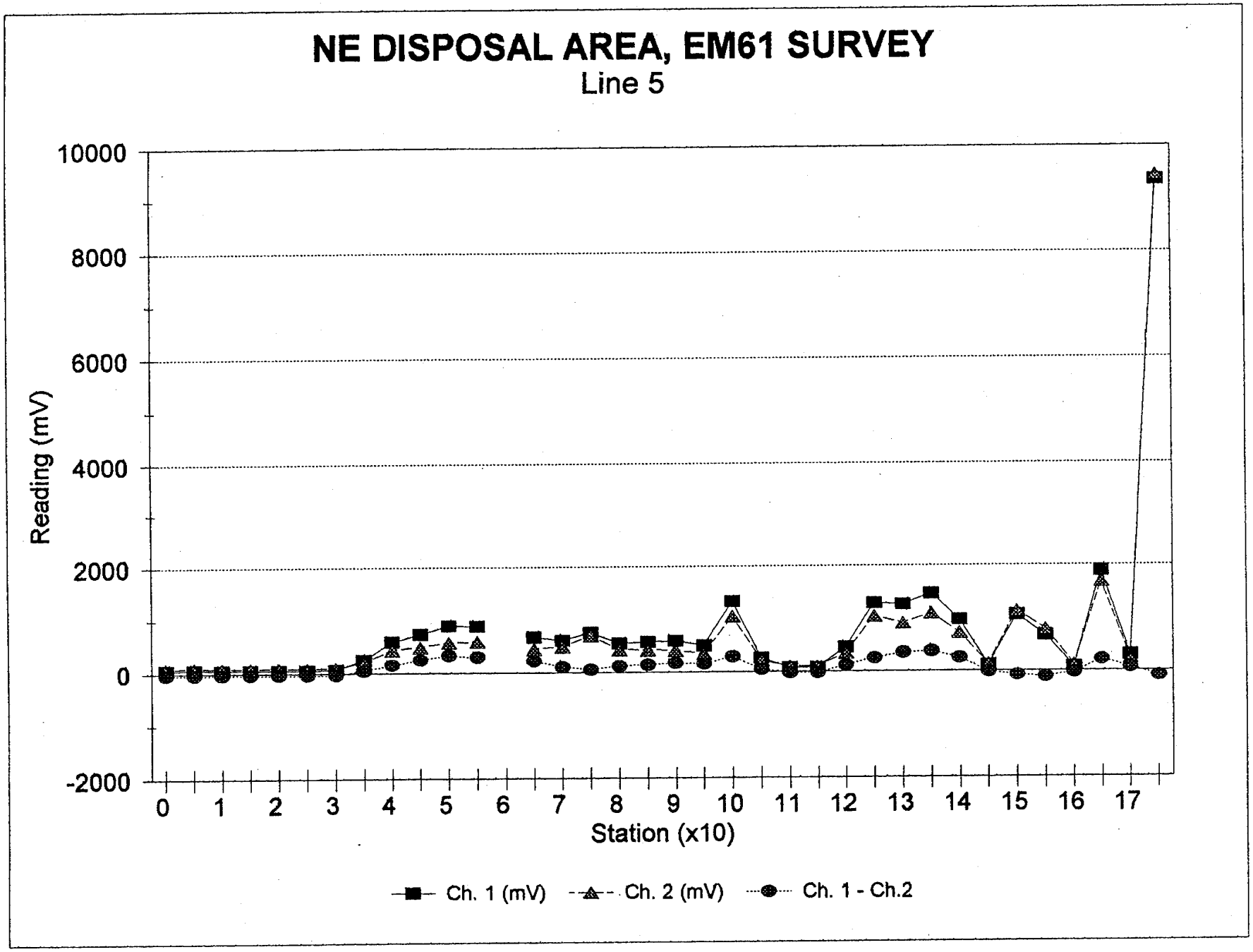


Scale: 1 inch = 100 feet

NE DISPOSAL AREA, EM61 SURVEY

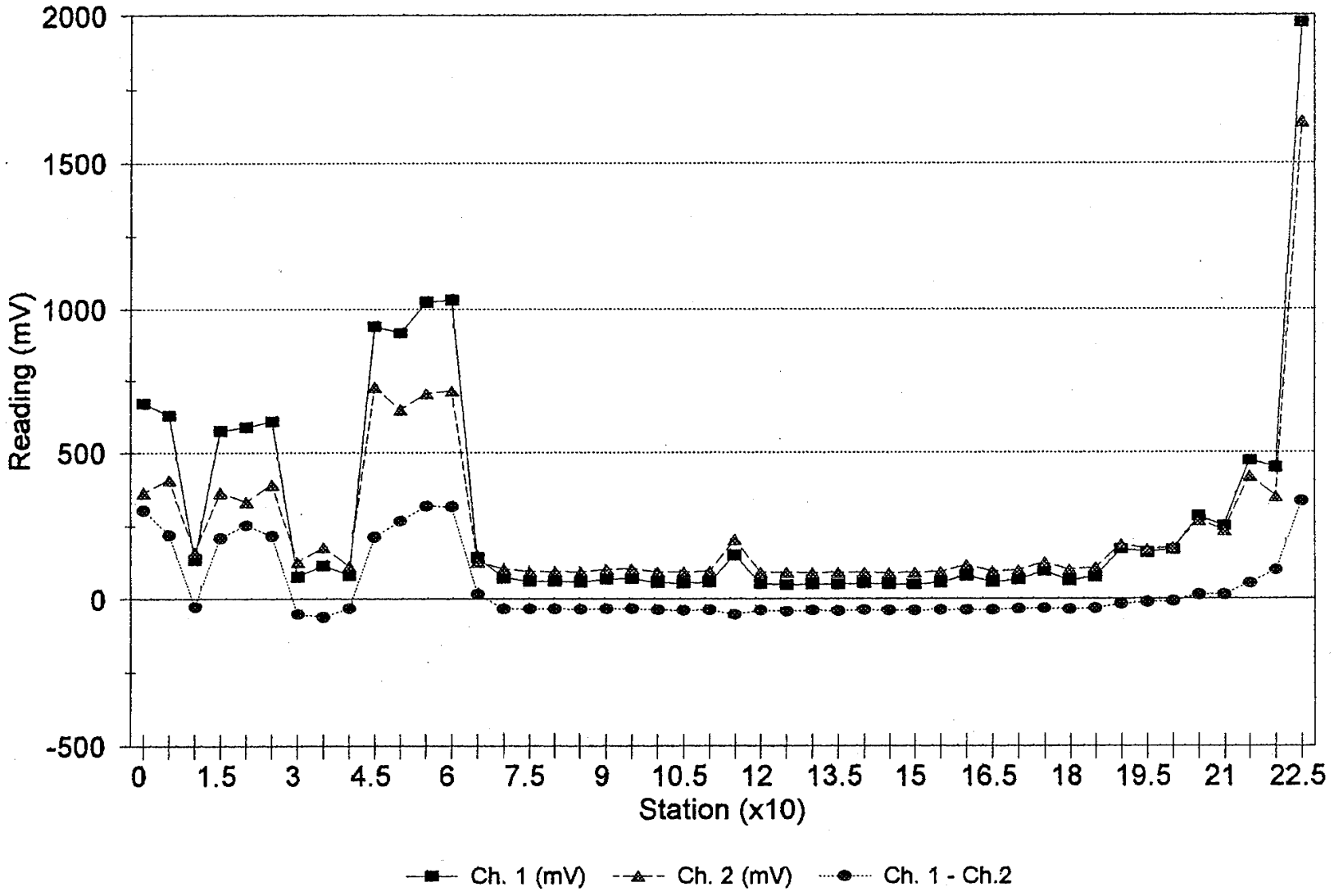
Line 4




NE DISPOSAL AREA, EM61 SURVEY
Line 5
10000
8000
6000
4000
2000
0
-2000
Reading (mV)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch.2

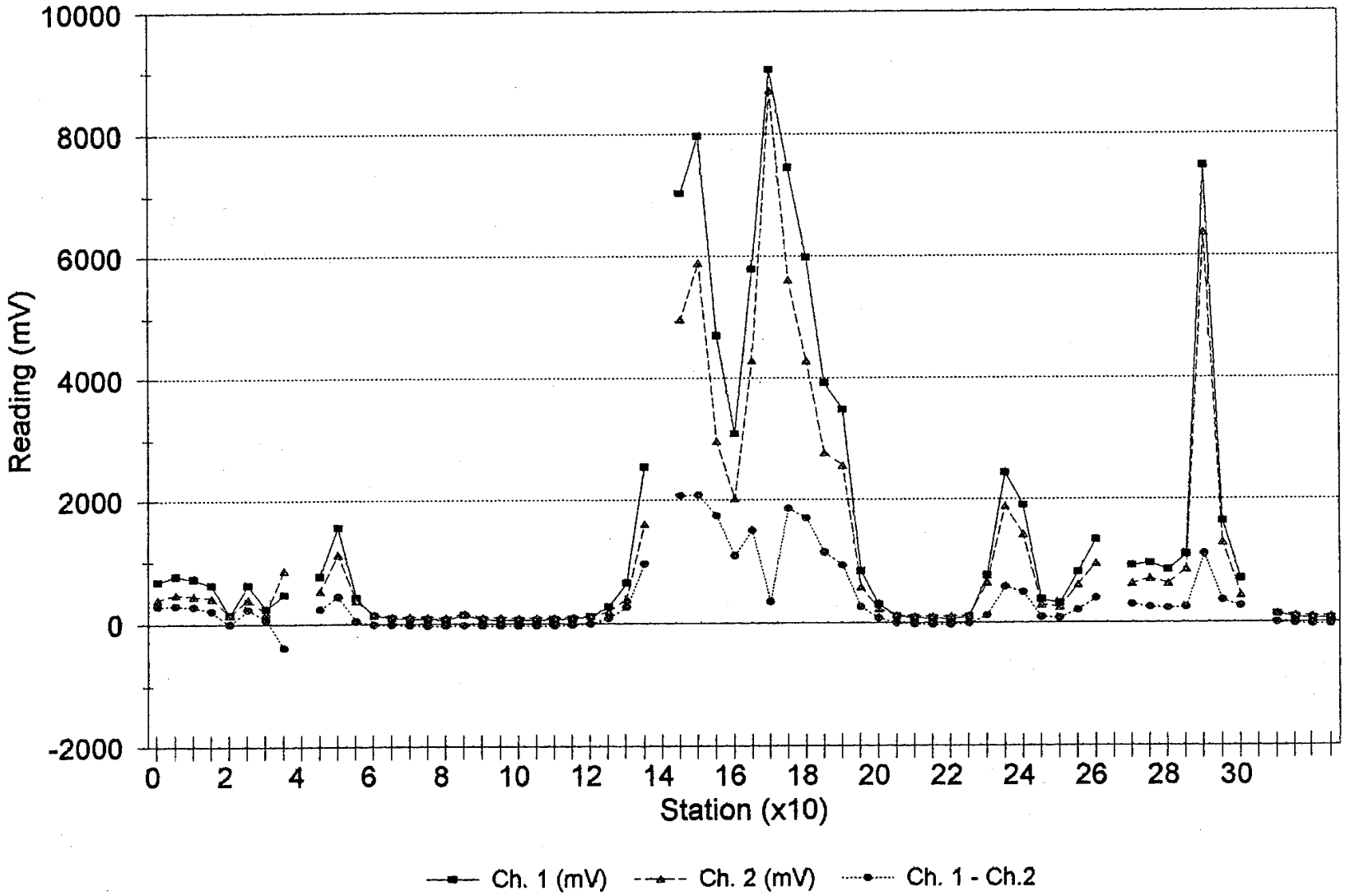
NE DISPOSAL AREA, EM61 SURVEY

Line 6



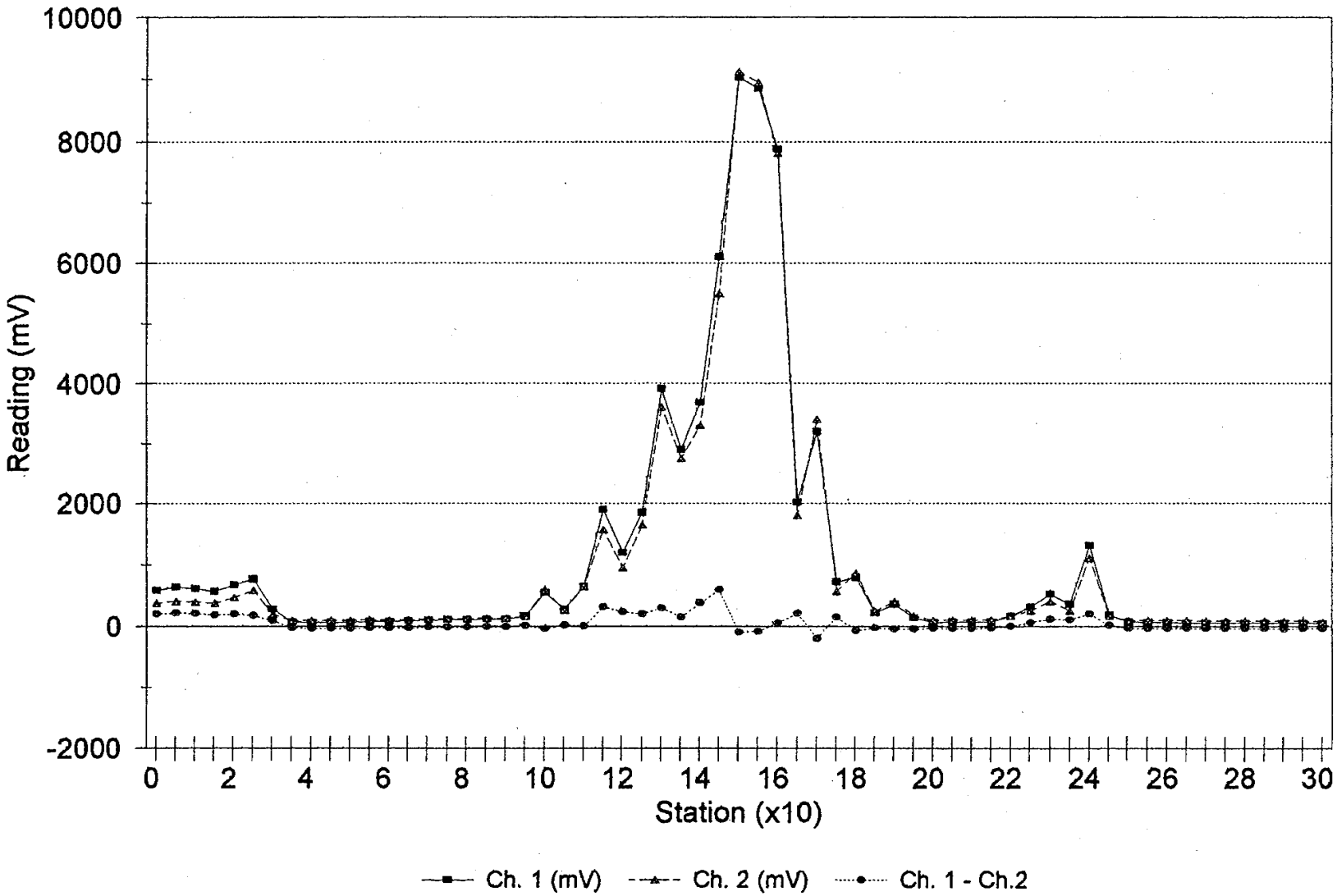
NE DISPOSAL AREA, EM61 SURVEY

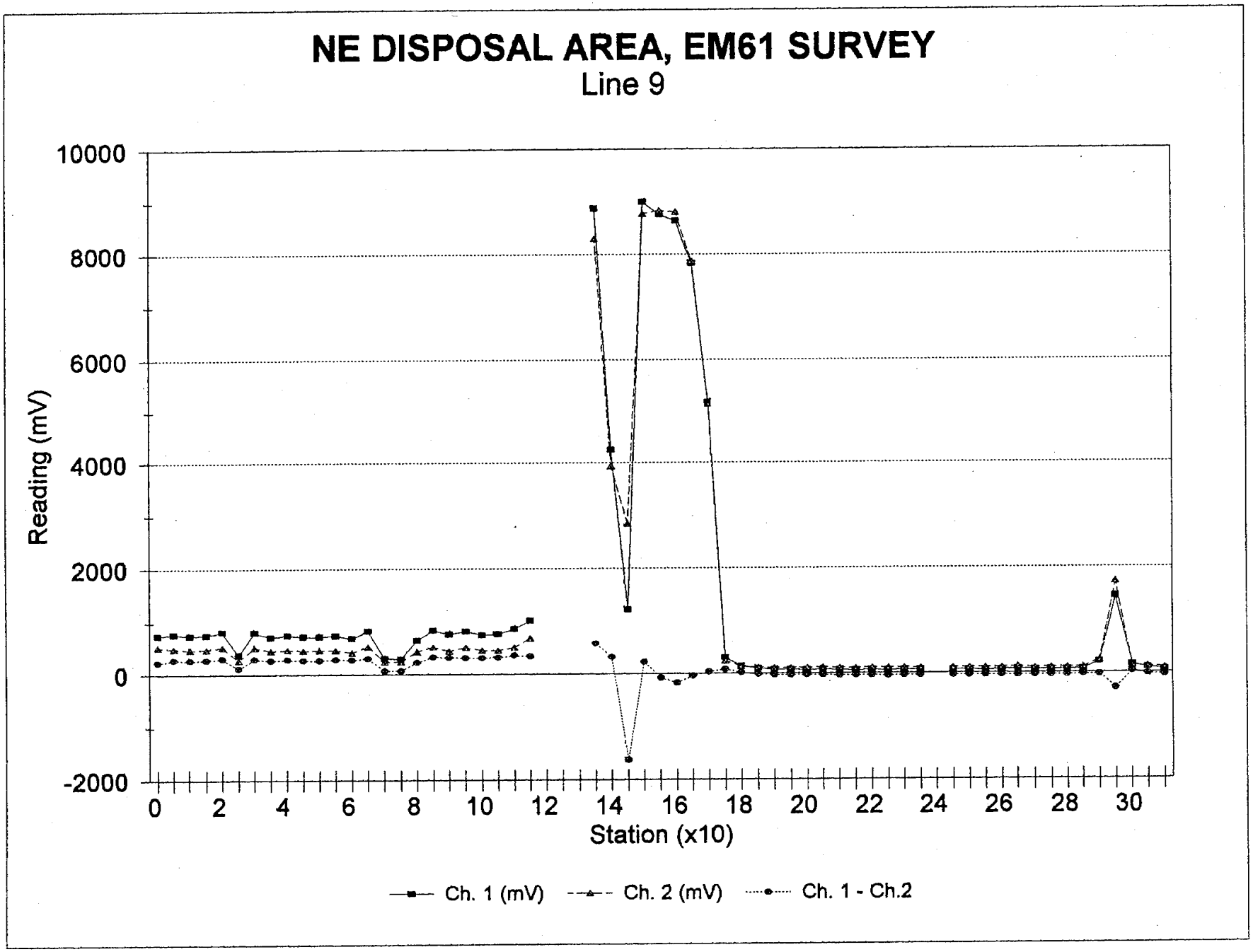
Line 7



NE DISPOSAL AREA, EM61 SURVEY

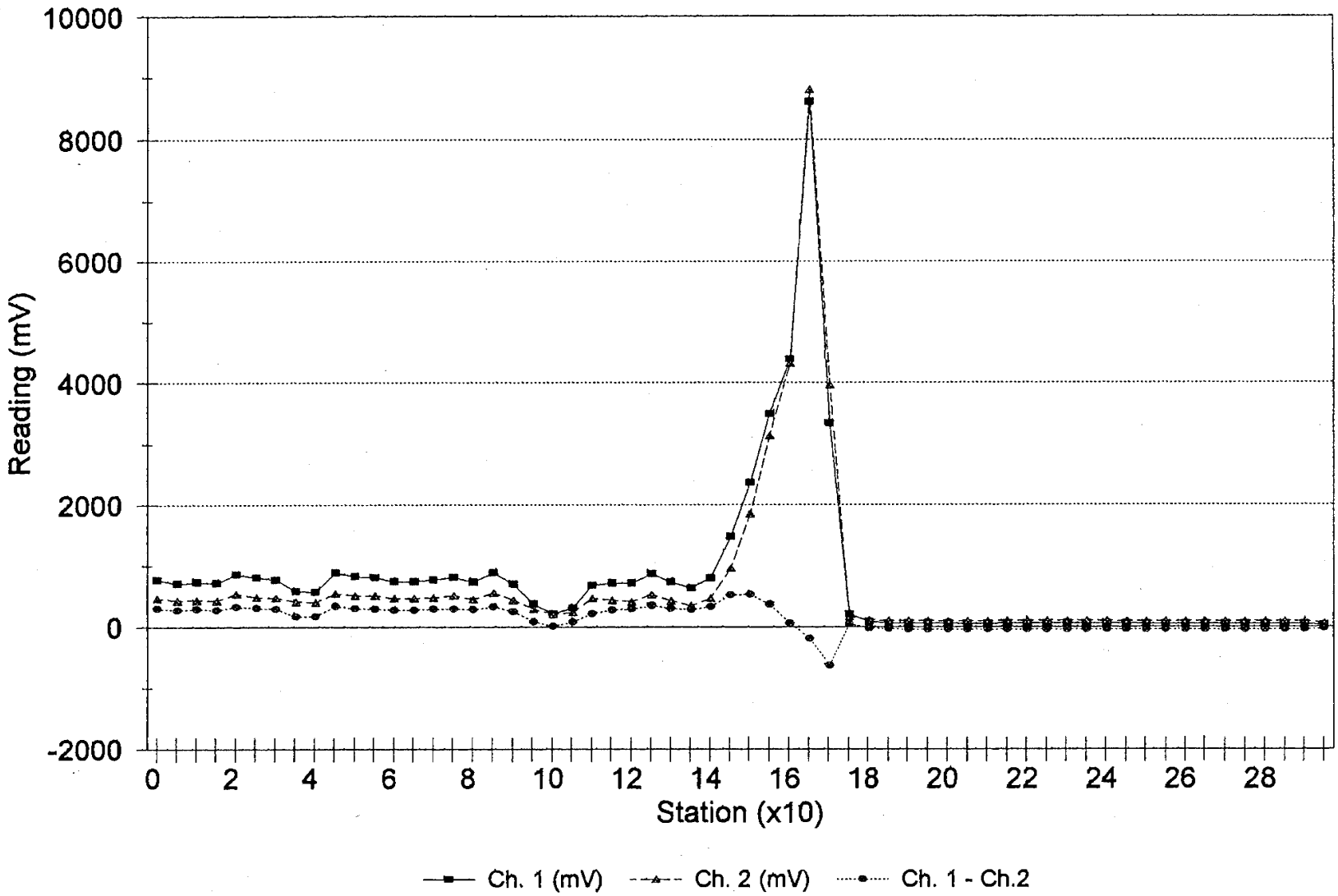
Line 8




NE DISPOSAL AREA, EM61 SURVEY
Line 9
10000
8000
6000
4000
2000
0
-2000
Reading (mV)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch.2

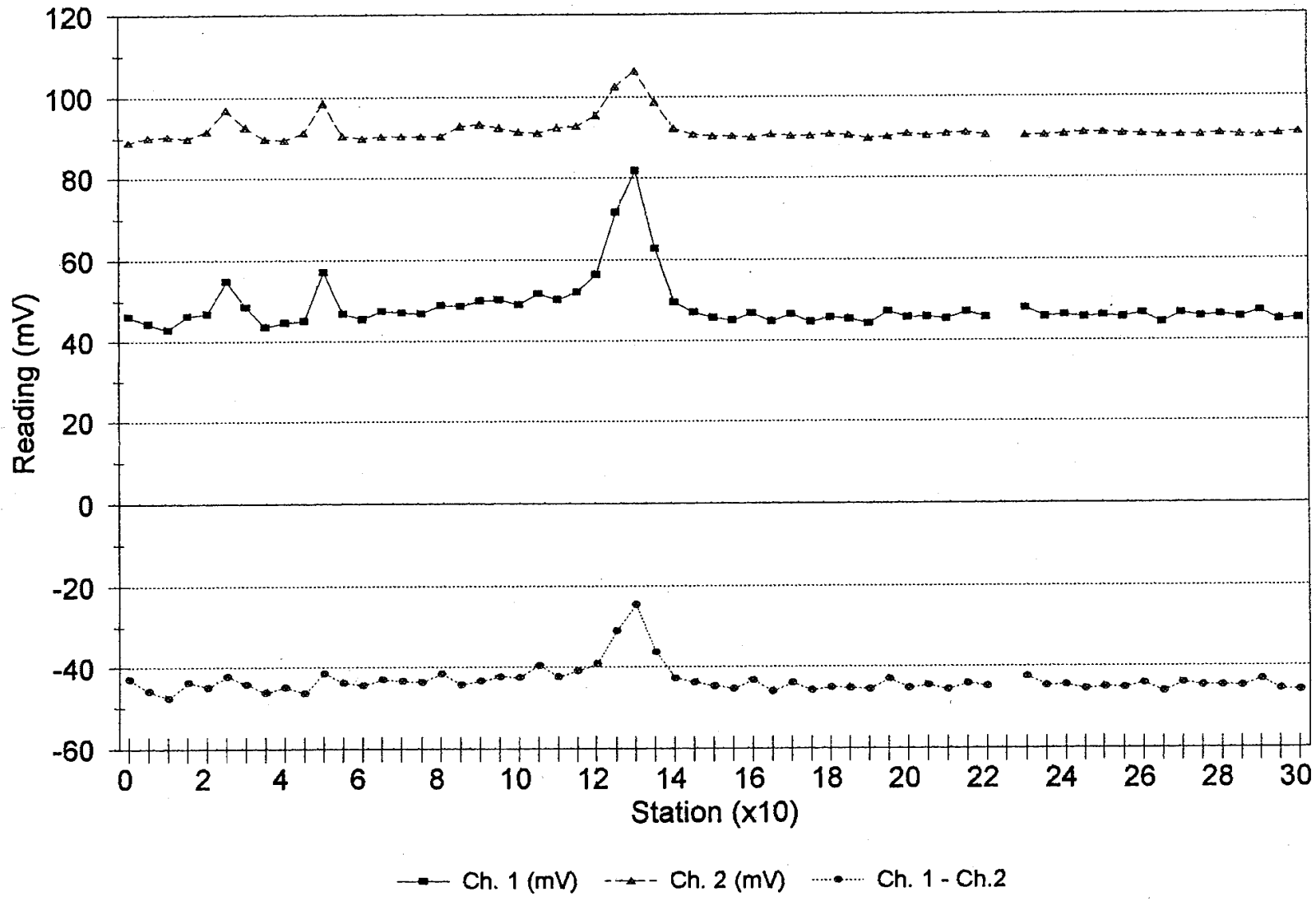
NE DISPOSAL AREA, EM61 SURVEY

Line 10

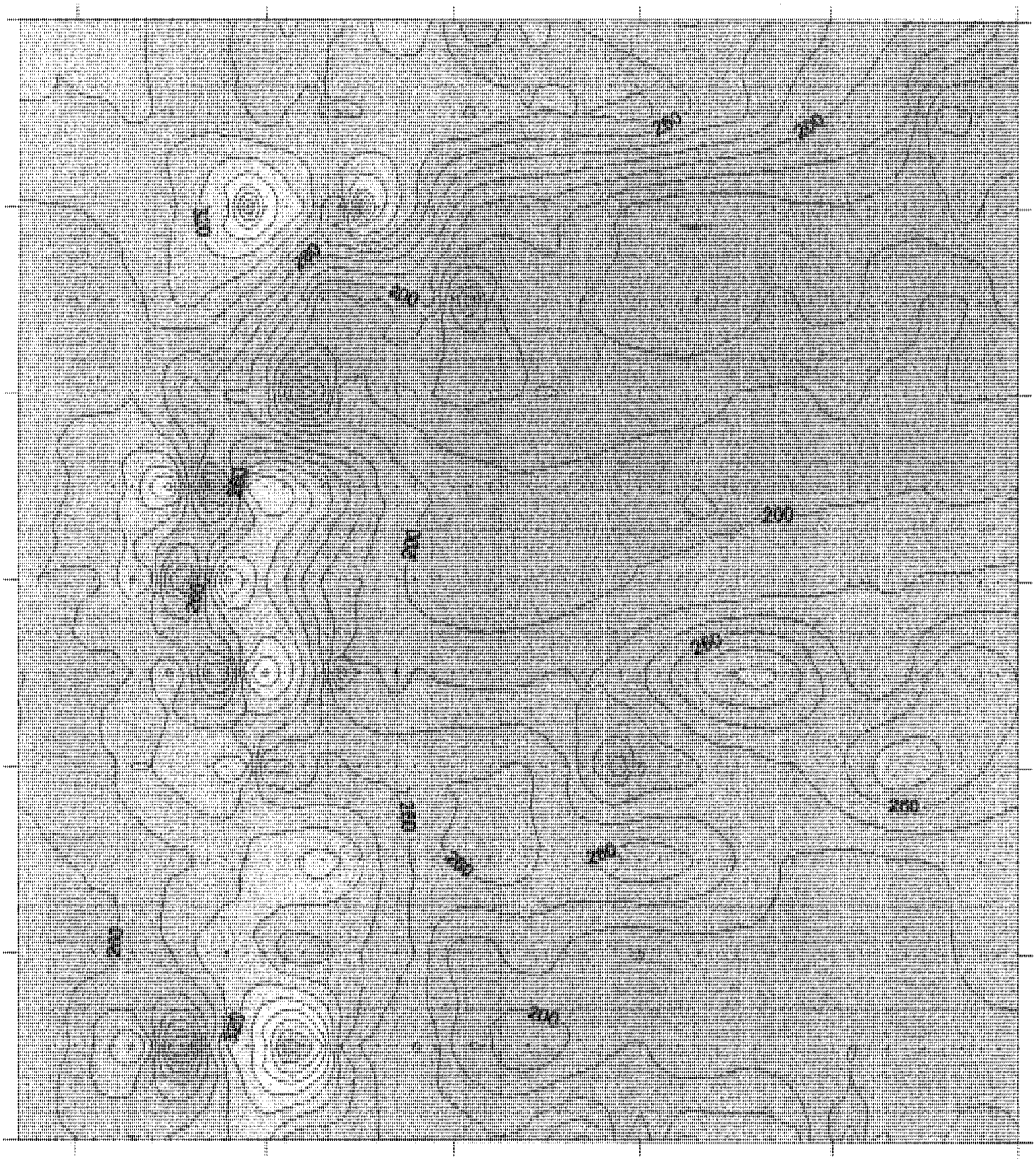


NE DISPOSAL AREA, EM61 SURVEY

Line 12



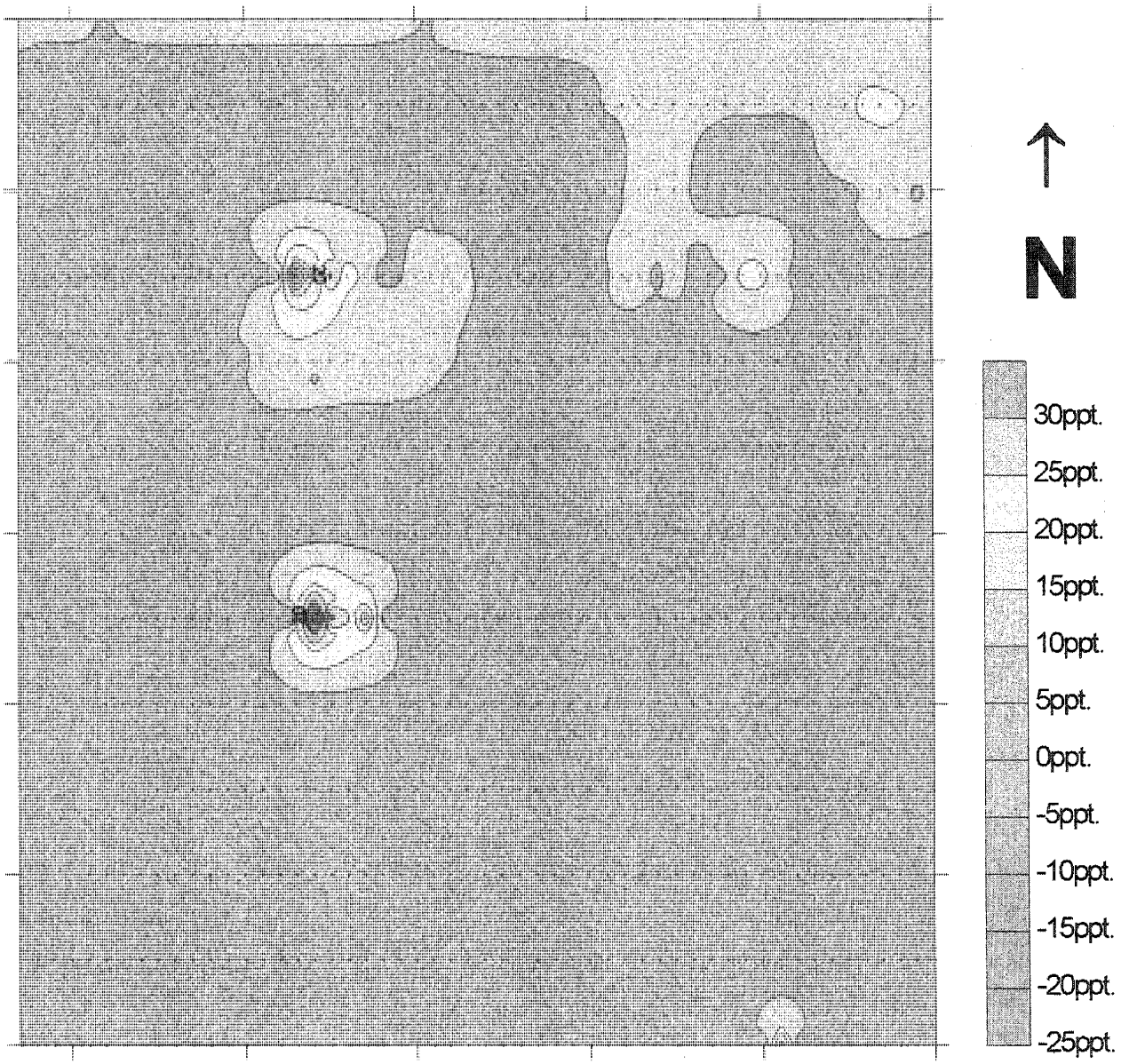
EM-31 Conductivity Data
Southwest Disposal Area
Eastern Island
Midway NAF



Scale: 1 inch = 50 feet

0feet 50feet 100feet 150feet 200feet

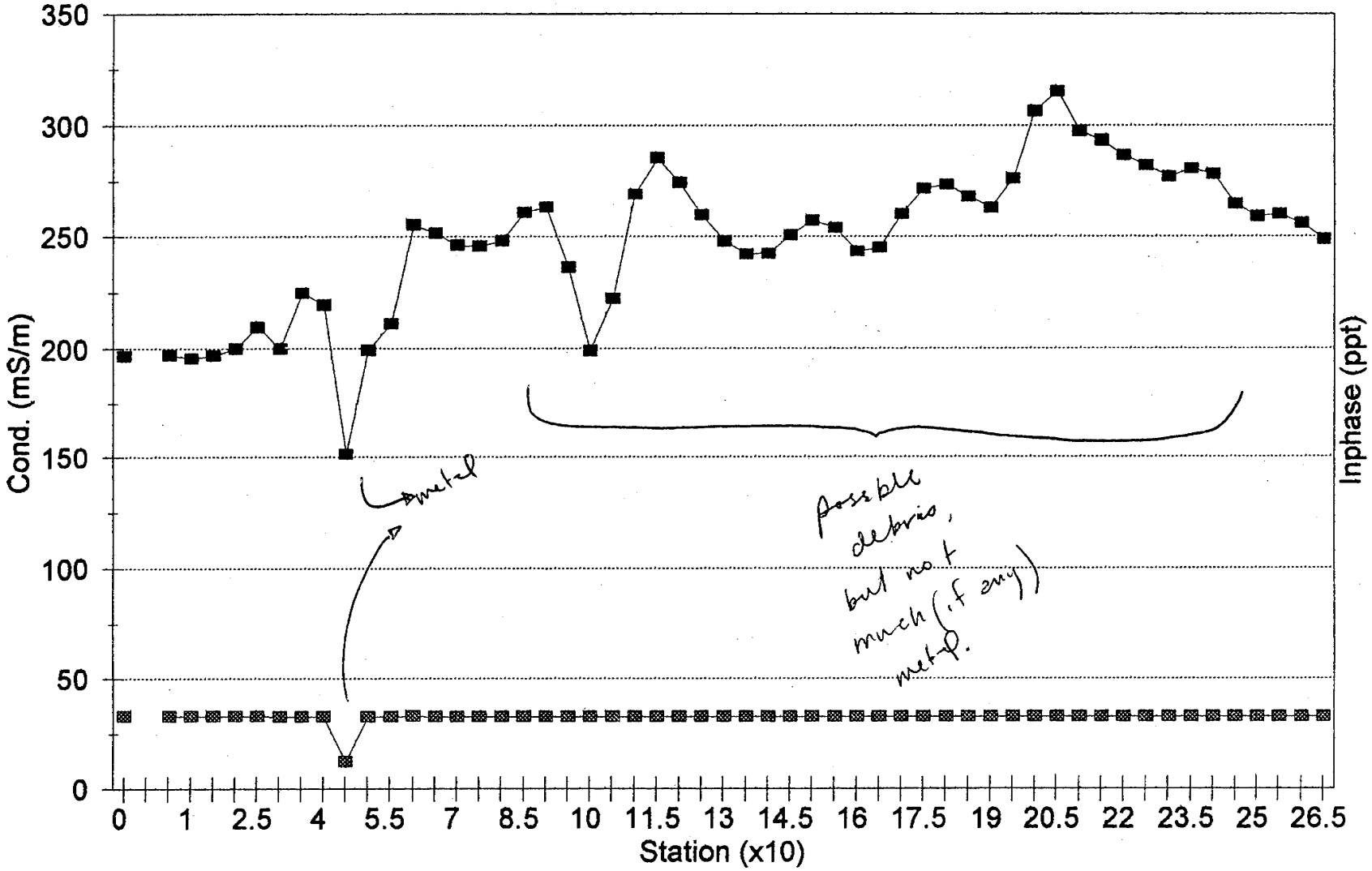
EM-31 In-Phase Data
Southwest Disposal Area
Eastern Island
NAF Midway

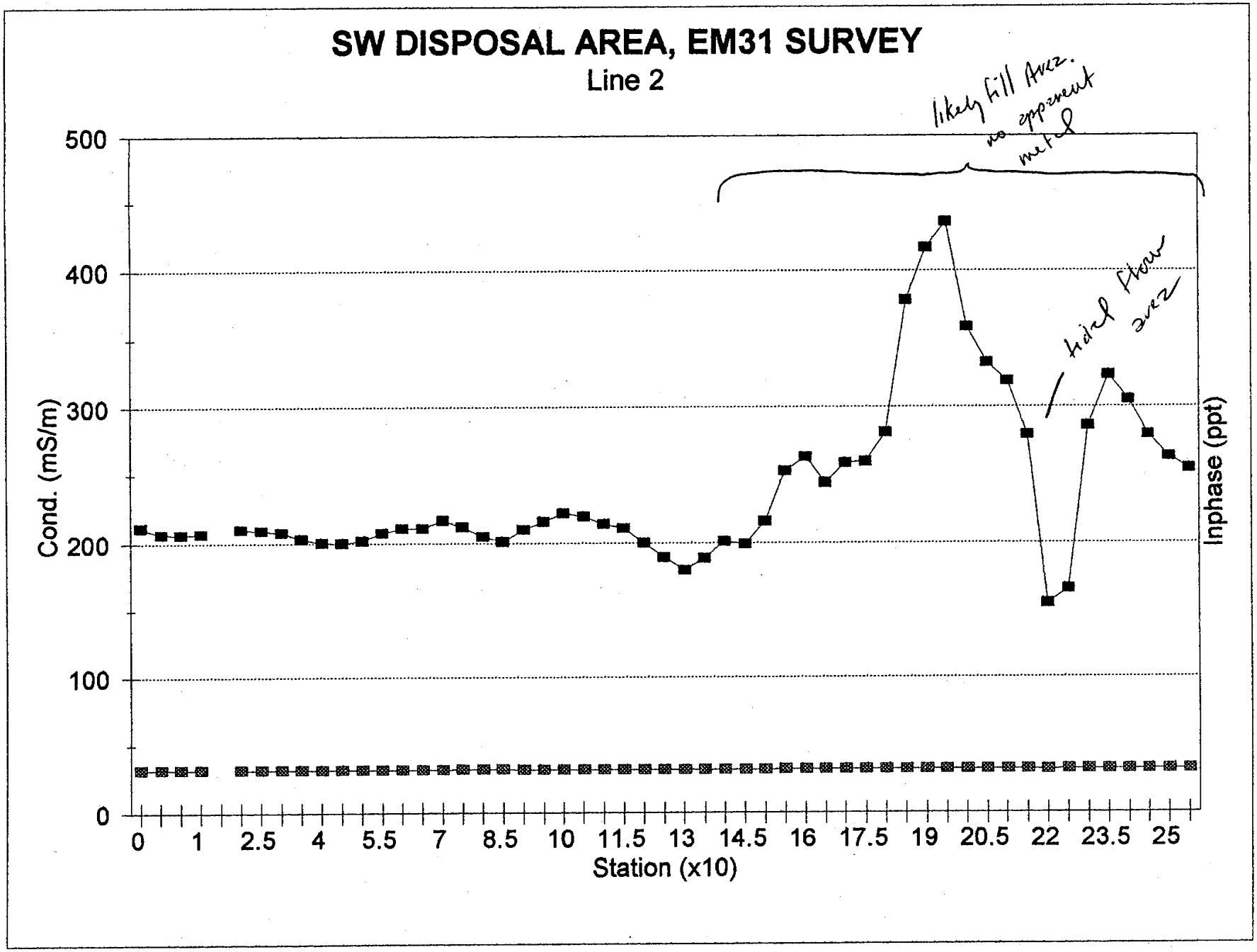


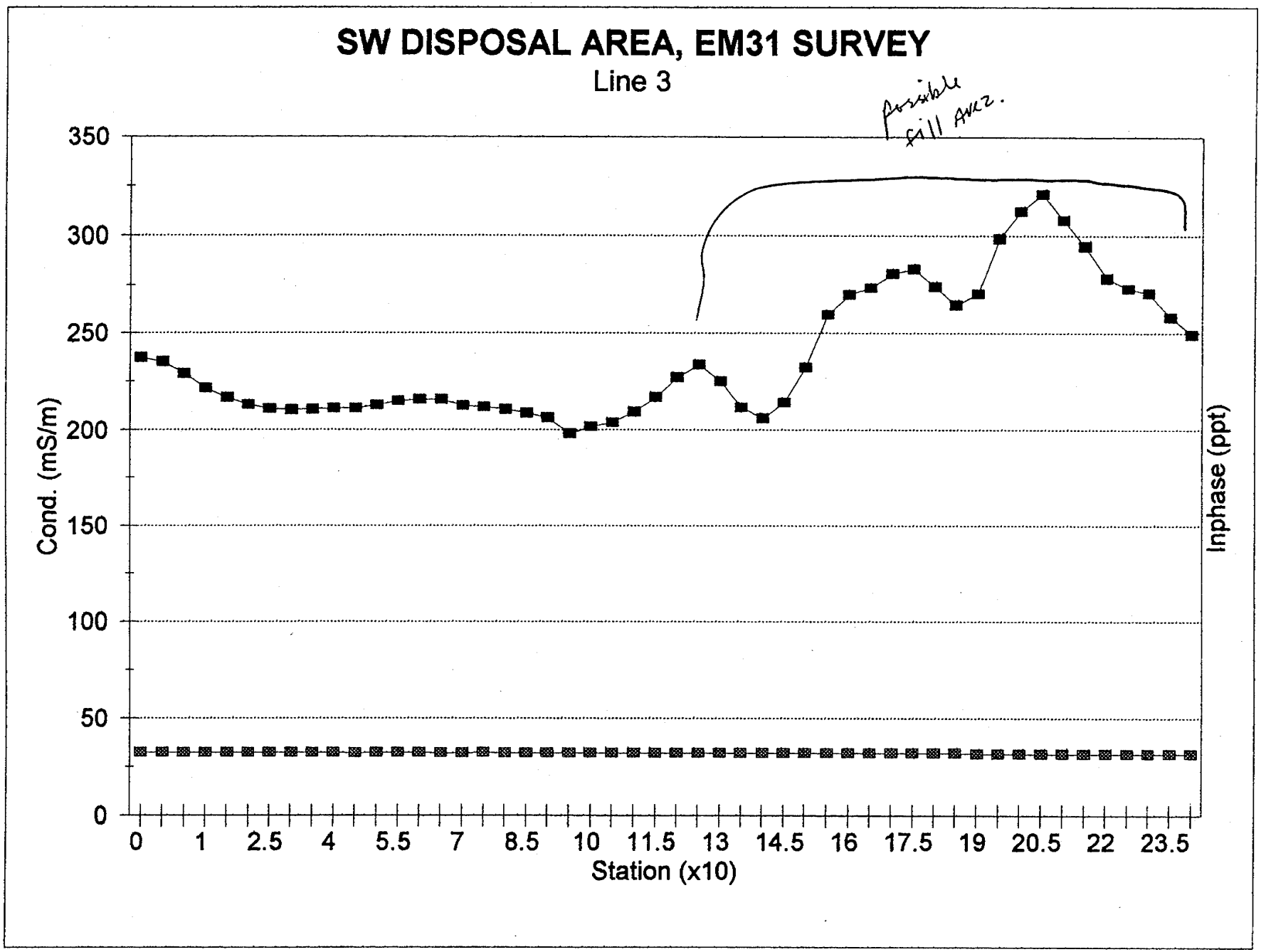
Scale: 1 inch = 50 feet

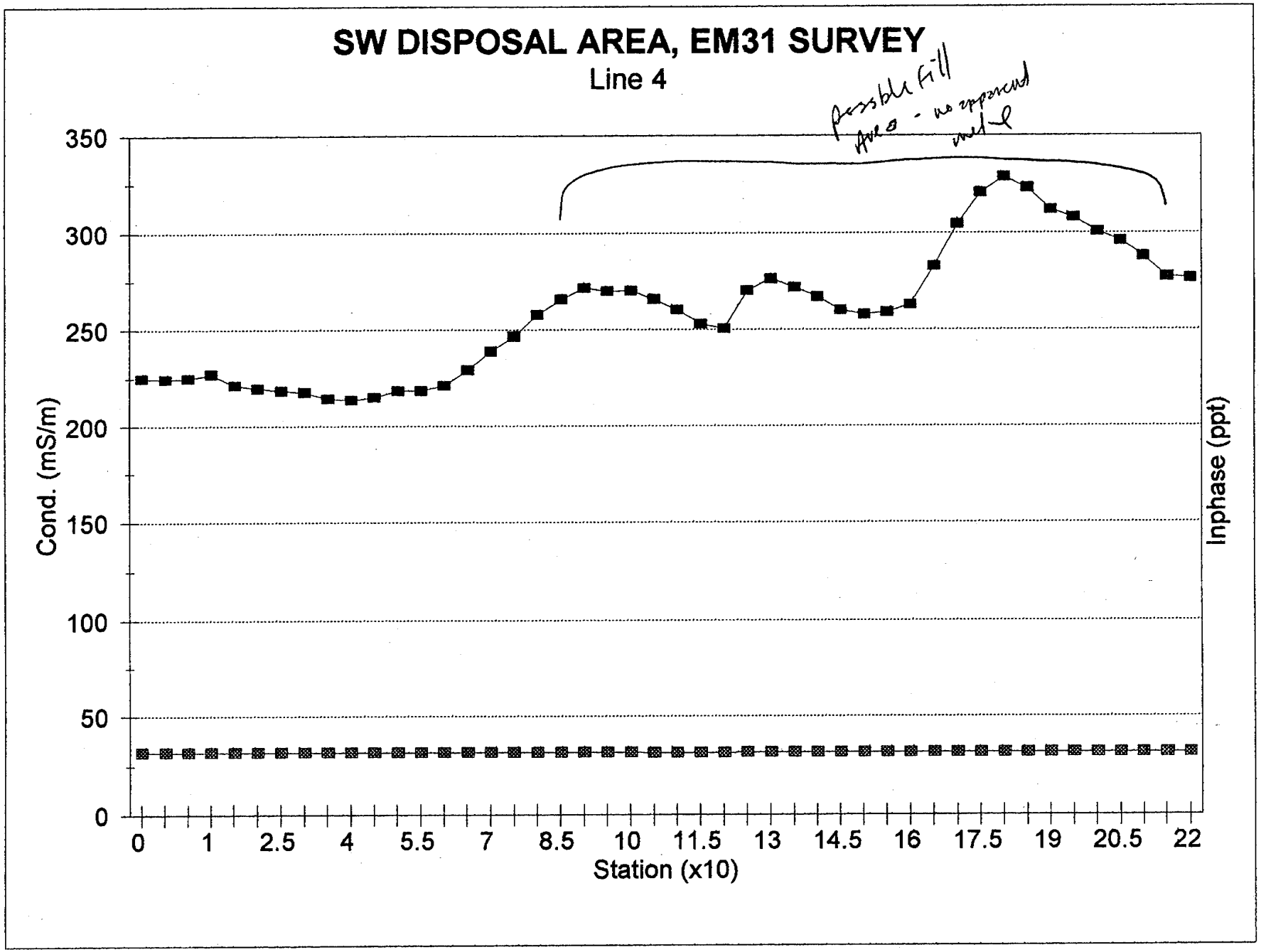
SW DISPOSAL AREA, EM31 SURVEY

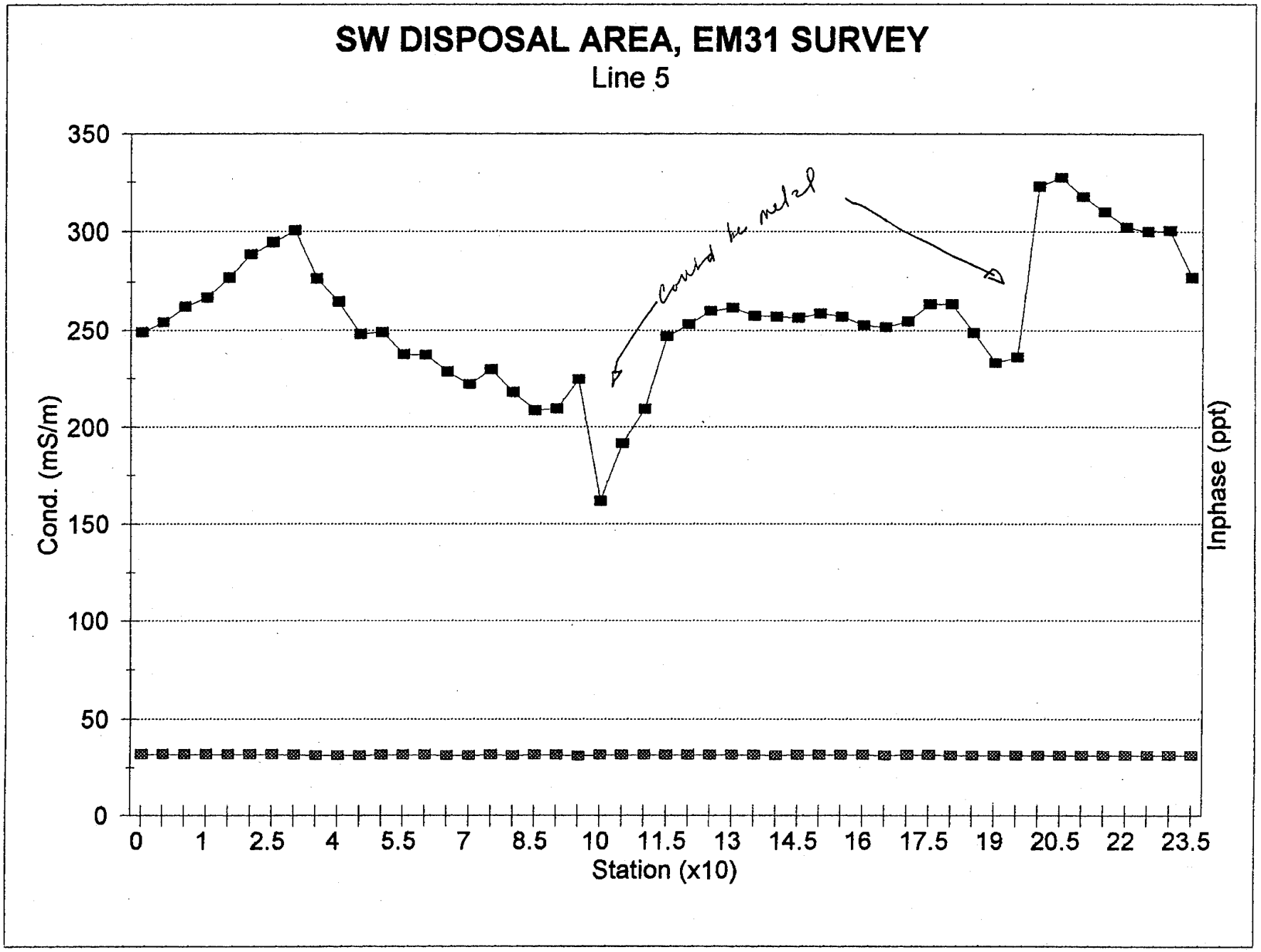
Line 1




SW DISPOSAL AREA, EM31 SURVEY
Line 2
likely fill area. no apparent metal
hard flow area
Cond. (mS/m)
Inphase (ppt)
Station (x10)
500
400
300
200
100
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
25

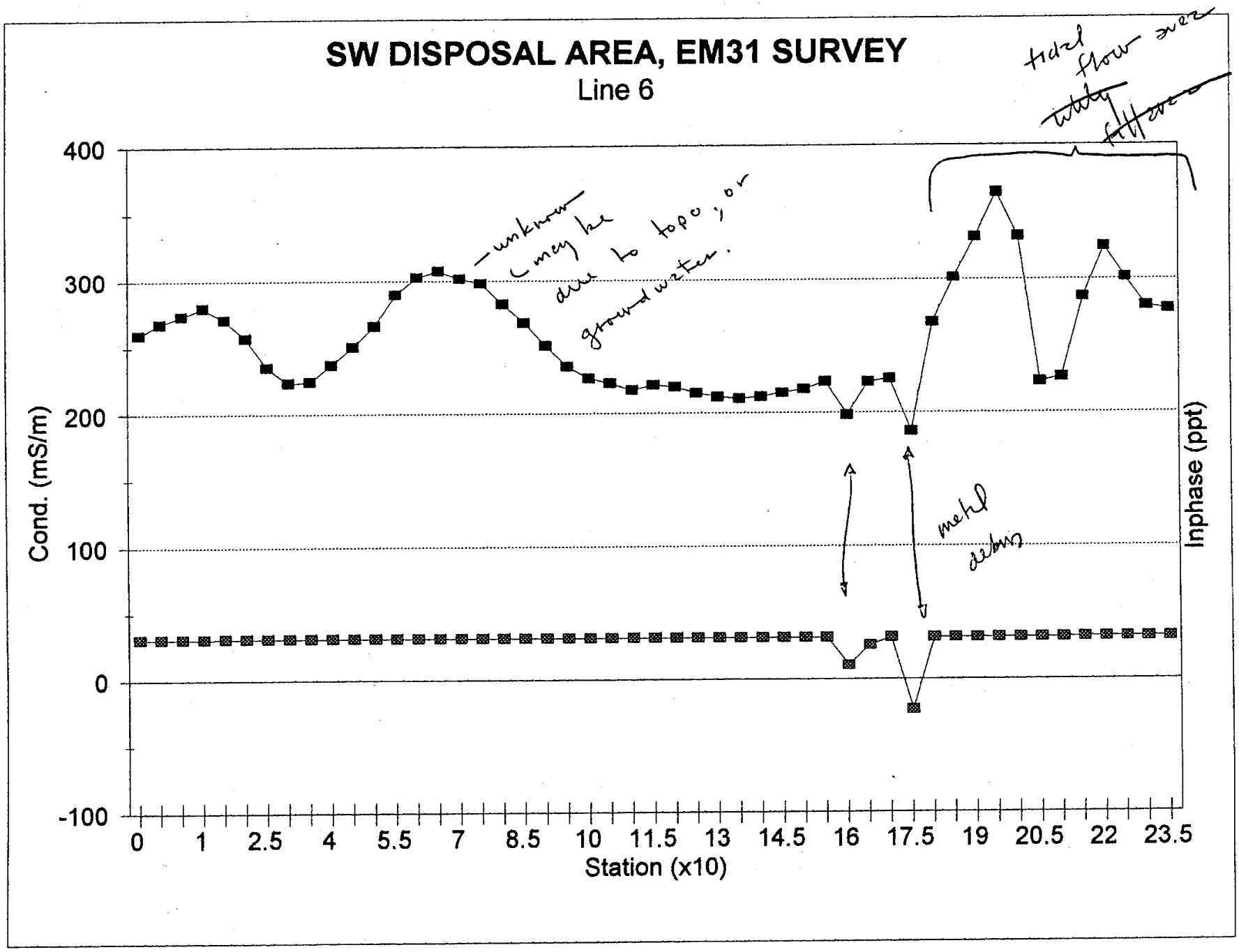

SW DISPOSAL AREA, EM31 SURVEY
Line 3
Possible fill area.
Cond. (mS/m)
Inphase (ppt)
350
300
250
200
150
100
50
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
Station (x10)

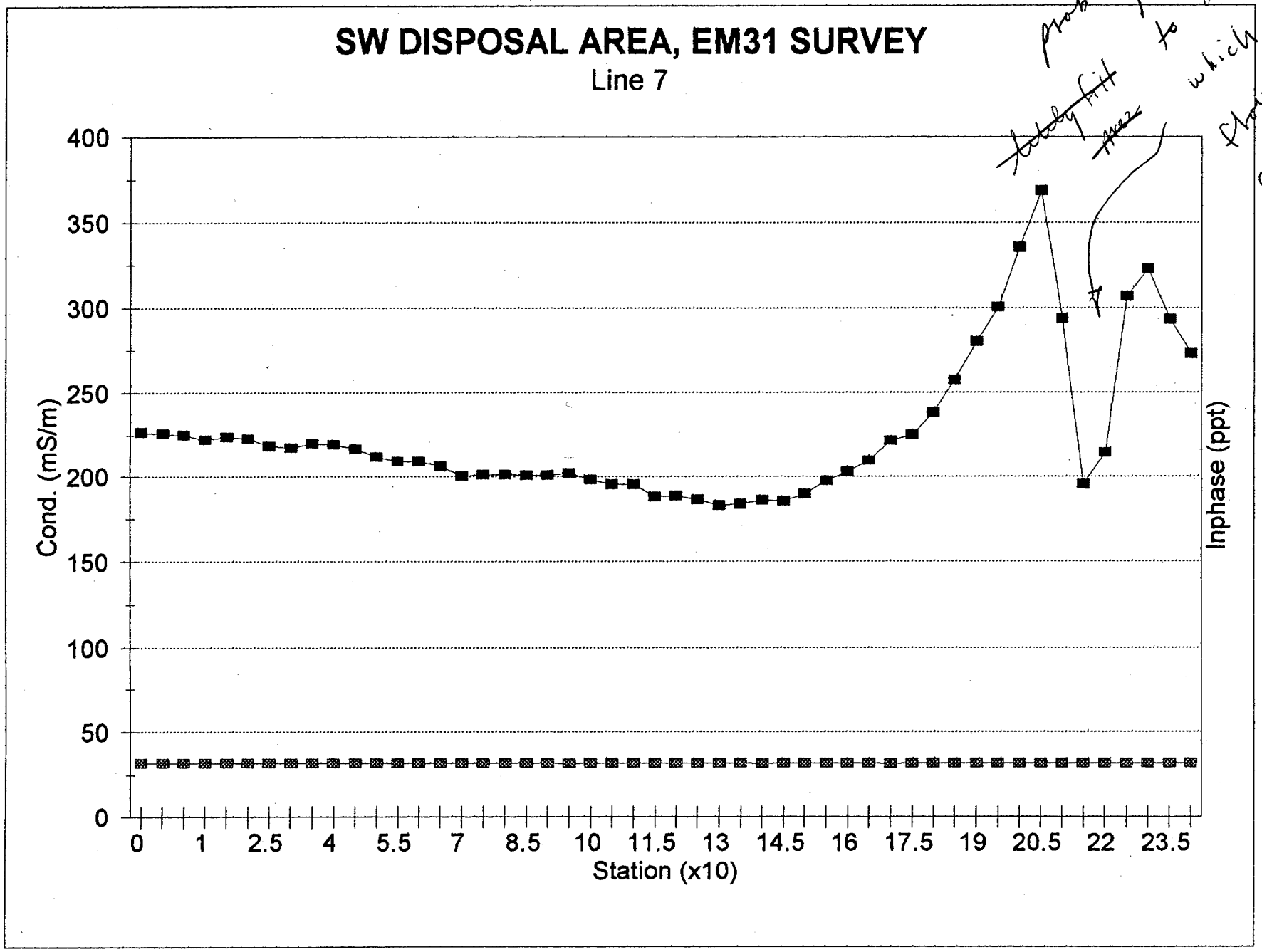

SW DISPOSAL AREA, EM31 SURVEY
Line 4
possible fill area - no apparent metal
Cond. (mS/m)
Inphase (ppt)
350
300
250
200
150
100
50
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
Station (x10)


SW DISPOSAL AREA, EM31 SURVEY
Line 5
Cond. (mS/m)
Inphase (ppt)
Station (x10)
350
300
250
200
150
100
50
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5
Could be metal

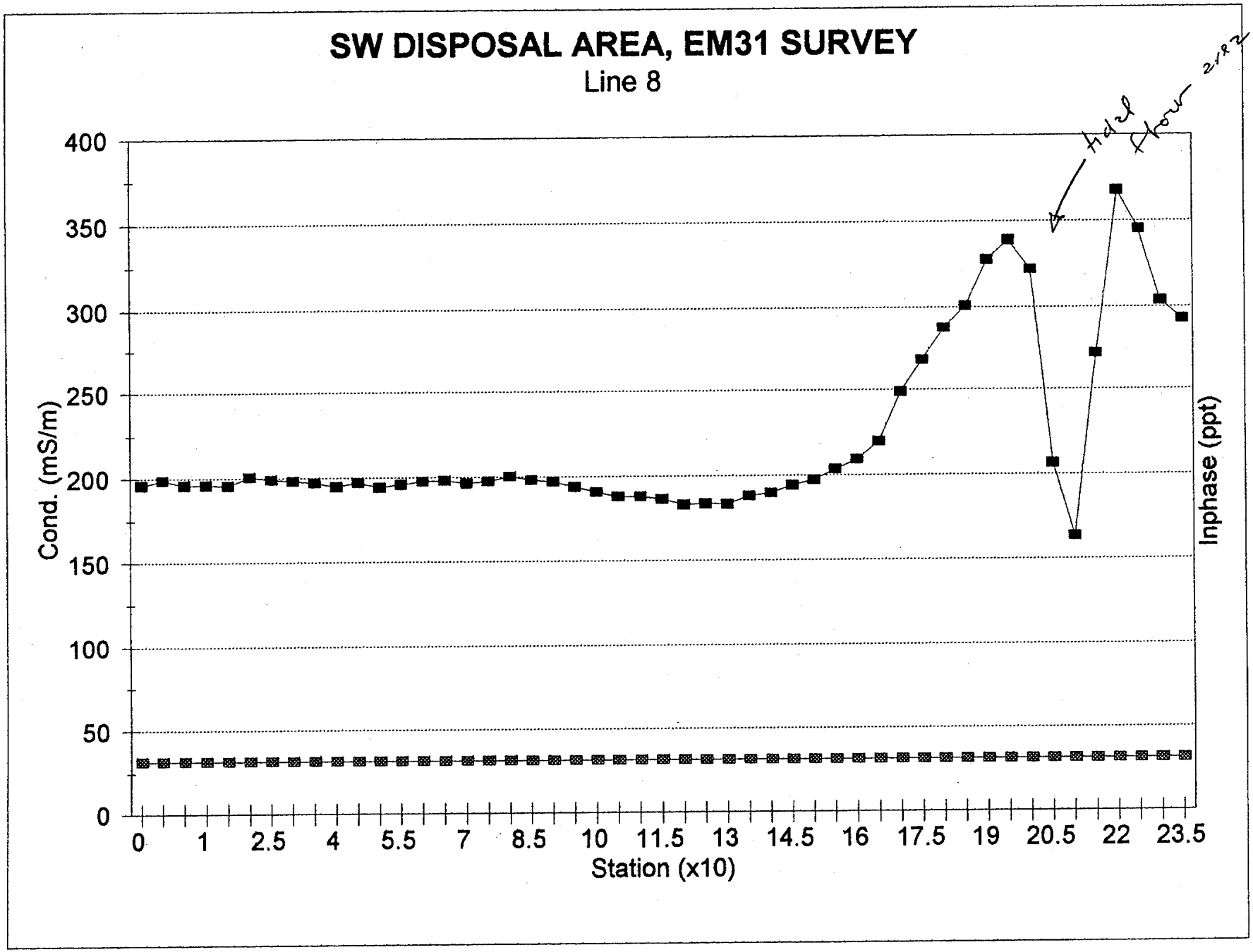
SW DISPOSAL AREA, EM31 SURVEY

Line 6



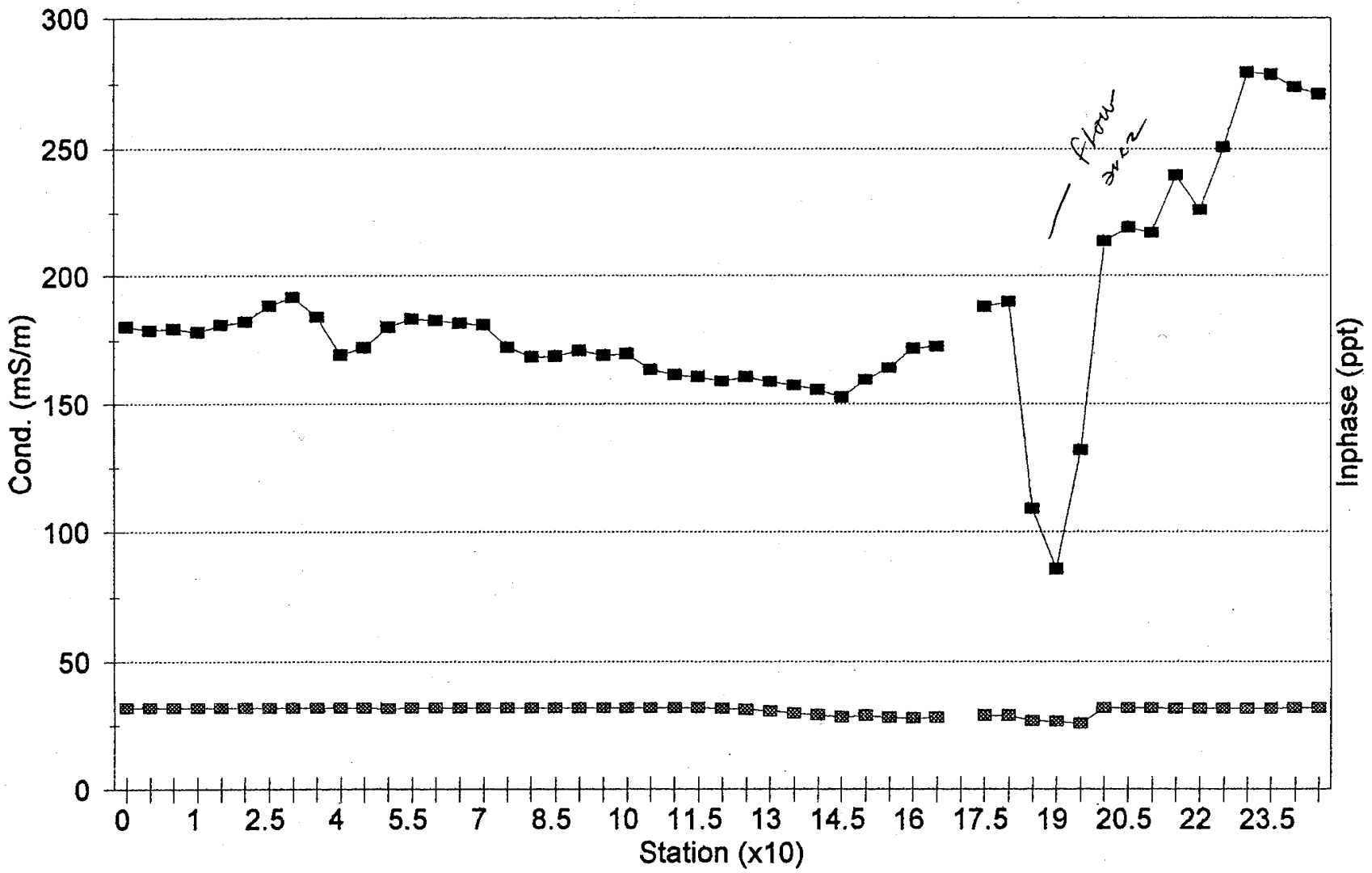


probably due to deep sion which showed flow from ocean


SW DISPOSAL AREA, EM31 SURVEY
Line 8
Tidal flow 2/82
Cond. (mS/m)
Inphase (ppt)
Station (x10)
400
350
300
250
200
150
100
50
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
23.5

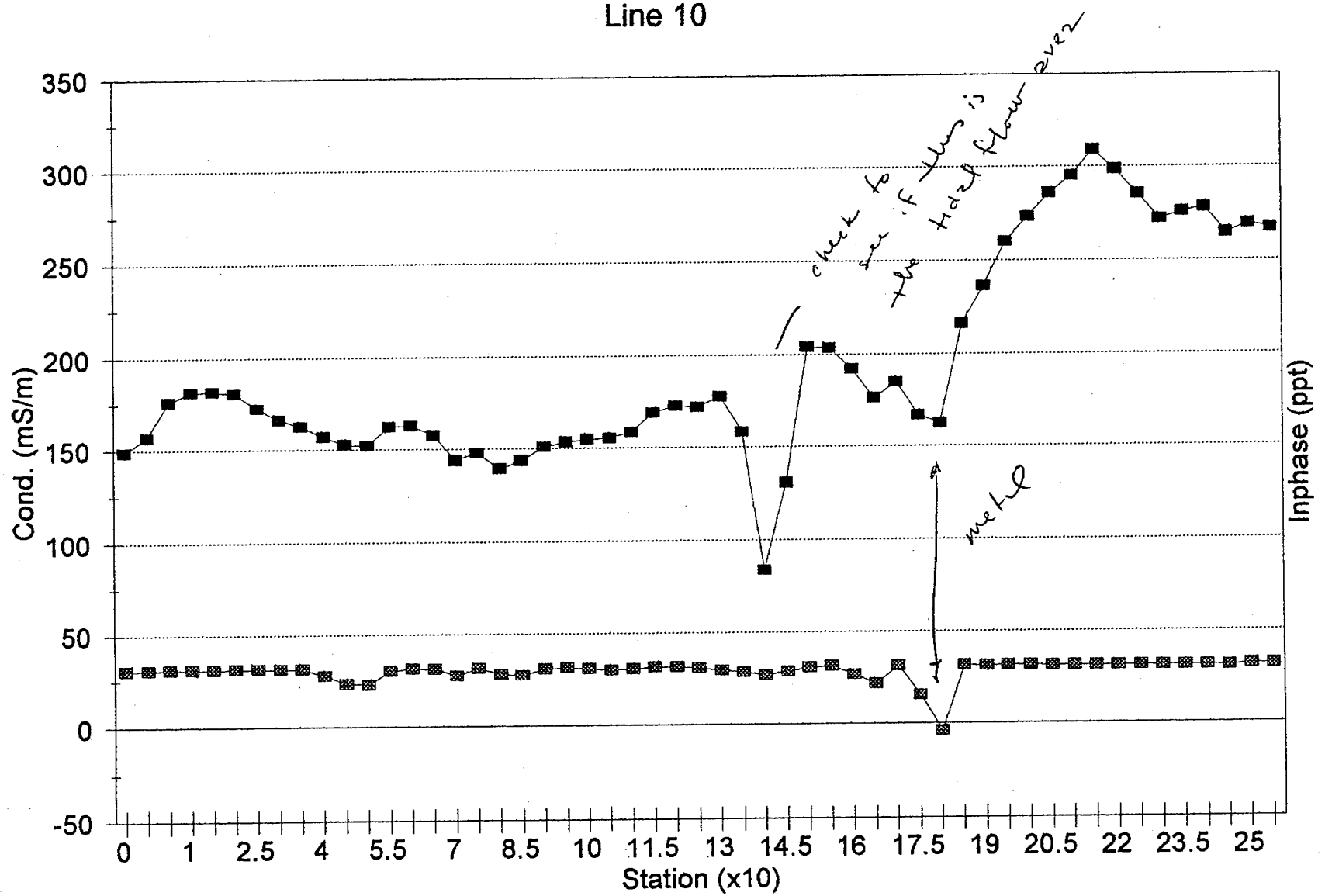
SW DISPOSAL AREA, EM31 SURVEY

Line 9



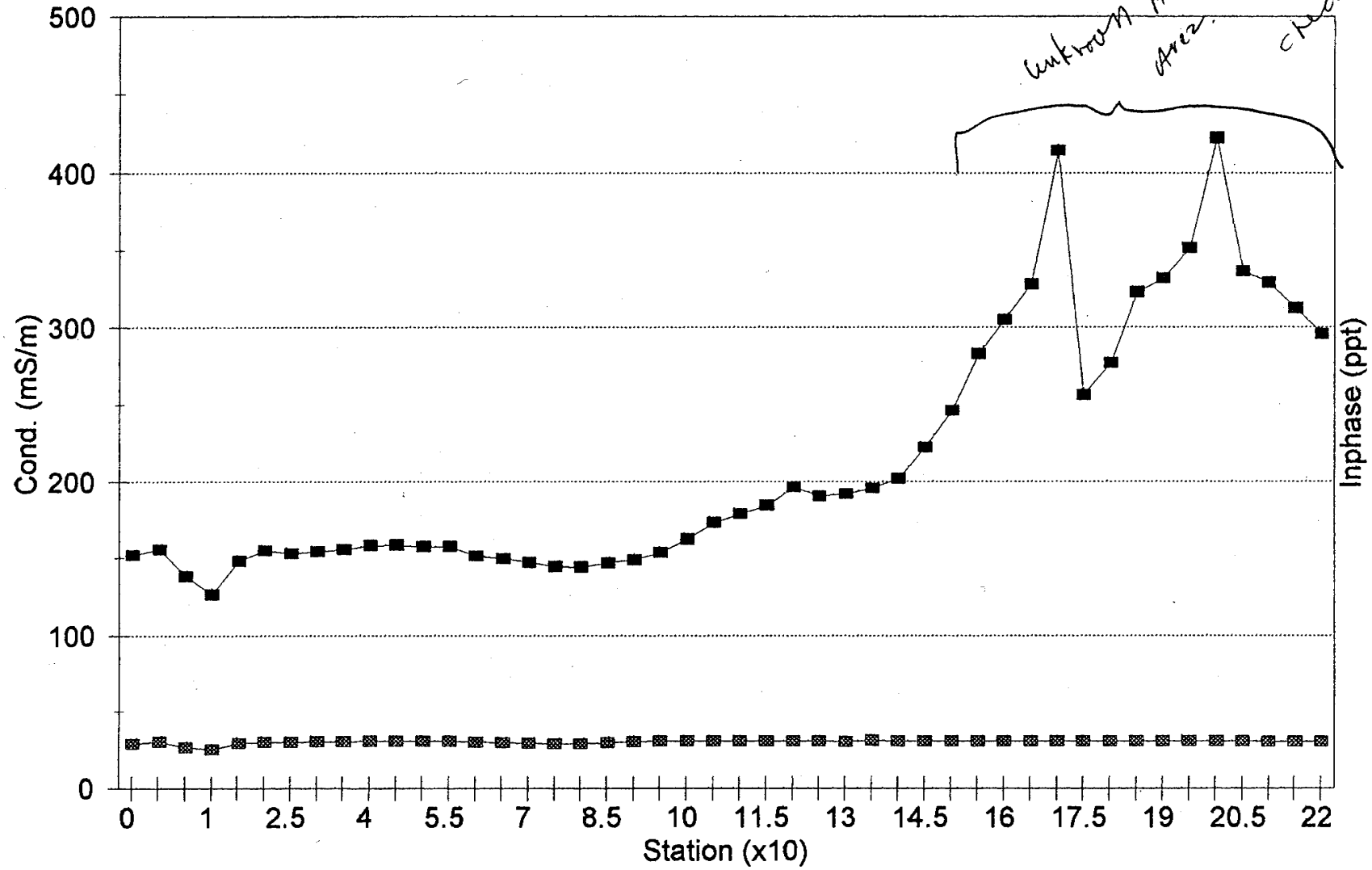
SW DISPOSAL AREA, EM31 SURVEY

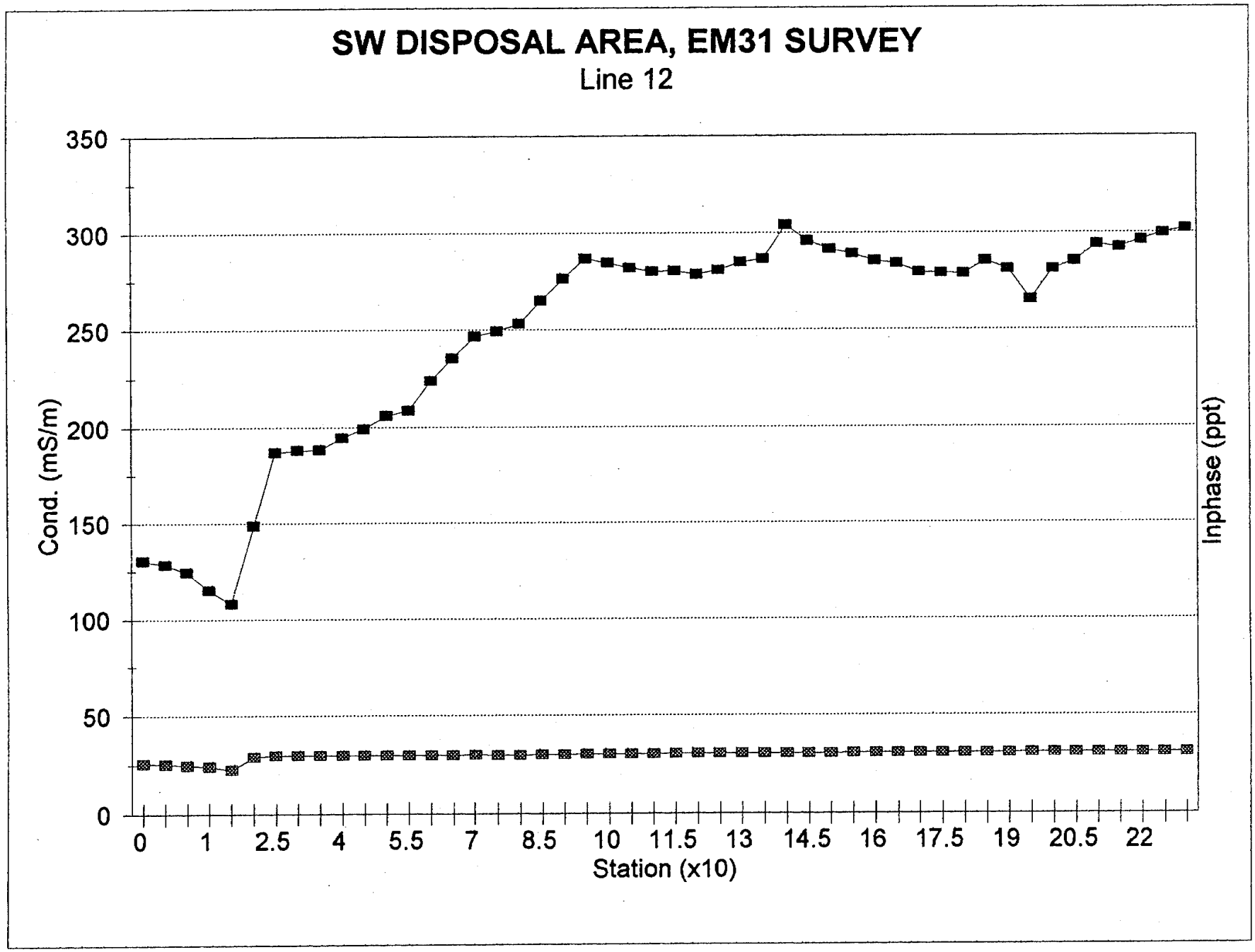
Line 10



SW DISPOSAL AREA, EM31 SURVEY

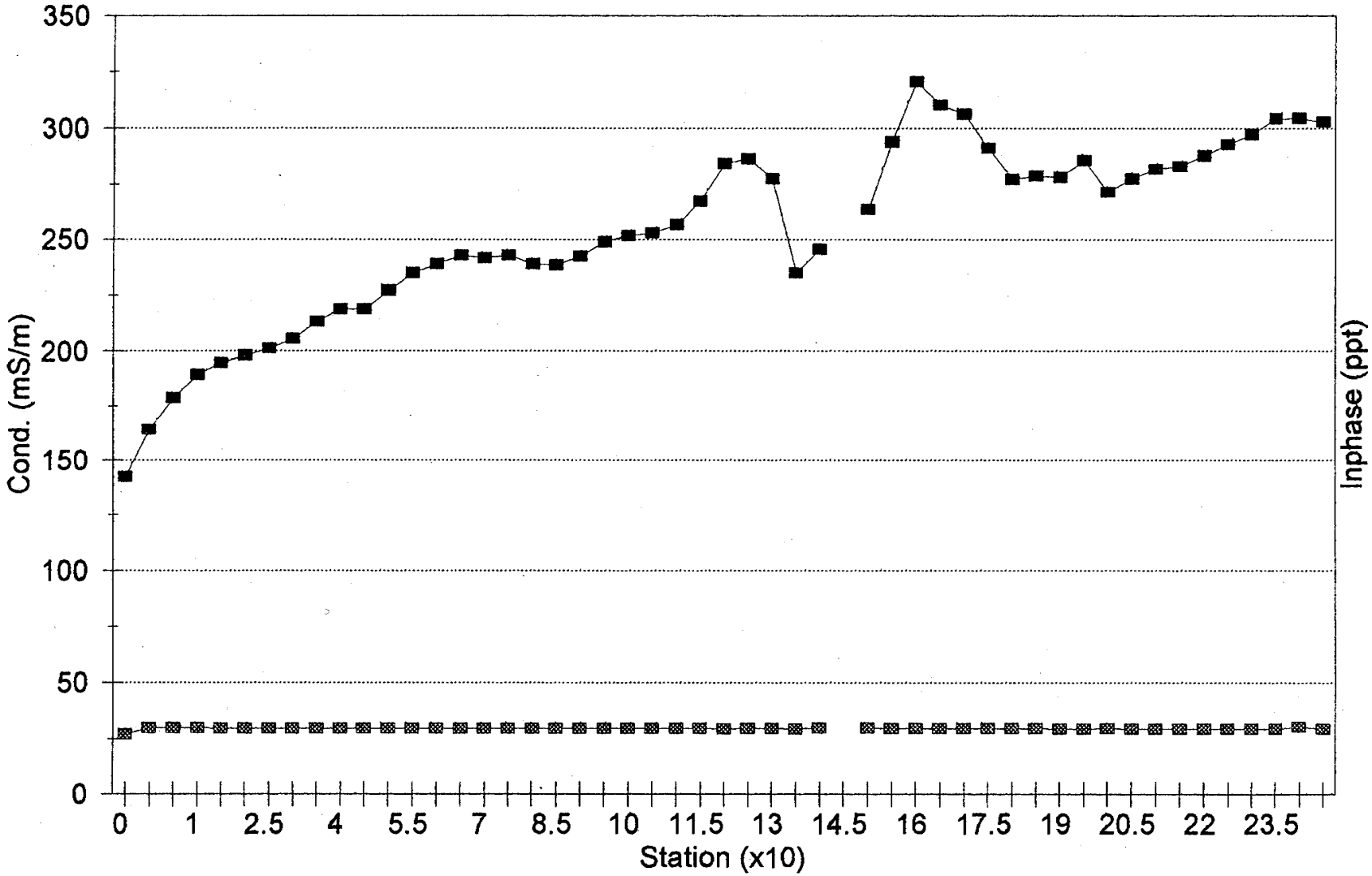
Line 11



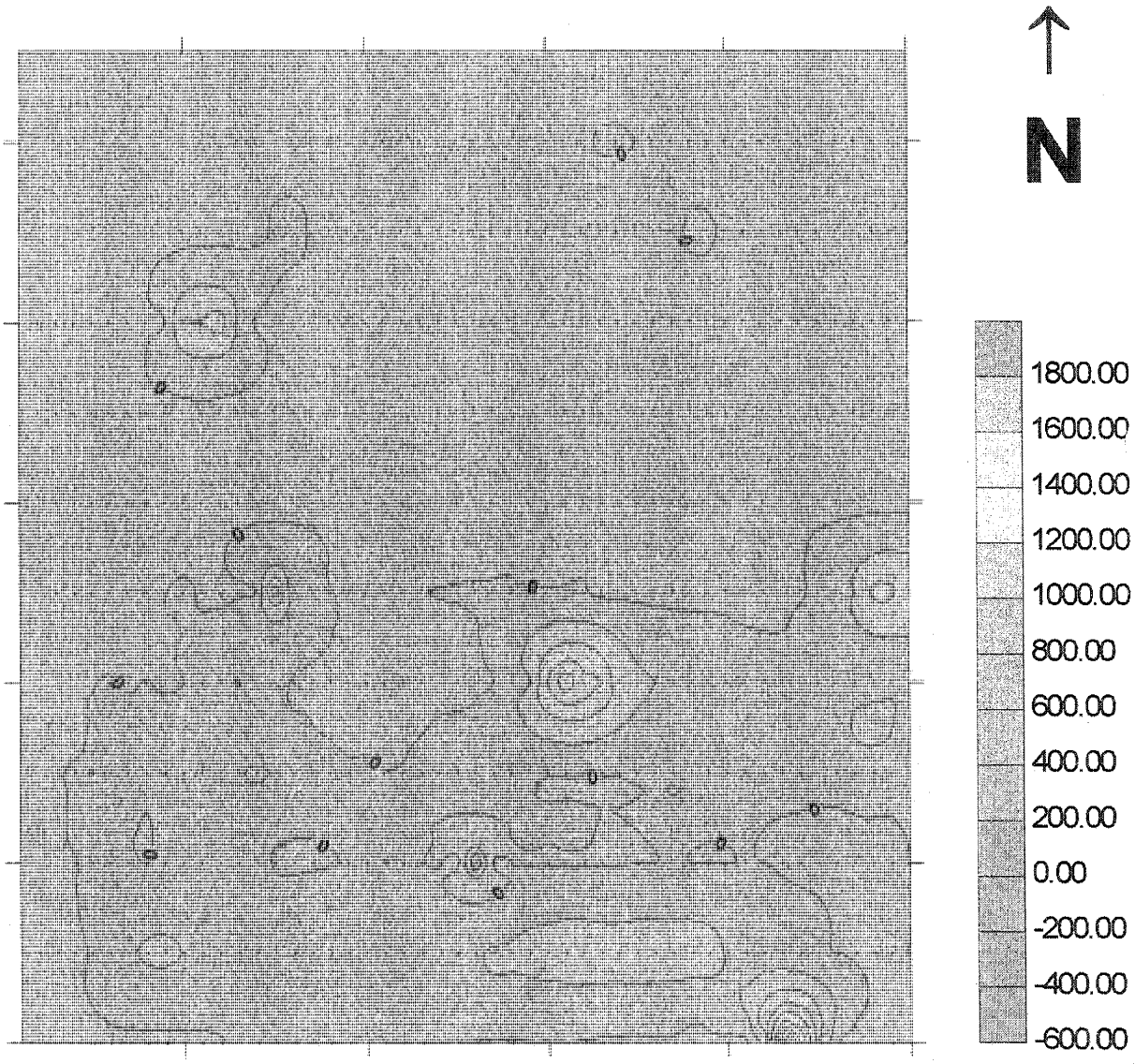

SW DISPOSAL AREA, EM31 SURVEY
Line 12
Cond. (mS/m)
Inphase (ppt)
350
300
250
200
150
100
50
0
0
1
2.5
4
5.5
7
8.5
10
11.5
13
14.5
16
17.5
19
20.5
22
Station (x10)

SW DISPOSAL AREA, EM31 SURVEY

Line 13



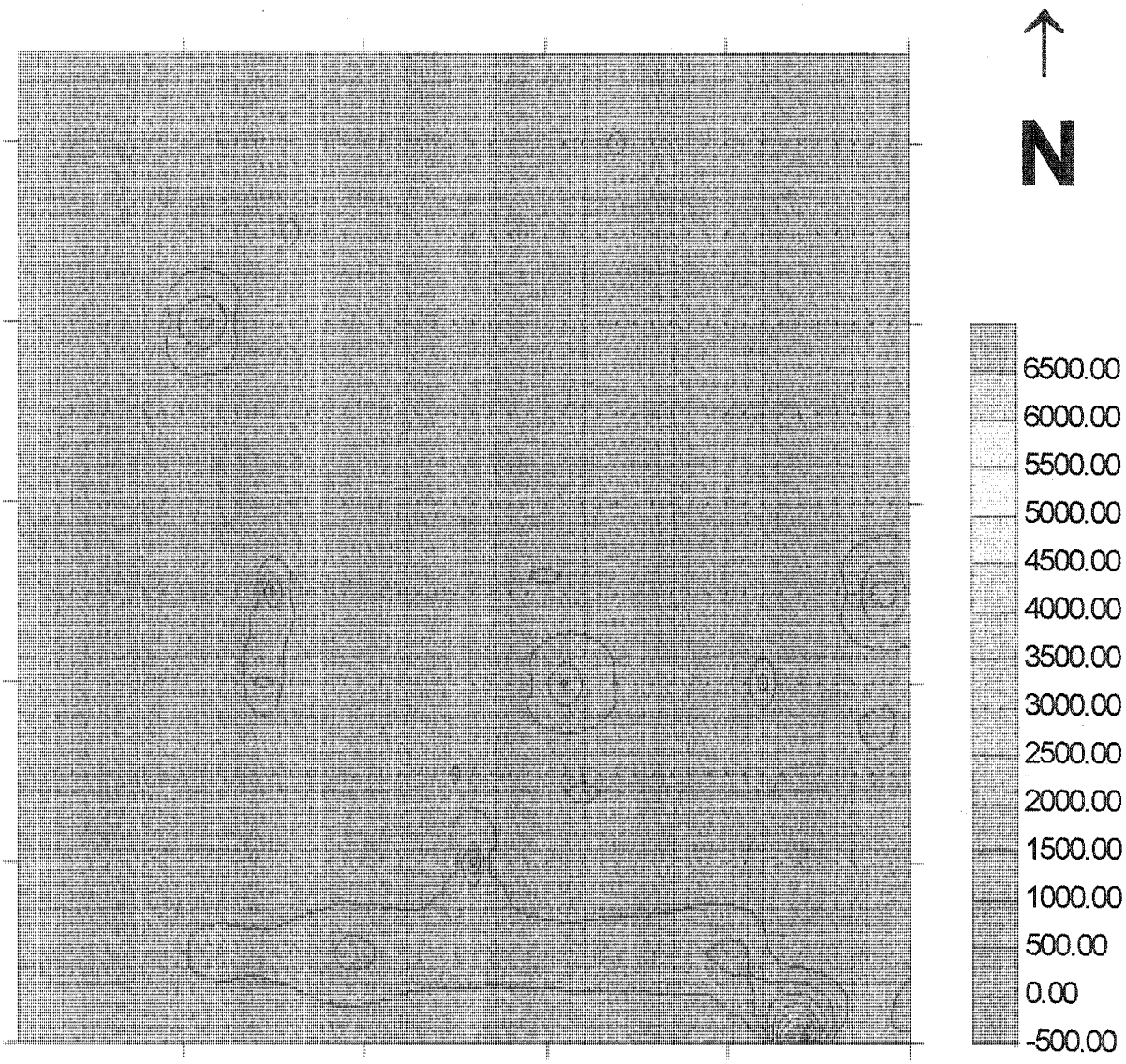
EM-61 Data (differential)
Southwest Disposal Area
Eastern Island
Midway NAF



Scale: 1 inch = 50 feet

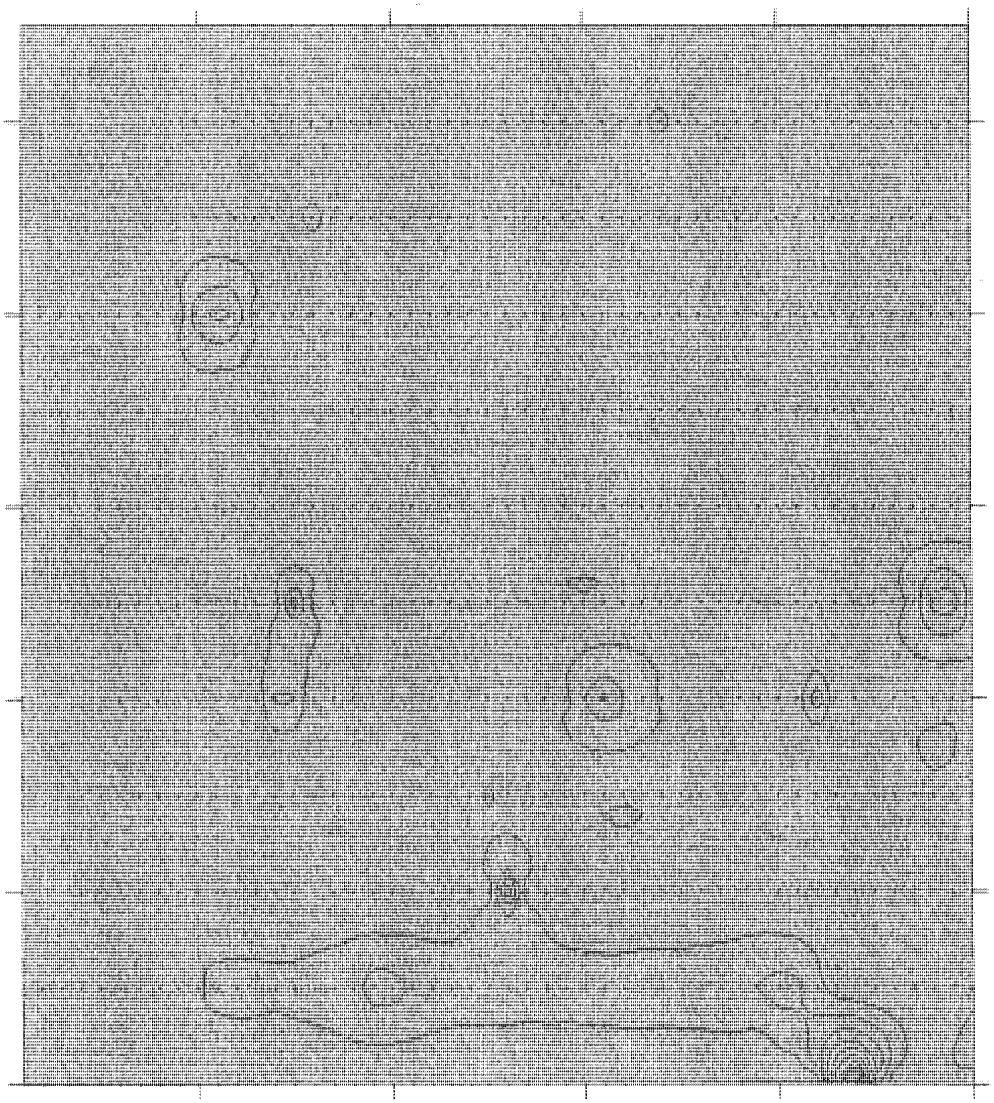
0ft. 50ft. 100ft. 150ft. 200ft.

EM-61 Data (column 1)
Southwest Disposal Area
Eastern Island
Midway NAF



Scale: 1 inch = 50 feet

EM-61 Data (column 2)
Southwest Disposal Area
Eastern Island
Midway NAF

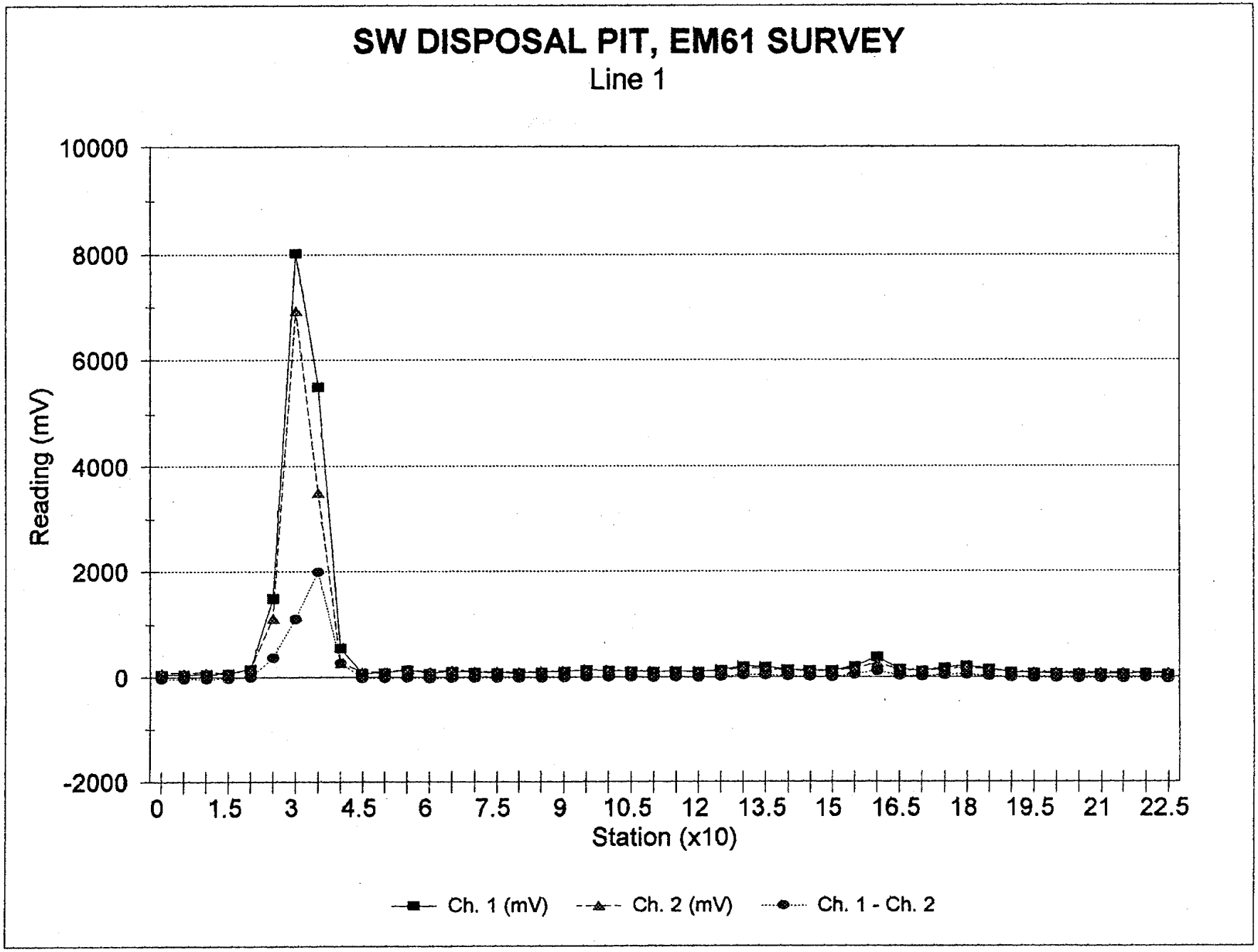


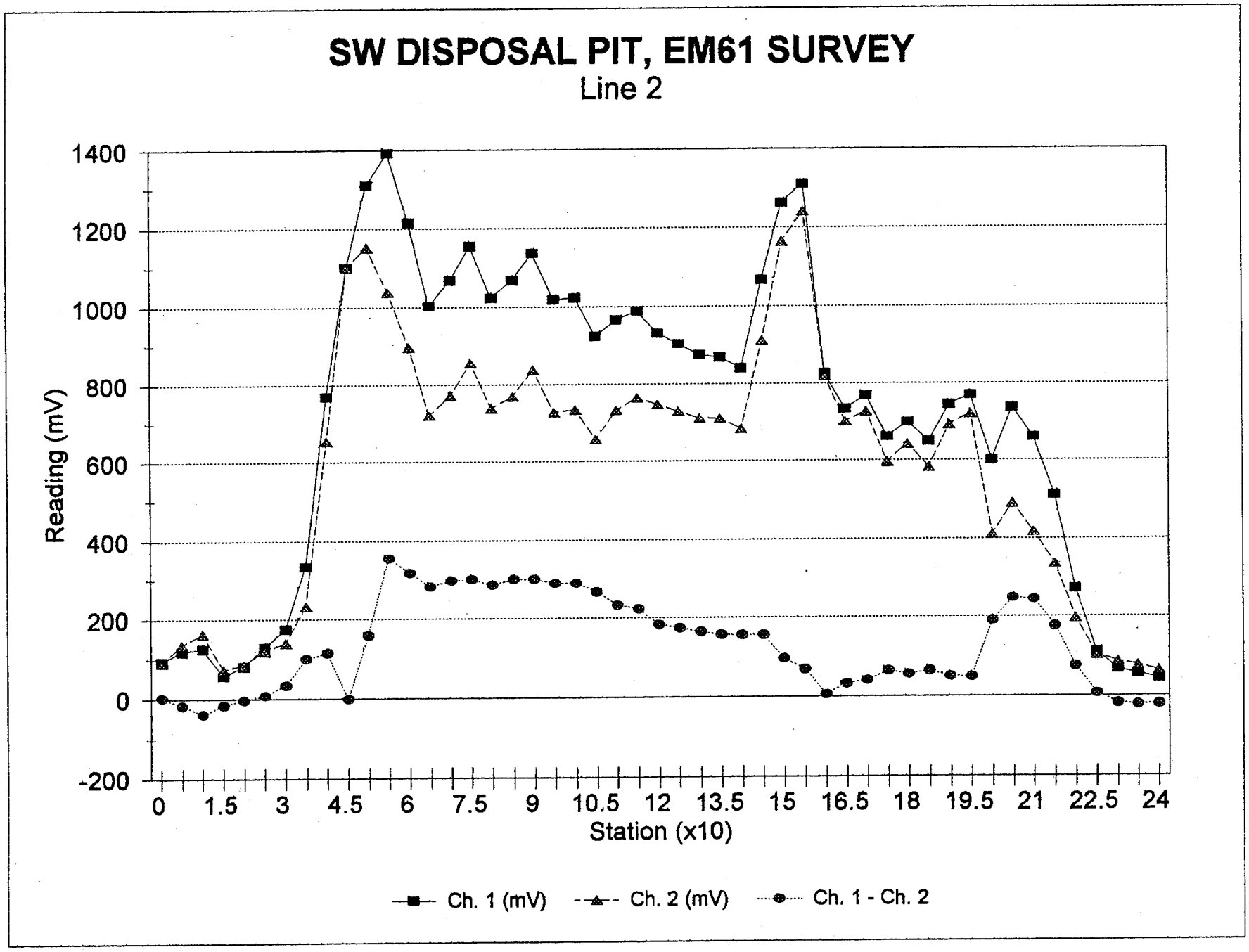
N

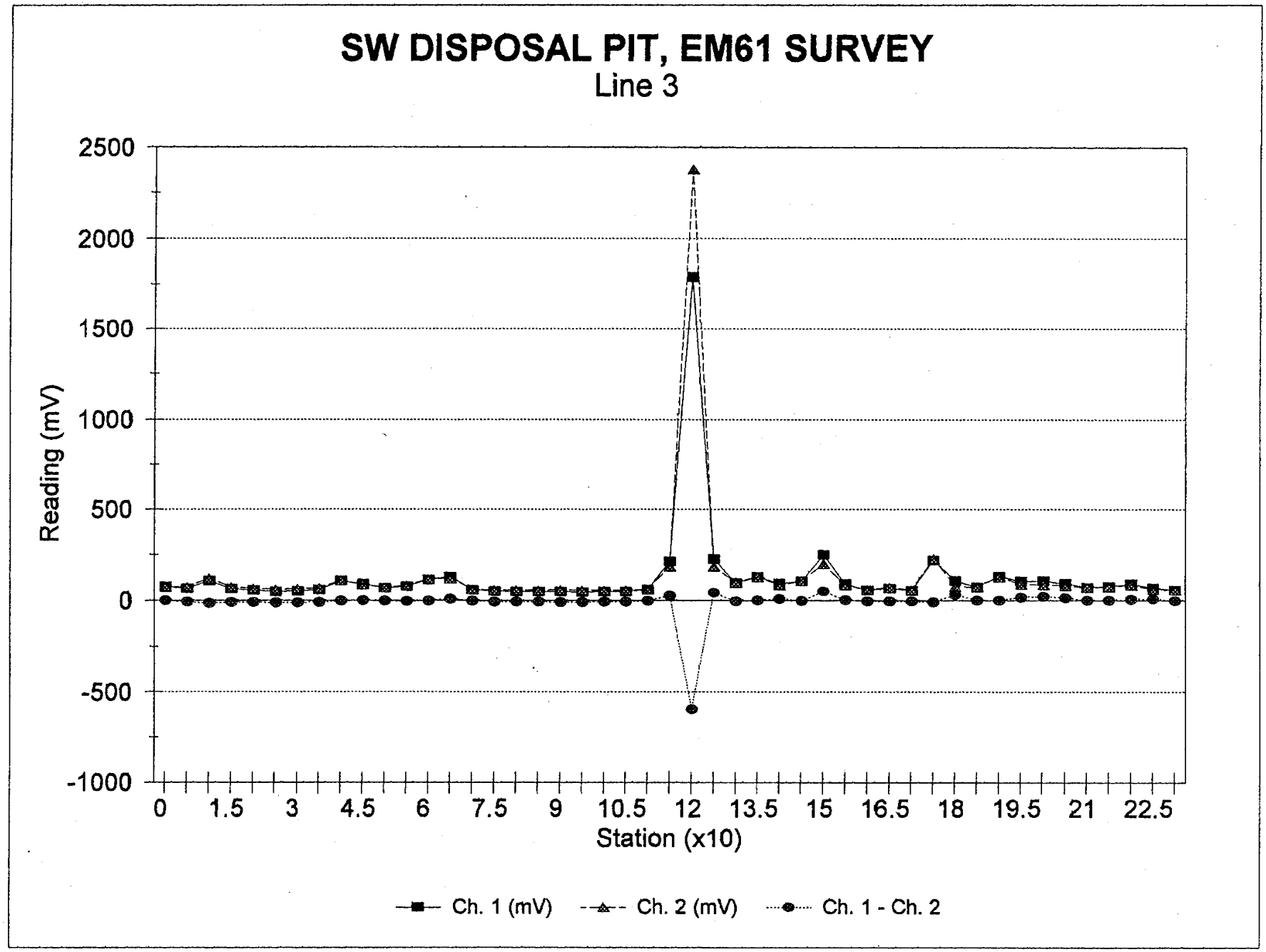
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00

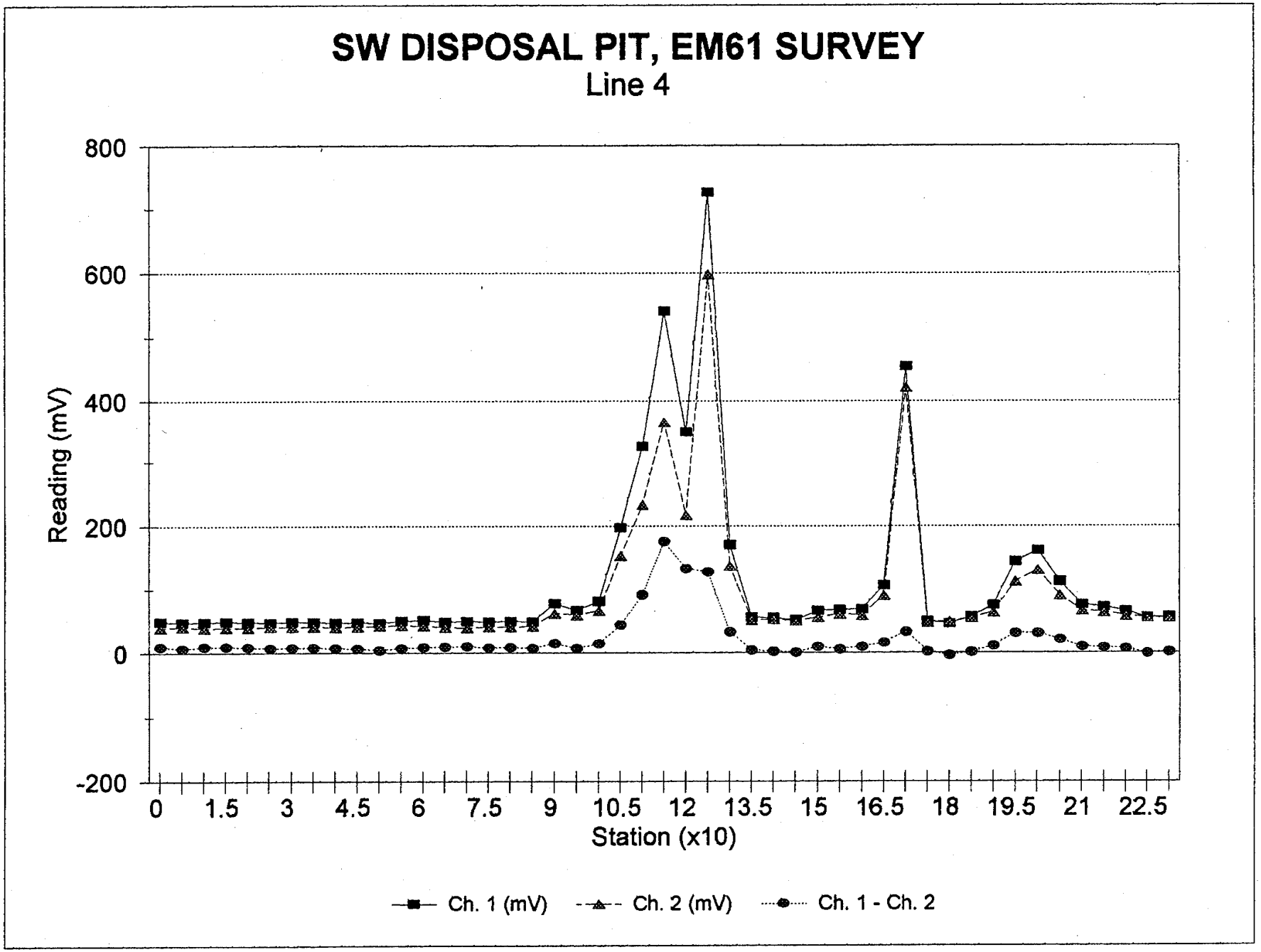
Scale: 1 inch = 50 feet

0ft. 50ft. 100ft. 150ft. 200ft.


SW DISPOSAL PIT, EM61 SURVEY
Line 1
10000
8000
6000
4000
2000
0
-2000
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

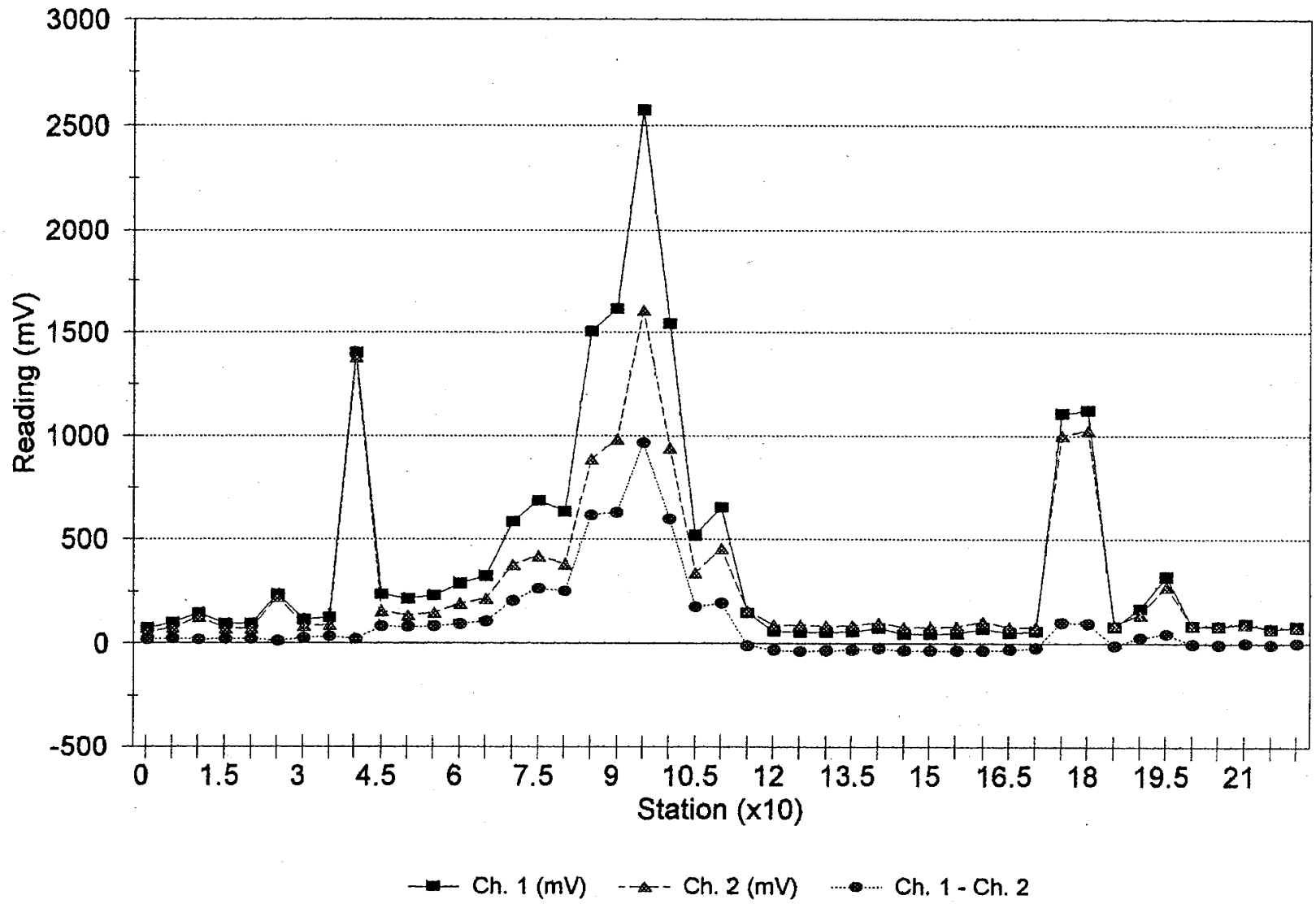

SW DISPOSAL PIT, EM61 SURVEY
Line 2
Reading (mV)
1400
1200
1000
800
600
400
200
0
-200
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

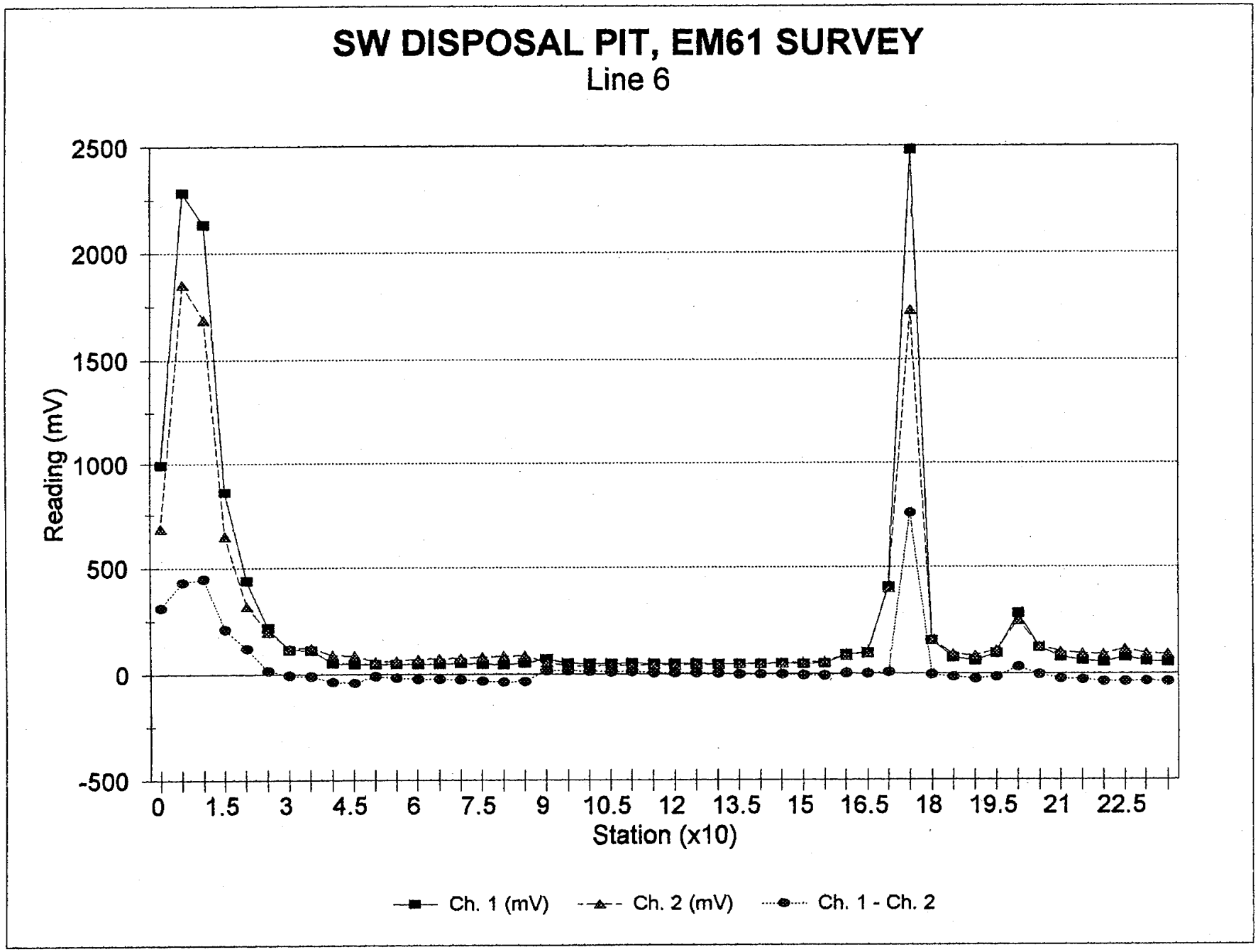

SW DISPOSAL PIT, EM61 SURVEY
Line 3
2500
2000
1500
1000
500
0
-500
-1000
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2


SW DISPOSAL PIT, EM61 SURVEY
Line 4
800
600
400
200
0
-200
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

SW DISPOSAL PIT, EM61 SURVEY

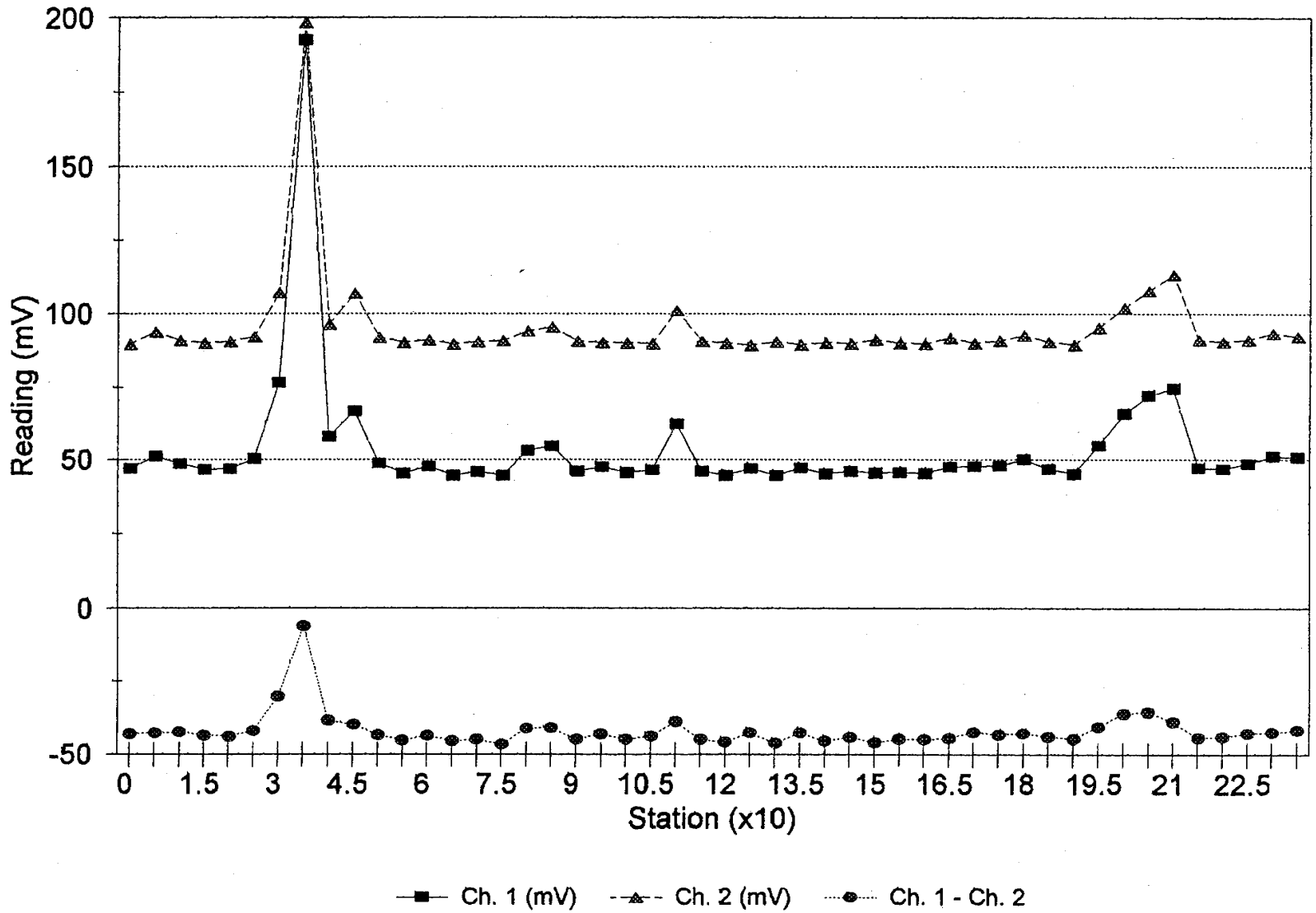
Line 5

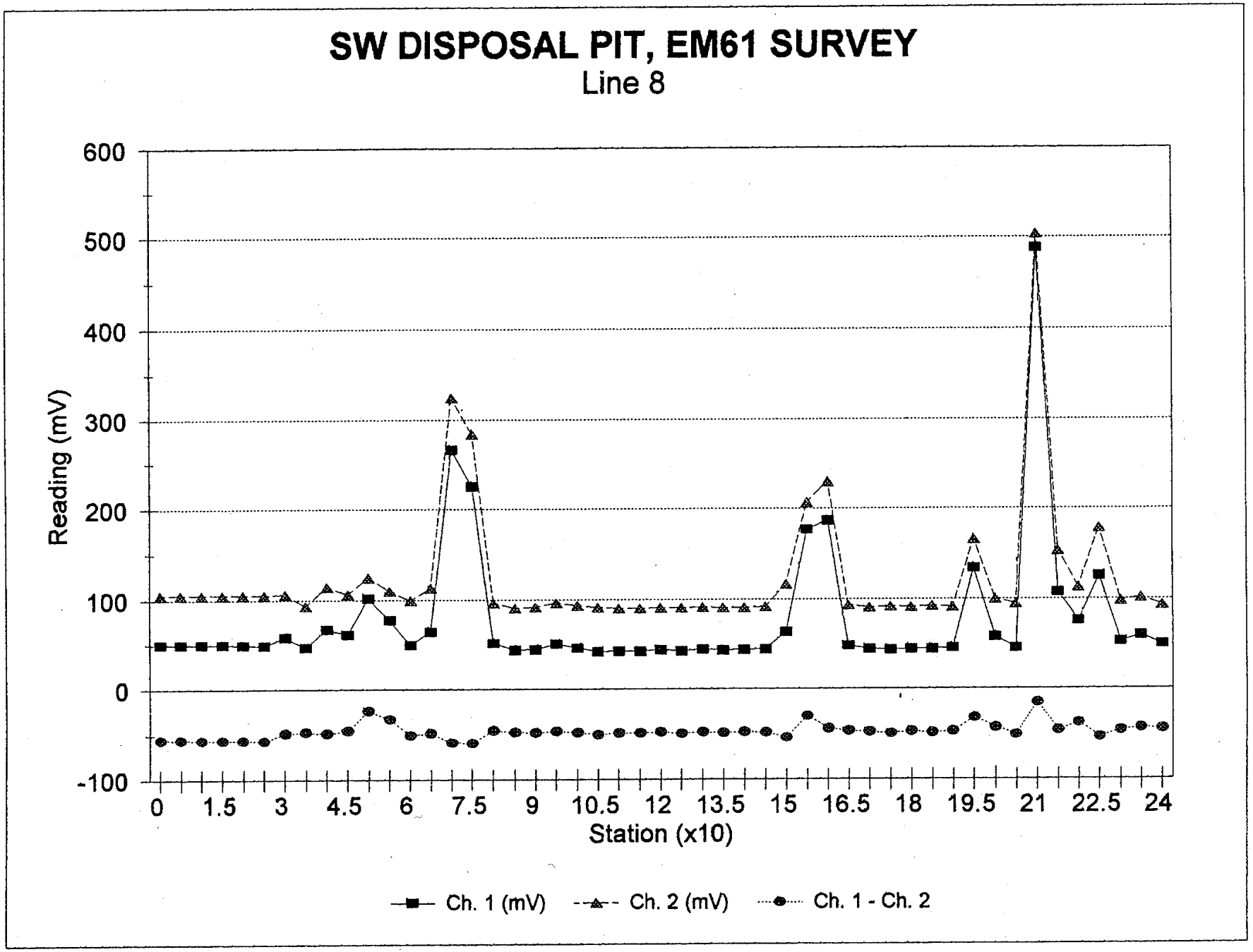


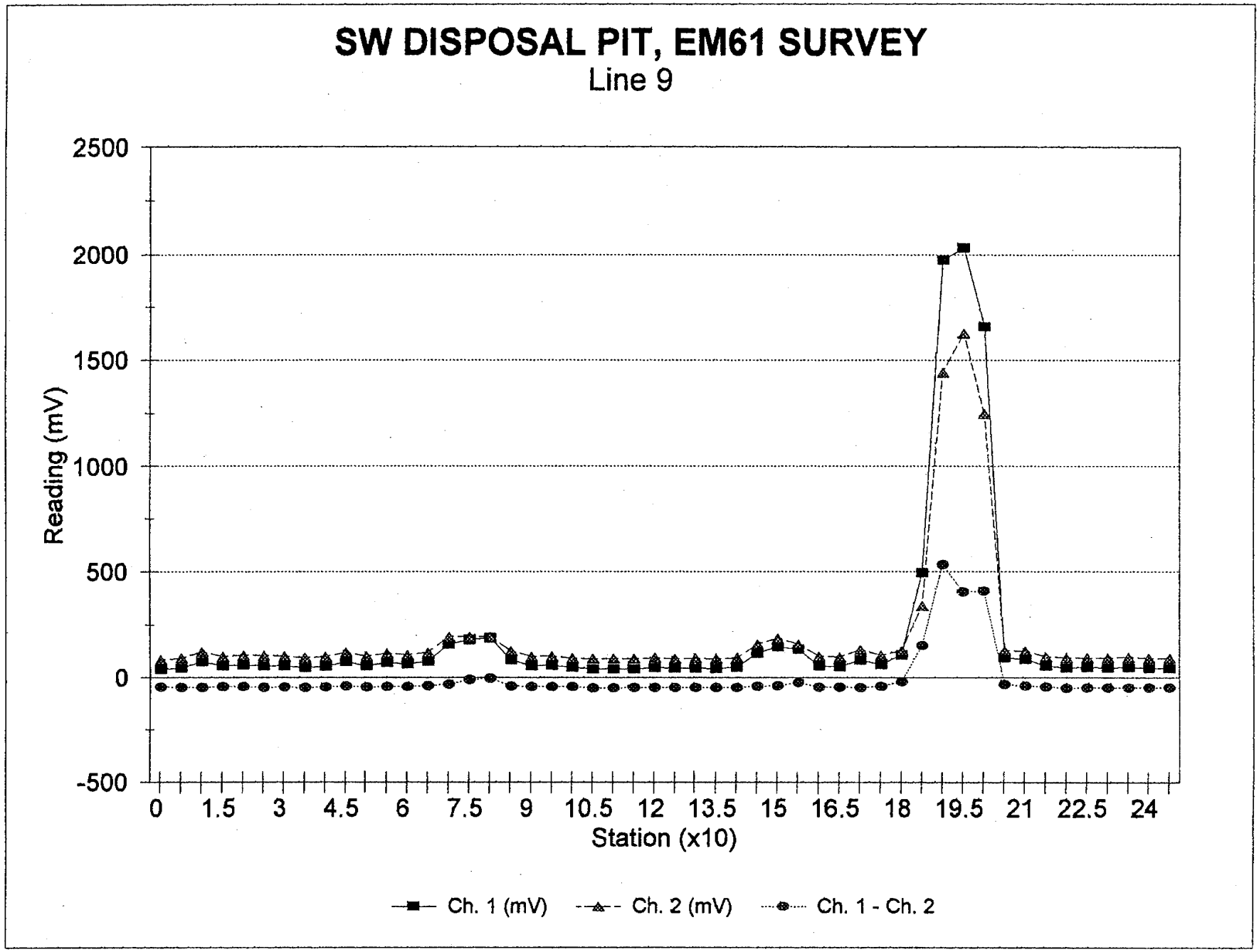

SW DISPOSAL PIT, EM61 SURVEY
Line 6
2500
2000
1500
1000
500
0
-500
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

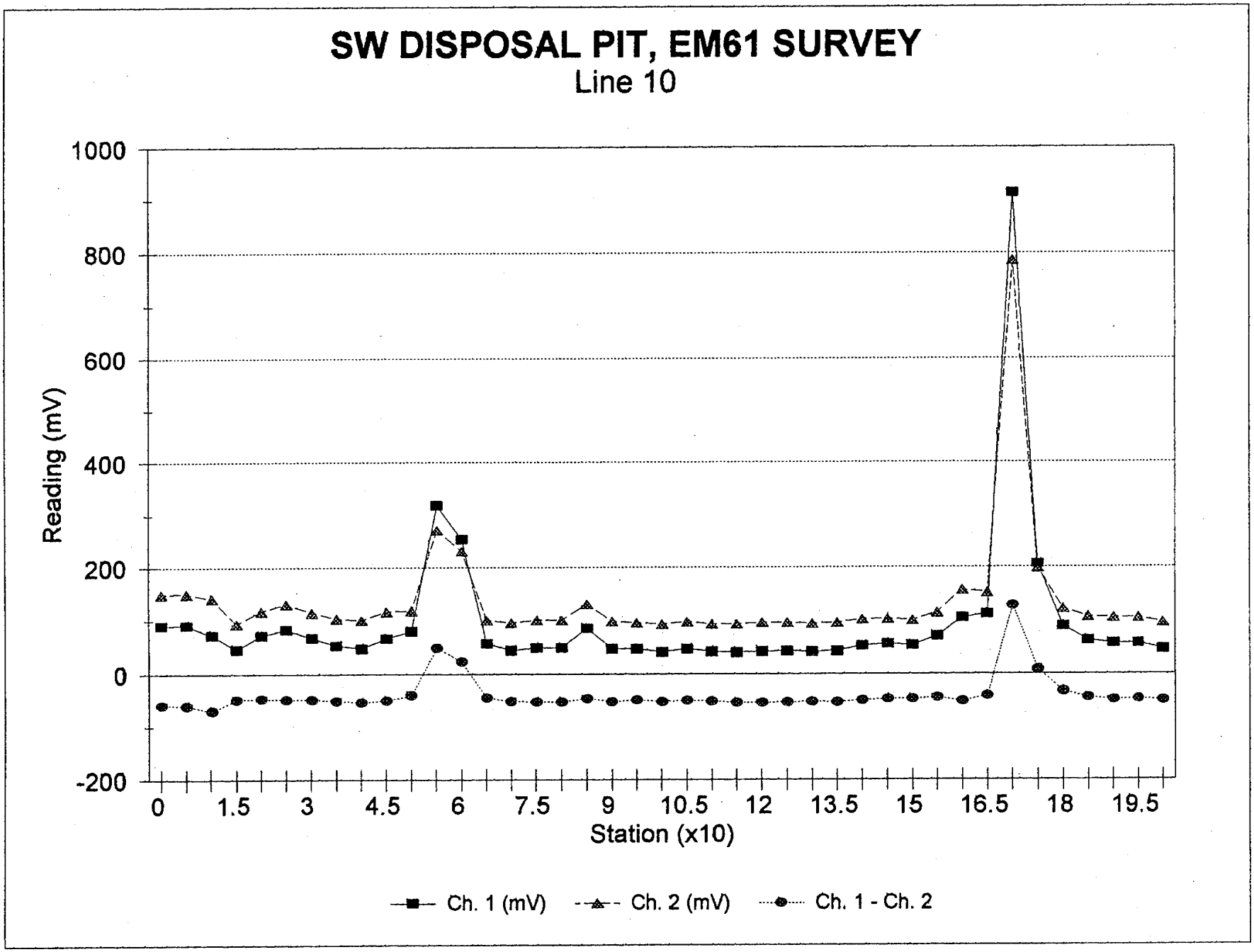
SW DISPOSAL PIT, EM61 SURVEY

Line 7



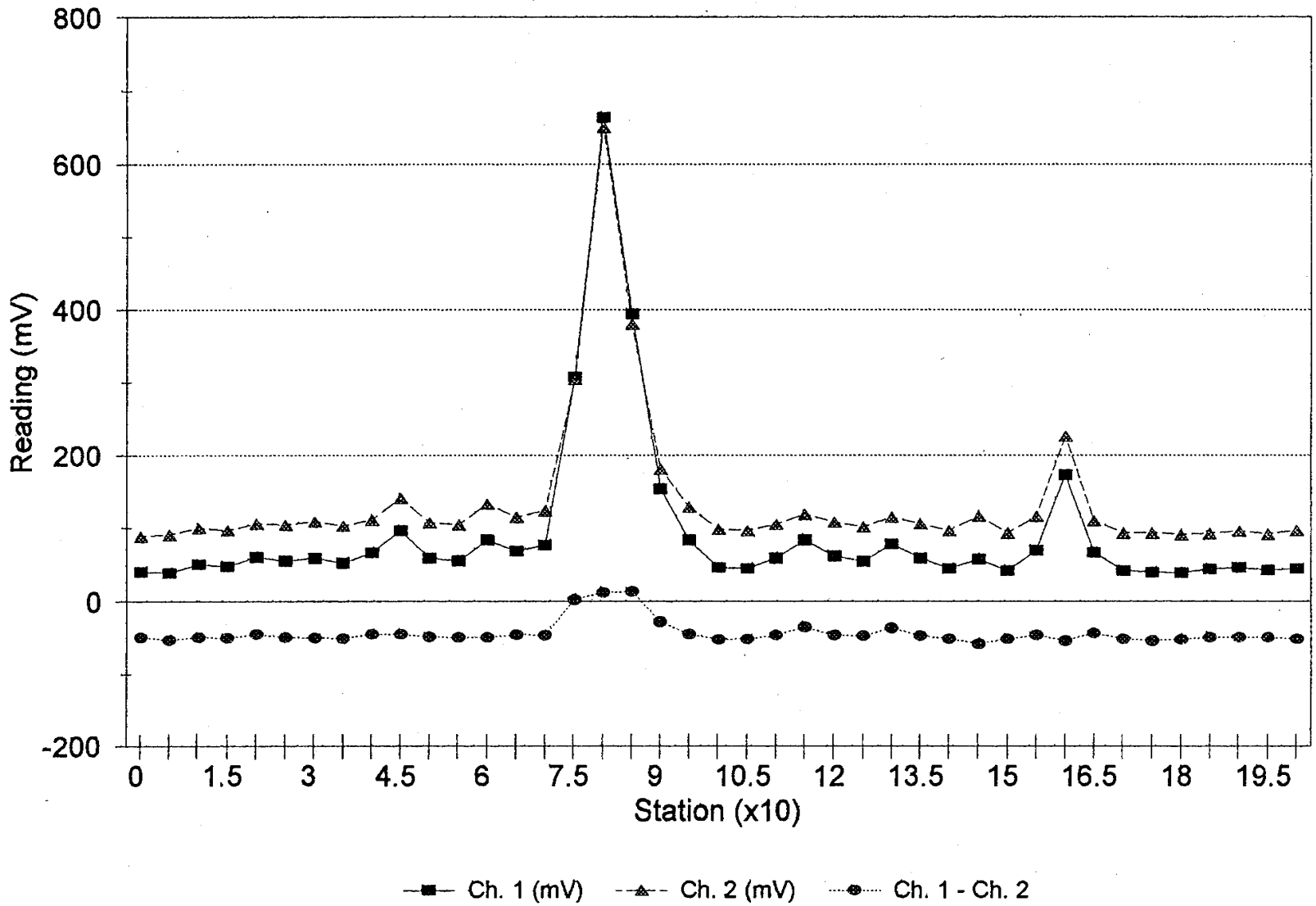

SW DISPOSAL PIT, EM61 SURVEY
Line 8
Reading (mV)
600
500
400
300
200
100
0
-100
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

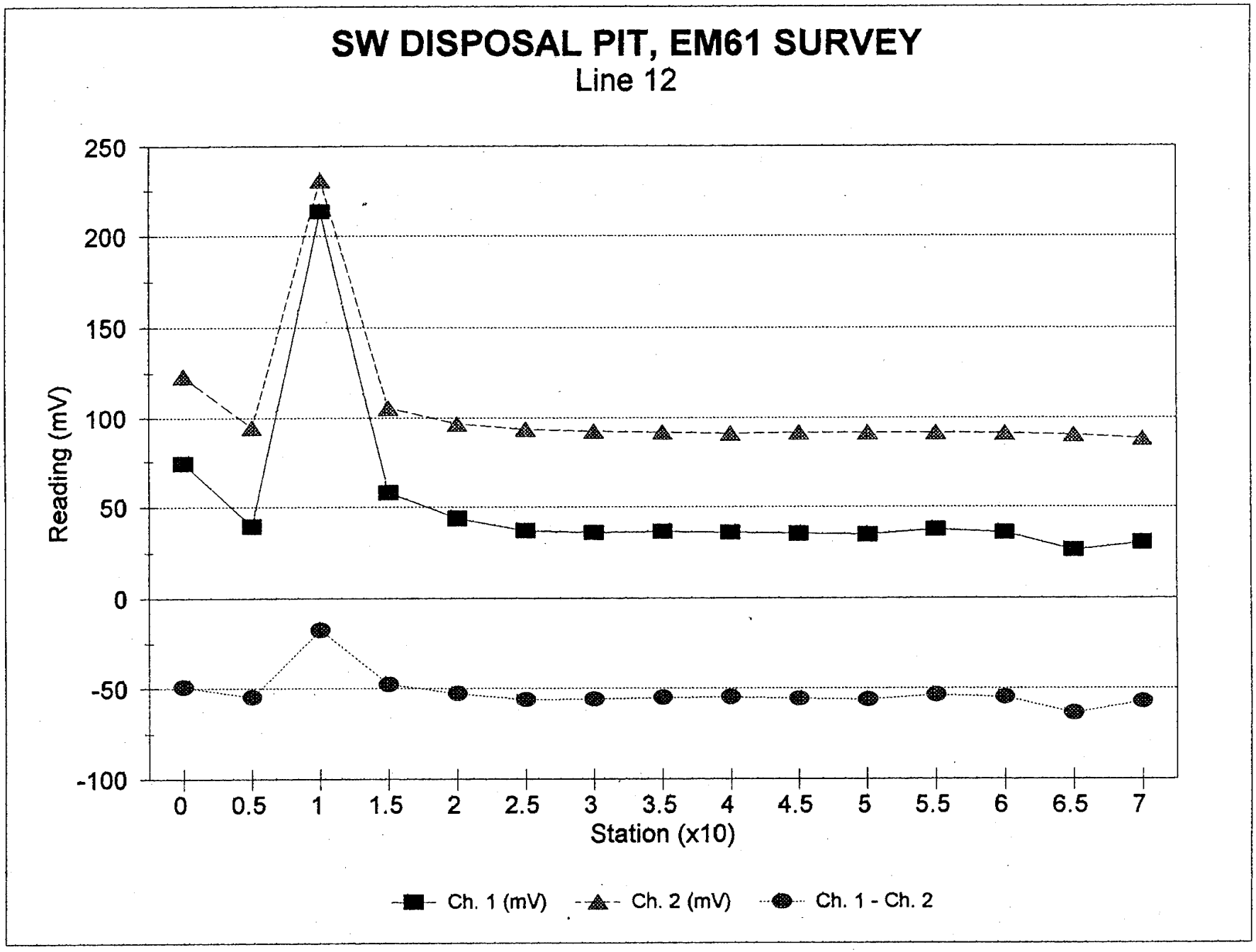

SW DISPOSAL PIT, EM61 SURVEY
Line 9
2500
2000
1500
1000
500
0
-500
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2


SW DISPOSAL PIT, EM61 SURVEY
Line 10
1000
800
600
400
200
0
-200
Reading (mV)
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

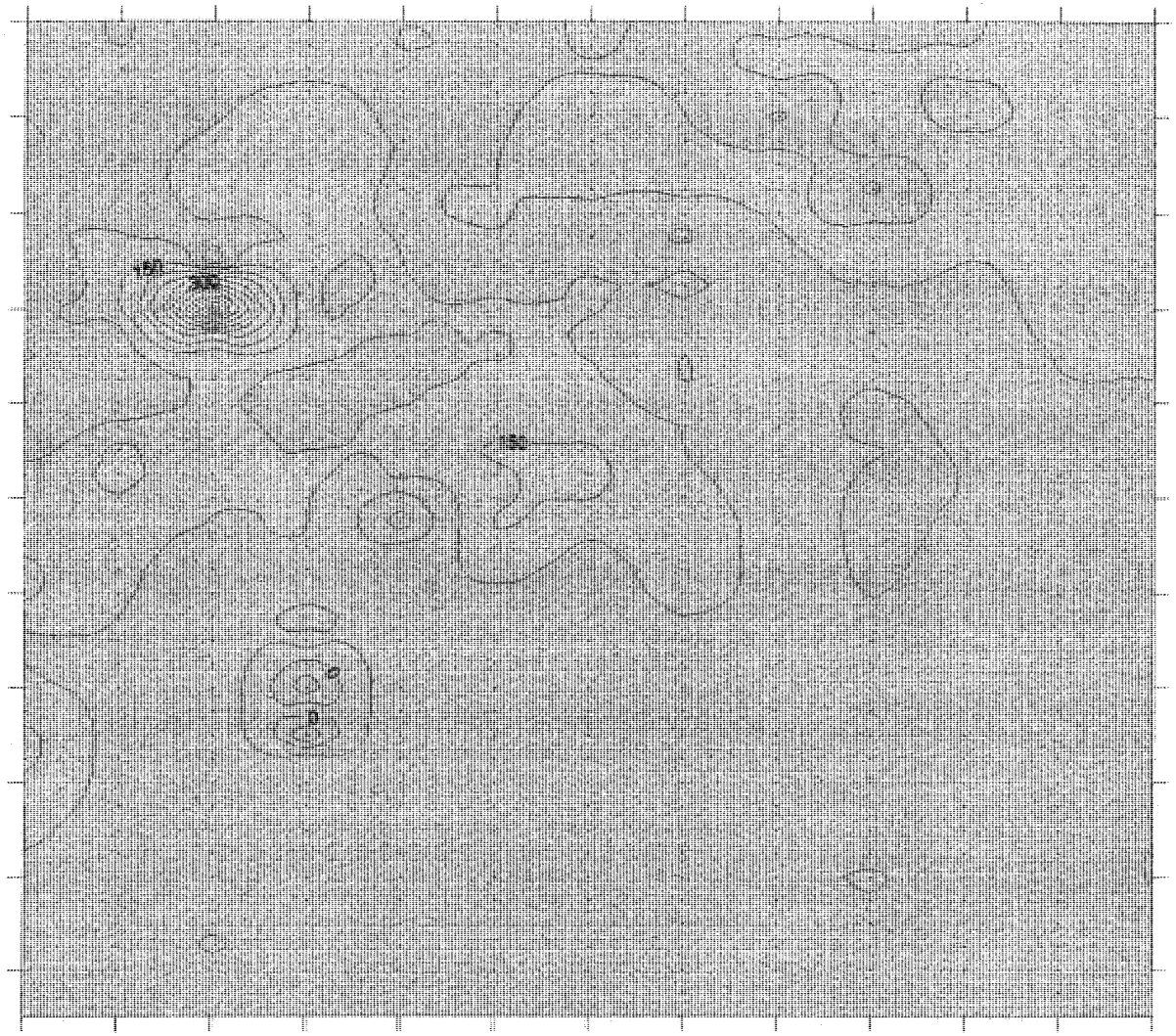
SW DISPOSAL PIT, EM61 SURVEY

Line 11




SW DISPOSAL PIT, EM61 SURVEY
Line 12
Reading (mV)
250
200
150
100
50
0
-50
-100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
Station (x10)
Ch. 1 (mV)
Ch. 2 (mV)
Ch. 1 - Ch. 2

EM-31 Conductivity Data
South East ~~Disposal Area~~ Landfill Pit (Site 54)
Eastern Island
Midway NAF



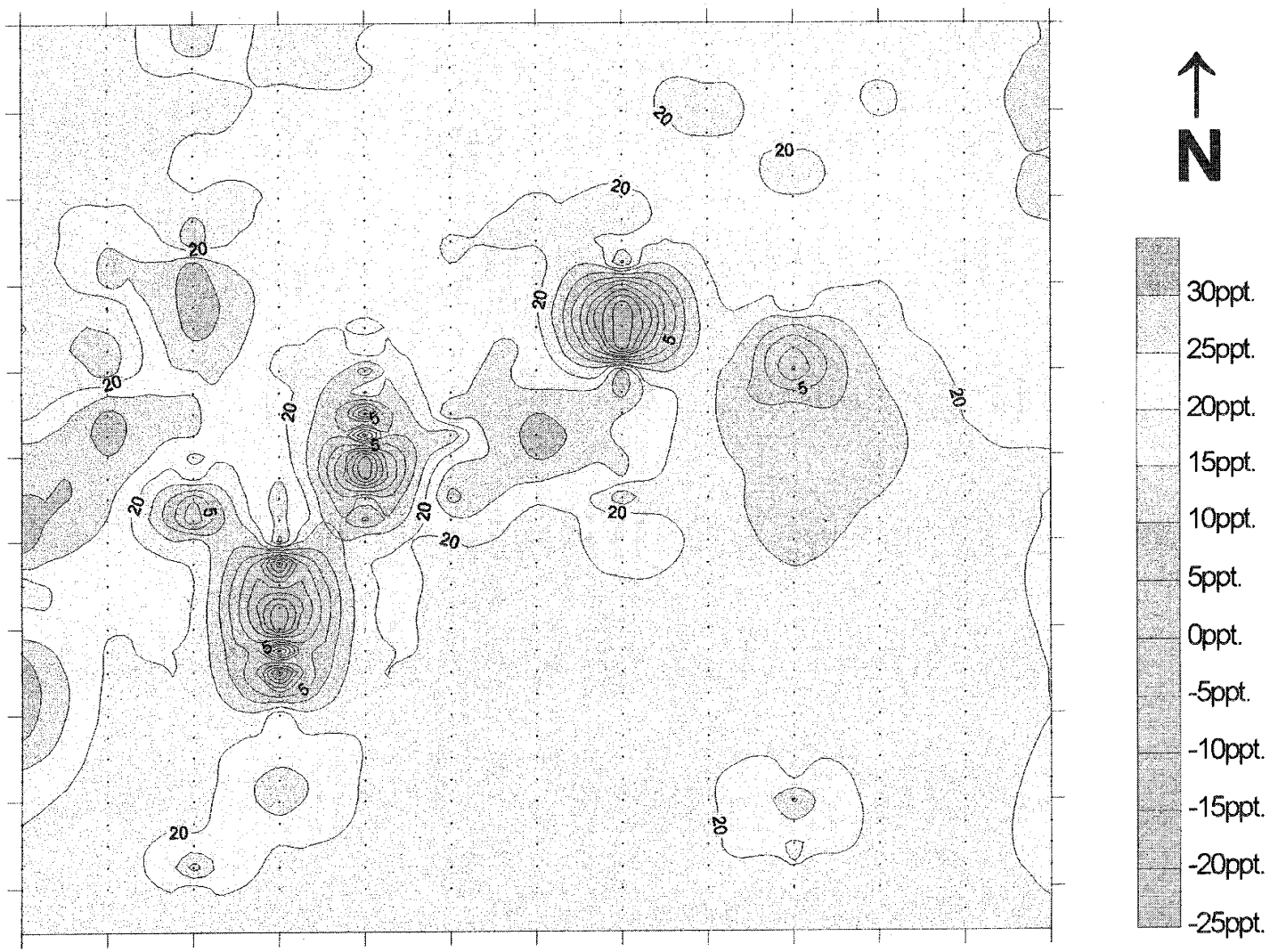
N

700mmhos/m
650mmhos/m
600mmhos/m
550mmhos/m
500mmhos/m
450mmhos/m
400mmhos/m
350mmhos/m
300mmhos/m
250mmhos/m
200mmhos/m
150mmhos/m
100mmhos/m
50mmhos/m
0mmhos/m
-50mmhos/m
-100mmhos/m
-150mmhos/m

Scale: 1 inch = 40 feet

0ft. 40ft. 80ft. 120ft. 160ft.

EM-31 In-Phase Data
South East Disposal Area
Eastern Island
Midway NAF

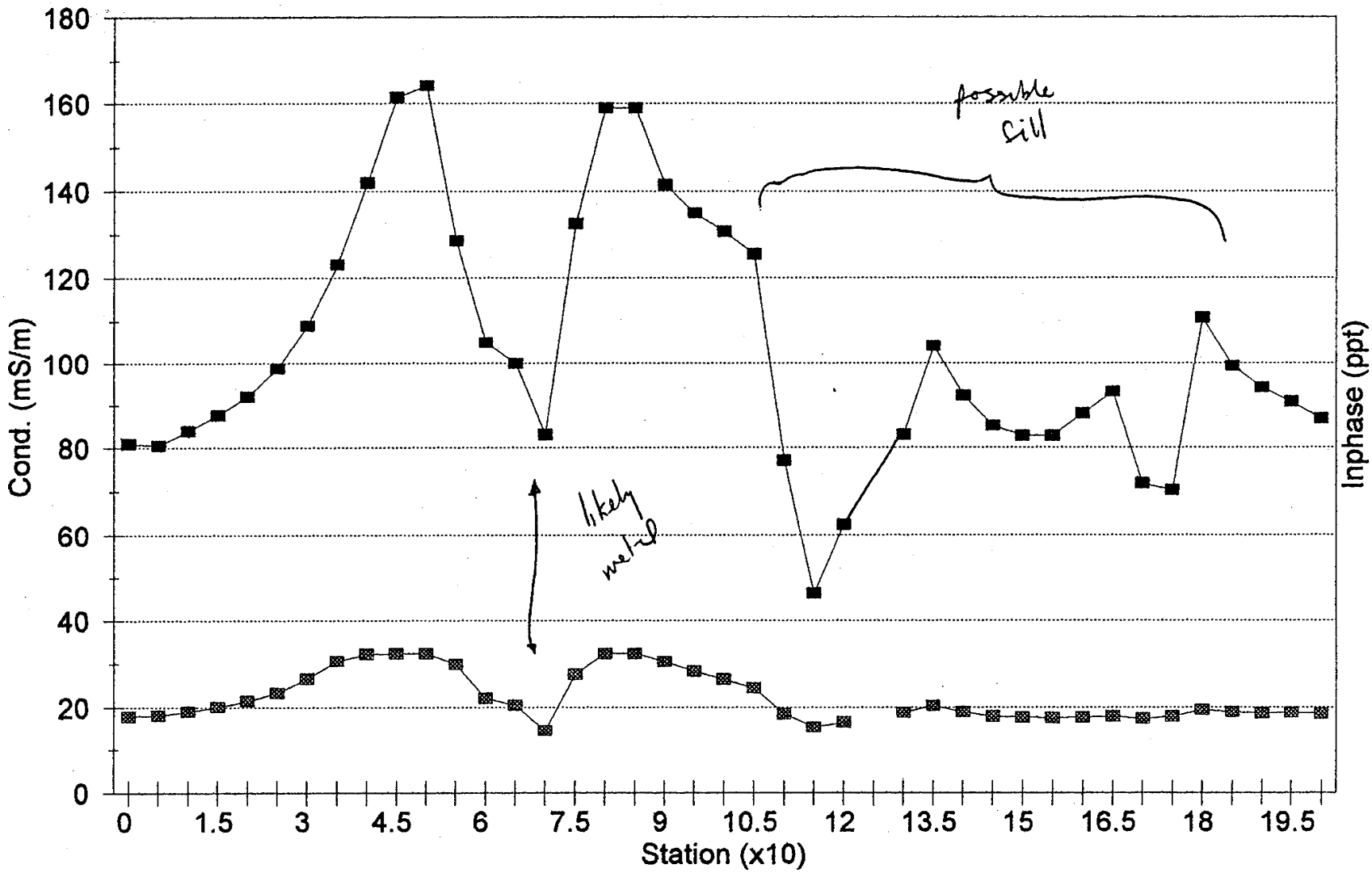


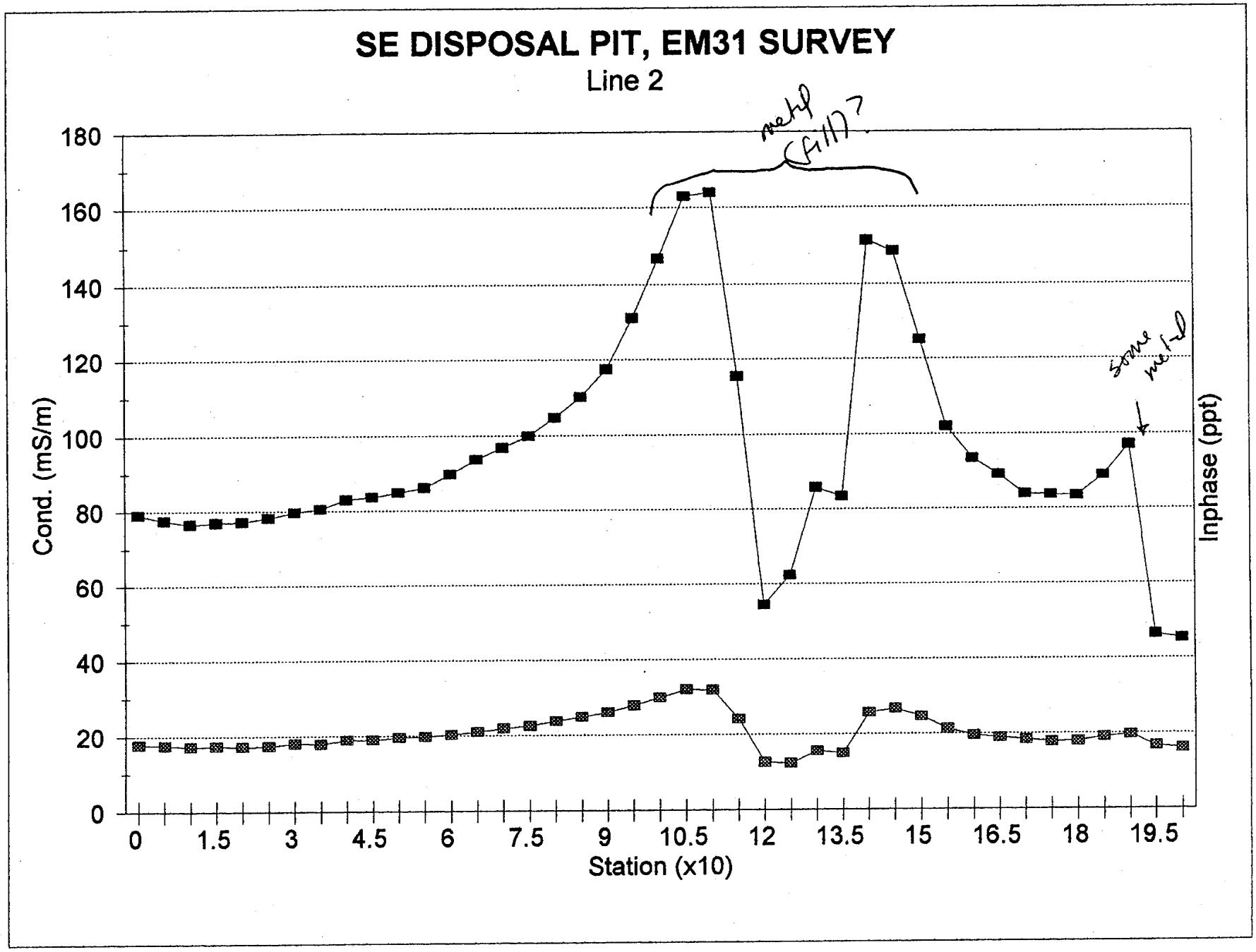
Scale: 1 inch = 40 feet

0ft. 40ft. 80ft. 120ft. 160ft.

SE DISPOSAL PIT, EM31 SURVEY

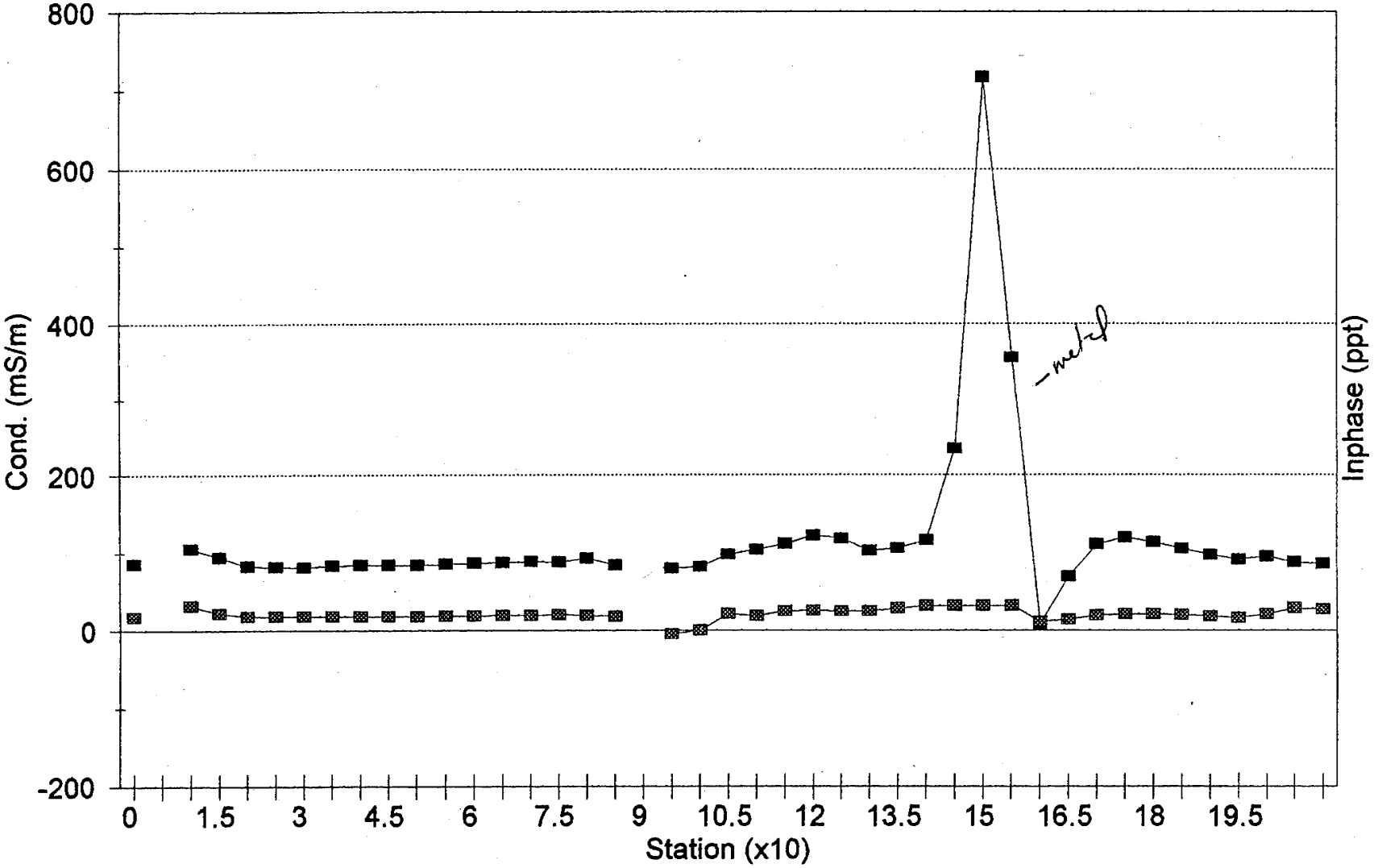
Line 1

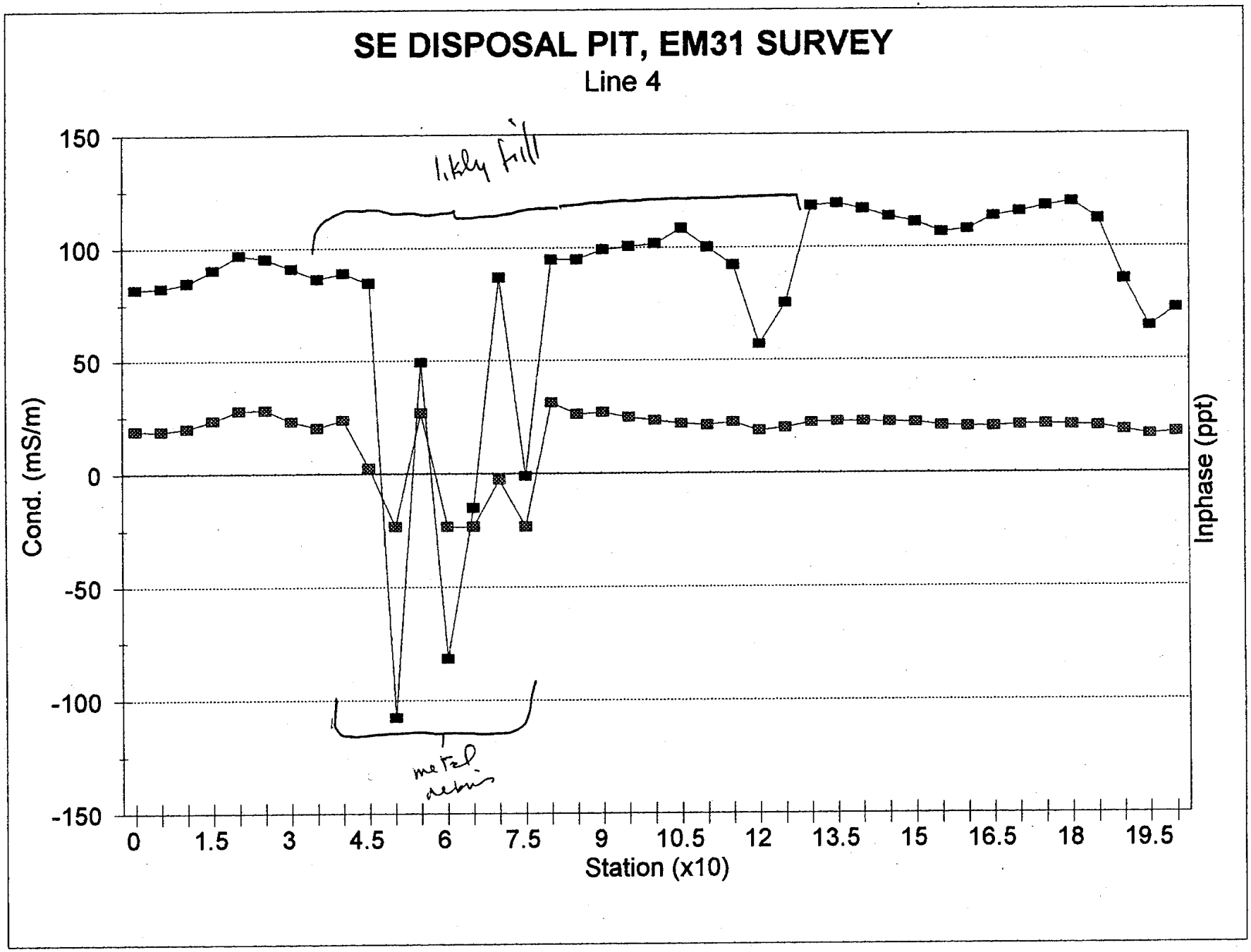


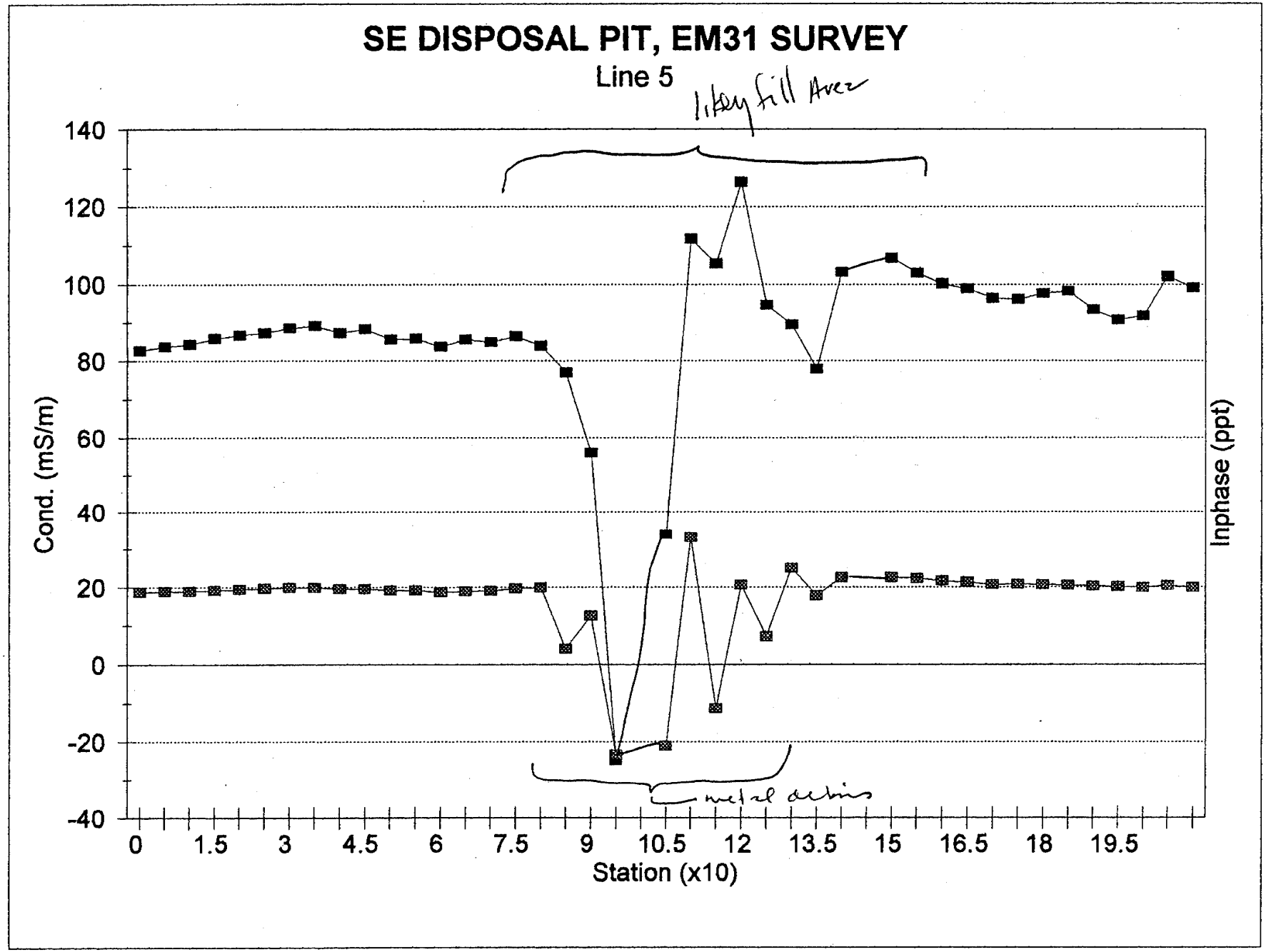

SE DISPOSAL PIT, EM31 SURVEY
Line 2
Cond. (mS/m)
Inphase (ppt)
Station (x10)
180
160
140
120
100
80
60
40
20
0
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
metal (fill?)
some metal

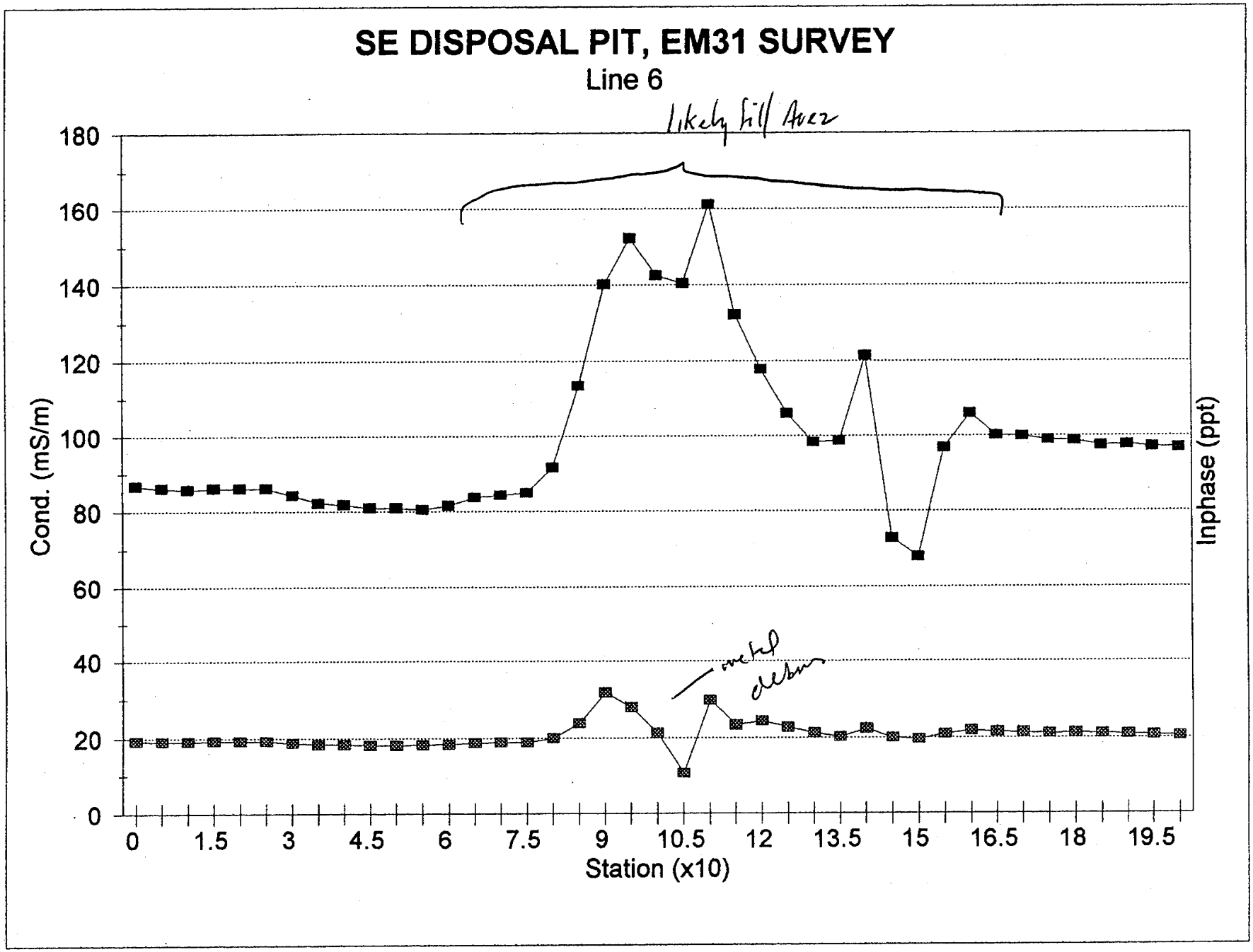
SE DISPOSAL PIT, EM31 SURVEY

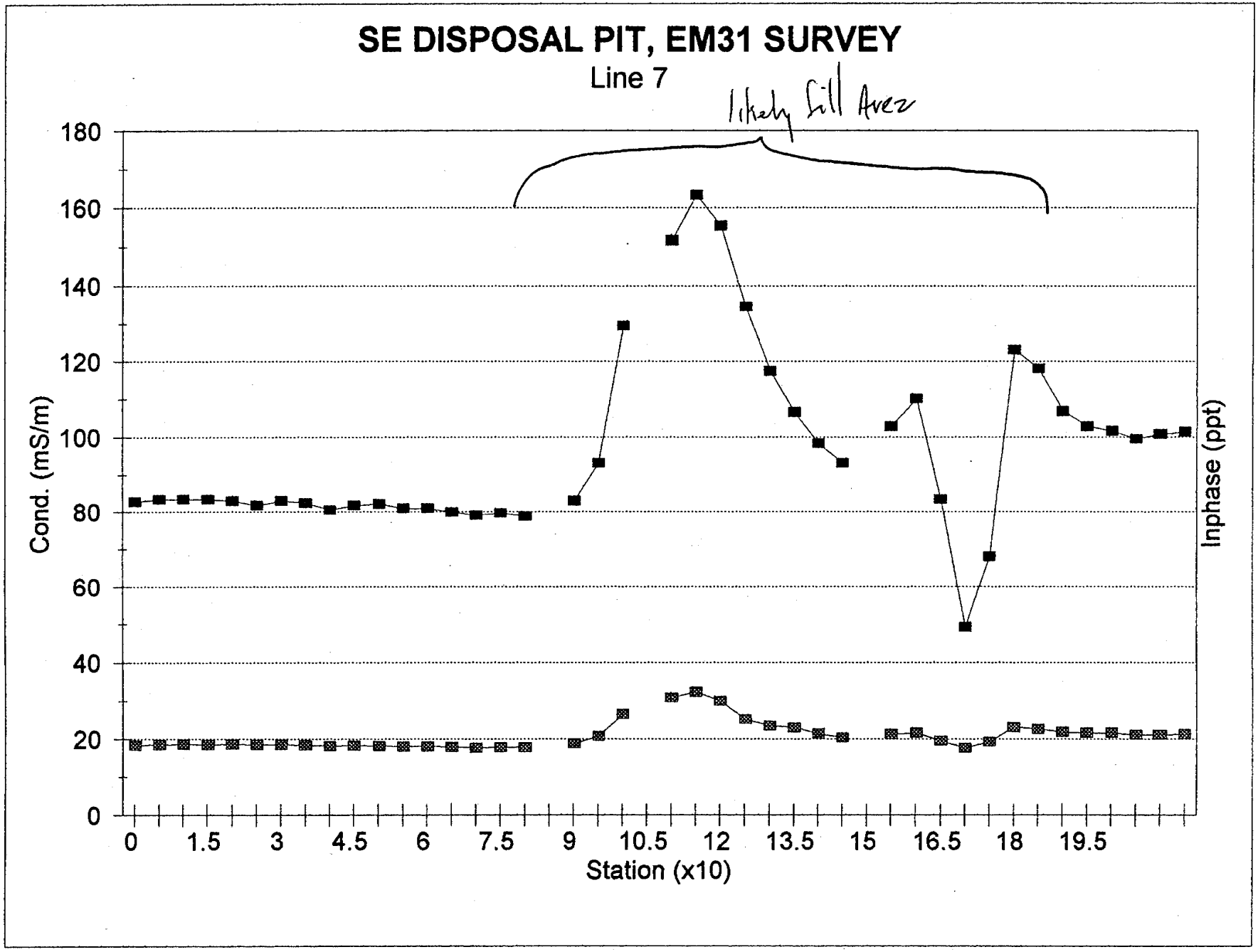
Line 3

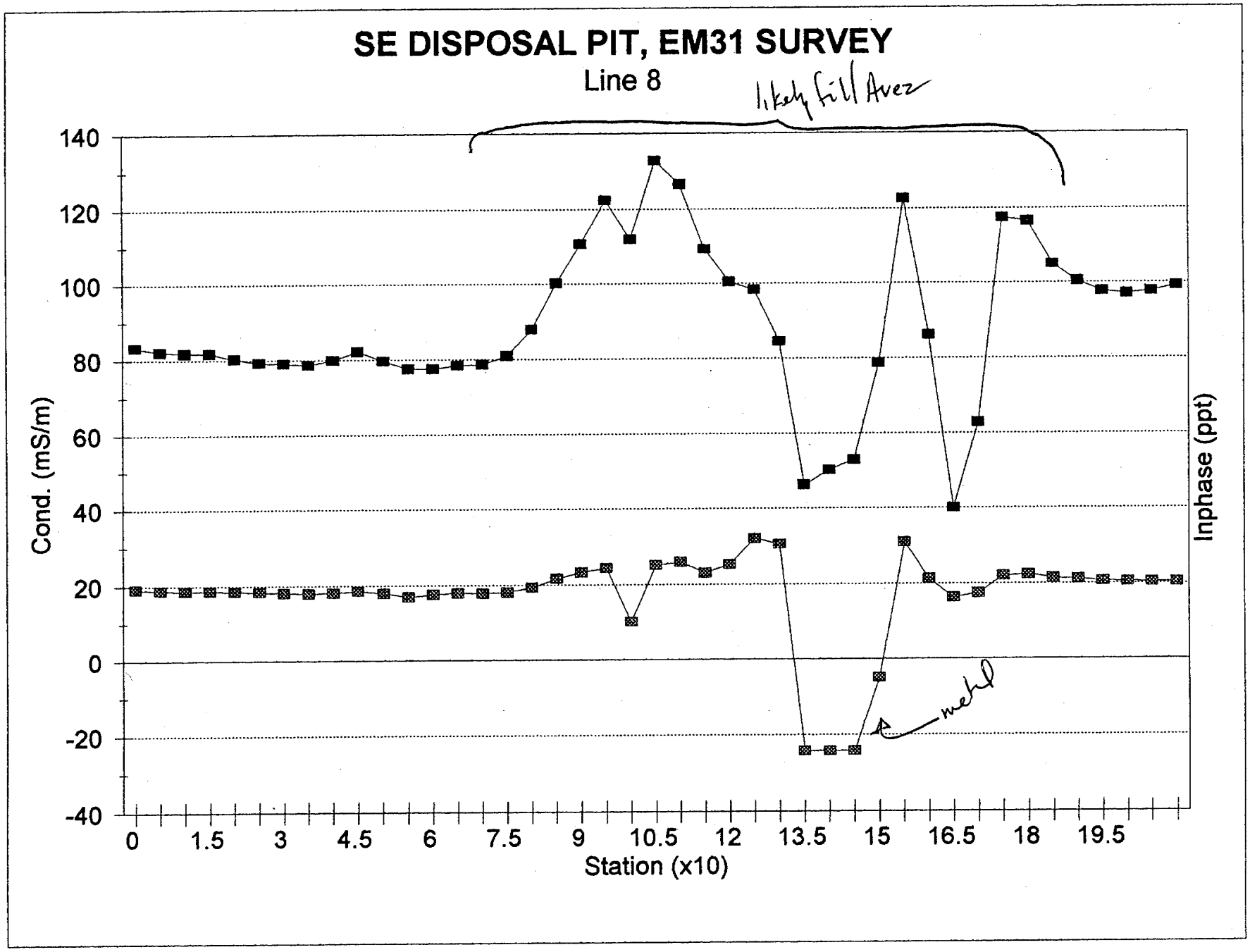



SE DISPOSAL PIT, EM31 SURVEY
Line 4
likely fill
metal debris
Cond. (mS/m)
Inphase (ppt)
Station (x10)
150
100
50
0
-50
-100
-150
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5


SE DISPOSAL PIT, EM31 SURVEY
Line 5
Cond. (mS/m)
Inphase (ppt)
Station (x10)
140
120
100
80
60
40
20
0
-20
-40
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5

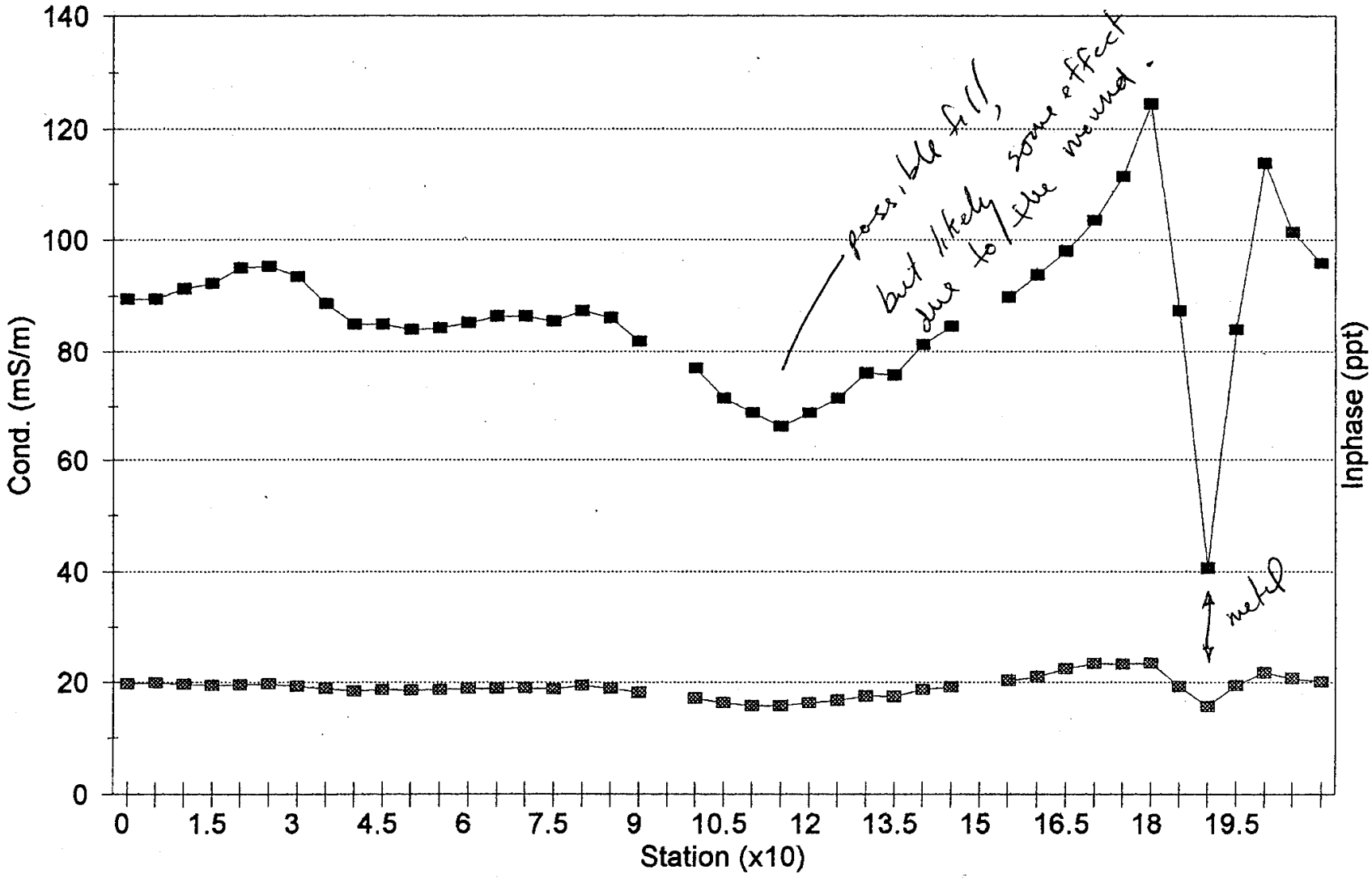

SE DISPOSAL PIT, EM31 SURVEY
Line 6
Likely fill Area
metal debris
Cond. (mS/m)
Inphase (ppt)
Station (x10)
0
20
40
60
80
100
120
140
160
180
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5

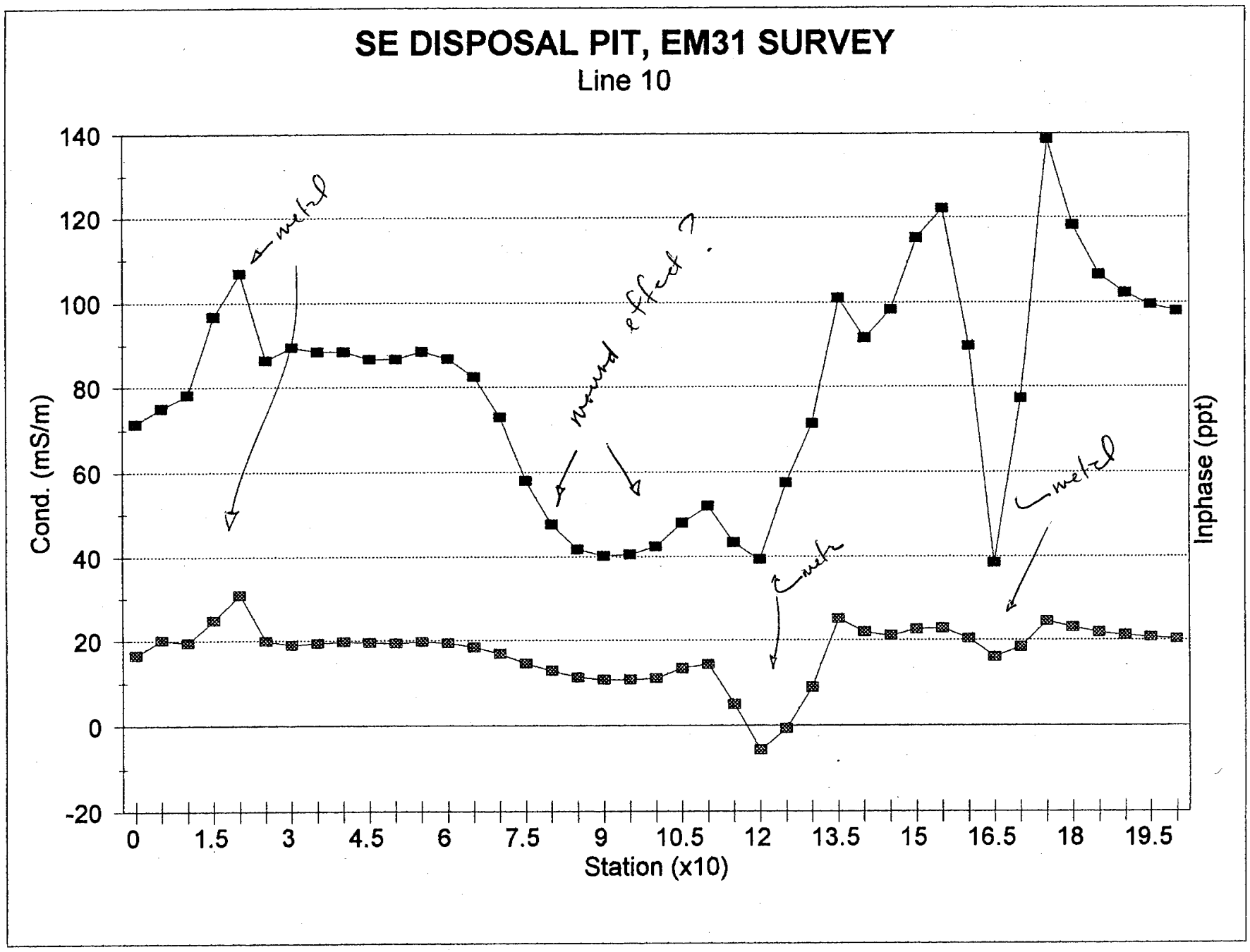

SE DISPOSAL PIT, EM31 SURVEY
Line 7
likely fill Area
Cond. (mS/m)
Inphase (ppt)
Station (x10)
180
160
140
120
100
80
60
40
20
0
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5


SE DISPOSAL PIT, EM31 SURVEY
Line 8
likely fill Area
metal
Cond. (mS/m)
Inphase (ppt)
Station (x10)
140
120
100
80
60
40
20
0
-20
-40
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5

SE DISPOSAL PIT, EM31 SURVEY

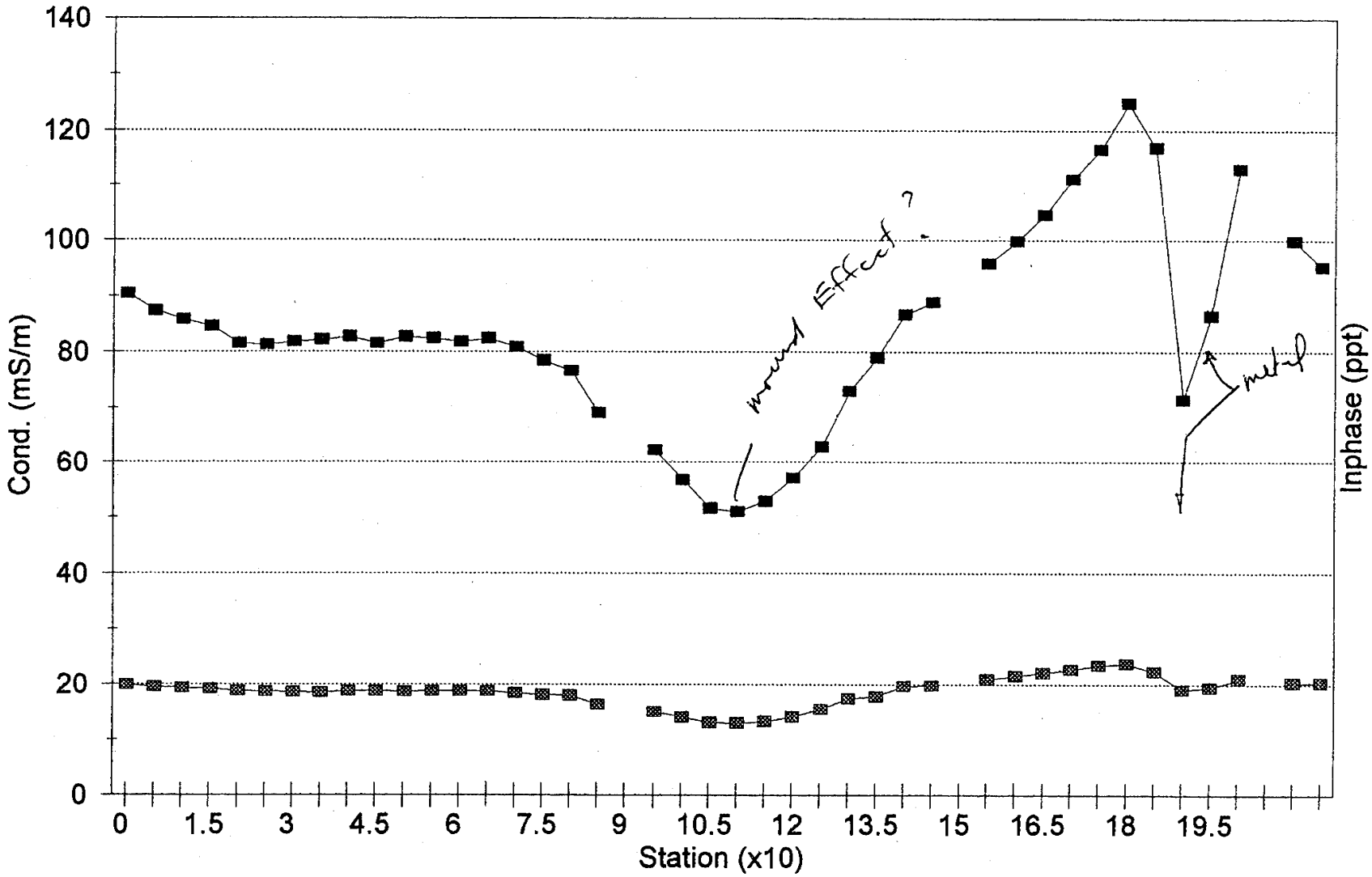
Line 9

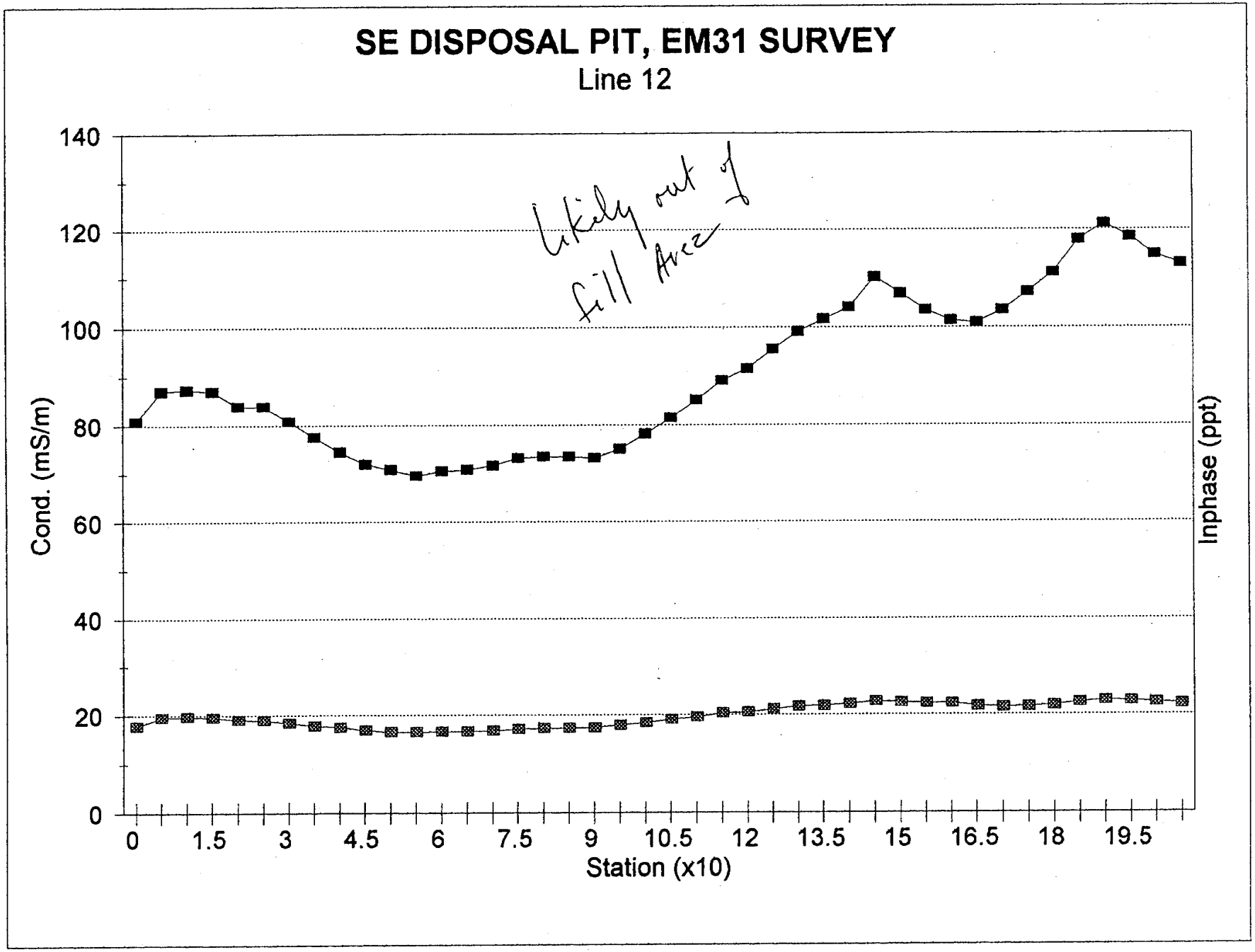



SE DISPOSAL PIT, EM31 SURVEY
Line 10
Cond. (mS/m)
Inphase (ppt)
Station (x10)
140
120
100
80
60
40
20
0
-20
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
metal
mound effect ?
metal
metal

SE DISPOSAL PIT, EM31 SURVEY

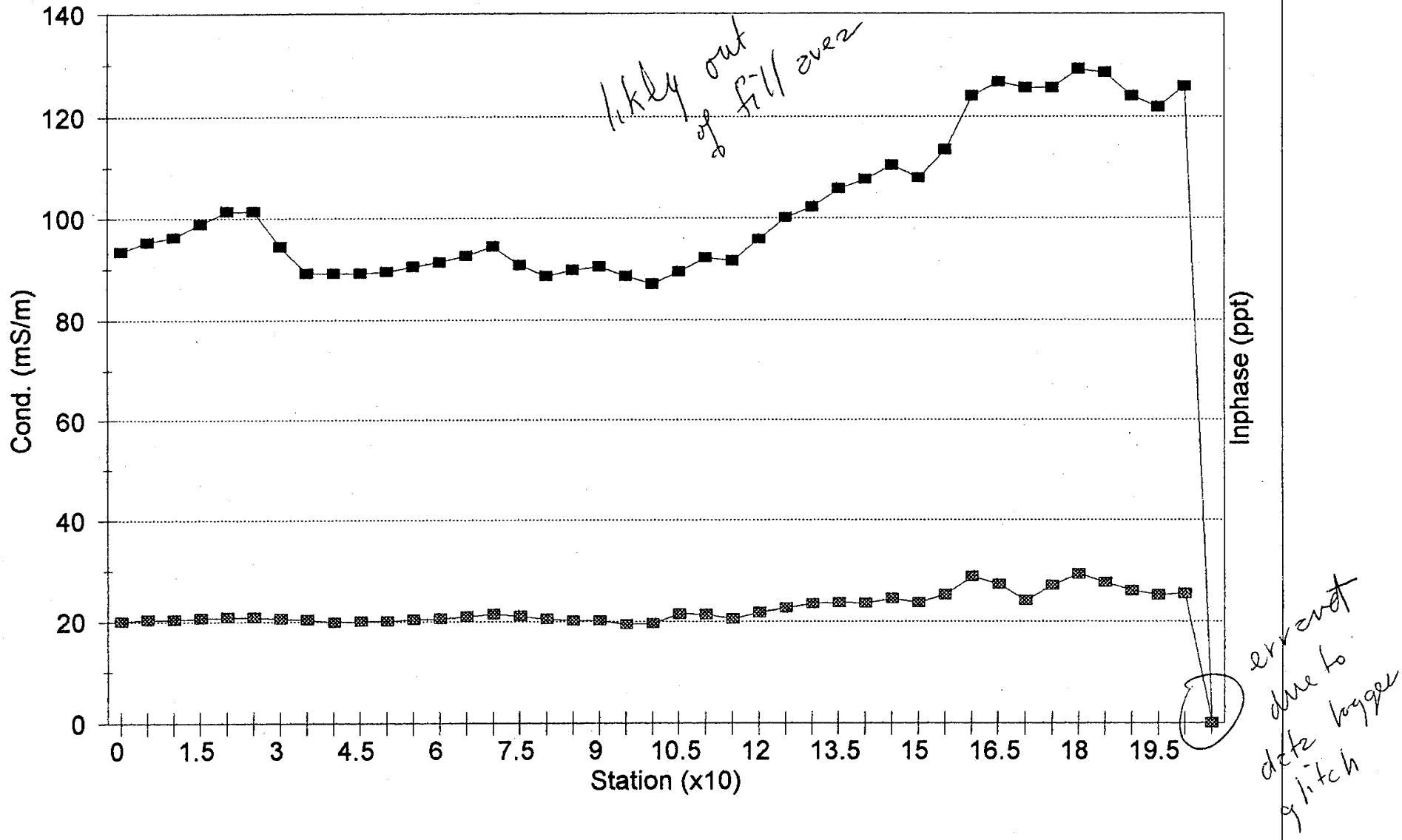
Line 11




SE DISPOSAL PIT, EM31 SURVEY
Line 12
Cond. (mS/m)
Inphase (ppt)
Station (x10)
0
20
40
60
80
100
120
140
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
Likely out of fill Area

SE DISPOSAL PIT, EM31 SURVEY

Line 13



Appendix C

APPENDIX C

SOIL VAPOR RESULTS

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - BACKGROUND SAMPLES

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	BLANK	BLANK	BG1-A	BG1-B	BG2-A	BG2-B	BG3-A	BG3-B	BG4-A	BG4-B	BG5-A
DATE ANALYZED	9/15/94	9/23/94	9/29/94	10/1/94	9/15/94	9/23/94	9/15/94	9/29/94	9/15/94	9/23/94	9/15/94	9/23/94	9/29/94
SAMPLING DEPTH (ft)	-	-	-	-	6	6	4.5	4	3	3	4	2	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	ND	ND	0.17	0.18	0.20	0.12	0.15	0.04	0.34	0.20	0.03
O2 (%)	21.00	19.09	19.59	19.27	19.87	19.36	21.55	1.61	20.86	20.31	22.44	19.04	19.18
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.07	0.01	0.00	0.02	0.01	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - BACKGROUND SAMPLES

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BG5-B	BG6-A	BG6-B	BG7-A	BG7-B
DATE ANALYZED	9/29/94	10/1/94	10/1/94	10/1/94	10/1/94
SAMPLING DEPTH (ft)	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND
CO2 (%)	0.04	0.13	0.15	0.17	0.18
O2 (%)	19.23	18.94	19.39	19.51	19.75
CO2/O2 RATIO	0.00	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #1

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV12-4	SV13-4	SV14-4	SV15-4	SV16-4	SV17-4	SV18-4	SV18-4 DUP	SV19-4	SV20-4	SV21-4	SV22-4	SV23-4	SV24-4
DATE ANALYZED	9/15/94	9/15/94	9/16/94	9/15/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/16/94	9/16/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	NO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.169	0.135	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.274	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.77	0.47	0.25	0.42	1.10	0.26	0.64	0.66	0.08	0.56	1.41	0.27	0.64	0.28
O2 (%)	16.48	17.03	19.62	18.23	16.86	19.79	17.47	18.07	20.72	17.88	14.84	20.16	16.61	19.67
CO2/O2 RATIO	0.05	0.03	0.01	0.02	0.07	0.01	0.04	0.04	0.00	0.03	0.10	0.01	0.04	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #1

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	BLANK	SV1-4	SV2-4	SV3-4	SV4-4	SV5-4	SV6-4	SV7-4	SV8-4	SV9-4	SV10-4	SV11-4
DATE ANALYZED	9/15/94	9/16/94	9/17/94	9/15/94	9/15/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94
SAMPLING DEPTH (ft)	-	-	-	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.6
CO2 (%)	ND	ND	ND	0.13	0.38	0.37	0.09	ND	0.22	0.23	0.85	0.56	0.66	ND
O2 (%)	21.00	21.42	20.88	20.52	18.40	18.54	20.36	21.79	19.89	21.26	16.95	19.54	18.11	20.69
CO2/O2 RATIO	0.00	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.01	0.01	0.05	0.03	0.04	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #1

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV25-4	SV26-4	SV27-4	SV28-3	SV29-4	SV30-4	SV31-4	SV31-4 DUP	SV32-3	SV33-4	SV34-3	SV34-3 DUP	SV35-3	SV36-4
DATE ANALYZED	9/16/94	9/16/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/17/94	9/16/94	9/16/94	9/16/94	9/16/94
SAMPLING DEPTH (ft)	4	4	4	3	4	4	4	4	3	4	3	3	3	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NO	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	0.115	ND	ND	ND	ND	ND	ND	0.238	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	4.9	ND	ND	382.0	ND	ND	ND	ND	15.0	3500.0	ND	ND	ND	ND
METHANE	ND	ND	ND	517.0	ND	ND	ND	ND	22.3	3600.0	ND	ND	ND	ND
CO2 (%)	0.65	0.50	1.43	0.33	1.49	0.88	0.67	0.73	1.00	1.62	0.77	0.73	ND	0.37
O2 (%)	16.25	15.16	14.07	19.04	14.01	16.70	17.43	17.57	15.45	7.62	16.27	16.40	21.44	18.65
CO2/O2 RATIO	0.04	0.03	0.10	0.02	0.11	0.05	0.04	0.04	0.06	0.21	0.05	0.04	0.00	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #1

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV37-3	SV38-4	SV38-4 DUP	SV39-4	SV40-4	SV40-4 DUP	SV41-4	SV42-4	SV43-4	SV44-4	SV45-4	SV46-4	SV47-4
DATE ANALYZED	9/16/94	9/17/94	9/17/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94
SAMPLING DEPTH (ft)	3	4	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLDROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	17.5	2210.0	2280.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	2310.0	2500.0	ND	ND	ND	ND	ND	ND	ND	ND	66.4	ND
CO2 (%)	1.06	1.48	1.48	0.48	0.71	0.61	3.16	1.31	0.96	0.50	1.14	ND	0.89
O2 (%)	15.10	1.50	1.48	18.71	17.11	16.35	6.26	14.37	18.20	18.38	14.56	20.99	16.69
CO2/O2 RATIO	0.07	0.99	1.00	0.03	0.04	0.04	0.50	0.09	0.05	0.03	0.08	0.00	0.05

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #1

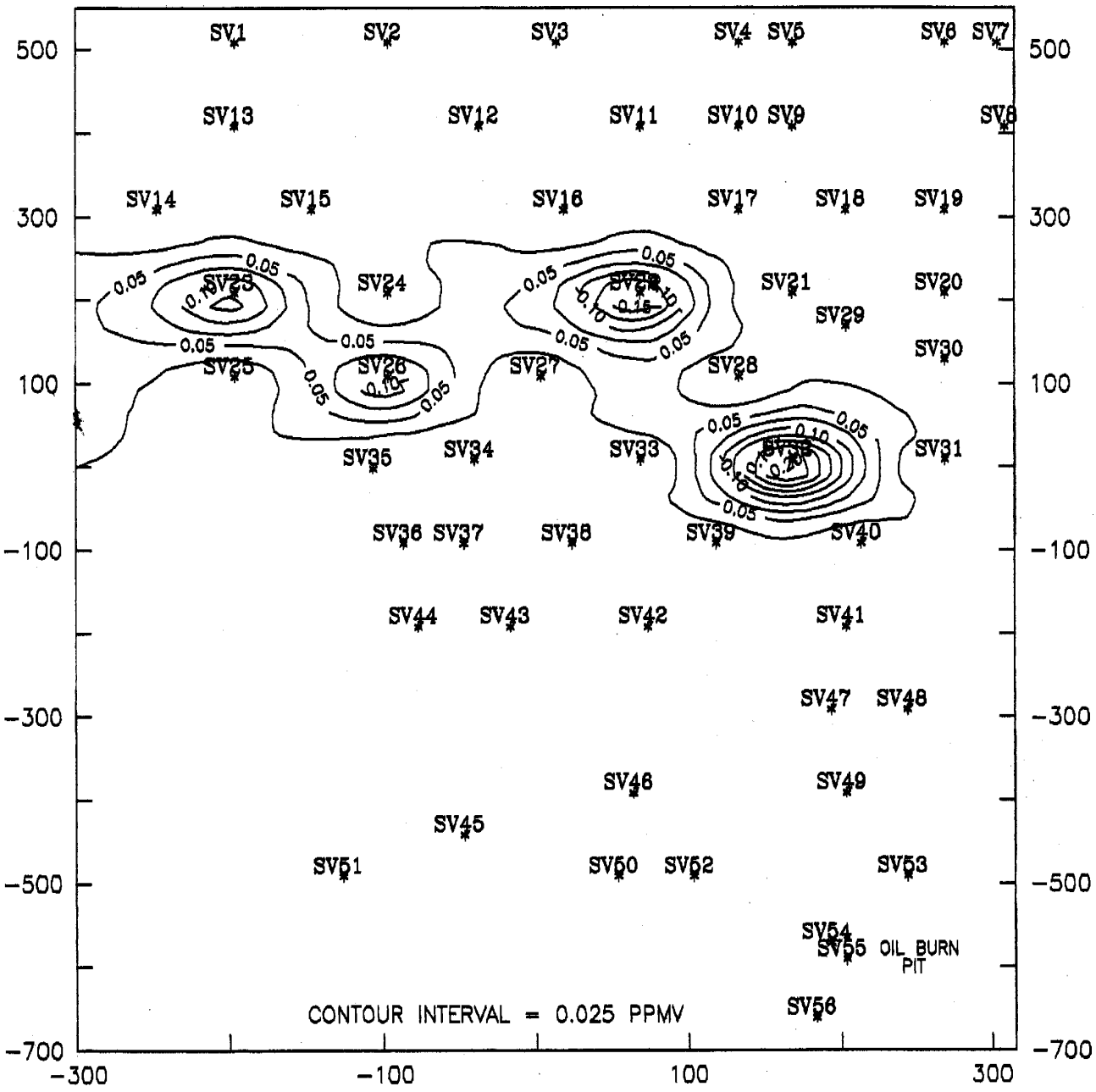
TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV48-4	SV49-4	SV50-4	SV51-4	SV52-4	SV53-4	SV54-2	SV55-2	SV56-2
DATE ANALYZED	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/16/94	9/17/94	9/17/94	9/17/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4	2	2	2
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLORDETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	2430.0	ND	228.0
METHANE	ND	ND	ND	ND	ND	ND	2540.0	ND	342.0
CO2 (%)	0.35	1.12	0.66	0.41	2.21	0.09	1.25	0.56	1.21
O2 (%)	18.18	14.72	20.34	18.63	11.52	20.14	5.81	17.11	12.78
CO2/O2 RATIO	0.02	0.08	0.03	0.02	0.19	0.00	0.22	0.03	0.09

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

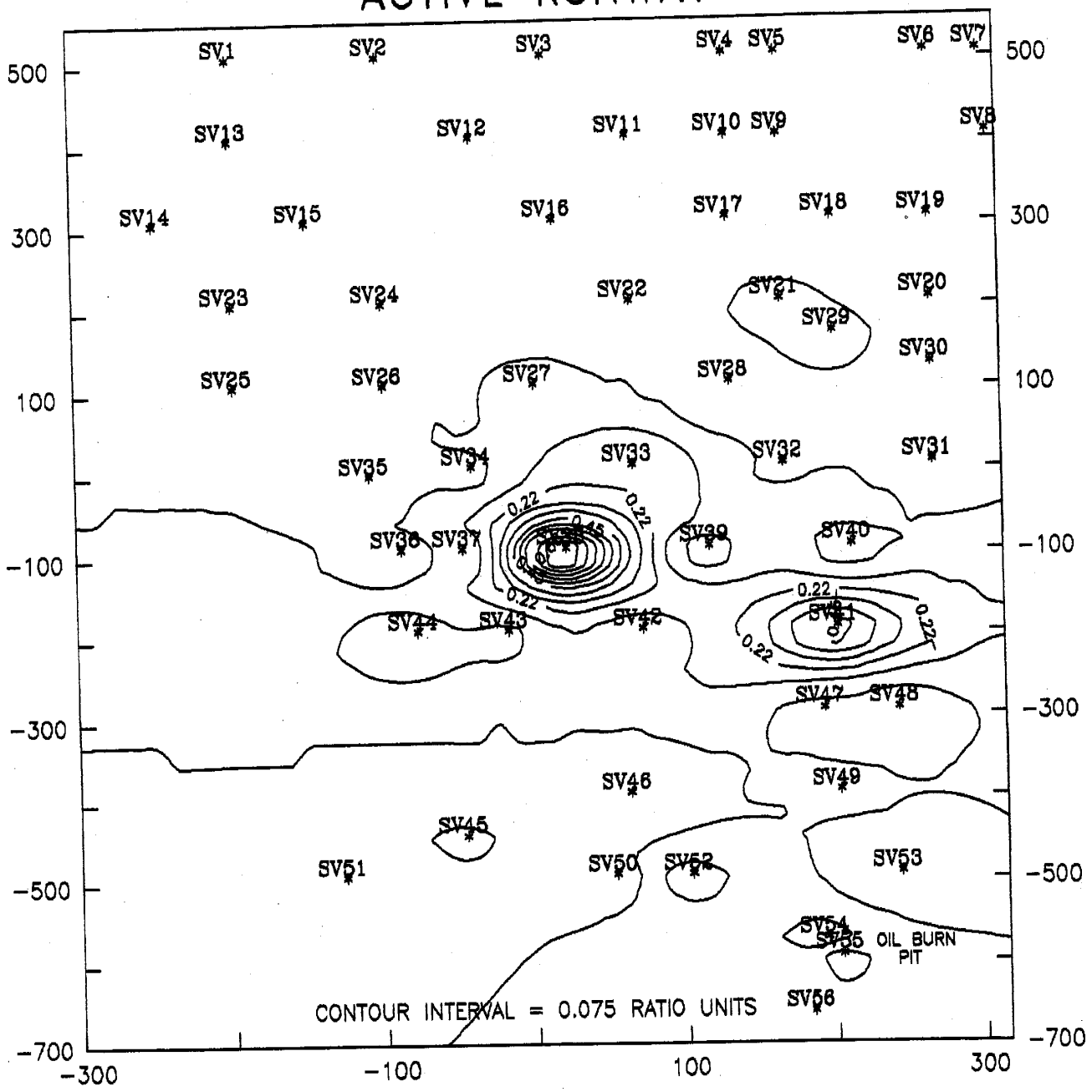
MIDWAY SITE 1 – TCE (PPMV)
ACTIVE RUNWAY



MAP ORIGIN = LANDFILL GATEPOST

TRANSGLOBAL ENVIRONMENTAL GEOCHEMISTRY

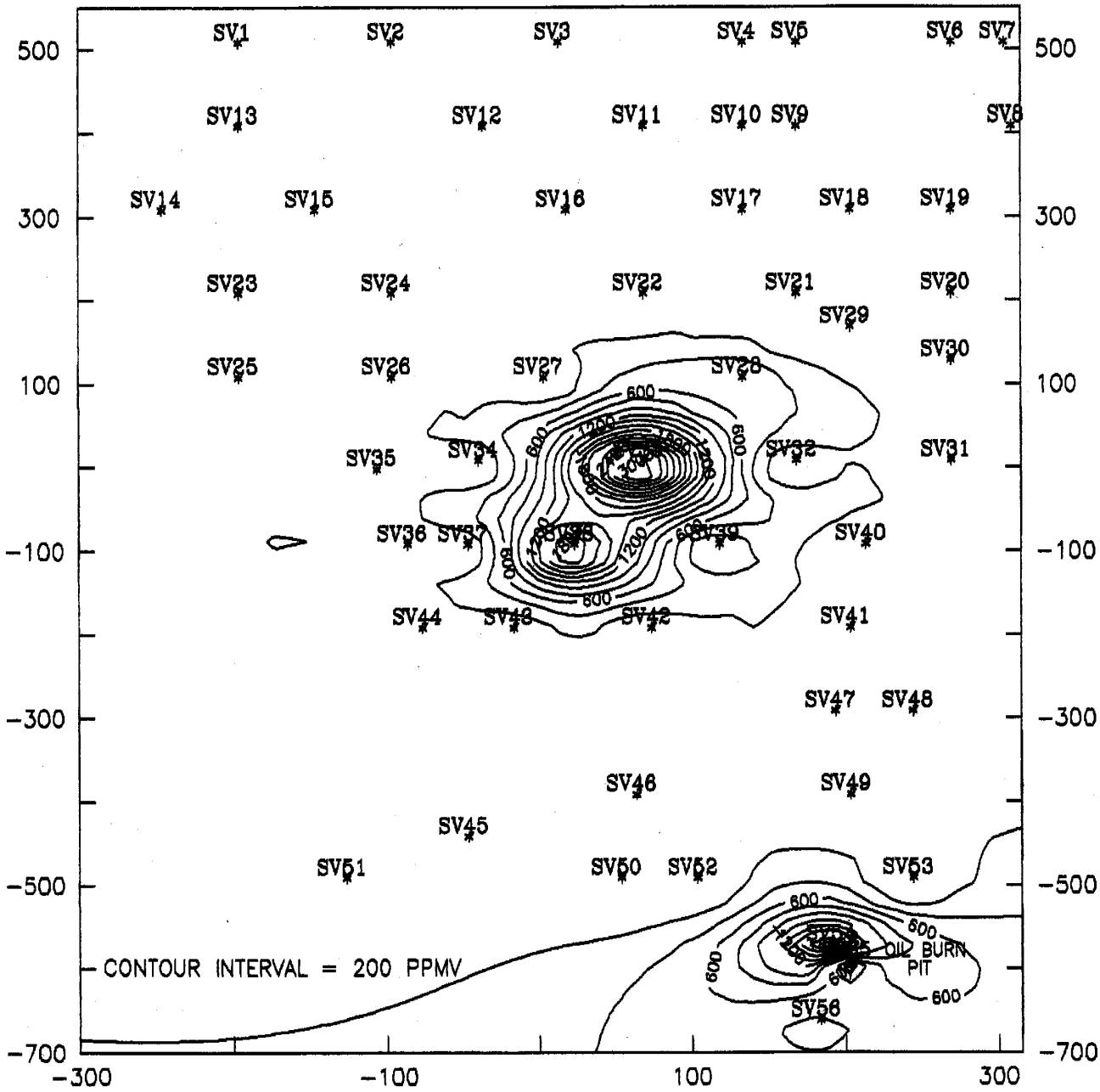
MIDWAY SITE 1 - CO2/O2 RATIO
ACTIVE RUNWAY



MAP ORIGIN = LANDFILL GATEPOST

TRANSGLOBAL ENVIRONMENTAL GEOCHEMISTRY

MIDWAY SITE 1 – METHANE (PPMV)
ACTIVE RUNWAY



MAP ORIGIN = LANDFILL GATEPOST

TRANSGLOBAL ENVIRONMENTAL GEOCHEMISTRY

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	BLANK	BLANK	BLANK	SV1-5	SV2-4	SV3-3	SV4-4	SV5-4	SV6-5	SV7-5	SV8-3	SV9-3
DATE ANALYZED	9/19/94	9/20/94	9/21/94	9/22/94	9/23/94	9/21/94	9/21/94	9/21/94	9/21/94	9/21/94	9/21/94	9/21/94	9/21/94	9/21/94
SAMPLING DEPTH (ft)	-	-	-	-	-	5	4	3	4	4	5	5	3	3
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.00	0.00	0.00	0.00	0.00	0.24	0.19	0.62	0.15	0.09	0.52	0.46	0.03	0.25
O2 (%)	21.08	19.33	20.41	19.96	19.09	19.36	19.92	17.96	20.13	20.61	18.19	18.08	20.60	19.82
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.01	0.00	0.03	0.03	0.00	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV9-3 DUP	SV10-3	SV11-5	SV12-2	SV13-3	SV14-6	SV14-6 DUP	SV15-4	SV16-4	SV16-4 dup	SV17-6	SV18-4	SV19-2
DATE ANALYZED	9/21/94	9/21/94	9/21/94	9/19/94	9/19/94	9/21/94	9/21/94	9/23/94	9/23/94	9/23/94	9/21/94	9/23/94	9/19/94
SAMPLING DEPTH (ft)	3	3	5	2	3	6	6	4	4	4	6	4	2
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.8
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.26	0.14	0.84	0.00	0.13	0.20	0.23	0.27	0.12	0.12	0.21	0.15	0.23
O2 (%)	19.78	19.90	18.29	21.41	21.12	20.07	19.23	19.16	19.41	19.59	19.39	19.75	20.48
CO2/O2 RATIO	0.01	0.01	0.05	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV20-2	SV21-3	SV22-6	SV23-6	SV24-3	SV25-3	SV25-3 DUP	SV26-2	SV27-2	SV28-2	SV29-4	SV30-5	SV31-2	SV32-4
DATE ANALYZED	9/19/94	9/19/94	9/21/94	9/21/94	9/19/94	9/19/94	9/19/94	9/19/94	9/19/94	9/19/94	9/23/94	9/23/94	9/21/94	9/22/94
SAMPLING DEPTH (ft)	2	3	6	6	3	3	3	2	2	2	4	5	2	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLORDETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLDROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLDROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	8.3	ND	ND	ND	ND	ND	ND	4.1	34.3	10.5	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.19	0.21	0.55	0.35	0.11	0.10	0.10	0.13	0.20	0.00	0.23	0.38	0.18	0.58
O2 (%)	20.96	20.48	19.43	19.20	20.93	20.92	21.36	21.10	20.39	21.38	19.18	19.01	18.36	17.71
CO2/O2 RATIO	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.03

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV33-4	SV34-3	SV35-2	SV36-2	SV37-2	SV38-2	SV38-2 DUP	SV39-2	SV40-3	SV40-3 DUP	SV41-3	SV42-2	SV43-4	SV44-4
DATE ANALYZED	9/23/94	9/21/94	9/21/94	9/21/94	9/20/94	9/20/94	9/20/94	9/21/94	9/19/94	9/19/94	9/19/94	9/20/94	9/23/94	9/22/94
SAMPLING DEPTH (ft)	4	3	2	2	2	2	2	2	3	3	3	2	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	1.3	0.0	1.7	ND	ND	ND	ND	928.0	1150.0	60.3	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	62.9	ND	ND	ND
CO2 (%)	0.52	0.94	0.36	0.33	0.19	0.59	0.58	0.44	0.40	0.35	0.25	0.24	0.52	1.11
O2 (%)	17.14	16.20	17.48	18.63	19.74	17.52	18.01	18.68	19.27	19.35	19.96	19.54	17.14	15.16
CO2/O2 RATIO	0.03	0.06	0.02	0.02	0.01	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.03	0.07

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV45-4	SV46-4	SV47-4	SV47-4 DUP	SV48-4	SV49-4	SV50-2	SV51-4	SV52-3	SV53-3	SV54-2	SV55-4	SV56-4	SV58-4
DATE ANALYZED	9/22/94	9/22/94	9/22/94	9/22/94	9/21/94	9/22/94	9/20/94	9/22/94	9/19/94	9/19/94	9/20/94	9/22/94	9/22/94	9/22/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4	2	4	3	3	2	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLORDETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLDROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	233.0	ND	ND	ND	ND	ND	ND	ND	4.9	ND	ND	ND	ND	0.0
METHANE	348.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0
CO2 (%)	3.06	0.55	1.38	1.31	0.50	0.53	0.11	0.39	0.78	0.25	0.50	0.80	0.35	0.32
O2 (%)	4.80	18.40	14.57	15.49	18.32	18.09	19.72	18.44	17.41	20.43	18.46	17.59	19.05	19.07
CO2/O2 RATIO	0.64	0.03	0.09	0.08	0.03	0.03	0.01	0.02	0.04	0.01	0.03	0.05	0.02	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV59-2	SV60-3	SV61-3	SV62-0.3	SV63-2	SV64-2	SV65-3	SV66-3	SV67-3	SV68-2	SV69-2	SV70-2	SV71-1	SV72-2
DATE ANALYZED	9/22/94	9/22/94	9/22/94	9/22/94	9/20/94	9/20/94	9/19/94	9/19/94	9/19/94	9/20/94	9/20/94	*	9/22/94	9/22/94
SAMPLING DEPTH (ft)	2	3	3	0.3	2	2	3	3	3	2	2	*	1	2
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	*	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,1 DICHLDROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND
CO2 (%)	0.22	0.23	0.15	0.00	0.54	0.55	0.33	0.00	0.28	0.32	0.30	*	0.07	0.45
O2 (%)	19.50	19.82	19.15	20.51	18.37	17.47	20.31	20.96	20.01	18.88	19.31	*	20.17	17.03
CO2/O2 RATIO	0.01	0.01	0.01	0.00	0.03	0.03	0.02	0.00	0.01	0.02	0.02	*	0.00	0.03

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

* POINT OMITTED DUE TO SHALLOW GROUNDWATER

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV73-2	SV74-1	SV75-2	SV76-2	SV77-2	SV78-3	SV79-1	SV80-2	SV81-3	SV82-2	SV83-5	SV84-5	SV85-2	SV86-5
DATE ANALYZED	9/22/94	9/22/94	9/20/94	9/20/94	9/20/94	9/19/94	9/19/94	9/20/94	9/20/94	9/20/94	9/22/94	9/22/94	9/22/94	9/22/94
SAMPLING DEPTH (ft)	2	1	2	2	2	3	1	2	3	2	5	5	2	5
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	39.9	17.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	64.4	27.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.22	0.06	0.33	0.25	0.24	0.32	0.07	0.13	0.26	0.13	0.35	0.22	0.51	0.33
O2 (%)	17.33	19.72	19.44	18.97	20.19	19.81	21.07	20.58	19.62	21.54	19.62	19.67	18.71	19.17
CO2/O2 RATIO	0.01	0.00	0.02	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.02	0.01	0.03	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV86-5 DUP	SV87-6	SV88-6	SV89-6	SV90-5	SV91-2	SV92-2	SV93-2	SV94-2	SV95-2	SV96-2	SV97-2	SV97-2 DUP	SV98-2
DATE ANALYZED	9/22/94	9/22/94	9/22/94	9/22/94	9/22/94	9/20/94	9/20/94	9/20/94	9/20/94	9/19/94	9/20/94	9/20/94	9/20/94	9/20/94
SAMPLING DEPTH (ft)	5	6	6	6	5	2	2	2	2	2	2	2	2	2
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.32	0.25	0.15	0.14	0.35	0.11	0.08	0.11	0.08	0.00	0.06	0.09	0.08	0.67
O2 (%)	19.37	19.59	19.93	20.19	19.65	20.12	20.56	20.11	20.23	20.67	20.59	19.74	20.39	17.78
CO2/O2 RATIO	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.04

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #2 RUNWAY LANDFILL

TEG PROJECT #F40910
PRELIMINARY DATA
SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV98-2 DUP	SV99-2	SV100-2	SV101-3
DATE ANALYZED	9/20/94	9/20/94	9/20/94	9/22/94
SAMPLING DEPTH (ft)	2	2	2	3
VOLUME WITHDRAWN (cc)	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND
TPH	ND	ND	ND	ND
METHANE	ND	ND	ND	ND
CO2 (%)	0.60	0.20	0.15	0.33
O2 (%)	15.71	20.17	19.71	19.28
CO2/O2 RATIO	0.04	0.01	0.01	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #401

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV10-4	SV9-4	SV14-4	SV15-4	SV20-4	SV19-4	SV18-4	SV17-4	SV13-4	SV13-4 DUP	SV7-4	SV8-4	SV12-4
DATE ANALYZED	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94
SAMPLING DEPTH (ft)	-	4	4	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	4.4	12.0	5.4	3.5	6.6	4.7	4.7	5.2	4.7	ND	3.0	1.0	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.00	1.51	0.63	1.43	0.62	1.27	1.35	0.63	0.59	0.93	1.70	0.19	0.73	0.04
O2 (%)	20.65	3.12	13.02	5.51	14.32	6.77	7.35	14.79	14.75	10.45	9.34	18.42	15.09	19.62
CO2/O2 RATIO	0.00	0.48	0.05	0.26	0.04	0.19	0.18	0.04	0.04	0.09	0.18	0.01	0.05	0.00

NO MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #401

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-4	SV2-4	SV3-4	SV4-4	SV5-4	SV6-4	SV11-4	SV16-4	SV2-4 DUP
DATE ANALYZED	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94
SAMPLING DEPTH (ft)	-	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLDROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	0.197	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	1.26	1.13	0.56	0.46	0.94	0.09	0.11	1.07	1.20
O2 (%)	21.13	7.33	8.70	14.31	15.61	7.23	18.61	18.71	9.25	8.45
CO2/O2 RATIO	0.00	0.17	0.13	0.04	0.03	0.13	0.00	0.01	0.12	0.14

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #401

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV21-4	SV22-4
DATE ANALYZED	9/13/94	9/13/94
SAMPLING DEPTH (ft)	4	4
VOLUME WITHDRAWN (cc)	60	60
VINYL CHLORIDE	ND	ND
1,1 DICHLOROETHENE	ND	ND
METHYLENE CHLORIDE	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND
1,1 DICHLOROETHANE	ND	ND
CHLOROFORM	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND
CARBON TETRACHLORIDE	ND	ND
1,2 DICHLOROETHANE	ND	ND
TRICHLOROETHENE (TCE)	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND
CHLOROBENZENE	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND
BENZENE	ND	ND
TOLUENE	ND	ND
ETHYLBENZENE	ND	ND
TOTAL XYLENES	ND	ND
TPH	1.0	0.0
METHANE	ND	ND
CO2 (%)	0.90	0.76
O2 (%)	12.98	14.28
CO2/O2 RATIO	0.07	0.05

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR T

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #7

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-6	SV2-6	SV3-6	SV4-6	SV5-6	SV5-6 DUP	SV6-6	SV7-6	SV8-6	SV9-6	SV10-6	SV11-6
DATE ANALYZED	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94	9/15/94
SAMPLING DEPTH (ft)	-	6	6	6	6	6	6	6	6	6	6	6	6
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLORDETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.00	0.17	0.19	0.27	0.47	0.39	0.23	0.30	0.32	0.32	0.51	0.29	0.39
O2 (%)	21.00	19.88	19.94	19.27	18.99	18.92	19.89	19.76	18.49	18.99	19.84	19.08	19.02
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #8

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV9-6	SV10-6	SV11-6	SV12-6	SV13-6	SV13-6 DUP	SV14-6	SV15-6	SV16-6	SV16-6 DUP
DATE ANALYZED	9/13/94	9/12/94	9/12/94	9/12/94	9/12/94	9/12/94	9/12/94	9/12/94	9/13/94	9/13/94
SAMPLING DEPTH (ft)	6	6	6	6	6	6	6	6	6	6
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	2.9	ND	3.7	2.5	1.5	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.30	0.72	0.87	1.60	0.22	0.21	0.16	0.47	0.42	0.42
O2 (%)	18.67	14.20	12.41	6.73	18.31	18.22	20.02	16.78	17.42	17.60
CO2/O2 RATIO	0.02	0.05	0.07	0.24	0.01	0.01	0.01	0.03	0.02	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #8

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	SV1-6	SV2-6	SV3-6	SV4-6	SV5-6	SV6-6	SV7-6	SV8-6
DATE ANALYZED	9/12/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94	9/13/94
SAMPLING DEPTH (ft)	-	-	6	6	6	6	6	6	6	6
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	0.15	0.46	0.47	0.64	0.32	0.49	0.35	0.41
O2 (%)	20.65	19.96	19.39	16.55	16.94	15.64	17.21	16.92	17.90	17.17
CO2/O2 RATIO	0.00	0.00	0.01	0.03	0.03	0.04	0.02	0.03	0.02	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SUPERBL

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	BLANK	SV1-4	SV2-4	SV3-4	SV4-4	SV5-4	SV6-4	SV7-4	SV8-4	SV9-4	SV9-4DUP	SV10-4
DATE ANALYZED	9/13/94	#######	#######	9/14/94	#######	#######	#######	#######	#######	#######	#######	#######	#######	9/13/94
SAMPLING DEPTH (ft)	-	-	-	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	0.263	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	ND	0.22	0.18	0.28	0.18	0.18	0.17	0.03	0.15	0.07	0.08	0.07
O2 (%)	19.96	19.00	21.00	18.65	18.89	19.06	19.16	19.42	19.14	20.44	19.49	20.04	19.77	20.14
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SUPERBLOCK

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV11-4	SV12-4	SV13-4	SV14-4	SV15-4	SV16-4	SV16-4 DUP	SV17-4	SV18-4	SV19-4	SV20-4	SV21-4	SV22-4
DATE ANALYZED	#######	#######	#######	#######	#######	#######	9/14/94	#######	9/14/94	#######	#######	#######	#######
SAMPLING DEPTH (ft)	4	4	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLDROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	1.189	1.064	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	688.0	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	1120.0	375.0	ND	ND
CO2 (%)	0.07	0.03	0.54	0.00	0.45	0.18	0.20	0.64	0.18	1.60	1.73	1.09	0.38
O2 (%)	20.10	19.97	15.44	17.57	17.38	17.62	18.33	10.83	13.43	3.92	1.58	9.80	16.56
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SUPERBLOCK

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV22-4DUP	SV23-4	SV24-4	SV25-4	SV26-4	SV27-4	SV28-4	SV29-4	SV30-4	SV31-4	SV32-4	SV33-4	SV34-4	SV35-4
DATE ANALYZED	9/14/94	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######
SAMPLING DEPTH (ft)	4	4	4	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLORDETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.37	0.72	0.19	0.36	0.23	0.24	0.11	0.14	0.15	0.27	0.50	0.43	0.00	0.36
D2 (%)	15.16	14.29	18.29	15.64	17.47	17.34	19.40	18.85	18.43	17.06	16.55	17.42	20.01	18.35
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SUPERBLOCK

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV35-4DUP	SV36-4	SV37-4	SV39-4	SV40-4	SV41-4	SV42-4
DATE ANALYZED	9/14/94	9/14/94	9/15/94	9/15/94	9/15/94	9/13/94	9/13/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.36	0.36	0.34	0.07	0.20	0.27	0.12
O2 (%)	18.18	16.99	19.04	20.61	20.26	18.75	20.18
CO2/O2 RATIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #22

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-3	SV2-3	SV3-3	SV4-3	SV5-3	SV6-3	SV6-3 DUP	SV7-3	SV8-3	SV9-2	SV9-4	SV10-2	SV10-4
DATE ANALYZED	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94	9/10/94
SAMPLING DEPTH (ft)	-	3	3	3	3	3	3	3	3	3	2	4	2	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	0.120	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	0.342	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	0.09	0.21	0.15	0.42	0.39	0.20	0.20	0.09	0.25	0.11	0.15	0.09	0.02
O2 (%)	21.13	19.91	18.47	18.91	16.90	17.18	17.02	17.16	19.53	18.92	18.68	18.07	20.61	21.47
CO2/O2 RATIO	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #45

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-5	SV2-6	SV3-5	SV4-5	SV5-5	SV6-5	SV7-5	SV8-5	SV9-5	SV10-5	SV10-5 DUP
DATE ANALYZED	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94	9/23/94
SAMPLING DEPTH (ft)	-	5	6	5	5	5	5	5	5	5	5	5
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLORDETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	1.04	0.18	0.24	0.51	0.42	0.12	0.10	0.14	0.10	0.71	1.26
O2 (%)	19.09	15.14	19.32	18.97	17.78	18.66	19.37	19.28	18.98	19.11	17.22	15.19
CO2/O2 RATIO	0.00	0.07	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.04	0.08

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

PRELIMINARY DATA

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - BUILDING 971

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-5	SV2-5	SV2-5 DUP
DATE ANALYZED	9/15/94	#######	9/15/94	9/15/94
SAMPLING DEPTH (ft)	-	5	5	5
VOLUME WITHDRAWN (cc)	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND
TPH	ND	ND	ND	ND
METHANE	ND	ND	ND	ND
CO2 (%)	ND	0.23	0.31	0.29
O2 (%)	21.00	20.00	20.49	18.78
CO2/O2 RATIO	0.00	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #98

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-3	SV2-3
DATE ANALYZED	9/23/94	9/23/94	9/23/94
SAMPLING DEPTH (ft)	-	3	3
VOLUME WITHDRAWN (cc)	60	60	60
VINYL CHLORIDE	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND
CHLOROFORM	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND
CHLOROBENZENE	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND
BENZENE	ND	ND	ND
TOLUENE	ND	ND	ND
ETHYLBENZENE	ND	ND	ND
TOTAL XYLENES	ND	ND	ND
TPH	ND	ND	ND
METHANE	ND	ND	ND
CO2 (%)	ND	0.14	ND
O2 (%)	19.09	19.19	18.91
CO2/O2 RATIO	0.00	0.01	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FO

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #10

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	SV1-6	SV2-6	SV3-4	SV4-4	SV4-4 DUP	SV5-2	SV6-4	SV7-4	SV8-4	SV9-4	SV10-4
DATE ANALYZED	9/28/94	9/29/94	9/28/94	9/28/94	9/28/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94	9/28/94	9/28/94	9/28/94
SAMPLING DEPTH (ft)	-	-	6	6	4	4	4	2	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	0.14	0.07	0.12	0.08	0.08	0.03	0.09	0.11	0.20	0.11	0.10
O2 (%)	19.56	19.59	19.99	18.67	19.22	19.01	18.84	18.60	18.44	18.94	18.90	19.02	16.78
CO2/O2 RATID	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #10 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV11-4	SV12-4	SV13-4	SV13-4 DUP	SV14-4	SV15-4	SV16-4	SV17-4	SV18-4	SV19-4	SV20-4
DATE ANALYZED	9/28/94	9/28/94	9/28/94	9/28/94	9/28/94	9/28/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	0.13	0.13	0.09	0.07	0.13	0.07	0.10	0.04	0.06	0.10	0.10
O2 (%)	19.09	19.02	18.94	19.11	18.35	19.01	18.46	18.87	18.77	18.48	19.23
CO2/O2 RATIO	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #12 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	SV1-5	SV2-4	SV3-4	SV4-4	SV4-4 DUP	SV5-4	SV6-4	SV7-4	SV8-4	SV9-4	SV10-4
DATE ANALYZED	9/29/94	9/30/94	9/30/94	9/30/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94	9/29/94
SAMPLING DEPTH (ft)	-	-	5	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	0.17	0.10	0.09	0.06	0.05	0.05	0.11	0.07	0.22	0.13	0.15
O2 (%)	19.59	19.33	19.21	19.37	18.72	18.95	19.36	18.87	18.94	19.11	17.90	18.89	18.81
CO2/O2 RATIO	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #12 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV11-4	SV12-4	SV13-4	SV14-4	SV14-4 DUP	SV15-4
DATE ANALYZED	9/29/94	9/29/94	9/29/94	9/30/94	9/30/94	9/30/94
SAMPLING DEPTH (ft)	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND
CO2 (%)	0.09	0.23	0.20	0.12	0.13	0.16
O2 (%)	19.09	17.45	18.12	18.98	18.77	19.86
CO2/O2 RATIO	0.00	0.01	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #13 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	BLANK	SV1-5	SV2-5	SV3-5	SV4-5	SV5-5	SV6-5	SV7-5	SV7-5 DUP	SV8-5	SV9-5	SV10-5
DATE ANALYZED	9/30/94	10/1/94	10/1/94	10/1/94	10/1/94	9/29/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94
SAMPLING DEPTH (ft)	-	-	5	5	5	4	5	5	5	5	5	5	5
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	ND	0.20	0.18	0.15	0.16	0.25	0.34	0.22	0.20	0.31	0.29	0.28
O2 (%)	19.33	19.27	19.32	19.06	19.06	18.83	18.83	18.26	19.33	19.33	18.47	18.23	17.94
CO2/O2 RATIO	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL
NAF MIDWAY ISLAND - SITE #13 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV11-4	SV12-5	SV12-5 DUP
DATE ANALYZED	9/30/94	10/1/94	10/1/94
SAMPLING DEPTH (ft)	5	5	5
VOLUME WITHDRAWN (cc)	60	60	60
VINYL CHLORIDE	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND
CHLOROFORM	NO	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND
TRICHLDROETHENE (TCE)	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND
CHLOROBENZENE	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND
BENZENE	ND	ND	ND
TOLUENE	ND	ND	ND
ETHYLBENZENE	ND	ND	ND
TOTAL XYLENES	ND	ND	ND
TPH	ND	ND	ND
METHANE	ND	ND	ND
CO2 (%)	0.11	0.36	0.37
O2 (%)	18.35	18.19	18.59
CO2/O2 RATIO	0.01	0.02	0.02

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPM

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #54 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-4	SV2-4	SV3-5	SV4-5	SV4-5 DUP	SV5-6	SV6-3	SV7-3	SV8-4	SV9-4	SV10-4	SV11-4	SV12-4
DATE ANALYZED	9/30/94	9/30/94	9/30/94	9/30/94	9/29/94	9/29/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94	9/30/94
SAMPLING DEPTH (ft)	-	4	4	5	4	4	6	3	3	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	0.14	0.12	0.19	0.10	0.08	0.10	0.07	0.10	0.16	0.26	0.10	0.11	0.12
O2 (%)	19.33	18.43	18.74	18.24	18.94	18.28	17.99	18.60	18.49	18.21	18.88	18.86	18.35	18.49
CO2/O2 RATIO	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #54 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	SV13-4	SV14-4
DATE ANALYZED	9/30/94	9/30/94
SAMPLING DEPTH (ft)	4	4
VOLUME WITHDRAWN (cc)	60	60
VINYL CHLORIDE	ND	ND
1,1 DICHLOROETHENE	ND	ND
METHYLENE CHLORIDE	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND
1,1 DICHLOROETHANE	ND	ND
CHLOROFORM	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND
CARBON TETRACHLORIDE	ND	ND
1,2 DICHLOROETHANE	ND	ND
TRICHLOROETHENE (TCE)	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND
CHLOROBENZENE	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND
BENZENE	ND	ND
TOLUENE	ND	ND
ETHYLBENZENE	ND	ND
TOTAL XYLENES	ND	ND
TPH	ND	ND
METHANE	ND	ND
CO2 (%)	0.04	0.12
O2 (%)	19.02	18.87
CO2/O2 RATIO	0.00	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - SITE #97 - EASTERN ISLAND

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-4	SV2-4	SV3-4	SV4-4	SV5-4	SV6-4	SV6-4 DUP	SV7-4
DATE ANALYZED	10/2/94	10/2/94	10/2/94	10/2/94	9/29/94	9/29/94	10/2/94	10/2/94	10/2/94
SAMPLING DEPTH (ft)	-	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	0.07	0.11	0.09	0.36	0.18	0.14	0.13	0.16
O2 (%)	20.27	20.45	19.26	19.47	18.82	19.57	18.70	18.33	18.86
CO2/O2 RATIO	0.00	0.00	0.01	0.00	0.02	0.01	0.01	0.01	0.01

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Preliminary Data

OGDEN ENVIRONMENTAL

NAF MIDWAY ISLAND - NO VEGETATION AREA - EASTERN ISLAND

Antenna Field

TEG PROJECT #F40910

SOIL VAPOR DATA IN PPM BY VOLUME IN THE GAS

SAMPLE DESCRIPTION	BLANK	SV1-4	SV2-4	SV3-4	SV4-4	SV5-4	SV6-4	SV7-4	SV8-4	SV9-4	SV9-4 DUP
DATE ANALYZED	10/1/94	10/1/94	10/1/94	10/1/94	9/29/94	10/1/94	10/1/94	10/1/94	10/1/94	10/1/94	10/1/94
SAMPLING DEPTH (ft)	-	4	4	4	4	4	4	4	4	4	4
VOLUME WITHDRAWN (cc)	60	60	60	60	60	60	60	60	60	60	60
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TR. 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS 1,2 DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1 TRICHLOROETHANE (TCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2 TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2 TETRACHLOROETHANE (PCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO2 (%)	ND	0.11	0.07	0.11	0.09	0.11	0.16	0.15	0.09	0.09	0.09
O2 (%)	19.27	18.35	18.50	18.60	19.11	19.17	19.16	18.97	19.04	18.73	19.48
CO2/O2 RATIO	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00

ND MEANS NOT DETECTED AT 0.010 PPMV FOR EACH COMPONENT - 1.0 PPMV FOR TPH

Appendix D

APPENDIX D

SURFACE SOIL SAMPLING LOGS

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-31-94	Time: 1410

Sample Identification Number and Time: M52	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - Surface soil with stainless steel spoon

Surface Description: Gravel pad

Notes:

Soil Sample Data

Location: Transformer pad behind chapel - Site 52

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SP	0.25	M52SS01S01D0025	0	100	0	Collected at 1430
		M52SS01D01				Collected at 1430
		SAND, fine- to medium-grained, pale yellow, dry,				Includes bird burrow sand
		loose, poorly sorted, with rounded shell fragments,				
		angular to rounded				
SP	0.25	M52SS02S01D0025	0	100	T	Collected at 1435
		SAND, fine- to medium-grained, tan, dry, loose,				
		poorly sorted, sub-angular to rounded				
SP	0.25	M52SS03S01D0025	0	100	0	Collected at 1440
		SAND, fine- to medium-grained, greyish tan, dry,				Includes bird burrow sand
		loose, poorly sorted, with shell fragments, angular				
		to rounded				
SP	0.25	M52SS04S01D0025	0	90	10	Collected at 1445
		SILTY SAND, fine- to coarse-grained, tannish				
		brown, dry, loose, poorly sorted, sub-angular to				
		sub-rounded, with minor organics				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-31-94	Time: 1320

Sample Identification Number and Time: M53	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - Surface soils with stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: Abandoned PW Admin. Bldg. 348 - Site 53

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
SP	0.25	M53SS01S01D0025	0	55	45	Collected at 1340
		SILTY SAND				
SP	0.25	M53SS02S01D0025	0	55	45	Collected at 1343
		SILTY SAND				
SP	0.25	M53SS03S01D0025	0	55	45	Collected at 1346
		M53SS03D01				
		SILTY SAND				
	0.25	M53SS04S01D0025	0	0	100	Collected at 1350
		ORGANIC SOIL				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-01-94	Time: 1245

Sample Identification Number and Time: M45	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - Surface soil with stainless steel table spoon

Surface Description: Gravel and old asphalt pavement - hard packed

Notes:

Soil Sample Data

Location: Area 7 Hazmat - Site 45

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
SM	0.25	M45SS01S01 - SANDY ORGANIC	0	20	80	Collected at 1310
SP	0.25	M45SS02S01 - SAND, fine- to medium-grained,	0	100	0	Collected at 1315
		pale yellow, damp, loose, sub-angular to sub				
		rounded				
SM	0.25	M45SS03S01 - SANDY ORGANIC	0	20	80	Collected at 1320
SM	0.25	M45SS04S01 - SANDY ORGANIC	0	20	80	Collected at 1325
SM	0.25	M45SS05S01 - SANDY ORGANIC	0	20	80	Collected at 1330
Pt	0.25	M45SS06S01, D01 - SANDY ORGANIC	0	10	90	Collected at 1335

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-10-94	Time: 0900

Sample Identification Number and Time: M98SS01	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab - spoon

Surface Description: Sandy/coral cobbles/numerous 45 rifle shells

Notes: 5 rusted decomposing 55 gallon drums - all empty and on surface

Soil Sample Data

Location: Northwest Drum Disposal Area, Site 98

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, fine-grained, cream, 2.5 Y 6/2, dry, loose,	0	95	5	
		poorly sorted, SP				
		(with some larger coral cobbles and minor				
		amounts of verbicena organics)				
	0.25	⊗ M98SS01S01 (0910) south end of trench under rusted drum				8015
	0.25	⊗ M98SS01S02 (0915) same as S01				LL
	0.25	⊗ M98SS01S03 (0920) north end				8015
	0.25	⊗ M98SS01S04 (0925) north end				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-26-94	Time: 0910

Sample Identification Number and Time: M00SS01	Checked by:
Sampled by: Brian House	Recorded by: Brian House

Method of Collection: Grab sample with spoon

Surface Description: Grassy-sandy

Notes: Weather rainy and windy - ground moist

Soil Sample Data

Location: Background sample location BG01 - north of hazardous materials building

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, fine- to medium-grained, cream, 2.5 Y 7/3,	0	95	5	Clean beach sand
		loose, poorly sorted, well rounded, moist, SP				
		(minor silt and organics with approx. 95% fine-				
		grained sand and 5% fines, some medium-grained				
		sand-sized shell fragments.)				
PID=0.0ppm	0.25	⊗ M00SS01S01D0.25 (0910) at stake				on site
PID=0.0ppm	0.25	⊗ M00SS01S02D0.25 (0925) at stake				CLP
PID=0.0ppm	0.25	⊗ M00SS01S03D0.25 (0930) at stake				LL
PID=0.0ppm	0.25	⊗ M00SS01S04D0.25 (0935) west of stake 10'				on site
PID=0.0ppm	0.25	⊗ M00SS01S05D0.25 (0940) west of stake 10'				CLP
PID=0.0ppm	0.25	⊗ M00SS01S06D0.25 (0945) west of stake 10'				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-26-94	Time: 1100

Sample Identification Number and Time: M00SS02	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab - trowil to clear surface - taken with spoon

Surface Description: Silty sand - bird and plastic debris

Notes:

Soil Sample Data

Location: Background sample location BG02 - west of runway - bunker road

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, fine-grained, dusky cream, 2.5 Y 6/2,	0	80	20	bird bones and plastic debris
		moist, loose, well rounded beach sand, SP				on surface
		(minor silt and organics, fines, dark brown,				
		2.5 Y 3/1, PT)				
PID=0.0ppm	0.25	⊗ M00SS02SS01D0.25 (1100) at stake	0	80	20	
PID=0.0ppm	0.25	⊗ M00SS02SS02D0.25 (1105) at stake	0	80	20	
PID=0.0ppm	0.25	⊗ M00SS02SS03D0.25 (1110) at stake	0	80	20	
PID=0.0ppm	0.25	⊗ M00SS02SS04D0.25 (1115) east of stake 10'	0	80	20	
PID=0.0ppm	0.25	⊗ M00SS02SS05D0.25 (1120) east of stake 10'	0	80	20	
PID=0.0ppm	0.25	⊗ M00SS02SS06D0.25 (1125) east of stake 10'	0	80	20	

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-26-94	Time: 1330

Sample Identification Number and Time: M00SS03	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab - trowil and spoon

Surface Description: Grass covered

Notes: Windy and rainy - dug up two baby birds

Soil Sample Data

Location: Background location BG03 - west of soccer field/baseball field

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SILTY SAND, fine-grained, brown, 2.5 Y 4/2, moist,	0	75	25	
		loose, SP				
		(minor organics approx 25%. 5% medium-grained				
		sand-sized shell fragments)				
PID=0.0ppm	0.25	⊗ M00SS03S01D0.25 (1345) at stake BG03				on site
PID=0.0ppm	0.25	⊗ M00SS03S02D0.25 (1350) at stake BG03				CLP
PID=0.0ppm	0.25	⊗ M00SS03S03D0.25 (1355) at stake BG03				LL
PID=0.0ppm	0.25	⊗ M00SS03S04D0.25 (1400) 10' from BG03 to north				on site
PID=0.0ppm	0.25	⊗ M00SS03S05D0.25 (1405) 10' from BG03 to north				CLP
PID=0.0ppm	0.25	⊗ M00SS03S06D0.25 (1410) 10' from BG03 to north				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-26-94	Time: 1520

Sample Identification Number and Time: M00SS04	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab - trowil and spoon

Surface Description: Thick grass - organics

Notes: Rainy

Soil Sample Data

Location: Background location BG04 - grassy field southeast of hanger

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SILTY SAND, fine-grained, brown, 10 YR 3/2, moist	0	70	30	
		loose, SP				
		(30% organics and grass roots)				
PID=0.0ppm	0.25	⊗ M00SS04S01D0.25 at stake				
PID=0.0ppm	0.25	⊗ M00SS04S02D0.25 at stake				
PID=0.0ppm	0.25	⊗ M00SS04S03D0.25 at stake				
PID=0.0ppm	0.25	⊗ M00SS04S04D0.25 10' east of stake				
PID=0.0ppm	0.25	⊗ M00SS04S05D0.25 10' east of stake				
PID=0.0ppm	0.25	⊗ M00SS04S06D0.25 10' east of stake				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-28-94	Time: 1400

Sample Identification Number and Time: M00SS05	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab - trowil/spoon

Surface Description: Coral gravel/bleached white

Notes:

Soil Sample Data

Location: Background location BG05 (Eastern Island)

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
middle of TS05	0.25	SAND, fine- to medium-grained, cream to brown,	5	85	10	
		10YR 6/3, slightly moist, loose, SP				
		(with 10% silt and 5% larger coral gravel)				
north end TS05	0.25	GRAVELY SAND, fine- to coarse-grained, cream to	60	30	10	
		brown, 10 YR 7/5, slightly moist, loose, SW				
		(with 10% fines and 30% coral sand)				
	0.25	⊗ M00SS05S01D0.25 (1400) middle of TS05	5	85	10	on site
	0.25	⊗ M00SS05S02D0.25 (1400) middle of TS05	5	85	10	off site CLP
	0.25	⊗ M00SS05S03D0.25 (1405) middle of TS05	5	85	10	LL
	0.25	⊗ M00SS05S04D0.25 (1415) north end TS05	60	30	10	onsite
	0.25	⊗ M00SS05S05D0.25 (1420) north end TS05	60	30	10	CLP
	0.25	⊗ M00SS05S06D0.25 (1425) north end TS05	60	30	10	LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-29-94	Time: 1500

Sample Identification Number and Time: M00SS06	Checked by:
Sampled by: A. Martin and Mark Tarone	Recorded by: A. Martin

Method of Collection: Stainless steel spoon

Surface Description: Mixed coral fragments

Notes:

Soil Sample Data

Location: Background location BG06 (Eastern Island)

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of			Comments
			G	S	F	
	0.25	Mixed size - angular coral fragments				
	0.25	⊗ M00SS06S01D0.25				on site
	0.25	⊗ M00SS06S02D0.25				CLP
	0.25	⊗ M00SS06S03D0.25				LL
	0.25	⊗ M00SS06S04D0.25				on site
	0.25	⊗ M00SS06S05D0.25				CLP
	0.25	⊗ M00SS06S06D0.25				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-29-94	Time: 1715

Sample Identification Number and Time: M00SS07	Checked by:
Sampled by: Mark Tarone, Alan Martin	Recorded by: Alan Martin

Method of Collection: Stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: Background location BG07 (Eastern Island)

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	CORAL SAND, poorly sorted angular and pebbles				
	1.0	SILTY SAND - organics (roots, detritus)				
		10 R 2.5/1				
	2	Silty coral sand				
		10 YR 6/2				
	0.25	⊗ M00SS07S01D0.25				on site
	0.25	⊗ M00SS07S02D0.25				CLP
	0.25	⊗ M00SS07S03D0.25				LL
	0.25	⊗ M00SS07S04D0.25				on site
	0.25	⊗ M00SS07S05D0.25				CLP
	0.25	⊗ M00SS07S06D0.25				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-22-94	Time: 1300

Sample Identification Number and Time: M02SS01	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Grassy with white beach sand

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ Middle of TS01

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	SAND, cream, 2.5 Y 8/4, slightly moist, loose,	0	100	0	
		fine-grained, SP				
PID=0.0ppm	0.25	⊗ M02TS01S01D0.25 middle of TS01				
PID=0.0ppm	0.25	⊗ M02TS01S02D0.25 middle of TS01				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-22-94	Time: 1410

Sample Identification Number and Time: M02SS02	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Iron wood tree needles - decomposed partially/rusted metal scraps

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ Middle of trench TS02 under rusted drum heap

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	ORGANICS, dark brown, 10 YR 2/2, dry, loose,	0	15	85	
		with 15% fine-grained coral sand, PT				
		(Iron wood partially decomposed organics)				
	0.25	⊗ M02SS02S01D0.25 middle of TS02, under drum				
	0.25	⊗ M02SS02S02D0.25 (critical sample)				
		middle of TS02, under rusted drums.				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-21-94	Time: 0845

Sample Identification Number and Time: M02SS03	Checked by:
Sampled by: Brian House	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Grass - wood debris, thin layer of silt

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/South end TS03

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	⊗ M02SS03S01D0.25 and dup (0845) south end	0	90	10	
	0.25	⊗ M02SS03S02D0.25 and dup (0845) south end	0	90	10	
	0.25	SILTY SAND, dusky cream, 2.5 Y 6/3, SM	0	90	10	
		dry, loose, fine-grained sand 10% silt				
		(with plant and wood debris, coral cobbles)				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-23-94	Time: 0756

Sample Identification Number and Time: M02SS04	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: 0.25 inches of iron wood tree needles

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ middle of active burn area

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, cream, 2.5 Y 8/3, dry, lose, well sorted,	0	95	5	
		with small amount of organics, SP				
	0.25	⊗ M02SS04S01D0.25 middle of TS04-critical sample				
	0.25	⊗ M02SS04S02D0.25 middle of TS04				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-21-94	Time: 1100

Sample Identification Number and Time: M02SS05	Checked by:
Sampled by: Alan M.	Recorded by: Brian House

Method of Collection: Grab - trowil

Surface Description: 3 inches of decomposed iron wood needles on surface

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ North end of trench / bottom portion of mound

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	⊗ M02SS05S01D0.25 (1100) south end				
	0.25	⊗ M02SS05D01D0.25 (1100) south end				
	0.25	⊗ M02SS05S02D0.25 (1100) south end				
	0.25	Gravelly SAND, gray, 2.5 Y 4/1, GM	0	85	15	
		moist, loose, fine-medium grained sand				
		(abundant coral gravel with glass and metal debris)				
		abundant silt in first 3 inches				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-23-94	Time: 1015

Sample Identification Number and Time: M02SS06	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Iron wood tree needles / larger chunks of coral

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ middle of TS06

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, cream, 2.5 Y 6/2, dry, loose, fine- to	15	85	0	
		medium-grained, well sorted, 15% coral gravel, SP				
	0.25	⊗ M02SS06S01D0.25 (1015) middle of TS06				
	0.25	⊗ M02SS06S02D0.25 (1015) middle of TS06				
		(critical sample)				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-23-94	Time: 0930

Sample Identification Number and Time: M02SS07	Checked by:
Sampled by: Larry E.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Iron wood needles on surface - sand

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ middle of TS07

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	SAND, white to cream, 2.5 Y 7/2, dry, loose,	10	90	0	
		fine- to coarse-grained sand, 10% coral gravel, SP				
	0.25	⊗ M02SS07S01D0.25 middle of TS07				
	0.25	⊗ M02SS07S02D0.25 middle of TS07				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-22-94	Time: 0945

Sample Identification Number and Time: M02SS08	Checked by:
Sampled by: Brian House	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Sandy with small amount of organics

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ Middle of TS08

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	SAND, cream to gray, 2.5 Y 7/3, dry, loose,	0	95	5	
		with 5% silt, 95% fine-grained sand, SP				
	0.25	⊗ M02SS08S01D0.25 middle of trench				
	0.25	⊗ M02SS08S02D0.25 middle of trench				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-21-94	Time: 1440

Sample Identification Number and Time: M02SS09	Checked by:
Sampled by: Brian House	Recorded by: Brian House

Method of Collection: Grab - trowil

Surface Description: Iron wood needles 1 inch thick - scraped away

Notes:

Soil Sample Data

Location: Runway Landfill, Site 2/ Middle of TS09

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, cream, 2.5 Y 8/4, dry, loose, with larger	0	90	10	
		coral cobbles and gravel, some silt and organics				
		on surface, SP				
	0.25	⊗ M02SS09S01D0.25 middle of TS09				
	0.25	⊗ M02SS09S02D0.25 middle of TS09				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-19-94	Time: 1030

Sample Identification Number and Time: M07SS01	Checked by:
Sampled by: Alan M.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Sandy with iron wood tree needles on surface

Notes:

Soil Sample Data

Location: Frigate Point / Drum disposal area Site 7/ Midpoint TS01 adjacent to exposed drum

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.5	SAND, fine-grained, well sorted beach sand,	0	95	5	
		light gray to cream, 2.5 YR 7/1, SP				
PID=1.5 ppm						
	0.5	⊗ M07SS01S01D0.5'				
	0.5	⊗ M07SS01S02D0.5' (1145) critical sample				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-19-94	Time: 1100

Sample Identification Number and Time: M07SS02	Checked by:
Sampled by: Alan M. / Robert M.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Dry sand - iron wood needles

Notes:

Soil Sample Data

Location: Frigate Point / Drum disposal area Site 7/ Midpoint TS02 adjacent to exposed drum

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.5	CORAL SAND, dry, fine-grained, light cream,				
		2.5 YR 6/3				
PID=1.0 ppm						
	0.5	⊗ M07SS02S01D0.5 on site				
	0.5	⊗ M07SS02S02D0.5 off site				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-19-94	Time: 1135

Sample Identification Number and Time: M07SS03	Checked by:
Sampled by: Alan M. / Robert M.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Beach sand with iron wood debris and decomposed rusted drum debris

Notes:

Soil Sample Data

Location: Frigate Point / Drum disposal area Site 7/ North end TS03 adjacent to exposed drum

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.5	SAND, fine-grained, 2.5 T 6/1, dry, loose, SP	0	95	5	
		(with 5% silty organics)				
PID=1.3 ppm						
	0.5	⊗ M07SS03S01D0.5				
	0.5	⊗ M07SS03S02D0.5				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-19-94	Time: 1155

Sample Identification Number and Time: M07SS04	Checked by:
Sampled by: Alan M. / Robert M.	Recorded by: Brian House

Method of Collection: Grab

Surface Description: Sand with wood debris and decomposed rusted drum debris

Notes:

Soil Sample Data

Location: Frigate Point / Drum disposal area Site 7/ South end TS03 adjacent to exposed drum

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.5	SAND, salt and paper, 2.5 Y 7/1, dry, loose,	0	90	10	
		fine-grained, with 10% organics, SP				
	0.5	⊗ M07SS04S01D0.5 (1155) on site				
	0.5	⊗ M07SS04S02D0.5 (1345) off site				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-31-94	Time: 0900

Sample Identification Number and Time: M07	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface soils with stainless steel spoons

Surface Description: Sandy with minor organics

Notes:

Soil Sample Data

Location: Drum Disposal Area - Frigate Point

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SW	0.25	M07SS05S01D0025	0	100	0	Collected at 0915
		SAND, fine-grained, tannish grey, dry, loose,				
		well graded, with minor organic fragments				
SW	0.25	M07SS06S01D0025	0	100	0	Collected at 0910
		same as above				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-29-94	Time: 1015

Sample Identification Number and Time: M08	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface soils - stainless steel table spoon

Surface Description: Sandy silt - organic (tree litter)

Notes:

Soil Sample Data

Location: Abandoned Power Plant 144 - Site 8

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	M08SS01S01	0	5	95	Collected at 1040
		M08SS01S02				Collected at 1040
	0.25	M08SS02S01	0	5	95	Collected at 1050
		M08SS02S02				Collected at 1050
		M08SS02D02				Collected at 1050
	0.25	M08SS03S01	0	5	95	Collected at 1055
		M08SS03S02				Collected at 1055
	0.25	M08SS04S01	0	5	95	Collected at 1045
		M08SS04D01				Collected at 1045
		M08SS04S02				Collected at 1045

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-29-94	Time: 0920

Sample Identification Number and Time: M09	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface soils - stainless steel table spoon

Surface Description: Turf - Silty sand with organic mat on top

Notes:

Soil Sample Data

Location: Old Pesticide Shop - Site 9

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	M09SS01S01D0025	0	90	10	Collected at 0945
	0.25	M09SS02S01D0025	0	90	10	Collected at 0948
	0.25	M09SS02D01D0025	0	90	10	Collected at 0948
	0.25	M09SS03S01D0025	0	95	5	Collected at 0951
		- collected @ bird burrow				
	0.25	M09SS04S01D0025	0	95	5	Collected at 0955
		- collected @ bird burrow				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-29-94	Time: 1400

Sample Identification Number and Time: MSB	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface soils - stainless steel table spoon

Surface Description: Sandy silt, greyish brown, fine to medium grain with gravels @SS01, 2, 3

Notes: Silty sand, tan, fine to medium grain with gravels @SS04

Soil Sample Data

Location: Old Power Plant- Site 20 - Superblock

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of			Comments
			G	S	F	
	0.25	MSBSS01S01	10	10	80	Collected at 1415
		MSBSS01S02				Collected at 1415
	0.25	MSBSS02S01	5	10	85	Collected at 1420
		MSBSS02D01				Collected at 1420
		MSBSS02S02				Collected at 1420
	0.25	MSBSS03S01	0	5	95	Collected at 1425
		MSBSS03S02				Collected at 1425
		MSBSS03D02				Collected at 1425
	0.25	MSBSS04S01	0	90	10	Collected at 1430
		MSBSS04S02				Collected at 1430

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-29-94	Time: 1600

Sample Identification Number and Time: M34	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface soil with stainless steel table spoon

Surface Description: Turf - Mostly sandy silt with organic mat on surface

Notes:

Soil Sample Data

Location:

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
OL/ML	0.25	M34SS01S01	5	10	85	Collected at 1600
		M34SS01S02				Collected at 1600
		SANDY SILT, fine-grained, 2.5 YR 2.5/0.25, dark				
		reddish brown, dry, loose, poorly sorted,				
		with sub-angular coral gravel and minor organics				
SM	0.25	M34SS02S01	5	85	10	Collected at 1605
		M34SS02S02				Collected at 1605
		SILTY SAND, fine- to medium-grained, 7.5 YR 6/1,				
		pinkish grey, dry, loose, poorly sorted, withsub-				
		angular to rounded gravel				
OL	0.25	M34SS03S01	0	10	90	Collected at 1610
		M34SS03S02				Collected at 1610
		ORGANIC SANDY SILT, fine- to medium-grained, 7.5 YR				
		2.5/2, dark brown, dry, loose, poorly sorted, with				
		sub-angular to sub-rounded gravel				
ML	0.25	M34SS04S01, D01	10	80	10	Collected at 1615
		M34SS04S02				Collected at 1615
		SANDY SILT, fine- to coarse-grained, 7.5 YR 5/1,				
		greyish brown, dry, loose, poorly sorted,				
		with angular gravel				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-31-94	Time: 0915

Sample Identification Number and Time: M34	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand Auger

Surface Description: Turf - Sandy silt with organic material

Notes:

Soil Sample Data

Location: Pesticide Storage Shop - Site 34

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SP	1.5	M34BS01S01	0	95	5	Collected at 0930
		M34BS01S02, D02				Collected at 0930
		SILTY SAND, fine- to medium-grained, greyish				
		brown, damp, loose, moderately sorted, sub-				
		rounded to rounded				
	1.5	M34BS02S01	10	90	0	Collected at 0945
		M34BS02S02				Collected at 0945
		SAND, fine- to coarse-grained, pale yellow, dry,				
		loose, poorly sorted, sub-angular to rounded, with				
		fine to coarse gravely subangular to sub-rounded				
		(coral gravels, small cobbles)				
SP	1.5	M34BS03S01	0	100	0	Collected at 1000
		M34BS03S02				Collected at 1000
		SAND, fine- to coarse-grained, pale yellow mottled				
		with greyish brown, damp, loose, sub-angular to				
		rounded, moderately sorted				
SP	1.5	M34BS04S01	10	90	0	Collected at 1015
		M34BS04S02				Collected at 1015
		SAND, fine- to coarse-grained, pale yellow, damp,				
		loose, angular to sub-rounded, poorly sorted,				
		with sub-angular to medium gravel				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-01-94	Time: 1130

Sample Identification Number and Time: M44	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - Surface soil with stainless steel table spoon

Surface Description: Verbisina growth - organic mat on sandy subsoil

Notes:

Soil Sample Data

Location: Abandoned Tacan Bldg. 6395 - Site 44

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	M44SS01S01 - SANDY ORGANIC SOIL, brown, dry,	0	30	70	Collected at 1140
		loose, poorly sorted, sub-angular to rounded,				
		with leaf and twig fragments				
		(SAND - fine-medium- grained)				
	0.25	M44SS02S01	0	30	70	Collected at 1145
		same as above				
	0.25	M44SS03S01	0	30	70	Collected at 1147
		same as above				
	0.25	M44SS04S01, D01	0	30	70	Collected at 1150
		same as above				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-31-94	Time:

Sample Identification Number and Time: M51	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - Surface soil with stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: George Cannon School - Site 51

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SW	0.25	M51SS01S01D0025	0	100	0	Collected at 1415
		M51SS01D01				Collected at 1415
		SAND, fine-grained, pale yellow, dry, loose,				
		well sorted, sub-angular				
SP	0.25	M51SS02S01D0025	0	70	30	Collected at 1419
		SILTY SAND, fine- to medium-grained, greyish tan,				
		dry, loose, poorly sorted, sub-angular to rounded				
		with minor organics				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-03-94	Time: 0900

Sample Identification Number and Time: M10SS01	Checked by:
Sampled by: Mark Tarone	Recorded by: Alan Martin

Method of Collection: Stainless steel spoon

Surface Description: Mixed trash, debris and steel

Notes:

Soil Sample Data

Location: Northeastern disposal area - Eastern Island - Trench 1, West end

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	SAND, fine- to medium-grained, cream,	20	75	5	
		7.5 YR 7/2, dry, loose, poorly sorted, SP				
		(20% gravels, 75% sands, 5% fines)				
	0.25	M10SS01S01D00.25				
	0.25	M10SS01S02D00.25 collected near west end of				
		trench location				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-30-94	Time: 1320

Sample Identification Number and Time: M10SS02	Checked by:
Sampled by: Alan Martin, Mark Tarone	Recorded by: Alan Martin

Method of Collection: Stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: Northeastern Disposal Area - Eastern Island - Trench 2

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of			Comments
			G	S	F	
	0.25	SAND, coarse-grained sand mixed with coral fragments (pebbles)				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 9-30-94	Time: 1530

Sample Identification Number and Time: M10SS03	Checked by:
Sampled by: A. Martin / M. Tarone	Recorded by: A. Martin

Method of Collection: Stainless steel spoon

Surface Description: Covered with verbicena

Notes:

Soil Sample Data

Location: Disposal Area - Northeastern point

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		SAND, coarse-grained sand with coral fragments	40	60	0	

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-05-94	Time: 0830

Sample Identification Number and Time: M11SS01	Checked by:
Sampled by: Mark Tarone, Alan Martin	Recorded by: Alan Martin

Method of Collection: Stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: Southwest Disposal Area - Site 11- Eastern Island

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	GRAVELLY SAND, fine- to medium-grained, very	50	50	0	
		pale brown, 10 YR 8/3, loose, pebbles - 40%,				
		cobbles - 10%, roots mixed with sand				
	0.25	⊗ M11SS01S01D00.25				
	0.25	⊗ M11SS01S02D00.25				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-05-94	Time: 1215

Sample Identification Number and Time: M11SS02	Checked by:
Sampled by: Mark Tarone	Recorded by: Alan Martin

Method of Collection: Stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: Southwest Disposal Area - Trench #2

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.025	MIXED SAND AND GRAVEL - roots	20	80	0	
		few cobbles (5%) 10 YR 8/3 very pale brown				
	0.025	⊗ M11SS02S01				
	0.025	⊗ M11SS02S02				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-08-94	Time: 0910

Sample Identification Number and Time: M54SS01	Checked by:
Sampled by: Brian House	Recorded by: Brian House

Method of Collection: Grab - spoon

Surface Description: Looks like some sort of insulation material and silty organics

Notes: Insulation material on top 6 inches of landfill

Soil Sample Data

Location: Southeast Landfill area Site 54/ TS01 - Eastern Island

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		SANDY SILT, dusky brown, 10 YR 4/2, dry, loose,	0	15	85	
		(with landfill debris - plastic, glass, insulation, and				
		minor amounts of larger coral cobbles and sand)				
PID=0.0ppm	0.25	⊗ M54SS01S01 (0905) east end TS01				on site
PID=0.0ppm	0.25	⊗ M54SS01S02 (0910) east end TS01				off site

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-08-94	Time: 1030

Sample Identification Number and Time: M54SS02	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab - spoon

Surface Description: Glass, cans, rebar, virbacena flowers / silt and angular coral gravel.

Notes:

Soil Sample Data

Location: Southeast Landfill area Site 54/ west end of TS02- Eastern Island

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	Gravelly SILT, cream-brown, 10 YR 4/3, dry,	50	0	50	
		loose, GP/PT				
		(equal amounts of organic silt and angular coral				
		gravel)				
	0.25	⊗ M54SS02S01 (1035) west end	50	0	50	
	0.25	⊗ M54SS02S02 (1040) west end	50	0	50	

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-08-94	Time: 1210

Sample Identification Number and Time: M54SS03	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab - spoon

Surface Description: Coral gravel and sandy silt

Notes:

Soil Sample Data

Location: Southeast Landfill Site 54 (mound)- Eastern Island

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	GRAVELLY SANDY SILT, cream to dusk brown,	20	10	70	
		10 YR 6/2, dry, loose				
		(with 20% angular coral gravel, 10% sand)				
	0.25	⊗ M54SS03S01 (1145)				on site
	0.25	⊗ M54SS03S02 (1150)				off site
	0.25	⊗ M54SS03D02 (1155)				quality As. sample

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-28-94	Time: 0930

Sample Identification Number and Time: M54

Checked by:

Sampled by: J. Frei

Recorded by: J. Frei

Method of Collection: Manual - with stainless steel spoon

Surface Description:

Notes: Surface soil samples

Soil Sample Data

Location: SE Landfill Pit - Site 54/ Eastern Island

Coordinates:

Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	M54SS04S01D0025				10-28-94 0945
	0.25	M54SS05S01D0025				10-28-94 0950
		M54SS05D01D0025				10-28-94 0950
	0.25	M54SS06S01D0025				10-28-94 0955
	0.25	M54SS07S01D0025				10-28-94 1000
	0.25	M54SS08S01D0025				10-28-94 1005
	0.25	M54SS09S01D0025				10-28-94 1010

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 1050

Sample Identification Number and Time: M12	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - surface sample with stainless steel table spoon

Surface Description: Verisina and exposed sand and gravel

Notes:

Soil Sample Data

Location: BLDG. 9101-9102 - Site 12

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
SP	0.25	M12SS01S01 - SAND, fine-coarse grained, tan,	0	95	5	Collected at 1110
		dry, loose, poorly sorted, with coral fragments and				
		minororganics				
SP	0.25	M12SS02S01 - SAND - same as above	0	90	10	Collected at 1115
SP	0.25	M12SS03S01 - SAND - same as above	0	95	5	Collected at 1120
SP	0.25	M12SS04S01, D01	5	95	0	Collected at 1125
		SAND, medium to coarse grained, lt. tan, dry,				
		loose, poorly sorted, with coral and shell fragments				
SP	0.25	M12SS05S01 - same as above	5	95	0	Collected at 1130
	0.25	M12SS06S01 - same as SS05				Collected at 1135
	0.25	M12SS07S01 - same as SS05				Collected at 1140
	0.25	M12SS08S01 - same as SS05				Collected at 1145

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 0840

Sample Identification Number and Time: M13

Checked by:

Sampled by: J. Frei

Recorded by: J. Frei

Method of Collection:

Surface Description: Australian Pines - organic litter

Notes:

Soil Sample Data

Location: BLDG. 9301-9303 - Site 13

Coordinates:

Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SM/SP	0.25	M13SS01S01 - SILTY SAND, greyish brown, dry,	0	90	10	Collected at 0900
		loose, fine-medium grained, with organic litter and				
		few pieces of coral gravel				
SP/SM	0.25	M13SS02S01 - SILTY SAND, fine-medium	5	85	10	Collected at 0905
		grained, greyish brown, dry, loose, with subangular				
		coral gravels and minor organic fragments				
SM/SP	0.25	M13SS03S01 - SILTY SAND, greyish brown, dry,	5	80	15	Collected at 0910
		loose, poorly sorted, with subangular coral gravels				
		and moderate amount of organic fragments				
OL	0.25	M13SS04S01,D01 - Organic soil, dk brown, damp,	0	5	95	Collected at 0915
		loose, poorly sorted, mostly organic fragments				
SM/SP	0.25	M13SS05S01 - SILTY SAND - same as SS02	5	85	10	Collected at 0920
SP	0.25	M13SS06S01 - SILTY SAND - same as SS01	5	85	10	Collected at 0925
SP	0.25	M13SS07S01 - SILTY SAND - same as SS01	5	85	10	Collected at 0930
SP	0.25	M13SS08S01 - SILTY SAND - same as SS02	10	80	10	Collected at 0935

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 1425

Sample Identification Number and Time: M23	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand with stainless steel table spoon

Surface Description: Sand and gravel

Notes:

Soil Sample Data

Location: BLDG. 9201 - Site 23

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SP	0.25	M23SS01S01, D01 - SAND, fine- to coarse-	0	100	0	Collected at 1435
		grained, tan, damp, loose, poorly sorted, sub-				
		angular to sub-rounded, with minor pieces of coral				
SP	0.25	M23SS02S01 - SAND, fine- to medium-grained,	0	100	0	Collected at 1440
		dark brown, damp, loose, poorly sorted,				
		sub-rounded to rounded, with coral fragments				
SP	0.25	M23SS03S01 - SAND, fine- to coarse-grained, tan,	0	100	0	Collected at 1445
		dry, loose, poorly sorted, sub-angular to rounded,				
		with minor gravel and coral fragments				
SP	0.25	M23SS04S01 - SAND, fine- to coarse-grained, tan,	5	95	0	Collected at 1450
		dry, loose, poorly sorted, sub-angular to				
		sub-rounded with sub-rounded coral fragments				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 1350

Sample Identification Number and Time: M24

Checked by:

Sampled by: J. Frei

Recorded by: J. Frei

Method of Collection: Hand with stainless steel spoon

Surface Description: Sand and gravel

Notes:

Soil Sample Data

Location: BLDG. 9123 - Site 24

Coordinates:

Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SP	0.25	M24SS01S01 - SAND, fine- to coarse-grained, tan,	0	100	0	Collected at 1405
		damp, moderately loose, poorly sorted, sub-				
		angular to sub-rounded, with coral and broken				
		shell				
SP	0.25	M24SS02S01 - SAND - same as SS01	0	100	0	Collected at 1410
SP	0.25	M24SS03S01 - SAND with organic fines, fine- to	0	90	10	Collected at 1415
		medium-grained, dk brown, damp, loose, poorly				
		sorted, sub-angular - sub-rounded				
SP	0.25	M24SS04S01, D01 - SAND - same as SS01	5	90	5	Collected at 1420
		except with small coral gravels				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 0950

Sample Identification Number and Time: M33	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand with stainless steel spoon

Surface Description:

Notes:

Soil Sample Data

Location: BLDG. 7137 - Site 33

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of			Comments
			G	S	F	
SW	0.25	M33SS01S01 - SAND, fine- to medium-grained,	0	95	5	Collected at 1015
		yellowish brown, dry, loose, sub-angular to				
		rounded, with coral fragments and minor organics				
SW	0.25	M33SS02S01, D01 - SAND - same as SS01	0	95	5	Collected at 1020
		except fine- to coarse-grained				
SW	0.25	M33SS03S01 - SAND - same as SS01	0	95	5	Collected at 1025
		except fine- to coarse-grained				
SW	0.25	M33SS04S01 - SAND - same as SS01	0	95	5	Collected at 1030
		except fine- to coarse-grained				

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 1230

Sample Identification Number and Time: M42	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - with stainless steel table spoon

Surface Description: Verisina and exposed sand with coral gravel

Notes:

Soil Sample Data

Location: BLDG. 7136 - Site 42

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
SP	0.25	M42SS01S01 - SAND, fine- to coarse-grained,	0	95	5	Collected at 1245
		lite tan, dry, loose, poorly sorted, sub-angular to				
		sub-rounded, with coarse coral and shell fragment				
		and minor organics				
SP	0.25	M42SS02S01 - SAND	0	95	5	Collected at 1250
		same as SS01				
SP	0.25	M42SS03S01 - SAND	0	95	5	Collected at 1255
		same as above, but no organics				
SM	0.25	M42SS04S01, D01 - SILTY SAND, fine- to	0	80	20	Collected at 1300
		medium-grained, brown, dry, loose, moderately				
		sorted, sub-rounded to rounded with few coral				
		fragments				

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Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-07-94	Time: 0900

Sample Identification Number and Time: M97SS01	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Spoon/trowil

Surface Description: Very dense coral sand and gravel - moss growth

Notes: West end of trench - weather is rainy

Soil Sample Data

Location: Eastern Island - Site 97 - next to pier, just west down beach

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
		GRAVELLY SAND, fine- to coarse-grained, cream,	30	70	0	
		2.5 YR 8/3, slightly moist, densely packed,				
		poorly sorted, GP/SP				
		(30% coral gravel with a minor amount of larger				
		coral cobbles)				
	0.25	⊗ M97SS01S01D0.25 (0900) west end TS01	30	70	0	on site
	0.25	⊗ M97SS01S02D0.25 (0905) west end TS01	30	70	0	off site

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-07-94	Time: 1015

Sample Identification Number and Time: M97SS02	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab - spoon/trowil

Surface Description: Gray colored coral sand and gravel (thin layer green moss on surface)

Notes:

Soil Sample Data

Location: Eastern Island - Site 97 - (near pier) east down beach from pier

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	SAND, fine- to coarse-grained, dusky cream,	5	95	0	
		10 YR 6/2, moist, loose, poorly sorted, SP				
		(with < 5% coral gravel)				
	0.25	⊗ M97SS02S01 (1010) west end TS02	5	95	0	on site
	0.25	⊗ M97SS02S02 (1015) west end TS02	5	95	0	off site

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 10-07-94	Time: 1230

Sample Identification Number and Time: M97SS03	Checked by:
Sampled by: Mark B.	Recorded by: Brian House

Method of Collection: Grab - spoon

Surface Description: Bleached coral gravel 0-1 inche / 1-2 inches gravelly sand with minor organics

Notes:

Soil Sample Data

Location: Eastern Island Site 97 east up beach from pier

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0.25	GRAVELLY SAND, fine- to coarse-grained,	10	90	0	
		dusky cream, 2.5 Y 6/3, dry, loose, poorly sorted,				
		SP				
		(with 10 coral gravel)				
	0.25	⊗ M97SS0301 (1230)				on site
	0.25	⊗ M97SS0302 (1235)				off site
	0.25	⊗ M97SS0303 (1240)				LL

OGDEN

Surface and Shallow Soil Sample Log

Project Number: 110190136	Project Name: Midway SI/RI	Date: 11-02-94	Time: 1500

Sample Identification Number and Time: MAF	Checked by:
Sampled by: J. Frei	Recorded by: J. Frei

Method of Collection: Hand - with stainless steel spoon

Surface Description: Vegetated sand and small coral gravel

Notes:

Soil Sample Data

Location: Antenna Field - Site 100

Coordinates:	Elevation:

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
SW	0.25	MAFSS01S01 - SAND, fine- to coarse-grained,	0	95	5	Collected at 1515
		tan, dry, loose, poorly sorted, sub-angular to				
		rounded, with coral fragments and minor organics				
SW	0.25	MAFSS02S01 - SAND, same as above	0	90	10	Collected at 1520
SW	0.25	MAFSS03S01 - SAND, same as above	0	95	5	Collected at 1525
SW	0.25	MAFSS04S01D01 - SAND, same as above but	5	95	0	Collected at 1530
		with sub-angular to sub-rounded coral gravel				
SW	0.25	MAFSS05S01 - SAND, same as SS06				Collected at 1535
SW	0.25	MAFSS06S01 - SAND, fine-coarse, tannish yellow,	0	100	0	Collected at 1540
		dry, loose, poorly sorted, sub-angular to sub-				
		rounded, with 1/4 inch (max) coral fragments				

Appendix E

APPENDIX E

TRENCH SOIL LOGS

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M97TS01	Project Number: 110190136	Elevation and Datum:	Location: Eastern Island Site 97
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-07-94 (0915)	Date and Time Completed: 10-07-94 (1000)
Equipment Type: Bobcat 743B	Trench Orientation: ~ W-E	Total Depth: 5.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 14 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	4.0	Sand, fine- to coarse-grained, cream,	5	95	0	
		2.5 Y 8/4, slightly moist, loose, poorly sorted,				
		SP (with 5% coral gravel and cobbles)				
PID=0.0ppm	5.0	⊗ M97TS01S01 (0930) west end	5	95	0	on site
PID=0.0ppm	5.0	⊗ M97TS01S02 (0930) west end	5	95	0	off site
PID=0.0ppm	4.0	⊗ M97TS01S03 (1000) east end	5	95	0	on site
PID=0.0ppm	4.0	⊗ M97TS01S04 (1000) east end	5	95	0	off site (metals)

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/07/94 / 09:15
DATE/TIME FINISHED 10/07/94 / 10:00
COORDINATES -1090.91, 14369.11
ELEVATION AND DATUM 7.64
TRENCH ORIENTATION W-E

TRENCH NUMBER M97TS01
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 14 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Russel O'Malia/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to coarse-grained, pale yellow, 2.5 Y 8/4, slightly moist, loose, poorly sorted, SP (with 5% coral gravel and cobbles).		
1							1
2							2
3							3
4	M97TS01S03 M97TS01S04	0 0					4
5	M97TS01S01 M97TS01S02	0 0					5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M97TS02	Project Number: 110190136	Elevation and Datum:	Location: Eastern Island (behind sheet piling)
Equipment Supplier: PMC	Operator: Dean Mclure	Date and Time Started: 10-07-94 (1045)	Date and Time Completed: 10-07-94 (1200)
Equipment Type: Bobcat 743B	Trench Orientation: ~ W-E	Total Depth: 4 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 16 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0-0.5	Sand, fine- to coarse-grained, gray,	0	100	0	
		10 YR 6/1, moist, stiff, poorly sorted, SP				
	0.5-1	Coral gravel, cream, 10 YR 8/2, moist, stiff,	0	100	0	
		GP				
	1-1.3	Sand, fine- to coarse grained, gray,	0	100	0	
		10 YR 5/1, moist, stiff, poorly sorted, SP				
	1.3-4	Sand, fine- to coarse-grained, cream,	5	95	0	
		10 YR 8/3, dry, loose, poorly sorted, SP				
		(with 5% coral gravel)				
	4.0	⊗ M97TS02S01 (1120) west end	0	100	0	on site
	4.0	⊗ M97TS02S02 (1125) west end	0	100	0	off site
	4.0	⊗ M97TS02S03 (1145) east end	0	100	0	on site
	4.0	⊗ M97TS02S04 (1150) east end	0	100	0	off site

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/07/94 / 10:45
DATE/TIME FINISHED 10/07/94 / 12:00
COORDINATES -988.65, 14531.41
ELEVATION AND DATUM 8.14
TRENCH ORIENTATION W-E

TRENCH NUMBER M97TS02
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 16 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Dean McClure
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to coarse-grained, gray, 10 YR 6/1, moist, stiff, poorly sorted, SP.		
				GP	CORAL GRAVEL, pale yellow, 10 YR 8/2, moist, stiff, GP.		
1				SP	CPRAL SAND, fine- to coarse-grained, gray, 10 YR 5/1, moist, stiff, poorly sorted, SP.	Two inch steel pipe running West to East, rusted and decomposed, two inch steel pipe running North to South, rusted and decomposed and one inch steel pipe running North to South, rusted and decomposed were found.	1
				SP	CORAL SAND, fine- to coarse-grained, pale yellow, 10 YR 8/3, dry, loose, poorly sorted, SP (with 5% coral gravel).		
2							2
3							3
4	M97TS02S01 M97TS02S02 M97TS02S03 M97TS02S04	0 0 0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M97TS03	Project Number: 110190136	Elevation and Datum:	Location: Eastern Island Site 97
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-07-94 (1245)	Date and Time Completed: 10-07-94 (1330)
Equipment Type: Bobcat 743B	Trench Orientation: ~ W-E	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0-0.3	Gravelly Sand, medium- to coarse-grained,	30	70	0	
		cream, 10 YR 8/2, dry, med. stiff, SP				
	0.3-0.5	Dark brown, 10 YR 3/1, dry, very stiff, looks				
		like asphalt with coral gravel mixed in (?)				
	0.5-1	Coral gravel, cream, 2.5 Y 8/2, dry, med. stiff,	60	40	0	
		with larger angular coral chunks, GP				
	1-1.3	Sand, fine- to medium-grained, light brown,	5	90	5	
		10 YR 5/4, dry, stiff, SP with minor amounts of				
		silt and gravel				
	1.3-1.5	Silty Sand, fine- to coarse-grained, gray,	0	70	30	
		10 YR 5/1, slightly moist, medium stiff, SP				
		(with 30% silt)				
	1.5-4	Sand, fine- to coarse-grained, cream,	0	100	0	
		10 YR 8/2, dry, loose, poorly sorted, SP, with				
		minor amounts of angular and subrounded				
		coral gravel				
PID=0.0ppm	4.0	⊗ M97TS03S01 (1315)	0	100	0	on site
PID=0.0ppm	4.0	⊗ M97TS03S02 (1320)	0	100	0	off site
PID=0.0ppm	1.0	⊗ M97TS03S03 (1335)				on site
PID=0.0ppm	1.0	⊗ M97TS03S04 (1340)				off site

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/07/94 / 12:45
DATE/TIME FINISHED 10/07/94 / 13:30
COORDINATES -861.30, 14664.53
ELEVATION AND DATUM 8.84
TRENCH ORIENTATION W-E

TRENCH NUMBER M97TS03
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 10 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Rukssel O'Malia
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL GRAVEL SAND, medium- to coarse-grained, pale yellow, 10 YR 8/2, dry, medium stiff, SP.		
				AP	ASPHALT, asphalt with coral gravel mixed in, dark brown 10 YR 3/1, dry, very stiff, AP.		
				GP	CORAL GRAVEL, pale yellow, 2.5 Y 8/2, dry, medium stiff, with larger, angular coral chunks, GP.	Possible dredge material.	
				SP	CORAL SAND, fine- to medium-grained, light brown, 10 YR 5/4, dry, stiff, with minor amounts of silt and gravel, SP.		
1	M97TS03S03 M97TS03S04	0 0		SP	SILTY CORAL SAND, fine- to coarse-grained, gray, 10 YR 5/1, slightly moist, medium stiff, SP (with 30% silt).		1
				SP	CORAL SAND, fine- to coarse-grained, pale yellow, 10 YR 8/2, dry, loose, poorly sorted, with minor amounts of angular and subrounded coral, gravel, SP.		
2							2
						Metal wires found.	
3							3
4	M97TS03S01 M97TS03S02	0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI

Trench Number: M00TS01	Project Number: 110190136	Elevation and Datum:	Location: Background 01
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-26-94 (0945)	Date and Time Completed: 9-26-94 (1030)
Equipment Type: Bobcat 743B	Trench Orientation: W-E	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 15 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.25	Described on SS log sheet	0	95	5	
PID=0.0ppm	4.0	⊗ M00TS01S01D4.0 (1000) west end TS01	0	100	0	on site
PID=0.0ppm	4.0	⊗ M00TS01S02D4.0 (1005) west end TS01	0	100	0	CLP
PID=0.0ppm	3.0	⊗ M00TS01S03D3.0 (1015) east end TS01	0	100	0	on site
PID=0.0ppm	3.0	⊗ M00TS01S04D3.0 (1015) east end TS01	0	100	0	CLP

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/26/94 / 09:45
DATE/TIME FINISHED 09/26/94 / 10:30
COORDINATES -3817.01, -3238.54
ELEVATION AND DATUM 10.06
TRENCH ORIENTATION W-E

TRENCH NUMBER M00TS01
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 15 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, moist, loose, subrounded, SP (minor amounts of medium-grained sand sized shell fragments).		
1							1
2							2
3	M00TS01S03 M00TS01S04	0 0					3
4	M00TS01S01 M00TS01S02	0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS02	Project Number: 110190136	Elevation and Datum:	Location: Background 02
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-26-94 (1130)	Date and Time Completed: 9-26-94 (1150)
Equipment Type: Bobcat 743B	Trench Orientation: W-E	Total Depth: 3.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		Surface soil description on SS sample log				
		sheet				
PID=0.0ppm		⊗ M00TS02S01D3.0 (1140) west end	0	100	0	clean beach sand
PID=0.0ppm		⊗ M00TS02S02D3.0 (1140) west end	0	100	0	clean beach sand
PID=0.0ppm		⊗ M00TS02S03D2.0 (1150) east end	0	100	0	clean beach sand
PID=0.0ppm		⊗ M00TS02S04D2.0 (1150) east end	0	100	0	clean beach sand

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/26/94 / 11:30
DATE/TIME FINISHED 09/26/94 / 11:50
COORDINATES -3246.09, -2834.93
ELEVATION AND DATUM 10.51
TRENCH ORIENTATION W-E

TRENCH NUMBER M00TS02
TOTAL DEPTH 3 ft.
TRENCH LENGTH & WIDTH 10 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				PT	ORGANIC SILT, weak red, 2.5 Y 5/2, organics mixed with sand, bones, and plastic, PT	Grass, bones and plastic were found on the surface.	
				SP	CORAL SAND, fine-to medium-grained, pale yellow, 2.5 Y 8/4, moist, loose, subrounded, SP (minor medium-grained sand sized shell fragments).		
1							1
2	M00TS02S03 M00TS02S04	0 0					2
3	M00TS02S01 M00TS02S02	0 0					3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS03	Project Number: 110190136	Elevation and Datum:	Location: Background 03
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-26-94 (1430)	Date and Time Completed: 9-26-94 (1510)
Equipment Type: Bobcat 743B	Trench Orientation: N-S	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
PID=0.0ppm	2.0	⊗ M00TS03S01D2.0 north end	0	95	5	
PID=0.0ppm	2.0	⊗ M00TS03S02D2.0 north end	0	95	5	
PID=0.0ppm	2.0	⊗ M00TS03S03D2.0 south end	0	95	5	
PID=0.0ppm	2.0	⊗ M00TS03S04D2.0 south end	0	95	5	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/26/94 / 14:30
DATE/TIME FINISHED 09/26/94 / 15:10
COORDINATES 949.18, -433.67
ELEVATION AND DATUM 3.69
TRENCH ORIENTATION N-S

TRENCH NUMBER M00TS03
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 10 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	SILTY SAND, fine-grained, brown, 2.5 Y 4/2, moist, loose, SP (with 25% organics).	Thick grass on the surface.	
1				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, moist to wet, loose, subrounded, SP.		1
2	M00TS03S01 M00TS03S02 M00TS03S03 M00TS03S04	0 0 0 0					2
3						First, water encountered at 3.5 ft.	3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS04	Project Number: 110190136	Elevation and Datum:	Location: Background 04
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-26-94 (1620)	Date and Time Completed: 9-26-94 (1700)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
PID=0.0ppm	3.0	⊗ M00TS04S01D3.0 east end	5	95	0	
PID=0.0ppm	3.0	⊗ M00TS04S02D3.0 east end	5	95	0	
PID=0.0ppm	2.0	⊗ M00TS04S03D2.0 west end	5	95	0	
PID=0.0ppm	2.0	⊗ M00TS04S04D2.0 west end	5	95	0	
		1st 1.0 ft. - 10 YR 3/2				
		below 1.0 ft. - 2.5 Y 8/3				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/26/94 / 16:20
DATE/TIME FINISHED 09/26/94 / 17:00
COORDINATES -1710.16, 1163.61
ELEVATION AND DATUM 5.53
TRENCH ORIENTATION E-W

TRENCH NUMBER M00TS04
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 10 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	SILTY SAND, fine-grained, brown, 10 YR 3/2, moist, loose, SP (with 30% organics).	Thick grass on the surface.	
				SP	CORAL SAND, fine- to medium-grained, very pale brown, 10 YR 7/4, moist to wet, loose, subrounded, SP (with 5% silt, 5% medium sand sized shell fragments, 1% coral gravels, and larger cobbles).		
1							1
2	M00TS04S03 M00TS04S04	0 0					2
3	M00TS04S01 M00TS04S02	0 0				First, water encountered at 3 ft.	3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS05	Project Number: 110190136	Elevation and Datum:	Location: Eastern I BG05
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-28-94 (1430)	Date and Time Completed: 9-28-94 (1455)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 15 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
						Description taken __ feet from
						__ end of trench.
PID=0.0ppm	3.5	⊗ M00TS05S01D3.5 (1440) south end TS05	0	100	0	on site
PID=0.0ppm	3.5	⊗ M00TS05S02D3.5 (1440) south end TS05	0	100	0	CLP
PID=0.0ppm	3.0	⊗ M00TS05S03D3.0 (1450) north end TS05	0	100	0	on site
PID=0.0ppm	3.0	⊗ M00TS05S04D3.0 (1450) north end TS05	0	100	0	CLP

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/28/94 / 14:30
DATE/TIME FINISHED 09/28/94 / 14:55
COORDINATES -2498.94, 13162.18
ELEVATION AND DATUM 7.23
TRENCH ORIENTATION S-N

TRENCH NUMBER M00TS05
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 15 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, very pale brown, 10 YR 8/4, slightly moist, loose, well sorted, SP.		
1				SP	CORAL SAND, coarse-grained, very pale brown, 10 YR 8/4, slightly moist, loose, well graded, SP (with 15%, coral gravels).		1
				SP	Same as first foot, SP.		
2				SP	Same as 1 foot coarse-grained layer, SP.		2
				SP	Same as first foot, SP.		
3	M00TS05S03 M00TS05S04	0 0					3
	M00TS05S01 M00TS05S02	0 0					
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS06	Project Number: 110190136	Elevation and Datum:	Location: Background BG06
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 9-29-94 (1500)	Date and Time Completed: 9-29-94 (1700)
Equipment Type: Bobcat 743B	Trench Orientation: NW-SE	Total Depth: 5	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin / 9-29-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0 - 1.0	Slightly silty, pebbles and sand, 10 YR 8/2, SP	10	75	15	
	1.0 - 2.0	Slightly silty, coral sand, with cobbles (30%),	10	75	15	
		10 YR 3/6, SP				
	2.0 - 5.0	Coral sand, well sorted, slightly moist at				
		depth, 10 YR 8/4, SW				
		⊗ M00TS06S01D				
		⊗ M00TS06S02D				
		⊗ M00TS06S03D				
		⊗ M00TS06S04D				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/29/94 / 15:00
DATE/TIME FINISHED 09/29/94 / 17:00
COORDINATES 312.91, 17299.52
ELEVATION AND DATUM 8.73
TRENCH ORIENTATION NW-SE

TRENCH NUMBER M00TS06
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 12 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	SILTY CORAL SAND, fine-grained, very pale brown, 10 YR 8/2, dry loose, subangular, SP.		
1				SP	CORAL SAND, fine- to medium-grained, dark yellowish brown, 10 YR 3/6, dry, loose, poorly sorted, subangular, SP (with coral gravel).		1
2				SW	CORAL SAND, fine- to medium-grained, very pale brown, 10 YR 8/4, slightly moist, loose, well sorted, SW.		2
3							3
4							4
5	M00TS06S01 M00TS06S02 M00TS06S03 M00TS06S04	0 0 0 0					5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M00TS07	Project Number: 110190136	Elevation and Datum:	Location: Eastern I - BG07
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 9-30-94 (1120)	Date and Time Completed: 9-30-94 (1200)
Equipment Type: Bobcat 743B	Trench Orientation: NW-SE	Total Depth: 5 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: ~18 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin 9-30-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0-0.5	Silty medium sand, angular coral fragments,	0	70	30	
		high organic content (roots), 5 YR 2.5/1				
	0.5-3.0	Slightly silty med sand, angular coral	0	90	10	
		fragments, 10 YR 8/2				
	3.0-5.0	Slightly silty sand (poorly sorted), with some	10	80	10	
		gravel & cobbles, slightly moist, 7.5 YR 7/2				
		⊗ M00TS07S01D4.5				on site
		⊗ M00TS07S02D4.5				CLP
		⊗ M00TS07S03D4.5				on site
		⊗ M00TS07S04D4.5				CLP

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/30/94 / 11:20
DATE/TIME FINISHED 09/30/94 / 12:00
COORDINATES -2015.10, 17595.61
ELEVATION AND DATUM 8.86
TRENCH ORIENTATION NW-SE

TRENCH NUMBER M00TS07
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 12 ft. x 18 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	SILTY CORAL SAND, medium-grained, black, 5 YR 2.5/1, poorly sorted, SP (with high organic contents).		
				SP	SILTY CORAL SAND, medium-grained, brown, 10 YR 3/6, poorly sorted, SP (with minor amounts fines and larger coral fragments).		
1							1
2							2
3				SP	SILTY CORAL SAND, fine- to medium-grained, pinkish gray, 7.5 YR 7/2, slightly moist, loose, poorly sorted, subangular, SP (with some coral gravel).		3
4							4
	M00TS07S01	0					
	M00TS07S02	0					
	M00TS07S03	0					
	M00TS07S04	0					
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS01	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-22-94 (1300)	Date and Time Completed: 9-22-94 (1330)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 5.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 15 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
		Grass and sand - surface				
PID=0.0ppm	4.0	⊗ M02TS01S01D4.0 (1315) east end TS01				
PID=0.0ppm	4.0	⊗ M02TS01S02D4.0 (1315) east end TS01				
PID=0.0ppm	4.5	⊗ M02TS01S03D4.5 (1335) west end TS01				
PID=0.0ppm	4.5	⊗ M02TS01S04D4.5 (1335) west end TS01				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/22/94 / 13:00
DATE/TIME FINISHED 09/22/94 / 13:30
COORDINATES -1120.71, 6126.01
ELEVATION AND DATUM 9.70
TRENCH ORIENTATION E-W

TRENCH NUMBER M02TS01
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 15 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, slightly moist, loose, well sorted, SP (with some coral gravel and cobbles).		
1							1
2							2
3							3
4	M02TS01S01 M02TS01S02 M02TS01S03 M02TS01S04	0 0 0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS02	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill/rusted drums
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-22-94 (1425)	Date and Time Completed: 9-22-94 (1515)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 15 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
						Description taken _ feet from
						_ end of trench.
PID=0.0ppm	4.0	⊗ M02TS02S01D4.0 south end	0	100	0	
PID=0.0ppm	4.0	⊗ M02TS02S02D4.0 south end	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS02S03D2.0 north end	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS02S04D2.0 north end critical sample	0	100	0	
		PID headspace = 0.0 ppm				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/22/94 / 14:25
DATE/TIME FINISHED 09/22/94 / 15:15
COORDINATES -1391.01, 5453.42
ELEVATION AND DATUM 5.37
TRENCH ORIENTATION S-N

TRENCH NUMBER M02TS02
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 15 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				PT	DECOMPOSED WOOD, decomposed iron wood tree organics, dark brown, 10 YR 2/2, loose, slightly moist, with 5% sand, PT.	Metal scraps, cans and plastic found at the surface.	
				SP	CORAL SAND, fine- to coarse-grained, pale yellow, 2.5 Y 8/2, moist to wet, densely packed, poorly sorted, sub angular, SP (with abundent coral gravel).		
1							1
2	M02TS02S03 M02TS02S04	0 0					2
3							3
4	M02TS02S01 M02TS02S02	0 0				First, water encountered at 4 ft.	4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS03	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-21-94 (0915)	Date and Time Completed: 9-21-94 (1010)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 3.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 15 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
		Heavily vegetated with grass and shrubs				
		2 in. organics at surface				
PID=0.0ppm	2.0	⊗ M02TS03S01D2.0 (0930) south end				
PID=0.0ppm	2.0	⊗ M02TS03S02D2.0 (0930)south end-critical sample				
PID=0.0ppm	2.0	⊗ M02TS03S03D2.0 (1005) north end				
PID=0.0ppm	2.0	⊗ M02TS03S04D2.0 (1005) north end				
		PID bucket of bobcat 0.3 ppm				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/21/94 / 09:15
DATE/TIME FINISHED 09/21/94 / 10:10
COORDINATES -1267.91, 4951.05
ELEVATION AND DATUM 6.02
TRENCH ORIENTATION S-N

TRENCH NUMBER M02TS03
TOTAL DEPTH 3 ft.
TRENCH LENGTH & WIDTH 15 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, pale yellow, 2.5 Y 6/3, dry, loose, fine-grained, SP (with coral cobbles and landfill debris).	Heavily vegitated with grass and shrubs at the surface and 2 inches of organics at the surface.	
1							1
2	M02TS03S01 M02TS03S02 M02TS03S03 M02TS03S04	0 0 0 0				Scattered garbage throughout, bottles, plastic - landfill waste.	2
3							3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS04	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-23-94 (0803)	Date and Time Completed: 9-23-94 (0820)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 4.5 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 16 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		Iron wood tree roots - first 4.5 ft. BGS				
PID=0.0ppm	4.5	⊗ M02TS04S01D4.5 south end of TS04	0	100	0	
PID=0.0ppm	4.5	⊗ M02TS04S02D4.5 south end of TS04	0	100	0	
PID=0.0ppm	4.0	⊗ M02TS04S03D4.0 north end	0	100	0	
PID=0.0ppm	4.0	⊗ M02TS04S04D4.0 north end-critical sample	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/23/94 / 08:03
DATE/TIME FINISHED 09/23/94 / 08:20
COORDINATES -1644.08, 5238.04
ELEVATION AND DATUM 6.58
TRENCH ORIENTATION S-N

TRENCH NUMBER M02TS04
TOTAL DEPTH 4.5 ft.
TRENCH LENGTH & WIDTH 16 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, pale yellow, 2.5 Y 8/4, moist, compactable, fine-grained, little to no coral gravel, SP.		
						Iron wood tree roots were found.	
1							1
2							2
3							3
4	M02TS04S03 M02TS04S04	0 0					4
	M02TS04S01 M02TS04S02	0 0					
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS05	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-21-94 (1310)	Date and Time Completed: 9-21-94 (1340)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 2.5 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 14 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		Iron wood needles at surface				
PID=0.0ppm	2.0	⊗ M02TS05S01D2.0 south end of trench	0	100	0	
		middle of heap				
PID=0.0ppm	2.0	⊗ M02TS05S02D2.0 north end toe of heap	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS05S03D2.0 south end middle of heap	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS05S04D2.0 north end toe of pile	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/21/94 / 12:10
DATE/TIME FINISHED 09/21/94 / 13:40
COORDINATES -1272.68, 4478.74
ELEVATION AND DATUM 8.82
TRENCH ORIENTATION S-N

TRENCH NUMBER M02TS05
TOTAL DEPTH 2.5 ft.
TRENCH LENGTH & WIDTH 14 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SM	SILTY CORAL SAND, gray, 10 YR 4/1, moist, loose with abundant coral 15% silt, SM.	Iron wood neddles and metal cable at the surface.	
1							1
2	M02TS05S01 M02TS05S02 M02TS05S03 M02TS05S04	0 0 0 0		GP	CORAL GRAVEL, pale yellow, 10 YR 8/2, GP.	Abundant roots found.	2
3							3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS06	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-23-94 (1025)	Date and Time Completed: 9-23-94 (1050)
Equipment Type: Bobcat 743B	Trench Orientation: W-E	Total Depth: 4.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 18 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
PID=0.0ppm	4.0	⊗ M02TS06S01D4.0 (1035) west end	0	100	0	
PID=0.0ppm	4.0	⊗ M02TS06S02D4.0 (1035) west end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS06S03D3.0 (1050) east end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS06S04D3.0 (1050) east end	0	100	0	
		critical sample to be sent off site				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/23/94 / 10:25
DATE/TIME FINISHED 09/23/94 / 10:50
COORDINATES -1997.17, 4369.99
ELEVATION AND DATUM 13.85
TRENCH ORIENTATION W-E

TRENCH NUMBER M02TS06
TOTAL DEPTH 4.0 ft.
TRENCH LENGTH & WIDTH 18 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				GP	CORAL GRAVEL, fine- to medium-grained, pale yellow, 2.5 Y 8/4, dry, loose, 25% larger coral cobbles and coral gravel, GP.	Iron wood tree roots found.	
1							1
				SP	CORAL SAND, pale yellow 2.5 Y 8/3, dry, loose, well sorted, fine-grained with 5% coral gravel, SP.	Plastic found.	
2							2
3	M02TS06S03 M02TS06S04	0 0					3
4	M02TS06S01 M02TS06S02	0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS07	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-23-94 (0930)	Date and Time Completed: 9-23-94 (0955)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 4.0	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 18 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
PID=0.0ppm	4.0	⊗ M02TS07S01D4.0 east end	0	100	0	
PID=0.0ppm	4.0	⊗ M02TS07S02D4.0 east end	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS07S03D2.0 (0955) west end	0	100	0	
PID=0.0ppm	2.0	⊗ M02TS07S04D2.0 (0955) west end	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/23/94 / 09:30
DATE/TIME FINISHED 09/23/94 / 09:55
COORDINATES -1695.28, 4208.23
ELEVATION AND DATUM 16.19
TRENCH ORIENTATION E-W

TRENCH NUMBER M02TS07
TOTAL DEPTH 4.0 ft.
TRENCH LENGTH & WIDTH 18 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/3, dry, slightly moist, loose, 5% coral, SP.	Iron wood tree roots found in first 2 ft. and organics on surface.	
1							1
2	M02TS07S03 M02TS07S04	0 0					2
3							3
4	M02TS07S01 M02TS07S02	0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS08	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-22-94 (0900)	Date and Time Completed: 9-22-94 (0930)
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 5 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 18 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
PID=0.0ppm	3.0	⊗ M02TS08S01D3.0 south end	0	100	0	on site
PID=0.0ppm	3.0	⊗ M02TS08S02D3.0 south end	0	100	0	off site / metals
PID=0.0ppm	4.0	⊗ M02TS08S03D4.0 north end	0	100	0	on site
PID=0.0ppm	4.0	⊗ M02TS08S04D4.0 north end	0	100	0	off site / metals

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/22/94 / 09:00
DATE/TIME FINISHED 09/22/94 / 09:30
COORDINATES -1493.38, 4147.62
ELEVATION AND DATUM 8.44
TRENCH ORIENTATION S-N

TRENCH NUMBER M02TS08
TOTAL DEPTH 5.0 ft.
TRENCH LENGTH & WIDTH 18 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, pale yellow, 10 YR 8/2, fine-to medium-grained, poorly sorted, SP.	One inch steel pipe found at surface. First three feet, landfill debris, glass, plastic and lead wire.	
1							1
2							2
3	M02TS08S01 M02TS08S02	0 0					3
4	M02TS08S03 M02TS08S04	0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M02TS09	Project Number: 110190136	Elevation and Datum:	Location: Runway Landfill
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-21-94 (1515)	Date and Time Completed: 9-21-94 (1545)
Equipment Type: Bobcat 743B	Trench Orientation: W-E	Total Depth: 3.5 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 18 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
		Iron wood organics at surface				
		2.5 Y 8/3				
PID=0.0ppm	3.0	⊗ M02TS09S01D3.0 (1500) west end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS09S02D3.0 (1500) west end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS09S03D3.0 (1515) east end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS09S04D3.0 (1500) west end	0	100	0	
PID=0.0ppm	3.0	⊗ M02TS09S05D3.0 (1515) east end	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/21/94 / 15:15
DATE/TIME FINISHED 09/21/94 / 15:45
COORDINATES -1233.12, 4054.96
ELEVATION AND DATUM 4.97
TRENCH ORIENTATION W-E

TRENCH NUMBER M02TS09
TOTAL DEPTH 3.5 ft.
TRENCH LENGTH & WIDTH 18 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/3, moist, loose, with coral gravel and cobbles, SP.	Iron wood needles and organics found at first 2 in. of surface.	
1							1
2							2
3	M02TS09S01 M02TS09S02 M02TS09S03 M02TS09S04	0 0 0 0					3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M07TS01	Project Number: 110190136	Elevation and Datum:	Location: Frigate Point
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-19-94 (1510)	Date and Time Completed: 9-19-94 (1540)
Equipment Type: Bobcat 743B	Trench Orientation: W-E	Total Depth: 6.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 20 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
PID = 1.0 ppm	6.0	⊗ M07TS01S01D6.0 (1550) west end	0	100	0	
PID = 1.0 ppm	6.0	⊗ M07TS01S02D6.0 (1550) west end	0	100	0	
	2.0	⊗ M07TS01S03D2.0 (1615) east end	0	100	0	
	2.0	⊗ M07TS01S04D2.0 (1615) east end	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/19/94 / 15:10
DATE/TIME FINISHED 09/19/94 / 15:40
COORDINATES -6126.38, -3936.60
ELEVATION AND DATUM 14.33
TRENCH ORIENTATION W-E

TRENCH NUMBER M07TS01
TOTAL DEPTH 6 ft.
TRENCH LENGTH & WIDTH 20 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, pale yellow, 2.5 Y 6/1, dry, loose, poorly sorted, SP (with 10% organics).	Rusted drums at surface.	
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, dry, loose, poorly sorted, SP.		
1							1
2	M07TS01S03 M07TS01S04	0 0					2
3							3
4							4
5							5
6	M07TS01S01 M07TS01S02	0 0					6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M07TS02	Project Number: 110190136	Elevation and Datum:	Location: Frigate Point
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-20-94 (0810)	Date and Time Completed: 9-20-94 (0900)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 3.0 ft.	Total Number of Samples: 4

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: 18 in.	No. of Samples	Bulk	Grab 4	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
PID=0.0ppm	3.0	⊗ M07TS02S01D3.0 analytical sample - east end	0	100	0	
PID=0.0ppm	3.0	⊗ M07TS02S02D3.0 analytical sample - east end	0	100	0	
PID=0.0ppm	3.0	⊗ M07TS02S03D3.0 analytical sample - west end	0	100	0	
PID=0.0ppm	3.0	⊗ M07TS02S04D3.0 analytical sample - west end	0	100	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/20/94 / 08:10
DATE/TIME FINISHED 09/20/94 / 09:00
COORDINATES -6193.21, -3835.88
ELEVATION AND DATUM 15.30
TRENCH ORIENTATION E-W

TRENCH NUMBER M07TS02
TOTAL DEPTH 3 ft.
TRENCH LENGTH & WIDTH 12 ft. x 18 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, pale yellow, 2.5 Y 6/1, dry, loose, with brown organics, silt, SP.		
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, dry, loose, SP (minor amounts of organics, and shell fragments).		
1							1
2							2
3	M07TS02S01 M07TS02S02 M07TS02S03 M07TS02S04	0 0 0 0					3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M07TS03	Project Number: 110190136	Elevation and Datum:	Location: Frigate Point drums
Equipment Supplier: PMC	Operator: Shim G.	Date and Time Started: 9-20-94	Date and Time Completed: 9-20-94
Equipment Type: Bobcat 743B	Trench Orientation: S-N	Total Depth: 3.0 ft.	Total Number of Samples: 5

Bucket Width: 18 in.	Trench Length: 30 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 5	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
PID=0.0ppm	2.0	⊗ M07TS03S01D2.0 north end				
PID=0.0ppm	2.0	⊗ M07TS03S02D2.0 south end under drums				
PID=0.0ppm	2.0	⊗ M07TS03D02D2.0 south end under drums				
PID=0.0ppm	2.0	⊗ M07TS03S03D2.0 north end				
PID=0.0ppm	2.0	⊗ M07TS03S04D2.0 south end under drums				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/20/94 /
DATE/TIME FINISHED 09/20/94 /
COORDINATES -6236.06, -3913.37
ELEVATION AND DATUM 13.50
TRENCH ORIENTATION S-N

TRENCH NUMBER M07TS03
TOTAL DEPTH 3 ft.
TRENCH LENGTH & WIDTH 30 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine-grained, gray, 2.5 Y 6/1, dry loose, dirt and paper, SP (with silty organics).	Decomposed drums, very rusted at surface.	
				SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5 Y 8/4, dry, loose, SP.		
1							1
2	M07TS03S01 M07TS03S02 M07TS03S03 M07TS03S04	0 0 0 0					2
3							3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI

Trench Number: M98TS01	Project Number: 110190136	Elevation and Datum:	Location: Northwest Drum Disposal
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-10-94 (0930)	Date and Time Completed: 10-10-94 (1015)
Equipment Type: Bobcat 743B	Trench Orientation: ~ N-S	Total Depth: 4.0 ft.	Total Number of Samples: 3

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 3	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
PID=0.0ppm	4.0	⊗ M98TS01S01 (1000) north end	0	100	0	off site
PID=0.0ppm	1.0	⊗ M98TS01S02 (1010) south end	0	100	0	off site
PID=0.0ppm	1.0	⊗ M98TS01D02 (1010) south end	0	100	0	duplicate

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/10/94 / 09:30
DATE/TIME FINISHED 10/10/94 / 10:15
COORDINATES .
ELEVATION AND DATUM
TRENCH ORIENTATION N-S

TRENCH NUMBER M98TS01
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 12 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Rukssel O'Malia
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine-grained, dusky yellow, 2.5 Y 6/2, dry, loose, with minor amounts of gray organic silt, SP.		
1	M98TS01S02	0		SP	CORAL SAND, fine-grained, pale yellow, 2.5 Y 10/4, well sorted, moist, loose, SP (minor amounts of organic silts in first foot).		1
2							2
3							3
4	M98TS01S01	0				First water encountered at 3.8 ft.	4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M10TS01	Project Number: 110190136	Elevation and Datum:	Location: Northeastern Disposal - Eastern Island
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 10-03-94 (0930)	Date and Time Completed: 10-03-94 (1200)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 5 ft.	Total Number of Samples: 9

Bucket Width: 18 in.	Trench Length: 5 ft.	Trench Width: 24 in./30 in.	No. of Samples	Bulk	Grab 9	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
		Mixed trash and debris, steel				
	0-1.5	Slightly silty sand with pebbles, angular coral	5	85	10	
		sand, with some roots, very loose, no moisture,				
		SP, 10YR 7/3, mixed with debris and trash				
	1.5-2.5	Slightly silty sand with pebbles (angular coral),	5	85	10	
		dry, 10 YR 8/2, very loose, SP				
	2.5-4	Poorly sorted sand with pebbles and cobbles,	15	85	0	
		7.5 YR 7/3, slightly moist, very loose material,				
		SP				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/03/94 / 09:30
DATE/TIME FINISHED 10/03/94 / 12:00
COORDINATES 1247.412, 17125.13
ELEVATION AND DATUM 11.0
TRENCH ORIENTATION E-W

TRENCH NUMBER M10TS01
TOTAL DEPTH 5.0 ft.
TRENCH LENGTH & WIDTH 5 ft. x 30 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
1				SP	CORAL SAND, fine- to coarse-grained, very pale brown, 10 YR 7/3, dry, loose, poorly sorted, angular, SP (with some coral gravel and roots).	Mixed trash, steel and debris found on the surface.	1
2				SP	CORAL SAND, fine- to medium-grained, very pale brown, 10 YR 8/2, dry, loose, angular, SP.		2
3				SP	CORAL SAND, fine- to coarse-grained, pink, 7.5 YR 7/3, slightly moist, loose, angular, poorly sorted, SP (with some coral gravel).		3
4	M10TS01S01 M10TS01S02 M10TS01S03 M10TS01S04	0 0 0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M10TS02	Project Number: 110190136	Elevation and Datum:	Location: Disposal Area, NE Point, Eastern Island
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 9-30-94 (1315)	Date and Time Completed: 9-30-94 (1440)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 4.5 ft.	Total Number of Samples: 9

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 30 in. max	No. of Samples	Bulk	Grab 9	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Allan Martin 9-30-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0.0-4.5	Slightly silty mixed size coral, angular sand,	0	95	5	
		poorly sorted, slightly moist, 10 YR 7/2, SP				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/30/94 / 13:15
DATE/TIME FINISHED 09/30/94 / 14:40
COORDINATES 1097.61, 17147.05
ELEVATION AND DATUM 12.60
TRENCH ORIENTATION E-W

TRENCH NUMBER M10TS02
TOTAL DEPTH 4.5 ft.
TRENCH LENGTH & WIDTH 10ft. x 30 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, light gray, 10 YR 7/2, loose, poorly sorted, angular, SP (with some fines).		
1							1
2							2
3							3
4	M10TS02S03 M10TS02S04	0 0					4
	M10TS02S01 M10TS02S02	0 0					
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI

Trench Number: M10TS03	Project Number: 110190136	Elevation and Datum:	Location: Disposal Area, NE Point, Eastern Island
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 9-30-94 (1525)	Date and Time Completed: 9-30-94 (1645)
Equipment Type: Bobcat 743B	Trench Orientation: N-S	Total Depth: 5.0 ft.	Total Number of Samples: 11

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 11	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Allan Martin 9-30-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0-0.5	Slightly silty, poorly sorted, angular coral sand,	0	95	5	
		SP, 10 YR 8/2				
	0.5-1.5	As above 10 YR 7/3				
	1.5-2.5	As above 10 YR 8/2				
	2.5-5	As above 2.5 Y 8/1				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 09/30/94 / 15:25
DATE/TIME FINISHED 09/30/94 / 16:45
COORDINATES 1331.81, 16937.91
ELEVATION AND DATUM 10.20
TRENCH ORIENTATION N-S

TRENCH NUMBER M10TS03
TOTAL DEPTH 5.0 ft.
TRENCH LENGTH & WIDTH 12ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 09/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine-grained, very pale brown, 10 YR 7/3, poorly sorted, angular, SP (with some fines).		
				SP	Same as above, except very pale brown 10YR 7/3.		
1							1
				SP	Same as above, except very pale brown 10YR 8/2.		
2							2
				SP	Same as above, except white 2Y 8/1.		
3							3
4	M10TS03S01 M10TS03S02	0 0					4
5	M10TS03S03 M10TS03S04	0 0					5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M10TS04	Project Number: 110190136	Elevation and Datum:	Location: Northeastern Disposal Area
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 10-03-94 (1230)	Date and Time Completed: 10-03-94 (1350)
Equipment Type: Bobcat 743B	Trench Orientation: ~ N-S	Total Depth: 4.0 ft. BGS	Total Number of Samples: 9

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 30 in.	No. of Samples	Bulk	Grab 9	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin 10-03-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0-0.25	Packed coral pebbles and cobbles, GP				
	0.25-4	Slightly silty, sand with coral pebbles and few	10	80	10	
		cobbles, angular coral sands, poorly sorted,				
		organics in top 10 in., very loose, with little				
		moisture, trench walls collapsing very easy,				
		SP, 7.5 YR 7/3				
		Surface soil sample collected:				
		M10SS04S01D0.25				
		M10SS04S02D0.25				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/03/94 / 12:30
DATE/TIME FINISHED 10/03/94 / 13:50
COORDINATES 1328.84, 17140.34
ELEVATION AND DATUM 11.80
TRENCH ORIENTATION N-S

TRENCH NUMBER M10TS04
TOTAL DEPTH 4.0 ft.
TRENCH LENGTH & WIDTH 10ft. x 30 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				GP	CORAL GRAVEL, dry, loose packed coral pebbles and cobbles, GP.		
				SP	CORAL SAND, fine- to coarse-grained, pink, 7.5 YR 7/3, dry, loose, poorly sorted, angular, SP (with organic silt top 10 inches, coral gravel).	Trench walls colapsing very easily.	
1							1
2							2
3							3
4	M10TS04S01 M10TS04S02 M10TS04S03 M10TS04S04	0 0 0 0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M11TS01	Project Number: 110190136	Elevation and Datum:	Location: Southwest Disposal Area
Equipment Supplier: PMC	Operator: Shim Garrett	Date and Time Started: 10-05-94 (0850)	Date and Time Completed: 10-05-94 (1015)
Equipment Type: Bobcat 743B	Trench Orientation: N-S	Total Depth: 5.0	Total Number of Samples: 2

Bucket Width: 18 in.	Trench Length: 13 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 2	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin 10-05-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0-0.25	Mixed sand and coral gravel - roots	50	50	0	
		some cobbles, GP, 10 YR 8/3, v. pale brown				
	0.25-1.0	Silty sand, med-grained, with few pebbles,	10	50	40	
		loose, partially cemented, dry, SM, 10 YR 8/2,				
		white				
	1.0-5.0	Silty sand, poorly sorted angular coral,	10	60	30	
		with pebbles and few cobbles, loose, slightly				
		moist, v. pale brown, SP, 10 YR 8/3				
		⊗ M11TS01S01D004.5 - south				
		⊗ M11TS01S02D004.5 - north				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/05/94 / 08:50
DATE/TIME FINISHED 10/05/94 / 10:15
COORDINATES -2519.05, 12202.73
ELEVATION AND DATUM 7.58
TRENCH ORIENTATION N-S

TRENCH NUMBER M11TS01
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 13 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Shim Garrett/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				GP	SANDY CORAL GRAVEL, pale brown, 10 YR 8/3, dry, loose, GP (with some roots coral gravel).		
				SM	SILTY SAND, medium-grained, white, 10 YR 8/2, dry, partially cmented, SM (with some coral gravel).		
1				SP	SILTY SAND, medium-grained, pale brown, 10 YR 8/3, slightly moist, loose, poorly sorted, angular, SP.		1
2							2
3							3
4							4
	M11TS01S01 M11TS01S02	0 0					
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M11TS02	Project Number: 110190136	Elevation and Datum:	Location: Southwest Disposal Area
Equipment Supplier: PMC	Operator: Dean McClure	Date and Time Started: 10-05-94 (1230)	Date and Time Completed: 10-05-94 (1330)
Equipment Type: Bobcat 743B	Trench Orientation: E-W	Total Depth: 4.5 ft.	Total Number of Samples: 2

Bucket Width: 18 in.	Trench Length: 10 ft.	Trench Width: 24 in.-30 in.	No. of Samples	Bulk	Grab 2	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Alan Martin 10-05-94

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
	0-0.25	Fine- to med-grained sand, with some coral	5	95	0	
		gravel, roots mixed with sand, 10 YR 8/2,				
		white, SP				
	0.25-1.5	Poorly sorted, angular, coral sand, with few	10	90	0	
		pebbles, very loose, intermixed with roots, SP,				
		10 YR 8/3, v. pale brown				
	1.5-4.5	As above, no roots, slightly moist, SP	10	90	0	
		⊗ M11TS02S01D0040 - west				
		⊗ M11TS02S02D0050 - east				
		M11QS02D01D0050 - east				

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/05/94 / 12:30
DATE/TIME FINISHED 10/05/94 / 13:30
COORDINATES -2373.55, 12184.47
ELEVATION AND DATUM 8.78
TRENCH ORIENTATION E-W

TRENCH NUMBER M11TS02
TOTAL DEPTH 5 ft.
TRENCH LENGTH & WIDTH 10 ft. x 30 ft.
EQUIPMENT OPERATOR/SUPPLIER Dean McClure/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Alan Martin 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	CORAL SAND, fine- to medium-grained, white, 10 YR 8/2, with some coral gravel, roots mixed with sand, SP.		
				SP	CORAL SAND, medium-grained, pale brown, 10 YR 8/3, dry, loose, angular, poorly sorted, SP (with some roots).		
1							1
				SP	SAME AS ABOVE, except no roots and slightly moist, SP.		
2							2
3							3
4	M11TS02S01	0					4
5	M11TS02S02	0					5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M54TS01	Project Number: 110190136	Elevation and Datum:	Location: Eastern Site 54
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-08-94 (0935)	Date and Time Completed: 10-08-94 (1030)
Equipment Type: Bobcat 743B	Trench Orientation: ~ W-E	Total Depth: 3 ft.	Total Number of Samples: 3

Bucket Width: 18 in.	Trench Length: 16 ft.	Trench Width: 20 in.	No. of Samples	Bulk	Grab 3	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	Est.% of S	Est.% of F	Comments
	0-0.4	Silt with debris, dusky brown, 10 YR 4/2, dry, loose, with minor amounts of sand and organics, PT	0	15	85	
	0.4-0.7	Asphalt, black, 7.5 YR 2.5/1, dry, stiff				
	0.7-1.5	Sand, fine- to coarse-grained, cream, 2.5 Y 8/2, dry, loose, poorly sorted, with minor amounts of larger coral gravel, SP	0	100	0	
	1.5-3.0	Gravel, brown, 7.5 YR 5/5, dry, loose, GM (100% angular (non eroded) coral pieces)	100	0	0	
PID=0.0ppm	3.0	⊗ M54TS01S01 (0950) west end	100	0	0	on site
PID=0.0ppm	3.0	⊗ M54TS01S02 (0955) west end	100	0	0	on site
PID=0.0ppm	3.0	⊗ M54TS01S03 (1000) west end	100	0	0	off site

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/08/94 / 09:35
DATE/TIME FINISHED 10/08/94 / 10:30
COORDINATES -1096.56, 17786.92
ELEVATION AND DATUM 8.50
TRENCH ORIENTATION E-W

TRENCH NUMBER M54TS01
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 16 ft. x 20 ft.
EQUIPMENT OPERATOR/SUPPLIER Russel O'Malia/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE J. Rock 2/91

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				PT	SILT with debris, dusky brown, 10YR 4/2, dry, loose, with minor amounts of sand and organics, PT.		
				AP	ASPHALT, black, 7.5YR 2.5/1, dry and stiff, AP.		
1				SP	CORAL SAND, fine- to coarse-grained, pale yellow, 2.5 Y 8/2, dry, loose, poorly sorted, with minor amounts of larger coral gravel, SP.		1
2				GM	CORAL GRAVEL, brown, 7.5 YR 5/5, dry, loose, GM [100% angular (non eroded) coral peices].		2
3	M54TS01S01 M54TS01S02 M54TS01S03	0 0 0					3
4							4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M54TS02	Project Number: 110190136	Elevation and Datum:	Location: Southeast Landfill
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-08-94	Date and Time Completed: 10-08-94 (1200)
Equipment Type: Bobcat 743B	Trench Orientation: ~ E-W	Total Depth: 4.0 ft.	Total Number of Samples: 3

Bucket Width: 18 in.	Trench Length: 12 ft.	Trench Width: 24 in.	No. of Samples	Bulk	Grab 3	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
		Silt, gray, 10 YR 4/1, dry, loose, PT	0	10	90	
		(organics and insulation material & land fill				
		debris - bottles, cans, metal)				
		Asphalt/Tar, black, 7.5 YR 2.5/1, dry, stiff,				
		massive				
		(looks like tar that was poured on surface and				
		soaked down 4-5 in. into the coral gravel)				
	4.0	⊗ M54TS02S01 east end	100	0	0	
	3.0	⊗ M54TS02S02 west end	100	0	0	
	3.0	⊗ M54TS02S03 west end	100	0	0	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/08/94 /
DATE/TIME FINISHED 10/08/94 / 12:00
COORDINATES -1072.89, 17833.91
ELEVATION AND DATUM 4.90
TRENCH ORIENTATION E-W

TRENCH NUMBER M54TS02
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 12 ft. x 24 ft.
EQUIPMENT OPERATOR/SUPPLIER Russel O'Malia/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				PT	SILT, gray, 10 YR 4/1, dry loose, PT (organics and insulation materials, landfill debris-bottles, cans, metals).		
				AP	ASPHALT/TAR, black, 7.5 YR 2.5/1, dry, stiff, massive, AP (looks like tar that was poured on surface and soaked down 4-5 ft. in to the coral gravel).		
				GW	CORAL GRAVEL, pale yellow, 2.5 Y 8/4, dry, loose, well graded, GW.		
1							1
2							2
3	M54TS02S02 M54TS02S03	0 0					3
4	M54TS02S01	0					4
5							5
6							6
7							7

OGDEN

Field Log of Trench

Project Name: Midway SI/RI			
Trench Number: M54TS03	Project Number: 110190136	Elevation and Datum:	Location: Eastern Island Site 54
Equipment Supplier: PMC	Operator: Russel O.	Date and Time Started: 10-08-94 (1250)	Date and Time Completed: 10-08-94 (1320)
Equipment Type: Bobcat 743B	Trench Orientation: ~ W-E	Total Depth: 4.0 ft.	Total Number of Samples: 3

Bucket Width: 18 in.	Trench Length: 16 ft.	Trench Width: 30 in.	No. of Samples	Bulk	Grab 3	Drive	Hand Auger

Geologist or Hydrogeologist/Date: Brian House

Soil Description

Lithology	Depth (ft.)	Soil Description	Est.% of G	S	F	Comments
PID=0.0ppm	3.0	⊗ M54TS03S01 west end	30	60	10	
PID=0.0ppm	3.0	⊗ M54TS03S02 west end	30	60	10	
PID=0.0ppm	4.0	⊗ M54TS03S03 (1320) east end	30	60	10	

OGDEN

CLIENT NAVY CLEAN
PROJECT NAME Midway SI/RI
PROJECT NUMBER 110190136
DATE/TIME STARTED 10/08/94 / 12:50
DATE/TIME FINISHED 10/08/94 / 13:20
COORDINATES -1064.56, 17887.94
ELEVATION AND DATUM 8.80
TRENCH ORIENTATION W-E

TRENCH NUMBER M54TS03
TOTAL DEPTH 4 ft.
TRENCH LENGTH & WIDTH 16 ft. x 30 ft.
EQUIPMENT OPERATOR/SUPPLIER Russel O'Malia/PMC
BUCKET WIDTH 18 in.
EQUIPMENT TYPE Bobcat 743B
GEOLOGIST/DATE Brian House 10/94
CHECKED BY/DATE

DEPTH feet	SAMPLE NUMBER	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	REMARKS	DEPTH feet
				SP	GRAVELLY CORAL SAND, fine- to coarse-grained, pale yellow, 10 YR 7/2, dry, loose, poorly sorted, SP (with 10% silt and 30% angular coral gravel).		
1						Bottle found.	1
2							2
3	M54TS03S01 M54TS03S02	0 0					3
4	M54TS03S03	0					4
5							5
6							6
7							7

Appendix F

APPENDIX F

BORING SOIL LOGS, WELL DEVELOPMENT LOGS, GROUNDWATER SAMPLING LOG

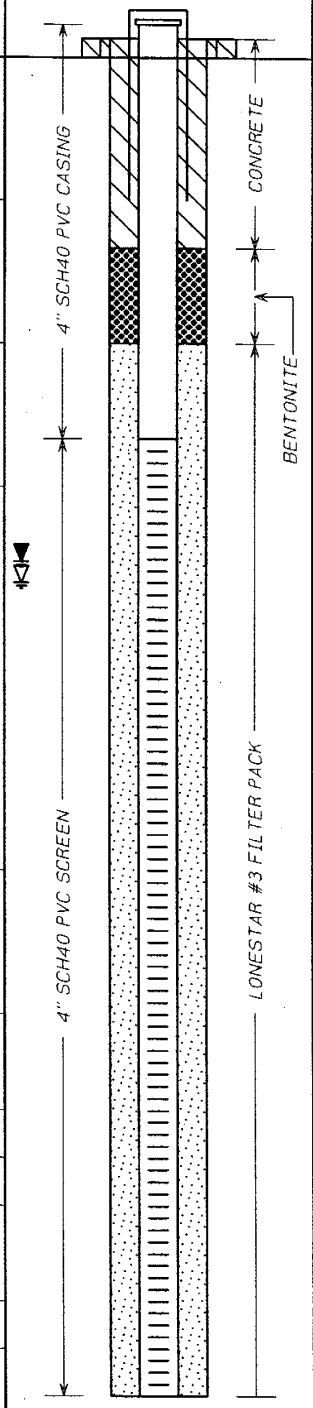
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/19/94 / 0835
DATE/TIME FINISHED 10/19/94 / 0935
COORDINATES -3884.27 N, 1635.32 E
ELEVATION AND DATUM 6.42 feet
TOP OF CASING ELEVATION 9.92 feet

BORING NUMBER M01BS01
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				04 08	0.0		SP	CORAL SAND, fine- to coase-grained, yellowish brown, 10YR 6/4, dry, loose, poorly sorted, subrounded, SP (with 5% organic silts, pieces of glass, roots, and one larger coral cobble).
2		65	M01BS01S01D2.5	09 07 25	0.0			silty CORAL SAND, fine- to medium-grained, dark bown, 10YR 4/2, moist, loose, poorly sorted, subrounded, SP (with wood fragments).
4		65	M01BS01S02D3.0	16 08 18	0.0			silty CORAL SAND, Same as above except very dark brown 10YR 3/1.
6		95		18/0"				NOTE: Refusal at 4.5 feet. Auger down to 8.5 feet. No samples.
8					0.0		SW	CORAL SAND, fine- to medium-grained, very dark brown, 10YR 3/1, saturated, loose, well sorted, subrounded to rounded, SW (with 4" hardened tar or burned rubber chunks at depth of 9.5 feet).
10		98		17 33 43 12	0.0			CORAL SAND, fine- to coarse-grained, gray, 2.5Y 5/1, saturated, loose, well sorted, rounded, SW
12		70		20 36 12 13	0.0			CORAL GRAVEL, pale yellow, 10YR 8/2, saturated, loose, angular, SW CORAL SAND, coarse-grained, pale yellow, 10YR 8/2, saturated, loose, well sorted, angular, SW CORAL SAND, same as above except fine-grained and rounded, SW
14		90		13 12	0.0		SW	NOTE: Refusal at 13.0. Auger down to 13.5 feet. No sample CORAL SAND, very fine-grained, yellow, 10YR 8/2, saturated, loose, well sorted, rounded, SW

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M01BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	95		09 18			SW	CORAL SAND, same as above except coarse-grained. END OF BORING at 15.0 feet below grade. Boring was completed on 10/19/94, at 0935 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

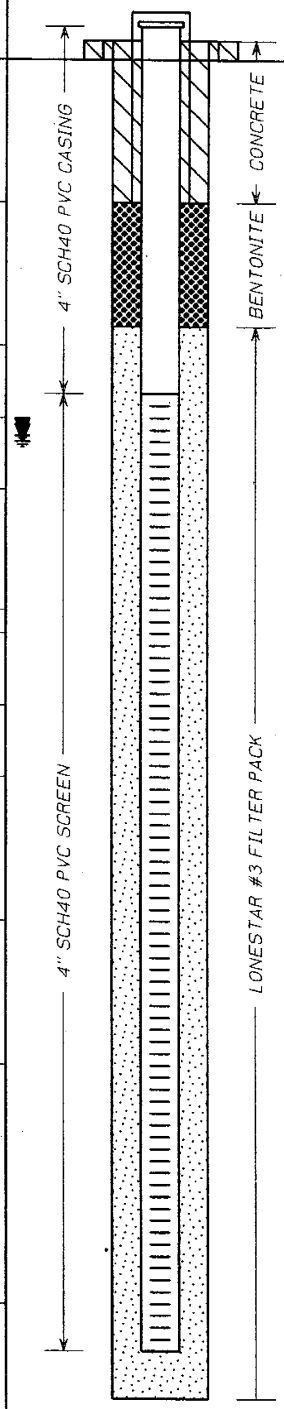
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/14/94 / 1415
DATE/TIME FINISHED 10/14/94 / 1540
COORDINATES -1398.80 N, 3993.23 E
ELEVATION AND DATUM 4.91 feet
TOP OF CASING ELEVATION 5.99 feet

BORING NUMBER M02BS05
COMPLETION DEPTH 14.5 ft.
BOREHOLE DIAMETER 6.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				03	0.0		SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 7/3, dry, loose, poorly sorted, SW.
			M02BS05S01D1.0	04				
		80	M02BS05S02D1.5	18	0.3			CORAL SAND, fine- to coarse-grained, pale brown, 10YR 8/2, moist, loose, SW (with some coral gravel).
2			M02BS05S04D2.0	14				
			M02BS05S03D2.5	16				
		95		18	0.0			CORAL SAND, fine- to coarse-grained, pale brown, 10YR 8/2, moist, loose, SW (with some coral gravel).
				17				
4				23			SP	Gravelly CORAL SAND, fine- to coarse-grained, light gray, 10YR 7/1, wet, loose, SP (with 30% subangular coral gravel chunks).
		60		29	0.0		SW	CORAL SAND, fine-grained, white, 10YR 8/1, wet, loose, well sorted, SW.
				15				
				25				
6		100		28	17.5		GP	CORAL GRAVEL, white, 10YR 8/1, well sorted, sub-rounded, GP.
				33			SW	CORAL SAND, fine-grained, white, 10YR 8/1, wet, loose, well sorted, SW.
				27			SP	Gravelly SAND, white, 10YR 8/1, wet, poorly sorted, SP (with larger subrounded-coral chunks and gravel).
		100		17	0.0		SW	CORAL SAND, fine-grained, white, 10YR 8/1, saturated, loose, well sorted, SW (with some coral gravel).
8				13				
				13				
		95		10	49.0			CORAL SAND, fine-grained, white, 10YR 8/1, saturated, loose, well sorted, SW.
				07				
10				05				
		100		11				Auger down to 13.0 feet. No samples taken
12								
					0.0		SW	CORAL SAND, fine-grained, white, 10YR 8/1, wet, loose, well sorted, SW.
				25				
14				20				

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M02BS05

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 14.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	100		19			SW	CORAL SAND, coarse grained, white, 10YR 8/1, wet, loose, well sorted, SW.		
								END OF BORING at 14.5 feet below grade. Boring was completed on 10/14/94, at 1540 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

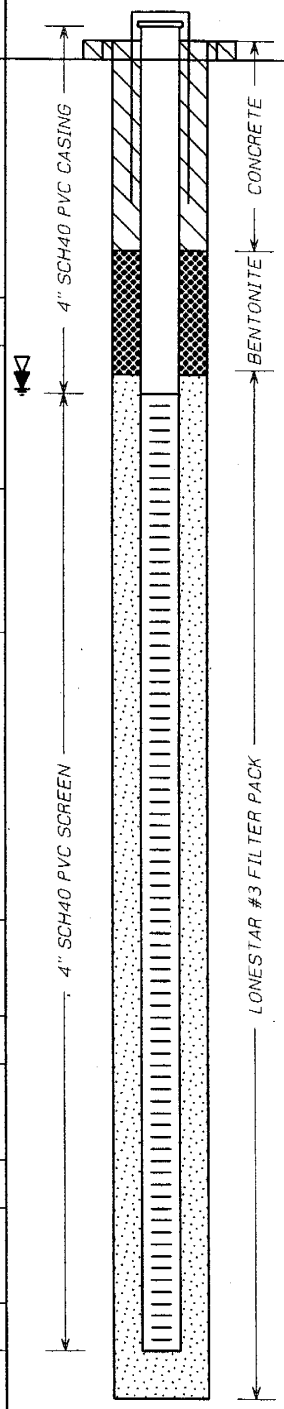
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/14/94 / 0840
DATE/TIME FINISHED 10/14/94 / 1000
COORDINATES -1909.13 N, 5065.50 E
ELEVATION AND DATUM 4.45 feet
TOP OF CASING ELEVATION 5.64 feet

BORING NUMBER M02BS06
COMPLETION DEPTH 14.5 ft.
BOREHOLE DIAMETER 6
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				07	0.0		SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 7/4, dry, loose, well sorted, SW (with some coral gravel and organics).
			M02BS06S01D1.0	13				
		100	M02BS06S02D1.5	16				
2			M02BS06S03D2.0	30				
			M02BS06S04D2.5	43	0.0		SP	CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 7/3, moist, loose, SP (with 5% crushed angular and subangular coral gravel).
		100		45			SW	CORAL SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/2, wet, loose-graduation from coarse-grained to fine-grained from 3.0 to 4.5 feet, SW (with some coral gravel and larger angular coral chunks).
				25				
4				25	3.0			
		90		23			SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 8/2, saturated, loose, SW.
				12				
				17	5.1			
6		100		09				Auger down to 9.0 feet. No samples taken.
8								
							SW	CORAL SAND, fine-grained, white 10YR 8/1, saturated, loose, SW.
				02				
10				02	15.6		ML	Marine SILT, white, 10YR 8/1, saturated, loose, ML.
		60		10				Marine SILT, white, 10YR 8/1, saturated, slight plasticity, gray to white color banding, ML.
				10				
				26	140		SW	CORAL SAND, fine-grained, white, 10 YR 8/1, saturated, loose, well sorted, SW.
12		100		37				Auger down to 13.0 feet. No samples taken.
							ML	Marine SILT, cream, 10YR 8/1, saturated, slight plasticity, gray to white color banding, ML.
				07	80.8		SW	CORAL SAND, medium-grained, cream, 2.5Y 8/1, saturated, loose, well sorted, SW.
14				07				

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M02BS06

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 14.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	80		07			SW	END OF BORING at 14.5 feet below grade. Boring was completed on 10/14/94, at 1000 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

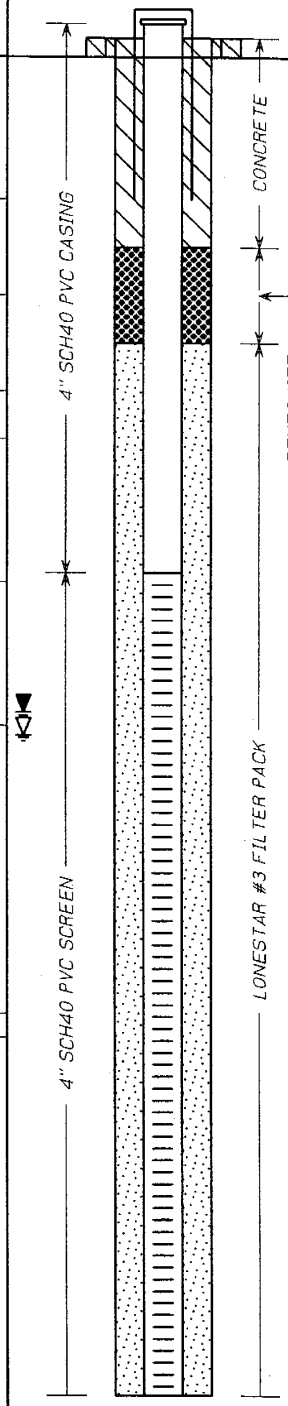
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/11/94 /
DATE/TIME FINISHED 11/11/94 /
COORDINATES 1723.23 N, 2983.48 E
ELEVATION AND DATUM 8.30 feet
TOP OF CASING ELEVATION 11.08 feet

BORING NUMBER M05BS01
COMPLETION DEPTH 16.5 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Shim Garrett./ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				20, 31, 40	0.0		SP	silty, gravelly CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y, dry, loose, poorly sorted, rounded to angular, SP.
2		60						NOTE: Auger down to 2.5 feet. No Samples
				40, 50/6"	0.0		SP	gravelly CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/2, moist, SP.
								NOTE: Refusal at 3.5 feet.
4		20		32, 75/6"			SP	gravelly CORAL SAND, Same as above.
6		40	M05BS01S01D5.5	50, 60/4"	85		SW	gravelly CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 6/2, moist to wet, SW (with HC odor).
								Auger down to 10.0 feet. Driller says augering through larger coral cobbles and gravel.
10				50/6"			SW	CORAL SAND, fine-grained, light gray, 2.5Y 6/1, saturated, SW. NOTE: Large coral cobbles in hole at 10-15'.
12								
14								

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M05BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 16.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16					83		SW	CORAL SAND, fine-grained, light gray 2.5Y 5/1, saturated, SW (with H2S odor).		16
								END OF BORING at 16.5 feet below grade. Boring was completed on 11/11/94.		
18										18
20										
22										22
24										24
26										26
28										28
30										30

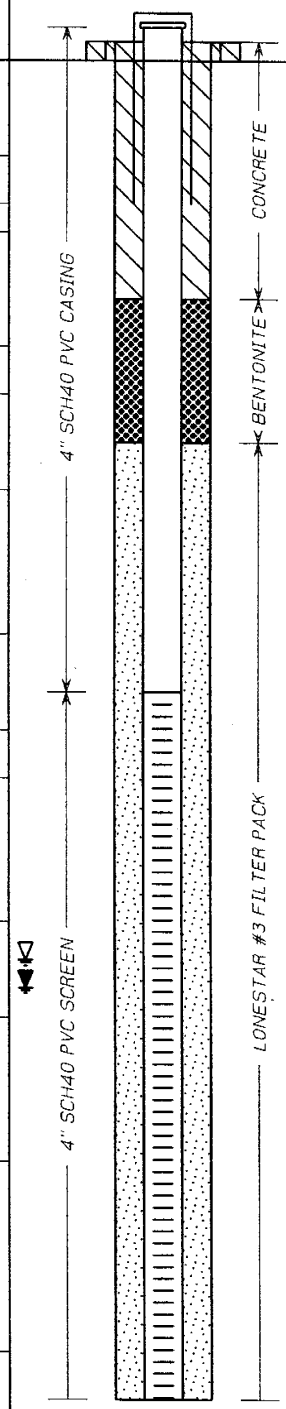
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/12/94 / 0825
DATE/TIME FINISHED 11/12/94 / 0930
COORDINATES 1514.31 N, 2896.12 E
ELEVATION AND DATUM 11.08 feet
TOP OF CASING ELEVATION 13.26 feet

BORING NUMBER M05BS02
COMPLETION DEPTH 17.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Shim Garrett/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6" I.D., Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				39	0.9		SP	gravelly CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/5, dry, loose, sub-rounded to sub-angular, SP (with 20% coral gravel and 10% organic silts).
				50/4"				NOTE: First 2" organics.
		40						NOTE: Refusal at 1.0'. Auger down to 1.5'.
2				60/3"	0.0		SP	gravelly CORAL SAND, Same as above, except very rocky with sub- angular coral gravel and cobbles.
								NOTE: Refusal at 1.8 feet. Auger down to 3.0'.
		30					SP	gravelly CORAL SAND, Same as above, except slightly moist. Coral gravel is angular.
				125/6	0.0			NOTE: Refusal at 3.5 feet. Auger down to 4.5'.
4								
		28					SW	CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/2, moist, loose, well-graded, rounded to sub-rounded, SW.
				47	0.0			
			M05BS02S01D5.5	40				
6		100	M05BS02S01D6.0	60				CORAL SAND, Same as above, except moist to wet and color change at 7.0 feet.
				8	0.0			
			M05BS02G01D7.0	15				NOTE: Distince color change at 7.0 feet from 2.5Y 8/2 to 2.5Y 5/3.
		100		21				CORAL SAND, fine- to medium-grained, light brown 10YR 5/3, wet, loose, well-graded, rounded to sub-rounded, SW (with HC odor and brown stained sand).
8				9	54			
				11				
		100		29				NOTE: Auger down to 10.0 feet. No samples taken.
10							SW	CORAL SAND, Same as above, except saturated and color changes to light gray 2.5Y 6/1, (with H2S and/or HC odor).
				7	25			
				9				
		60		11				NOTE: Auger down to 13.5 feet. No samples taken.
12								
14				50/6"				Sample washed out. Refusal due to compaction

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M05BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16									4" SCH40 PVC SCREEN; LONESTAR #3 FILTER PACK	16
							SW	CORAL SAND, fine- to medium-grained, light gray 2.5Y 7/1, loose, saturated, SW.		
18								END OF BORING at 17.5 feet below grade. Boring was completed on 11/12/94 at 0930 hours.		18
20										
22										22
24										24
26										26
28										28
30										30

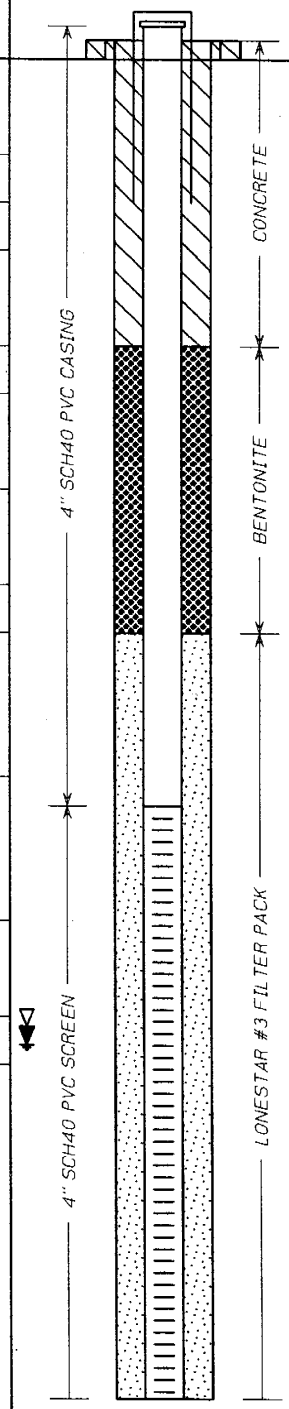
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/12/94 / 1150
DATE/TIME FINISHED 11/12/94 / 1230
COORDINATES 1485.27 N, 2737.52 E
ELEVATION AND DATUM 11.69 feet
TOP OF CASING ELEVATION 13.79 feet

BORING NUMBER M05BS03
COMPLETION DEPTH 17.5 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				25	0.0		SP	gravelly SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, dry, loose, poorly sorted, rounded to angular, with 30% sub-angular to angular coral gravel, SP.
		20		50/4"				NOTE: Refusal at 1.0 feet. Auger down to 1.5 feet.
2				75/6"	0.0		SP	gravelly SAND, Same as above.
								NOTE: Refusal at 2.0 feet due to coral cobbles. Auger down to 3.0'.
4				60/6"	0.0		SW	CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 7/3, moist, loose, well-graded, sub-rounded with 15% coral gravel and very dark brown 2.5Y 4/2, solidified sand in shoe, SW.
								NOTE: Refusal at 3.5'. Auger down to 4.5'.
				50	0.0		SW	CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/2, moist, loose, well-graded, rounded, SW.
				75/6"				NOTE: Refusal at 5.5 feet. Auger down to 6.0 feet.
6		75		32	1.8		SW	CORAL SAND, Same as above, except slightly more moist.
			M05BS03D01D7.0	42				
		90	M05BS03S01D7.5	50				CORAL SAND, Same as above, except highly moist.
8				11	0.0			
				25				
		80		50				NOTE: Auger down to 10.0 feet.
10		100		50	255		SW	CORAL SAND, coarse-grained, pale yellow 2.5Y 8/2, saturated, angular, SW.
								NOTE: Auger down to 16.0 feet. No samples taken.
12								
14								

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M05BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16				8 9	41		SW	CORAL SAND, fine- to medium-grained, light gray 2.5Y 7/1, saturated, loose, angular, well-graded, SW.	4" SCH40 PVC SCREEN LONESTAR #3 FILTER PACK	16
18		100		9				END OF BORING at 17.5 feet below grade. Boring was completed on 11/12/94 at 1130 hours.		18
20										20
22										22
24										24
26										26
28										28
30										30

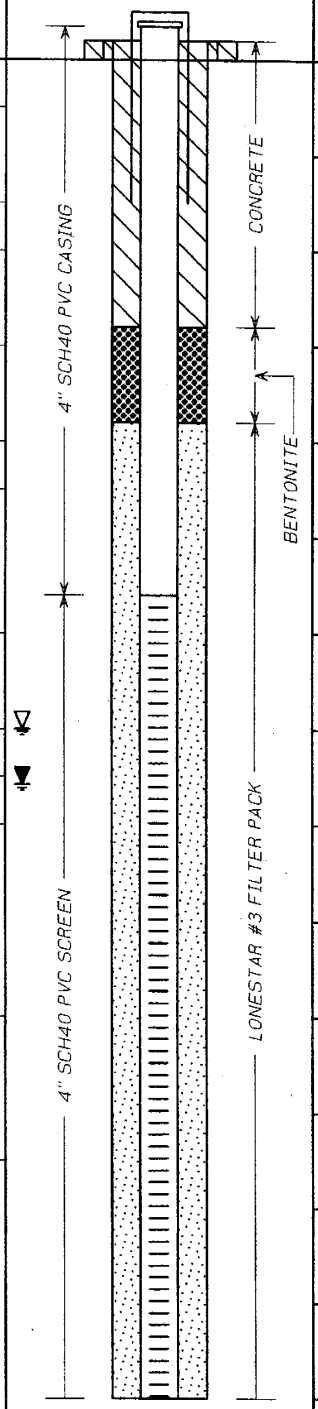
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/09/94 / 0940
DATE/TIME FINISHED 11/09/94 / 1100
COORDINATES 690.18 N, 3893.15 E
ELEVATION AND DATUM 8.69 feet
TOP OF CASING ELEVATION 11.13 feet

BORING NUMBER M08BS01
COMPLETION DEPTH 16.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-4", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
		30		50/3	0.0		SP	Coral SAND, fine-to coarse-grained, pale yellow, 2.5Y 8/3, dry, loose, poorly sorted, sub-angular, SP (with 15% coral gravel and organic peat).
								NOTE: Refusal at 4 inches below ground surface. Auger down to 1.5 feet. No samples.
					0.0		SP	
2		100	M08BS01G01D2.0	75/6				Coral SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/3, dry, loose, poorly sorted, sub-angular, SP (with 5% concrete chunks).
		0						NOTE: Refusal at 2.0 feet. Auger down to 3.0 feet. No samples.
		0			0.0		SW	
				50				Coral SAND, fine- to medium-grained, pale yellow, 2.5Y 8/2, moist, loose, well sorted, subrounded to rounded, SW.
4		100	M08BS01S01D4.0	60				Auger down to 4.5 feet. No samples.
					1.2		SW	Coral SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/2, distinct color changes at 5.5 feet to 2.5Y 5/4, moist, loose, well sorted, subangular sand, poorly weathered, SW.
				34				
				40				
6		70		45	0.8			Coral SAND, fine-grained, pale yellow, 2.5Y 8/5, well graded, moist to wet, subrounded, SW.
				15				
		100		60/6				Auger down to 7.5 feet. No samples.
					40.6		SW	Coral SAND, fine-grained, white, 2.5Y 8/1, saturated, well graded, sub-rounded, SW.
8				60/6				NOTE: Refusal at 8.0 feet. Auger down to 10.0 feet. No samples, compacting fine-grained sand
10					5.4		SW	Coral SAND, fine-grained, white, 2.5Y 8/1, saturated, well graded, sub-rounded, SW.
				04				
				08				
		100		06				Auger down to 14.5 feet. No samples
12								
14								

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M08BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 16.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
				08 10 14	11.3		SW	Coral SAND, fine-grained, white, 2.5Y 8/1, saturated, well graded, sub-rounded, SW.		
16		60						END OF BORING at 16.0 feet below grade. Boring was completed on 11/09/94, at 1100 hours.		16
18										18
20										
22										22
24										24
26										26
28										28
30										30

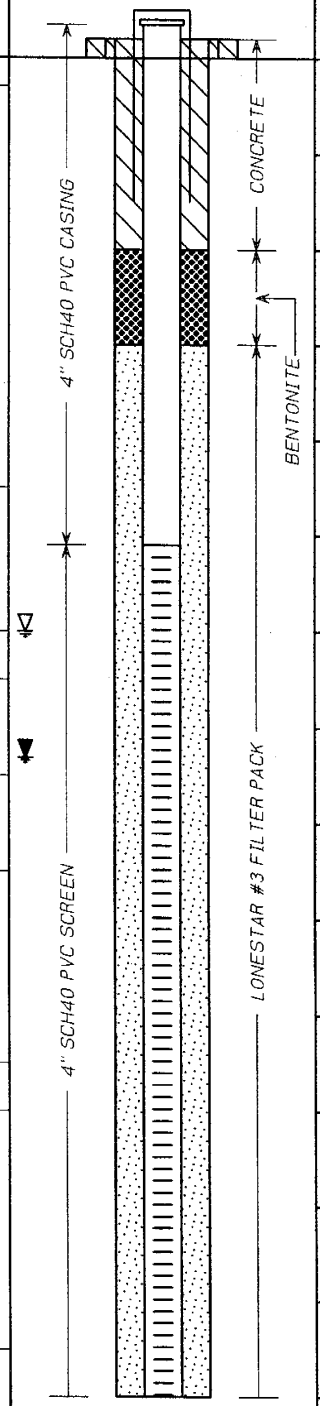
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/09/94 / 1350
DATE/TIME FINISHED 11/09/94 / 1430
COORDINATES 599.38 N, 3862.86 E
ELEVATION AND DATUM 8.24 feet
TOP OF CASING ELEVATION 10.90 feet

BORING NUMBER M08BS02
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Shim Garret/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
		100		65/4			SP	Coral SAND, fine- to coarse-grained, 2.5Y 7/3, pale yellow, moist, SP (with organic gravel). NOTE: Auger down to 4.5 feet. No sample.
2								
4					0.0		SP	Coral SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/4, moist, poorly sorted, sub-angular to angular, SP.
				23				
				27				
6				50/6				Coral SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/4, moist, poorly sorted, sub-angular to angular, SP.
			M08BS02S01D6.5	65/6				Auger down to 7.5 feet. No samples
8				32			SW	Coral SAND, fine- to medium-grained, pale yellow, 2.5Y 8/2, saturated, loose, well graded with gray stained sand in upper portion of spoon, SW (well weathered sand).
		100		75/6				Augder down to 10.5 feet. No samples
10								
		05		75/6			SW	Coral SAND, fine- to medium-grained, pale yellow, 2.5Y 8/2, saturated, loose, well graded with gray stained sand in upper portion of sand, SW (well weathered spoon). NOTE: Sample washed out.
12								Auger down to 13.5 feet.
14				65/6	6.2		SW	Coral SAND, fine-grained, light gray, 2.5Y 7/1, saturated, loose, well graded, SW (HC odor). NOTE: Sample washing out.

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M08BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								END OF BORING at 15.0 feet below grade. Boring was completed on 11/09/94, at 1430 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

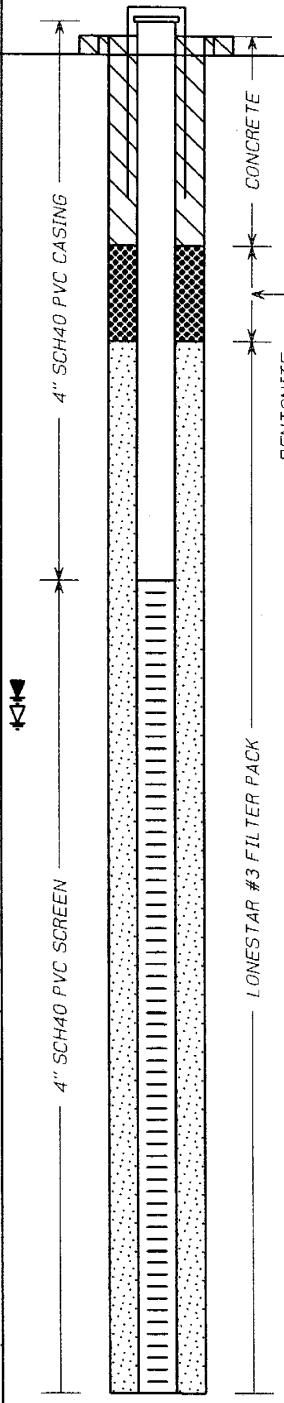
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/10/94 / 0820
DATE/TIME FINISHED 11/10/94 / 0900
COORDINATES 736.79 N, 3793.75 E
ELEVATION AND DATUM 7.70 feet
TOP OF CASING ELEVATION 10.26 feet

BORING NUMBER M08BS03
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Shim Garret/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
		100		60/6"	0.0		SP	Coral SAND with coral GRAVEL, pale yellow, 2.5Y 8/3, compacted, dry, SP (with 15% gravel and 10% fines).
								NOTE: Refusal at 0.5 feet. Auger down to 1.5 feet. No sample
2				34	0.8		SW	Coral SAND, fine- to medium-grained, pale yellow, 2.5Y 8/2, dry, loose, sub-rounded to rounded, SW (with 5% fines).
		100		60/6"				NOTE: Refusal at 2.5 feet. Auger down to 3.0 feet. No sample
				32	0.0		SW	Coral SAND, fine- to medium grained, pale yellow, 2.5Y 8/2, dry, loose, sub-rounded to rounded, SW (with one coral cobble).
4		90	M08BS03G01D4.0	55/6"				NOTE: Refusal at 4.0 feet. Auger down to 4.5 feet. No sample
			M08BS03D01D5.0	42			SW	Coral SAND, fine-grained, pale yellow, 2.5Y 8/2, dry, loose, sub-rounded to rounded, SW.
		100	M08BS03S01D5.5	56/6"				NOTE: Refusal at 5.5 feet. Auger down to 6.0 feet. No sample
6				32	0.0		SW	Coral SAND, fine-grained, pale yellow, 2.5Y 8/2, saturated, loose, well graded, subrounded to rounded, SW.
		95		51/6"				NOTE: Refusal at 7.0 feet. Auger down to 7.5 feet. No sample
8				50 35	0.0		SW	Coral SAND, fine-grained, pale yellow, 2.5Y 8/2, saturated, loose, well graded, subrounded to rounded, SW.
		80		37				Auger down to 10.0 feet. No sample
10		100		75/6"	0.0		SW	Coral SAND, fine-grained, light gray, 2.5Y 7/1, saturated, loose, rounded, SW.
								NOTE: Refusal at 10.5 feet. Auger down to 13.5 feet. No sample
12								
14				30	0.0		SW	Coral SAND, fine- to medium-grained, light gray, 2.5Y 7/1, saturated, loose, rounded, SW.

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M08BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	☒	60		50/2"			SW	NOTE: Refusal at 14.2 feet.		
								END OF BORING at 15.0 feet below grade. Boring was completed on 11/10/94, at 0900 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

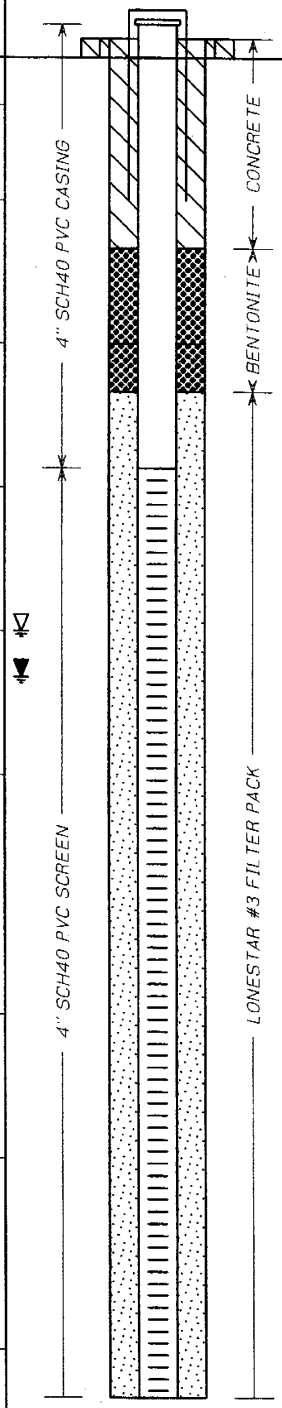
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/10/94 / 1100
DATE/TIME FINISHED 11/10/94 / 1145
COORDINATES -1073.43 N, 2579.69 E
ELEVATION AND DATUM 7.03 feet
TOP OF CASING ELEVATION 8.97 feet

BORING NUMBER MSBBS01
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY SHIM GARRETT/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6",Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				65/6	0.8		SP	Sitly SAND, fine- to coase-grained, dark gray, 2.5Y 4/1, dry, loose, poorly sorted, 10 coral gravel, 40 organic and silts, SP. NOTE: Refusal at 0.5 feet. Auger down to 1.5 feet. No samples.
2				17 18			SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 8/3, slightly moist, well graded, rounded, SW.
		90		15 17	3.0 60			CORAL SAND, Same as above except slightly stained and moist to very moist, 2.5Y 6/3, SW (HC odor).
4			MSBBS01G01D4.0	18				
		100	MSBBS01S01D4.5	25 22 25	264			CORAL SAND, Same as above except saturated, SW (strong odor).
6		100		32 11 21	35			CORAL SAND, Same as above except color change to, 2.5Y 8/2, SW.
8		100		35	184			NOTE: Auger down to 10.0 feet. No samples.
10				11 22			SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 8/2, saturated, loose, well sorted, rounded, SW.
12		100		50/5	118			NOTE: Auger down to 13.5 feet. No samples.
14				10			SW	CORAL SAND, fine to medium-grained, pale yellow, 2.5Y 8/2, saturated, well graded, rounded, loose, SW.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MSBBS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
		80		15 25			SW			
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

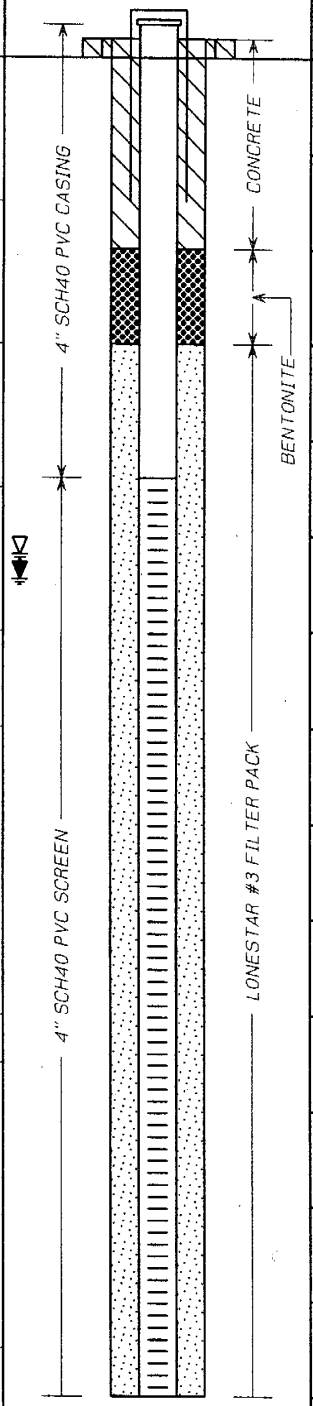
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/10/94 / 1450
DATE/TIME FINISHED 11/10/94 / 1545
COORDINATES -1168.04 N, 2225.02 E
ELEVATION AND DATUM 7.09 feet
TOP OF CASING ELEVATION 6.66 feet

BORING NUMBER MSBBS02
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY SHIM GARRETT/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6",Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				25 26	0.8		SP	GRAVELLY SAND, fine- to coase-grained, pale yellow, 2.5Y 8/2, dry, loose, poorly sorted, sub-angular, SP (with organics and silt in top 5" and distinct gray colored band from 1.2'-1.4').
2		100		25 7 10	0.4		SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 7/2, dry, loose, well graded, rounded, SW.
4		40	MSBBS02G01D4.0	10 13 16	0.4		SW	CORAL SAND, Same as above except moist.
		70	MSBBS02S01D4.5	10 15 15	0.0			CORAL SAND, fine to medium-grained, pale yellow, 10YR 8/3, wet to saturated, loose, well graded, rounded, SW.
6		70		17 20	0.0			CORAL SAND, Same as above, SW.
		50		5				NOTE: Refusal at 7.0 feet. Auger down to 10.0 feet. No samples.
10		20		20/6			SW	CORAL SAND, Same as above, SW.
								NOTE: Refusal at 10.5 feet. Auger down to 13.5 feet.
14				15				NOTE: No recovery - sample washed out of split spoon.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MSBBS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	0		20 50						
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

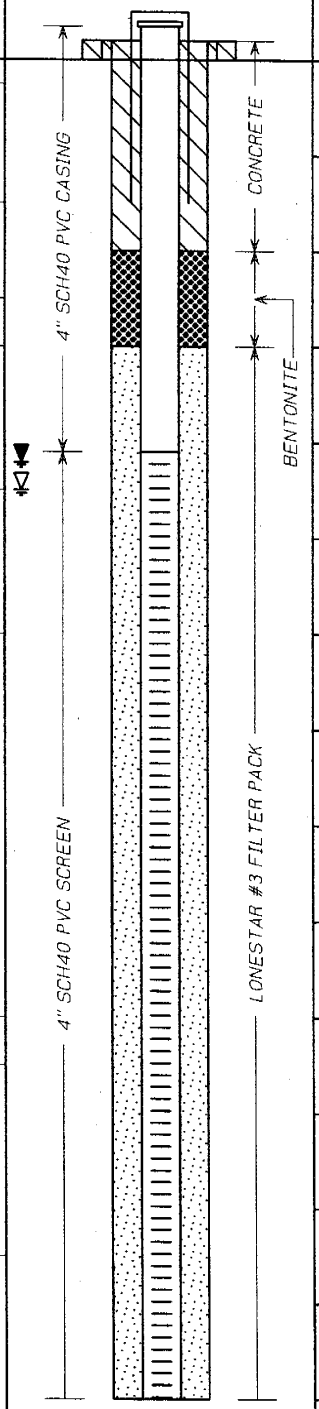
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/11/94 / 0800
DATE/TIME FINISHED 11/11/94 / 0845
COORDINATES -1288.38 N, 1948.72 E
ELEVATION AND DATUM 5.93 feet
TOP OF CASING ELEVATION 7.99 feet

BORING NUMBER MSBBS03
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY SHIM GARRETT/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6",Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
		100		50/3	0.0		SP	silty SAND, fine- to coase-grained, dark gray-brown, 2.5Y 4/1, dry, loose, poorly sorted, sub-rounded, SP (with 15% silt and fines, 10% gravel and chunks of asphalt).
								NOTE: Refusal at 0.25 feet. Auger down to 1.5 feet. No samples.
2				50			SW	CORAL SAND, fine to coarse-grained, pale yellow, 2.5Y 8/2, moist, loose, well graded, sub-rounded to rounded with 10% angular coral gravel, SW.
		100		50/4	0.0			
								NOTE: Refusal at 2.5 feet. Auger down to 3.0 feet.
				18			SW	CORAL SAND, Same as above except moist to wet, SW.
4			MSBBS03D01D4.0	21				
		70	MSBBS03S01D4.5	25	0.0			CORAL SAND, fine to medium-grained, pale yellow, 2.5Y 8/1, saturated, loose, well graded, sub-rounded to angular, SW.
				20				
				22				
6		50		26	0.0			NOTE: Refusal at 6.0 feet. Auger down to 10.0 feet. No samples.
8								
10							SW	CORAL SAND, Same as above, SW.
		80		50				NOTE: Refusal due to compaction. Auger down to 12.5 feet. No samples.
12								
								NOTE: Split spoon stuck in auger. No sample.
				50				
14		0						

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MSBBS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

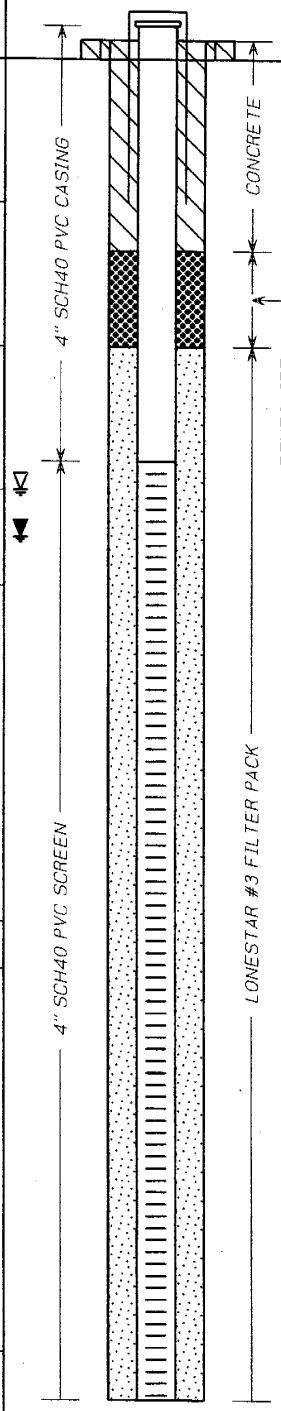
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/11/94 / 1015
DATE/TIME FINISHED 11/11/94 /
COORDINATES -756.30 N, 2525.22 E
ELEVATION AND DATUM 6.55 feet
TOP OF CASING ELEVATION 8.46 feet

BORING NUMBER MSBBS04
COMPLETION DEPTH 14.5 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY SHIM GARRETT/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6",Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				15, 20, 25	0.0		SW	CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 8/4, dry, loose, well graded, SW (with 15% angular coral, gravel and first top 4" brown organic silt).
2		80		9				CORAL SAND, Same as above, except 10% less coral gravel and little to no fines.
			MSBBS04G01D2.5	11				
		80	MSBBS04S01D3.0	15, 10, 15	0.0			CORAL SAND, fine- to medium- grained, pale yellow, 2.5Y 8/3, moist loose, well graded, rounded, clean, SW.
4		75		22, 20	0.0			CORAL SAND, Same as above, except saturated.
6				50	0.0			NOTE: Refusal at 5.5 feet due to compaction. Auger down to 9.0 feet. No samples.
8								
		100		50/5			SW	CORAL SAND, Same as above, except some sub-angular coral sand. NOTE: Split spoon locked in auger. Auger down to 13.5 feet.
10								
12								
14		100		50/4			SW	CORAL SAND, Same as above.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MSBBS04

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 14.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

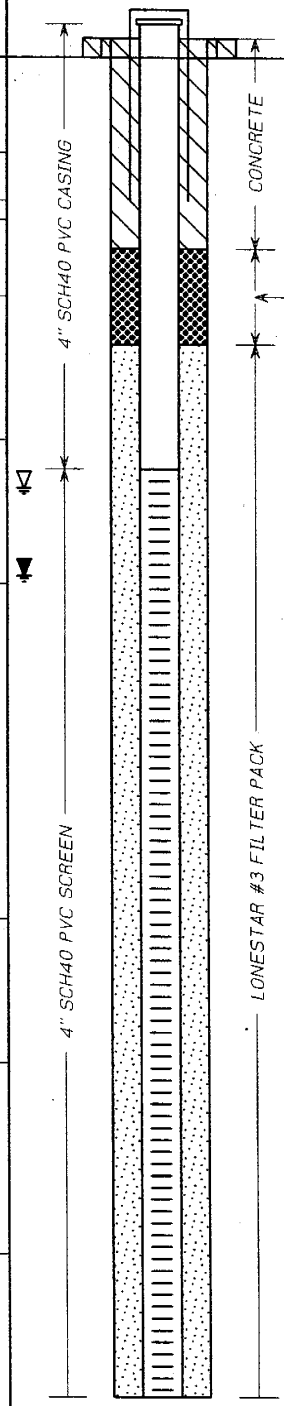
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/11/94 / 1300
DATE/TIME FINISHED 11/11/94 / 1345
COORDINATES -946.07 N, 2180.21 E
ELEVATION AND DATUM 7.11 feet
TOP OF CASING ELEVATION 9.40 feet

BORING NUMBER MSBBS05
COMPLETION DEPTH 14.5 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY SHIM GARRETT/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-3.25",Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				26			SW	CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 5/2, dry, loose, rounded to sub-angular, SP (with 10% coral gravel).
		60		50/6	0.0			NOTE: Refusal at 1.0 feet. Auger down to 1.5 feet.
2		50		50/2	0.0		SW	CORAL SAND, Same as above, except darker gray, 2.5Y 5/2. NOTE: Refusal at 1.7 feet. Auger down to 2.5 feet.
				12			SW	CORAL SAND, fine- to medium-grained, 2.5Y 8/3, well graded moist to wet, SW.
			MSBBS05G01D3.5	20				
4		90	MSBBS05S01D4.0	25	0.0			CORAL SAND, Same as above, except sand slightly more angular and saturated, SW.
				14				
				16				
		90		22	0.0			NOTE: Auger down to 9.0 feet. No samples.
6								
8								
				16			SW	CORAL SAND, fine-to medium-grained, pale yellow, 2.5Y 8/3, saturated, well graded, loose, sub-rounded to sub-angular, SW.
10				25				
		75		40	0.0			NOTE: Auger down to 12.5 feet. No smaples.
12								
		5		50/6			SW	CORAL SAND, Same as above.
14								

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MSBBS05

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 14.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

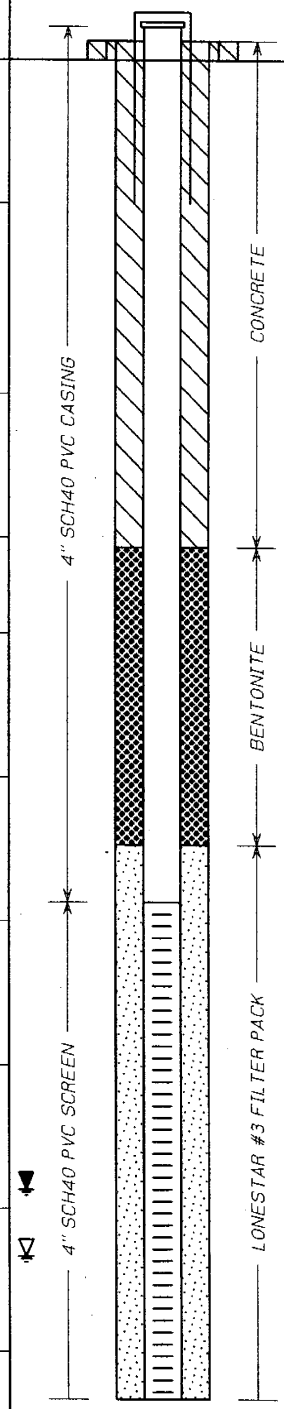
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/24/94 / 1200
DATE/TIME FINISHED 10/24/94 / 1400
COORDINATES 1061.38 N, 17111.38 E
ELEVATION AND DATUM 13.14 feet
TOP OF CASING ELEVATION 15.98 feet

BORING NUMBER M10BS01
COMPLETION DEPTH 20.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				18 21				NOTE: No recovery to 1.5 feet (very loose sand).
2		0 40	M10BS01S01D3.0	40 50 100	0.0		SP	CORAL SAND, fine- to coarse-grained, cream 10YR 7/2, dry, loose, poorly sorted, SP (with 15% angular coral gravel and minor organics).
4		40	M10BS01G01D4.5	40 80	0.0			CORAL SAND, Same as above with some larger coral cobbles.
6		75		12 15 15				CORAL SAND, fine- to coarse-grained, cream 2.5Y 8/2, dry, loose, poorly sorted with 5% angular coral gravel, SP (sand, poorly eroded - very angular).
8		100	M10BS01S02D7.5	12 14 14 12 12	0.0		SW	CORAL SAND, Same as above, except well graded sands.
10		100		10 12 10	0.0			CORAL SAND, fine- to coarse-grained, cream 2.5Y 8/2, dry, loose, angular, SW.
12		100 100		10 17 17 17 16 16	0.0			CORAL SAND, Same as above with gradation fine-grained 2" layer in interval.
14		100		17				CORAL SAND, Same as above with coarse-grained layers and fine- grained layering, shoe very moist.
								CORAL SAND, fine- to coarse-grained, cream 2.5YR 8/2, wet, loose, poorly sorted, SW (sand - angular to sub-rounded).
								NOTE: Drill down to 16.5 feet. No samples taken.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

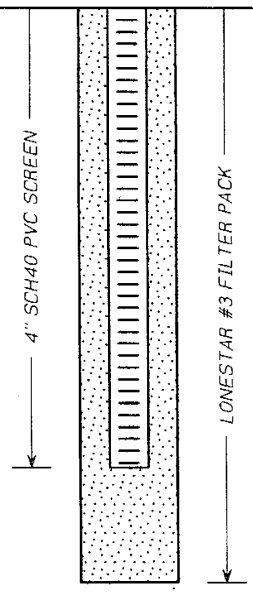
BORING NUMBER M10BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 20.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
16								
				18				NOTE: No distinct contact within split spoon, appears to be all sluff and coral gravel. Drill down to 18.5 feet. No samples taken.
				20				
18		40		25				
				13	0.0		SW	CORAL SAND, fine- to coarse-grained, cream 2.5Y 8/2, saturated, loose, poorly sorted, with minor amounts of larger coral cobbles, SW.
				21				
20		100		21				END OF BORING at 20.0 feet below grade. Boring was completed on 10/24/94 at 1400 hours.
22								
24								
26								
28								
30								

WELL DIAGRAM



DEPTH feet: 16, 18, 22, 24, 26, 28, 30

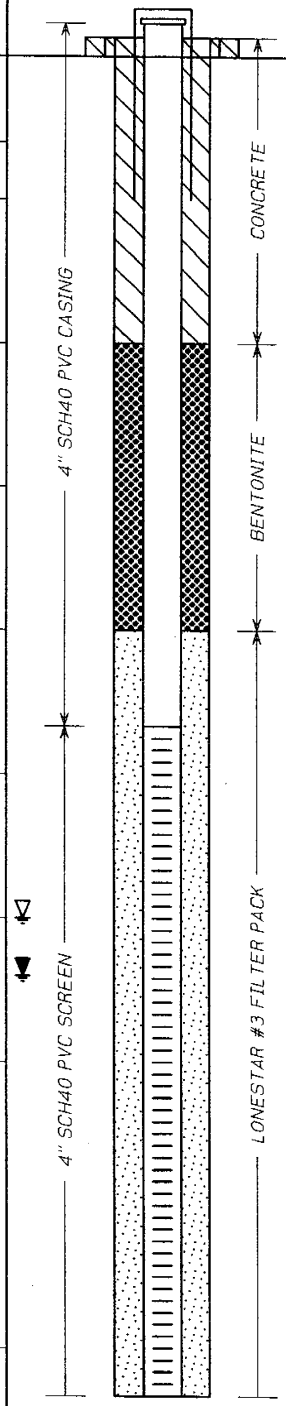
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/26/94 / 0905
DATE/TIME FINISHED 10/26/94 / 1015
COORDINATES 1300.01 N, 17132.51 E
ELEVATION AND DATUM 11.18 feet
TOP OF CASING ELEVATION 13.94 feet

BORING NUMBER M10BS02
COMPLETION DEPTH 17.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				21			SP	silty SAND, fine- to medium-grained, grayish brown 2.5Y 5/2, dry, loose, poorly sorted, SP (with 5% coral gravel and asphalt fragments).
				50/4"				NOTE: Refusal at 0.9 feet.
2		20		16			SP	silty SAND, fine- to coarse-grained, brownish gray, 2.5Y 6/2, dry, loose, poorly sorted, with 5% coral gravel and fines SP (An asphalt chunk stuck in shoe caused low recovery).
				50/4"				
4		10		15	0.0		SW	CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/4, dry, loose, well-sorted, rounded, well-weathered, SW.
				15				
		100		13				CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/2, slighty moist, loose, poorly sorted, rounded to angular, SW.
				10	0.0			
			M10BS02S01D5.5	11				
6		100		11				CORAL SAND, Same as above, except with 5% sub-rounded to angular coral gravel.
				24	0.0			
				25				
8		100		25				CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/4, moist, loose, rounded to sub-rounded, SW.
				14	0.0			
				16				
10		100		19				CORAL SAND, fine- to coarse-grained, saturated, loose, pale yellow 2.5Y 8/3, sub-rounded to angular, SW.
				19				
				8				
12		100		5				NOTE: Drill down to 13.5 feet. No samples taken.
14				13	0.0		SW	CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, saturated, loose, rounded to sub-angular, SW.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

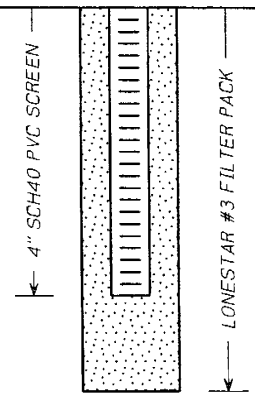
BORING NUMBER M10BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
	X	80		11 9			SW	
								NOTE: Drill down to 15.5 feet.
16	X			13 8	0.0		SW	CORAL SAND, Same as above.
		75		8				END OF BORING at 17.0 feet below grade. Boring was completed on 10/26/94 at 1015 hours.
18								
20								
22								
24								
26								
28								
30								

WELL DIAGRAM



DEPTH feet: 16, 18, 22, 24, 26, 28, 30

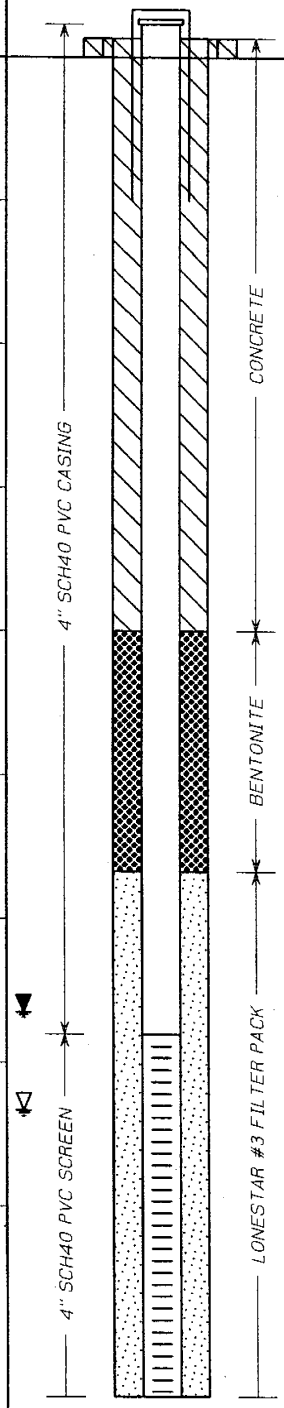
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/25/94 / 1345
DATE/TIME FINISHED 10/25/94 / 1550
COORDINATES 1285.60 N, 16954.32 E
ELEVATION AND DATUM 11.40 feet
TOP OF CASING ELEVATION 14.41 feet

BORING NUMBER M10BS03
COMPLETION DEPTH 19.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				11				NOTE: Loose dry sand at surface. No recovery.
				27				
		0		23			SP	CORAL SAND, fine- to coarse-grained, dusky cream (pale yellow) 2.5Y 7/3, dry, loose, angular to sub-rounded, SP (with 5% coral gravel and 5% organic silt).
2				14				
				12				
		5		10				CORAL SAND, Same as above with slightly more coral gravel - angular to sub-angular.
				4	0.0			
4				3				
		75		3				NOTE: No recovery.
				5				
				6				
6		0		8			SW	CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 7/3, moist, loose, angular, SW (little weathering of sands).
				15				
			M10BS03D01D7.0	25				
		80	M10BS03S01D7.5	26				CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/3, moist to wet, loose, sub-rounded to rounded, SW (well-weathered sand).
8				8	0.0			
				8				
		80		11				CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, wet, loose, with sub-angular gravel, poorly weathered sand, SW.
				9				
10				9				
		90		13				CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, saturated, loose, angular to sub-rounded, poorly sorted, moderately weathered, SW (recovered one coral cobble).
				40				
				44				
12		100		11				NOTE: Drilled down to 17.5 feet. No samples taken.
14								

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M10BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 19.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16										16
18				27 18			SW	CORAL SAND, fine- to medium-grained, dusky yellow 2.5Y 8/2, saturated, loose, poorly sorted, sub-angular to sub-rounded, moderately weathered, SW (minor amounts of sub-rounded coral cobbles).	4" SCH40 PVC SCREEN LONESTAR #3 FILTER PACK	18
		95		11				END OF BORING at 19.0 feet below grade. Boring was completed on 10/25/94 at 1550 hours.		
20										20
22										22
24										24
26										26
28										28
30										30

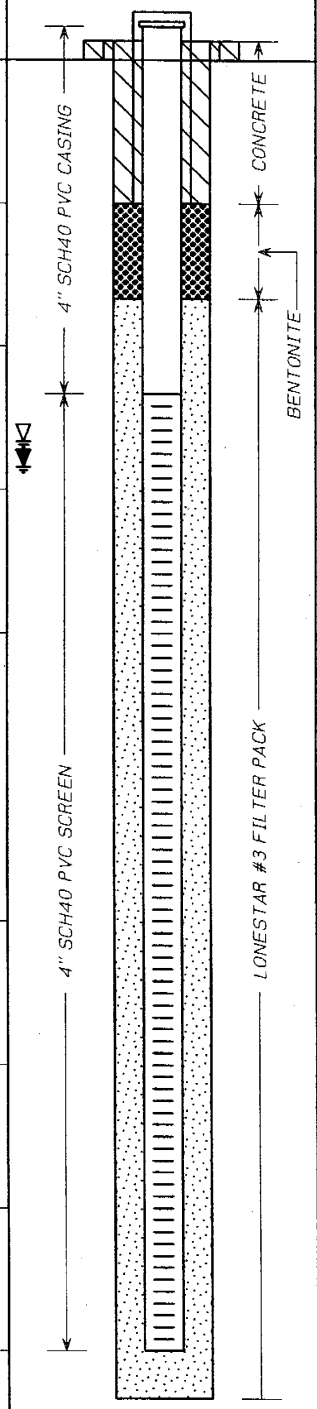
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/01/94 / 1255
DATE/TIME FINISHED 11/01/94 / 1355
COORDINATES -2481.21 N, 12235.19 E
ELEVATION AND DATUM 6.03 feet
TOP OF CASING ELEVATION 7.76 feet

BORING NUMBER M11BS01
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA 6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				10, 10			SP	CORAL SAND, fine- to coarse-grained, pink, 7.5 YR 7/3, loose, slightly moist, angular to subrounded, SP (10% gravel, 15% fines, with thin, 5-10 millimeter roots and burnt wood at 1.25 feet)
2		80		10, 10, 12				CORAL SAND, fine- to coarse-grained, pale brown, 7.5 YR 7/4, loose, slightly moist, angular to subrounded, SP (with 5% gravel and 25% fines)
4		50	M11BS01S01D3.5	15, 29, 35	66			CORAL SAND, fine- to coarse-grained, cream, 7.5 YR 8/2, dense, moist at top of sleeve, saturated at bottom 0.6 inches, angular to subrounded, odor of solvents, SP (with 10% gravel).
6		75, 75		40/0", 10, 15, 15	22.8		SW	CORAL SAND, fine- to coarse-grained, cream, 7.5 YR 8/2, loose, saturated, angular to subrounded, odor of solvents, SW (5% gravel).
8								Auger down to 9.0 feet. No samples
10		0		50/6"				No recovery
12								Auger down to 12.0 feet. No samples
14		0						No recovery
								Auger down to 15.0 feet. No samples

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M11BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								END OF BORING at 15.0 feet below grade. Boring was completed on 11/01/94, at 1355 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

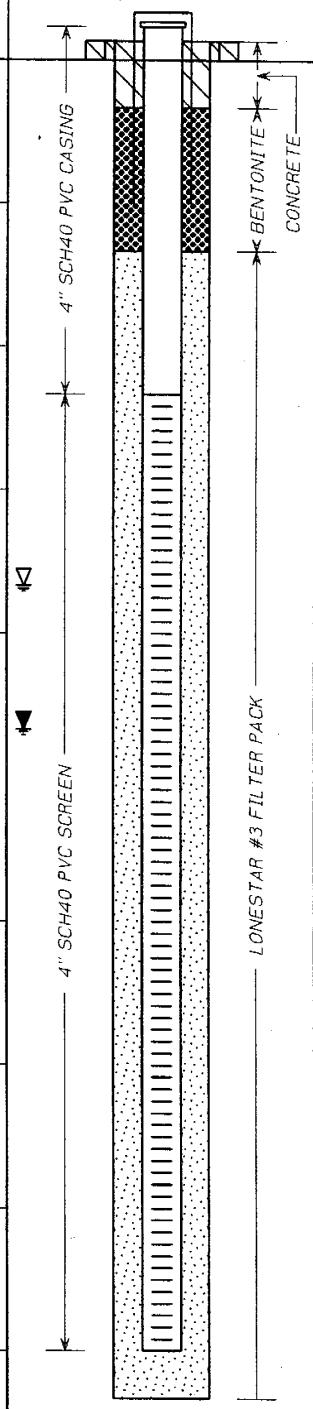
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/01/94 / 1000
DATE/TIME FINISHED 11/01/94 /
COORDINATES -2397.11 N, 12193.06 E
ELEVATION AND DATUM 8.01 feet
TOP OF CASING ELEVATION 9.61 feet

BORING NUMBER M11BS02
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				04 06 06 03 03 03 06 06 06 15 05 05 30 50/3" 50/6"			SP	CORAL SAND, fine- to coarse-grained, pink, 7.5YR 7/3, dry, loose, angular to subrounded, poorly sorted, SP (with some roots and bones).
		50			0.0			CORAL SAND, fine- to medium-grained, pale brown, 7.5YR 6/3, dry, loose, angular to subrounded, poorly sorted, SP (with some roots).
		25			0.0			CORAL SAND, fine- to coarse-grained, cream, 7.5YR 8/2, dry, loose, angular to subrounded, poorly sorted, SP (coral gravels).
		01	M11BS02S01D5.0		0.0		SW	CORAL SAND, fine- to coarse-grained, cream/pale yellow, 7.5YR 8/2, loose, moist at top of spoon and saturated at bottom 6 inches, angular to subrounded, moderately sorted, SW.
		90			0.0			Auger down to 9.0 feet. No samples
							SW	CORAL SAND, fine- to coarse-grained, pale yellow, 7.5YR 8/2, saturated, dense, angular to subrounded, poorly sorted, SW.
		25			0.0			Auger down to 12.0 feet. No samples
							SW	CORAL SAND, fine- to coarse-grained, saturated, very dense, angular to subrounded, poorly sorted, SW.
		15			0.0			END OF BORING at 15.0 feet below grade. Boring was completed on 11/01/94.

WELL DIAGRAM



DEPTH feet: 2, 4, 6, 8, 10, 12, 14

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M11BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

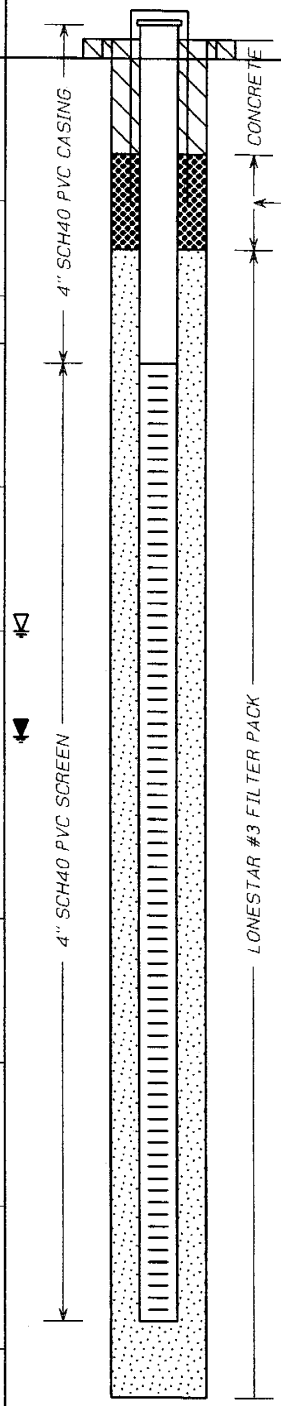
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/01/94 / 1615
DATE/TIME FINISHED 11/02/94 /
COORDINATES -2370.34 N, 12290.27 E
ELEVATION AND DATUM 8.11 feet
TOP OF CASING ELEVATION 11.21 feet

BORING NUMBER M11BS03
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				03			SP	CORAL SAND, fine- to medium-grained, brown, 7.5YR 5/4 mottled, loose dry, poorly sorted, angular to subrounded, high organic content, SP.
				04				
		50		06	0.0			CORAL SAND, fine- to coarse-grained, pinkish white, 7.5YR 8/2, loose, dry, poorly sorted, angular to subrounded, minimal organic content, SP.
2				04				
			M11BS03G01D2.5	06				CORAL SAND, fine- to coarse-grained, pinkish white, 7.5YR 8/2, loose, dry, poorly sorted, angular to subrounded, SP.
		95		07	0.0			CORAL SAND, fine- to coarse-grained, cream, 7.5YR 8/2, loose, slightly moist, poorly sorted, angular to subrounded, SP.
				03				
4				03				
				03	0.0		SW	CORAL SAND, fine- to coarse-grained, loose, moist, cream, 7.5YR 8/2, poorly sorted, angular to subangular, moderately weathered, SW.
			M11BS03D01D5.0	10				
			M11BS03S01D5.5	15				
6				15	0.0			Auger down to 9.0 feet. Cuttings saturated starting at approximately 6.0 feet. No samples
8								
							SW	CORAL SAND, fine- to coarse-grained, cream, 7.5YR 8/2, medium dens to dense, saturated, angular to subrounded, SW (shell fragments abundant).
				30				
10				50/6"				
								Auger down to 12.0 feet. No samples
12								No recovery
				70/6"				
14								Auger down to 15 feet with 10 inch outer diameter to install monitoring well.

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M11BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								END OF BORING at 15.0 feet below grade. Boring was completed on 11/02/94.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

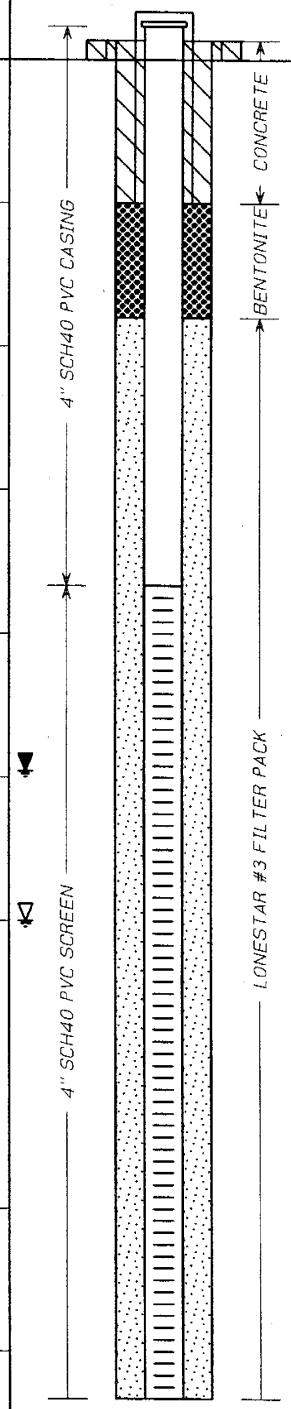
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/29/94 / 0900
DATE/TIME FINISHED 10/29/94 / 1035
COORDINATES ~1077.70 N, 17771.34 E
ELEVATION AND DATUM 8.85 feet
TOP OF CASING ELEVATION 12.52 feet

BORING NUMBER M54BS01
COMPLETION DEPTH 17.5 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				12 13	0.0		SP	CORAL SAND, fine- to coarse-grained, dusky brown 7.5YR 7/3, moist (rain water), loose, sub-angular to sub-rounded, poorly sorted, SP.
2		40		9 7 21	0.0			CORAL SAND, fine- to coarse-grained, dusky brown 7.5YR 7/3, moist (rain water), loose, sub-angular to sub-rounded, poorly sorted, SP.
4		75		21 20 25	0.0			CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, loose, dry, sub-rounded to sub-angular, poorly sorted, SP.
		95		30 20 30	0.0		SW	CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, moist, loose, angular to sub-rounded, poorly sorted, SW.
6		100		45 20 30				CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, moist, loose, angular to sub-rounded, poorly sorted, SW.
8		80	M54BS01S01D7.0	45 15 20				CORAL SAND, Same as above, except saturated.
10		70		20				NOTE: Drill down to 12.0 feet. No samples taken.
12				12 10				NOTE: No recovery.
14		0		15				NOTE: Drill down to 16.0 feet. No samples taken.

WELL DIAGRAM



OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M54BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16				10 15 25			SW	CORAL SAND, fine- to medium-grained, pale yellow 2.5Y 8/3, saturated, loose, sub-rounded to angular, SW.		16
18								END OF BORING at 17.5 feet below grade. Boring was completed on 10/29/94 at 1035 hours.		18
20										20
22										22
24										24
26										26
28										28
30										30

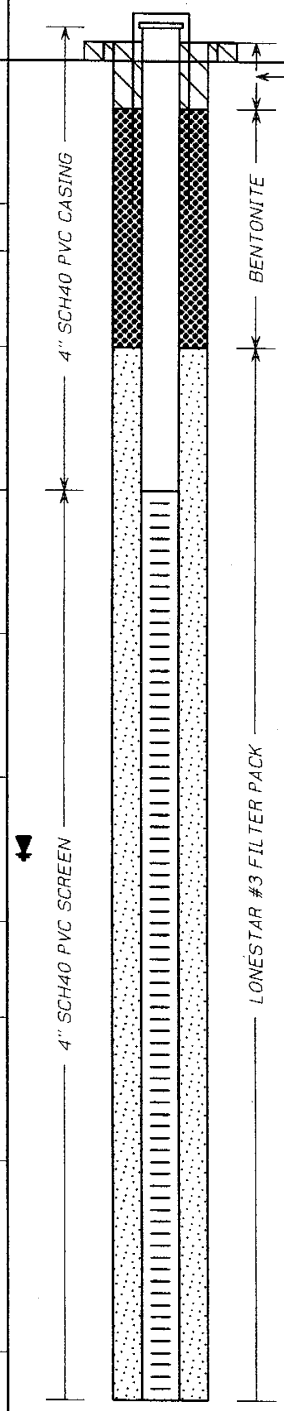
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/31/94 / 1030
DATE/TIME FINISHED 10/31/94 / 1115
COORDINATES -1037.25 N, 17883.58 E
ELEVATION AND DATUM 9.76 feet
TOP OF CASING ELEVATION 13.42 feet

BORING NUMBER M54BS02
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				15	0.0		SP	CORAL SAND, fine- to coarse-grained, very pale brown 7.5YR 7/3, dry, loose, sub-angular/sub-rounded, poorly sorted, SP.
				20				
		35		20				CORAL SAND, Same as above.
2				50/4"	0.0			NOTE: Refusal of spoon at ~2.0 feet. Auger through to 3.0 feet.
		20					SP	CORAL SAND, fine- to coarse-grained, brown 7.5YR 5/3, dry loose, angular to sub-rounded, poorly sorted, SP.
				15				
4				10				
		70		25				CORAL SAND, Same as above, except very pale brown 10YR 8/4 and slightly moist.
				15	0.0			
			M54BS02G01D5.5	20				
6				25			SW	CORAL SAND, fine- to coarse-grained, very pale brown 10YR 8/3, loose, moist at top of spoon, saturated bottom ~6", angular to sub-rounded, poorly sorted, SW.
				15	0.0			
			M54BS02S01D7.0	18				
				20				CORAL SAND, Same as above, except saturated.
8				15				
				50/5"				
								NOTE: Auger down to 10.0 feet. No sample collected.
10							SP	CORAL SAND, fine- to coarse-grained, very pale brown 10YR 8/3, loose, saturated, angular to sub-rounded, moderately weathered, small to medium gravels, SP.
				10				
				15				
		70		15				NOTE: Drill down to 13.5 feet. No samples taken.
12								
							SW	CORAL SAND, fine- to medium-grained, very pale brown 10YR 8/3, loose, saturated, SW.
14				25				

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M54BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	100		50/3"			SW	CORAL SAND, fine- to coarse-grained, very pale brown 10YR 8/3, loose, saturated, angular to sub-rounded, moderately weathered, SW.		
16								END OF BORING at 15.0 feet below grade. Boring was completed on 10/31/94 at 1115 hours.		16
18										18
20										
22										22
24										24
26										26
28										28
30										30

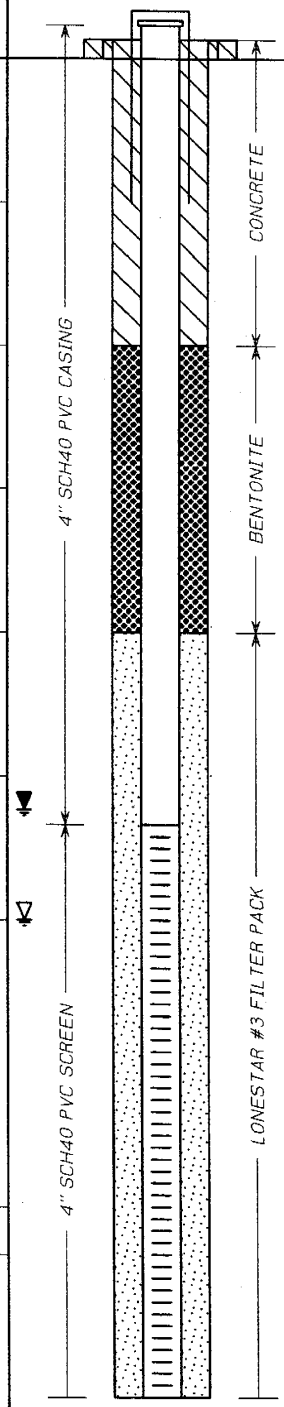
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/26/94 / 1335
DATE/TIME FINISHED 10/26/94 / 1430
COORDINATES -1096.59 N, 17864.65 E
ELEVATION AND DATUM 9.31 feet
TOP OF CASING ELEVATION 11.44 feet

BORING NUMBER M54BS03
COMPLETION DEPTH 18.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				10	0.0			NOTE: 3" hardened tar or asphalt pluging sleeve. No sample recovered.
				11				
2		15		13			SP	CORAL SAND, fine- to coarse-grained, dusky brown 7.5YR 7/3, dry, loose, poorly sorted, sub-rounded to sub-angular, SP (with 10% coral gravel and 10% fines).
				4				
				3				
		70		2				NOTE: No recovery.
				3				
4				2				
		0		2			SW	CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/3, dry to moist at bottom of shoe, sub-rounded, SW.
				3	0.0			
				2				
6		30		2				CORAL SAND, Same as above.
				3	0.0			
				4				
		100	M54BS03S01D7.5	4				CORAL SAND, fine- to coarse-grained, pale brown 10YR 7/4, saturated, loose, poorly sorted, sub-angular, moderately weathered, SW.
8				4	0.0			
				4				
		55		5				NOTE: Drill down to 12.0 feet. No samples taken.
10								
12								NOTE: Refusal at 12.0 feet. Drill down to 12.5.
				50/1"			SW	CORAL SAND, fine- to coarse-grained, pale yellow 2.5Y 8/2, saturated, loose, poorly sorted, sub-rounded to sub-angular, SW.
				26	0.0			
				18				
14		100		19				

WELL DIAGRAM



DEPTH feet

OGDEN

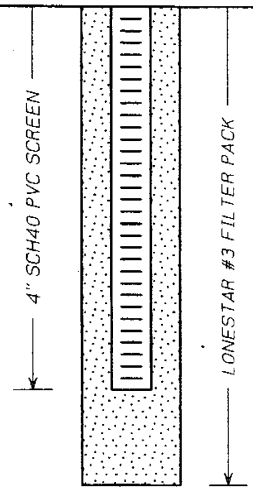
CLIENT NAVY CLEAN

BORING NUMBER M54BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 18.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								NOTE: Drill down to 16.5 feet. No samples taken.		
16										16
				30			SW	CORAL SAND, Same as above.		
				40						
18		100		40				END OF BORING at 18.0 feet below grade. Boring was completed on 10/26/94.		18
20										20
22										22
24										24
26										26
28										28
30										30



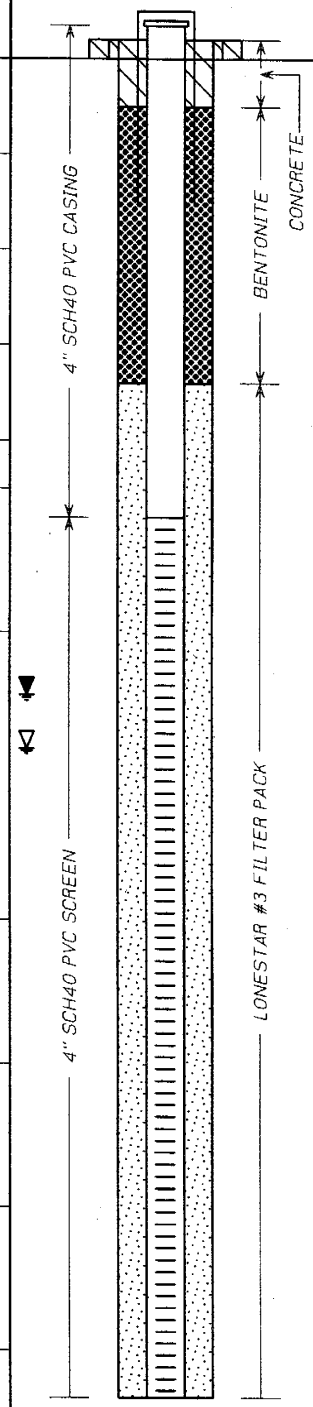
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/02/94 / 1400
DATE/TIME FINISHED 11/02/94 / 1540
COORDINATES -2461.54 N, 14032.94 E
ELEVATION AND DATUM 7.97 feet
TOP OF CASING ELEVATION 11.30 feet

BORING NUMBER MAFBS01
COMPLETION DEPTH 16.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Alan Martin
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				17			SW	CORAL SAND, fine- to coarse-grained, light reddish brown, 5YR 6/3, medium dense, dry, SW (approximately 20% fines).
				20				CORAL SAND, fine- to coarse-grained, pink, 7.5YR 8/2, medium dense, dry, angular to subrounded, SW (with 5% gravels, 15% silts, shell fragments, largest cobble is 80 millimeters).
2		100		25				
				50				
				50/4"				CORAL SAND, fine- to coarse-grained, pink, 7.5YR 8/2, moist, dense, angular to subrounded, SW (with 10% dry gravel, 15% silt, largest cobble is 50 millimeters).
		40			0.0			
				30				CORAL SAND, fine- to coarse-grained, pink, 7.5YR 8/2, medium dense to dense, moist, subangular to subrounded, SW (with approximately 5% gravels, 10% fines, largest pebble is 20 millimeters)
4			MAFBS01S01D4.0	60/6"				
		40			0.0			CORAL SAND, fine- to medium-grained, pink, 7.5YR 8/2, medium dense to dense, moist, subangular to subrounded, SW (with 5% fines)
				26				
				32				CORAL SAND, fine- to coarse-grained, pink, 7.5YR 8/2, medium dense, saturated, angular to subrounded, SW (with approximately 5% gravels, 5% fines, largest pebble is 60 millimeters)
6				25	0.0			
								Auger down to 9.0 feet. No samples
8								
							SP	CORAL SAND, fine-grained, pink, 7.5YR 8/2, dense, saturated, well sorted, subangular to subrounded, SP.
				50				
10				50/2"				
		01						Auger down to 12.0 feet. No samples
12							SW	CORAL SAND, fine- to medium-grained, pink, 7.5YR 8/2, moderately sorted, subangular to subrounded, SW.
				50				
				50/4"				
		01						Auger down to 16 feet. No samples
14								

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MAFBS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 16.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
16								END OF BORING at 16.0 feet below grade. Boring was completed on 11/02/94, at 1540 hours.		16
18										18
20										
22										22
24										24
26										26
28										28
30										30

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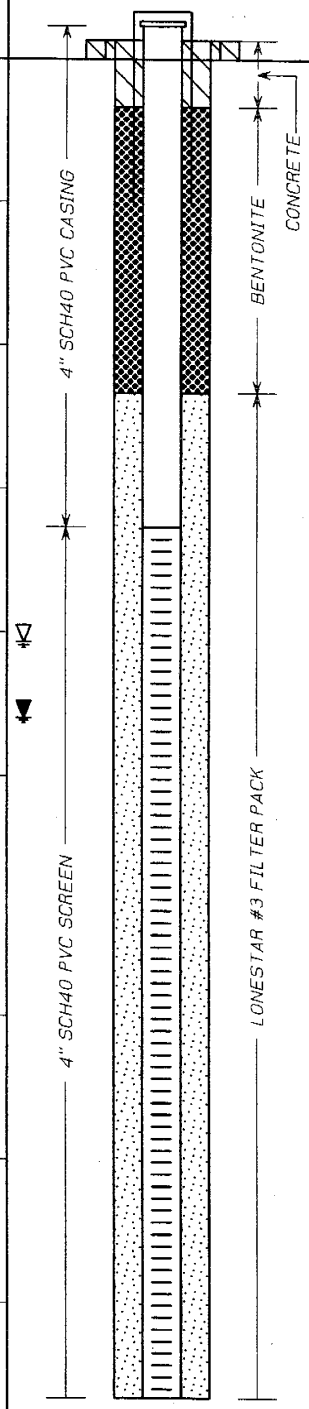
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/03/94 / 0830
DATE/TIME FINISHED 11/03/94 / 0945
COORDINATES -2475.49 N, 14243.31 E
ELEVATION AND DATUM 8.25 feet
TOP OF CASING ELEVATION 11.51 feet

BORING NUMBER MAFBS02
COMPLETION DEPTH 17.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Jim Frei
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				14			SW	CORAL SAND, fine- to coarse-grained, very pale brown, 10YR 8/3, medium density, dry, poorly sorted, subangular to subrounded, SW (few 20 millimeter to 40 millimeter coral gravels, fine shell fragments).
				15				
		75		20	0.0			CORAL SAND, fine- to coarse-grained, dark grayish brown, 10YR 3/2, very dense, damp, poorly sorted, subangular to subrounded, SW (with coarse coral fragments).
2		100		50/6"				
		0						
		0			0.0			CORAL SAND, fine- to coarse-grained, pale brownish yellow, 2.5Y 7/4, medium density, damp, poorly sorted, angular to subrounded, SW (with fine coral fragments)
				15				
4				20				
		100	MAFBS02S01D4.5	16	0.0			CORAL SAND, fine- to medium-grained, yellow, 10YR 8/4, medium density, damp, poorly sorted, subangular to subrounded, SW (with subrounded, medium coral gravels and coral fragments)
				26				
				34				
6		100	MAFBS02G01D6.0	40	0.0			CORAL SAND, fine- to medium-grained, very pale brown, 10YR 8/2, dense, saturated, moderately sorted, angular to subrounded, SW (one 60 millimeter cobble recovered)
				40				
		100		50/3"				
					0.0			Auger down to 10.0 feet. No samples
8								
10							SP	CORAL SAND, fine-grained, white, 10YR 8/1, dense, saturated, well sorted, angular to subangular, SP.
					0.0			Auger down to 13.0 feet. No samples
12								
							SP	CORAL SAND, fine-grained, white, 10YR 8/1, dense, saturated, well sorted, angular to subangular, SP.
14				20			SW	

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MAFBS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	100		50/6"	0.0		SW	CORAL SAND, fine- to coarse-grained, very pale brown, 10YR 8/2, saturated, poorly sorted, angular to subrounded, SW (with coral fragments). Auger down to 17.0 feet. No samples	LONESTAR #3 FILTER PACK	
16										16
								END OF BORING at 17.0 feet below grade. Boring was completed on 11/03/94, at 0945 hours.		
18										18
20										
22										22
24										24
26										26
28										28
30										30

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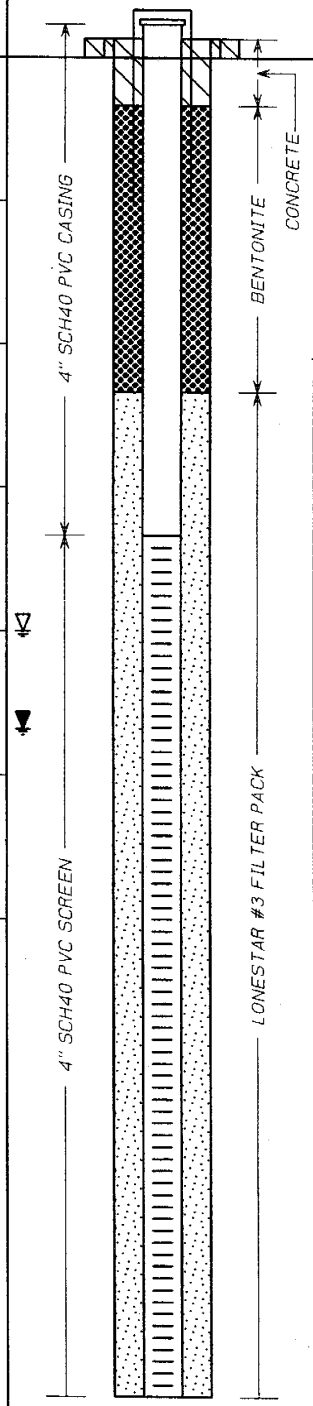
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 11/03/94 / 1210
DATE/TIME FINISHED 11/03/94 /
COORDINATES -2648.62 N, 14178.03 E
ELEVATION AND DATUM 8.40 feet
TOP OF CASING ELEVATION 11.65 feet

BORING NUMBER MAFBS03
COMPLETION DEPTH 17.0 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Shim Garrett/Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Jim Frei
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				20, 22			SW	CORAL SAND, fine- to coarse-grained, pale brown, 10YR 7/4, dry, medium density, poorly sorted, angular to subrounded, SW (with subangular coral gravel and shell fragments)
		40		25	1.8			CORAL SAND, same as above, SW.
2		60		20, 50/6"				
					1.8			CORAL SAND, fine- to coarse-grained, pink, 7.5YR 7/4, slightly damp, medium to dense, poorly sorted, angular to rounded, SW (with small pieces of coral)
4			MAFBS03D01D4.0	21, 26				
		60	MAFBS03S01D4.5	36	0.0			CORAL SAND, fine- to coarse-grained, very pale brown, 10YR 8/3, wet, medium to dense, poorly sorted, angular to subrounded, SW (with minor pieces of fines, shell, coral, and 2 - 30 millimeter gravels)
6		75		21, 27, 35				CORAL SAND, fine- to coarse-grained, white, 10YR 8/1, saturated, medium density, poorly sorted, angular to subrounded, SW (with medium sized coral gravels, several 20 millimeter gravels, and shell fragments)
8		50, 25		21, 26, 36, 60/6"			SM	Silty CORAL SAND, fine- to medium-grained, white, 10YR 8/1, saturated, very dense, subangular to rounded, SM (with minor shell fragments)
10, 12, 14				20				Auger down to 17.0 feet. No samples

WELL DIAGRAM



DEPTH feet

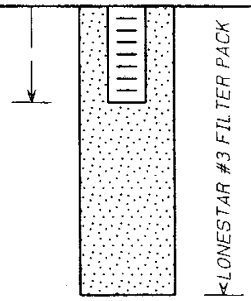
OGDEN

CLIENT NAVY CLEAN

BORING NUMBER MAFBS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
				50/6"				No recovery		
16										16
								END OF BORING at 17.0 feet below grade. Boring was completed on 11/03/94.		
18										18
20										
22										22
24										24
26										26
28										28
30										30

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M01 MW01
JOB NO.	110190136	SITE NAME	Bulk Waste Lnadfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 5.5' BGS

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-19-94	1025/1045	surge block	10 min.							
[illegible]-94	1118	bail	0							
10-22-94	1126	bail	8		5	7.59	6.60	cloudy gray	83	gray color cloudy turb
10-22-94	1131	bail	5		10	7.56	7.05	cloudy gray	82	fine sands in solution
10-22-94	1135	bail	4		15	7.57	7.39	slightly dk gray	82	initial WL = 8.65 } final WL = 8.65 } measurements taken
10-22-94	1140	bail	5		20	7.55	7.63	slightly dk gray	83	initial BOS = 17.5 } from TOC final BOS = 17.4 }
10-22-94	1143	bail	3		25	7.54	7.90	slightly dk gray	81	
10-22-94	1147	bail	4		30	7.52	7.80	lighter gray	82	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M01 MW02
JOB NO.	110190136	SITE NAME	Bulk Waste Lnadfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 5.7' BGS }during
FINAL WATER LEVEL 5.1' BGS }surging

REMARKS: 2 inches of silt to be purged
BOS = 14' 8" actual = 15.0'

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-18-94	1525	surge block								
	1535		10 min.							
10-22-94	1337	bail	0							
10-22-94	1343	bail	6		5	7.47	9.22	murky dark gray	84	dark gray color
10-22-94	1348	bail	5		10	7.49	8.31	murky dark gray	85	initial WL = 7.9 } final WL = 8.0 } measurements taken
10-22-94	1352	bail	4		15	7.41	12.85	murky dark gray	84	initial BOS = 17.75 } final BOS = 17.90 } from TOC
10-22-94	1357	bail	5		20	7.39	14.09	murky dark gray	84	
10-22-94	1400	bail	3		25	7.38	13.16	murky dark gray	84	
10-22-94	1405	bail	5		30	7.41	12.10	murky dark gray	84	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M01 MW03
JOB NO.	110190136	SITE NAME	Bulk Waste Lnadfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 6.0' BGS

FINAL WATER LEVEL 5.8' BGS

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-19-94	1538/1547		9 min.							initial = 6.0 final = 5.8
10-22-94	1010	bail								
10-22-94	1015	bail	5		5	7.32	> 20	black, murky	84	black and murky, oil sheen on surface
10-22-94	1023	bail	8		10	7.59	> 20		82	slight H. C. odor
10-22-94	1027	bail	4		15	7.55	> 20		82	initial WL = 5.3 TOC final WL = 5.4 TOC
10-22-94	1033	bail	6		20	7.63	> 20		82	initial BOS = 16.8 TOC final BOS = 16.8 TOC
10-22-94	1037	bail	4		25	7.89	> 20		81	
10-22-94	1042	bail	5		30	7.93	> 20		81	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M01 MW04
JOB NO.	110190136	SITE NAME	Bulk Waste Lnadfill	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE ____
- BAILER ____
- SURGE BLOCK X
- AIR LIFT ____
- OTHER ____

INITIAL WATER LEVEL 4.5' BGS
FINAL WATER LEVEL 4.5' BGS

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =
WELL CASING INSIDE DIAMETER d_w ID =
OUTSIDE DIAMETER d_w OD =
DEPTH TO: WATER LEVEL H =
BASE OF SEAL S =
BASE OF WELL TD =
EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-17-94	1733/1743	surge block	10							
10-28-94	1506	hand bail	0		0					
10-28-94	1508		1		1	8.15	> 20	v. high	86	black
10-28-94	1514				5/6	7.58	18.54	v. high	85	black
10-28-94	1519				5/11	7.51	18.71	v. high	85	black
10-28-94	1522				5/16	7.54	> 20	high	84	dk. grey
10-28-94	1524				5/21	7.58	> 20	high	85	dk. grey
10-28-94	1529				5/26	7.61	> 20	high	85	dk. grey
10-28-94	1533				5/30	7.68	> 20	high	84	dk. grey, slightly clearer

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW01
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL	6.5
FINAL WATER LEVEL	6.0

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

4" - 0.65

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

4" CASING AND 10" HOLE = 1.37

HOLE DIAMETER	d_h =	0.83'
WELL CASING INSIDE DIAMETER	d_w ID =	0.33'
OUTSIDE DIAMETER	d_w OD =	0.34'
DEPTH TO: WATER LEVEL	H =	6.0'
BASE OF SEAL	S =	3.0'
BASE OF WELL	TD =	17.0'
EST. FILTER PACK POROSITY	P =	~ 0.40

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-11-94	1630	bailer	15 min.		30					used bailer because of fine-grained sands

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW02
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 7.0 BGS

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =	0.83'
WELL CASING INSIDE DIAMETER	d_w ID =	0.33'
OUTSIDE DIAMETER	d_w OD =	0.35'
DEPTH TO: WATER LEVEL	H =	7.0'
BASE OF SEAL	S =	5.0'
BASE OF WELL	TD =	16.0'
EST. FILTER PACK POROSITY	P =	0.40

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-12-94	1315/1325	surge block	10 min.							
							(20 mS)			
10-12-94	1335	bail			5	7.52	18.70	milky, cloudy		4 ppm on H_2S meter
10-12-94	1343	bail			10	7.49	> 20	milky, cloudy		
10-12-94	1347	bail			15	7.48	> 20	milky, cloudy		
10-12-94	1350	bail			20	7.44	> 20	milky, cloudy		
10-12-94	1355	bail			30 gal.	7.32	> 20	milky, cloudy		

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW03
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 6' 2"

FINAL WATER LEVEL 6.0'

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-13-94	1255	surge block								
	1305	"	10 min.							
10-13-94	1313	bail			5	7.50	8.62	cloudy	82	
10-13-94	1318	bail			10	7.31	12.07	cloudy	80	strong HS, odor
10-13-94	1322	bail			15	7.24	14.26	cloudy	79	
10-13-94	1326	bail			20	7.18	16.20	slightly less cloudy	78	
10-13-94	1330	bail			25	7.16	16.40	slightly less cloudy	78	
10-13-94	1334	bail			30	7.17	16.11	slightly less cloudy	79	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW04
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 3.0'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-13-94	1645/1650	surge block	5 min.							
10-13-94	1655	bail			5	7.56	12.88	milky	79	
10-13-94	1700	bail	5		10	7.23	> 20	settles out quickly	77	
10-13-94	1705	bail	5		15	7.18	> 20	slightly less cloudy	77	
10-13-94	1707	bail	2		20	7.15	> 20	slightly less cloudy	76	
10-13-94	1710	bail	3		25	7.13	> 20	slightly less cloudy	75	
10-13-94	1713	bail	3		30	7.09	> 20	slightly less cloudy	75	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW05
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 3' 6" BGS

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-14-94	1627/1637	surge block	10 min.							
-94	1635	bail			5	7.42	18.14	slightly cloudy	74	strong H_2S odor
10-14-94	1645	bail	5 min.		10	7.41	18.20	slightly cloudy	74	
10-14-94	1648	bail	3		15	7.41	18.65	less cloudy	74	suspended silt settling out quickly
10-14-94	1652	bail	4		20	7.40	18.41	less cloudy	74	
10-14-94	1656	bail	4		25	7.42	18.64	less cloudy	74	
10-14-94	1700	bail	4		30	7.37	19.42	less cloudy	73	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M02 MW06
JOB NO.	110190136	SITE NAME	Runway Landfill	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 3.0'
FINAL WATER LEVEL 3.45'

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-14-94	1345/1350	surge block	5 min.							
							20 mS			
10-14-94	1100	bail	0		5	8.14	3.02	milky cloudy	83	
10-14-94	1104	bail	4		10	7.65	5.97	milky cloudy	81	
10-14-94	1106	bail	2		15	7.53	8.82	slightly less cloudy	81	
10-14-94	1108	bail	2		20	7.45	12.38	slightly less cloudy	80	
10-14-94	1110	bail	2		25	7.39	12.12	slightly less cloudy	82	
10-14-94	1112	bail	2		30	7.34	14.56	slightly less cloudy	81	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M05 MW01
JOB NO.	110190136	SITE NAME	Form.er Drum Storage Area 401	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 7.1' (1630)

FINAL WATER LEVEL

REMARKS : DTW = 6.6 (1705)

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
1-94	1705/1715	surge block	10 min.							
11-11-94	1724	over-pumpage	0		0					
11-11-94	1724	over-pumpage	0		1	8.03	1.70	very cloudy	84	milky white
11-11-94	1725	over-pumpage	1		5	7.98	1.90	very cloudy	84	
11-11-94	1726	over-pumpage	1		10	7.74	1.95	very cloudy	84	
11-11-94	1727	over-pumpage	1		15	7.55	2.04	less cloudy	86	
11-11-94	1728	over-pumpage	1		20	7.68	2.51	clearing up	86	
11-11-94	1729	over-pumpage	1		25	7.77	2.76	moderate	88	
11-11-94	1730	over-pumpage	1		30	7.63	2.91	clear	86	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M05 MW02
JOB NO.	110190136	SITE NAME	Form.er Drum Storage Area 401	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 9.4 (0930)

FINAL WATER LEVEL

REMARKS : DTW = suspect DTW will come up from 9.4'

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =

WELL CASING INSIDE DIAMETER d_w ID =

OUTSIDE DIAMETER d_w OD =

DEPTH TO: WATER LEVEL H =

BASE OF SEAL S =

BASE OF WELL TD =

EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					conductivity meter broken
11-12-94	1000/1010	surge block	10 min.							
11-12-94	1020	over-pumpage	0		0		see comm.	cloudy moderate		
11-12-94	1020	over-pumpage	0		1	7.75	1.37	cloudy moderate	80	slight yellow tint
11-12-94	1021	over-pumpage	1		5	7.86	1.25	cloudy moderate	80	
11-12-94	1022	over-pumpage	1		10	7.74	1.65	cloudy moderate	80	
11-12-94	1023	over-pumpage	1		15	7.49	1.70	clearing slightly	81	
11-12-94	1024	over-pumpage	1		20	7.46	1.65	clearing slightly	80	
11-12-94	1025	over-pumpage	1		25	7.40	1.65	clearing slightly	80	
11-12-94	1026	over-pumpage	1		30	7.49	1.68	clear	81	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M05 MW03
JOB NO.	110190136	SITE NAME	Form.er Drum Storage Area 401	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	X
BAILER	
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 10.1 (1200)

FINAL WATER LEVEL

REMARKS : TD = 17.8

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-12-94	1200/1210	surge block	10 min.							
[illegible]-94	1221	over-pumpage	0		0		mS			
11-12-94	1221	over-pumpage	0		1	8.34	1.54	cloudy	85	slight yellow tint
11-12-94	1222	over-pumpage	1		5	8.36	1.59	cloudy	85	
11-12-94	1223	over-pumpage	1		10	7.80	1.83	slightly clearer	87	
11-12-94	1224	over-pumpage	1		15	7.58	1.98	slightly clearer	87	clearing up
11-12-94	1225	over-pumpage	1		20	7.56	2.02		87	
11-12-94	1226	over-pumpage	1		25	7.44	2.05		80	
11-12-94	1227	over-pumpage	1		30			clear		

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M08 MW01
JOB NO.	110190136	SITE NAME	Aban. Power Plant (B;dg. 144)	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 7.4'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =
WELL CASING INSIDE DIAMETER d_w ID =
OUTSIDE DIAMETER d_w OD =
DEPTH TO: WATER LEVEL H =
BASE OF SEAL S =
BASE OF WELL TD =
EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.³ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-09-94	1135/1145	surge block	10		0					
11-09-94	1305	over-pumpage	0		0					
11-09-94	1305	over-pumpage	0		1	7.87	2.62 mS	milky yellow tint	79	
11-09-94	1307	over-pumpage	2 min.		5	7.97	3.26	milky yellow tint	79	no yellow tint
11-09-94	1308	over-pumpage	1 min.		10	7.69	4.53	cloudy	80	clearing up
11-09-94	1309	over-pumpage	1 min.		15	7.58	4.97	less cloudy	80	
11-09-94	1310	over-pumpage	1		20	7.54	5.31	less cloudy	80	
11-09-94	1311	over-pumpage	1		25	7.54	5.59	less cloudy	81	
11-09-94	1312	over-pumpage	1		30	7.48	5.86	clear	80	cleared up

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M08 MW02
JOB NO.	110190136	SITE NAME	Aban. Power Plant (B;dg. 144)	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 7.0'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H)$ = 3.14 (/ 2)²(-) =

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P)$ = 3.14 [(/ 2)² - (/ 2)²] (-) ( ) =
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c$ = + = _____ ft.³ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-09-94	1515/1525	surge block	10							
[illegible]-94	1536	over-pumpage	0		0					
11-09-94		over-pumpage	1							
11-09-94		over-pumpage	5							
11-09-94		over-pumpage	10							
11-09-94		over-pumpage	15							
11-09-94		over-pumpage	20							
11-09-94		over-pumpage	25							
11-09-94	1545	over-pumpage	30							

OGDEN

WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M08 MW03
JOB NO.	110190136	SITE NAME	Aban. Power Plant (B;dg. 144)	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	X
BAILER	
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 6.5' (0945)

FINAL WATER LEVEL

REMARKS : rainy

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-10-94	0940/0950	surge block	10 min.							
11-10-94	1005	over-pumpage	0		0					
11-10-94	1005	over-pumpage	0		1	8.30	3.24	slightly	79	slightly cloudy
11-10-94	1006	over-pumpage	1		5	8.15	3.14	slightly	78	
11-10-94	1007	over-pumpage	1		10	7.94	3.50	slightly	79	
11-10-94	1008	over-pumpage	1		15	7.59	4.28	slightly	79	clearing up
11-10-94	1009	over-pumpage	1		20	7.49	4.53	slightly	79	clearing up
11-10-94	1010	over-pumpage	1		25	7.41	4.47	slightly	80	clear yellow tinge
11-10-94	1011	over-pumpage	1		30	7.39	4.40	low	80	clear yellow tinge

OGDEN

WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MSB MW01
JOB NO.	110190136	SITE NAME	Super Block	PREPARED BY B. H.

HOD:

OVERPUMPAGE	X
BAILER	
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 5.2'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-10-94	1338/1348	surge block	10 min.							
0-94	1357	over-pumpage	0		0					
0-94	1357	over-pumpage	0		1	8.47	-	moderate	81	cloudy with a yellow tinge
11-10-94					5		-		80	conductivity & pH meter broken
					10					
					15					
					20					
					25					
	1405				30					

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MSB MW02
JOB NO.	110190136	SITE NAME	Super Block	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	X
BAILER	
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 5.2'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-10-94	1600/1610	surge block	10 min.							
11-10-94	1620	over-pumpage			30					

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MSB MW03
JOB NO.	110190136	SITE NAME	Super Block	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 4.0'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =

WELL CASING INSIDE DIAMETER d_w ID =

OUTSIDE DIAMETER d_w OD =

DEPTH TO: WATER LEVEL H =

BASE OF SEAL S =

BASE OF WELL TD =

EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					Conductivity meter not in greatest working order.
1-94	0915/0925	surge block	10 min.							
11-11-94	1040	over-pumpage	0		0					
11-11-94	1040	over-pumpage	0		1	7.89	2.90	cloudy	80	cloudy/yellow tint
11-11-94	1041	over-pumpage	1		5	8.13	2.15	cloudy	81	
11-11-94	1042	over-pumpage	1		10	8.10	2.17	less cloudy	82	
11-11-94	1043	over-pumpage	1		15	7.98	2.17	less cloudy	82	milky-white color
11-11-94	1044	over-pumpage	1		20	7.88	2.16	less cloudy	83	
11-11-94	1045	over-pumpage	1		25	7.83	2.10	clear	83	
11-11-94	1046	over-pumpage	1		30	7.84	2.10	clear	83	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MSB MW04
JOB NO.	110190136	SITE NAME	Super Block	PREPARED BY B. H.

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 4.7'

FINAL WATER LEVEL

REMARKS : MW-4

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =

WELL CASING INSIDE DIAMETER d_w ID =

OUTSIDE DIAMETER d_w OD =

DEPTH TO: WATER LEVEL H =

BASE OF SEAL S =

BASE OF WELL TD =

EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-11-94	1107/1117	surge block	10 min.							
11-11-94	1124	over-pumpage	0		0					
11-11-94	1124	over-pumpage	0		1	8.55	2.10	cloudy	80	
11-11-94	1125	over-pumpage	1		5	8.55	2.10	cloudy	80	
11-11-94	1126	over-pumpage	1		10	8.49	2.05	cloudy	81	
11-11-94	1127	over-pumpage	1		15	8.41	1.90	less cloudy	81	clearing up
11-11-94	1128	over-pumpage	1		20	8.32	1.78	clear	81	
11-11-94	1129	over-pumpage	1		25	8.24	1.70	clear	81	
11-11-94	1130	over-pumpage	1		30	8.17	1.67	clear	82	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MSB MW05
JOB NO.	110190136	SITE NAME	Super Block	PREPARED BY	B. H.

METHOD:

- OVERPUMPAGE: X
- BAILER:
- SURGE BLOCK: X
- AIR LIFT:
- OTHER:

INITIAL WATER LEVEL 5.4'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
1-94	1410/1420	surge block								
11-11-94	1433	over-pumpage	0		0					
11-11-94	1433	over-pumpage	0		1	7.80	1.25	highly cloudy	83	milky white (H_2S odor)
11-11-94	1434	over-pumpage	1		5	7.83	1.37	highly cloudy	84	
11-11-94	1435	over-pumpage	1		10	7.77	1.28	highly cloudy	84	
11-11-94	1436	over-pumpage	1		15	7.76	1.14	less cloudy	84	clearing up
11-11-94	1437	over-pumpage	1		20	7.74	1.05	less cloudy	84	
11-11-94	1438	over-pumpage	1		25	7.72	1.00	clear	85	
11-11-94	1439	over-pumpage	1		30	7.71	0.97	clear	84	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M10 MW01
JOB NO.	110190136	SITE NAME	Disposal Area Northeast Point	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 12.8 BGS
FINAL WATER LEVEL 12.2 BGS (1500)

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-25-94	1218/1228	surge block	10 min.							
							20 mS			
10-25-94		bail								
10-25-94	1238	bail	0		1	7.45	> 20	milky/ cloudy	80	cloudy cream color
10-25-94	1243	bail	5		5	7.46	> 20	milky/ cloudy	78	
10-25-94	1246	bail	3		10	7.45	> 20	milky/ cloudy	77	
10-25-94	1249	bail	3		15	7.45	> 20	slightly less cloudy	76	
10-25-94	1252	bail	3		20	7.45	> 20	slightly less cloudy	76	
10-25-94	1255	bail	3		25	7.44	> 20	clearing up	75	
10-25-94	1258	bail	3		30	7.45	> 20	almost clear	75	

OGDEN

WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI	WELL NO.	M10 MW02
JOB NO.	110190136	SITE NAME	Disposal Area Northeast Point
PREPARED BY	B. H.		

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 9.0' BGS (0930)
FINAL WATER LEVEL 10.0' BGS (1230)

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
6-94	1105/1115	surge block	10 min.							
							20 mS			
10-26-94	1213	bail			3	7.64	> 20	milky	78	settling out quickly
10-26-94	1217	bail	4		5	7.63	> 20	slightly cloudy	77	milky in color
10-26-94	1220	bail	3		10	7.64	> 20		76	
10-26-94	1223	bail	3		15	7.63	> 20		76	
10-26-94	1225	bail	2		20	7.64	> 20	more transparent	75	
10-26-94	1227	bail	2		25	7.64	> 20	clearing up	75	
10-26-94	1230	bail	3		30	7.63	> 20		75	

OGDEN

WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M10 MW03
JOB NO.	110190136	SITE NAME	Disposal Area Northeast Point	PREPARED BY JDF

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 11.0 BGS

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-25-94	1540/1550	surge block	10							
							20 mS			
10-25-94	1631	bail	0		0					
10-25-94	1633	bail	2		1	7.48	> 20	v. high	78	off white milky color
10-25-94	1637	bail	4		5	7.49	> 20	v. high	77	off white milky color
10-25-94	1640	bail	3		10	7.50	> 20	v. high	76	off white milky color
10-25-94	1643	bail	3		15	7.50	> 20	v. high	76	lt. greyish milky color
10-25-94	1646	bail	3		20	7.50	> 20	v. high	75	lt. greyish milky color
10-25-94	1648	bail	2		25	7.50	> 20	v. high	75	same color, but clearing
10-25-94	1651	bail	3		30	7.51	> 20	v. high	74	still clearing
10-25-94	1657	bail	6		40	7.54	> 20	v. high	76	still clearing, less grey
										WSEL = 11.0' @ 1700

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M11 MW01
JOB NO.	110190136	SITE NAME	Disposal Area Southwest Point	PREPARED BY A. Martin

METHOD:

OVERPUMPAGE	X 40 gal.
BAILER	
SURGE BLOCK	X 10 min.
AIR LIFT	
OTHER	

INITIAL WATER LEVEL ~ 4.0' BGS
FINAL WATER LEVEL ~ 4.3' BGS

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
-94	1420/1430	surge block	10 min.	NA	NA					
11-01-94	1443	over-pumpage	0	~ 10	0	7.79	> 20	moderate	79	
11-01-94	1444	over-pumpage	1	~ 10	5	7.75	> 20	moderate	80	
11-01-94	1444	over-pumpage	1.5	~ 10	10	7.71	> 20	moderate	80	
11-01-94	1445	over-pumpage	2	~ 10	15	7.72	> 20	moderate	80	
11-01-94	1446	over-pumpage	3	~ 10	20	7.72	> 20	moderate	81	
11-01-94	1446	over-pumpage	3.5	~ 10	25	7.71	> 20	clearer	80	
11-01-94	1447	over-pumpage	4	~ 10	30	7.71	> 20	clearer	80	
11-01-94	1447	over-pumpage	4.5	~ 10	35	7.70	> 20	clearer	80	
11-01-94	1448	over-pumpage	5	~ 10	40	7.69	> 20	clearer	80	
				~ 8 gpm						

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M11 MW02
JOB NO.	110190136	SITE NAME	Disposal Area Southwest Point	PREPARED BY A. Martin

METHOD:

OVERPUMPAGE	X 40 gal.
BAILER	
SURGE BLOCK	X 10 min.
AIR LIFT	
OTHER	

INITIAL WATER LEVEL ~ 5.5'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-01-94	1104/1114	surge block	10 min.	NA						
11-01-94	1213/1220	over-pumpage	0	5-10 gpm	0	7.86	> 20	very	80	
11-01-94		over-pumpage	0.5 min.	5-10 gpm	5	7.73	> 20	very	79	
11-01-94		over-pumpage	1 min.	5-10 gpm	10	7.69	> 20	very	79	
11-01-94		over-pumpage	2.0 min.	5-10 gpm	15	7.66	> 20	clearing	78	
11-01-94		over-pumpage	3.5 min.	5-10 gpm	20	7.64	> 20	clearing	78	
11-01-94		over-pumpage	4.5 min.	5-10 gpm	25	7.62	> 20	clearing	78	
11-01-94		over-pumpage	5.0 min.	5-10 gpm	30	7.61	> 20	clearing	77	
11-01-94		over-pumpage	6.0 min.	5-10 gpm	35	7.60	> 20	clearing	78	
11-01-94	1250	over-pumpage	7.0 min.	5-10 gpm	40	7.60	> 20	clearing	78	

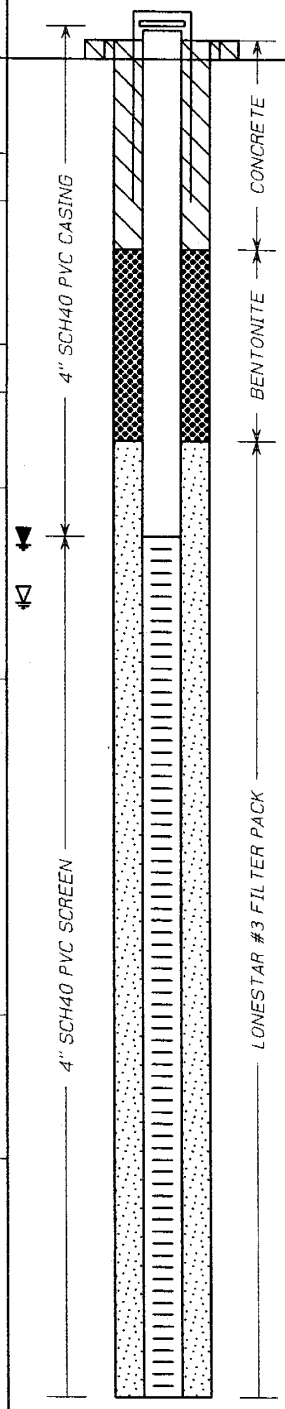
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/18/94 / 1305
DATE/TIME FINISHED 10/18/94 / 1410
COORDINATES -4340.96 N, 1862.68 E
ELEVATION AND DATUM 5.91 feet
TOP OF CASING ELEVATION 8.80 feet

BORING NUMBER M01BS02
COMPLETION DEPTH 16.5 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				20	0.0		SP	siltly CORAL SAND, fine-grained, grayish brown, 10YR 6/2, dry, loose, moderately sorted, SP (with asphalt, glass, and root fragments - 85% sand and 15% fines).
				50/4"				NOTE: Refusal at 1.0 feet. Large pieces of copper metal taken from bore hole. Auger down to 1.5 feet.
2		20		13	0.0			silty CORAL SAND, Same as above except slighty darker in color 10YR 4/2, slightly moist, and 10% fines.
				20				
		35	M01BS02S02D3.0	50/3"				silty CORAL SAND, Same as above except very dark brown 10YR 3/1.
				50/5"				NOTE: Refusal at 3.5 feet. Auger down to 4.5 feet.
4		05					SW	CORAL SAND, fine- to medium-grained, gray brown, 10YR 5/1, moist to wet, loose, well sorted, subrounded, SW (with wood fragments in sampler shoe - sand heavily stained)
				22	0.0			
			M01BS02D01D5.5	25				
6		70	M01BS02S01D6.0	30				
				50/2"				NOTE: Refusal at 6.5 feet. Auger down to 10.0 feet. No samples
		0						
8								
10								NOTE: No recovery.
				30				
				13				
		0		14				NOTE: Refusal - Auger down to 15.0 feet. No samples
12								
14								

WELL DIAGRAM



DEPTH feet

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CLIENT NAVY CLEAN

BORING NUMBER M01BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 16.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
				31			SW	CORAL SAND, fine-grained, gray, 2.5Y 5/1, saturated, loose, well sorted, subrounded, SW		
16				36				CORAL SAND, same as above except change in color from gray to pale yellow 2.5Y 8/2 and strong H2S odor.		16
		100		45				END OF BORING at 16.5 feet below grade. Boring was completed on 10/18/94, at 1410 hours.	LONESTAR #3 FILTER PACK	
18										18
20										
22										22
24										24
26										26
28										28
30										30

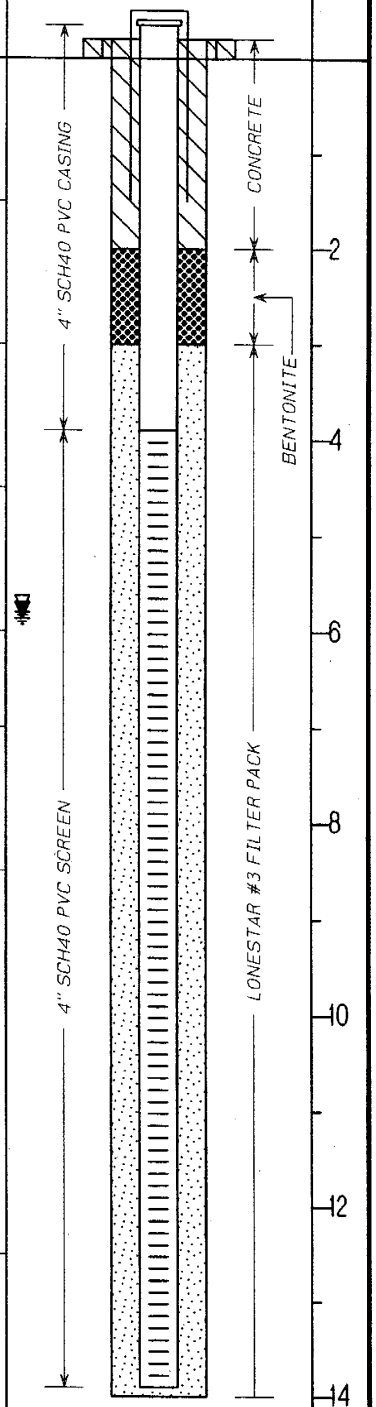
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/18/94 / 0845
DATE/TIME FINISHED 10/18/94 / 0950
COORDINATES -4170.66N, 2002.49E
ELEVATION AND DATUM 6.62 feet
TOP OF CASING ELEVATION 9.39 feet

BORING NUMBER M01BS03
COMPLETION DEPTH 15.5 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				12 20	0.0		SP	siltly CORAL SAND, fine-grained, grayish brown, 10YR 5/2, dry, loose, moderately sorted, SP (with concrete chunks, glass fragments, roots in the first 8", and 10% fines).
2		95		35 25 34	0.0		SP	silty CORAL SAND, Same as above except 15% organic silt.
4		30	M01BS03S01D3.0	55 35 20	0.0		SP	silty CORAL SAND, finge grained, dark brown, 7.5R 3/2 dry loose,SP (with concrete chunks throughout and 10% fines).
6		60	M01BS03S02D4.5	31 3 5	0.0		SW	CORAL SAND, fine- to medium-grained, very dark brown, 10YR 3/1, moist, loose, SW (with dark discoloration).
		55		22/0"				NOTE: Drill down to 7.0 feet. No samples
8		22		22 27 29	0.0		SW	CORAL SAND, fine-grained, yellow brown, 10YR 5/4, wet, loose, well sorted, subrounded, SW (with darker staining at bottom of split spoon)
		50						NOTE: Drill down to 12.5 feet. No samples
12				27 15	0.6		SW	CORAL SAND, fine-grained, very dark brown, 10YR 3/1, saturated, loose, well sorted, SW (looks like asphalt)
14		35		8	0.0			

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M01BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
				23			SW	CORAL SAND, same as above		
				27				CORAL SAND, fine-grained, white, 10YR 8/1, saturated, loose, well sorted, subrounded to rounded, SW (very clean sand)		
		50		30				END OF BORING at 15.5 feet below grade. Boring was completed on 10/18/94, at 0950 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

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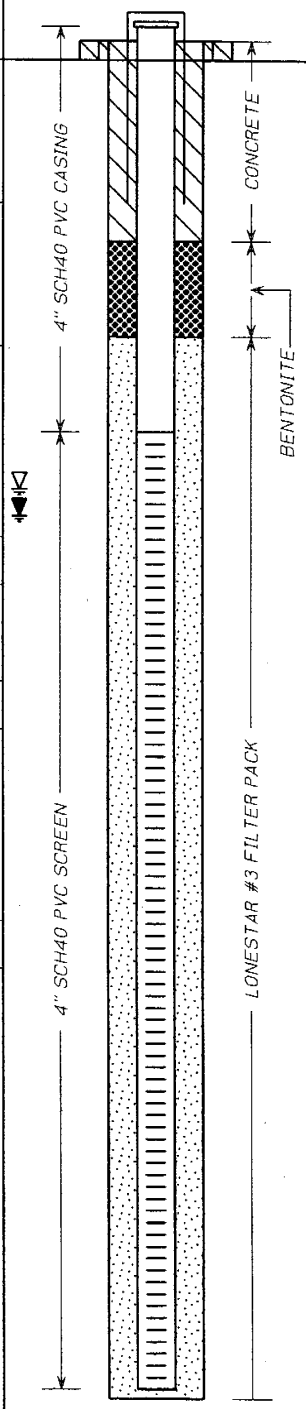
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/17/94 / 1430
DATE/TIME FINISHED 10/17/94 / 1510
COORDINATES -4715.33 N, 2133.62 E
ELEVATION AND DATUM 5.27 feet
TOP OF CASING ELEVATION 8.27 feet

BORING NUMBER M01BS04
COMPLETION DEPTH 16.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				18	0.0		SP	CORAL SAND, fine- to medium-grained, dark brown, 2.5Y 3/1, dry to slightly oily, loose, moderately sorted, subrounded, SP (with 5% coral gravel and 5% fines).
			M01BS04D01D1.0	28				
		100	M01BS04S01D1.5	30	0.0			CORAL SAND, fine- to medium-grained, redish brown, 10YR 5/6, moist, loose, moderately sorted, subrounded, SP (with concrete chunks and metal debris).
2				18				
			M01BS04S02D2.5	28				
		65		37				NOTE: Drill down to 5.0 feet. No samples
				50/2"				
4								
		0						
				12/4"	190.5		SW	CORAL SAND AND GRAVEL, fine- to coasre-grained, very dark brown, 10YR 3/1, saturated, loose, SW (heavily stained from burning)
		3						
6								NOTE: Drill down to 6.5 feet. No samples
				9/4"	57.4		SW	CORAL SAND, fine- to medium-grained, very dark brown, 10YR 3/1, saturated, loose, moderately sorted, SW (with rubber, glass, and wood debris)
		0						
8								NOTE: Drill down to 9.0 feet. No Samples
				28				NOTE: No recovery
		0		50/4"				NOTE: Drill down to 14.5 feet. No Samples
10								
12								
14								

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M01BS04

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 16.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X			16 16 17	12.4		GW	CORAL GRAVEL, white, 10YR 8/1, saturated, compact, GW (with 20% coral sand)		
16		45						END OF BORING at 16.0 feet below grade. Boring was completed on 10/07/94, at 1510 hours.		16
18										18
20										20
22										22
24										24
26										26
28										28
30										30

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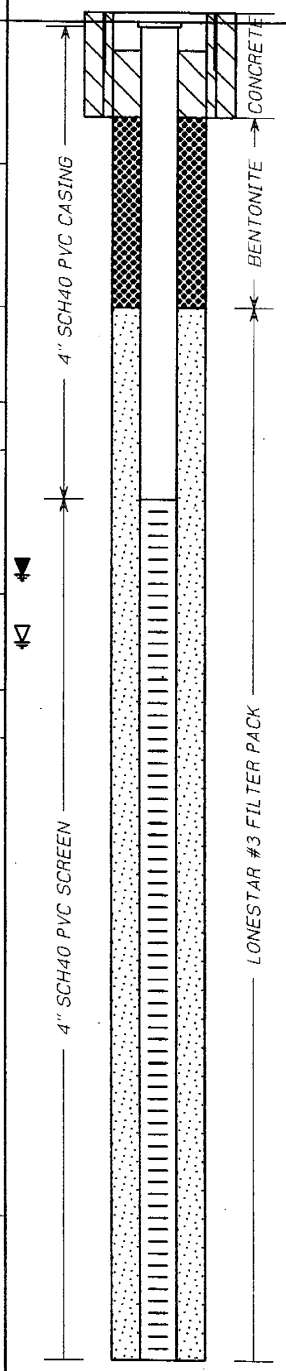
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/11/94 / 0930
DATE/TIME FINISHED 10/11/94 / 1400
COORDINATES -1213.34 N, 6184.72 E
ELEVATION AND DATUM 6.65 feet
TOP OF CASING ELEVATION 6.73 feet

BORING NUMBER M02BS01
COMPLETION DEPTH 15.0 ft.
BOREHOLE DIAMETER 8.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				02	0.4		SP	CORAL SAND, fine-grained, pale yellow, 2.5Y 7/3, dry, loose, poorly sorted, subrounded to subangular, SP (with 10% organic silt in first foot of sample)
				10				
		75		11				CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 7/2, slighty moist, loose, moderately sorted, subrounded, SP (with some larger coral chunks)
2				07	0.3			
			M02BS01D02D2.5	09				
		75	M02BS01S02D3.0	08				CORAL SAND, Same as above except light yellowish brown, 2.5Y 6/3, SP (with 5% coral gravel)
				08	0.4			
4				18				Gravelly CORAL SAND, medium-to coarse-grained, pale yellow 2.5Y 8/3, slightly moist, loose, poorly sorted, SP (with 30% gravel)
		90		45				
				20	1.1			Gravelly CORAL SAND, same as above except moist and with 20% coral gravel
			M02BS01D03D5.5	40				
6		90	M02BS01S03D6.0	35			GP	CORAL GRAVEL with sand, pale yellow, 2.5Y 8/2, wet, loose, subangular to subrounded, poorly sorted, GP (with 15% sand)
				25	0.4			
			M02BS01D04D7.0	27				CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 8/2, wet, loose, poorly sorted, subrounded, SP (with 15% coral gravel)
		95	M02BS01S04D7.5	21				
8								NOTE: Auger down to 12.5 feet. No samples
10								
12								
				13				CORAL SAND, very fine-grained, gray, 2.5Y 7/1, saturated, loose, well sorted, rounded, SW (slight H2S odor)
				12	0.0			
14		40	M02BS01S05D14.0	09			SW	

WELL DIAGRAM



DEPTH feet

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CLIENT NAVY CLEAN

BORING NUMBER M02BS01

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 15.0 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
				14 23			SW	NOTE: No recovery sample washed out.		
		5		15				END OF BORING at 15.5 feet below grade. Boring was completed on 10/11/94, at 1400 hours.	LONESTAR #3 FILTER PACK	
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

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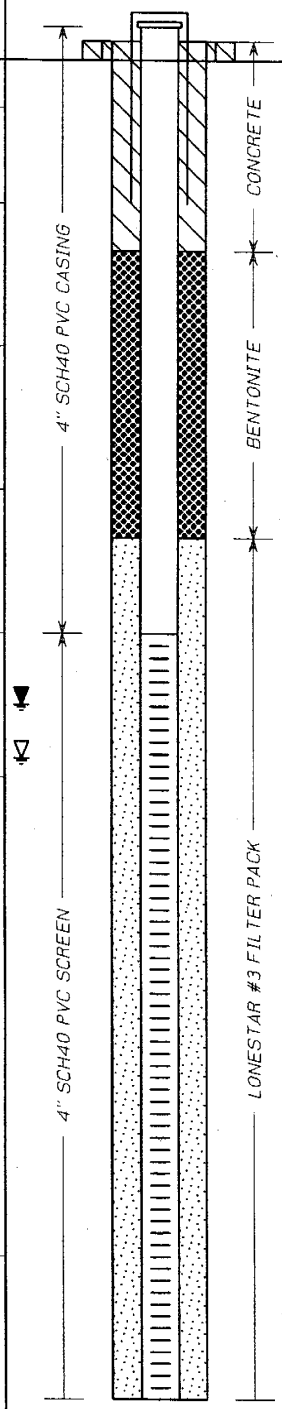
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/12/94 / 1000
DATE/TIME FINISHED 10/12/94 / 1130
COORDINATES -1372.48 N, 5455.02 E
ELEVATION AND DATUM 7.50 feet
TOP OF CASING ELEVATION 9.75 feet

BORING NUMBER M02BS02
COMPLETION DEPTH 17.5 ft.
BOREHOLE DIAMETER 7.0
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
							PT	ORGANICS, dark brown, 10YR 3/3, dry, loose, PT (with 10% sand).
		100		12	0.3		SP	CORAL SAND, fine- to coarse-grained, pale yellow, 2.5Y 7/3, dry, loose, SP (with 5% coral gravel).
		100		27				
		10		27				CORAL SAND, fine- to coarse-grained, pale yellow, 2.5Y 8/2 dry, loose, SP (with 15% coral gravel).
2		0		15				
		30		31				
		100	M02BS02S01D3.0	28				CORAL SAND, fine- to medium-grained, pale yellow, 2.5 8/3, moist, loose, SP (with 10% coral gravel and larger coral chunks).
		50		23				
4		100		31				
		100	M02BS02S02D4.5	34				CORAL SAND, fine- to medium-grained, pale yellow, 2.5Y 8/4, moist, loose, SP (with coral gravel, cobbles, and some shell fragments).
		10		38				
		100		38				
6		100		33			SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 8/4, wet, loose, SW (with 10% larger coral chunks).
		5		27				
		100		17				
		100		15				Auger down to 12.5 feet. No samples taken
8								
10								
12								
		0		42			SW	CORAL SAND, fine-grained, light gray, 2.5Y 7/1, saturated, loose, well sorted, sulfur odor, SW.
		50		54				
14		100		60				

WELL DIAGRAM



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CLIENT NAVY CLEAN

BORING NUMBER M02BS02

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								Auger down to 17.0 feet. No samples taken		
16										16
	X						SW	CORAL SAND, fine-grained, gray, 2.5Y 7/1, saturated, well sorted, sulfur odor, SW.	LONESTAR #3 FILTER PACK	
18								END OF BORING at 17.5 feet below grade. Boring was completed on 10/12/94, at 1130 hours.		18
20										20
22										22
24										24
26										26
28										28
30										30

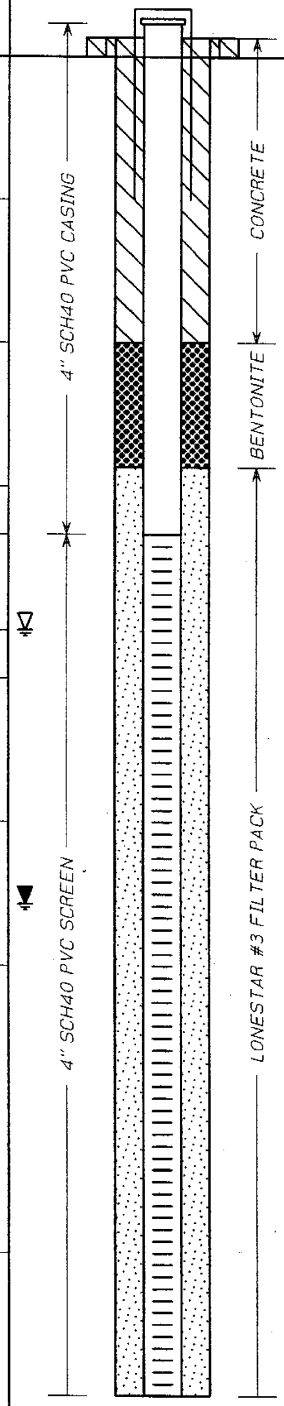
OGDEN

CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/13/94 / 0900
DATE/TIME FINISHED 10/13/94 / 1045
COORDINATES -1251.29 N, 4956.28 E
ELEVATION AND DATUM 7.38 feet
TOP OF CASING ELEVATION 9.67 feet

BORING NUMBER M02BS03
COMPLETION DEPTH 17.5 ft.
BOREHOLE DIAMETER 7
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				03			SP	silty SAND, fine-grained, light gray, 2.5Y 7/2, dry, loose, poorly sorted, SP (with 15% silt, 5% coral gravel, beer can fragments, grass in top 5 inches of spoon).
				08				
		60	M02BS03S01D1.5	10				CORAL SAND, fine-grained, yellow brown, 2.5Y 6/3, dry, loose, poorly sorted, SP (with 10% fines, dark charcoal chunks in spoon shoe, rusted metal fragments, glass pieces, wood). No analytical samples - not enough recovery.
2				05				
				03				
		30		03	0.0			CORAL SAND, fine- to medium-grained, grayish brown, 10YR 5/2, slightly moist, loose, well sorted, SP (with 5% coral gravel, plastic, metal, glass fragments throughout).
				05	0.8			
4			M02BS03S02D4.0	08				
		60	M02BS03D02D4.5	50				NOTE: Refusal at 4.5 feet. Auger down to 5.0 feet. Possible metal debris. No samples
							SW	CORAL SAND, fine-grained, yellowish brown, 2.5Y 6/4, moist, loose, well sorted, SW (with glass fragments throughout). Distinct change at 5.5-6.2 feet, gray to black stained sands, oily, HC odor.
			M02BS03S04D5.5	11				
6			M02BS03S03D6.0	15	92			
		100		28				CORAL SAND, fine-grained, dark gray, N 4/, moist, loose, well sorted, SW (with coral chunks and glass fragments).
				23	1.4			
				23				CORAL SAND, fine-grained, light gray, 2.5Y 7/1, wet, loose, well sorted, SW (with some coral gravel at 6.5-7.0 feet, crushed shell layer of one inch at 7.8 feet, and very fine-grained sands at the bottom of spoon).
8		90		26				
				32				CORAL SAND, fine-grained, white, 10YR 8/1, wet, compacted, well sorted, SW (larger coral chunks at 9.3-9.5 feet, into the very fine-grained sands, H2S odor).
				40				
		100		32				Auger down to 12.5 feet. No samples.
10								
12								
				13			SW	CORAL SAND, fine-grained, white, 10YR 8/1, moist, compact, well sorted, SW, (seems as though the water is squeezed out of spoon, sample is relatively dry for below the water table).
				13				
14				13				

WELL DIAGRAM



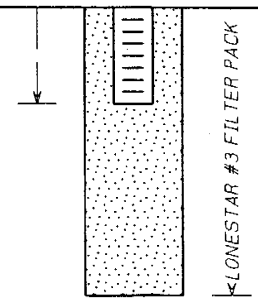
OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M02BS03

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 17.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
								Auger down to 16.0 feet. No samples.		
16	X			07 20 31	13		SW	CORAL SAND, fine-grained, white, 10YR 8/1, wet, loose, well sorted, SW, (distinct changes in grain size each 6 inches of sample, from fine-grained, to ultra-fine-grained, to medium-grained).		16
18								END OF BORING at 17.5 feet below grade. Boring was completed on 10/13/94, at 1045 hours.		18
20										20
22										22
24										24
26										26
28										28
30										30

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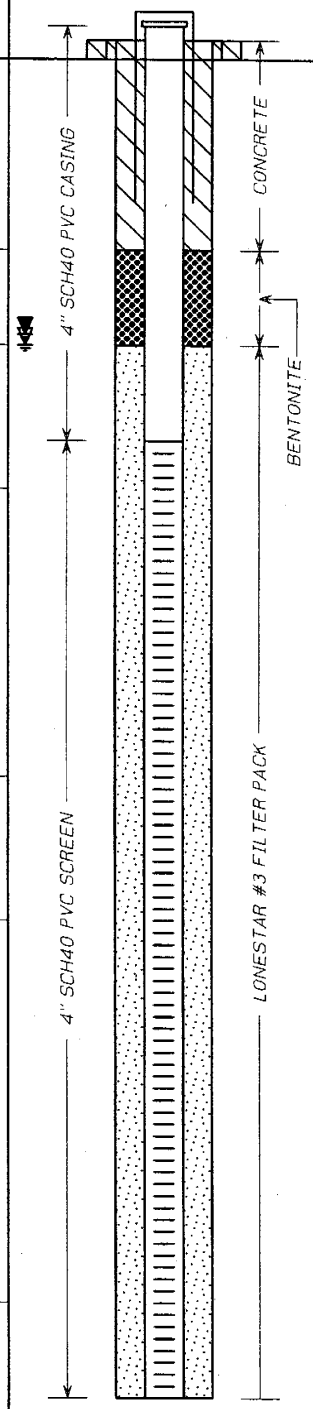
CLIENT NAVY CLEAN
PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136
DATE/TIME STARTED 10/13/94 / 1450
DATE/TIME FINISHED 10/13/94 / 1545
COORDINATES -1933.06 N, 4724.41 E
ELEVATION AND DATUM 3.70 feet
TOP OF CASING ELEVATION 4.58 feet

BORING NUMBER M02BS04
COMPLETION DEPTH 14.5 ft.
BOREHOLE DIAMETER 6
DRILLER/COMPANY Russell O'Malia/ Valley Well Drilling
DRILLING METHOD/FLUID HSA-6", Ream with 10" Auger/none
DRILLING EQUIPMENT Mobile B-59
GEOLOGIST Brian House
CHECKED BY

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION
				15			SW	CORAL SAND, fine-grained, pale yellow, 2.5Y 8/3, dry, loose, well sorted, SW (with some larger coral chunks and organic root material).
			M02BS04S01D1.0	50				
		80	M02BS04S02D1.5	50/5"	0.0			
2			M02BS04S04D2.0	33				CORAL SAND, fine- to medium-grained, yellow, 2.5Y 7/6, at end of shoe (last three inches of spoon) is 2.5Y 8/3, moist to wet, poorly sorted, strong H2S odor, SW (minor amount of gravel).
				35				
		75		36	30			
				20				CORAL SAND, fine-grained, pale yellow, 2.5Y 8/2, wet, compact, SW.
4				34				
		60		34				Auger down to 7.5 feet.
6								
8							SW	CORAL SAND, very fine-grained, white, 10YR 8/1, wet, compact, strong H2S odor, SW
				13				
				13	343			
		80		13				Auger down to 13.0 feet. No samples were taken.
10								
12								
				21	129		SW	CORAL SAND, fine- to medium-grained, white, 10YR 8/2, saturated, loose, SW (two inches of coral gravel layer at 13.5 to 13.7 feet, medium-grained sand at 13.0 to 13.5 feet, and fine grained sand from 13.5 feet and down).
14				30				

WELL DIAGRAM



DEPTH feet

OGDEN

CLIENT NAVY CLEAN

BORING NUMBER M02BS04

PROJECT NAME/NUMBER NAF MIDWAY SI/RI, NO. 110190136

COMPLETION DEPTH 14.5 ft.

DEPTH feet	SAMPLE	RECOVERY %	SAMPLE NUMBER	BLOW COUNT	HEADSPACE (ppm)	GRAPHIC LOG	SOIL CLASS	DESCRIPTION	WELL DIAGRAM	DEPTH feet
	X	100		21			SW	END OF BORING at 14.5 feet below grade. Boring was completed on 10/13/94, at 1545 hours.		
16										16
18										18
20										
22										22
24										24
26										26
28										28
30										30

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M11 MW03
JOB NO.	110190136	SITE NAME	Disposal Area Southwest Point	PREPARED BY A. Martin

METHOD:

OVERPUMPAGE	X ~ 45 gal.
BAILER	
SURGE BLOCK	X 10 min.
AIR LIFT	
OTHER	

INITIAL WATER LEVEL ~ 6' BGS
FINAL WATER LEVEL ~ 6.55' BGS

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-02-94	0853/0903	surge block	10 min.	NA	NA					
2-94		over-pumpage	0		0					
11-02-94	0925	over-pumpage	0	5 gpm	2	7.99	> 20		80	
11-02-94	0928	over-pumpage	3	5 gpm	5	7.95	> 20		80	
11-02-94	0930	over-pumpage	2	5 gpm	10	7.89	> 20		79	
11-02-94	0930	over-pumpage	0.5	5 gpm	15	7.84	> 20		79	
11-02-94	0930	over-pumpage	0.5	5 gpm	20	7.79	> 20		79	
11-02-94	0932	over-pumpage	2.0	5 gpm	25	7.77	> 20			temp probe deceased
11-02-94	0933	over-pumpage	1.0	5 gpm	30	7.76	> 20			
11-02-94	0934	over-pumpage	1	5 gpm	35	7.73	> 20			
11-02-94	0936	over-pumpage	2	5 gpm	40	7.71	> 20			
11-02-94	0936	over-pumpage	2	5 gpm	45		> 20			

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M54 MW01
JOB NO.	110190136	SITE NAME	Southeast Landfill Pit	PREPARED BY	A. Martin

METHOD:

OVERPUMPAGE	X ~55 gal.
BAILER	X
SURGE BLOCK	X 10 min.
AIR LIFT	
OTHER	

INITIAL WATER LEVEL ~ 9' BGS

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
10-31-94	0935	over-pumpage	0 (BEGIN)	2-3 gpm	0					
10-31-94	0937	over-pumpage		2-3 gpm	5	7.58	off scale	very		temp probe - dead battery
10-31-94	0939	over-pumpage		2-3 gpm	10	7.54	> 20	very		temp probe - dead battery
10-31-94	0940	over-pumpage		5 gpm	15	7.53	> 20	very		temp probe - dead battery
10-31-94	0941	over-pumpage		5 gpm	20	7.47	> 20	very		temp probe - dead battery
10-31-94	0942	over-pumpage		5 gpm	25	7.44	> 20			
10-31-94	0943	over-pumpage		5 gpm	30	7.41	> 20			
10-31-94	0944	over-pumpage		5 gpm	35	7.39				
10-31-94	0944	over-pumpage		5 gpm	40	7.40				

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M54 MW02
JOB NO.	110190136	SITE NAME	Southeast Landfill Pit	PREPARED BY A. Martin

METHOD:

- OVERPUMPAGE: X
- BAILER:
- SURGE BLOCK: X 10 min.
- AIR LIFT:
- OTHER:

INITIAL WATER LEVEL 8.3' BGS
FINAL WATER LEVEL 8.0' BGS

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =
WELL CASING INSIDE DIAMETER d_w ID =
OUTSIDE DIAMETER d_w OD =
DEPTH TO: WATER LEVEL H =
BASE OF SEAL S =
BASE OF WELL TD =
EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
31-94	1242/1252	surge	10 min.							
10-31-94	1300	over-pumpage	0	5 gpm	0	7.94	2.90 mS	very	-	temp probe - dead battery
10-31-94			1	5 gpm	5	7.65	6.94	very	-	
10-31-94			2	5 gpm	10	7.56	7.40	very	-	
10-31-94			3	5 gpm	15	7.51	7.75	very	-	
10-31-94			4	5 gpm	20	7.44	8.02	very	-	
10-31-94			5	5 gpm	25	7.41	8.11	very	-	
10-31-94			6	5 gpm	30	7.39	8.30	very	-	
10-31-94			6.5	5 gpm	35	7.37	8.38	clearing	-	
10-31-94			7.0	5 gpm	40	7.35	8.39	clearing	-	
10-31-94	1307		7.5	5 gpm	45	7.36	8.36	clearing	-	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	M54 MW03
JOB NO.	110190136	SITE NAME	Southeast Landfill Pit	PREPARED BY B. H.

METHOD:

OVERPUMPAGE	
BAILER	X
SURGE BLOCK	X
AIR LIFT	
OTHER	

INITIAL WATER LEVEL 9.0 BGS (1430)

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
10-26-94	1545/1555	surge block	10 min.							
							20 mS			
10-26-94	1625	bail	0		1	7.47	> 20	milky very turbid	79	silt settles out quickly
10-26-94	1630	bail	5		5	7.48	> 20	milky very turbid	79	
10-26-94	1635	bail	5		10	7.47	> 20	milky very turbid	81	
10-26-94	1638	bail	3		15	7.45	> 20	milky very turbid	81	
10-26-94	1640	bail	2		20	7.44	> 20	milky very turbid	81	
10-26-94	1643	bail	3		25	7.40	> 20	milky very turbid	80	
10-26-94	1646	bail	3		30	7.39	> 20	slightly less cloudy	80	

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MAF MW01
JOB NO.	110190136	SITE NAME	Antenna Field	PREPARED BY A. Martin

METHOD:

OVERPUMPAGE	X
BAILER	
SURGE BLOCK	X 10 min.
AIR LIFT	
OTHER	

INITIAL WATER LEVEL ~ 7.21'

FINAL WATER LEVEL

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)	VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)
2" - 0.16	2" CASING AND 6" HOLE = 0.52
4" - 0.65	2" CASING AND 8" HOLE = 0.98
6" - 1.47	4" CASING AND 10" HOLE = 1.37
	4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER	d_h =
WELL CASING INSIDE DIAMETER	d_w ID =
OUTSIDE DIAMETER	d_w OD =
DEPTH TO: WATER LEVEL	H =
BASE OF SEAL	S =
BASE OF WELL	TD =
EST. FILTER PACK POROSITY	P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
-- 02-94	1600/1610	surge block	10 min.	NA	NA					
		over-pumpage								

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MAF MW02
JOB NO.	110190136	SITE NAME	Antenna Field	PREPARED BY J FREI

METHOD:

- OVERPUMPAGE X
- BAILER
- SURGE BLOCK X
- AIR LIFT
- OTHER

INITIAL WATER LEVEL 6.10' BGS
FINAL WATER LEVEL 7.05' BGS

REMARKS :

CAPACITY OF CASING (Vc)
(GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT)
(ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =
WELL CASING INSIDE DIAMETER d_w ID =
OUTSIDE DIAMETER d_w OD =
DEPTH TO: WATER LEVEL H =
BASE OF SEAL S =
BASE OF WELL TD =
EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2 (-) =$

FILTER PACK
PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$
(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-03-94	0958/1008	surge block	10							
11-03-94	1021	over-pumpage	1		1	7.80	3.19	v. high	81	creamy color
11-03-94	1023	over-pumpage	2		6	7.99	9.96	v. high	82	
11-03-94	1024	over-pumpage	1		11	7.90	14.12	v. high	82	
11-03-94	1025	over-pumpage	1		16	7.84	16.22	high	82	
11-03-94	1027	over-pumpage	2		21	7.82	16.92	high	82	clearing
11-03-94	1028	over-pumpage	1		26	7.73	> 20	high	82	clearing
11-03-94	1029	over-pumpage	1		31	7.74	> 20	high	82	clearing
11-03-94	1030	over-pumpage	1		36	7.73	> 20	med.	81	clearing
11-03-94	1031	over-pumpage	1		41	7.70	> 20	med.	80	same
11-03-94	1032	over-pumpage	1		46	7.68	> 20	slight	80	clearing
11-03-94	1033	over-pumpage	1		51	7.64	> 20	med.	80	not as clear

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WELL DEVELOPMENT

PROJECT	NAF Midway SI/RI		WELL NO.	MAF MW03
JOB NO.	110190136	SITE NAME	Antenna Field	PREPARED BY JFREI

METHOD:

- OVERPUMPAGE: X
- BAILER:
- SURGE BLOCK: X
- AIR LIFT:
- OTHER:

INITIAL WATER LEVEL 6.0' BGS

FINAL WATER LEVEL 8.5' BGS

REMARKS :

CAPACITY OF CASING (Vc) (GALLONS / LINEAR FOOT)

2" - 0.16
4" - 0.65
6" - 1.47

VOLUME BETWEEN CASING AND HOLE (Vf)(GALLONS / LINEAR FOOT) (ASSUMING 40% POROSITY)

2" CASING AND 6" HOLE = 0.52
2" CASING AND 8" HOLE = 0.98
4" CASING AND 10" HOLE = 1.37
4" CASING AND 12" HOLE = 2.09

HOLE DIAMETER d_h =

WELL CASING INSIDE DIAMETER d_w ID =

OUTSIDE DIAMETER d_w OD =

DEPTH TO: WATER LEVEL H =

BASE OF SEAL S =

BASE OF WELL TD =

EST. FILTER PACK POROSITY P =

WELL VOLUME CALCULATION:

CASING VOLUME = $V_c = \pi (d_w ID / 2)^2 (TD - H) = 3.14 (/ 2)^2(-) =$

FILTER PACK

PORE VOLUME = $V_f = \pi [(d_h / 2)^2 - (d_w OD / 2)^2] (TD - (S \text{ or } H)^*) (P) = 3.14 [(/ 2)^2 - (/ 2)^2] (-) ( ) =$

(* if S > H use S, if S < H use H.)

TOTAL WELL VOLUME = $V_T = V_f + V_c = + =$ _____ ft.^{3} x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	CONDUCTIVITY	TURBIDITY	TEMP.	COMMENTS:
			0 (BEGIN)		0					
11-03-94	1326/1336	surge block	10							
11-03-94	1350	over-pumpage	0		1	7.84	6.55	v. high	84	creamy/bone colored
11-03-94	1351	over-pumpage	1		5	7.83	7.38	high	87	
11-03-94	1353	over-pumpage	3		10	7.70	11.09	high	85	
11-03-94	1356	over-pumpage	6		15	7.64	15.26	high	80	
11-03-94	1403	over-pumpage	13		20	7.83	10.01	high	88	may have pumped well dry
11-03-94	1405	over-pumpage	15		25	7.67	13.78	high	83	
11-03-94	1406	over-pumpage	16		30	7.48	18.02	high	84	
11-03-94	1408	over-pumpage	18		35	7.54	18.30	high	88	
11-03-94	1409	over-pumpage	19		40	7.76	19.87	clearer	88	may have pumped well dry
11-03-94	1415	over-pumpage	25		45	7.47	> 20	clearer	85	
11-03-94	1417	over-pumpage	27		50	7.60	> 20	same	89	

GROUND-WATER SAMPLING LOG

WELL NO. M01 MW01 LOCATION: Bulky Waste Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 1406 CLIMATIC CONDITIONS: Mostly cloudy, breezy, 32°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.75'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.78' TOC @ 1416

WELL PURGING: LENGTH OF SATURATED ZONE: 8.97 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.97 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.4 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 128 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/1406	0				
1426	1	27.3	10.60	3.71	slight
1428	5	27.2	10.25	5.72	moderate
1429	10	27.1	10.60	5.99	clearing
1431	15	27.0	10.71	6.49	clearing
1433	20	27.1	11.25	6.97	clear
1435	25	27.1	10-11.5	7.31	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M01MW01S01D150 @1440 SAMPLED BY:

M01MW01S02D150 @1445

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH/Cond meter giving semi-erratic readings, not sure if accurate

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: Total Purged Volume (Gal) Total Purged Volume (Number of Well Volumes)

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M01 MW02 LOCATION: Bulky Waste Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 1500 CLIMATIC CONDITIONS: Mostly cloudy, breezy, 32°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.25'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 7.98' TOC @ 1506

WELL PURGING: LENGTH OF SATURATED ZONE: 10.27 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.27 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 20.0 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 90 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/1500	0				
1512	1	29.0	12.49	8.10	high
1515	5	28.7	9.61	6.08	moderate
1517	10	29.1	11.73	9.50	moderate
1519	15	29.0	11.76	9.81	clearing
1521	20	28.9	11.97	9.92	still gray
1525	25	28.9	11.76	9.99	slight

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M01MW02S01D150 @1525 SAMPLED BY:

M01MW02S02D150 @1535

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH/Cond meter behaving semi-erratically, readings bouncing all over

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M01 MW03 LOCATION: Bulky Waste Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 1550 CLIMATIC CONDITIONS: Cloudy, breeze, 26°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.06'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.64' TOC @ 1557

WELL PURGING: LENGTH OF SATURATED ZONE: 8.42 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.42 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 16.4 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 94 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/1550	0				
1605	1	28.4	11.70	13.87	high
1607	5	28.4	11.20	> 20	clearing
1609	10	28.4	10.86	> 20	slight
1612	15	28.4	11.20	> 20	clear, gray color
1615	20	28.4	11.23	> 20	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M01MW03S01D150 @1615 SAMPLED BY:

M01MW03S02D150 @1620

M01MW03D01D150 @1615

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH/Cond meter giving semi-erratic readings, not sure if accurate

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M01 MW04 LOCATION: Bulky Waste Landfill PROJECT NO. 110190136

DATE: 11-14-94 TIME: 0800 CLIMATIC CONDITIONS:

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.22'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 7.78' @ 0815

WELL PURGING: LENGTH OF SATURATED ZONE: 9.4 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.4 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 18.4 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 94 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-14-94/0800	0				
0829	1	28.9	7.88	> 20	moderate
0831	5	29.1	8.07	> 20	clearing
0834	10	28.9	8.15	> 20	clearing
0836	15	29.0	8.28	> 20	clearing
0839	20	28.7	8.33	> 20	clearing
0842	25	28.8	8.22	> 20	slight/grey

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M01MW04S01D150 @0845 SAMPLED BY:

M01MW04S02D150 @0850

M01MW04D02D150 @0850

APPEARANCE OF SAMPLE: COLOR Lt. grey TEMPERATURE 28.8°C

TURBIDITY slight PH 8.22

SEDIMENT none COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V v/HCl

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M02 MW01 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-11-94 TIME: 1225 CLIMATIC CONDITIONS: Cloudy, windy, 23.9°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 15.16' TOC

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 5.88' @ 1231

WELL PURGING: LENGTH OF SATURATED ZONE: 9.28 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.28 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 18.1 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-11-94/1225	0				
1243	1	25.8	6.28	> 20	slight
1245	5	25.8	6.64	> 20	
1246	10	25.8	6.88	> 20	clearing
1247	15	25.8	6.90	> 20	clear
1248	20	25.7	6.91	> 20	clear
1249	25	25.7	6.92	> 20	clear
1250	30	25.7	6.95	> 20	clear

SAMPLE WITHDRAWAL METHOD: Redi-Flo pump

SAMPLE NUMBER(S) AND TIME: M02MW01S01D100 @1255 SAMPLED BY: J. FREI, W. ZAYAC

M02MW01S02D100 @1300

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 25.7°C

TURBIDITY almost clear PH 6.95

SEDIMENT negligible COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8 V w/HCl,

STIV141A, STIV141C, STIV141E, STII1213 w/o preserv.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: S01: 3-40 ml VOA's by bailer

S02: 2-1 l poly's, 2-2 1/2 l ambers

D02: 2-1 l poly's, 2-2 1/2 l ambers

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M02 MW02 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-11-94 TIME: 1410 CLIMATIC CONDITIONS: Cloudy, windy, 23.9 °C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.01'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.99' @ 1420

WELL PURGING: LENGTH OF SATURATED ZONE: 9.02 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.02 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.6 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 176 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-11-94/1410	0				
1427	1	24.5	8.09	> 20	slight
1429	5	25.0	8.01	> 20	
1430	10	25.1	7.95	> 20	
1431	15	25.0	7.95	> 20	clearing
1433	20	25.1	7.89	> 20	
1434	25	25.1	7.87	> 20	clear
1435	30	25.1	7.87	> 20	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M02MW02S01D130 @1440 SAMPLED BY: JF, WZ

M02MW02D01D130 @1440

M02MW02S02D130 @1445

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 25.1°C

TURBIDITY clear PH 7.87

SEDIMENT negligible COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V w/HCl

STIV 141A, STIV141C, STIV141E, STII1213 w/o pres.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: S01, D01: 3-40 ml vials ea. (6 total)

S02: 2-1 l poly's, 2-2 1/2 l ambers.

DECONTAMINATION PROCEDURES:

AMPLES DELIVERED TO: TRANSPORTER

TE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M02 MW03 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-11-94 TIME: 1505 CLIMATIC CONDITIONS: Cloudy, windy, 22.2°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC): -

STATIC WATER LEVEL (TOC): 8.86 (1518) TOTAL DEPTH OF WELL (TOC): 17.63'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.86' TOC @ 1518

WELL PURGING: LENGTH OF SATURATED ZONE: 8.77 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.77 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.1 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 174 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-11-94/1505	0				
1521	1	27.6	8.37	17.54	slight
1523	5	27.6	8.37	16.26	
1524	10	27.7	8.11	16.35	
1526	15	27.7	7.99	16.36	clearing
1527	20	27.6	7.75	16.66	
1528	25	27.6	7.77	15.98	clear
1529	30	27.5	7.70	15.36	

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M02MW03S01D156 @1535 SAMPLED BY: JF, WZ

M02MW03S02D156 @1540

APPEARANCE OF SAMPLE: COLOR Lt. grey TEMPERATURE 27.5°C

TURBIDITY slight PH 7.7

SEDIMENT negligible COND. 15.36 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V w/HCl

STIV141A, STIV141C, STIV141E, STII1213 w/o pres.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: S01: 3-40 ml vials w/ hand bailer

S02: 2-1 l poly's, 2-2 1/2 l ambers w/ pump

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

.L NO. M02 MW04 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 0805 CLIMATIC CONDITIONS: Cloudy, no wind, 21.7°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 15.18'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 3.77' @ 0810

WELL PURGING: LENGTH OF SATURATED ZONE: 11.4 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 11.4 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 22.2 GALS.

METHOD OF REMOVAL: PUMPING RATE: 95 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/0805	0				
0823	1	25.8	9.51	17.19	slight
0825	5	25.9	9.70	17.69	moderate
0827	10	25.9	9.16	17.54	clearing
0829	15	25.9	9.15	17.35	clearing
0833	20	25.9	9.16	18.03	clearing
0835	25	25.8	9.07	> 20	
0837	30	25.9	9.08	> 20	slight

SAMPLE WITHDRAWAL METHOD: VOA's - bailer, others - pump

SAMPLE NUMBER(S) AND TIME: M02MW04S01D120 @0845 SAMPLED BY: WZ, JF

M02MW04S02D120 @0850

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH meter giving semi-erratic readings, not sure if accurate

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 3-40 ml VOA vials, w/ HCl (OLM01.8V)

2-1 l poly w/o pres. (STII1213)

2-2 1/2 l ambers w/o pres. (STIV141A, STIV141C, STIV141E)

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES: Alconox - Clean H_2O - rinse, isopropyl, H_2O rinse

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M02 MW05 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 0915 CLIMATIC CONDITIONS: Partly sunny, no wind, 22.8°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 15.14'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 5.02' TOC @ 0924

WELL PURGING: LENGTH OF SATURATED ZONE: 10.1 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.1 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 19.7 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 100 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/0915	0				
0933	1	24.7	10.56	16.75	moderate
0936	5	24.9	10.36	17.45	clearing
0938	10	25.0	10.40	17.78	clearing
0940	15	25.0	10.39	17.79	slight
0942	20	25.1	10.40	17.79	clear
0944	25	25.1	10.39	17.85	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M02MW05S01D130 @0945 SAMPLED BY: WZ, JF

M02MW05S02D130 @0950

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH meter giving semi-erratic readings, not sure if accurate

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M02 MW06 LOCATION: Runway Landfill PROJECT NO. 110190136

DATE: 11-12-94 TIME: 1015 CLIMATIC CONDITIONS: Sunny, lt. breeze, 24.4°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 15.14'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 4.65' TOC @ 1021

WELL PURGING: LENGTH OF SATURATED ZONE: 10.5 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.5 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 20.5 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 103 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-12-94/1015	0				
1030	1	26.6	10.17	17.2	slight
1032	5	26.5	9.6	11.78	slight
1034	10	26.7	9.87	11.75	clearing
1036	15	26.6	9.83	13.85	clearing
1039	20	26.7	9.75	14.51	clear
1041	25	26.7	9.75	14.45	clear

SAMPLE WITHDRAWAL METHOD: VOA's - hand bailer, others - pump

SAMPLE NUMBER(S) AND TIME: M02MW06S01D130 @1045 SAMPLED BY: WZ, JF

M02MW06S02D130 @1050

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: pH meter giving semi-erratic readings, not sure if accurate

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V w/ HCl

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml VOA vials, 2-1 l poly's, 2-2 1/2 l ambers

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M05 MW01 LOCATION: Area 401 PROJECT NO. 110190136

DATE: 11-15-94 TIME: 1550 CLIMATIC CONDITIONS: Partly cloudy, breeze

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.32'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 9.64' @ 1429

WELL PURGING: LENGTH OF SATURATED ZONE: 8.7 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.7 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 16.9 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 95 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-15-94/1550	0				
1556	1	28.6	7.74	2.62	clear
1558	5	29.0	7.70	2.40	clear
1601	10	29.2	7.60	2.34	slightly more turbid
1604	15	29.5	7.59	2.44	clearing
1609	20	29.2	7.52	2.49	clear

SAMPLE WITHDRAWAL METHOD: VOA's & fuels by hand bailer, others by pump

SAMPLE NUMBER(S) AND TIME: M05MW01S01D160 @1615 SAMPLED BY:

M05MW01D01D160 @1615 JF, AM

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES: Duplicate for this sample

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG & OLM01.8V w/ HCl;

Metals & Hg w/ HNO_3; 8150, 8140, 619, 632, OLM01.8B, OLM01.8P w/o preserv.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M05 MW02 LOCATION: Area 401 PROJECT NO. 110190136

DATE: 11-16-94 TIME: 0745 CLIMATIC CONDITIONS: Mostly sunny, lt breeze, 22.7°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.76'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 11.87' on 11-15-94 @ 1441

WELL PURGING: LENGTH OF SATURATED ZONE: 6.9 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 6.9 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 13.4 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 93 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-16-94/0745	0				
0756	1	28.3	7.33	2.13	slight
0800	5	29.1	7.35	1.83	slight
0803	10	29.3	7.37	1.80	clearing
0805	15	29.2	7.32	1.80	almost clear
0810	20	29.2	7.30	1.81	almost clear

MPLE WITHDRAWAL METHOD: VOA's & fuels by hand bailer, others by pump

SAMPLE NUMBER(S) AND TIME: M05MW02S01D160 @0815 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR very pale yellow TEMPERATURE 29.2°C

TURBIDITY almost clear PH 7.30

SEDIMENT very minor amount COND. 1.81 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M05 MW03 LOCATION: Area 401 PROJECT NO. 110190136

DATE: 11-16-94 TIME: 0858 CLIMATIC CONDITIONS: Sunny, lt. breeze, 26.1°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 20.08'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 12.39' on 11-15-94 @ 1448

WELL PURGING: LENGTH OF SATURATED ZONE: 7.7 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.7 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15.0 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 94 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-16-94/0858	0				
0921	1	29.5	7.32	1.73	almost clear
0924	5	29.9	7.29	1.67	almost clear
0926	10	30.1	7.25	1.68	almost clear
0928	15	29.9	7.22	1.73	almost clear
0932	20	30.0	7.26	1.77	clear

SAMPLE WITHDRAWAL METHOD: VOA's & fuels by hand bailer, others by pump

SAMPLE NUMBER(S) AND TIME: M05MW03S01D180 @0940 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 30.0°C

TURBIDITY clear PH 7.26

SEDIMENT none COND. 1.77 mS

NOTES: Extra volume sample

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

'LL NO. M08 MW01 LOCATION: Abandoned Power Plant PROJECT NO. 110190136

DATE: 11-15-94 TIME: 1005 CLIMATIC CONDITIONS: Mostly sunny, lt. breeze, 26.4°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.14'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.20' TOC @ 1014

WELL PURGING: LENGTH OF SATURATED ZONE: 7.9 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.9 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15.5 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 94 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-15-94/1005	0				
1024	1	26.6	7.80	4.81	clear
1026	5	27.1	7.79	5.38	clear
1029	10	27.0	7.82	6.02	clear
1032	15	27.2	7.80	6.18	clear
1035	20	27.1	7.74	6.23	clear

'MPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M08MW01S01D160 @1040 SAMPLED BY: JF, AM

M08MW01S02D160 @1040

M08MW01D02D160 @1040

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 27.1°C

TURBIDITY clear PH 7.74

SEDIMENT none COND. 6.23 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG & OLM01.8V w/ HCl;

Gen Min, STII1213, STIV141A & STIV141C w/o preserv.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml vials, 1-4 oz BA, 8-1l poly's, 4-2 1/2 l BA jugs

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M08 MW02 LOCATION: Abandoned Power Plant PROJECT NO. 110190136

DATE: 11-15-94 TIME: 1100 CLIMATIC CONDITIONS: Cloudy, no breeze, 24.5°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.70'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 9.97' @ 1113

WELL PURGING: LENGTH OF SATURATED ZONE: 7.7 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.7 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15.1 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 94 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS.	TURBIDITY
11-15-94/1100	0				
1125	1	26.6	7.66	8.90	almost clear
1128	5	26.8	7.70	9.80	almost clear
1130	10	26.8	7.67	9.73	almost clear
1133	15	26.8	7.67	9.70	clear
1136	20	26.8	7.68	9.72	clear

SAMPLE WITHDRAWAL METHOD: VOA's by hand bailer, others by pump

SAMPLE NUMBER(S) AND TIME: M08MW02S01D150 @1138 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR v. lt. yellow TEMPERATURE 26.8°C

TURBIDITY clear PH 7.68

SEDIMENT none COND. 9.72 mS

NOTES: Extra volume sample

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V & 8015M/OG w/ HCl;

Gen Min, STII1213, STIV141A & STIV141C w/o preserv.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 9-40 ml vials, 2-4 oz BA, 6-1 l poly's, 3-2 1/2 BA jugs

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

ELL NO. M08 MW03 LOCATION: Abandoned Power Plant PROJECT NO. 110190136

DATE: 11-15-94 TIME: 1300 CLIMATIC CONDITIONS: Sunny, no breeze, 29.0°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.18'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 9.29' TOC @ 1306

WELL PURGING: LENGTH OF SATURATED ZONE: 8.9 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.9 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.3 GALS.

METHOD OF REMOVAL: Redi-Flo 2 pump PUMPING RATE: 93 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-15-94/1300	0				
1314	1	28.0	8.16	7.56	very slight
1316	5	28.0	7.96	5.14	clearing
1318	10	27.6	7.93	4.96	clear
1321	15	27.7	7.90	4.94	clear
1324	20	27.7	7.80	4.94	clear

MPLE WITHDRAWAL METHOD: VOA's by hand bailer, others by pump

SAMPLE NUMBER(S) AND TIME: M08MW03S01D160 @1335 SAMPLED BY: JF, AM

M08MW03S02D160 @1340

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG & OLM01.8V w/ HCl;

STII1213, STIV141A & STIV141C w/o preservative; Gen Min w/o preserv.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml vials, 1-4 oz BA, 2-2 1/2 l BA jugs, 4-1 l poly's

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MSB MW01 LOCATION: Super Block PROJECT NO. 110190136

DATE: 11-14-94 TIME: 1315 CLIMATIC CONDITIONS: Sunny, lt. breeze, 30.4°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.35'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.42' @ 1320

WELL PURGING: LENGTH OF SATURATED ZONE: 8.9 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.9 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.4 GALS.

METHOD OF REMOVAL: Redi-Flow pump PUMPING RATE: 90 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-14-94/1315	0				
1323	1	28.8	8.27	2.76	slight
1329	5	28.7	8.40	1.63	clearing
1332	10	28.7	8.36	1.50	clearing
1334	15	28.9	8.43	1.46	almost clear
1337	20	28.9	8.50	1.46	almost clear
1342	25	29.3	8.53	1.47	almost clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MSBMW0S01D150 @1350 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 29.3°C

TURBIDITY clear PH 8.53

SEDIMENT none COND. 1.47 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V w/ HCl, 8015M/OG w/ HCl, OLM01.8B, OLM01.8P & ILM03.0x w/o pres.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 5-40 ml VOA vials, 2-4 oz vials (HS), 4-1 l poly's, 6-1 l BA's

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

'LL NO. MSB MW02 LOCATION: Super Block PROJECT NO. 110190136

DATE: 11-14-94 TIME: 1410 CLIMATIC CONDITIONS: Sunny, lt. breeze, 33.8°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 16.92'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 7.84' @ 1416 * 5.03' final TOC

WELL PURGING: LENGTH OF SATURATED ZONE: 9.1 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.1 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.7 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 91 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-14-94/1410	0				
1426	1	27.6	9.07	1.30	almost clear
1430	5	27.5	9.43	1.09	almost clear
1432	10	27.4	9.12	1.08	almost clear
1434	15	27.3	9.03	1.11	clear
1437	20	27.3	8.63	1.12	clear

'MPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MSBMW02S01D150 @1440 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 27.3°C

TURBIDITY clear PH 8.64

SEDIMENT very negligible COND. 1.12 mS

NOTES: * TOC to be re-set at grade level after date of this log. pH meter may not be accurate.

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG & OLM01.8V w/ HCl, OLM01.8B, OLM01.8P, ILM03.0x w/o preservative

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml VOA vials, 1-4 oz HS vial, 4-1 l BA's, 2-1 l poly's

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MSB MW03 LOCATION: Super Block PROJECT NO. 110190136

DATE: 11-14-94 TIME: 1515 CLIMATIC CONDITIONS: Cloudy, breezy, 29.6°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 16.29'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 6.27' TOC @ 1520

WELL PURGING: LENGTH OF SATURATED ZONE: 10.0 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.0 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 19.5 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 96 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-14-94/1515	0				
1529	1	27.7	9.21	0.88	clear
1532	5	27.7	9.15	0.78	clear
1534	10	28.0	9.06	0.78	clear
1536	15	28.0	9.07	0.79	clear
1538	20	28.0	9.03	0.79	clear
1540	25	28.1	9.00	0.80	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MSBMW03S01D140 @1545 SAMPLED BY: JF, AM

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 28.1°C

TURBIDITY clear PH 9.00

SEDIMENT none COND. 0.80 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG w/ HCl, OLM01.8V w/ HCl, OLM01.8B, OLM01.8P & ILM03.0x w/o preservatives

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml VOA vials, 1-4 oz HS vials, 4-1 l BA's, 2-1 l poly's

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. MSB MW04 LOCATION: Super Block PROJECT NO. 110190136

DATE: 11-15-94 TIME: 0749 CLIMATIC CONDITIONS: Partly cloudy, lt. breeze, 24°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 16.21'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 6.90' TOC @ 0755

WELL PURGING: LENGTH OF SATURATED ZONE: 9.31 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.31 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 18.1 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 93 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-15-94/0749	0				
0804	1	26.4	8.62	0.43	almost clear
0806	5	26.8	9.10	0.40	almost clear
0808	10	27.0	9.15	0.39	clear
0810	15	26.9	9.13	0.38	clear
0815	20	26.9	9.12	0.38	clear

MPLE WITHDRAWAL METHOD: VOA's & fuels by hand bailer, others by redi-flo pump

SAMPLE NUMBER(S) AND TIME: MSBMW04S01D140 @0825 SAMPLED BY:

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 26.9°C

TURBIDITY clear PH 9.12

SEDIMENT none COND. 0.38 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG w/ HCl, OLM01.8V w/ HCl, OLM01.8B & OLM01.8P w/o pres., ILM03.0x w/ HNO_3

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-40 ml vials, 1-4 oz amber, 4-1/2 l poly's, 4-1 l BA's

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MSB MW05 LOCATION: Super Block PROJECT NO. 110190136

DATE: 11-15-94 TIME: 0838 CLIMATIC CONDITIONS: Mostly sunny, lt. breeze, 24.5°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 16.84'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 7.71' TOC @ 0850

WELL PURGING: LENGTH OF SATURATED ZONE: 9.1 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.1 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.8 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 93 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-15-94/0838	0				
0858	1	27.1	8.44	0.99	almost clear
0901	5	27.9	8.59	0.87	almost clear
0903	10	28.1	8.39	0.81	almost clear
0906	15	28.1	8.53	0.81	clear
0909	20	28.1	8.51	0.82	clear
0911	22	28.1	8.51	0.82	clear

SAMPLE WITHDRAWAL METHOD: VOA's by hand bailer, others by Redi-Flo pump

SAMPLE NUMBER(S) AND TIME: MSBMW05S01D140 @0920 SAMPLED BY:

MSBMW05D01D140 @0920 JF, AM

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 28.1°C

TURBIDITY clear PH 8.51

SEDIMENT very very minor COND. 0.82 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES 8015M/OG & OLM01.8V w/ HCl; ILM03.0x w/ HNO_3; OLM01.8B & OLM01.8P, w/o pres.

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 6-40 ml vials, 2-4 oz ambers, 8-1/2 l poly's, 8-1 l BA's (Duplicate required at site)

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M10 MW01 LOCATION: E.I. Northeast Disposal PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1310 CLIMATIC CONDITIONS: Sunny, hot

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 21.90'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 14.64' @ 1015

WELL PURGING: LENGTH OF SATURATED ZONE: 7.26 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.26 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 14 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-05-94/1310	0				
1310	1	26.1	7.52	> 20	milky/mod
1312	5	25.6	7.50	> 20	slightly less milky
1314	10	26.1	7.49	> 20	slightly less milky
1316	15	26.1	7.49	> 20	clear
1318	25	26.7	7.50	> 20	clear
1320	30	26.7	7.50	> 20	clear

SAMPLE WITHDRAWAL METHOD: Redi-Flo2 pump, disposable bailers for VOA's

SAMPLE NUMBER(S) AND TIME: M10MW01S01 @1330 SAMPLED BY: Brian House

M10MW01D01 @1330

M10MW01S02 @1335

APPEARANCE OF SAMPLE: COLOR clear TEMPERATURE 26.1°C

TURBIDITY none PH 7.50

SEDIMENT - COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES VOA, SVOC, LL PCB, LL Metal, LL Pest

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 4-VOA's, 1-1 l poly, 1-2 1/2 l amber

DECONTAMINATION PROCEDURES: Dedicated pumps/ disposable bailers

MPLES DELIVERED TO: TRANSPORTER

ATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M10 MW02 LOCATION: E.I. Northeast Disposal Area PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1000 CLIMATIC CONDITIONS: Sunny w/ scattered clouds

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC): -

STATIC WATER LEVEL (TOC): 12.36 TOTAL DEPTH OF WELL (TOC): 20.60'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 12.36' @ 1005

WELL PURGING: LENGTH OF SATURATED ZONE: 8.24 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.24 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 16 GALS.

METHOD OF REMOVAL: submergable pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-05-94/1000	0				
1033	1	26.7	7.66	> 20	none/clear
1038	5	26.1	7.66	> 20	none/clear
1041	10	26.1	7.66	> 20	none/clear
1043	20	26.1	7.67	> 20	none/clear
1045	25	26.1	7.67	> 20	none/clear
1046	30	26.7	7.67	> 20	none/clear

SAMPLE WITHDRAWAL METHOD: Submergable Redi-Flow pump/ VOA's - bailer

SAMPLE NUMBER(S) AND TIME: M10MW02S01 @1055 SAMPLED BY:

M10MW02S02 @1060 Brian House

APPEARANCE OF SAMPLE: COLOR clear TEMPERATURE 26.1°C

TURBIDITY none/clear PH 7.66

SEDIMENT none COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLM01.8V VOC

STIV141A (SVOC), STIV141C (LL PCB), STII1213 (LL Metal), STIV141E (LL Pest)

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 2-VOAs (HCl); 1-1 l poly (unpreserved); 1-2 l amber (unpreserved)

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

'LL NO. M10 MW03 LOCATION: E.I. Northeast Disposal Area PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1215 CLIMATIC CONDITIONS: Sunny, hot

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 23.37'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 12.98' @ 1010

WELL PURGING: LENGTH OF SATURATED ZONE: 10.39 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.39 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 20 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-05-94/1215	0				
1220	1	26.1	7.45	> 20	slightly cloudy
1223	5	26.1	7.45	> 20	
1225	12	26.1	7.45	> 20	clear
1227	20	25.6	7.45	> 20	clear
1230	30	26.1	7.45	> 20	crystal

SAMPLE WITHDRAWAL METHOD: Redi-Flo pump / Grundfos BMI/MP1 / VOAs bailer

SAMPLE NUMBER(S) AND TIME: M10MW03S01 @1240 SAMPLED BY: Brian House

M10MW03S02 @1245

APPEARANCE OF SAMPLE: COLOR slightly milky TEMPERATURE 26.1°C

TURBIDITY slightly PH 7.45

SEDIMENT some COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES S01-VOA / S02-SVOC, LL PCB, LL Metals, LL Pest

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 2-VOAs, 1-1 l poly, 1-2 1/2 l amber

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M11 MW01 LOCATION: SW Disposal Area E. I. PROJECT NO. 110190136

DATE: 11-09-94 TIME: 1345 CLIMATIC CONDITIONS: Sunny, breezy, 27.8°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC):

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 6.00' TOC @ 1346

WELL PURGING: LENGTH OF SATURATED ZONE: 9.05 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 9.05 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 17.65 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 124 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-09-94/1345	0				
1353	2	29.4	7.56	> 20	slight
1357	7	27.8	7.57	> 20	clear
1359	12	27.2	7.57	> 20	clear
1400	17	27.2	7.58	> 20	clear
1401	22	27.2	7.57	> 20	clear
1403	27	26.7	7.58	> 20	clear
1405	32	26.7	7.58	> 20	clear
1406	37	26.7	7.58	> 20	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M11MW01S01D150 @1412 SAMPLED BY: MT, JF

M11MW01S02D150 @1420

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: VOAs @ 1412, bottles @ 1420 inc (Extra Vol.)

6-40 ml, 1-4 oz VOA, 4-poly's, 3-2 l ambers

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M11 MW02 LOCATION: E.I. Southwest Disposal PROJECT NO. 110190136

DATE: 11-07-94 TIME: 1320 CLIMATIC CONDITIONS: Cloudy

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 14.85'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 8.60'

WELL PURGING: LENGTH OF SATURATED ZONE: 6.25 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 6.25 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 12 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-07-94/1320	0				
1319	1	26.7	7.48	> 20	slightly cloudy
1321	5	26.1	7.47	> 20	less cloudy
1323	10	26.1	7.47	> 20	clear
1325	15	26.1	7.46	> 20	clear
1328	25	26.1	7.47	> 20	clear
1330	30	26.7	7.47	> 20	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: M11MW02S01 @1350 SAMPLED BY: Brian House

M11MW02D01 @1350

M11MW02S02 @1400

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M11 MW03 LOCATION: SW Disposal Area - E. I. PROJECT NO. 110190136

DATE: 11-10-94 TIME: 0830 CLIMATIC CONDITIONS: Mostly Cloudy, Windy, 21.1°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 16.72'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.20' @ 0900

WELL PURGING: LENGTH OF SATURATED ZONE: 6.5 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 6.5 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 12.7 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 140 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-10-94/0830	0				
0925	1	26.1	7.56	> 20	clearing
*0931	5	25.0	7.57	> 20	clear
0934	10	25.0	7.57	> 20	clear
0937	15	25.6	7.56	> 20	clear
0941	20	27.2	7.09	> 20	clear
	25		meter failed		clear
0950	30	27.2			clear
0952	35	26.1			clear

SAMPLE WITHDRAWAL METHOD: Bailer for VOAs, pump for others

SAMPLE NUMBER(S) AND TIME: M11MW03S01D147 @0955 SAMPLED BY:

M11MW03S02D147 @1015 JF

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 26.1°C

TURBIDITY clear PH

SEDIMENT negligible COND.

NOTES: * Had voltage problems w/ generator, pump controller kept stalling

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

L NO. M54 MW01 LOCATION: E. I. Southeast Landfill Pit PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1620 CLIMATIC CONDITIONS: Sunny

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 19.20'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 11.10' @ 1610

WELL PURGING: LENGTH OF SATURATED ZONE: 8.1 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.1 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 16 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-05-94/1620	0				
1620	1	26.7	7.21	13.45	very slight cloudiness
1622	7	26.7	7.23	11.15	clear
1624	15	27.2	7.20	11.29	clear
1626	25	26.1	7.20	11.05	clear
1628	30	26.1	7.20	11.64	clear

MPLE WITHDRAWAL METHOD: Redi-Flo 2 pump / VOA's - bailer

SAMPLE NUMBER(S) AND TIME: M54MW01S01D17 @1640 SAMPLED BY:

M54MW01D01D17 @1640

M54MW01S02D17 @1645 Brian House

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 26.7°C

TURBIDITY clear PH 7.20

SEDIMENT - COND. 11.12 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. M54 MW02 LOCATION: E. I. Southeast Landfill PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1447 CLIMATIC CONDITIONS: Sunny, Hot

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.90'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 11.95' @ 1455

WELL PURGING: LENGTH OF SATURATED ZONE: 5.95 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 5.95 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 11 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-05-94/1457	0				
1458	1	28.3	7.22	12.94	slightly cloudy
1501	7	27.2	7.35	9.12	less cloudy
1503	15	26.7	7.34	8.72	clear
1505	22	26.1	7.33	9.21	clear
1507	30	26.1	7.32	9.10	clear

SAMPLE WITHDRAWAL METHOD: Redi-Flo 2 pump / VOA - disposable bailer

SAMPLE NUMBER(S) AND TIME: M54MW02S01D16.0 @1515 SAMPLED BY: Brian House

M54MW02S02D16.0 @1520

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 26.7°C

TURBIDITY clear PH 7.34

SEDIMENT - COND. 9.20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES VOA, LLs

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. M54 MW03 LOCATION: E. I. Southeast Landfill Pit PROJECT NO. 110190136

DATE: 11-05-94 TIME: 1540 CLIMATIC CONDITIONS: Sunny, hot

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 20.03'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 9.98'

WELL PURGING: LENGTH OF SATURATED ZONE: 10.05 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 10.05 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 20 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
	0				
1540	1	27.8	7.14	> 20	slightly milky
1542	10	26.7	7.16	> 20	slightly milky
1544	15	26.1	7.15	> 20	clear
1546	20	26.1	7.16	> 20	clear
1549	30	26.1	7.15	> 20	clear

MPLE WITHDRAWAL METHOD: Redi-Flo 2 pump / VOA's - disposable bailer

SAMPLE NUMBER(S) AND TIME: M54MW03S01D18.0 @1555 SAMPLED BY: Brian House

M54MW03S02D18.0 @1600

M54MW03D02D18.0 @1600

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 26.1°C

TURBIDITY clear PH 7.15

SEDIMENT - COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES VOA, LLs

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MAF MW02 LOCATION: E. I. Antenna Field PROJECT NO. 110190136

DATE: 11-07-94 TIME: 1057 CLIMATIC CONDITIONS: Cloudy, cool

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.46'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.15' @ 1000

WELL PURGING: LENGTH OF SATURATED ZONE: 7.31 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.31 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 14 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-07-94/1057	0				
1057	1	28.3	7.36	> 20	slightly cloudy
1059	5	28.3	7.32	> 20	less cloudy
1101	15	26.7	7.31	> 20	less cloudy
1103	20	28.3	7.29	> 20	less cloudy
1105	25	26.1	7.28	> 20	clear
1114	30	27.2	7.27	> 20	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MAFMW02S01D155 @1125 SAMPLED BY: Brian House

APPEARANCE OF SAMPLE: COLOR clear TEMPERATURE 27.8°C

TURBIDITY none PH 7.30

SEDIMENT none COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO: MAF MW01 LOCATION: E. I. Antenna Field PROJECT NO. 110190136

DATE: 11-07-94 TIME: 1215 CLIMATIC CONDITIONS: Cloudy

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.88'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 9.98' @ 1210

WELL PURGING: LENGTH OF SATURATED ZONE: 7.9 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.9 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-07-94/1215	0				
1216	1	26.1	7.36	> 20	very slightly cloudy
1219	10	25.6	7.35	19.86	very slightly cloudy
1221	15	26.1	7.33	19.38	less cloudy
1223	20	25.6	7.32	19.30	clear
1225	25	26.7	7.32	19.30	clear
1226	30	27.8	7.31	19.27	clear

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MAFMW01S01D160 @1240 SAMPLED BY:

APPEARANCE OF SAMPLE: COLOR TEMPERATURE

TURBIDITY PH

SEDIMENT COND.

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MAF MW03 LOCATION: E. I. Antenna Field Site 100 PROJECT NO. 110190136

DATE: 11-07-94 TIME: 0930 CLIMATIC CONDITIONS: Cloudy, rainy

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 17.82'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.27' @ 0935

WELL PURGING: LENGTH OF SATURATED ZONE: 7.55 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 7.55 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 180 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-07-94/0930	0				
1010	1	23.9	7.41	> 20	slightly milky moderate
1012	7	26.7	7.44	> 20	clearer than above
1015	15	27.2	7.44	> 20	clear
1017	20	27.2	7.45	> 20	clear
1019	25	27.2	7.45	> 20	clear
1020	30	27.2	7.48	> 20	clear

SAMPLE WITHDRAWAL METHOD: Bail - VOA's & 8015 / pump - Metals

SAMPLE NUMBER(S) AND TIME: MAFMW03S01D160 @1030 SAMPLED BY: Brian House

APPEARANCE OF SAMPLE: COLOR slightly milky TEMPERATURE 27.2°C

TURBIDITY slightly PH 7.45

SEDIMENT none COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES OLMO1.8V, 8015, STIV141A (SVOC's)

NUMBER AND TYPES OF SAMPLES CONTAINERS USED:

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

LL NO. MAF MW01 LOCATION: Antenna Field - E. I. PROJECT NO. 110190136

DATE: 11-10-94 TIME: 1045 CLIMATIC CONDITIONS: Sunny, breezy, 23.9°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC): 18.19'

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.02' @ 1055

WELL PURGING: LENGTH OF SATURATED ZONE: 8.2 LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X 8.2 LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = 15.9 GALS.

METHOD OF REMOVAL: Redi-Flo pump PUMPING RATE: 135 Hz

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-10-94/1045	0				
1105	1	26.1	meter not working		mod cloudy
1108	5	27.8			mod cloudy
1110	10	26.7			clearing
1112	15	26.7			clearing
1114	20	27.2			almost clear
1116	25	27.2			still clearing

SAMPLE WITHDRAWAL METHOD:

SAMPLE NUMBER(S) AND TIME: MAFMW01S02D160 @1117 SAMPLED BY: JF

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 27.2°C

TURBIDITY clear PH

SEDIMENT none COND.

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 2-2 1/2 l amber jugs

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 • 4" - 0.65 • 6" - 1.47 • 8" - 2.61 • 10" - 4.08 • 12" - 5.87

GROUND-WATER SAMPLING LOG

WELL NO. MAF MW02 LOCATION: Antenna Field - E. I. PROJECT NO. 110190136

DATE: 11-09-94 TIME: 1025 CLIMATIC CONDITIONS: Sunny, breezy, 23.9°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC):

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.09' @ 1031

WELL PURGING: LENGTH OF SATURATED ZONE: LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = GALS.

METHOD OF REMOVAL: PUMPING RATE:

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-09-94/1025	0				
1033	1	22.2	7.46	> 20	v. slight
1036	3	22.8	7.40	> 20	almost clear
1038	6	22.8	7.35	> 20	almost clear
1042	9	22.2	7.35	> 20	cloudier
1043	12	21.7	7.38	> 20	clearing
1045	15	21.7	7.38	> 20	clearing

SAMPLE WITHDRAWAL METHOD: Redi-Flo pump

SAMPLE NUMBER(S) AND TIME: MAFMW02S02D160 @1048 SAMPLED BY: JF

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 21.7°C

TURBIDITY almost clear PH 7.37

SEDIMENT v. minor amount COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-2 1/2 l amber jugs

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

GROUND-WATER SAMPLING LOG

'LL NO. MAF MW03 LOCATION: Antenna Field - E. I. PROJECT NO. 110190136

DATE: 11-09-94 TIME: 0900 CLIMATIC CONDITIONS: Sunny, breezy, 22.8°C

OVA/PID READING WHEN WELL OPENED: DEPTH TO PRODUCT (TOC):

STATIC WATER LEVEL (TOC): TOTAL DEPTH OF WELL (TOC):

80% RECOVERY DTW (TOC): DTW BEFORE SAMPLING/TIME: 10.22' @ 0945

WELL PURGING: LENGTH OF SATURATED ZONE: LINEAR FT.

VOLUME OF WATER TO BE EVACUATED: 0.65 GALS./LINEAR FT.X LINEAR FT.

OF SATURATED X 3 CASING VOLUMES = GALS.

METHOD OF REMOVAL: PUMPING RATE:

WELL PURGE DATA:

DATE/TIME	GALLONS REMOVED	TEMP (°C)	PH	SP. COND mS	TURBIDITY
11-09-94/0900	0				
1007		21.7	7.48	> 20	sl. cloudy
1009	3	21.7	7.44	> 20	clearing
1010	6	22.2	7.51	> 20	almost clear
1011	9	22.2	7.51	> 20	clearing
1012	12	21.7	7.52	> 20	clear
1014	15	21.7	7.53	> 20	clear

SAMPLE WITHDRAWAL METHOD: Redi-Flo pump

SAMPLE NUMBER(S) AND TIME: MAFMW03S02D160 @1015 SAMPLED BY: JF

APPEARANCE OF SAMPLE: COLOR none TEMPERATURE 21.7°C

TURBIDITY none PH 7.53

SEDIMENT none COND. > 20 mS

NOTES:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLES CONTAINERS USED: 3-2 1/2 l amber jugs

DECONTAMINATION PROCEDURES:

SAMPLES DELIVERED TO: TRANSPORTER

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2" - 0.16 · 4" - 0.65 · 6" - 1.47 · 8" - 2.61 · 10" - 4.08 · 12" - 5.87

Appendix G

APPENDIX G

GEOTECHNICAL REPORT

SUMMARY OF LABORATORY TEST RESULTS

Project: MIDWAY SI/RI (CTO 136)

Project Number: 1-1019-0136

Date: January 16, 1995

Sample ID	Natural Moisture (%)	UNIT WEIGHT (PCF) Wet	UNIT WEIGHT (PCF) Dry	SPECIFIC GRAVITY G_s	PERMEABILITY (CM/SEC)	Unified Soil Classification	Other Test **	Soil Description
M54BS02G01D05.5	11.3	88.1	79.2	2.72	1.7×10^{-4}	SW	P,CM,TOC,S,R	SAND, shell fragments, light brown
M54BS01G01D01.5	10.9	88.1	79.4	2.60	3.5×10^{-5}	SW	P,CM,TOC,S,R	SAND, shell fragments, organics, gray to brown, mottled dark brown
M10BS01G01D04.5	10.1	94.9	86.2	2.67	1.0×10^{-4}	SW	P,CM,TOC,S,R	SAND, shell fragments, tan to gray
M10BS02G01D01.5	9.2	93.2	85.3	2.71	1.2×10^{-3}	SP	P,CM,TOC,S,R	SAND, large coral and shell fragments, tan
MAFBS01G01D02.0	9.9	86.4	78.6	2.67	2.5×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell and coral fragments, organics, light gray
MAFBS02G01D06.0	13.2	88.1	77.8	2.66	7.8×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell fragments, slightly gravely, tan
M11BS01G01D02.0	7.8	78.0	72.4	2.75	2.9×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell and coral fragments, organics, light brown
M11BS03G01D02.5	6.3	86.4	81.3	2.75	2.9×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell and coral fragments, organics, light gray
MSBBS02G01D04.0	10.0	91.5	83.2	2.78	2.3×10^{-5}	SP	P,CM,TOC,S,R	SAND, shell and coral fragments, organics, light gray
MSBBS01G01D04.0	11.3	98.3	88.3	2.76	1.2×10^{-4}	SP	P,CM,TOC,S,R	SAND, slightly organic, pebbles, very light brown, mottled black
MSBBS04G01D02.5	9.5	83.1	75.9	2.73	3.4×10^{-5}	SP	P,CM,TOC,S,R	SAND, pebbles, slightly organic, tan

**TEST RESULTS REPORTED ON OTHER SHEETS:

DATA CHECKED BY _____

OGDEN Technical Services

P-PERMEABILITY
CM-CAPILLARY MOISTURE
TOC-TOTAL ORGANIC CARBON
S-SIEVE OR GRAIN SIZE ANALYSIS
R-REDOX POTENTIAL

SUMMARY OF LABORATORY TEST RESULTS

Project: MIDWAY SI/RI (CTO 136)

Project Number: 1-1019-0136

Date: January 16, 1995

Sample ID	Natural Moisture (%)	UNIT WEIGHT (PCF) Wet	UNIT WEIGHT (PCF) Dry	SPECIFIC GRAVITY G_s	PERMEABILITY (CM/SEC)	Unified Soil Classification	Other Test **	Soil Description
MSBBS05G01D03.5	10.1	94.9	86.2	2.73	4.0×10^{-5}	SP	P,CM,TOC,S,R	SAND, very light gray, mottled black
M02BS01G01D02.0	8.7	86.4	79.5	2.70	8.1×10^{-5}	SP	P,CM,TOC,S,R	SAND, pebbles, slightly organic, light brown, mottled black
M02BS02G01D01.0	3.2	78.0	75.6	2.67	1.5×10^{-3}	SP	P,CM,TOC,S,R	SAND, pebbles, light brown to gray
M02BS03G01D01.0	11.3	86.4	77.6	2.66	1.1×10^{-4}	SP	P,CM,TOC,S,R	SAND, slightly organic, pebbles, tan, mottled black
M02BS04G01D01.5	13.1	88.1	77.9	2.75	2.6×10^{-5}	SP	P,CM,TOC,S,R	SAND, pebbles, slightly organic, tan, mottled black
M08BS01G01D02.0	6.1	94.9	89.4	2.76	1.1×10^{-4}	SP	P,CM,TOC,S,R	SAND, pebbles, shell fragments, tan, mottled black
M08BS03G01D04.0	8.7	91.5	84.2	2.73	6.9×10^{-4}	SP	P,CM,TOC,S,R	SAND, pebbles, tan, mottled gray
M01BS01G01D01.0	4.8	88.1	84.1	2.76	3.9×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell and coral fragments, organic, light gray
M01BS02G01D01.5	8.3	91.5	84.5	2.67	1.4×10^{-4}	SP	P,CM,TOC,S,R	SAND, shell fragments, tan to dark brown and gray
M01BS04G01D01.0	8.5	101.7	93.7	2.65	3.1×10^{-6}	SW	P,CM,TOC,S,R	SAND, shell and coral fragments, tan to dark gray
M05BS02G01D07.0	11.0	87.4	78.7	2.75	1.3×10^{-3}	SP	P,CM,TOC,S,R	SAND, light yellow

**TEST RESULTS REPORTED ON OTHER SHEETS:

DATA CHECKED BY KB

OGDEN Technical Services

P-PERMEABILITY
CM-CAPILLARY MOISTURE
TOC-TOTAL ORGANIC CARBON
S-SIEVE OR GRAIN SIZE ANALYSIS
R-REDOX POTENTIAL

SUMMARY OF TOTAL ORGANIC CARBON ASA 90 - 3.2
AND
SUMMARY OF OXIDATION REDUCTION POTENTIAL MOD. ASTM D1498

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

Sample ID	ORP mV	TOC (WB) %
M54BS02G01D05.5	339	0.41
M54BS02G01D01.5	335	2.8
M10BS01G01D04.5	258	0.67
M10BS02G01D01.5	264	0.39
MAFBS01G01D02.0	315	0.95
MAFBS02G01D06.0	292	0.35
M11BS01G01D02.0	300	0.77
M11BS03G01D02.5	293	0.17
MSBBS02G01D04.0	301	0.86
MSBBS01G01D04.0	291	0.94
MSBBS04G01D02.5	302	0.78
MSBBS05G01D03.5	284	0.44
M02BS01G01D02.0	256	1.0
M02BS02G01D01.0	275	2.1
M02BS03G01D01.0	262	0.75
M02BS04G01D01.5	258	0.46
M08BS01G01D02.0	266	0.37
M08BS03G01D04.0	247	0.032
M01BS01G01D01.0	247	0.11
M01BS02G01D01.5	253	1.3
M01BS04G01D01.0	255	5.5
M05BS02G01D07.0	253	0.17

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M54BS02G01D05.5	**Depth of Tested Sample** :	5.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	88.1
Diameter (in.) :	2.4	**Weight (lbs)** :	0.52	**Dry Density (PCF):**	79.2
Area (ft^2) :	0.0314	**Moisture (%)** :	11.3		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(139)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{856{,}154.15}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 1.7 \times 10^{-4}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. : M54BS01G01D01.5 **Depth of Tested Sample** : 1.5

Remolded : Yes **% Compaction** : N/A

INITIAL SPECIMEN PROPERTIES

Length (in.)	:	2.26	**Volume (ft^3)**	:	0.0059	**Wet Density (PCF):**	88.1
Diameter (in.)	:	2.4	**Weight (lbs)**	:	0.52	**Dry Density (PCF):**	79.4
Area (ft^2)	:	0.0314	**Moisture (%)**	:	10.9		

Chamber Pressure (psi)	:	20	**Change in Pore Pressure (psi)**	:	5.0
Influent Pressure (psi)	:	18	**Change in Chamber Pressure (psi)**	:	4.9
Back Pressure (psi)	:	15	**"B" Factor**	:	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(237)\ (5.74)}{(29.19)(6327)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{1360.38}{38{,}970{,}409.28}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 3.5 \times 10^{-5} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. : M10BS01G01D04.5 **Depth of Tested Sample** : 4.5

Remolded : Yes **% Compaction** : N/A

INITIAL SPECIMEN PROPERTIES

Length (in.)	:	2.26	**Volume (ft^3)**	:	0.0059	**Wet Density (PCF):**	94.9
Diameter (in.)	:	2.4	**Weight (lbs)**	:	0.56	**Dry Density (PCF):**	86.2
Area (ft^2)	:	0.0314	**Moisture (%)**	:	10.1		

Chamber Pressure (psi)	:	20	**Change in Pore Pressure (psi)**	:	5.0
Influent Pressure (psi)	:	18	**Change in Chamber Pressure (psi)**	:	5.0
Back Pressure (psi)	:	15	**"B" Factor**	:	1.00

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(224)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) = $\frac{143.50}{1{,}379{,}701.55}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) = 1.0×10^{-4} cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID.	:	M10BS02G01D01.5	**Depth of Tested Sample**	:	1.5
Remolded	:	Yes	**% Compaction**	:	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.)	:	2.26	**Volume (ft^3)**	:	0.0059	**Wet Density (PCF):**	93.2
Diameter (in.)	:	2.4	**Weight (lbs)**	:	0.55	**Dry Density (PCF):**	85.3
Area (ft^2)	:	0.0314	**Moisture (%)**	:	9.2		

Chamber Pressure (psi)	:	20	**Change in Pore Pressure (psi)**	:	5.0
Influent Pressure (psi)	:	18	**Change in Chamber Pressure (psi)**	:	5.0
Back Pressure (psi)	:	15	**"B" Factor**	:	1.00

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(20)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{123{,}876.64}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 1.2 \times 10^{-3}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MAFBS01G01D02.0	**Depth of Tested Sample** :	2.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	86.4
Diameter (in.) :	2.4	**Weight (lbs)** :	0.51	**Dry Density (PCF):**	78.6
Area (ft^2) :	0.0314	**Moisture (%)** :	9.9		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(94)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{578{,}981.90}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 2.5 \times 10^{-4}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MAFBS02G01D06.0	**Depth of Tested Sample** :	6.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	88.1
Diameter (in.) :	2.4	**Weight (lbs)** :	0.52	**Dry Density (PCF):**	77.8
Area (ft^2) :	0.0314	**Moisture (%)** :	13.2		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(30)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{184{,}781.46}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 7.8 \times 10^{-4}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M11BS01G01D02.0	**Depth of Tested Sample** :	2.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	78.0
Diameter (in.) :	2.4	**Weight (lbs)** :	0.46	**Dry Density (PCF):**	72.4
Area (ft^2) :	0.0314	**Moisture (%)** :	7.8		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(79)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.5}{486{,}591.2}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 2.9 \times 10^{-4} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M11BS03G01D02.5	**Depth of Tested Sample** :	2.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	86.4
Diameter (in.) :	2.4	**Weight (lbs)** :	0.51	**Dry Density (PCF):**	81.3
Area (ft^2) :	0.0314	**Moisture (%)** :	6.3		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(81)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{498{,}909.93}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 2.9 \times 10^{-4} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MSBBS02G01D04.0	**Depth of Tested Sample** :	4.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	91.5
Diameter (in.) :	2.4	**Weight (lbs)** :	0.54	**Dry Density (PCF):**	83.2
Area (ft^2) :	0.0314	**Moisture (%)** :	10.0		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)(5.74)}{(29.19)(1016)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{6{,}257{,}932.01}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 2.3 \times 10^{-5} \text{ cm/sec}$$

OGDEN

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MSBBS01G01D04.0	**Depth of Tested Sample** :	4.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	98.3
Diameter (in.) :	2.4	**Weight (lbs)** :	0.58	**Dry Density (PCF):**	88.3
Area (ft^2) :	0.0314	**Moisture (%)** :	11.3		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)(5.74)}{(29.19)(187)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{1{,}151{,}804.42}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 1.2 \times 10^{-4} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MSBBS04G01D02.5	**Depth of Tested Sample** :	2.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	83.1
Diameter (in.) :	2.4	**Weight (lbs)** :	0.49	**Dry Density (PCF):**	75.9
Area (ft^2) :	0.0314	**Moisture (%)** :	9.5		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(687)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{4{,}231{,}495.37}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 3.4 \times 10^{-5} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	MSBBS05G01D03.5	**Depth of Tested Sample** :	3.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	94.9
Diameter (in.) :	2.4	**Weight (lbs)** :	0.56	**Dry Density (PCF):**	86.2
Area (ft^2) :	0.0314	**Moisture (%)** :	10.1		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(586)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{3{,}609{,}397.79}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 4.0 \times 10^{-5} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M02BS01G01D02.0	**Depth of Tested Sample** :	2.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	86.4
Diameter (in.) :	2.4	**Weight (lbs)** :	0.51	**Dry Density (PCF):**	79.5
Area (ft^2) :	0.0314	**Moisture (%)** :	8.7		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(286)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{1{,}761{,}583.22}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 8.1 \times 10^{-5}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M02BS02G01D01.0	**Depth of Tested Sample** :	1.0
Remolded :	No	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	4.52	**Volume (ft^3)** :	0.0118	**Wet Density (PCF):**	78.0
Diameter (in.) :	2.4	**Weight (lbs)** :	0.92	**Dry Density (PCF):**	75.6
Area (ft^2) :	0.0314	**Moisture (%)** :	3.2		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)(11.48)}{(29.19)(32)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{287.00}{197{,}100.22}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 1.5 \times 10^{-3}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M02BS03G01D01.0	**Depth of Tested Sample** :	1.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	86.4
Diameter (in.) :	2.4	**Weight (lbs)** :	0.51	**Dry Density (PCF):**	77.6
Area (ft^2) :	0.0314	**Moisture (%)** :	11.3		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(215)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{1{,}324{,}267.11}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 1.1 \times 10^{-4}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M02BS04G01D01.5	**Depth of Tested Sample** :	1.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	88.1
Diameter (in.) :	2.4	**Weight (lbs)** :	0.52	**Dry Density (PCF):**	77.9
Area (ft^2) :	0.0314	**Moisture (%)** :	13.1		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(880)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{5{,}420{,}256.07}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 2.6 \times 10^{-5} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M08BS01G01D02.0	**Depth of Tested Sample** :	2.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	94.9
Diameter (in.) :	2.4	**Weight (lbs)** :	0.56	**Dry Density (PCF):**	89.4
Area (ft^2) :	0.0314	**Moisture (%)** :	6.1		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	4.9
Back Pressure (psi) :	15	**"B" Factor** :	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(218)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) $= \frac{143.50}{1{,}342{,}745.25}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) $= 1.1 \times 10^{-4}$ cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M08BS03G01D04.0	**Depth of Tested Sample** :	4.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	91.5
Diameter (in.) :	2.4	**Weight (lbs)** :	0.54	**Dry Density (PCF):**	84.2
Area (ft^2) :	0.0314	**Moisture (%)** :	8.7		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(34)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{209{,}418.98}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 6.9 \times 10^{-4} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M01BS01G01D01.0	**Depth of Tested Sample** :	1.0
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	88.1
Diameter (in.) :	2.4	**Weight (lbs)** :	0.52	**Dry Density (PCF):**	84.1
Area (ft^2) :	0.0314	**Moisture (%)** :	4.8		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(59)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2) = $\frac{143.50}{363{,}403.53}$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm) = 3.9×10^{-4} cm/sec

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. :	M01BS02G01D01.5	**Depth of Tested Sample** :	1.5
Remolded :	Yes	**% Compaction** :	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.) :	2.26	**Volume (ft^3)** :	0.0059	**Wet Density (PCF):**	91.5
Diameter (in.) :	2.4	**Weight (lbs)** :	0.54	**Dry Density (PCF):**	84.5
Area (ft^2) :	0.0314	**Moisture (%)** :	8.3		

Chamber Pressure (psi) :	20	**Change in Pore Pressure (psi)** :	5.0
Influent Pressure (psi) :	18	**Change in Chamber Pressure (psi)** :	5.0
Back Pressure (psi) :	15	**"B" Factor** :	1.0

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\ (5.74)}{(29.19)(164)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{1{,}010{,}138.63}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 1.4 \times 10^{-4} \text{ cm/sec}$$

Printed on recycled paper

OGDEN

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID.	:	M01BS04G01D01.0	**Depth of Tested Sample**	:	1.0
Remolded	:	Yes	**% Compaction**	:	N/A

INITIAL SPECIMEN PROPERTIES

Length (in.)	:	2.26	**Volume (ft^3)**	:	0.0059	**Wet Density (PCF):**	101.7
Diameter (in.)	:	2.4	**Weight (lbs)**	:	0.60	**Dry Density (PCF):**	93.7
Area (ft^2)	:	0.0314	**Moisture (%)**	:	8.5		

Chamber Pressure (psi)	:	20	**Change in Pore Pressure (psi)**	:	5.0
Influent Pressure (psi)	:	18	**Change in Chamber Pressure (psi)**	:	4.9
Back Pressure (psi)	:	15	**"B" Factor**	:	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)\,(5.74)}{(29.19)(7467)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{143.50}{45{,}992{,}104.65}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 3.1 \times 10^{-6} \text{ cm/sec}$$

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CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Midway SI/RI (CTO 136)

PROJECT # : 1-1019-0136

DATE : January 11, 1995

SAMPLE LOCATION AND CONDITIONS

Sample ID. : M05BS02G01D07.0 **Depth of Tested Sample** : 7.0

Remolded : No **% Compaction** : N/A

INITIAL SPECIMEN PROPERTIES

Length (in.)	:	4.86	**Volume (ft^3)**	:	0.0127	**Wet Density (PCF):**	87.4
Diameter (in.)	:	2.4	**Weight (lbs)**	:	1.11	**Dry Density (PCF):**	78.7
Area (ft^2)	:	0.0314	**Moisture (%)**	:	11.0		

Chamber Pressure (psi)	:	20	**Change in Pore Pressure (psi)**	:	5.0
Influent Pressure (psi)	:	18	**Change in Chamber Pressure (psi)**	:	4.9
Back Pressure (psi)	:	15	**"B" Factor**	:	0.98

PERMEABILITY CALCULATIONS

$$k = \frac{QL}{Ath} = \text{cm/sec}$$

k = Hydraulic Conductivity, (cm/sec)

$$k = \frac{(25.0)(12.34)}{(29.19)(38)(211.01)}$$

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

$$= \frac{308.50}{234{,}056.51}$$

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$= 1.3 \times 10^{-3} \text{ cm/sec}$$

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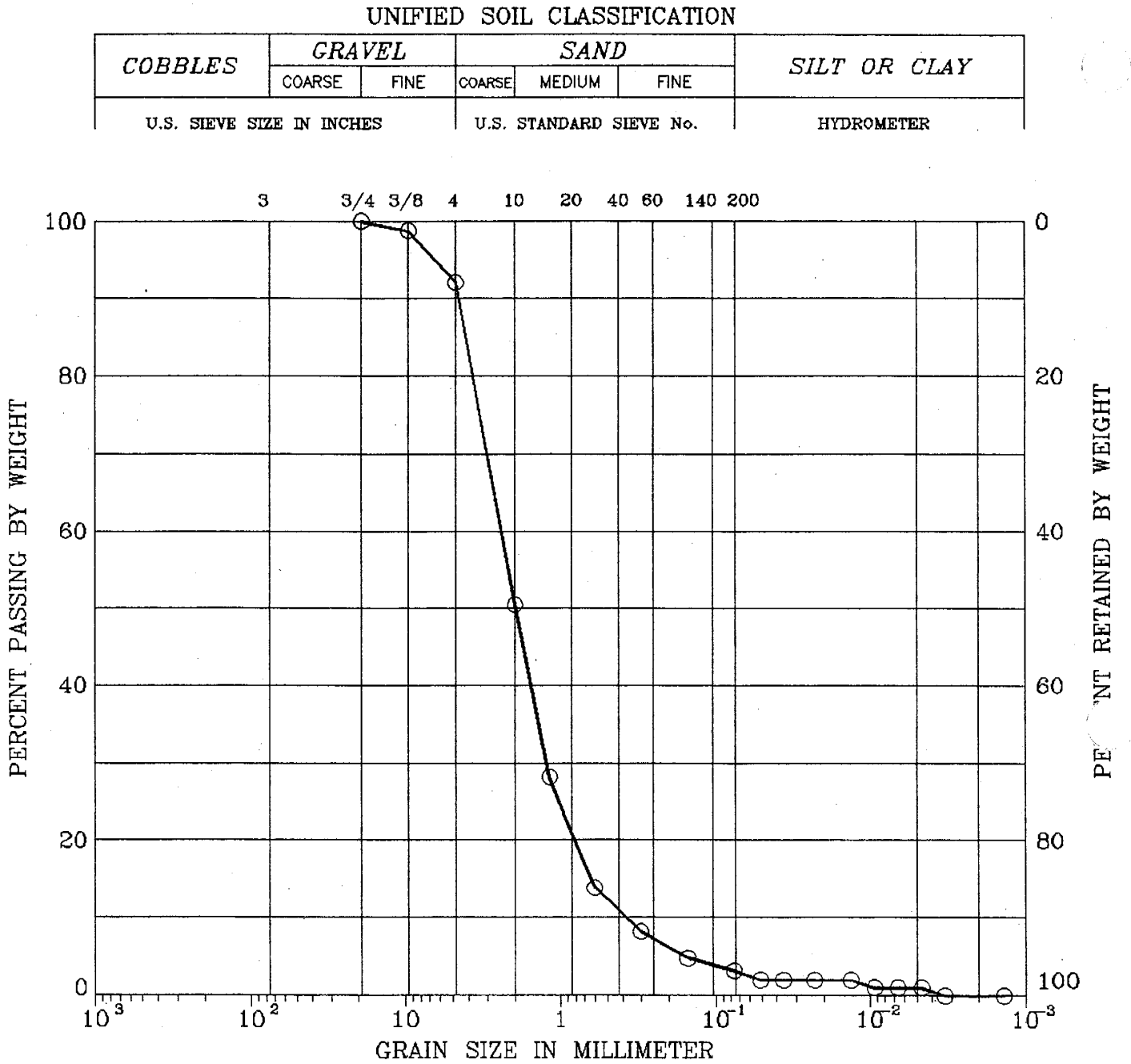


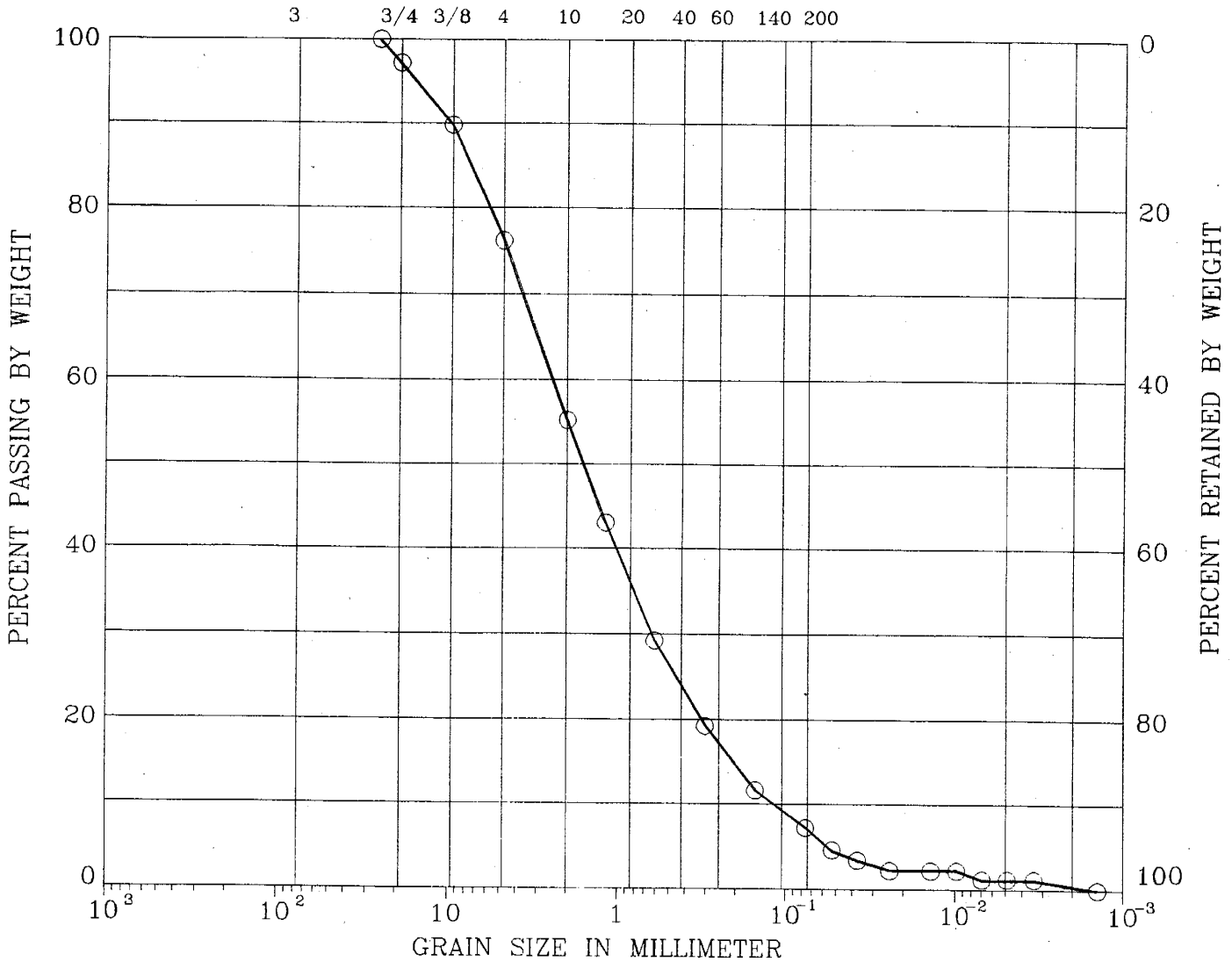
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M54 BS02	G1 D5.5			SAND, shell frags, light brown	USC=SW

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994

UNIFIED SOIL CLASSIFICATION

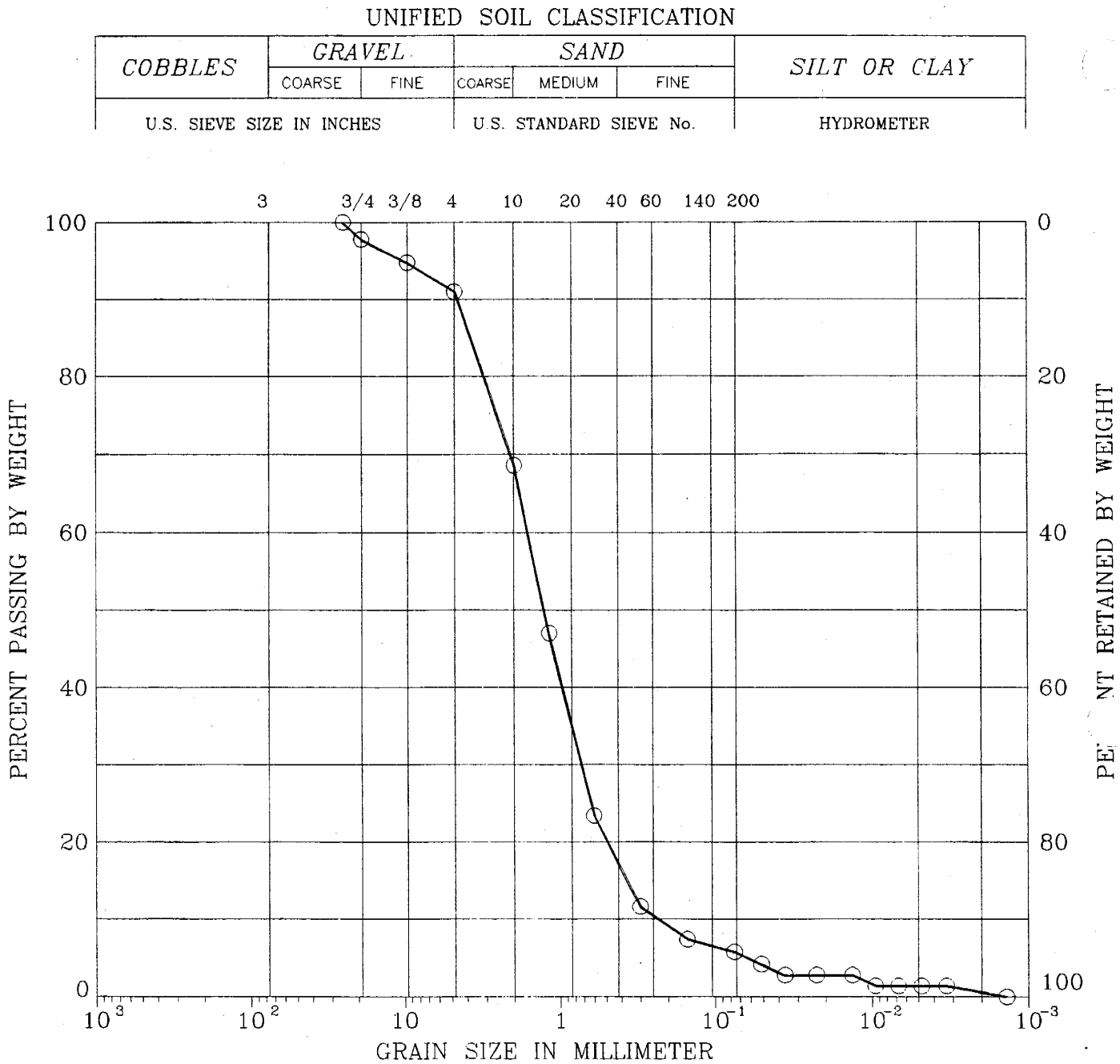
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	M54 BS01	G1 D1.5			SAND, shell frags,org,gr to br,mott dk br USC=SW

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 12,1995



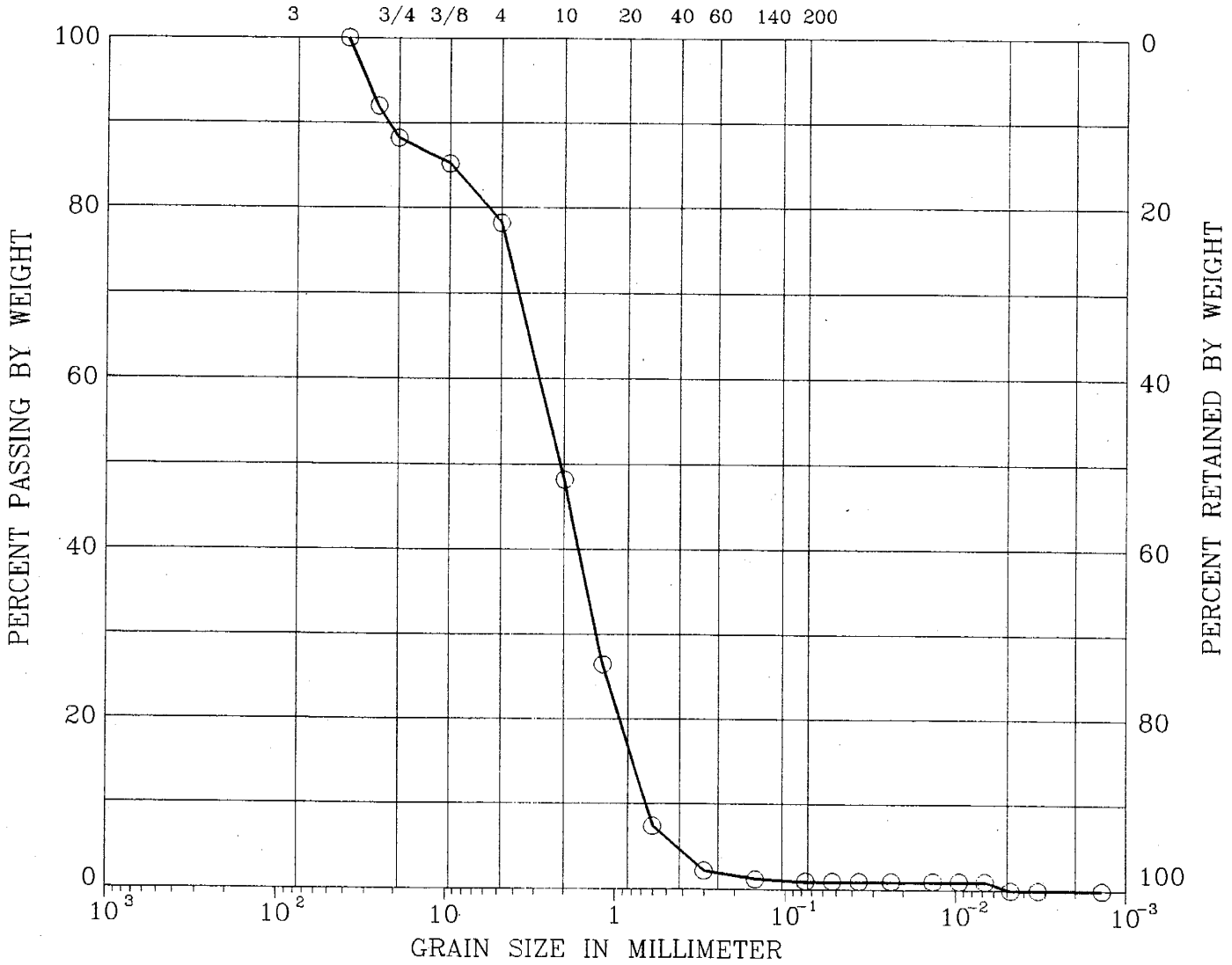
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M10 BS01	G1 D4.5			SAND, shell fragments, tan to gray	USC=SW

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



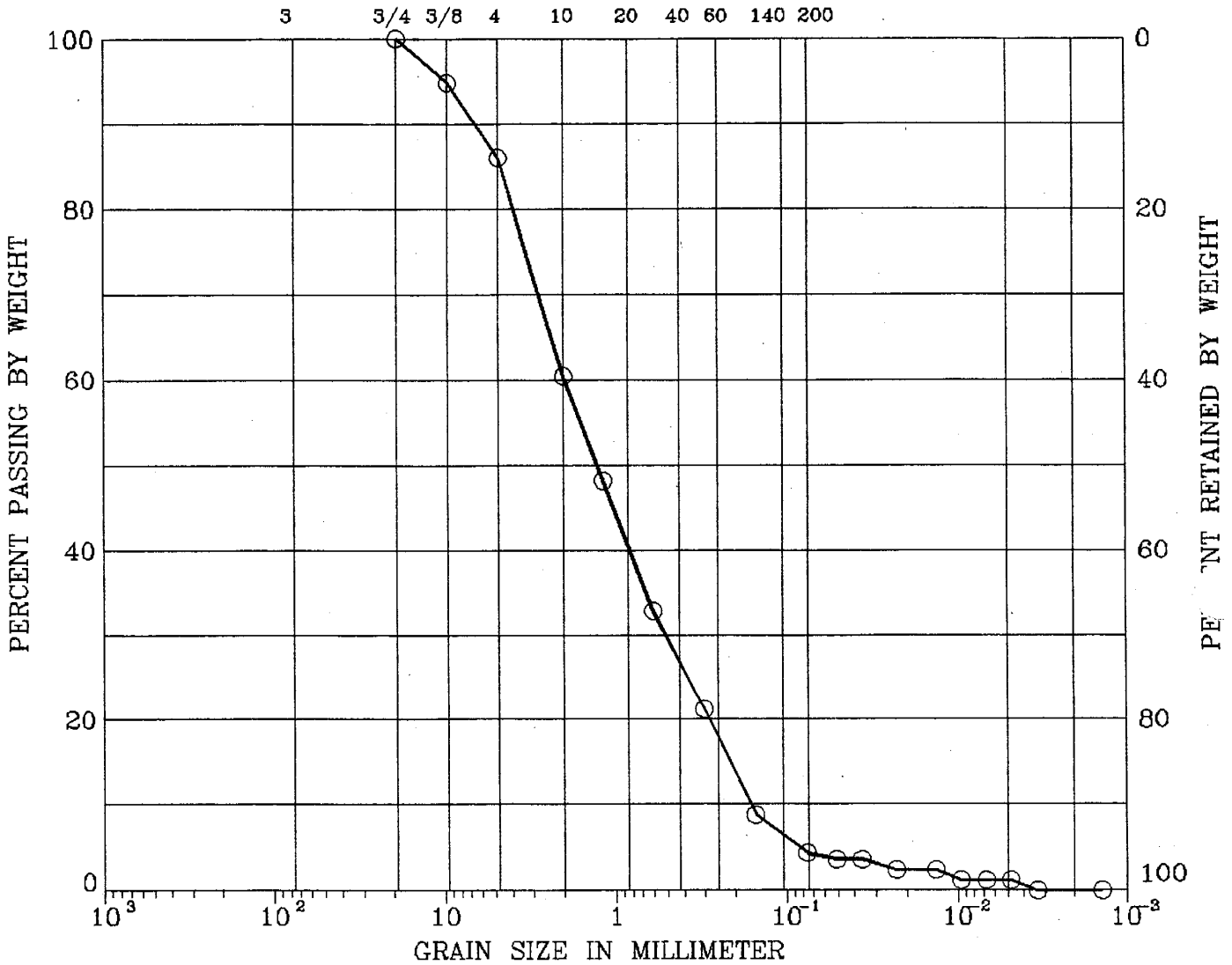
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M10 BS02	G1 D1.5			SAND,lg coral,shell frags,lgt yel to tan	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



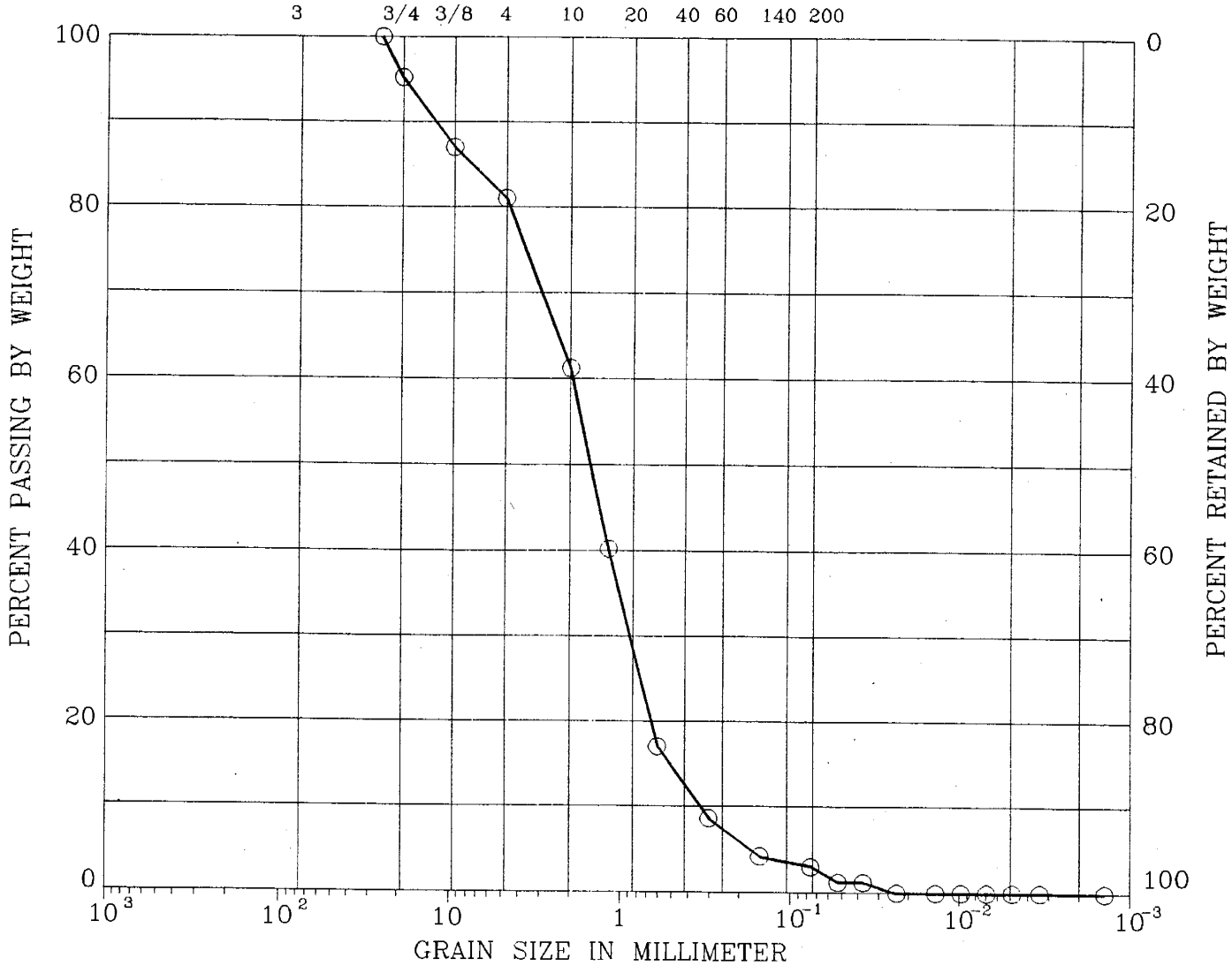
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	MAF BS01	G1 D2.0			SAND, shell and coral frags, org, lt gray	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994

UNIFIED SOIL CLASSIFICATION

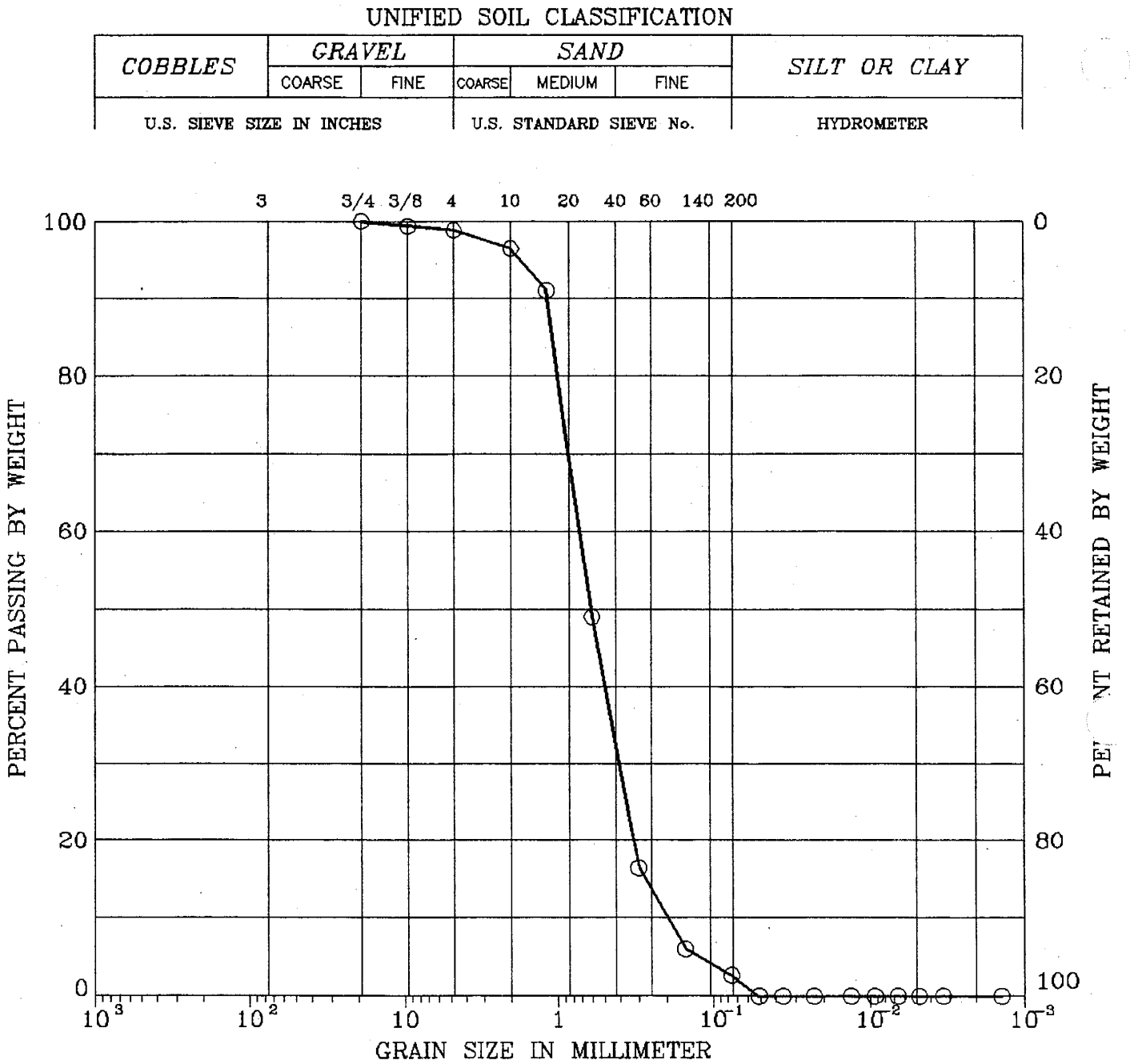
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	MAF BS02	G1 D6.0			SAND, shell frags, sl gvly, tan	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995



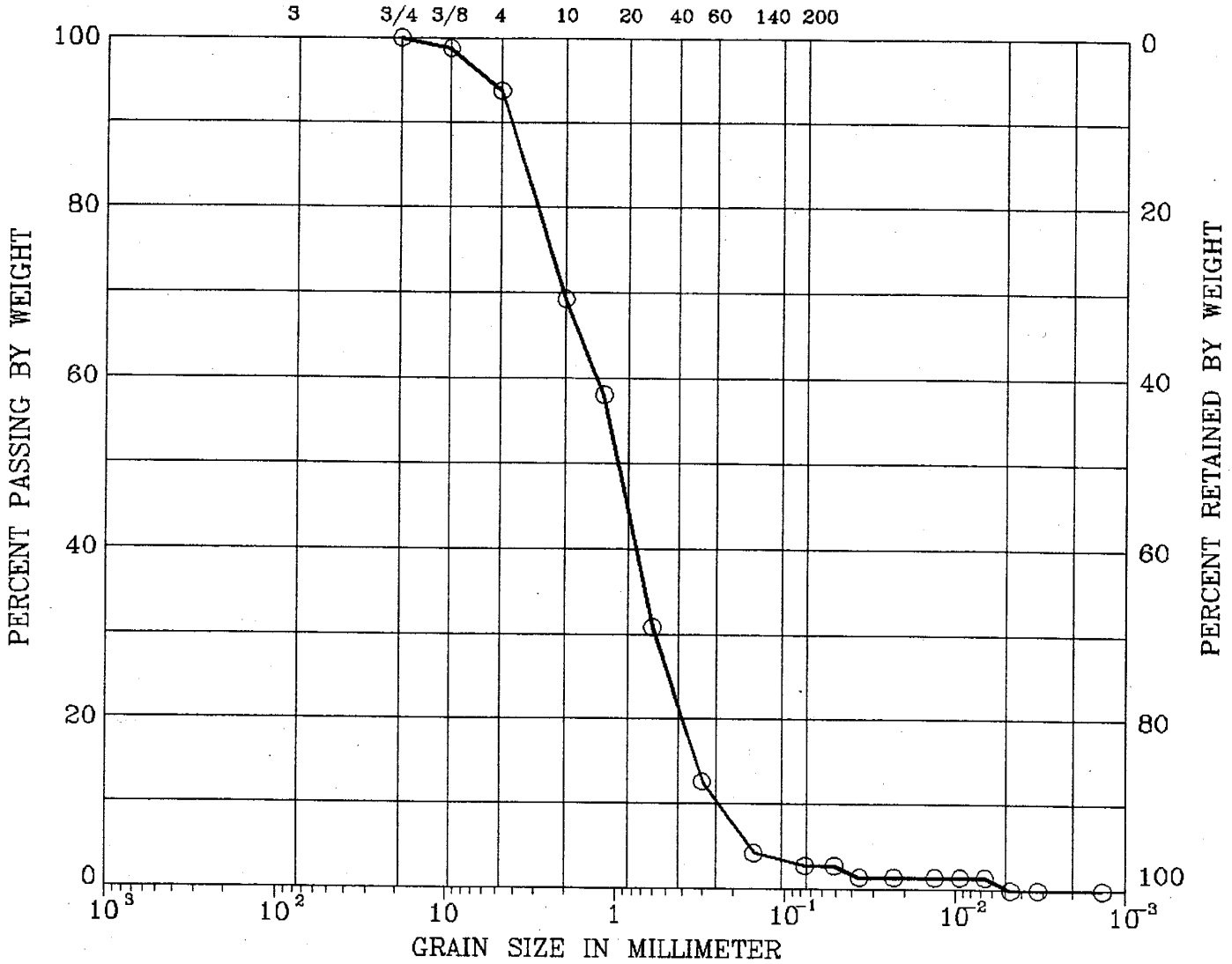
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M11 BS01	G1 D2.0			SAND, shell and coral frags, org, lt brn	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994

UNIFIED SOIL CLASSIFICATION

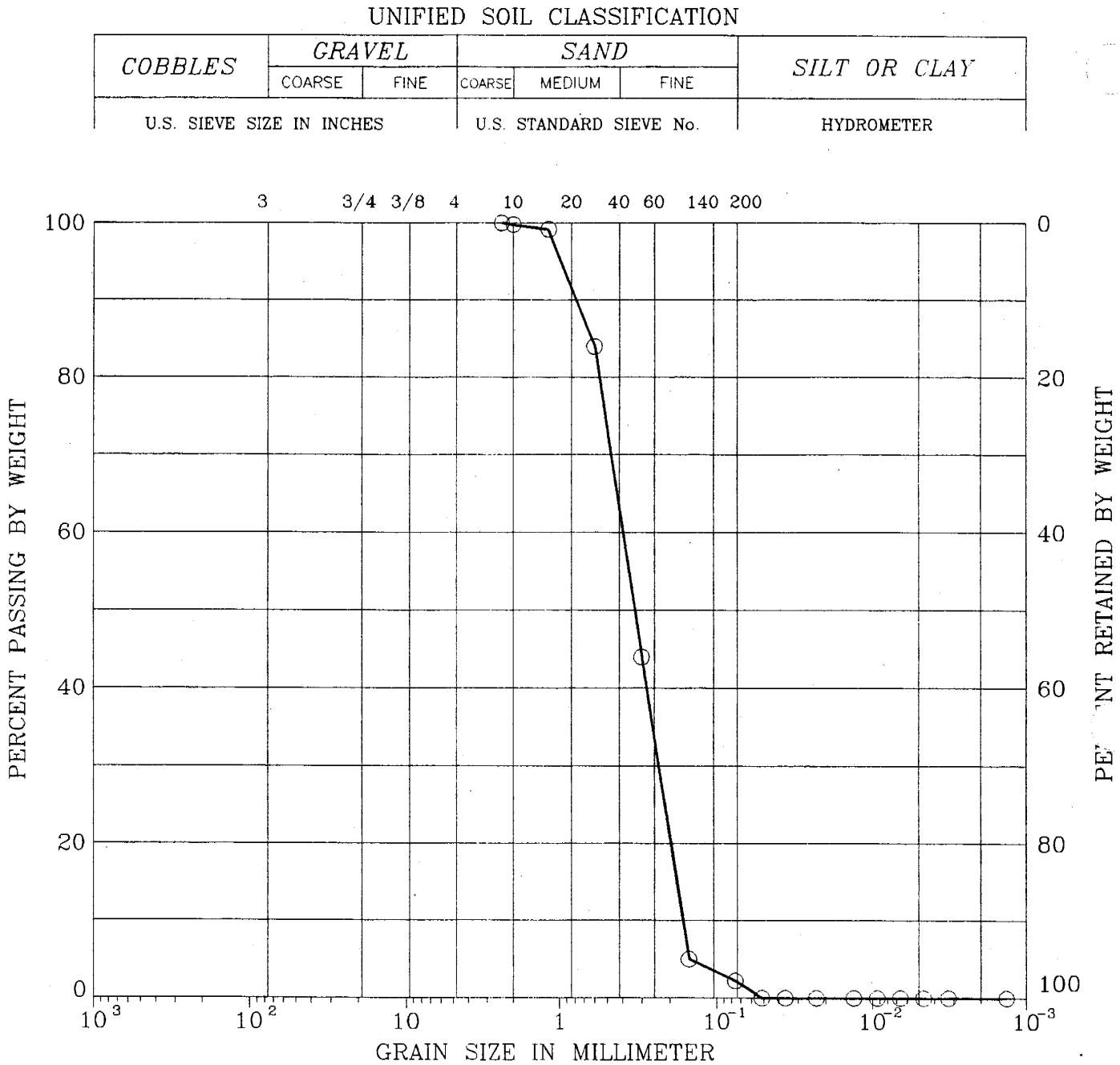
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	M11 BS03	G1 D2.5			SAND, shell and coral frags, org, lt gray USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994



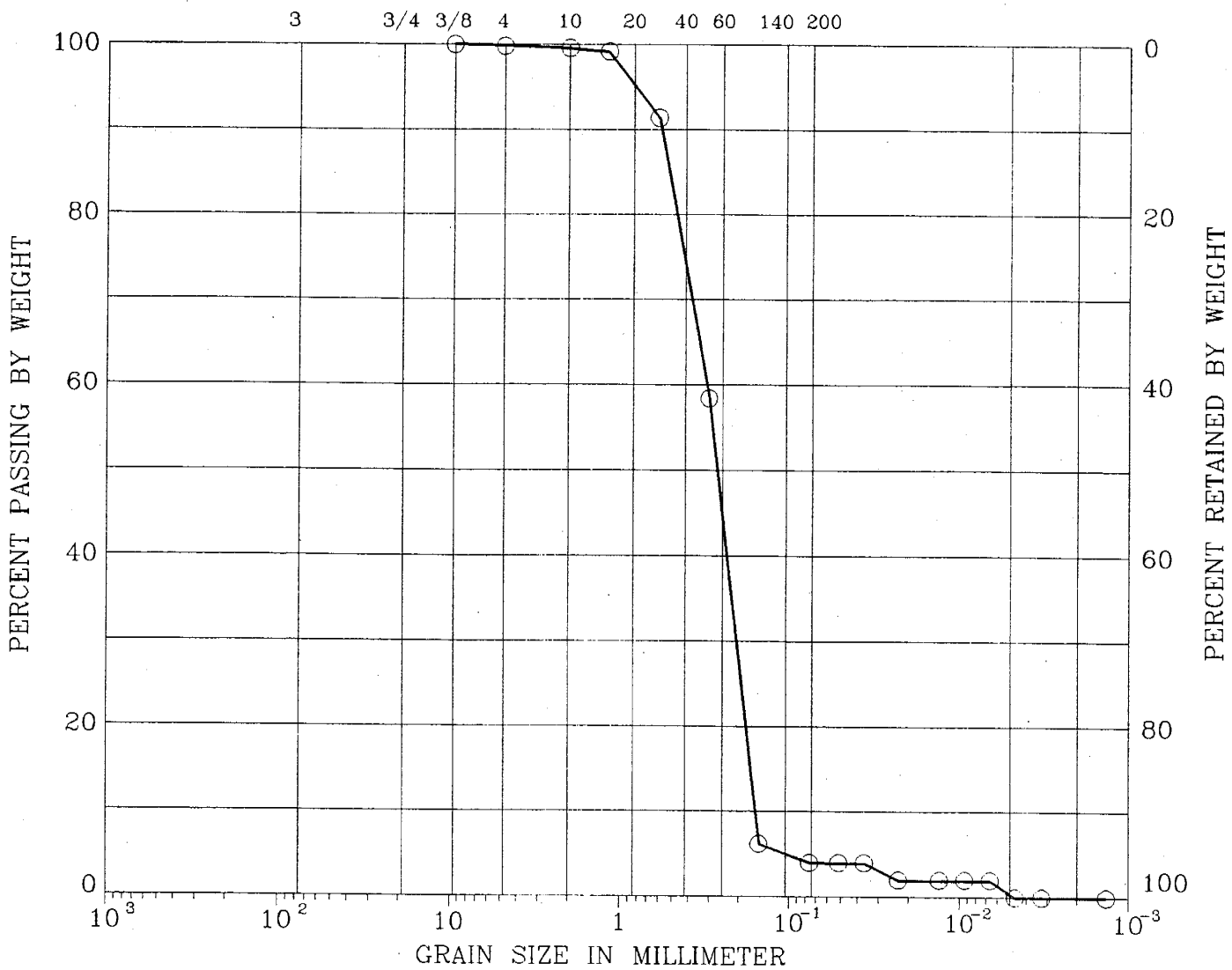
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	MSB BS02	G1 D4.0			SAND, shell and coral frag, org, lgt gray	USC=SP

Remark :

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



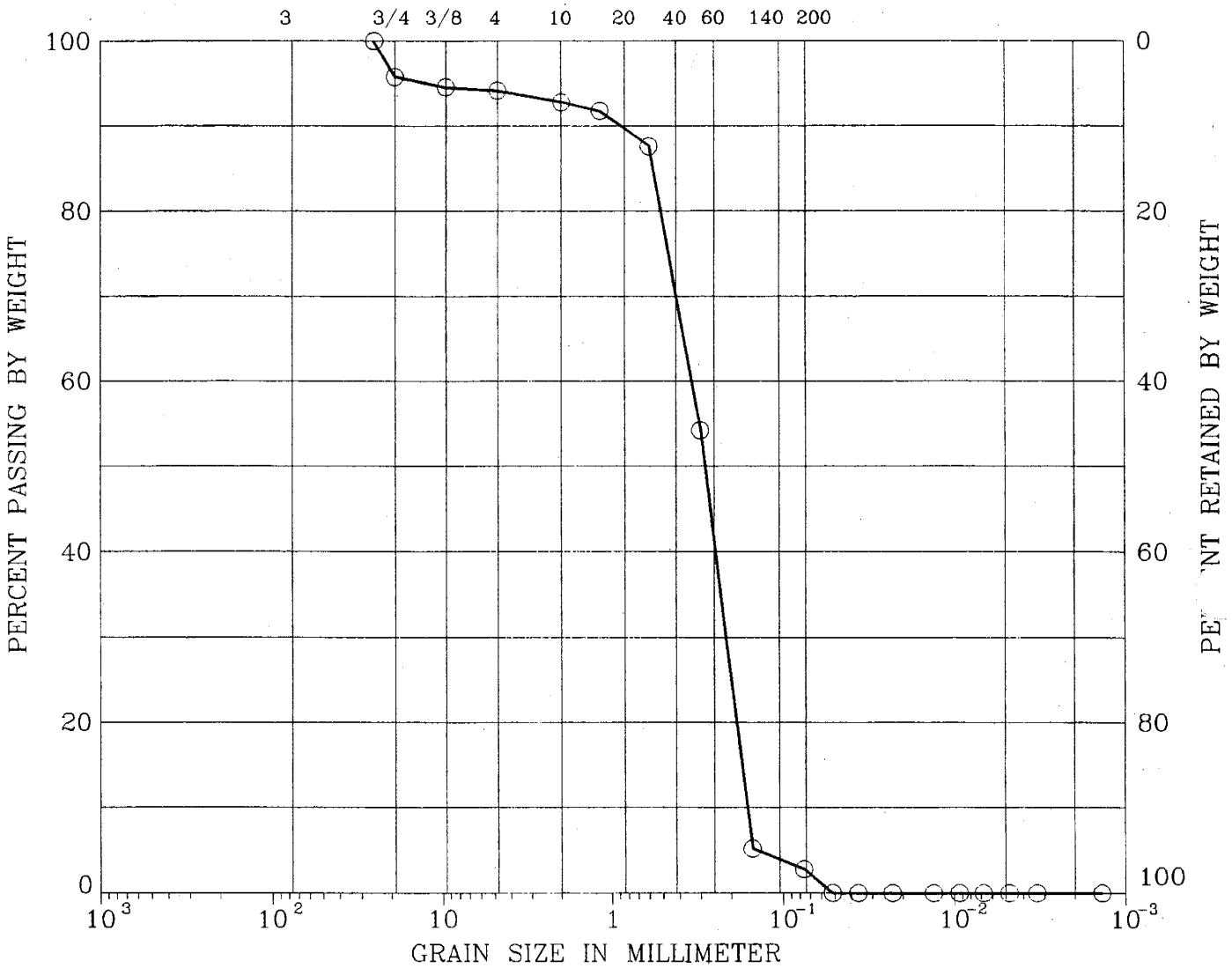
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	MSB BS01	G1 D4.0			SAND,sl orgs,pbls,v lgt brn, mottled black · USC=SP

Remark :

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



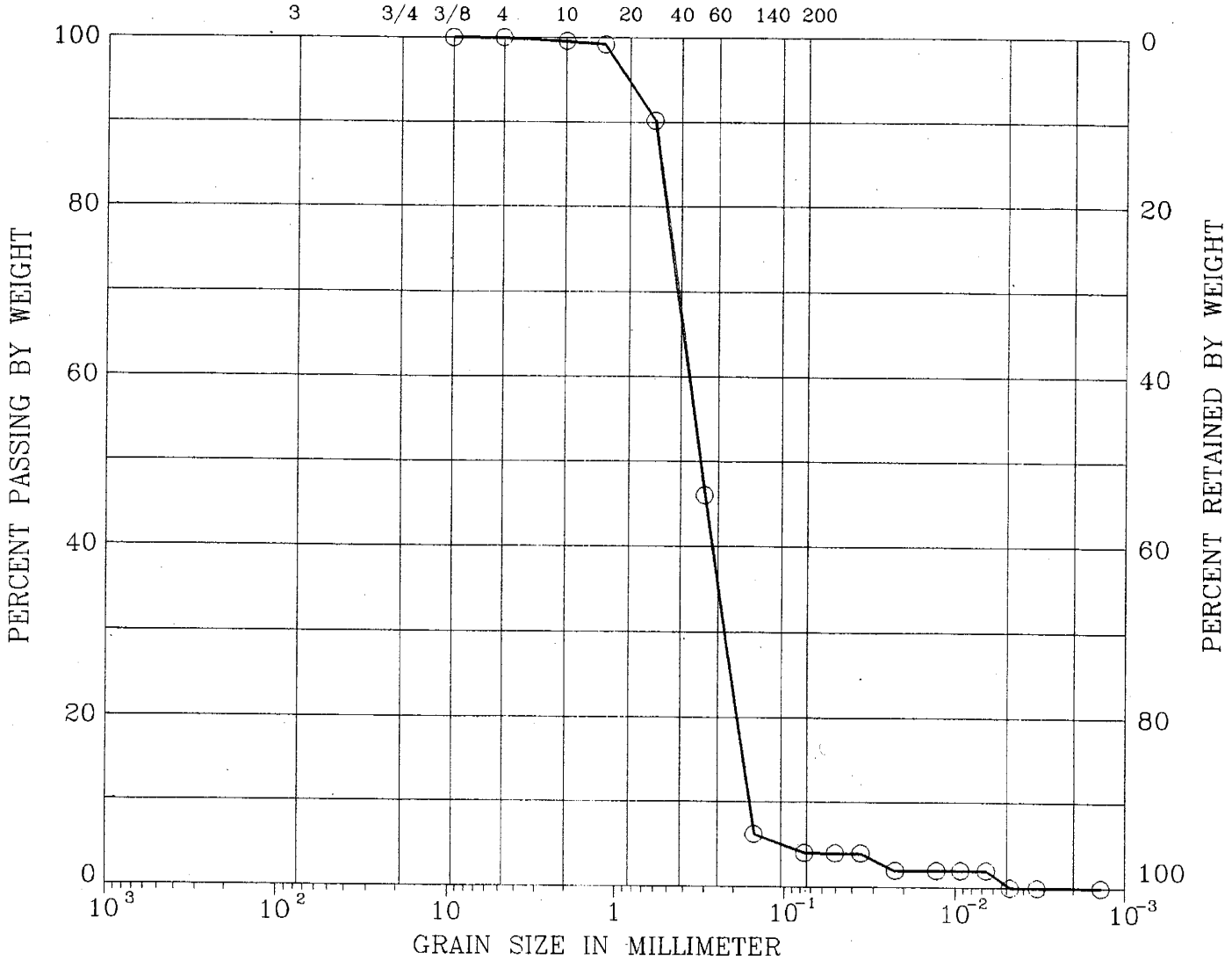
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	MSB BS04	G1 D2.5			SAND, pebbles, sl organic, tan	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



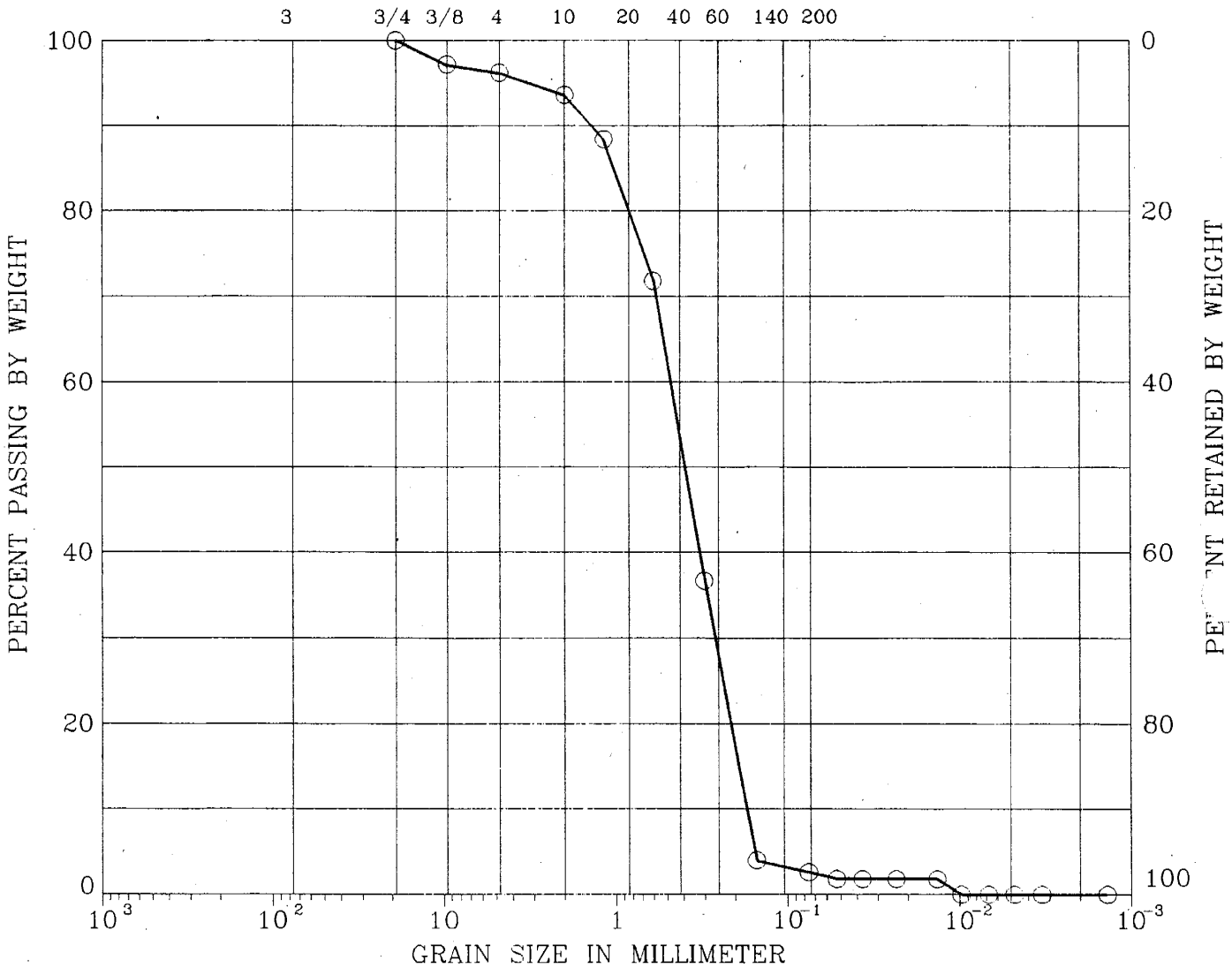
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	MSB BS05	G1 D3.5			SAND, very light gray, mottled black	USC=SP

Remark :

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 5, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



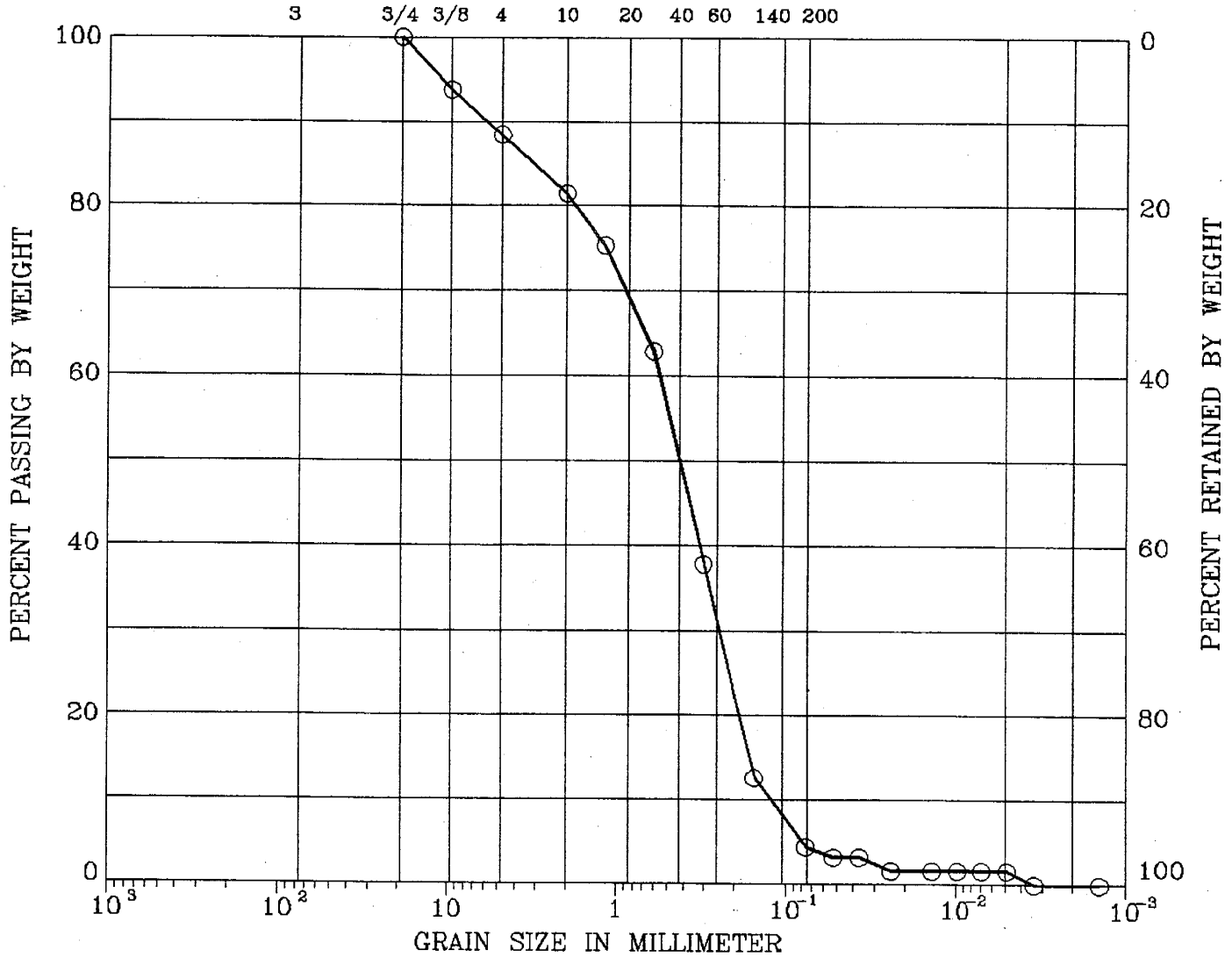
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	M02 BS01	G1 D2.0			SAND, pebbles, sl org, lgt brn, mottled blk USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



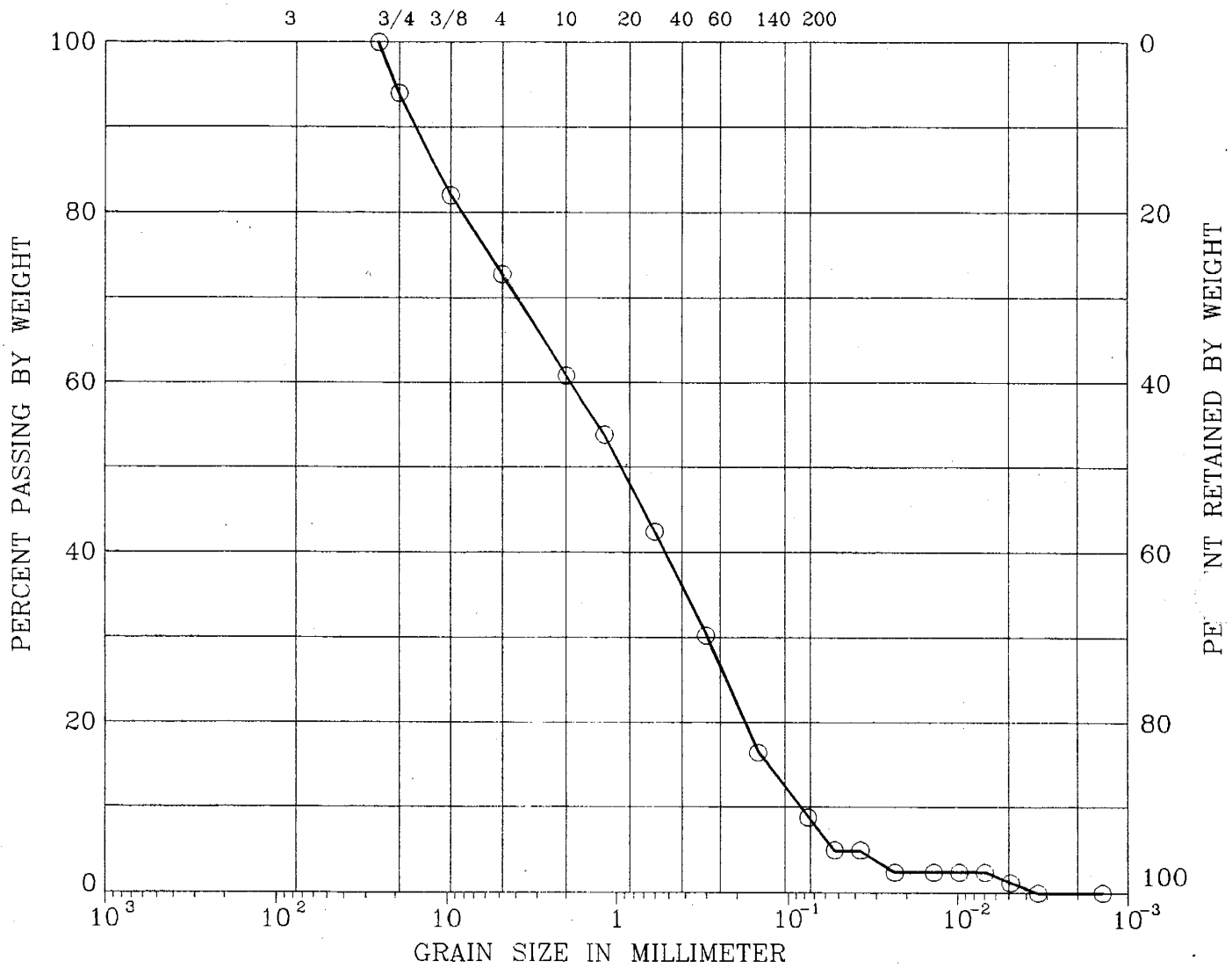
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M02 BS02	G1 D1.0			SAND, pebbles, light brown to gray	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



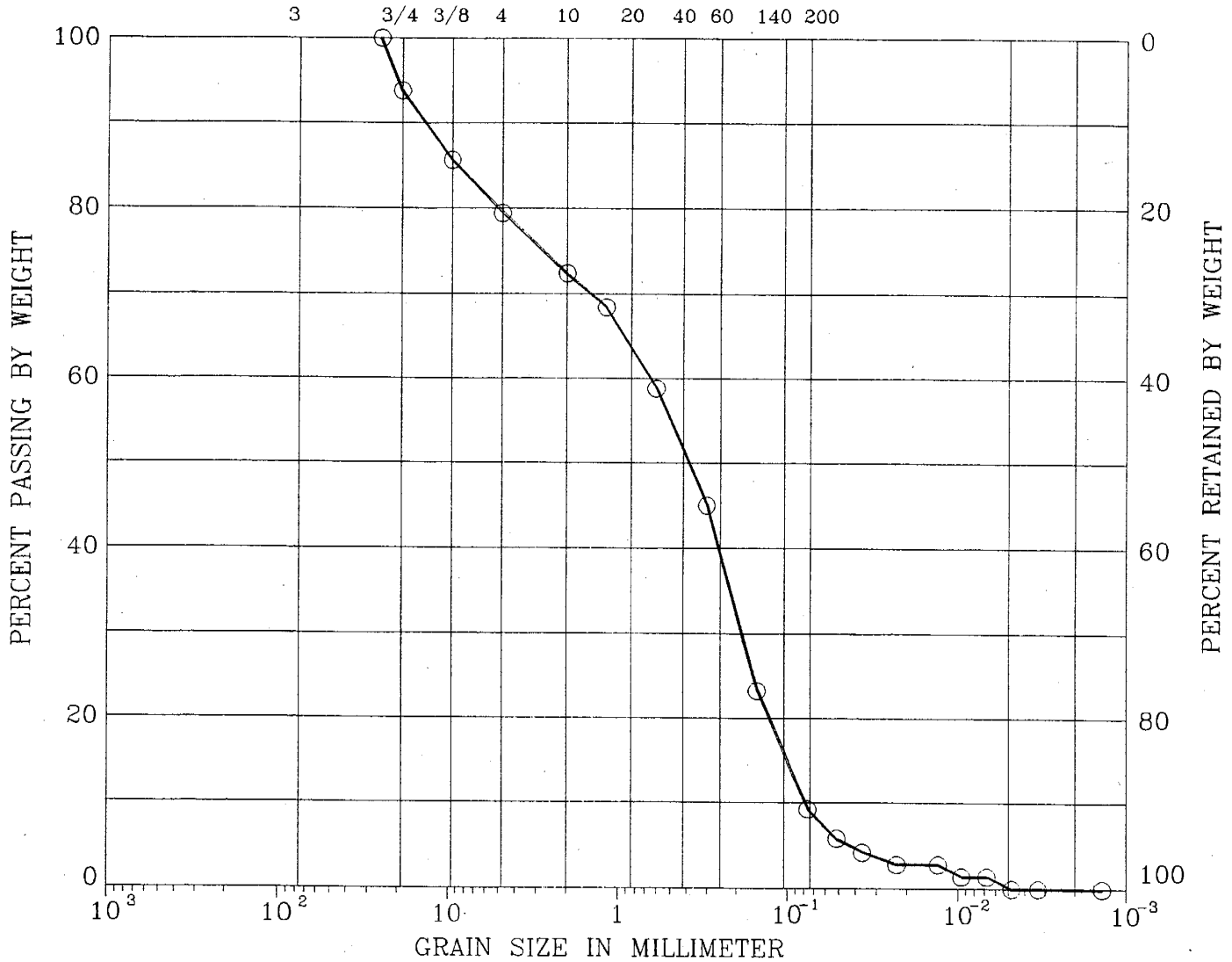
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M02 BS03	G1 D1.0			SAND,sl orgs,pbls,tan,mottled black	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

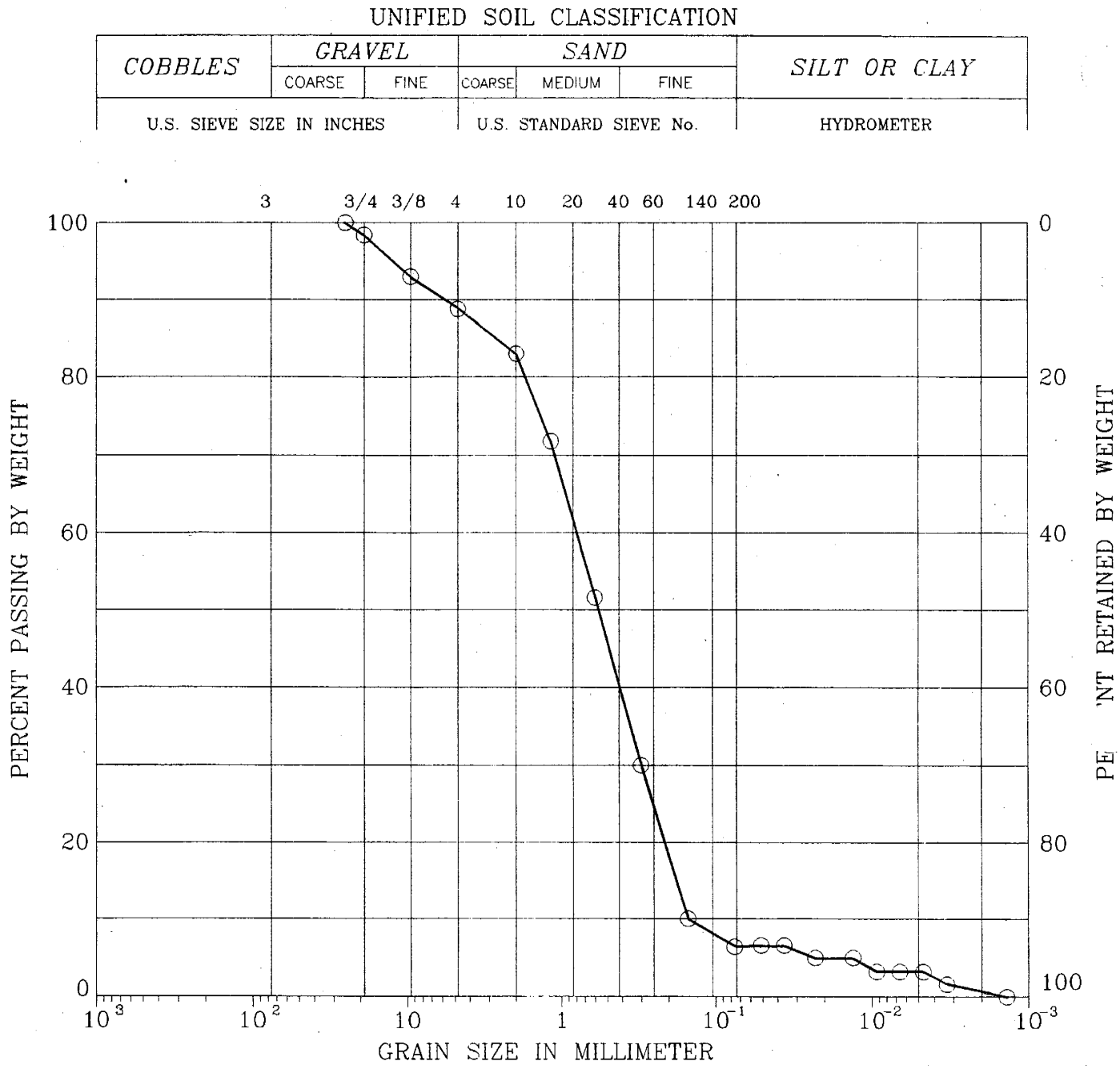
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M02 BS04	G1 D1.5			SAND, pebbles, sl org, tan, mottled black	USC=SP

Remark : Sample mass less than specified in ASTM D422

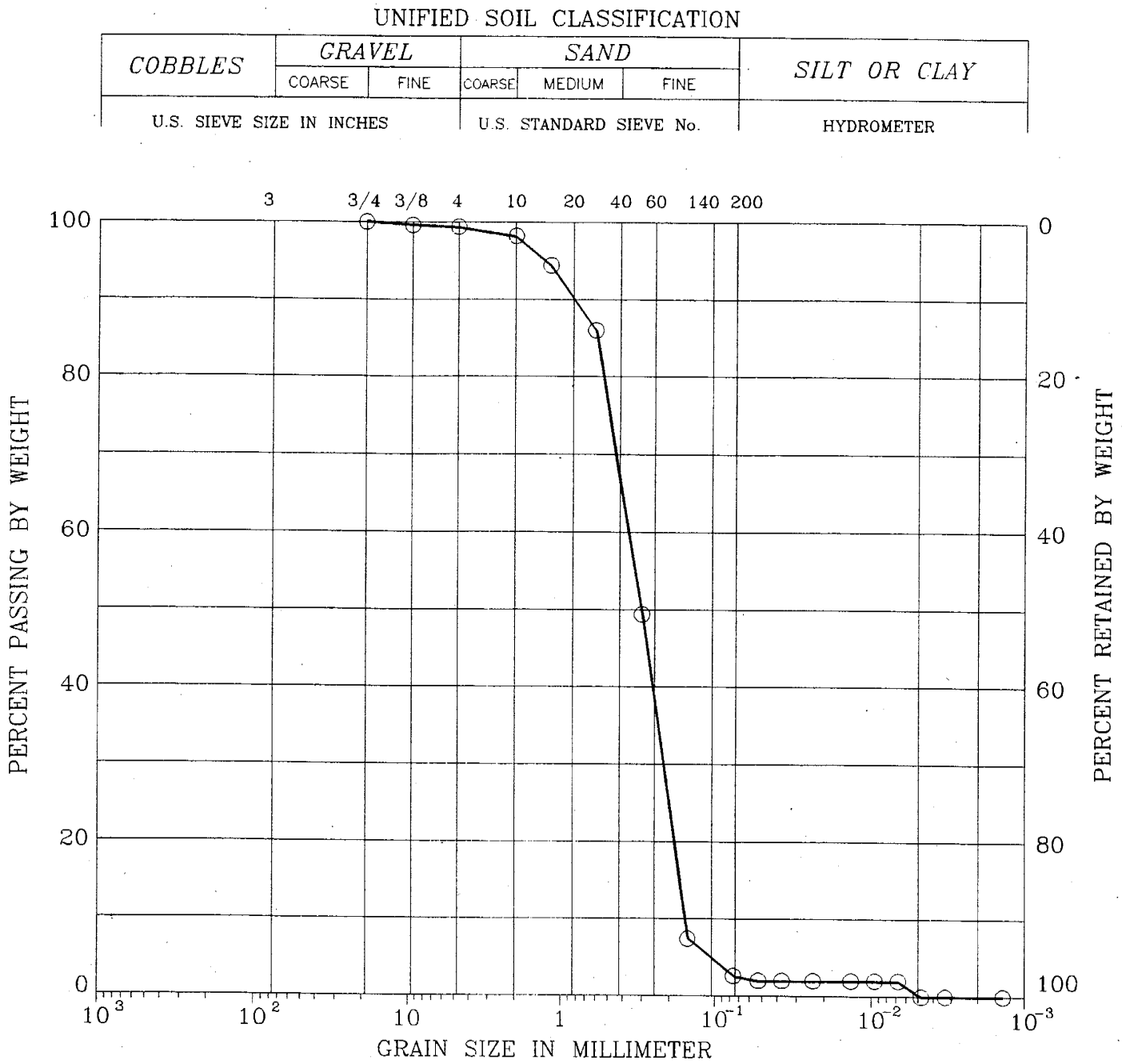
PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 5, 1995



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	M08 BS01	G1 D2.0			SAND, pbls, shell frags, tan, mottled black USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995



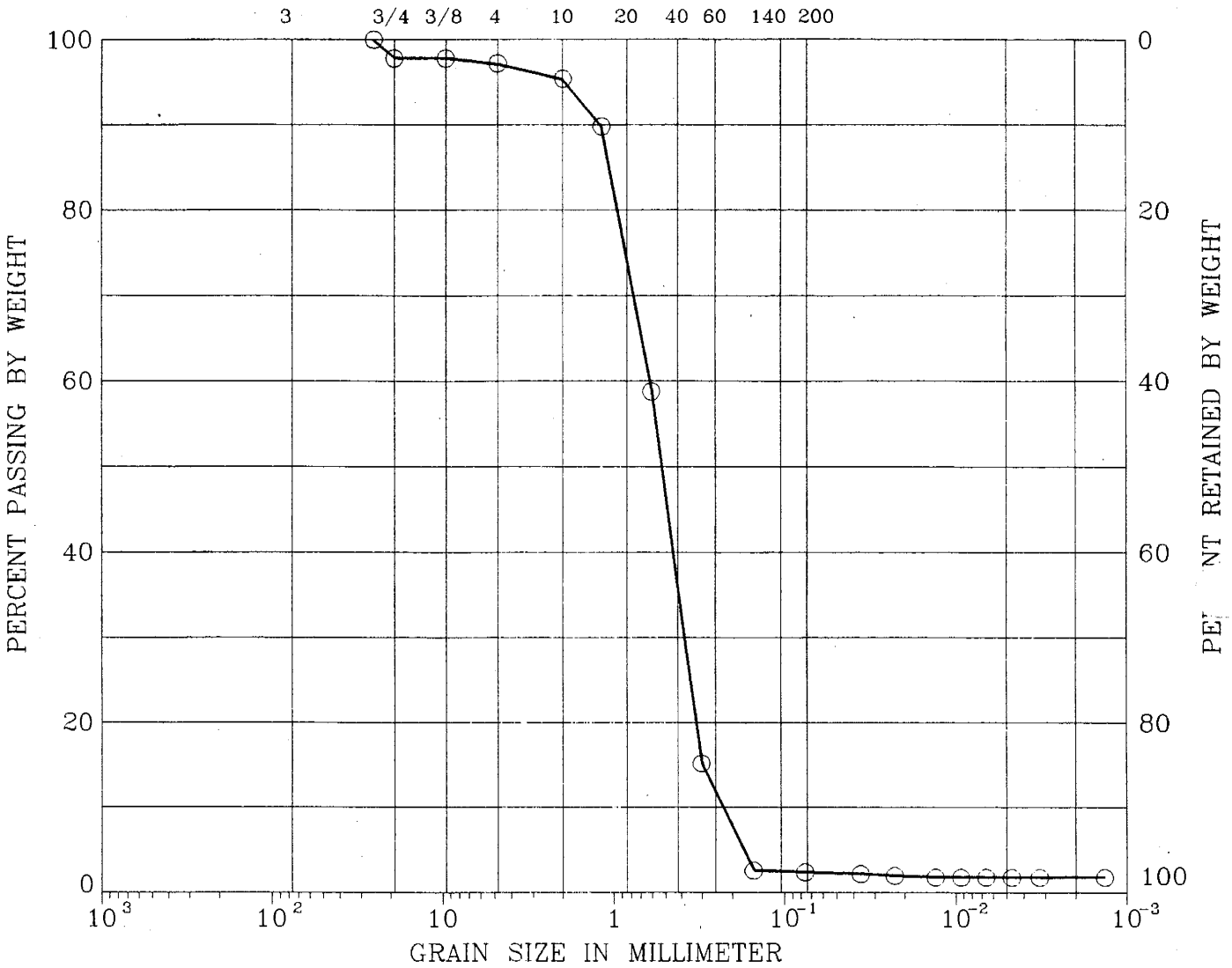
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M08 BS03	G1 D4.0			SAND, pebbles, tan, mottled gray	USC=SP

Remark :

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 10, 1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



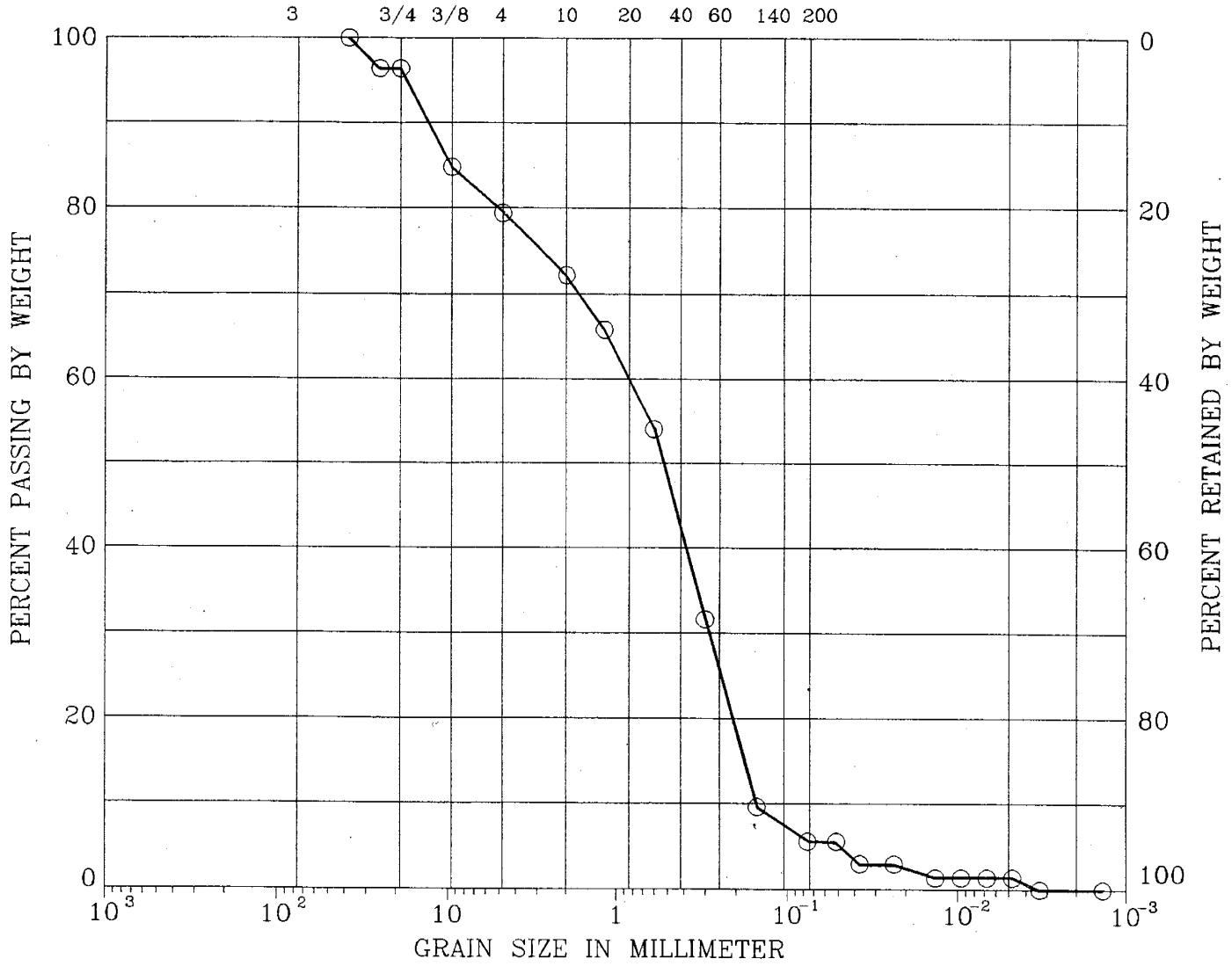
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	M01 BS01	G1 D1.0			SAND,shell and coral frag, organic, lgt gr USC=SW

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 12,1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



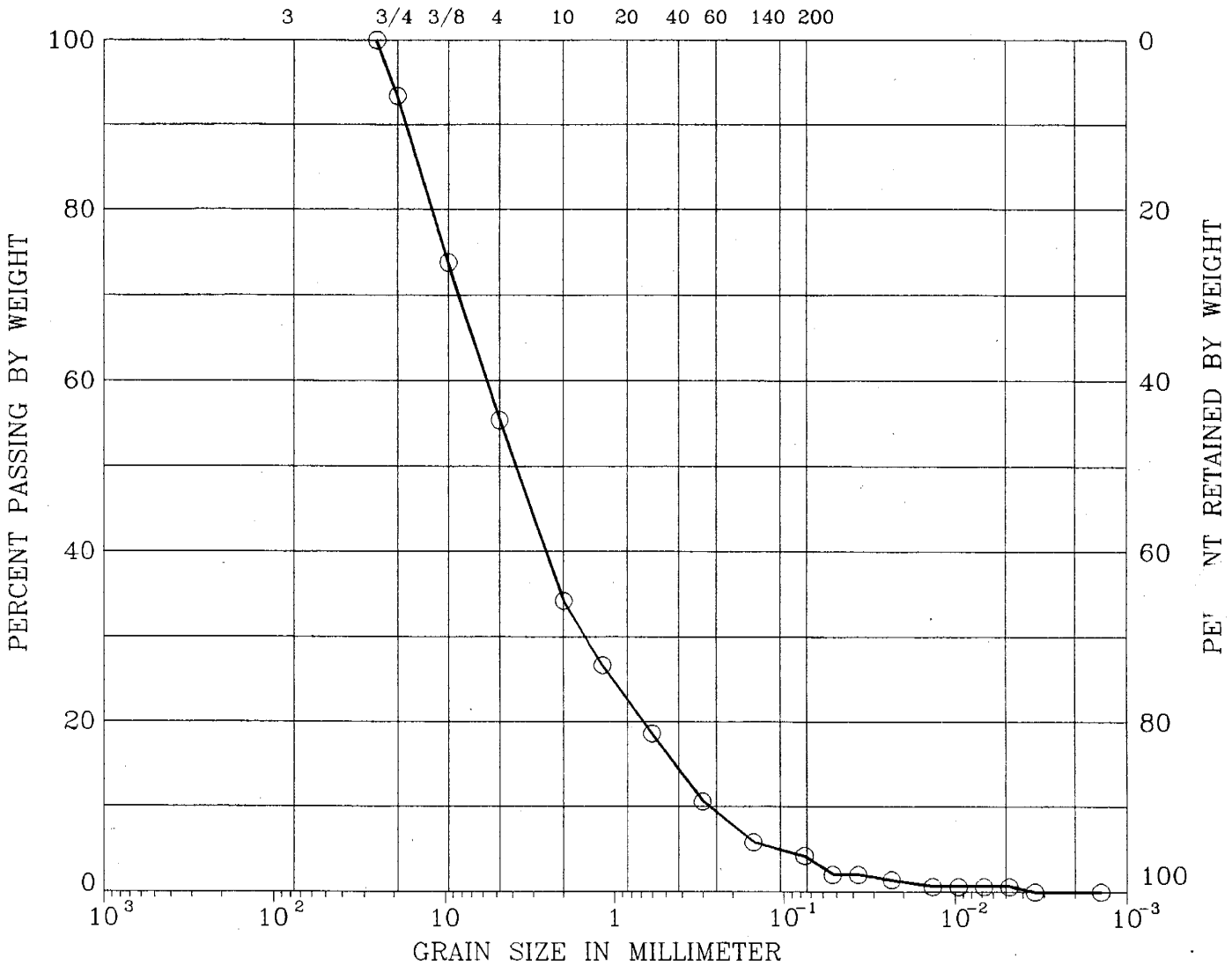
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M01 BS02	G1 D1.5			SAND, shell frags,tan to drk brn and gr	USC=SP

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 12,1995

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



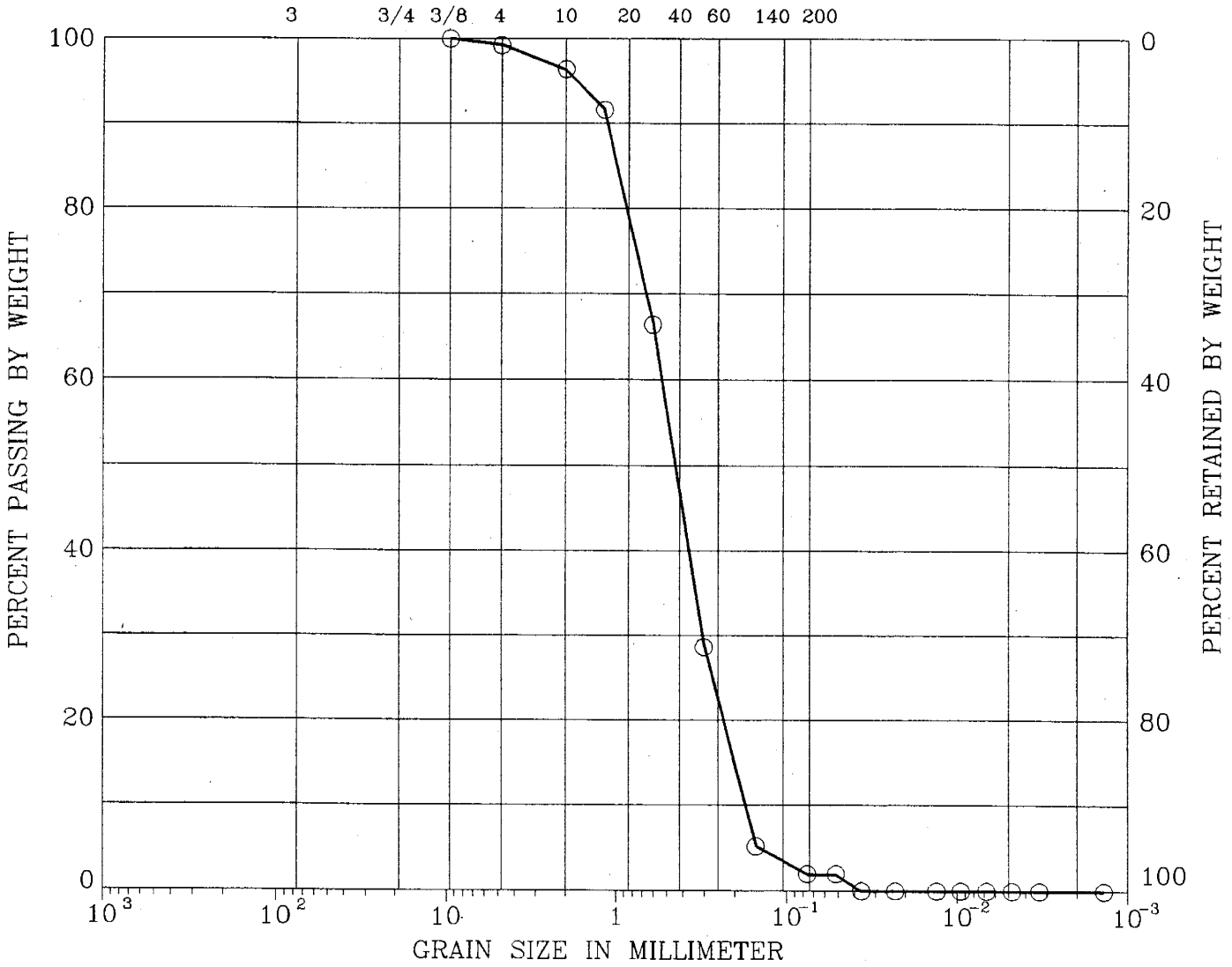
SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M01 BS04	G1 D1.0			SAND, shell and coral fragments, tan	USC=SW

Remark : Sample mass less than specified in ASTM D422

PROJ. 1-1019-0136	Midway (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION December 29,1994

UNIFIED SOIL CLASSIFICATION

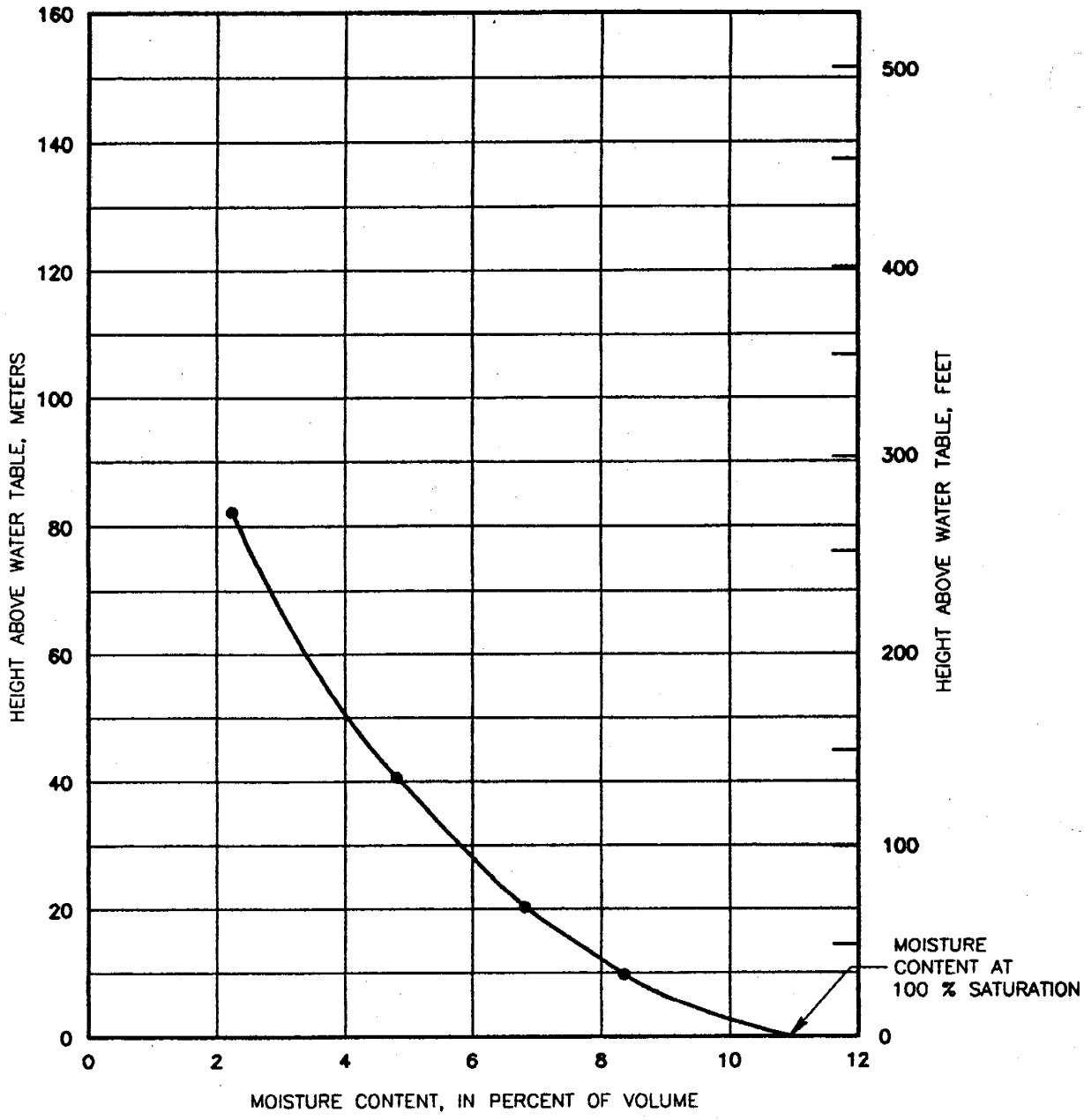
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION	
○	M05 BS02	G1 D7.0			SAND, light yellow	USC=SP

Remark :

PROJ. 1-1019-0136	Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL	GRAIN SIZE DISTRIBUTION January 5, 1995



SAMPLE ID: *M54 BS02 G01 D05.5*
SOILTYPE: *SAND, shell fragments, light brown*
SAMPLE TYPE: *Remolded*

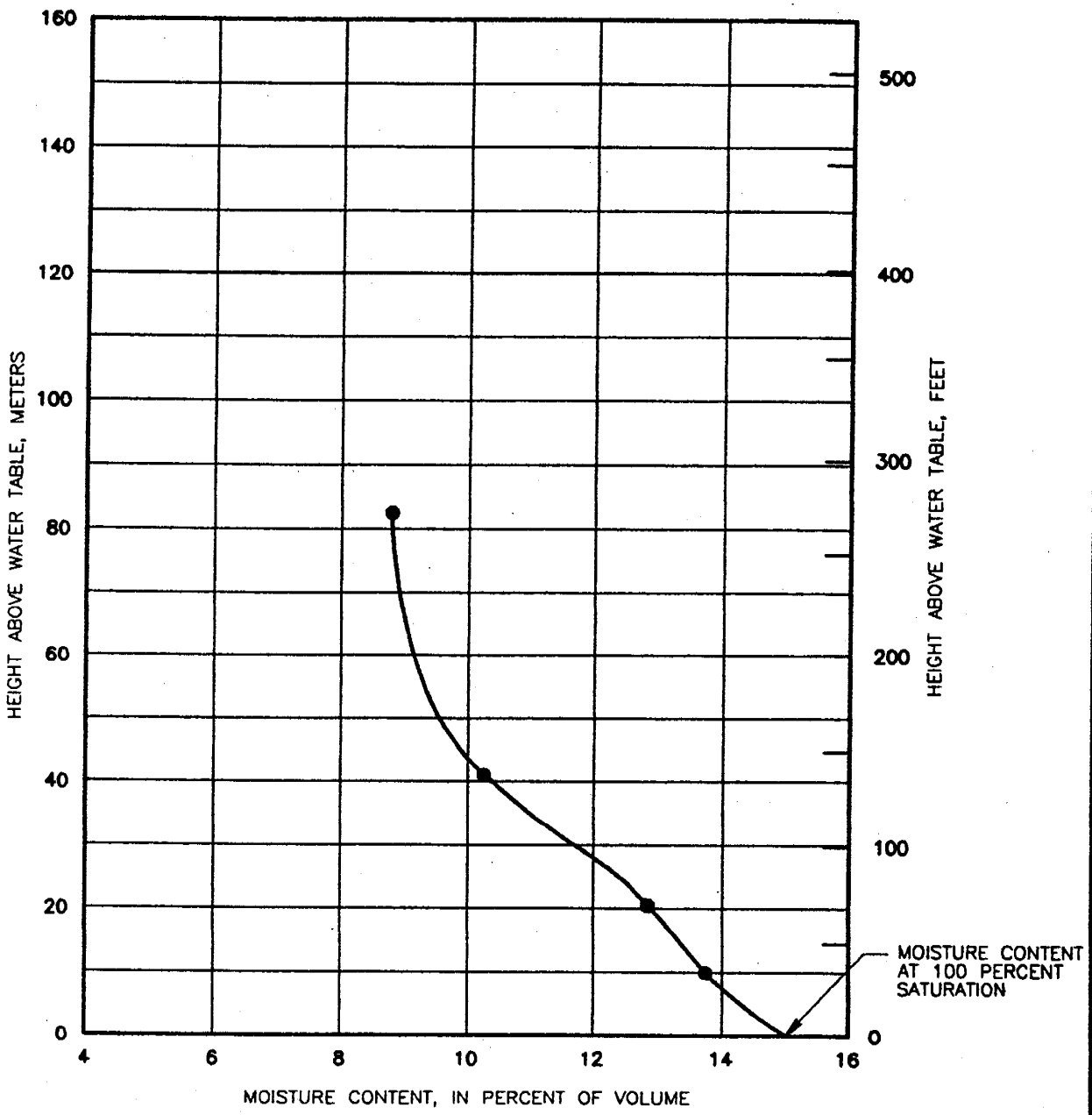
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*6.73*	*8.29*
2	*20.67*	*5.43*	*6.76*
4	*41.33*	*3.89*	*4.83*
8	*82.66*	*2.63*	*3.21*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

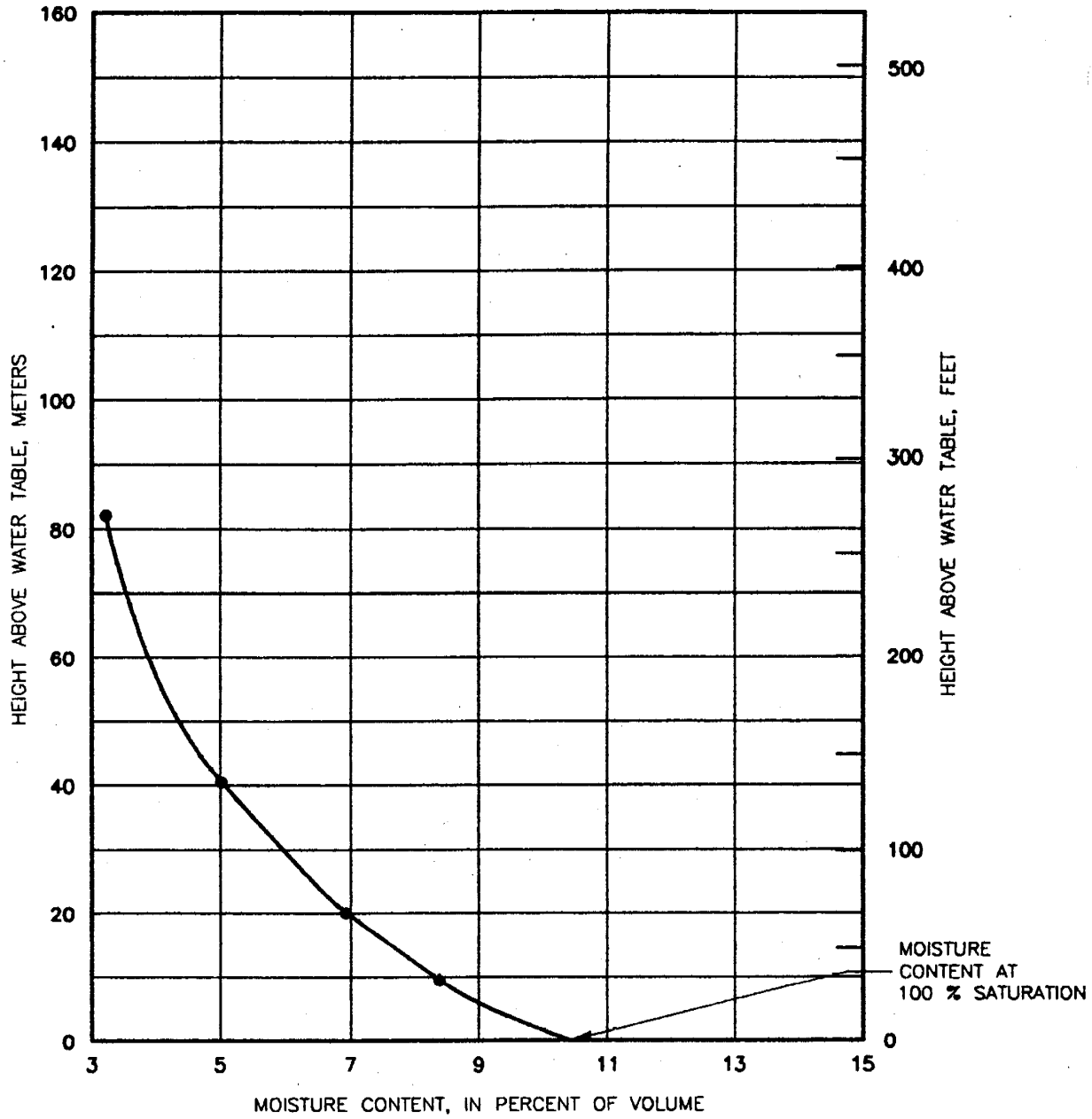
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M54 BS01 G01 D01.5*
SOILTYPE: *SAND, shell fragments, organics, gray to brown, mottled dark brown*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*11.20*	*13.75*
2	*20.67*	*10.54*	*12.86*
4	*41.33*	*8.40*	*10.26*
8	*82.66*	*7.38*	*8.86*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M10 BS01 G01 D04.5*
SOILTYPE: *SAND, shell fragments, tan to gray*
SAMPLE TYPE: *Remolded*

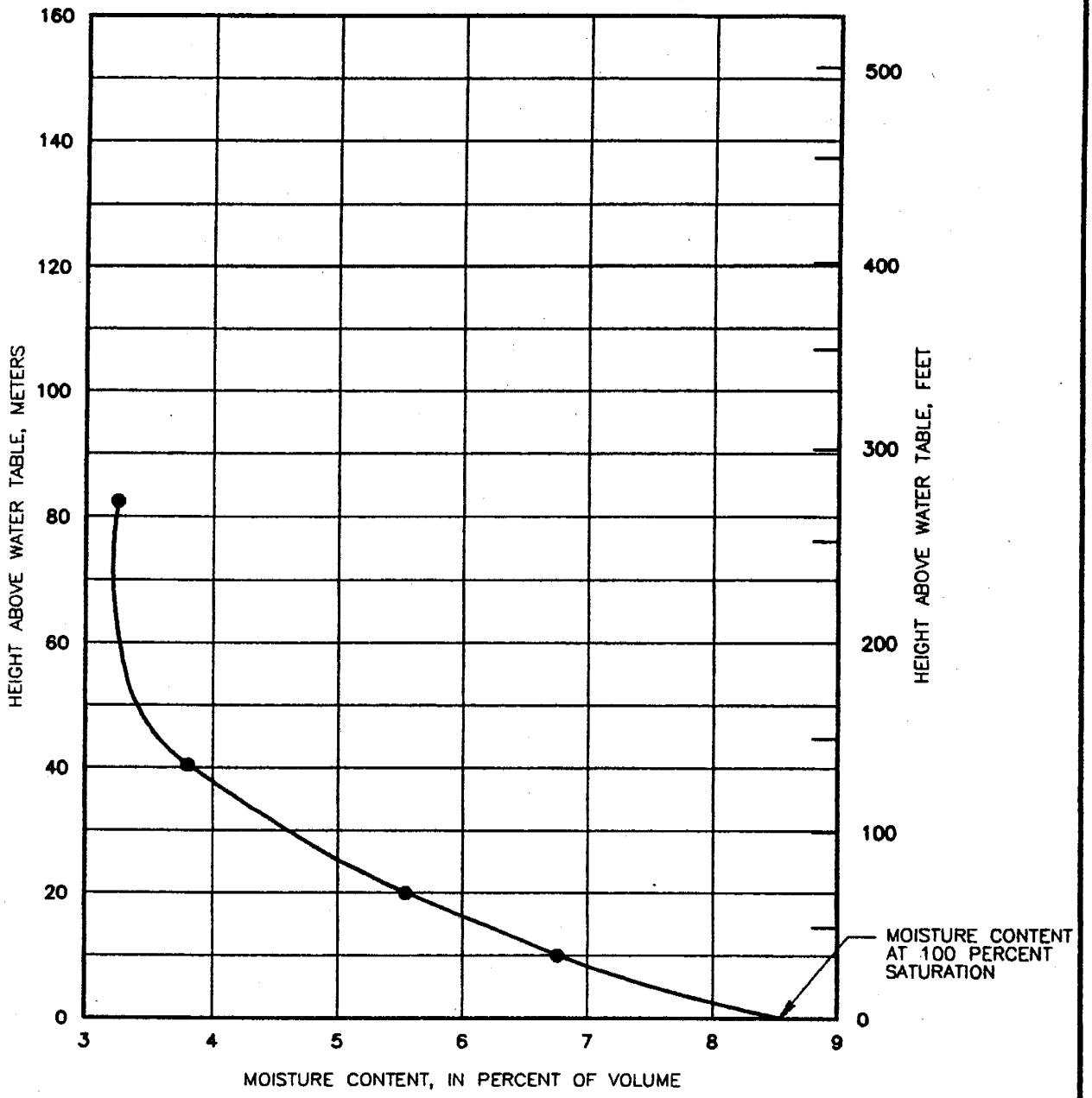
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*6.79*	*8.42*
2	*20.67*	*5.59*	*6.96*
4	*41.33*	*4.04*	*5.04*
8	*82.66*	*2.62*	*3.21*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

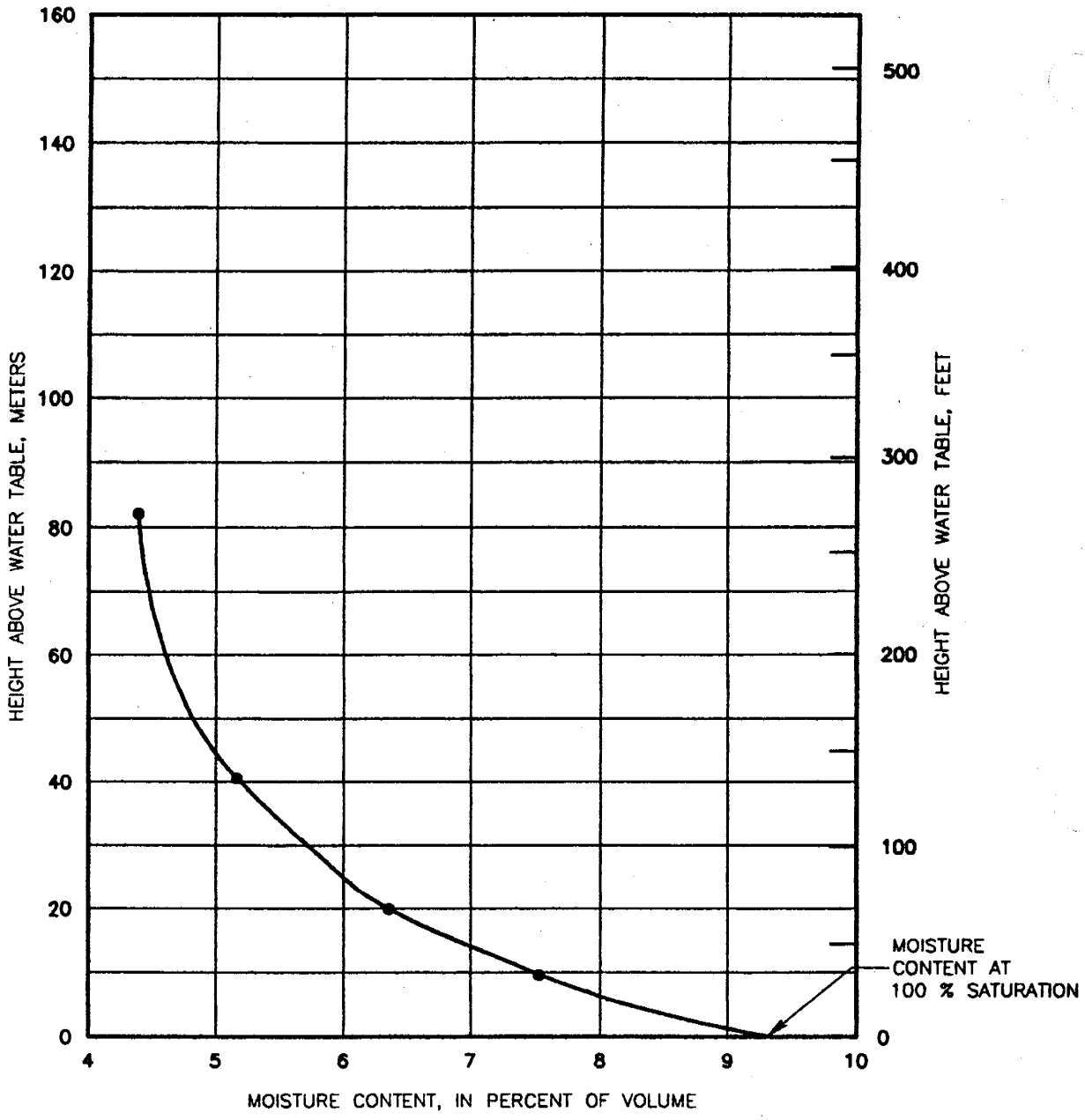
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M10 BS02 G01 D01.5*
SOILTYPE: *SAND, large coral and shell fragments, light yellow to tan*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.42*	*6.73*
2	*20.67*	*4.52*	*5.53*
4	*41.33*	*3.09*	*3.79*
8	*82.66*	*3.38*	*3.26*

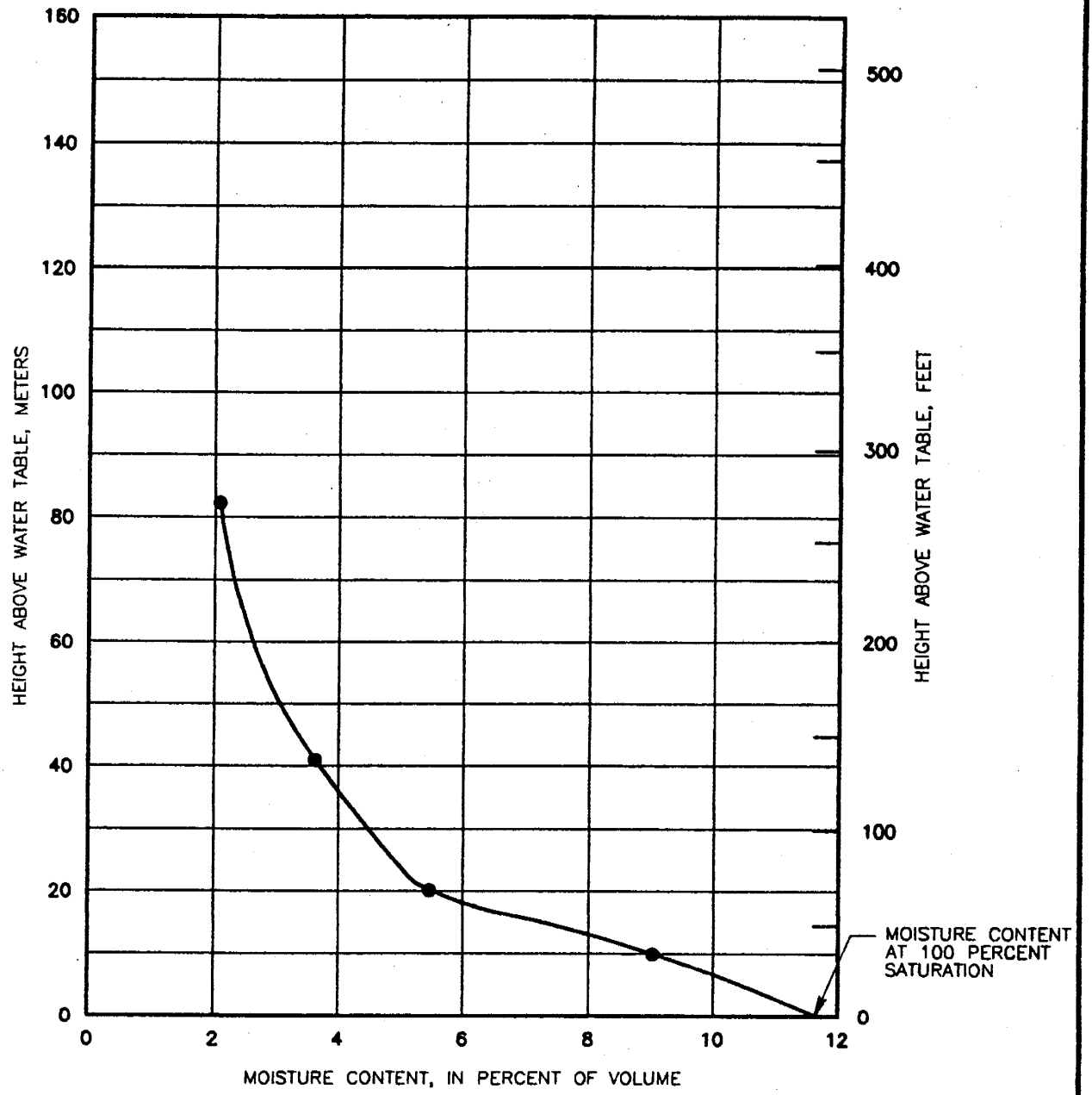
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MAF BS01 G01 D02.0*
SOILTYPE: *SAND, shell & coral fragments, organics, light gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*6.10*	*7.49*
2	*20.67*	*5.53*	*6.96*
4	*41.33*	*4.25*	*5.17*
8	*82.66*	*3.59*	*4.39*

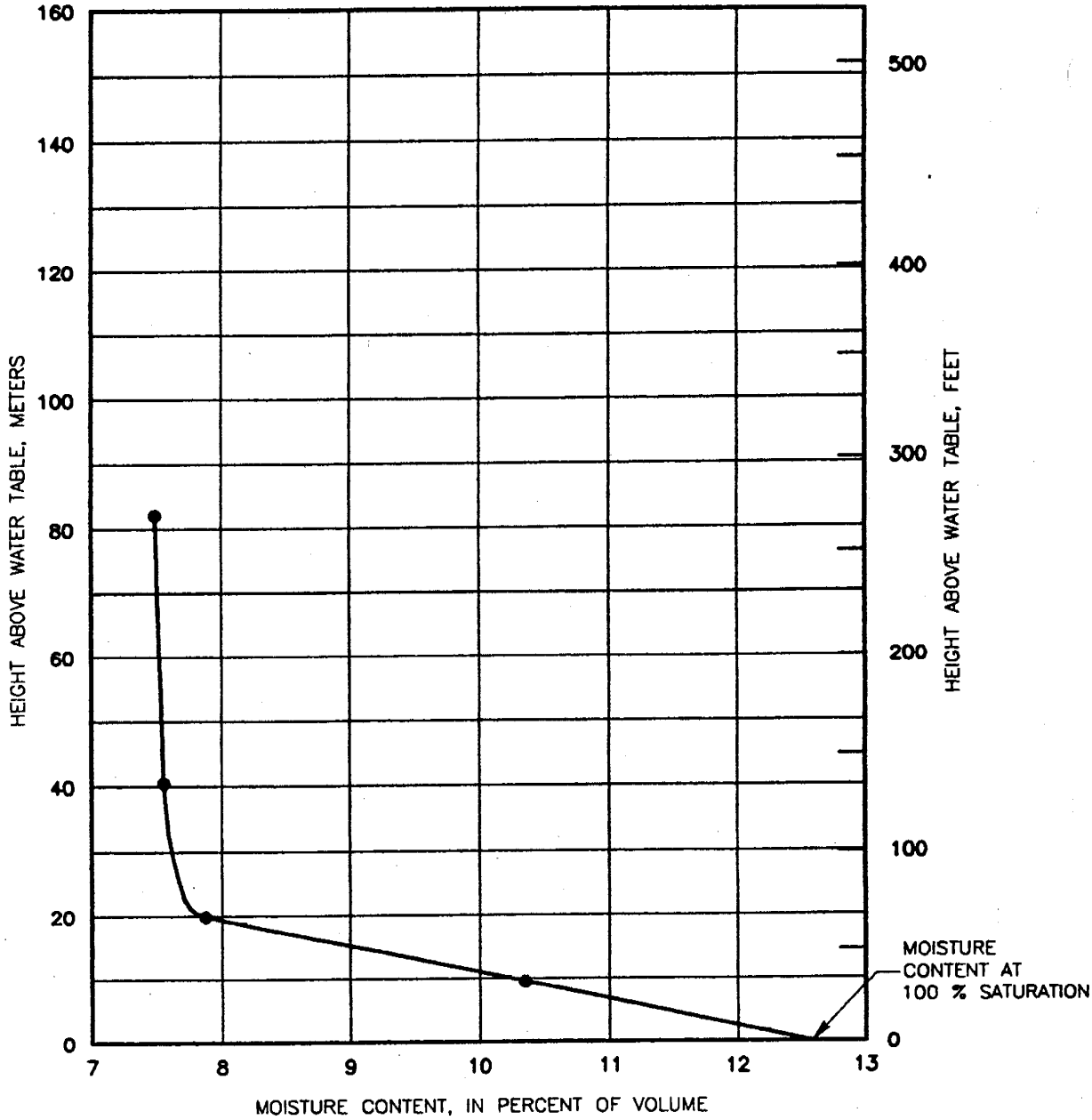
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MAF BS02 G01 D06.0*
SOILTYPE: *SAND, shell fragments, slightly gravely, tan*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*7.40*	*9.03*
2	*20.67*	*4.48*	*5.47*
4	*41.33*	*2.93*	*3.54*
8	*82.66*	*1.77*	*2.05*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M11 BS01 G01 D02.0*
SOILTYPE: *SAND, shell & coral fragments, organics, light brown*
SAMPLE TYPE: *Remolded*

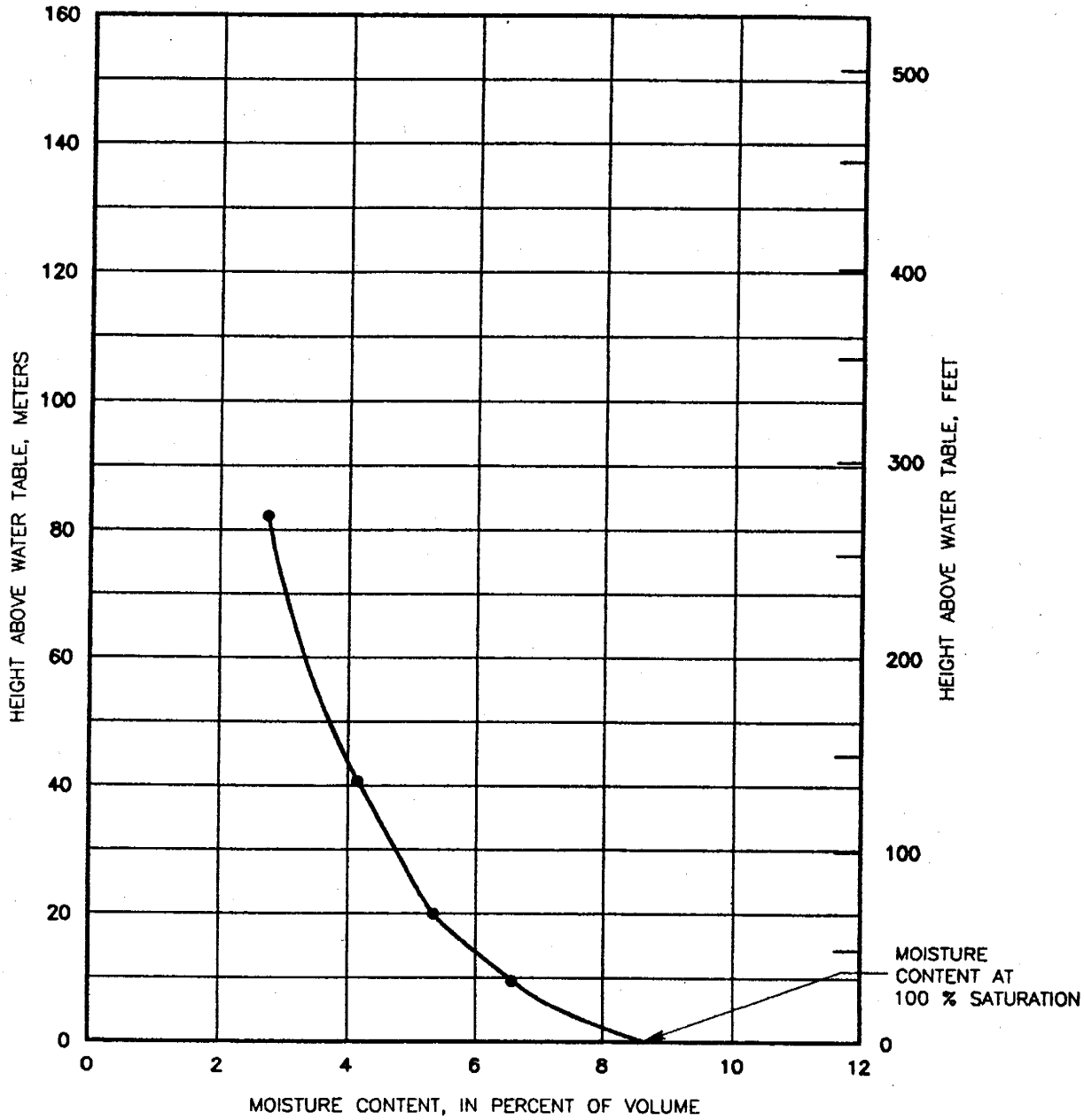
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*8.49*	*10.36*
2	*20.67*	*6.35*	*7.89*
4	*41.33*	*6.22*	*7.55*
8	*82.66*	*6.17*	*7.49*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

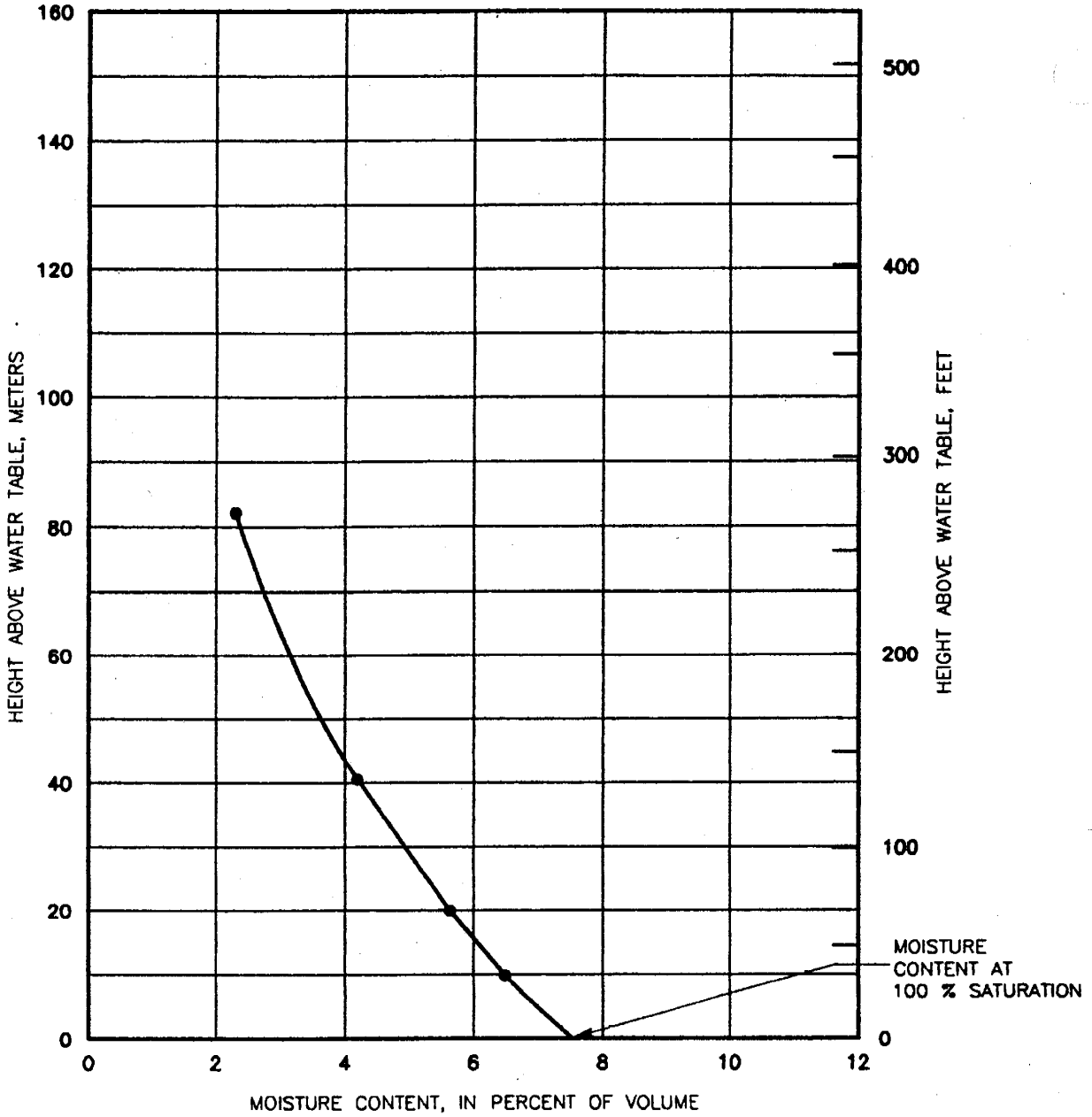
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M11 BS03 G01 D02.5*
SOILTYPE: *SAND, shell & coral fragments, organics, light gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.34*	*6.56*
2	*20.67*	*4.32*	*5.38*
4	*41.33*	*3.37*	*4.14*
8	*82.66*	*2.26*	*2.77*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MSB BS02 G01 D04.0*
SOILTYPE: *SAND, shell & coral fragments, organics, light gray*
SAMPLE TYPE: *Remolded*

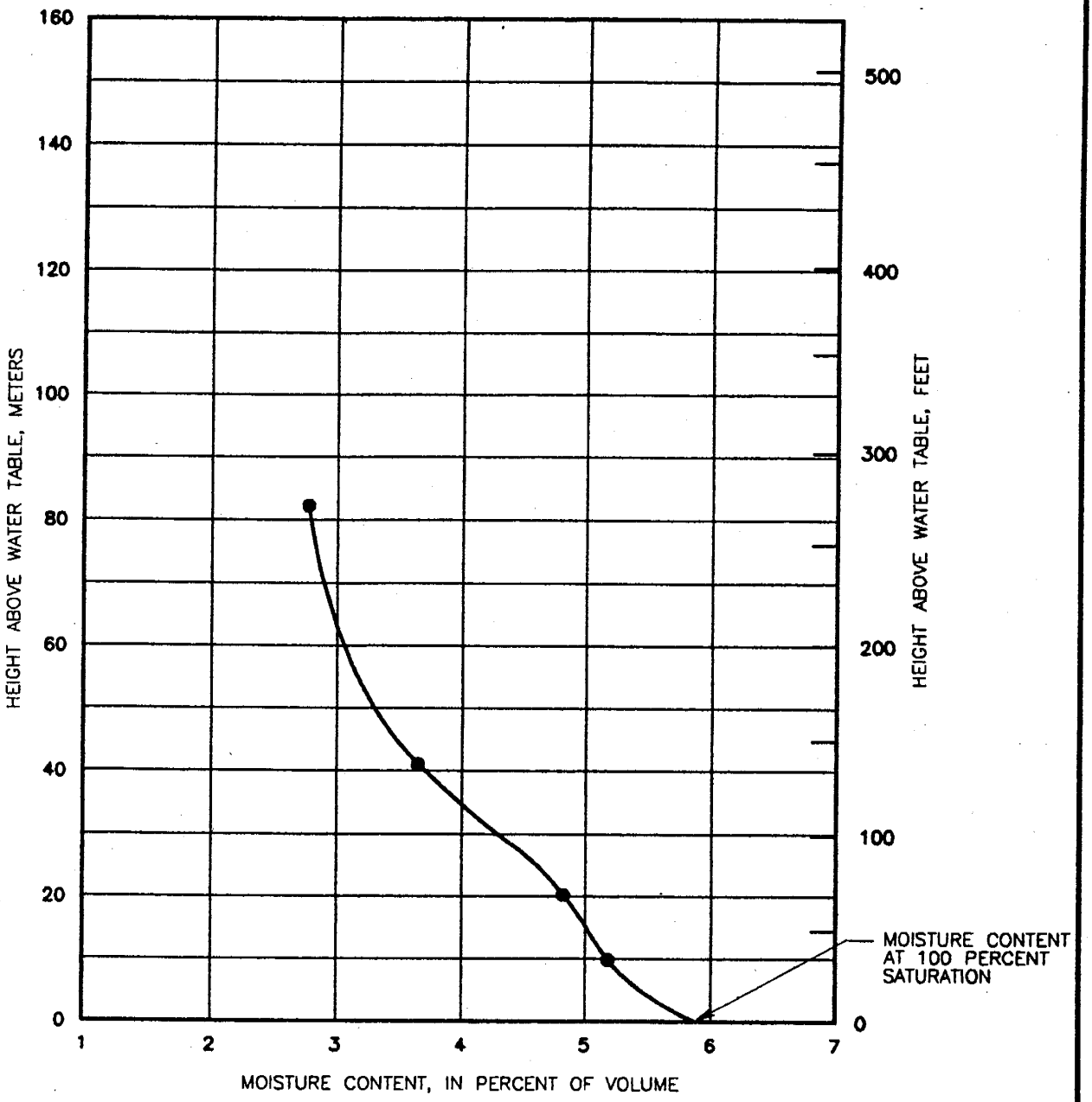
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.32*	*6.43*
2	*20.67*	*4.55*	*5.62*
4	*41.33*	*3.41*	*4.19*
8	*82.66*	*1.86*	*2.27*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

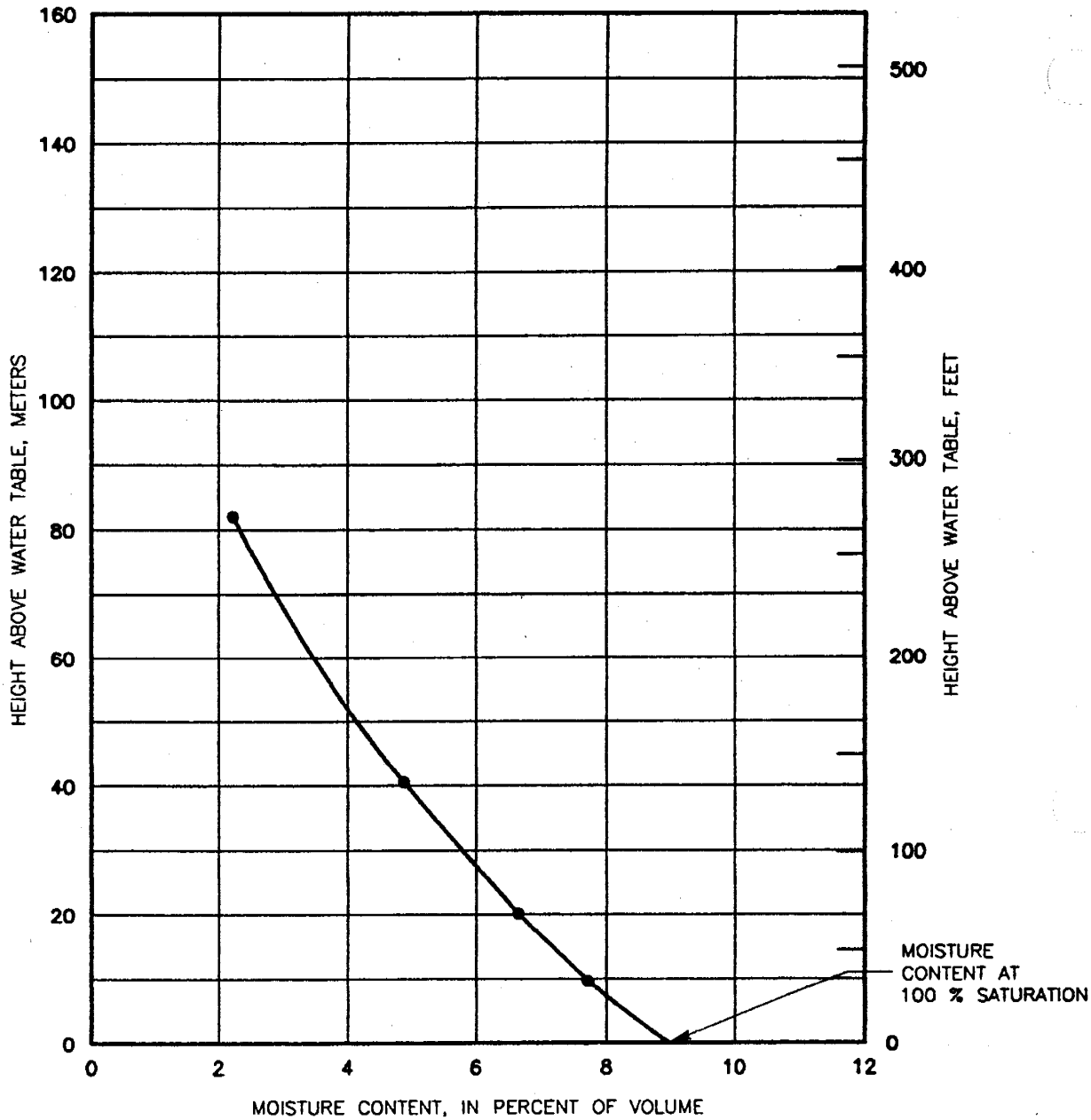
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MSB BS01 G01 D04.0*
SOILTYPE: *SAND, slightly organic, pebbles, very light brown, mottled black*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*4.59*	*5.17*
2	*20.67*	*3.99*	*4.84*
4	*41.33*	*3.03*	*3.65*
8	*82.66*	*2.40*	*2.76*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MSB BS04 G01 D02.5*
SOILTYPE: *SAND, pebbles, slightly organic, tan*
SAMPLE TYPE: *Remolded*

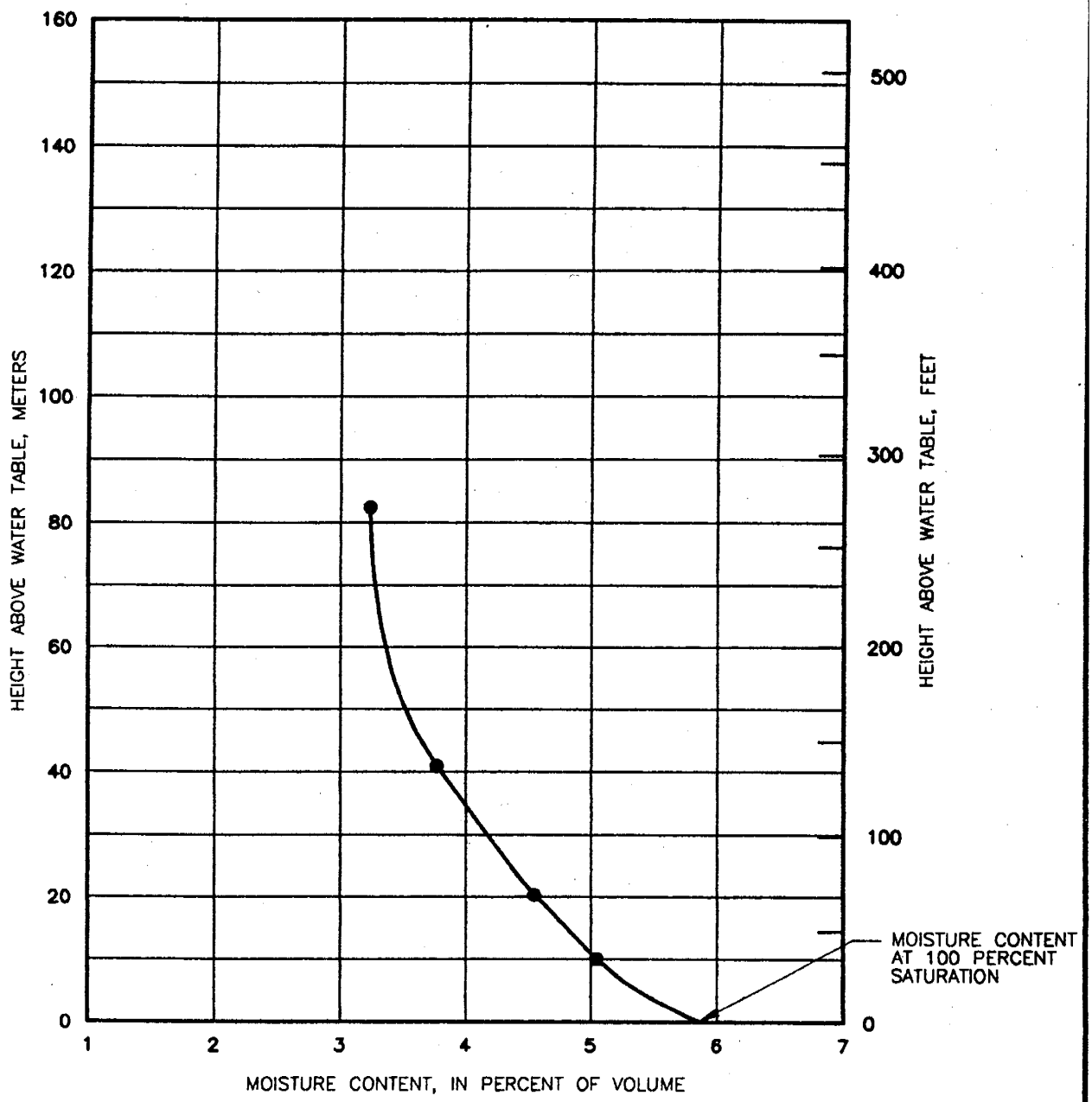
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*6.37*	*7.74*
2	*20.67*	*5.32*	*6.61*
4	*41.33*	*4.01*	*4.93*
8	*82.66*	*1.82*	*2.22*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

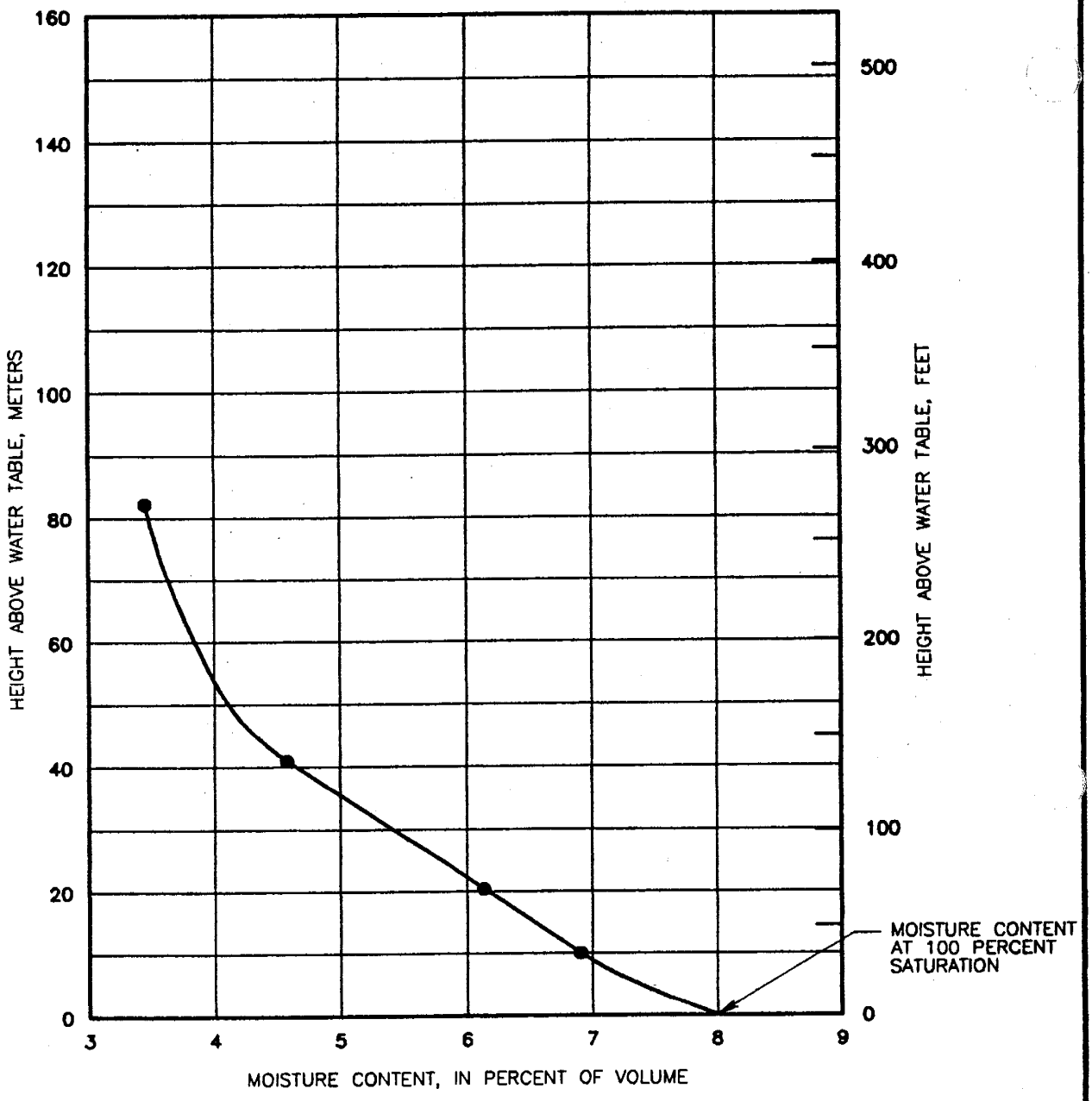
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *MSB BS05 G01 D03.5*
SOILTYPE: *SAND, very light gray, mottled black*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*4.07*	*5.03*
2	*20.67*	*3.72*	*4.58*
4	*41.33*	*3.05*	*3.75*
8	*82.66*	*2.86*	*3.23*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M02 BS01 G01 D02.0*

SOILTYPE: *SAND, pebbles, slightly organic, light brown, mottled black*

SAMPLE TYPE: *Remolded*

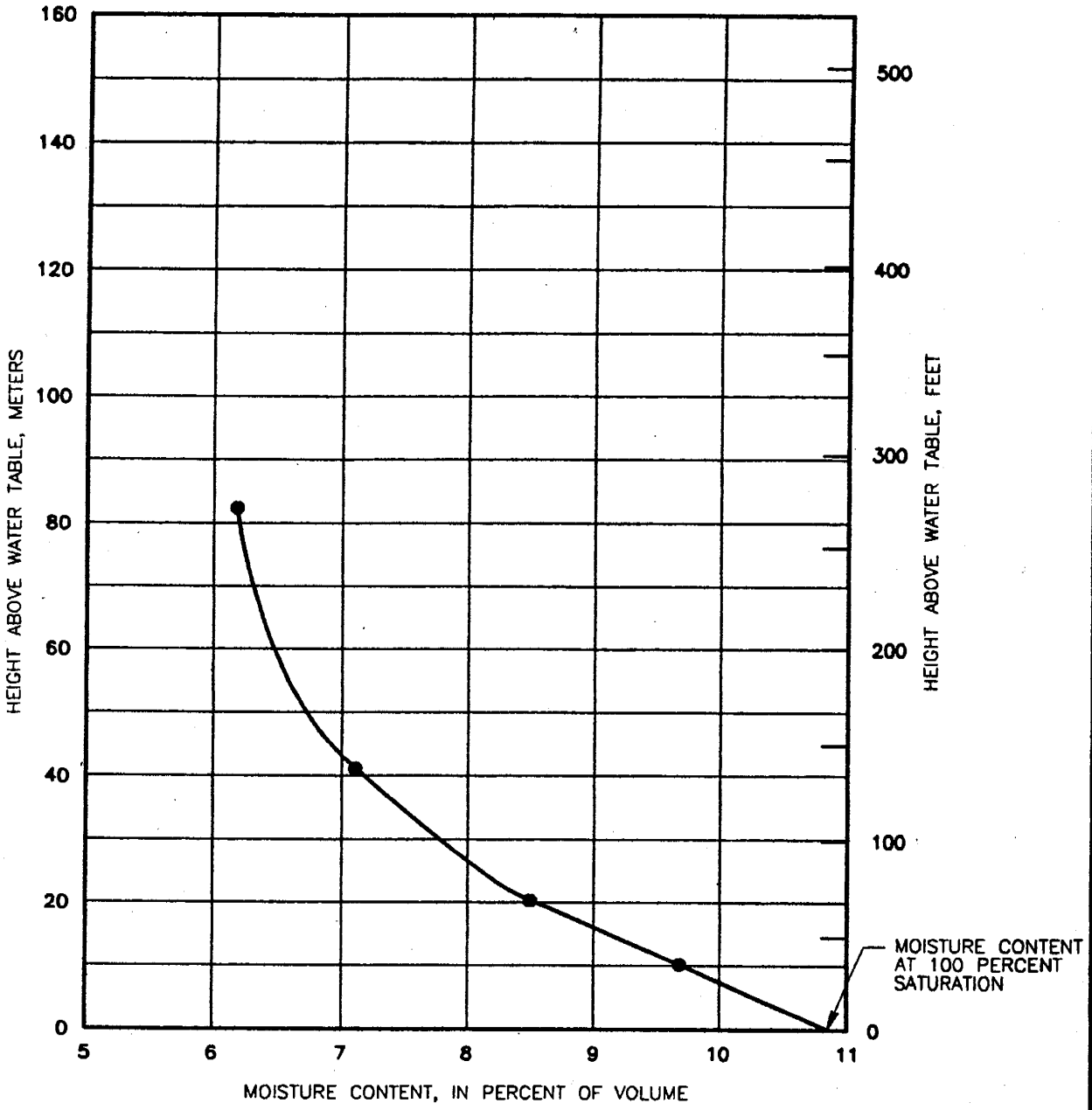
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.69*	*6.89*
2	*20.67*	*5.10*	*6.16*
4	*41.33*	*3.90*	*4.59*
8	*82.66*	*3.09*	*3.46*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

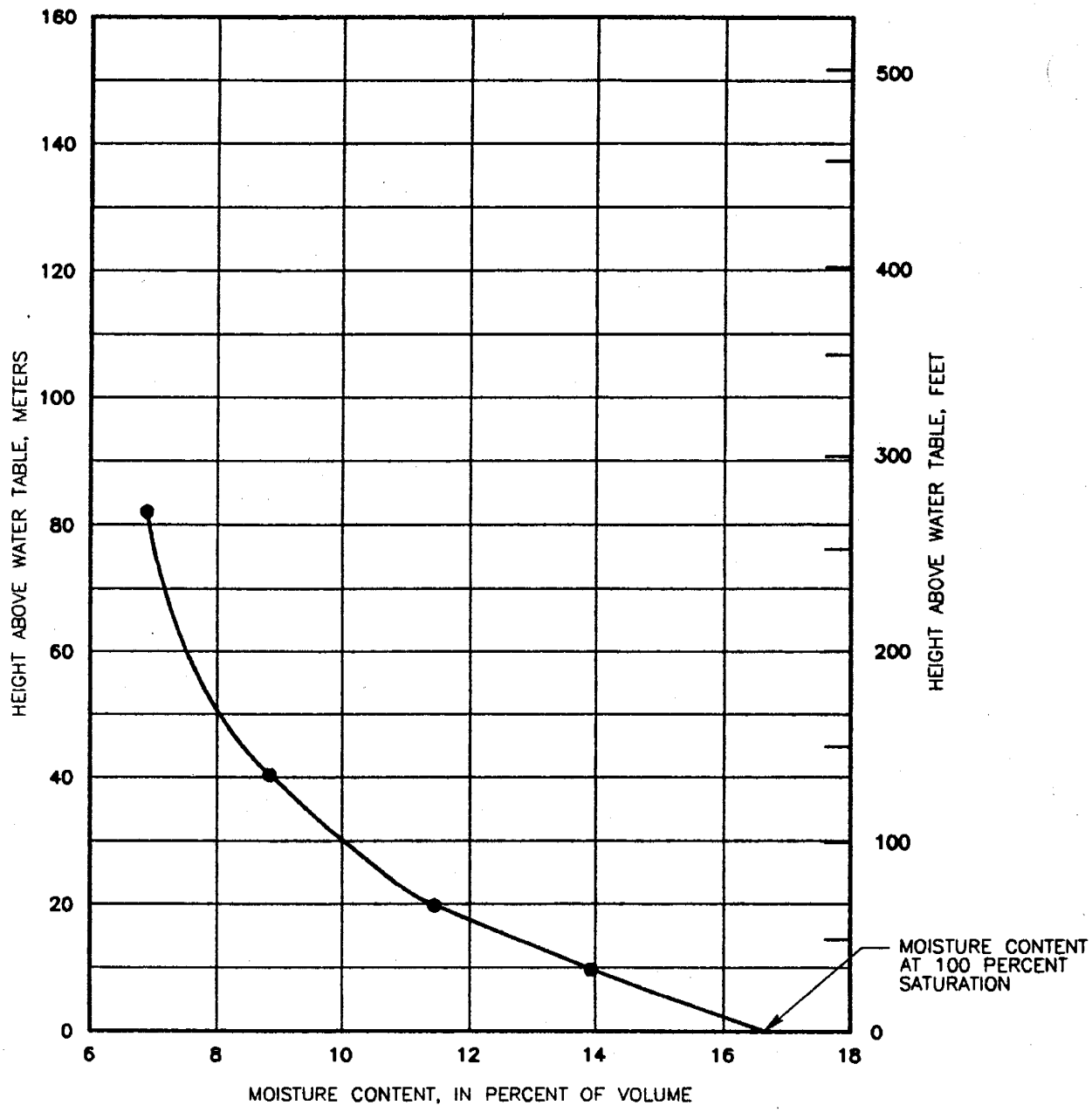
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M02 BS02 G01 D01.0*
SOILTYPE: *SAND, pebbles, light brown to gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*7.90*	*9.71*
2	*20.67*	*7.13*	*8.52*
4	*41.33*	*5.84*	*7.10*
8	*82.66*	*5.17*	*6.20*

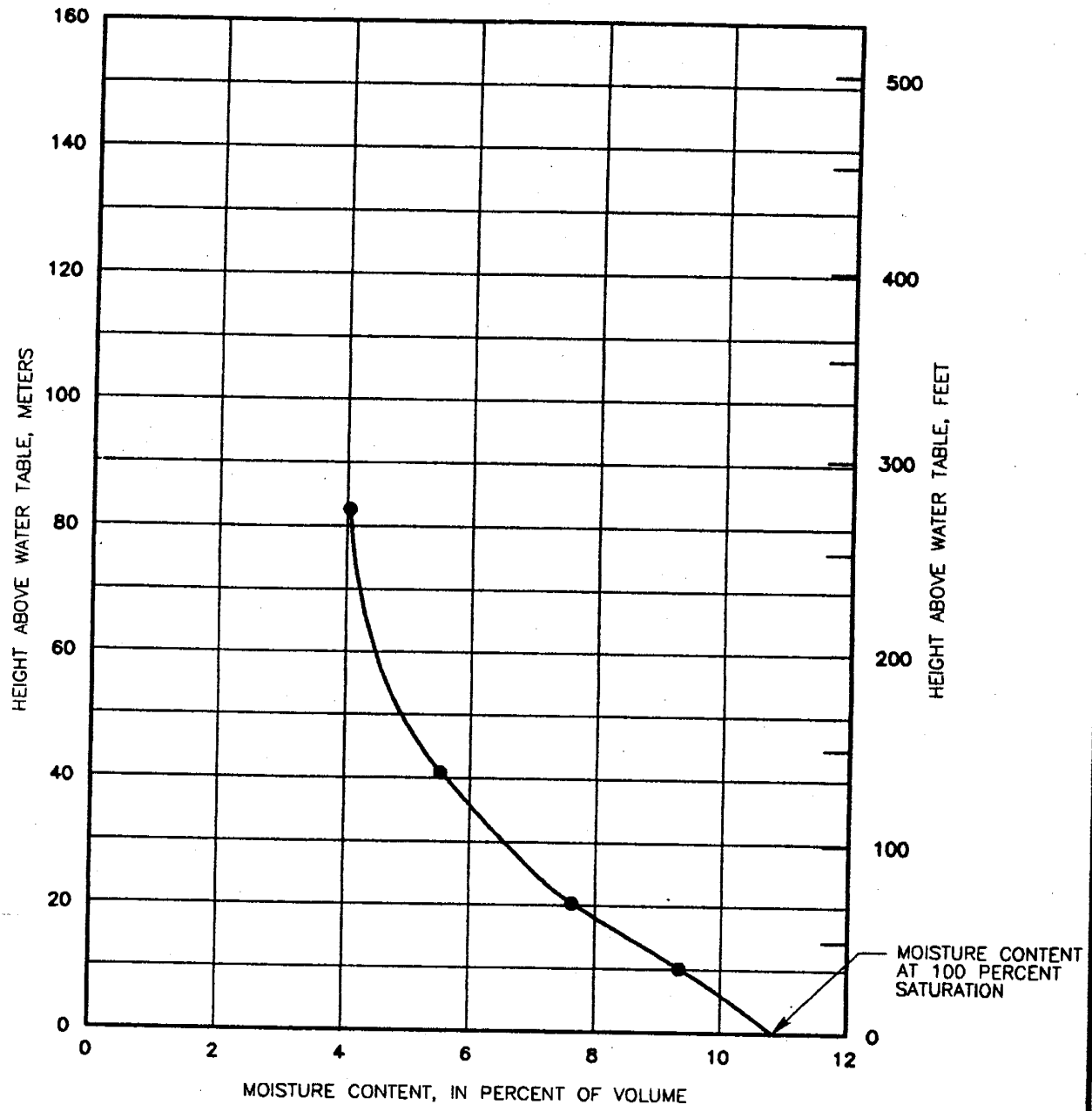
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M02 BS03 G01 D01.0*
SOILTYPE: *SAND, slightly organic, pebbles, tan, mottled black*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*11.37*	*13.91*
2	*20.67*	*9.29*	*11.48*
4	*41.33*	*7.41*	*8.93*
8	*82.66*	*5.71*	*6.80*

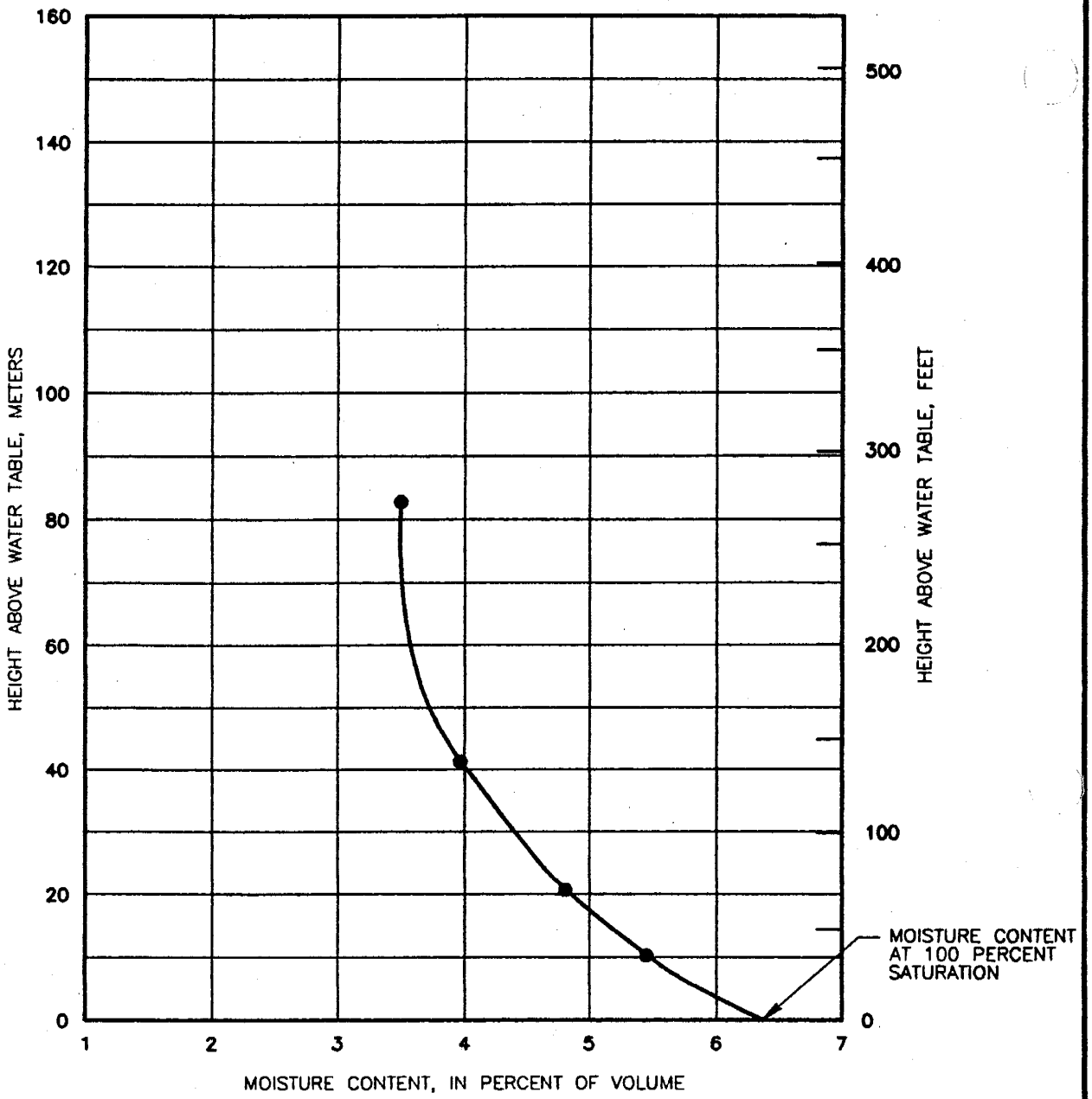
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M02 BS04 G01 D01.5*
SOILTYPE: *SAND, pebbles, slightly organic, tan, mottled black*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*7.64*	*9.38*
2	*20.67*	*6.24*	*7.69*
4	*41.33*	*4.51*	*5.53*
8	*82.66*	*3.43*	*4.08*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



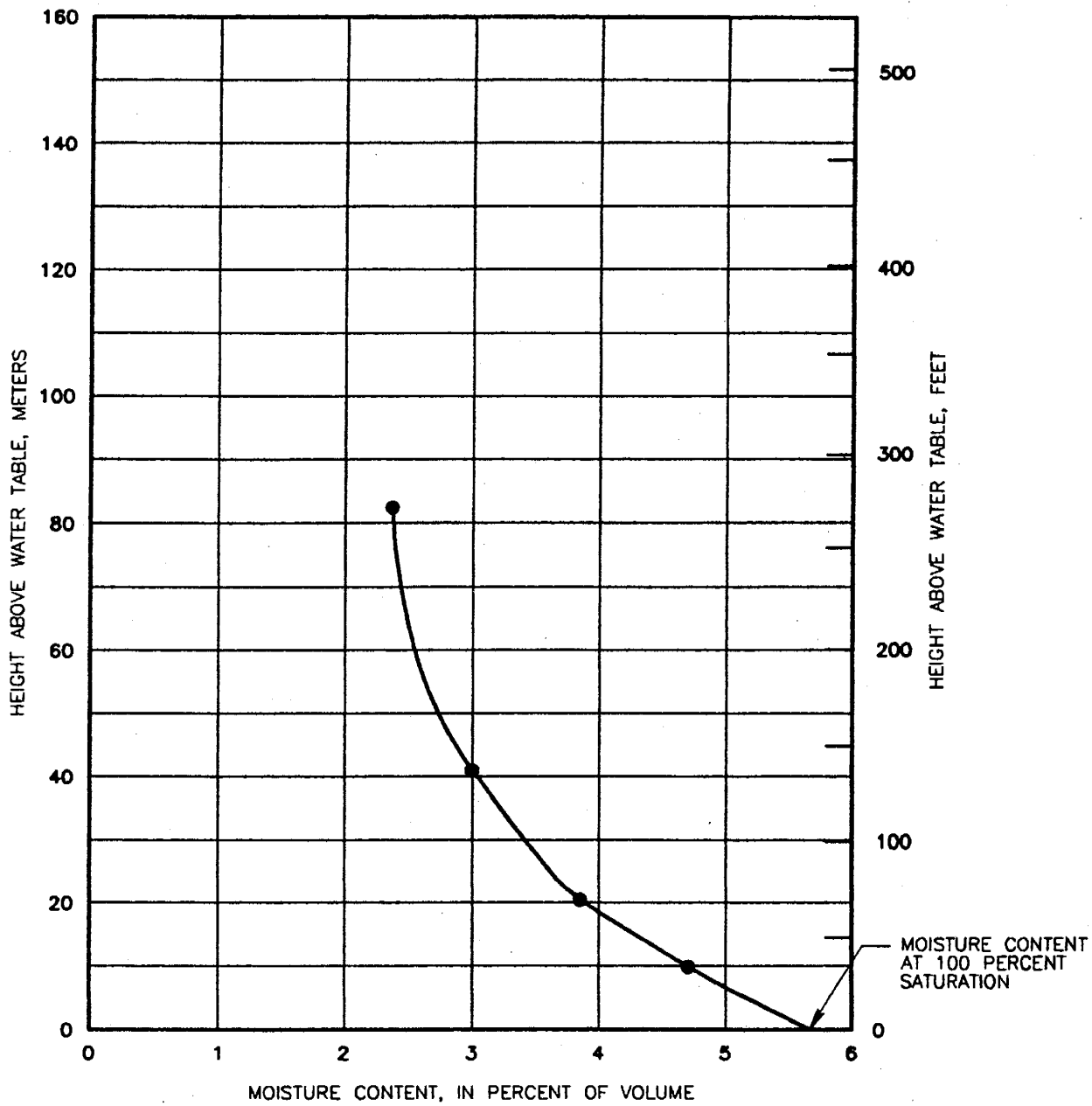
SAMPLE ID: *M08 BS01 G01 D02.0*
SOILTYPE: *SAND, pebbles, shell fragments, tan, mottled black*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*4.53*	*5.43*
2	*20.67*	*4.06*	*4.87*
4	*41.33*	*3.29*	*3.99*
8	*82.66*	*3.13*	*3.47*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

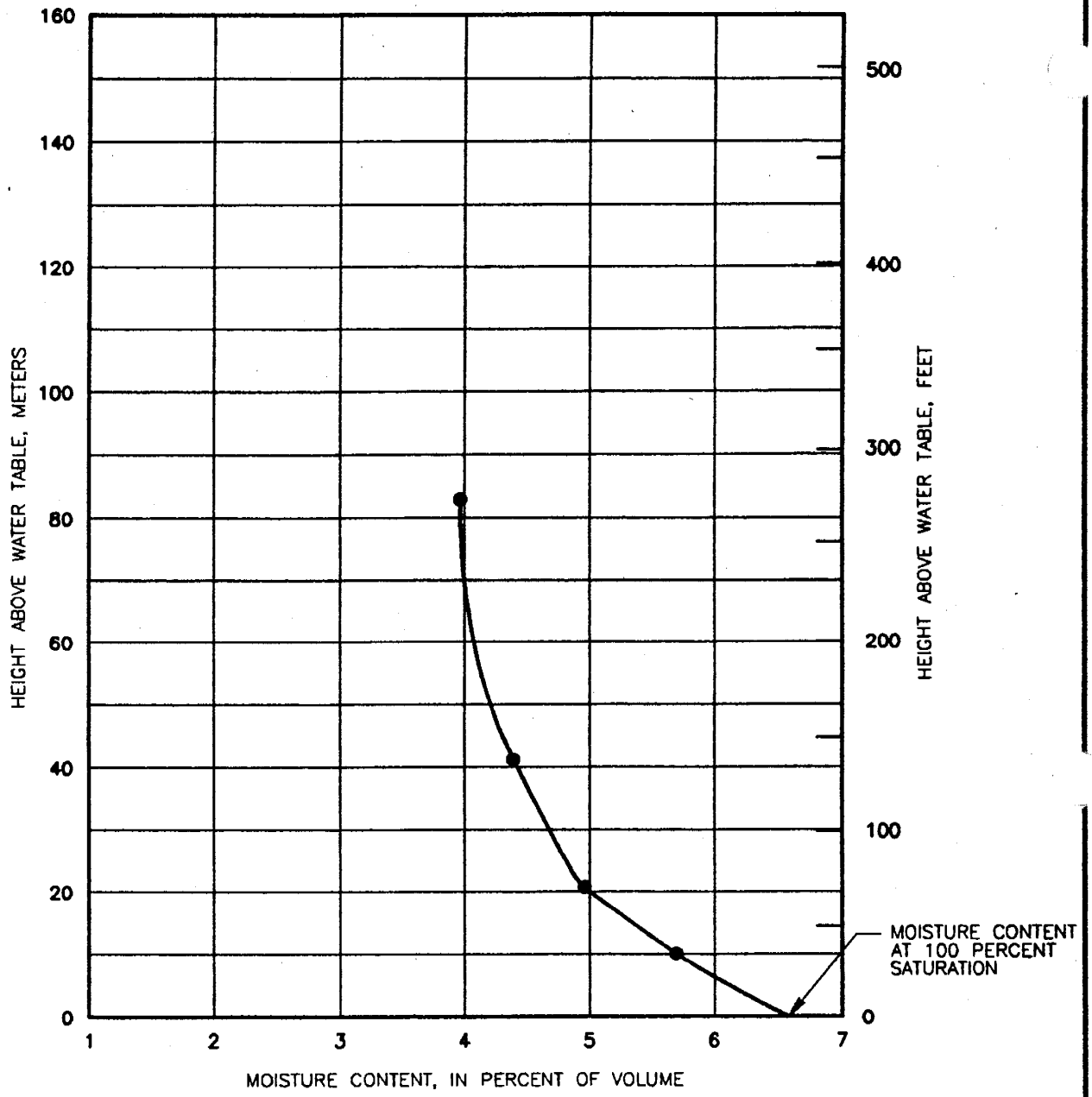
CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M08 B03 G01 D04.0*
SOILTYPE: *SAND, pebbles, tan, mottled gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*3.90*	*4.73*
2	*20.67*	*3.18*	*3.85*
4	*41.33*	*2.44*	*3.00*
8	*82.66*	*2.05*	*2.40*

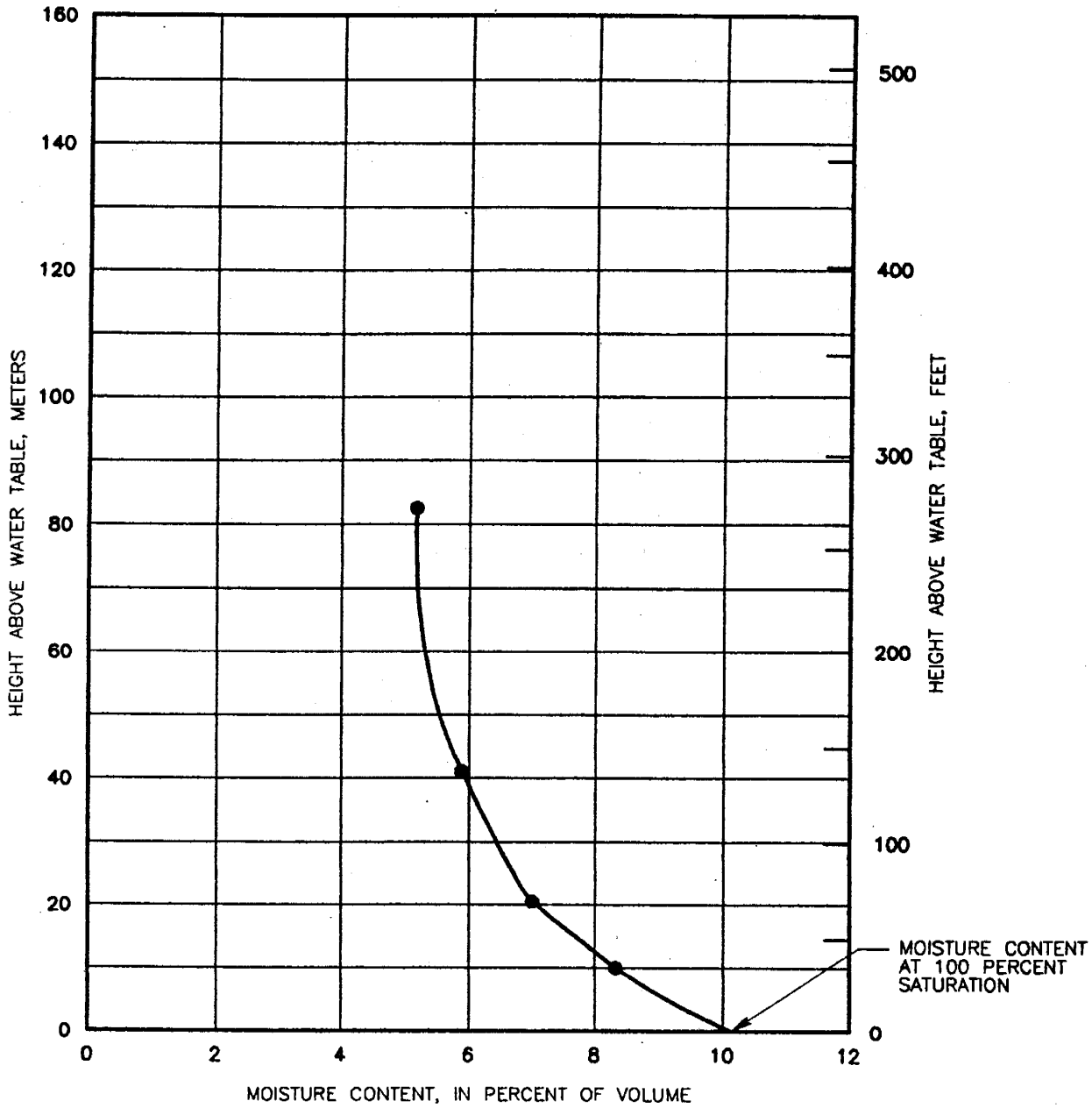
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M01 BS01 G01 D01.0*
SOILTYPE: *SAND, shell and coral fragments, organic, light gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*4.94*	*5.72*
2	*20.67*	*4.23*	*4.99*
4	*41.33*	*3.78*	*4.38*
8	*82.66*	*3.47*	*3.99*

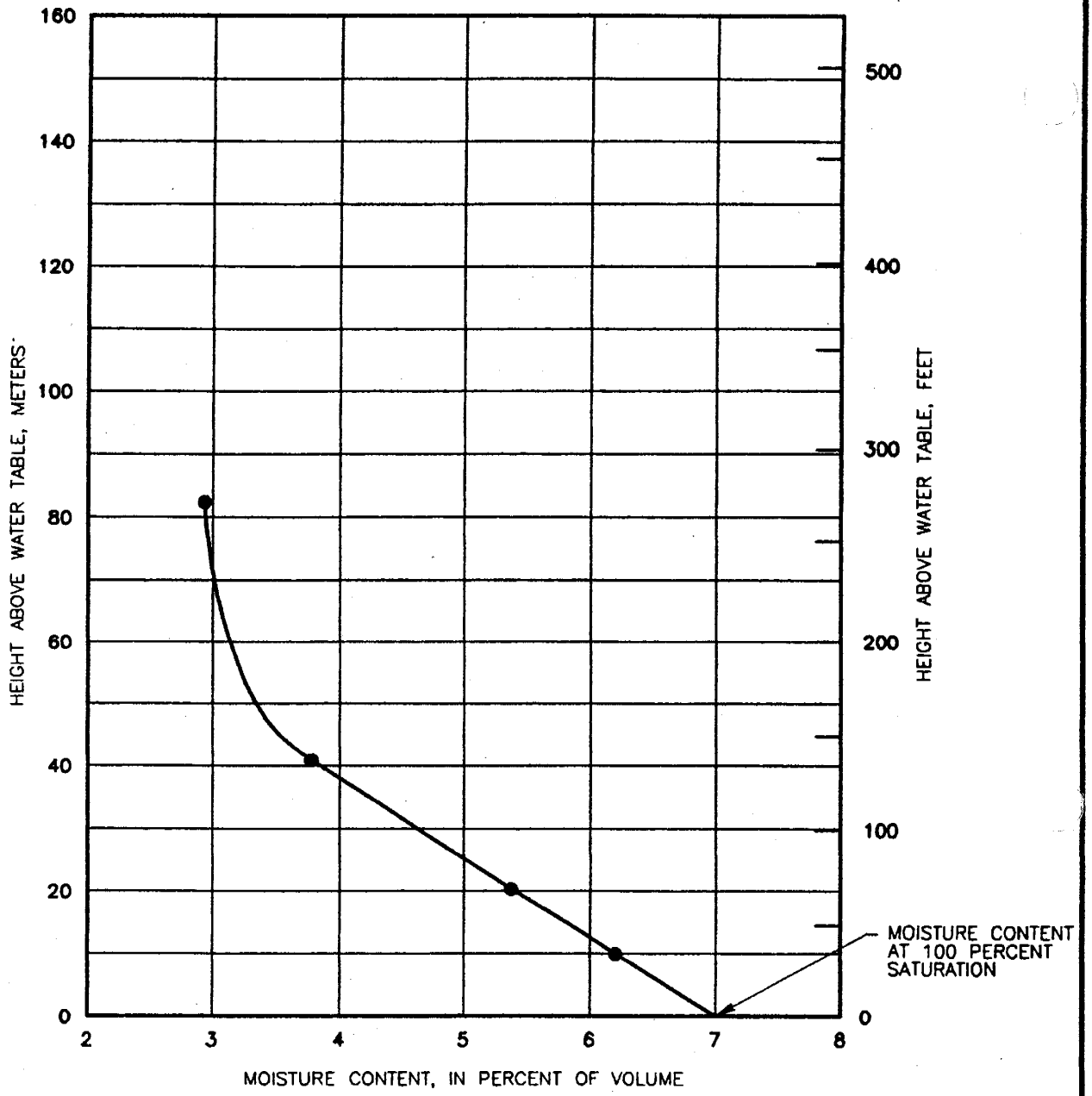
Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M01 BS02 G01 D01.5*
SOILTYPE: *SAND, shell fragments, tan to dark brown and gray*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*6.85*	*8.29*
2	*20.67*	*5.72*	*7.00*
4	*41.33*	*4.85*	*5.92*
8	*82.66*	*3.98*	*4.62*

Project No: 1-1019-0136	Project Name: Midway SI/RI (CTO 136)
OGDEN ENVIRONMENTAL AND ENERGY SERVICES 1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830	CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M01 BS04 G01 D01.0*
SOILTYPE: *SAND, shell and coral fragments, tan to dark gray*
SAMPLE TYPE: *Remolded*

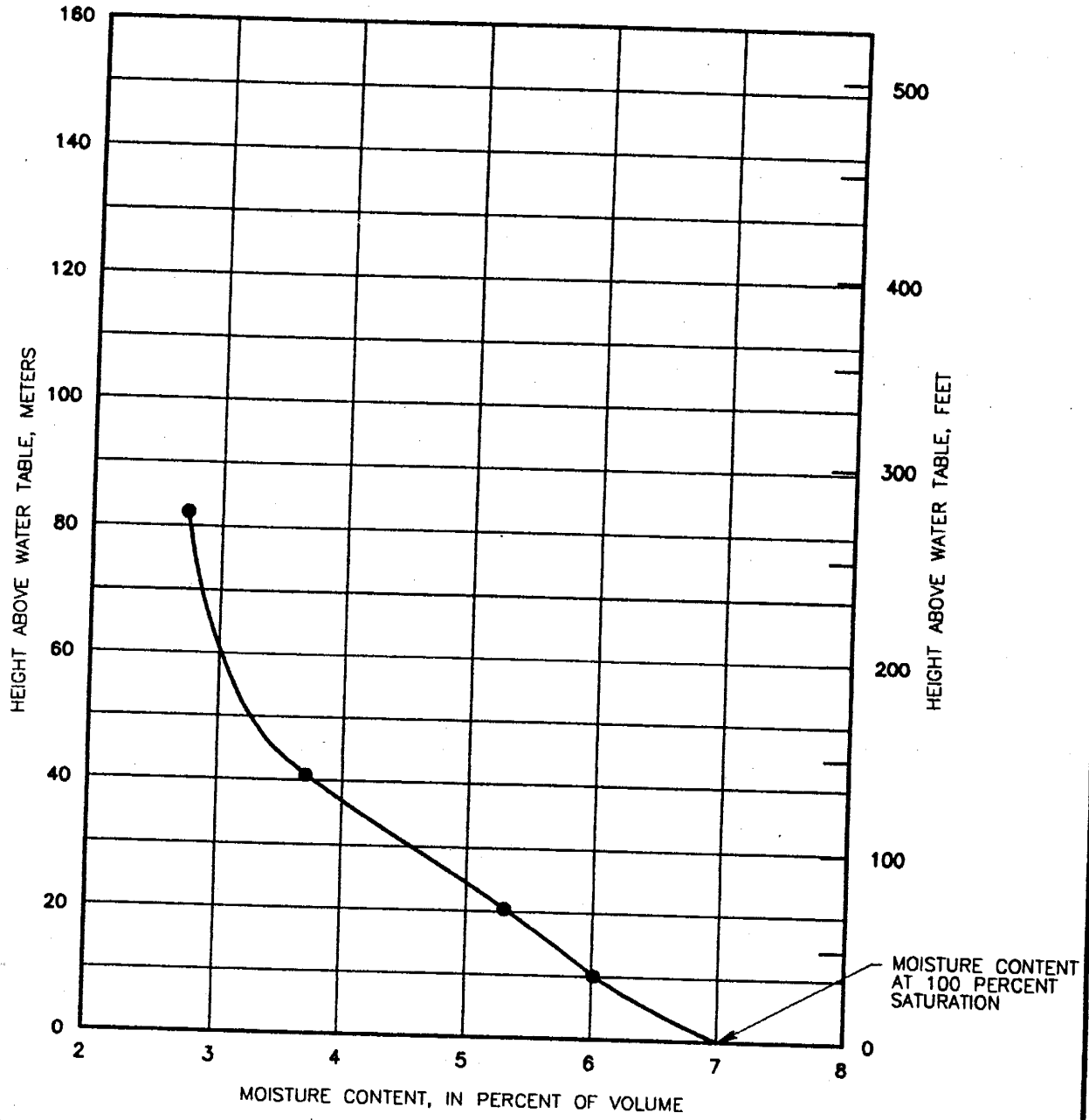
Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.34*	*6.21*
2	*20.67*	*4.58*	*5.38*
4	*41.33*	*3.24*	*3.79*
8	*82.66*	*2.44*	*2.93*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152



SAMPLE ID: *M05 BS02 G01 D07.0*
SOILTYPE: *SAND, light yellow*
SAMPLE TYPE: *Remolded*

Tension, atm	Capillary Head (meters of water)	Moisture Content (%)	Moisture Content, in percent of volume
1	*10.33*	*5.26*	*6.00*
2	*20.67*	*4.65*	*5.28*
4	*41.33*	*3.13*	*3.69*
8	*82.66*	*2.28*	*2.73*

Project No: 1-1019-0136

Project Name: Midway SI/RI (CTO 136)

OGDEN ENVIRONMENTAL AND ENERGY SERVICES
1009 COMMERCE PARK DRIVE SUITE 100 OAK RIDGE, TN 37830

CAPILLARY-MOISTURE RELATIONS OF SOILS ASTM D2325/D3152

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GA TECHNICAL SERVICES

CHAIN OF CUSTODY

DATE 12/5/94 PAGE 3 OF 3

1009 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830
(615) 481-2769 Fax (615) 481-2783

PROJECT: Midway SI/RI

PROJECT MANAGER: Jeff Cotter

CLIENT: Pacdiv

ADDRESS: Ogden EES
680 Iwi Ki Rd #660
Honolulu, HI 96817

SAMPLERS: (Signature) M. Bigelow PHONE NUMBER (808) 545-2462

ASSIGNED TESTS

SAMPLE ID	SAMPLE DATE	TIME	MATRIX	LAB ID	Moisture Content (ASTM D2216)	Atterberg Limits (ASTM D4318)	Coarse Sieve 3 in. to 200 (ASTM D422)	Coarse Sieve w/Hydrometer (ASTM D422)	Specific Gravity (ASTM D854)	Unconfined Compression (ASTM D2166)*	Triaxial-UU---CD---CU---CUw/PP...**	Proctor-Standard (ASTM D698)	Proctor-Modified (ASTM D1557)	California Bearing Ratio (ASTM D1883)	Consolidation (ASTM D2435)*	Permeability-Constant Head (ASTM D5084/EPA9100)**	Permeability-Falling Head (ASTM D5084/EPA9100)**	Gradient Ratio (ASTM D5101)	Capillary Moisture Relationship (ASTM D3152)**	ASTM 2487	ASTM 2937	TOC EPA 9060	ReDox Potential					NOTE: *Requires insitu sample (ie. Shelbytube or sleeve) **Requires insitu sample (ie. Shelbytube or sleeve) or remolding. If remold, please specify remolding criteria.	Number of Containers
M08BS01G01D02.0	11/4/94	1015	Soil		X		X	X	X								X		X	X	X	X	X						1
M08BS03G01D04.0	11/10/94	0835			X		X	X	X								X		X	X	X	X	X						1
M01BS01G01D01.0	11/18	1450			X		X	X	X								X		X	X	X	X	X						1
M01BS02G01D01.5	11/18	1440			X		X	X	X								X		X	X	X	X	X						1
M01BS04G01D01.0	11/18	1425			X		X	X	X								X		X	X	X	X	X						1
M05BS02G01D07.0	11/12	0900			X		X	X	X								X		X	X	X	X	X						1
					X		X	X	X								X		X	X	X	X	X						1

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 11019013 6	TOTAL NUMBER OF CONTAINERS	
PROJECT NAME: Midway	CHAIN OF CUSTODY SEALS Y/N/NA	
PURCHASE ORDER NUMBER:	SEALS INTACT? Y/N/NA	
VIA: Fed-ex	RECEIVED GOOD COND. Y/N	

SAMPLE DISPOSAL INSTRUCTIONS

☐ Return to Shipper ☐ Pickup

Comments: GATS will dispose of Samples

RELINQUISHED BY: 1	RELINQUISHED BY: 2	RELINQUISHED BY: 3
Signature: M. Bigelow Time: 0600	Signature: Time:	Signature: Time:
Printed Name: Bigelow Date: 12-5-94	Printed Name: Date:	Printed Name: Date:
Company: Ogden	Company:	Company:

RECEIVED BY: 1	RECEIVED BY: 2	RECEIVED BY: (LAB) 3
Signature: Time: 9:45	Signature: Time:	Signature: Time:
Printed Name: Rachel Beadline Date: 12/7	Printed Name: Date:	Printed Name: Date:
Company: OGDEN	Company:	Company

DISTRIBUTION: White, Canary - GATS; Pink - ORIGINATOR

COT

GA TECHNICAL SERVICES

CHAIN OF CUSTODY

DATE 12-5-94 PAGE 2 OF 3

1009 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830
(615) 481-2769 Fax (615) 481-2783

PROJECT: Midway SI/RI CTO136
PROJECT MANAGER: Jeff Cotter
CLIENT: PAC DIV
ADDRESS: Ogden EES
680 Iwilei Rd #660
Honolulu, HI 96817

Mark Bingham (808) 545-2462
SAMPLERS: (Signature) PHONE NUMBER

ASSIGNED TESTS

SAMPLE ID	SAMPLE DATE	TIME	MATRIX	LAB ID	Moisture Content (ASTM D2216)	Atterberg Limits (ASTM D4318)	Coarse Sieve 3 in. to 200 (ASTM D422)	Coarse Sieve w/Hydrometer (ASTM D422)	Specific Gravity (ASTM D854)	Unconfined Compression (ASTM D2166)*	Triaxial-UU---CD---CU---CUw/PP---*	Proctor-Standard (ASTM D698)	Proctor-Modified (ASTM D1557)	California Bearing Ratio (ASTM D1883)	Consolidation (ASTM D2435)*	Permeability-Constant Head (ASTM D5084/EPA9100)**	Permeability-Falling Head (ASTM D5084/EPA9100)**	Gradient Ratio (ASTM D5101)	Capillary Moisture Relationship (ASTM D3152)**	ASTM D2487	ASTM D2937	TX EPA 9060	Redox Potential					NOTE: *Requires insitu sample (ie. Shelbytube or sleeve) **Requires insitu sample (ie. Shelbytube or sleeve) or remolding. If remold, please specify remolding criteria.	Number of Containers
MSBBS02G01D04.0	11/10/94	1510	soil		X		X	X	X							X	X		X	X	X	X	X						1
MSBBS01G01D04.0	11/10	1115			X		X	X	X							X	X		X	X	X	X	X						1
MSBBS04G01D02.5	11/11	1020			X		X	X	X							X	X		X	X	X	X	X						1
MSBBS05G01D03.5	11/11	1325			X		X	X	X							X	X		X	X	X	X	X						1
M02BS01G01D02.0	11/18	1345			X		X	X	X							X	X		X	X	X	X	X						1
M02BS02G01D01.0	10/28	1400			X		X	X	X							X	X		X	X	X	X	X						1
M02BS03G01D01.0	11/18	1355			X		X	X	X							X	X		X	X	X	X	X						1
M02BS04G01D01.5	11/18	1405			X		X	X	X							X	X		X	X	X	X	X						1

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 110190136	TOTAL NUMBER OF CONTAINERS	
PROJECT NAME: Midway	CHAIN OF CUSTODY SEALS Y/N/NA	
PURCHASE ORDER NUMBER:	SEALS INTACT? Y/N/NA	
VIA: Fed-ex	RECEIVED GOOD COND. Y/N	

SAMPLE DISPOSAL INSTRUCTIONS

☐ Return to Shipper ☐ Pickup

Comments: GATS to dispose of samples

RELINQUISHED BY: 1	RELINQUISHED BY: 2	RELINQUISHED BY: 3
Signature: Bingham Time: 0600	Signature: Time:	Signature: Time:
Printed Name: M. Bingham Date: 12/5/94	Printed Name: Date:	Printed Name: Date:
Company: Ogden	Company:	Company:

RECEIVED BY: 1	RECEIVED BY: 2	RECEIVED BY:(LAB) 3
Signature: Time: 9:45	Signature: Time:	Signature: Time:
Printed Name: Rocko Bradling Date:	Printed Name: Date:	Printed Name: Date:
Company: OGDEN H/7	Company:	Company:

DISTRIBUTION: White, Canary - GATS; Pink - ORIGINATOR

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GA TECHNICAL SERVICES

CHAIN OF CUSTODY

DATE 12-5-94 PAGE 1 OF 3

1009 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830
(615) 481-2769 Fax (615) 481-2783

PROJECT: MIDWAY S1/R1 CTO136

PROJECT MANAGER: JEFF COTTER

CLIENT: PACDIV

ADDRESS: OGDEN HONOLULU
680 IWILEI RD STE 660
HONOLULU HI 96817

Mark Bigelow — SAMPLERS: (Signature)
(808) 545-2462 — PHONE NUMBER

SAMPLE ID	SAMPLE DATE	TIME	MATRIX	LAB ID
M54BS02G01D05.5	10/31/94	1020	Soil	
M54BS01G01D01.5	11/19/94	0825		
M10BS01G01D04.5	10/24	1245		
M10BS02G01D01.5	11/19	0800		
MAFBS01G01D02.0	11/19	0855		
MAFBS02G01D06.0	11/3	0900		
M11BS01G01D02.0	11/19	0920		
M11BS03G01D02.5	11/2	1625		

ASSIGNED TESTS

SAMPLE ID	Moisture Content (ASTM D2216)	Atterberg Limits (ASTM D4318)	Coarse Sieve 3 in. to 200 (ASTM D422)	Coarse Sieve w/Hydrometer (ASTM D422)	Specific Gravity (ASTM D854) Porosity	Unconfined Compression (ASTM D2166)*	Triaxial-UU---CD---CU---CUw/PP...**	Proctor-Standard (ASTM D698)	Proctor-Modified (ASTM D1557)	California Bearing Ratio (ASTM D1883)	Consolidation (ASTM D2435)*	Permeability-Constant Head (ASTM D5084/EPA9100)**	Permeability-Falling Head (ASTM D5084/EPA9100)**	Gradient Ratio (ASTM D5101)	Capillary Moisture Relationship (ASTM D3152)**	SOIL CLASSIFICATION (ASTM D2487)	BULK DENSITY (ASTM D2937)	TOC (EPA Method 9060)	~~[illegible]~~	REDOX POTENTIAL (ASTM D1498-76)					NOTE: *Requires insitu sample (ie. Shelbytube or sleeve) **Requires insitu sample (ie. Shelbytube or sleeve) or remolding. If remold, please specify remolding criteria.	Number of Containers
M54BS02G01D05.5	X		X	X	X								X		X	X	X	X	X	X						1
M54BS01G01D01.5	X		X	X	X								X		X	X	X	X		X						1
M10BS01G01D04.5	X		X	X	X								X		X	X	X	X		X						1
M10BS02G01D01.5	X		X	X	X								X		X	X	X	X		X						1
MAFBS01G01D02.0	X		X	X	X								X		X	X	X	X		X						1
MAFBS02G01D06.0	X		X	X	X								X		X	X	X	X		X						1
M11BS01G01D02.0	X		X	X	X								X		X	X	X	X		X						1
M11BS03G01D02.5	X		X	X	X								X		X	X	X	X		X						1

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT NUMBER: 110190136	TOTAL NUMBER OF CONTAINERS	
PROJECT NAME: Midway	CHAIN OF CUSTODY SEALS Y/N/NA	
PURCHASE ORDER NUMBER:	SEALS INTACT? Y/N/NA	
VIA: Fed-ex	RECEIVED GOOD COND. Y/N	

SAMPLE DISPOSAL INSTRUCTIONS

☐ Return to Shipper ☐ Pickup

Comments: GATS will dispose of samples

RELINQUISHED BY: 1	RELINQUISHED BY: 2	RELINQUISHED BY: 3
Signature: Mark B. Time: 0600	Signature: Time:	Signature: Time:
Printed Name: Mark Bigelow Date: 12/5/94	Printed Name: Date:	Printed Name: Date:
Company: Ogden	Company:	Company:
RECEIVED BY: 1	**RECEIVED BY: 2**	**RECEIVED BY:(LAB) 3**
Signature: Time: 9:45A	Signature: Time:	Signature: Time:
Printed Name: Rachel Beadling Date: 12/7	Printed Name: Date:	Printed Name: Date:
Company: OGDEN	Company:	Company:

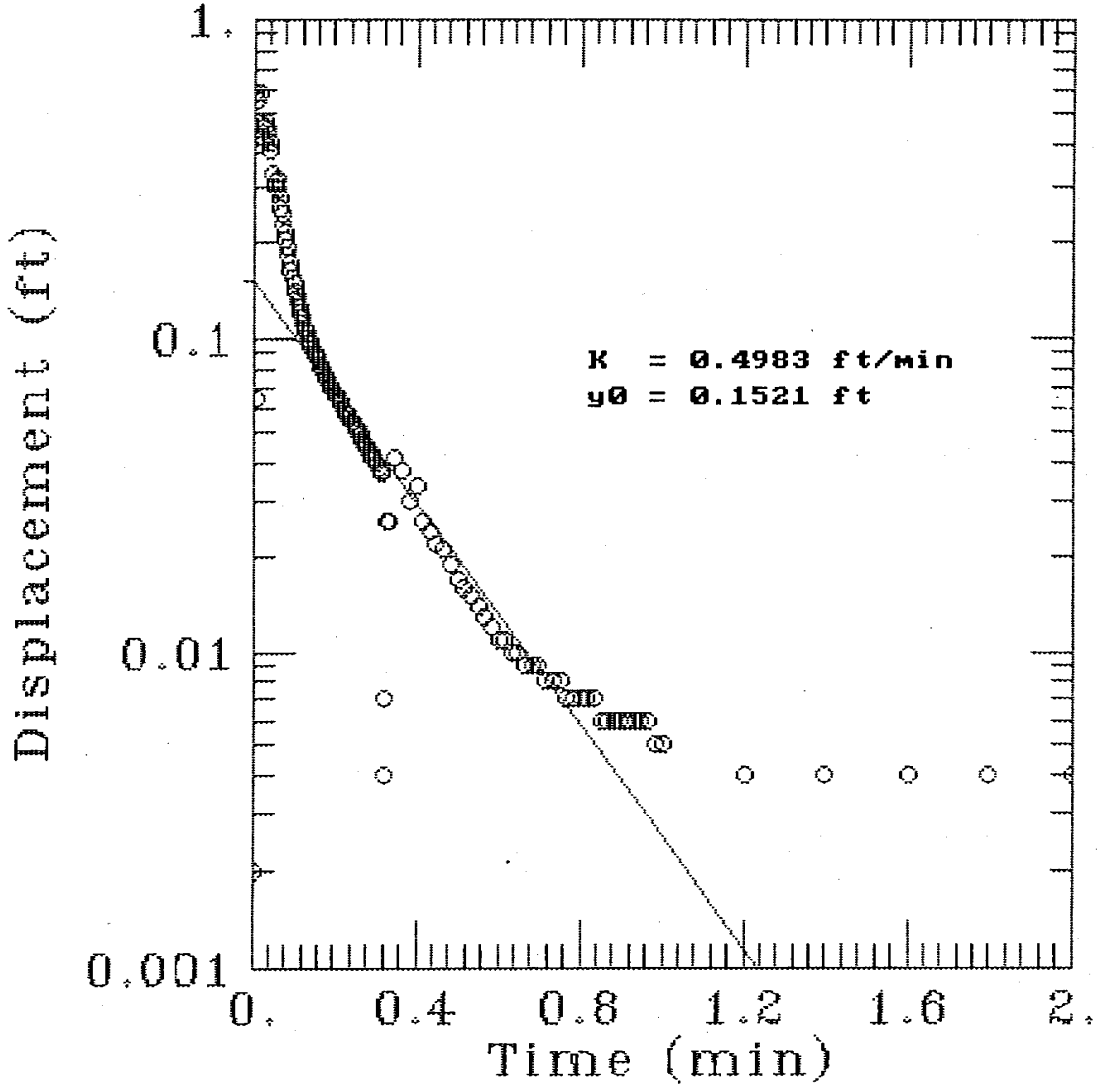
DISTRIBUTION: White, Canary - GATS; Pink - ORIGINATOR

Appendix H

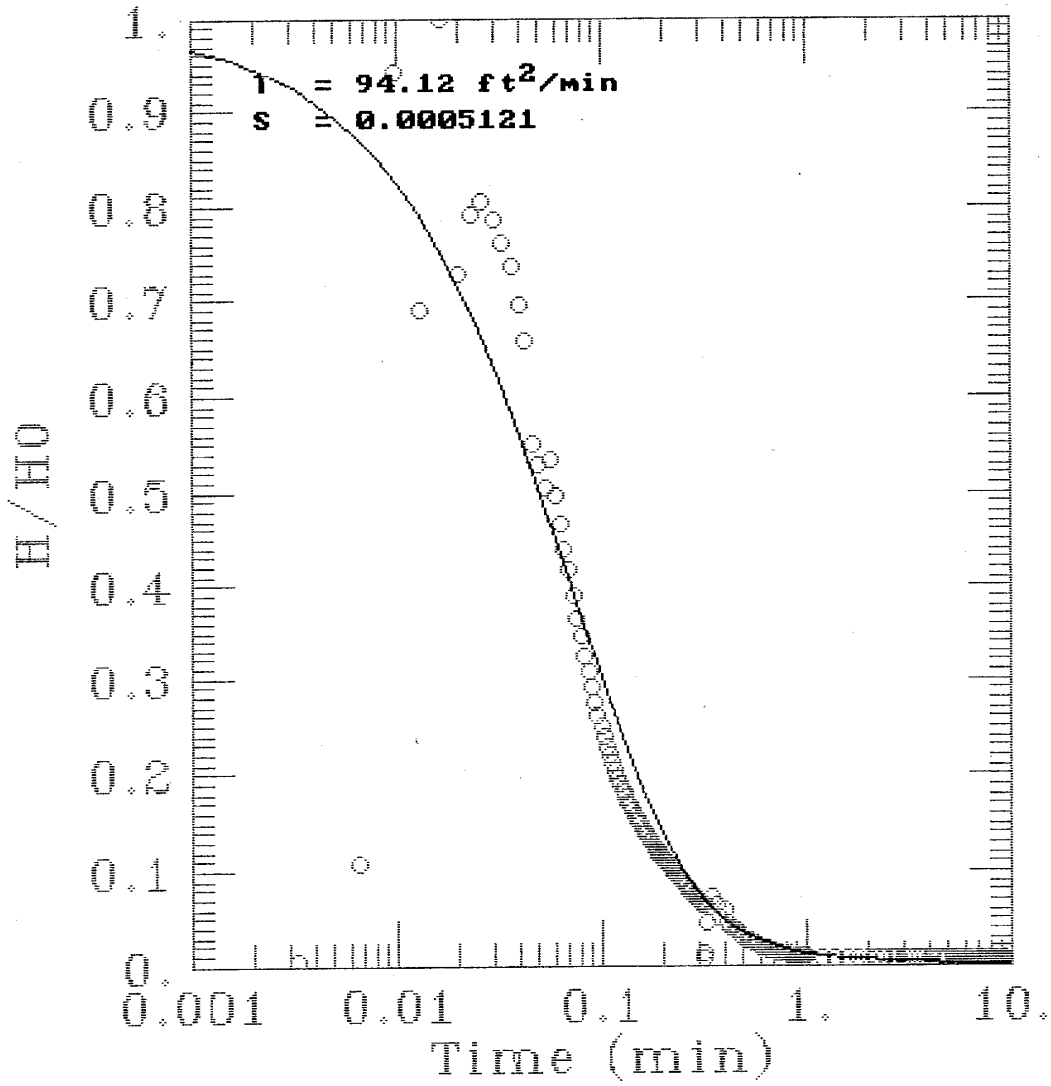
APPENDIX H

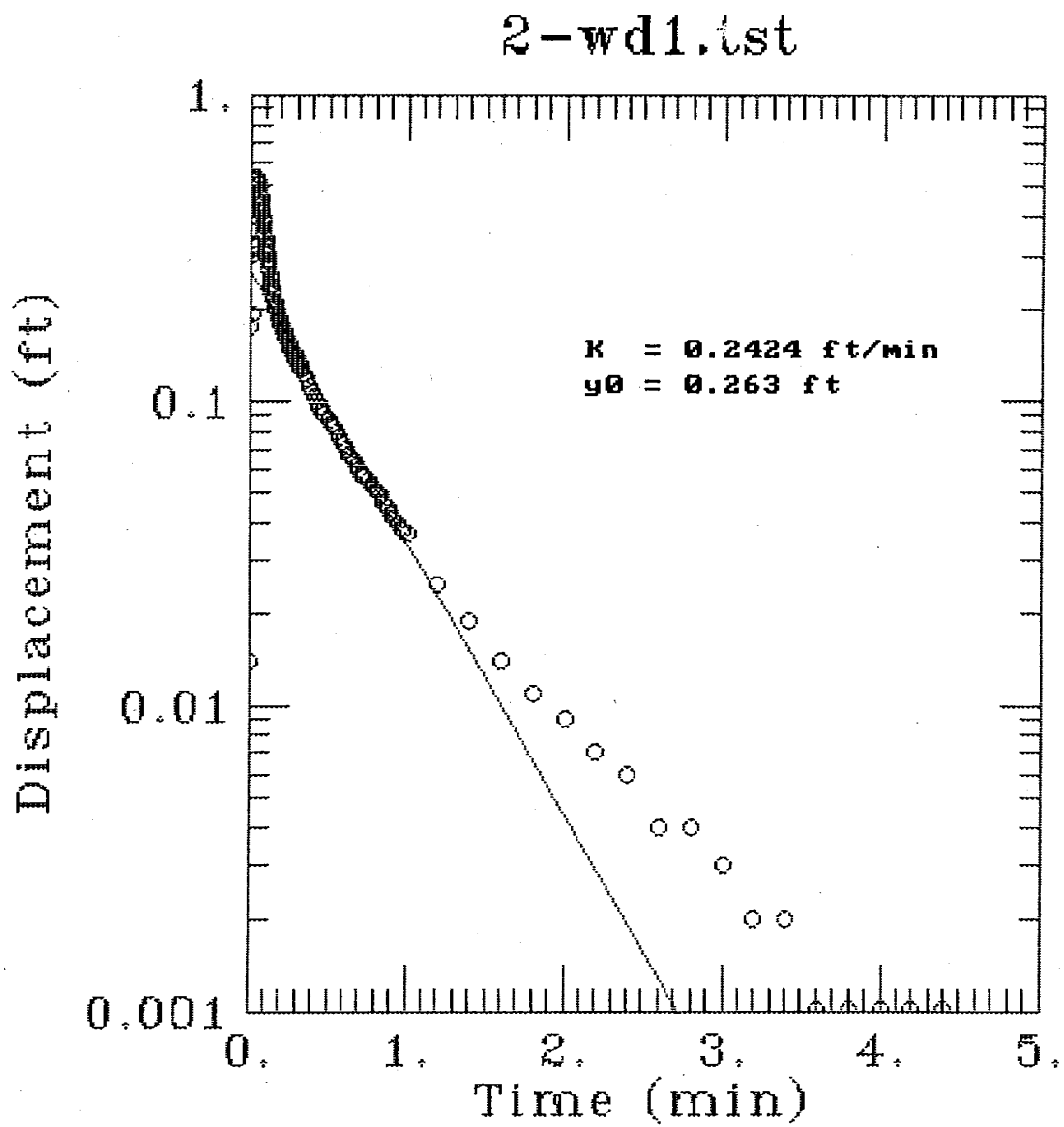
SLUG TEST ANALYSIS

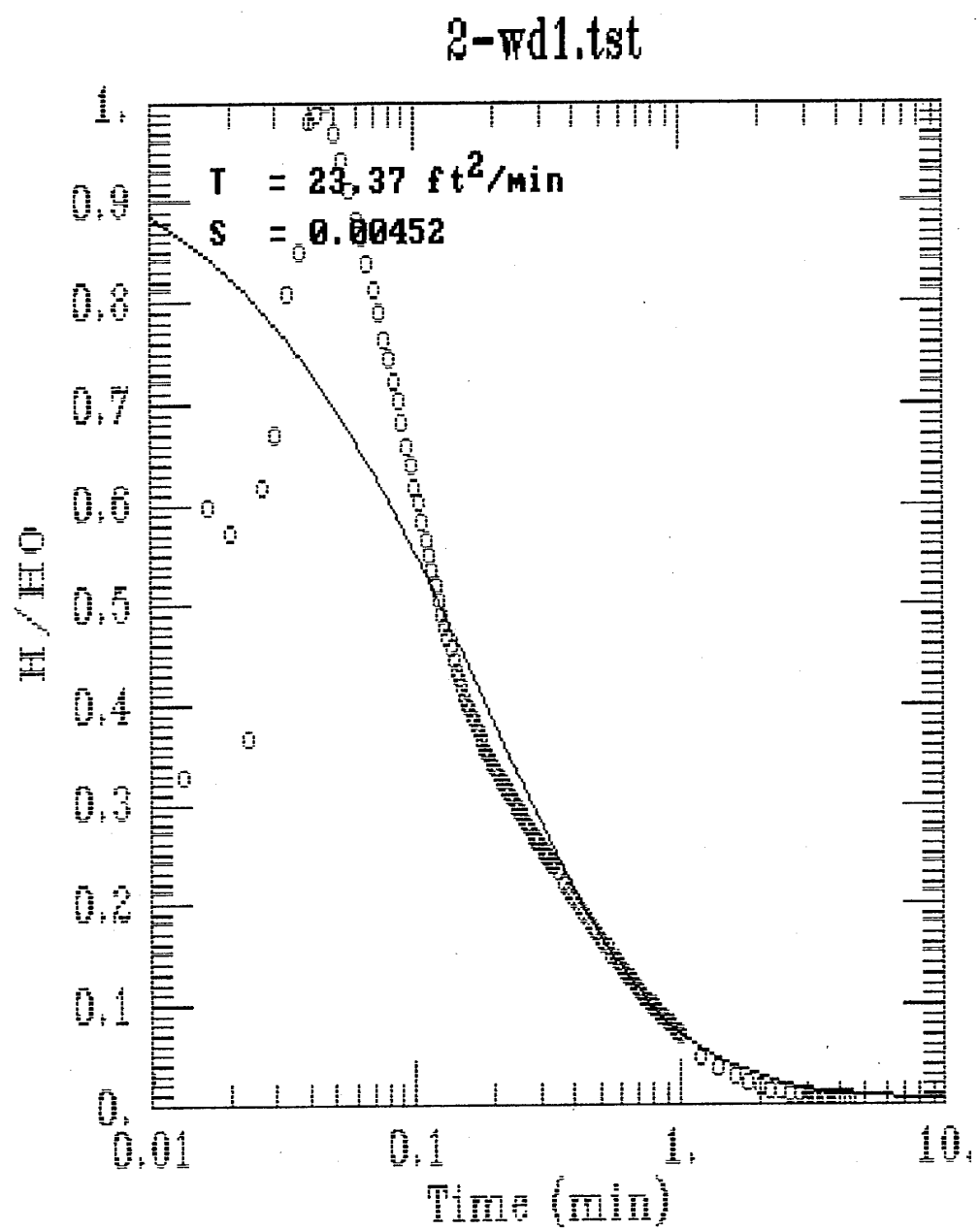
1-wd1.tst

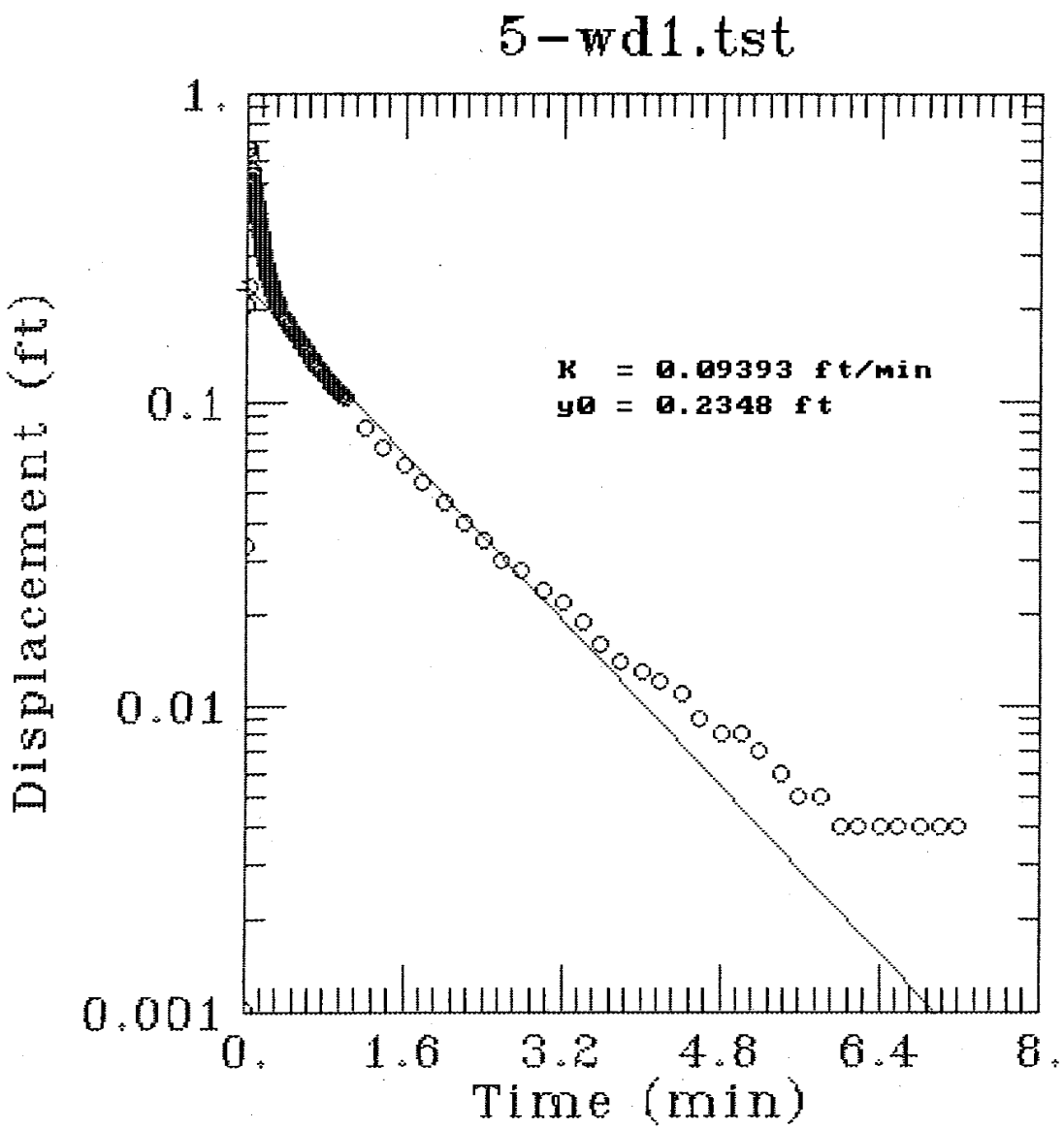

K = 0.4983 ft/min
y0 = 0.1521 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.4
0.8
1.2
1.6
2.
Time (min)

1-wd1.tst

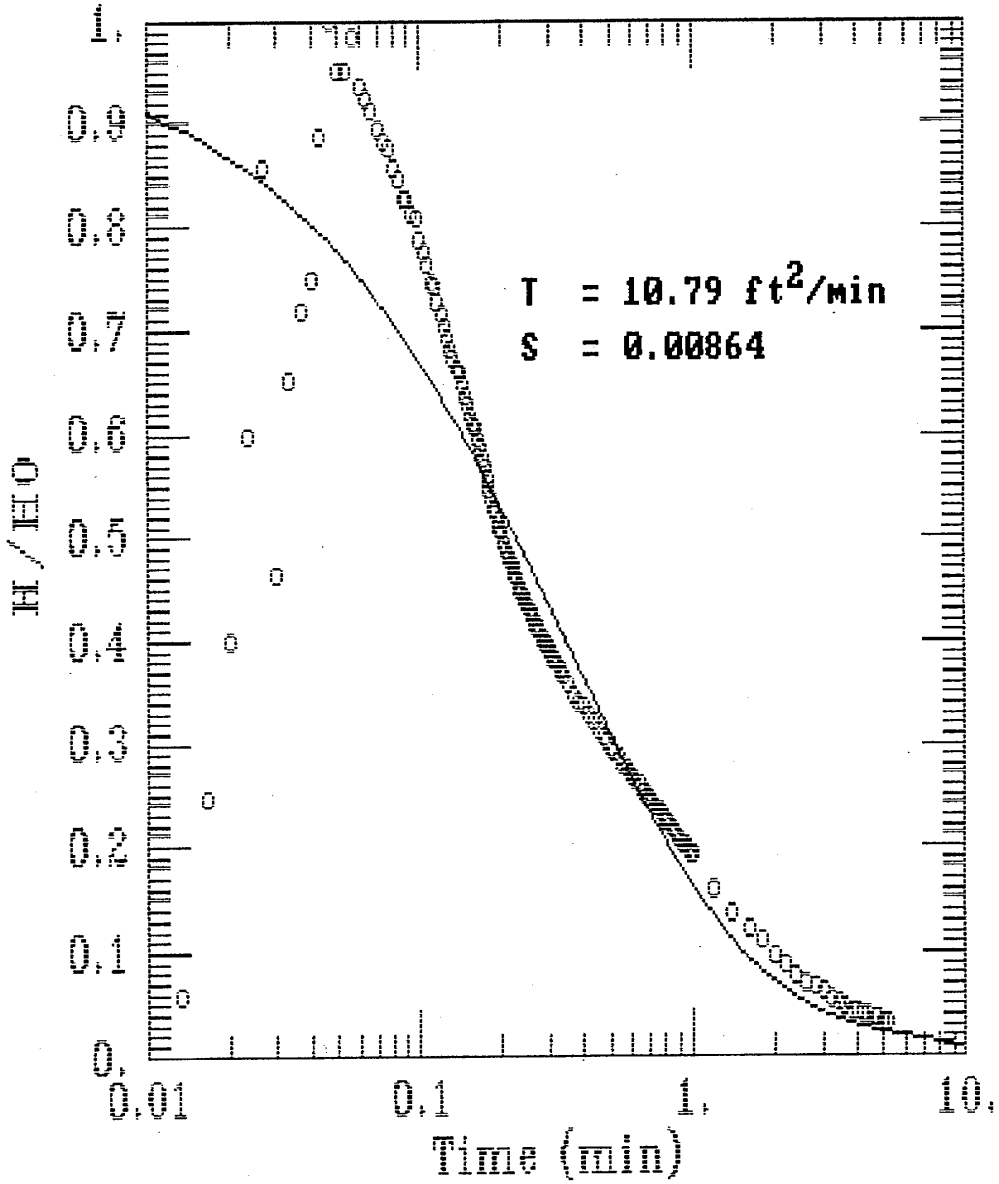

T = 94.12 ft²/min
S = 0.0005121
H/H0
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.001
0.01
0.1
1.
10.
Time (min)


2-wd1.tst
K = 0.2424 ft/min
y0 = 0.263 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
1.
2.
3.
4.
5.
Time (min)

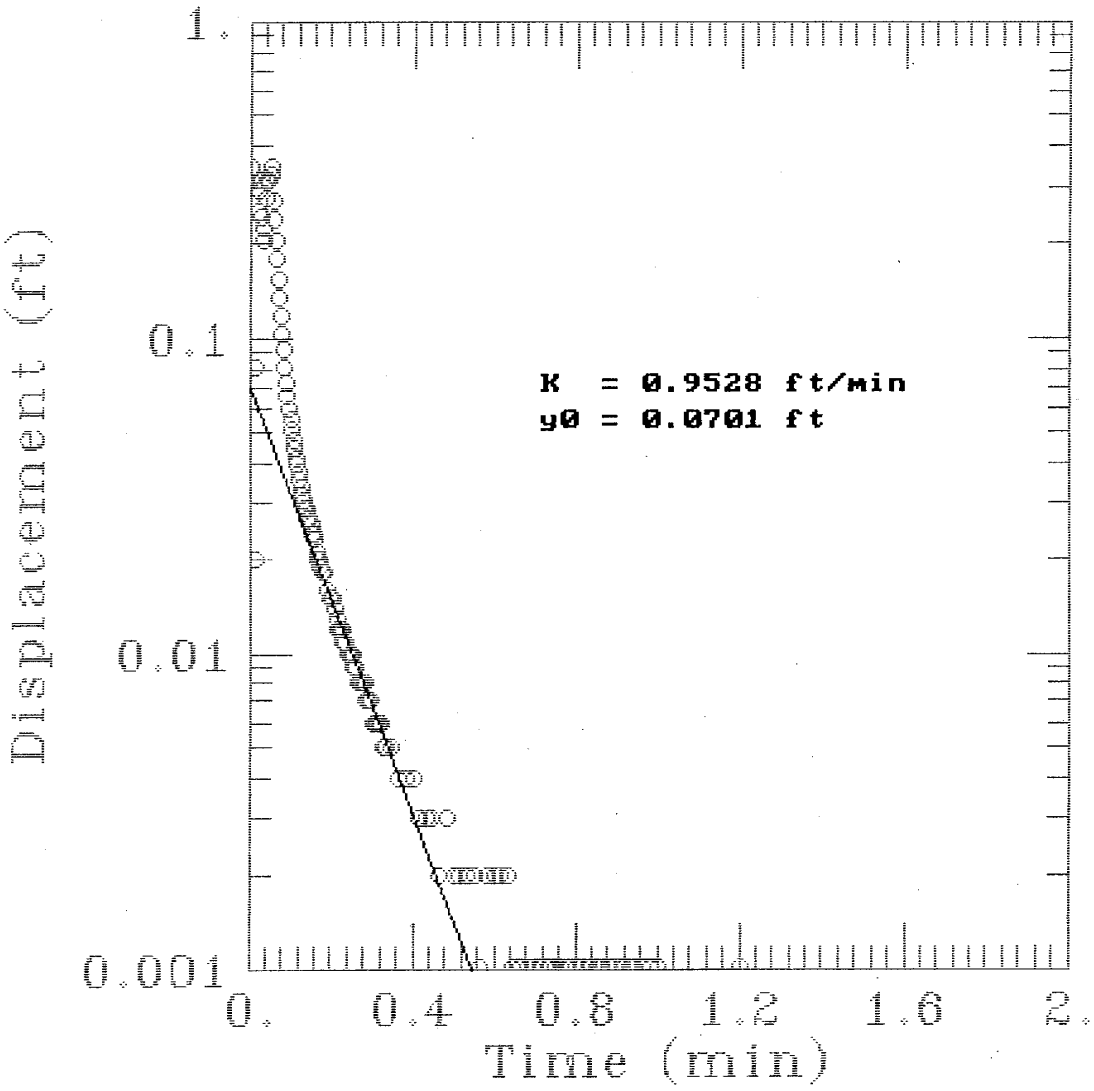

2-wd1.tst
T = 23.37 ft²/min
S = 0.00452
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
H/H0
0.01
0.1
1.
10.
Time (min)


5-wd1.tst
K = 0.09393 ft/min
y0 = 0.2348 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
1.6
3.2
4.8
6.4
8.
Time (min)

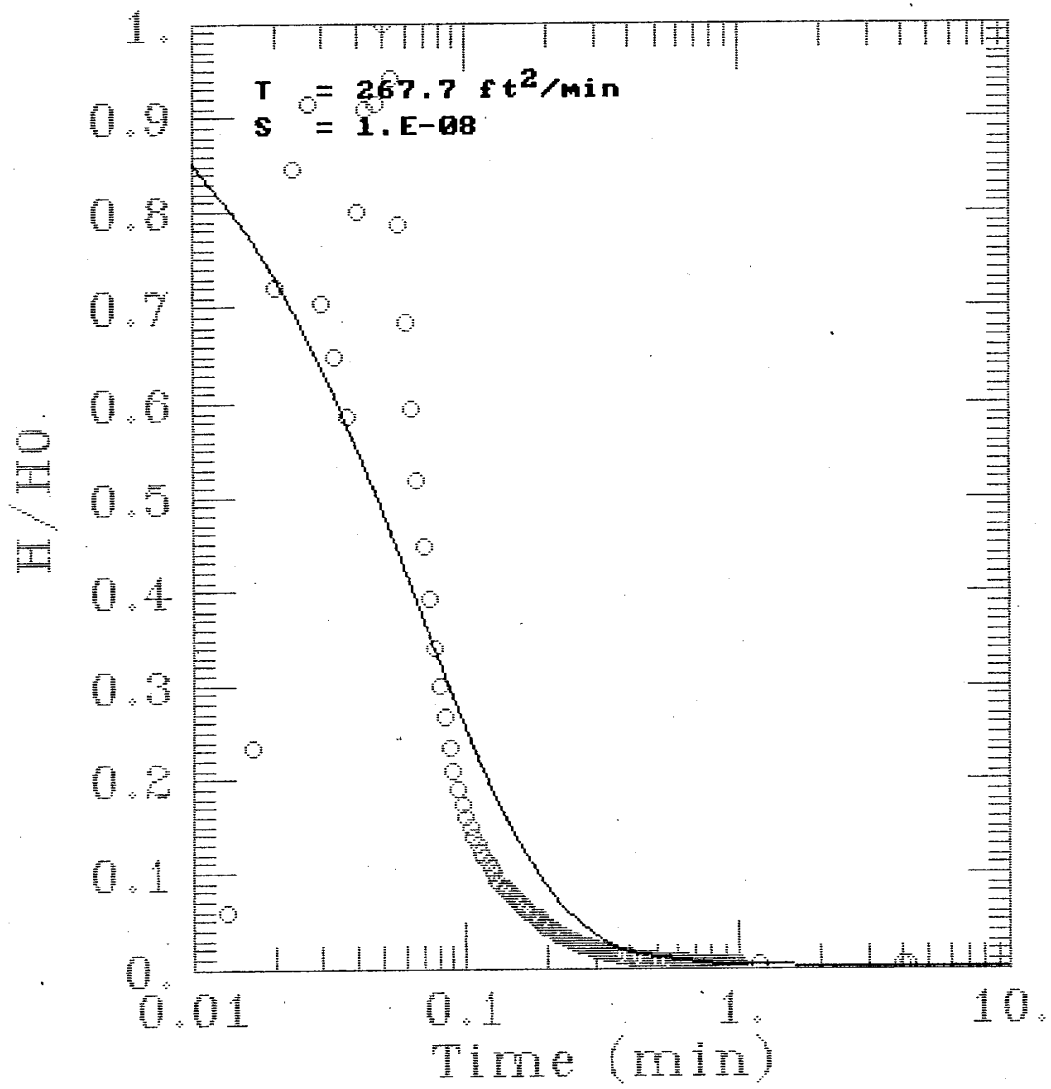
5-wd2.tst


T = 10.79 ft²/min
S = 0.00864
H / H0
Time (min)
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.
10.

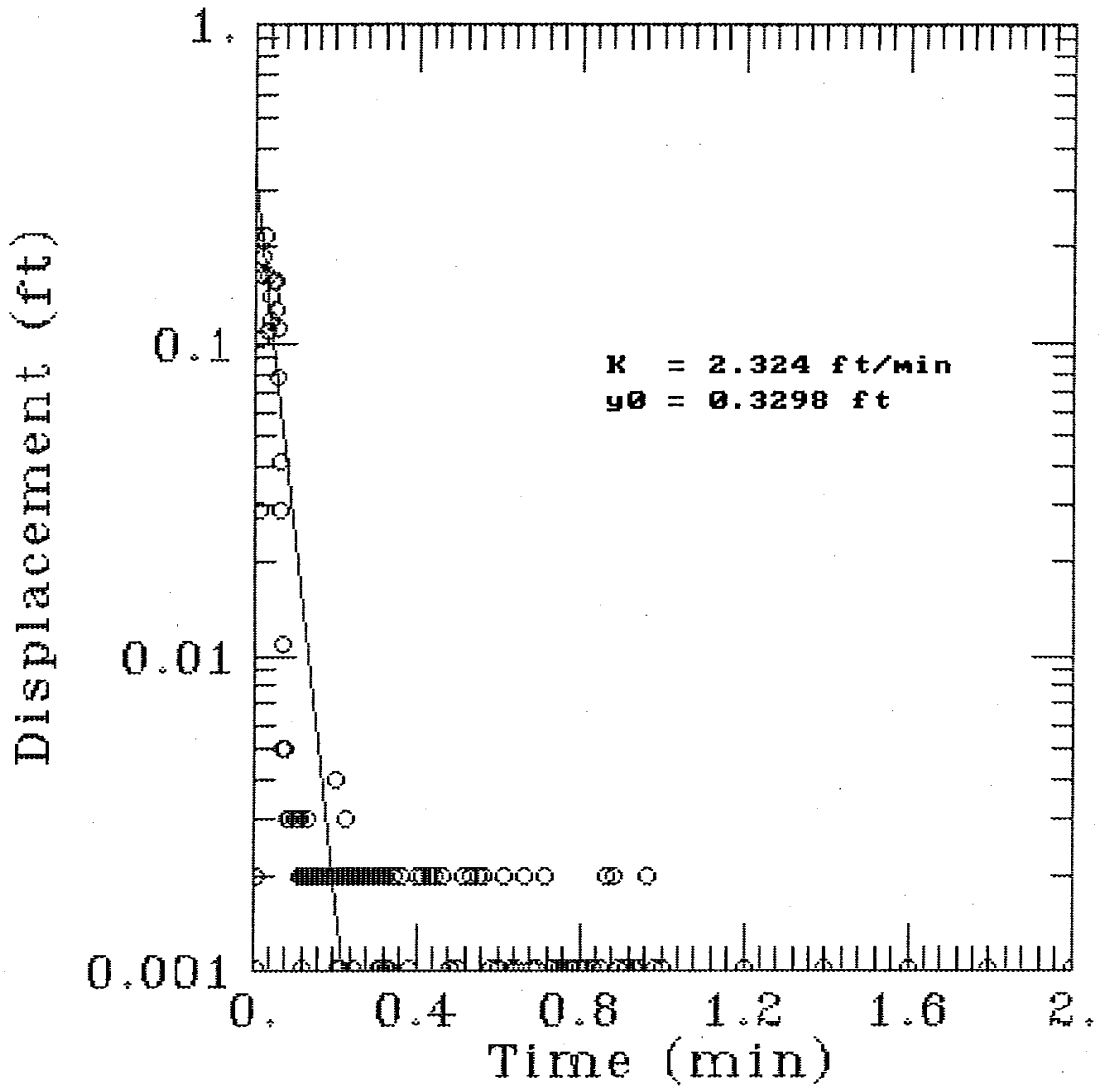
8-wd2.tst


K = 0.9528 ft/min
y0 = 0.0701 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.4
0.8
1.2
1.6
2.
Time (min)

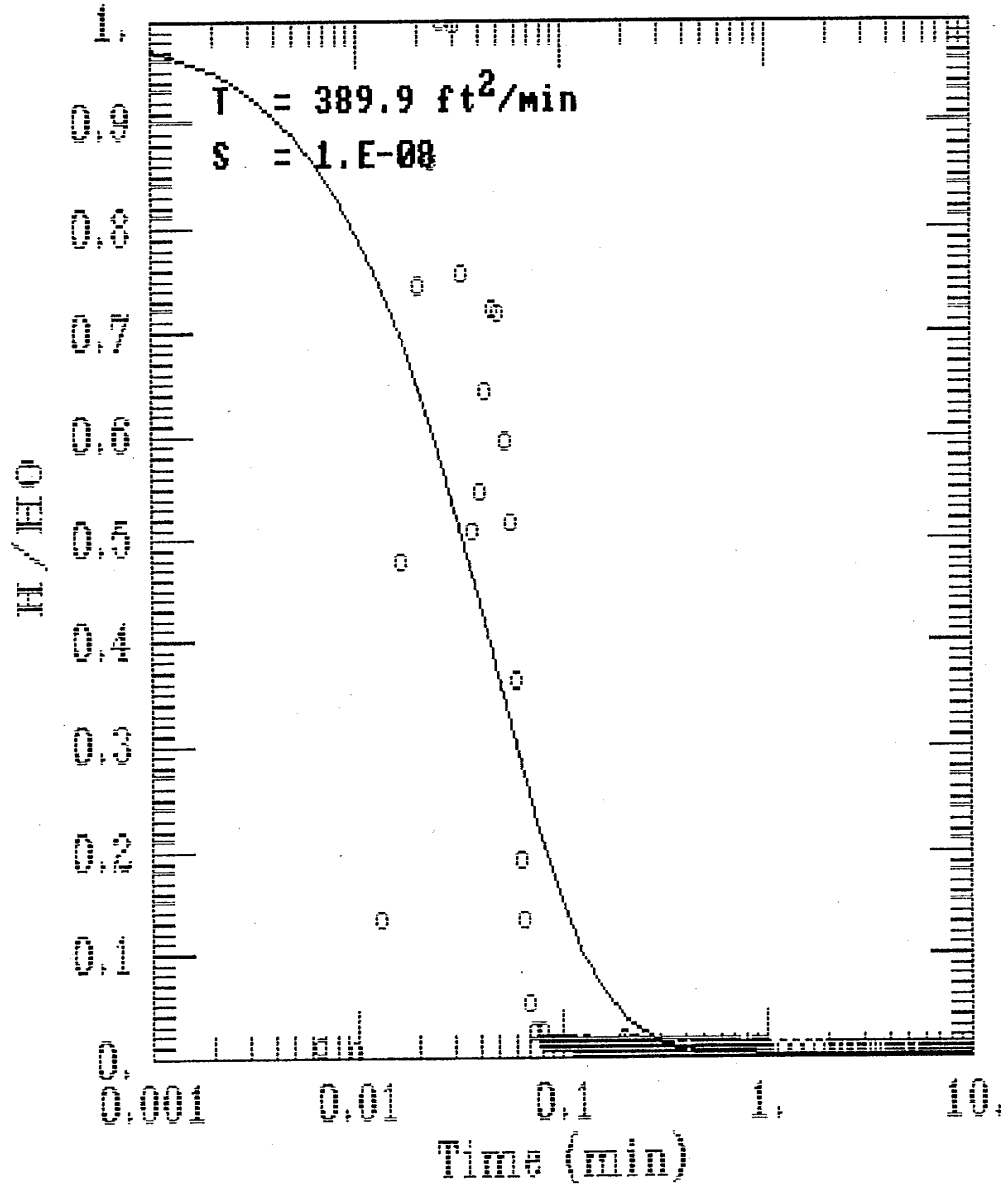
8-wd2.tst

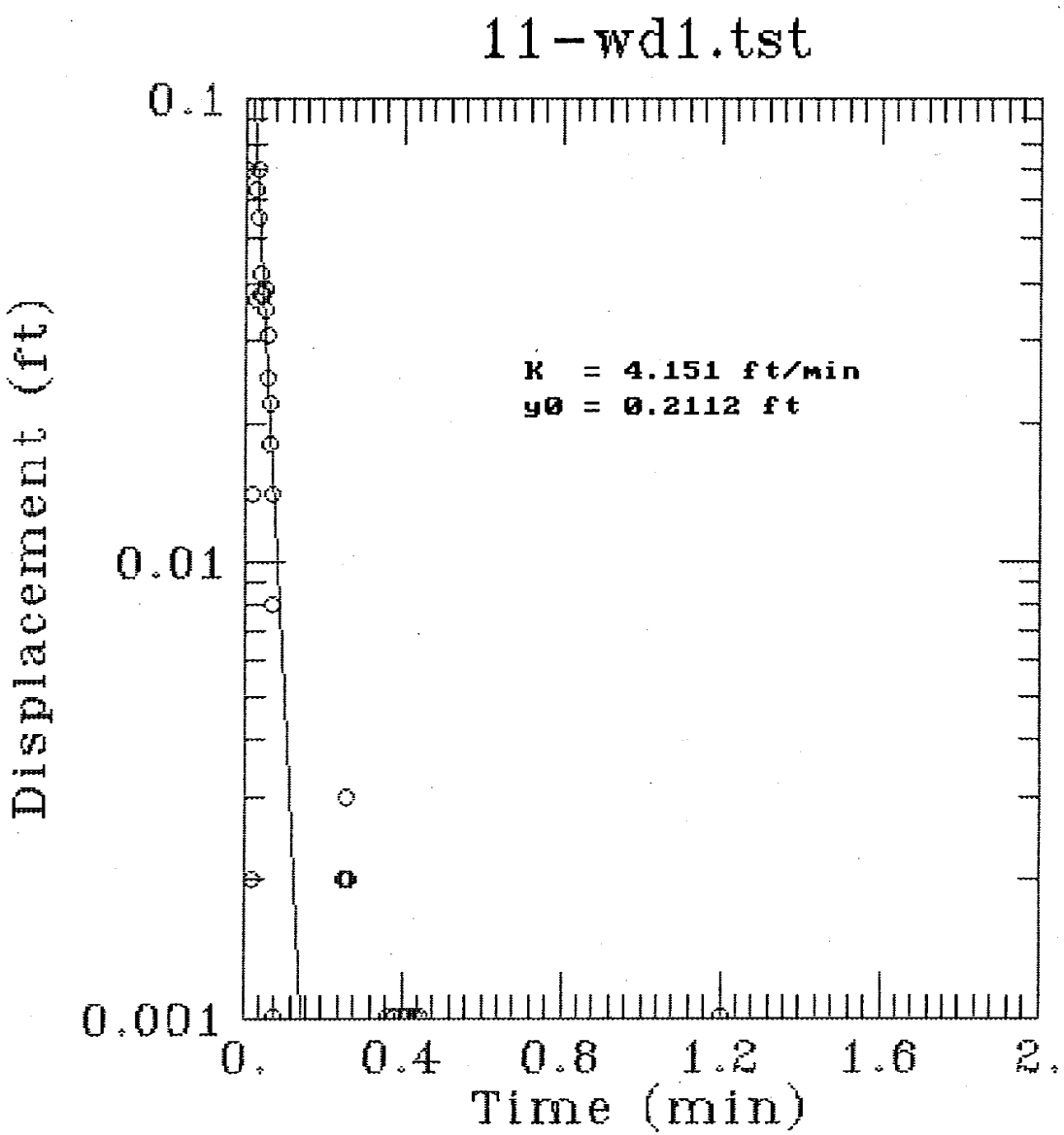

T = 267.7 ft²/min
S = 1.E-08
H/H0
Time (min)
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.
10.

10-wd2.tst

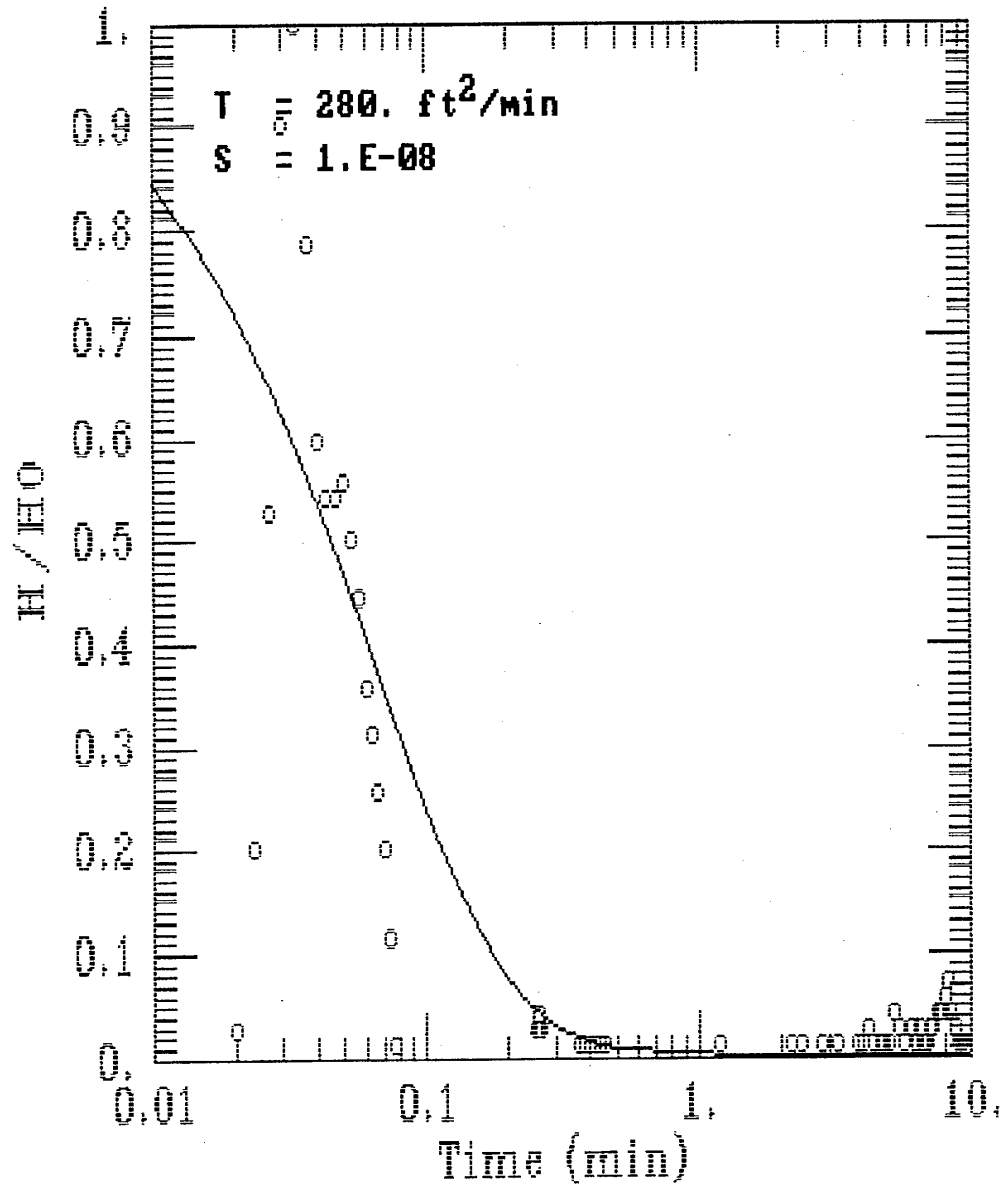

K = 2.324 ft/min
y0 = 0.3298 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.4
0.8
1.2
1.6
2.
Time (min)

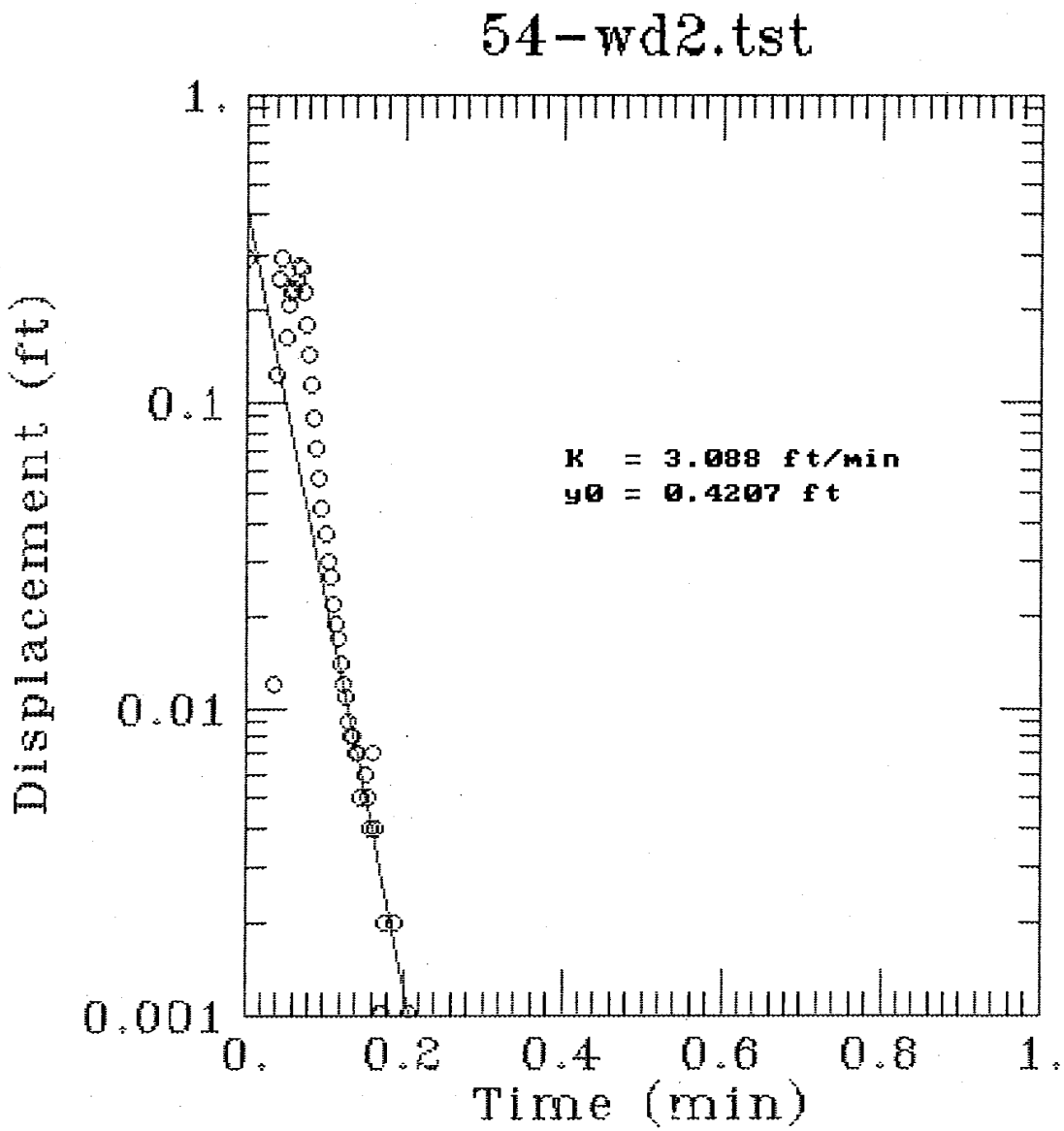
10-wd2.tst


T = 389.9 ft²/min
S = 1.E-08
H/H0
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.001
0.01
0.1
1.
10.
Time (min)

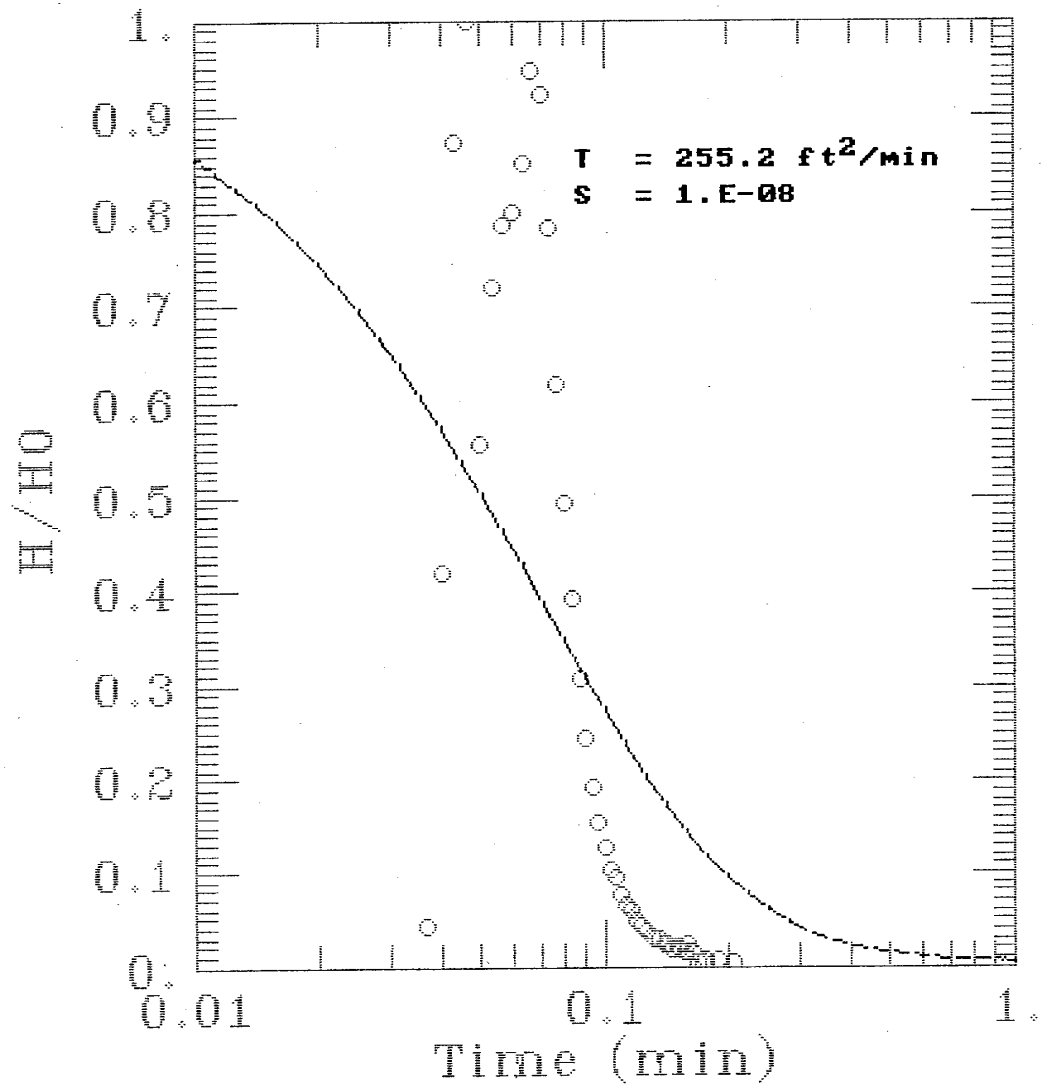

11-wd1.tst
K = 4.151 ft/min
y0 = 0.2112 ft
0.1
0.01
0.001
Displacement (ft)
0.
0.4
0.8
1.2
1.6
2.
Time (min)

11-wd1.tst

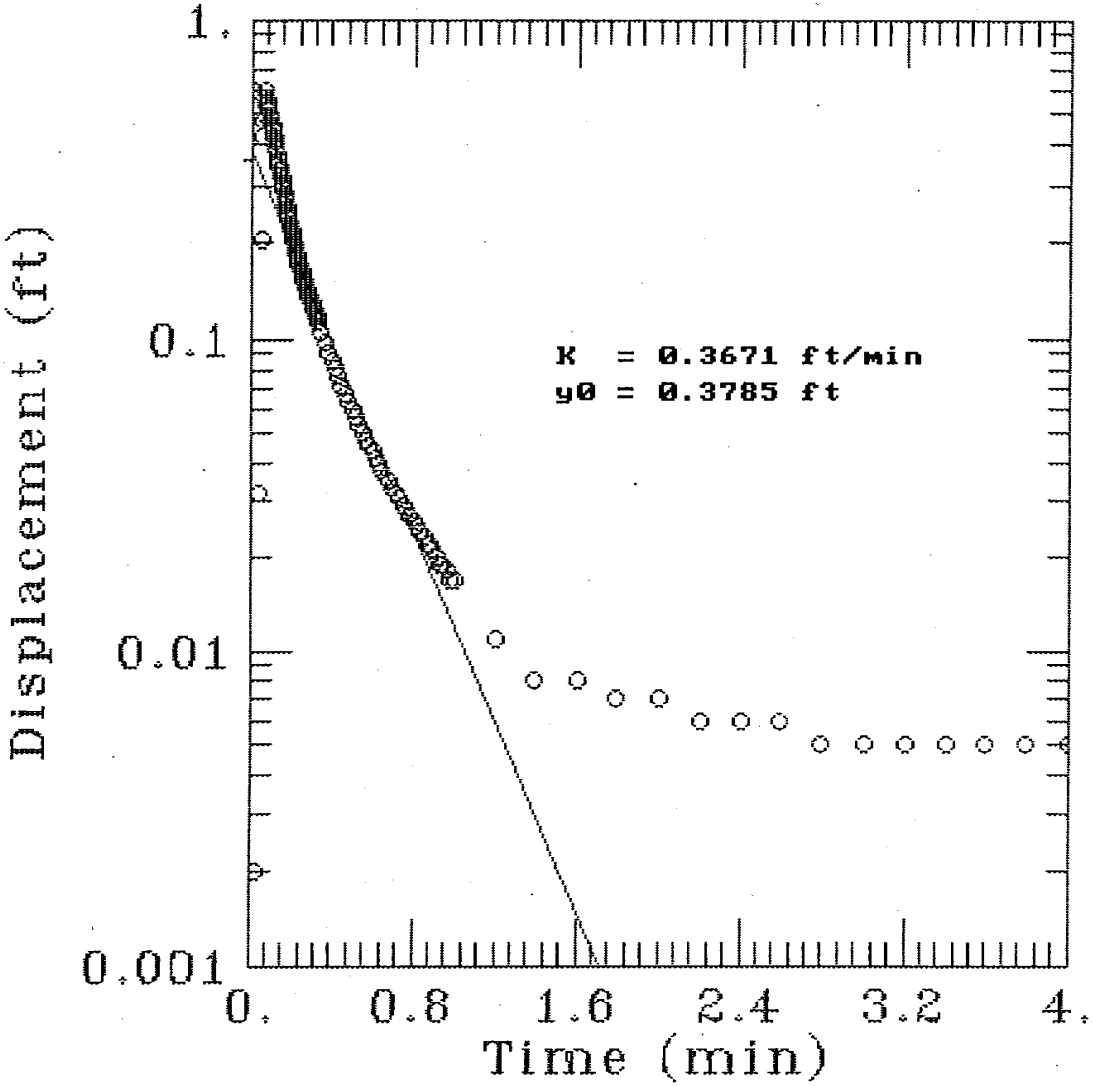

T = 280. ft²/min
S = 1.E-08
H/H0
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.
10.
Time (min)


54-wd2.tst
K = 3.088 ft/min
y0 = 0.4207 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.2
0.4
0.6
0.8
1.
Time (min)

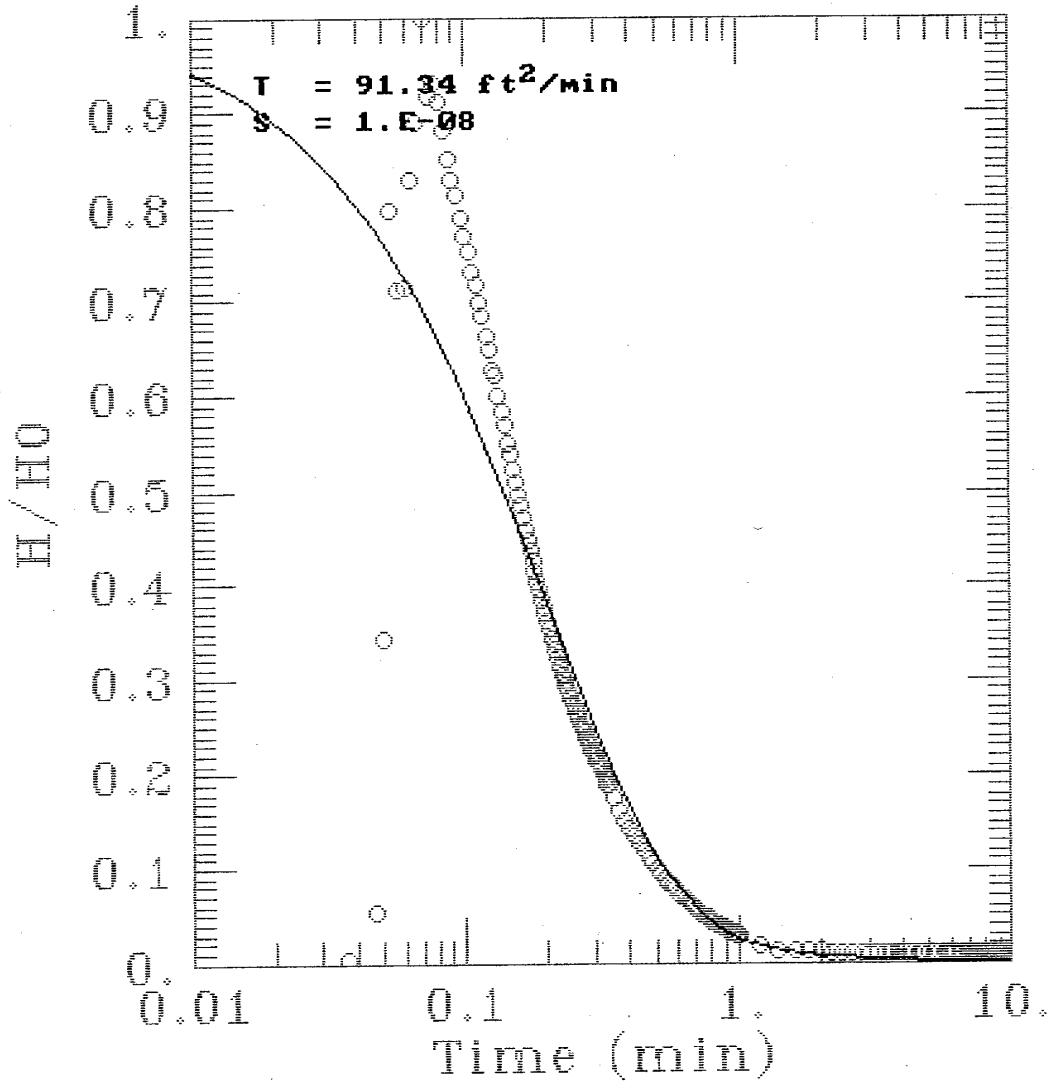
54-wd2.tst

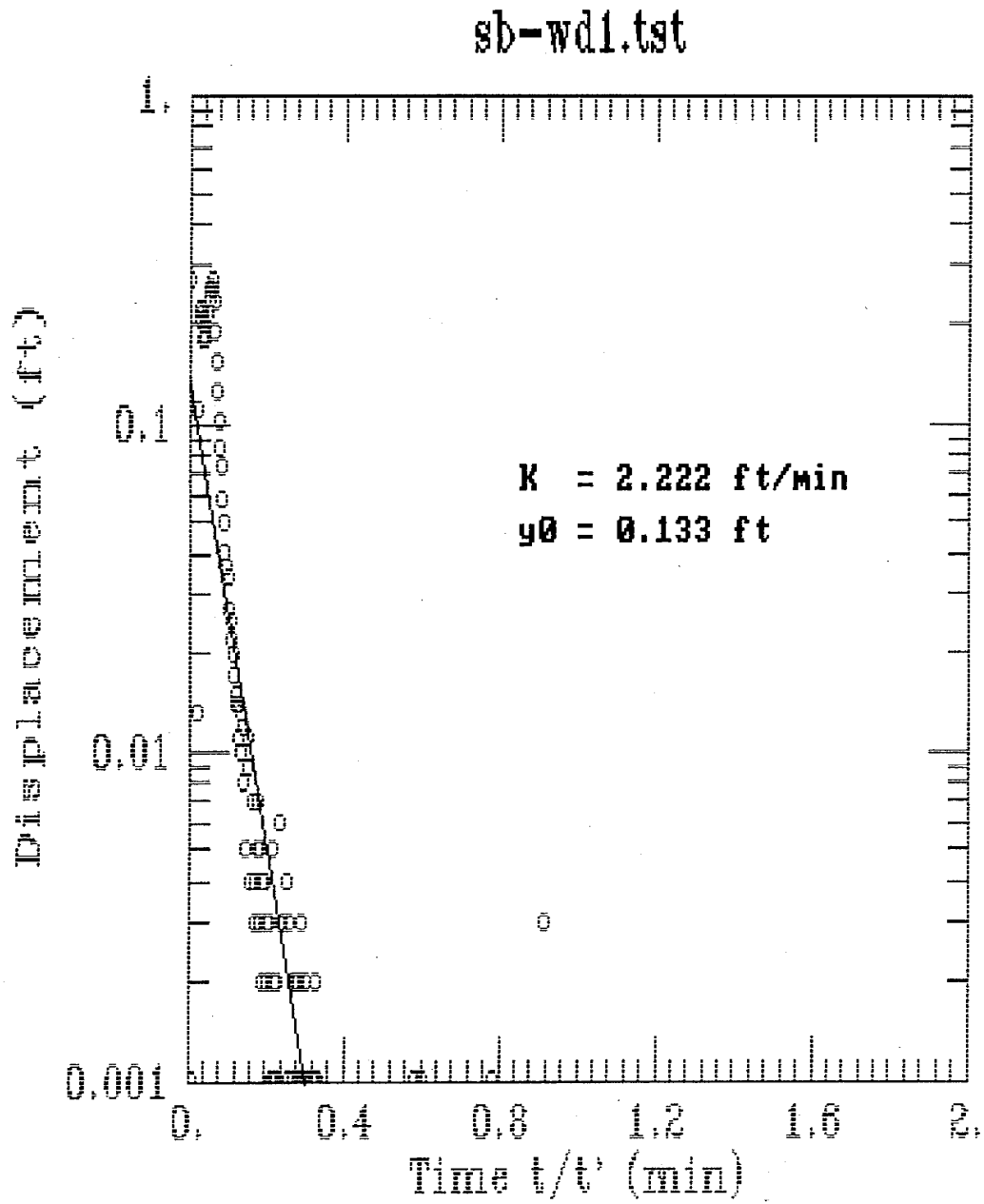

T = 255.2 ft²/min
S = 1.E-08
H/H0
Time (min)
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.

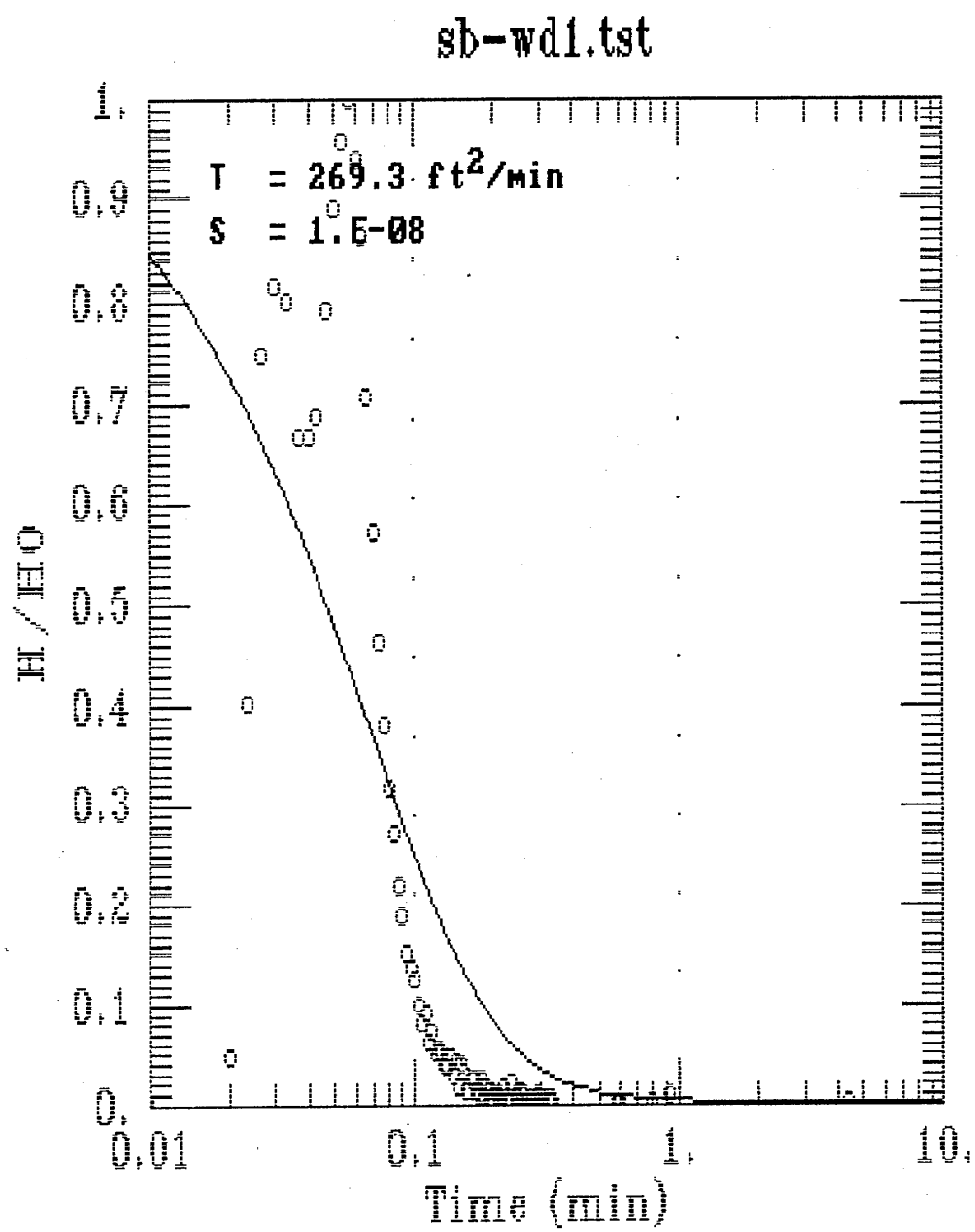
100-wd1.tst


K = 0.3671 ft/min
y0 = 0.3785 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.8
1.6
2.4
3.2
4.
Time (min)

100-wd1.tst


T = 91.34 ft²/min
S = 1.E-08
H/H0
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.
10.
Time (min)


sb-wd1.tst
K = 2.222 ft/min
y0 = 0.133 ft
Displacement (ft)
1.
0.1
0.01
0.001
0.
0.4
0.8
1.2
1.6
2.
Time t/t' (min)


sb-wd1.tst
T = 269.3 ft²/min
S = 1.E-08
H/H0
Time (min)
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
0.01
0.1
1.
10.

Appendix I

APPENDIX I

IDW SUMMARY TABLES

IDW DRUM INVENTORY
NAF MIDWAY SI/RI
CTO 136

SITE	DRUM NUMBER	DRUM STORAGE LOCATION	IDW SOURCE(S)	IDW TYPE	WASTE VOLUME (% FULL)	IDW GENERATION DATE	EXPECTED DISPOSAL DATE	ACTUAL DISPOSAL DATE	EXPECTED DISPOSAL METHOD
Bulky Waste Landfill-Site 01									
	0136-01-D001	Bunker S7122	MW-1	PPE	100%	10/19/94	TBD	TBD	Incineration
	0136-01-D002	Bunker S7122	MW-2	PPE	100%	10/18/94	TBD	TBD	Incineration
	0136-01-D003	Bunker S7122	MW-3	PPE	100%	10/18/94	TBD	TBD	Incineration
	0136-01-D004	Bunker S7122	MW-4	PPE	100%	10/17/94	TBD	TBD	Incineration
	0136-01-D005	Bunker S7122	SB-1	Soil Cuttings	75%	10/19/94	TBD	TBD	TBD
	0136-01-D006	Bunker S7122	SB-2	Soil Cuttings	75%	10/18/94	TBD	TBD	TBD
	0136-01-D007	Bunker S7122	SB-3	Soil Cuttings	75%	10/18/94	TBD	TBD	TBD
	0136-01-D008	Bunker S7122	SB-4	Soil Cuttings	75%	10/17/94	TBD	TBD	TBD
	0136-01-D009	Bunker S7122	MW-1	Purge Water	50%	10/22/94	TBD	TBD	TBD
	0136-01-D010	Bunker S7122	MW-2	Purge Water	50%	10/22/94	TBD	TBD	TBD
	0136-01-D011	Bunker S7122	MW-3	Purge Water	50%	10/22/94	TBD	TBD	TBD
	0136-01-D012	Bunker S7122	MW-4	Purge Water	50%	10/24/94	TBD	TBD	TBD
	0136-01-D013	Bunker S7122	MW-1 thru 4	Decon Water	75%	10/17 - 10/24/94	TBD	TBD	TBD
	0136-01-D014	Bunker S7122	MW-1	Purge Water	50%	11/14/94	TBD	TBD	TBD
	0136-01-D015	Bunker S7122	MW-2	Purge Water	50%	11/14/94	TBD	TBD	TBD
	0136-01-D016	Bunker S7122	MW-3	Purge Water	50%	11/14/94	TBD	TBD	TBD
	0136-01-D017	Bunker S7122	MW-4	Purge Water	50%	11/14/94	TBD	TBD	TBD
Runway Landfill-Site 02									
	0136-02-D001	Bunker S7122	MW-1 & MW-2	PPE	100%	10/12/94	TBD	TBD	Incineration
	0136-02-D002	Bunker S7122	MW-3	PPE	100%	10/12/94	TBD	TBD	Incineration
	0136-02-D003	Bunker S7122	MW-4	PPE	100%	10/13/94	TBD	TBD	Incineration
	0136-02-D004	Bunker S7122	MW-5	PPE	100%	10/14/94	TBD	TBD	Incineration
	0136-02-D005	Bunker S7122	MW-6	PPE	100%	10/14/94	TBD	TBD	Incineration
	0136-02-D006	Bunker S7122	SB-1	Soil Cuttings	90%	10/11/94	TBD	TBD	TBD
	0136-02-D007	Bunker S7122	SB-2	Soil Cuttings	40%	10/12/94	TBD	TBD	TBD
	0136-02-D008	Bunker S7122	SB-3	Soil Cuttings	40%	10/12/94	TBD	TBD	TBD
	0136-02-D009	Bunker S7122	SB-2	Soil Cuttings	100%	10/12/94	TBD	TBD	TBD
	0136-02-D010	Bunker S7122	SB-3	Soil Cuttings	100%	10/12/94	TBD	TBD	TBD
	0136-02-D011	Bunker S7122	SB-4	Soil Cuttings	100%	10/13/94	TBD	TBD	TBD
	0136-02-D012	Bunker S7122	SB-5	Soil Cuttings	100%	10/14/94	TBD	TBD	TBD
	0136-02-D013	Bunker S7122	SB-6	Soil Cuttings	100%	10/14/94	TBD	TBD	TBD
	0136-02-D014	Bunker S7122	SB-6	Soil Cuttings	100%	10/14/94	TBD	TBD	TBD
	0136-02-D015	Bunker S7122	MW-1	Purge Water	60%	10/11/94	TBD	TBD	TBD
	0136-02-D016	Bunker S7122	MW-2	Purge Water	60%	10/12/94	TBD	TBD	TBD
	0136-02-D017	Bunker S7122	MW-3	Purge Water	60%	10/12/94	TBD	TBD	TBD
	0136-02-D018	Bunker S7122	MW-4	Purge Water	60%	10/13/94	TBD	TBD	TBD

IDW DRUM INVENTORY
NAF MIDWAY SI/RI
CTO 136

SITE	DRUM NUMBER	DRUM STORAGE LOCATION	IDW SOURCE(S)	IDW TYPE	WASTE VOLUME (% FULL)	IDW GENERATION DATE	EXPECTED DISPOSAL DATE	ACTUAL DISPOSAL DATE	EXPECTED DISPOSAL METHOD
	0136-02-D019	Bunker S7122	MW-5	Purge Water	60%	10/14/94	TBD	TBD	TBD
	0136-02-D020	Bunker S7122	MW-6	Purge Water	60%	10/14/94	TBD	TBD	TBD
	0136-02-D021	Bunker S7122	MW-1 thru 6	Decon Water	80%	10/11 - 10/14/94	TBD	TBD	TBD
	0136-02-D022	Bunker S7122	MW-1	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D023	Bunker S7122	MW-2	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D024	Bunker S7122	MW-3	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D025	Bunker S7122	MW-4	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D026	Bunker S7122	MW-5	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D027	Bunker S7122	MW-6	Purge Water	75%	11/14/94	TBD	TBD	TBD
	0136-02-D028	Bunker S7122	MW-1-6	Decon Water	40%	11/14/94	TBD	TBD	TBD
Area 401-Site 05									
	0136-05-D001	Bunker S7122	SB-1	Soil Cuttings	100%	11/11/94	TBD	TBD	TBD
	0136-05-D002	Bunker S7122	SB-2	Soil Cuttings	100%	11/12/94	TBD	TBD	TBD
	0136-05-D003	Bunker S7122	SB-3	Soil Cuttings	100%	11/12/94	TBD	TBD	TBD
	0136-05-D004	Bunker S7122	MW-1	Purge Water	90%	11/11/94	TBD	TBD	TBD
	0136-05-D005	Bunker S7122	MW-2	Purge Water	90%	11/12/94	TBD	TBD	TBD
	0136-05-D006	Bunker S7122	MW-3	Purge Water	90%	11/12/94	TBD	TBD	TBD
	0136-05-D007	Bunker S7122	MW-2,3	PPE	100%	11/12/94	TBD	TBD	Incineration
	0136-05-D008	Bunker S7122	MW-1	PPE	100%	11/11/94	TBD	TBD	Incineration
	0136-05-D009	Bunker S7122	SB-2	Soil Cuttings	50%	11/12/94	TBD	TBD	TBD
	0136-05-D010	Bunker S7122	SB-3	Soil Cuttings	50%	11/12/94	TBD	TBD	TBD
	0136-05-D011	Bunker S7122	MW-1	Purge Water	90%	11/16/94	TBD	TBD	TBD
	0136-05-D012	Bunker S7122	MW-2	Purge Water	90%	11/16/94	TBD	TBD	TBD
	0136-05-D013	Bunker S7122	MW-3	Purge Water	90%	11/16/94	TBD	TBD	TBD
Bldg. 144-Site 08									
	0136-08-D001	Bunker S7122	SB-1	Soil Cuttings	90%	11/9/94	TBD	TBD	TBD
	0136-08-D002	Bunker S7122	SB-2	Soil Cuttings	90%	11/9/94	TBD	TBD	TBD
	0136-08-D003	Bunker S7122	SB-3	Soil Cuttings	100%	11/10/94	TBD	TBD	TBD
	0136-08-D004	Bunker S7122	MW-1	Purge Water	90%	11/9/94	TBD	TBD	TBD
	0136-08-D005	Bunker S7122	MW-2	Purge Water	90%	11/9/94	TBD	TBD	TBD
	0136-08-D006	Bunker S7122	MW-3	Purge Water	90%	11/10/94	TBD	TBD	TBD
	0136-08-D007	Bunker S7122	MW-1,2,3	PPE	100%	11/9-11/10/94	TBD	TBD	Incineration
	0136-08-D008	Bunker S7122	MW-1	Purge Water	50%	11/15/94	TBD	TBD	TBD
	0136-08-D009	Bunker S7122	MW-2	Purge Water	50%	11/15/94	TBD	TBD	TBD
	0136-08-D010	Bunker S7122	MW-3	Purge Water	50%	11/15/94	TBD	TBD	TBD
	0136-08-D011	Bunker S7122	SB-3	Soil Cuttings	50%	11/10/94	TBD	TBD	TBD
	0136-08-D012	Bunker S7122	SB-2	Soil Cuttings	100%	11/9/94	TBD	TBD	TBD

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SITE	DRUM NUMBER	DRUM STORAGE LOCATION	IDW SOURCE(S)	IDW TYPE	WASTE VOLUME (% FULL)	IDW GENERATION DATE	EXPECTED DISPOSAL DATE	ACTUAL DISPOSAL DATE	EXPECTED DISPOSAL METHOD
	0136-08-D013	Bunker S7122	MW-1,2,3	PPE	100%	11/10/94	TBD	TBD	Incineration
	0136-08-D014	Bunker S7122	SB-1	Soil Cuttings	90%	11/9/94	TBD	TBD	TBD
NE Disposal Area-Site 10									
	0136-10-D001	Bunker S7122	SB-1	Soil Cuttings	100%	10/25/94	TBD	TBD	TBD
	0136-10-D002	Bunker S7122	SB-2	Soil Cuttings	100%	10/26/94	TBD	TBD	TBD
	0136-10-D003	Bunker S7122	SB-3	Soil Cuttings	100%	10/25/94	TBD	TBD	TBD
	0136-10-D004	Bunker S7122	MW-1	Purge Water	50%	10/25/94	TBD	TBD	TBD
	0136-10-D005	Bunker S7122	MW-2	Purge Water	50%	10/26/94	TBD	TBD	TBD
	0136-10-D006	Bunker S7122	MW-3	Purge Water	70%	10/25/94	TBD	TBD	TBD
	0136-10-D007	Bunker S7122	MW-1 thru MW-3	PPE	100%	10/25 - 10/26/94	TBD	TBD	Incineration
	0136-10-D008	Bunker S7122	MW-1 thru MW-3	Decon Water	100%	10/25 - 10/26/94	TBD	TBD	TBD
	0136-10-D009	Bunker S7122	MW-1	Purge Water	90%	11/5/94	TBD	TBD	TBD
	0136-10-D010	Bunker S7122	MW-2	Purge Water	90%	11/5/94	TBD	TBD	TBD
	0136-10-D011	Bunker S7122	MW-3	Purge Water	90%	11/5/94	TBD	TBD	TBD
	0136-10-D012	Bunker S7122	MW-1 to MW-3	PPE	100%	10/25-11/5/94	TBD	TBD	Incineration
SW Disposal Area-Site 11									
	0136-11-D001	Bunker S7122	SB-1	Soil Cuttings	90%	11/1/94	TBD	TBD	TBD
	0136-11-D002	Bunker S7122	SB-2	Soil Cuttings	90%	11/1/94	TBD	TBD	TBD
	0136-11-D003	Bunker S7122	SB-3	Soil Cuttings	90%	11/1/94	TBD	TBD	TBD
	0136-11-D004	Bunker S7122	MW-1	Purge Water	90%	11/1/94	TBD	TBD	TBD
	0136-11-D005	Bunker S7122	MW-2	Purge Water	90%	11/1/94	TBD	TBD	TBD
	0136-11-D006	Bunker S7122	MW-3	Purge Water	90%	11/2/94	TBD	TBD	TBD
	0136-11-D007	Bunker S7122	MW-1 to 3	PPE	100%	11/1-11/2/94	TBD	TBD	Incineration
	0136-11-D008	Bunker S7122	MW-1 to MW-3	Decon Water	100%	11/1-11/2/94	TBD	TBD	TBD
	0136-11-D009	Bunker S7122	MW-1	Purge Water	90%	11/16/94	TBD	TBD	TBD
	0136-11-D010	Bunker S7122	MW-2	Purge Water	90%	11/7/94	TBD	TBD	TBD
	0136-11-D011	Bunker S7122	MW-3	Purge Water	90%	11/16/94	TBD	TBD	TBD
	0136-11-D012	Bunker S7122	MW-1-3	PPE	100%	11/1-11/15/94	TBD	TBD	Incineration
SE Landfill Pit-Site 54									
	0136-54-D001	Bunker S7122	SB-1	Soil Cuttings	100%	10/31/94	TBD	TBD	TBD
	0136-54-D002	Bunker S7122	SB-2	Soil Cuttings	100%	10/31/94	TBD	TBD	TBD
	0136-54-D003	Bunker S7122	SB-3	Soil Cuttings	100%	10/26/94	TBD	TBD	TBD
	0136-54-D004	Bunker S7122	MW-1	Purge Water	100%	10/31/94	TBD	TBD	TBD
	0136-54-D005	Bunker S7122	MW-2	Purge Water	60%	10/31/94	TBD	TBD	TBD
	0136-54-D006	Bunker S7122	MW-3	Purge Water	60%	10/26/94	TBD	TBD	TBD
	0136-54-D007	Bunker S7122	MW-1 to MW-3	PPE	100%	10/26-10/27/94	TBD	TBD	Incineration
	0136-54-D008	Bunker S7122	MW-1 to MW-3	Decon Water	90%	10/26-10/31/94	TBD	TBD	TBD

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SITE	DRUM NUMBER	DRUM STORAGE LOCATION	IDW SOURCE(S)	IDW TYPE	WASTE VOLUME (% FULL)	IDW GENERATION DATE	EXPECTED DISPOSAL DATE	ACTUAL DISPOSAL DATE	EXPECTED DISPOSAL METHOD
	0136-54-D009	Bunker S7122	MW-1	Purge Water	90%	11/5/94	TBD	TBD	TBD
	0136-54-D010	Bunker S7122	MW-2	Purge Water	90%	11/5/94	TBD	TBD	TBD
	0136-54-D011	Bunker S7122	MW-3	Purge Water	90%	11/5/94	TBD	TBD	TBD
Antenna Field-Site 100 (AF)									
	0136-AF-D001	Bunker S7122	SB-1	Soil Cuttings	100%	11/2/94	TBD	TBD	TBD
	0136-AF-D002	Bunker S7122	SB-2	Soil Cuttings	100%	11/3/94	TBD	TBD	TBD
	0136-AF-D003	Bunker S7122	SB-3	Soil Cuttings	100%	11/3/94	TBD	TBD	TBD
	0136-AF-D004	Bunker S7122	MW-1	Purge Water	90%	11/4/94	TBD	TBD	TBD
	0136-AF-D005	Bunker S7122	MW-2	Purge Water	90%	11/3/94	TBD	TBD	TBD
	0136-AF-D006	Bunker S7122	MW-3	Purge Water	100%	11/3/94	TBD	TBD	TBD
	0136-AF-D007	Bunker S7122	MW-1 to MW-3	Decon Water	90%	11/2-11/4/94	TBD	TBD	TBD
	0136-AF-D008	Bunker S7122	MW-1	Purge Water	90%	11/7/94	TBD	TBD	TBD
	0136-AF-D009	Bunker S7122	MW-2	Purge Water	90%	11/7/94	TBD	TBD	TBD
	0136-AF-D010	Bunker S7122	MW-3	Purge Water	90%	11/7/94	TBD	TBD	TBD
Superblock-Site SB									
	0136-SB-D001	Bunker S7122	SB-1	Soil Cuttings	100%	11/10/94	TBD	TBD	TBD
	0136-SB-D002	Bunker S7122	SB-2	Soil Cuttings	100%	11/10/94	TBD	TBD	TBD
	0136-SB-D003	Bunker S7122	SB-3	Soil Cuttings	100%	11/11/94	TBD	TBD	TBD
	0136-SB-D004	Bunker S7122	SB-4	Soil Cuttings	100%	11/11/94	TBD	TBD	TBD
	0136-SB-D005	Bunker S7122	SB-5	Soil Cuttings	100%	11/11/94	TBD	TBD	TBD
	0136-SB-D006	Bunker S7122	SB-2	Soil Cuttings	50%	11/10/94	TBD	TBD	TBD
	0136-SB-D007	Bunker S7122	SB-3	Soil Cuttings	50%	11/11/94	TBD	TBD	TBD
	0136-SB-D008	Bunker S7122	SB-4	Soil Cuttings	50%	11/11/94	TBD	TBD	TBD
	0136-SB-D009	Bunker S7122	SB-5	Soil Cuttings	50%	11/11/94	TBD	TBD	TBD
	0136-SB-D010	Bunker S7122	MW-1	Purge Water	90%	11/10/94	TBD	TBD	TBD
	0136-SB-D011	Bunker S7122	MW-2	Purge Water	90%	11/10/94	TBD	TBD	TBD
	0136-SB-D012	Bunker S7122	MW-3	Purge Water	90%	11/11/94	TBD	TBD	TBD
	0136-SB-D013	Bunker S7122	MW-4	Purge Water	90%	11/11/94	TBD	TBD	TBD
	0136-SB-D014	Bunker S7122	MW-5	Purge Water	90%	11/11/94	TBD	TBD	TBD
	0136-SB-D015	Bunker S7122	MW-2	PPE	100%	11/10/94	TBD	TBD	Incineration
	0136-SB-D016	Bunker S7122	MW-3,4,5	PPE	100%	11/11/94	TBD	TBD	Incineration
	0136-SB-D017	Bunker S7122	MW-1	Purge Water	70%	11/14/94	TBD	TBD	TBD
	0136-SB-D018	Bunker S7122	MW-2	Purge Water	50%	11/14/94	TBD	TBD	TBD
	0136-SB-D019	Bunker S7122	MW-3	Purge Water	50%	11/14/94	TBD	TBD	TBD
	0136-SB-D020	Bunker S7122	MW-4	Purge Water	50%	11/15/94	TBD	TBD	TBD
	0136-SB-D021	Bunker S7122	MW-5	Purge Water	50%	11/15/94	TBD	TBD	TBD
	0136-SB-D022	Bunker S7122	MW-5	Soil Cuttings	40%	11/10/94	TBD	TBD	TBD

IDW DRUM INVENTORY
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SITE	DRUM NUMBER	DRUM STORAGE LOCATION	IDW SOURCE(S)	IDW TYPE	WASTE VOLUME (% FULL)	IDW GENERATION DATE	EXPECTED DISPOSAL DATE	ACTUAL DISPOSAL DATE	EXPECTED DISPOSAL METHOD
Direct Push Sampling IDW-Multiple Sites									
	0136-DP-D001	Bunker S7122	Multiple Sites	PPE	100%	10/5/94	TBD	TBD	Incineration
	0136-DP-D002	Bunker S7122	Multiple Sites	PPE	100%	10/6/94	TBD	TBD	Incineration
	0136-DP-D003	Bunker S7122	Multiple Sites	PPE	100%	10/10/94	TBD	TBD	Incineration
	0136-DP-D004	Bunker S7122	Multiple Sites	PPE	100%	10/17/94	TBD	TBD	Incineration
	0136-DP-D005	Bunker S7122	Multiple Sites	Decon Water	75%	10/5/94	TBD	TBD	TBD
	0136-DP-D006	Bunker S7122	Multiple Sites	Decon Water	100%	10/8/94	TBD	TBD	TBD
	0136-DP-D007	Bunker S7122	Multiple Sites	Decon Water	75%	10/17/94	TBD	TBD	TBD
Marine Sampling IDW-Mutiple Sites									
	0136-MI-D001	Bunker S7122	All Sites	PPE	100%	9/15 - 11/10/94	TBD	TBD	Incineration
	0136-MI-D002	Bunker S7122	All Sites	Al. Core Tubes	100%	9/15 - 11/10/94	TBD	TBD	TBD
	0136-MI-D003	Bunker S7122	All Sites	PPE	100%	9/15 - 11/10/94	TBD	TBD	Incineration
	0136-MI-D004	Bunker S7122	Sand Is.	Decon Water	100%	9/15 - 11/10/94	TBD	TBD	TBD
	0136-MI-D005	Bunker S7122	Eastern Is.	Decon Water	20%	9/15 - 11/10/94	TBD	TBD	TBD
	0136-MI-D006	Bunker S7122	All Sites	Sed./Water	50%	9/15 - 11/10/94	TBD	TBD	TBD
PCB Wipe Sampling IDW-Multiple Sites									
	0136-WW-D001	Bunker S7122	All PCB Wipe Sites	Decon Water	30%	11/3 - 11/10/94	TBD	TBD	TBD
	0136-WW-D002	Bunker S7122	All PCB Wipe Sites	PPE	50%	11/3 - 11/10/94	TBD	TBD	Incineration
Eastern Island Decontamination Basin-Mutiple Eastern Island Sites									
	0136-EI-D001	Bunker S7122	All Eastern I. Sites	PPE	100%	11/7/94	TBD	TBD	Incineration
Sand Island Decontamination Basin-Mutiple Sand Island Sites									
	0136-SI-D001	Bunker S7122	All Sand Is. Sites	Grout	75%	10/1 - 11/10/94	TBD	TBD	Landfill
	0136-SI-D002	Bunker S7122	All Sand Is. Sites	Decon Water	80%	10/1 - 11/10/94	TBD	TBD	TBD
	0136-SI-D003	Bunker S7122	All Sand Is. Sites	Decon Water	90%	10/1 - 11/10/94	TBD	TBD	TBD
	0136-SI-D004	Bunker S7122	All Sand Is. Sites	Decon Water	90%	10/1 - 11/10/94	TBD	TBD	TBD
Archived Onsite Lab Samples-Multiple Sites									
	0136-BB-D001	Bunker S7122	All Sites	Soil and Water	100%	9/15 - 10/15/94	TBD	TBD	TBD
	0136-BB-D002	Bunker S7122	All Sites	Soil and Water	100%	9/15 - 10/15/95	TBD	TBD	TBD

Appendix J

APPENDIX J

TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

APPENDIX J
TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

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APPENDIX J
TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

ORGANICS

1.0 POLYCHLORINATED BIPHENYLS (PCBs)

1.1 Physicochemical Properties

Polychlorinated biphenyls (PCBs) are multi-substituted chlorinated aromatic hydrocarbons with a possible 209 isomers. Aroclors are commercial mixtures of PCBs manufactured from batch chlorination of biphenyl, followed by fractionation and purification of the congeners by molecular weight. Aroclor mixtures have a characteristic proportion of chlorine based on the relative degree of substitution of the constituent congeners. Aroclor 1260 has proportionally more highly chorinated congeners than Aroclor 1254, and therefore has some differences in physicochemical properties, such as volatility and solubility. These chemical properties affect bioavailability, persistence and toxicity of the different Aroclor mixtures (deVoogt and Brinkman, 1989).

Earlier toxicological studies focused on biological effects of PCB mixtures, such as the Aroclors or their European counterparts (Clophens). More recently the analytical emphasis has been shifted away from PCB mixtures and toward individual congeners, due to the recognized differential in both accumulation and toxicity based on chlorine substitution patterns of the individual compounds. Their toxicological and pharmacokinetic properties are based on their isomeric configurations. Non- and mono-ortho substituted biphenyls which are substituted at the meta and para positions are coplanar and tend to have greater biological activity than lesser substituted congeners or

those with more than one substituted ortho position (nonplanar). The structural features of PCB congeners enable determination of structure-activity relationships for relative toxicological activity, environmental occurrence, and persistence.

1.2 Environmental Transport and Distribution

Global levels of PCBs have diminished in the last decade due to greatly reduced production. However, PCBs have attained steady-state in some ecological and biological systems due to persistent atmospheric deposition (Baumann and Whittle, 1988; Falandyz et. al., 1994; Harris et. al., 1993). Global distribution studies indicate that there are disproportionately high environmental levels associated with developing countries in tropical and subtropical Asia and Oceania (Tanabe et. al., 1994; Iwata et. al., 1994), in addition to relatively high residue levels in air and surface seawater from the North American and European continents (Iwata et. al., 1993).

Global transport and distribution processes include volatility, leaching, partitioning, particle transfer and transport by ocean currents. Atmospheric transport and ocean circulation are reported to be the primary mechanisms for circum-global dispersion of PCBs (Tanabe and Tatsukawa, 1986). Regional water and air sampling efforts have been conducted to characterize contaminant dispersion in relation to ocean current flow patterns of the Pacific (Iwata, et. al., 1993). The North Pacific current flow pattern is summarized here. The Kuroshio current flows off the coast of Japan in a northeasterly direction following a pattern that circulates water from low-latitude eastern Pacific regions north to Japan, and on through the north-central Pacific as far north as Alaska and Siberia. The primary stream flows easterly across the Pacific Ocean and bifurcates to flow south along the U.S. west coast, and north around the periphery of the Gulf of Alaska and along the Aleutian Chain. Counter-current gyres branch off the primary current as it moves easterly across the Pacific, traveling south into the latitudes occupied

by the Northwestern Hawaiian Islands (Seckel, 1962; Stowe, 1979,). With this circulation pattern, organochlorine compounds can be transported from the low-latitude regions of Indochina, China and the Philippines, and also Japan, and deposited in distant, remote regions well away from direct emission sources.

The environmental contamination survey conducted by Iwata et. al., (1993) demonstrated significant HCH, chlordane and PCB contamination in air and water along the route followed by the Kuroshio current up into the Gulf of Alaska and the Bering Sea. The survey was comprised of five cruises with different sampling routes, one of which crossed the North Pacific at the approximate latitude of the Northwestern Hawaiian Islands. Seawater samples taken across the North Pacific contained levels of PCBs and HCHs ranging from 9.1 to 63 pg/L, and 75 to 550 pg/L, respectively. Measurable levels of chlordanes and DDT were also reported, although they were lower than those for PCBs and HCHs. It may be speculated that the southerly counter-current gyres which branch off the primary stream of the Kuroshio current transport organochlorines to this region from the western Pacific basin. HCH levels in surface water along the North Pacific trek was four to eight times greater than those measured in the Northern North Pacific, the Gulf of Alaska, and the Bering Sea, regions through which the Kuroshio current passes. PCB levels in surface waters along the North Pacific trek were twice as high as those reported for PCBs in the northerly regions; PCB air samples taken from the North Pacific were as high or higher than samples from the northerly regions (Iwata et. al., 1993). These levels suggest the Northwestern Hawaiian Islands has been exposed to comparatively high ambient environmental PCB levels. [To illustrate this, some minimum PCB hits from Midway were measured in the same range reported for the Iwata, et. al., 1993, North Pacific trek].

PCBs are generally not subject to chemical transformation processes (i.e. oxidation and hydrolysis) in aqueous media, such that natural degradation in the aqueous environment

is a result of limited photolysis and biodegradation. Chemical half-lives of PCBs in this media tend to be on the order of months to years.PCBs are lipophilic and, as a result, tend to associate with the organic carbon fraction in benthic and suspended sediments, and with the lipid fraction in phytoplankton , zooplankton, and natural surface oil films. Assimilation of PCBs into aquatic and terrestrial food chains generally occurs at this level as they are incidentally ingested by fish and invertebrates, or taken up by aquatic plants and algae. Exposure of a particular organism to PCBs is related to the chemical fate and environmental compartmentalization of the compounds, as well as the ecological niche (i.e. trophic level) of the organism. PCBs are currently recognized as ubiquitous in marine, estuarine and freshwater food chains, with the highest biological concentrations occurring in fish-eating aquatic seabirds and marine mammals

1.3 Individual Effects

1.3.1 General Toxicology

PCBs are generally present as complex mixtures in association with other organochlorine compounds, including the dioxins (PCDD and PCDF), DDT and DDE. Much attention has been given to dioxin exposure effects in wildlife during the past decade. However, in recent years it has become apparent that many dioxin-like effects can be attributed to specific coplanar PCB congeners which mimic the biochemical activity of dioxins. Many toxic effects of both PCBs and dioxins are mediated through the cytosolic aryl hydrocarbon (Ah) receptor. These effects include induction of hepatic monooxegenase (detoxification) enzymes, reproductive and immunological toxicity, dermal disorders, hepatomegaly, reduced body weight gain and, in birds, chick edema syndrome. Non-planar PCB congeners cause toxic effects which are different from Ah-mediated effects. These include induction of certain hepatic enzymes, hypovitaminosis A, hypothyroidism,

and neurotoxic and carcinogenic effects. In conjunction with coplanar PCB congeners and/or dioxins, these congeners may cause various additive or mixed toxic responses.

Earlier studies on PCB effects centered on toxicity of total PCBs or Aroclor mixtures, rather than individual congeners. Bird and mammalian exposure studies were usually based on controlled laboratory dose-response experiments involving domestic species or commonly utilized test species (i.e. chickens, rats, mink). Much of the effects data in wildlife are based on experimental findings from laboratory studies. However, long-term subchronic exposure from contaminated foodstuffs in the wild, as opposed to chronic or acute laboratory exposures, can have variable toxic effects on receptors in the wild due to such factors as additive or mixed exposure effects from multiple contaminants, metabolic effects through the food chain which alter the chemical makeup and therefore toxicity, of the contaminants, and a tendency for contaminants to sequester in body tissues and express toxicity differently from the observed physiological manifestations reported in laboratory experiments.

Due to the complexity of toxic responses to organochlorine mixtures, alternative approaches are in use to assess exposure effects of PCBs on wildlife. These approaches include:

1) calculating Toxicity Equivalency Factors (TEFs) to specific PCB congeners. TEFs quantify the toxicity of a congener as a fraction equivalent of the known toxicity of 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD), yielding standardized TCDD-based toxicity values (TCDD-eq). Safe (1990) has reported TEFs for non-, mono- and di-ortho substituted PCBs, which were derived by standardized hepatic microsome enzyme induction assays. Toxic effects to wildlife appear to be correlated more with total toxicity equivalents than absolute PCB concentrations. Giesy et. al., (1994)

propose the use of TEF values to determine levels of acceptable risk toward the protection of wildlife and human health;

2) the routine use of technical and analytical methodologies which enable evaluation of toxicity as a function of individual congeners in organochlorine mixtures. Knowledge of the biological activity of PCB congener classes and the relative toxicity of congeners enable more effective assessment of the risks associated with exposure or dose levels.

1.3.2 Aquatic Invertebrates and Fish

Trace concentrations of persistent PCBs are detected globally in fish and invertebrates from major rivers and the oceans. Dispersal of contaminated sediments, atmospheric transport and ongoing use and deposition all contribute to the ubiquity of PCBs in aquatic organisms (Eisler, 1986). Crustacean and insect larvae play important roles in the cycling and transport of PCBs in aquatic systems. Larvae transport PCBs from one compartment to another through ingestion and egestion processes, and diurnal vertical migration. Larvae are also a significant route of entry into the food chain as prey items for fish and other invertebrates (Eisler, 1986, and references within).

Diet is probably the principle route of PCB uptake and assimilation in fish, and absorption from water is a minor route. Some species-specific differences have been reported regarding the proportional contribution of these routes to total body burden. Uptake from water is the major route of ingestion for the coho salmon and food consumption is the major route of uptake in lake trout and flounder (Grieg et. al., 1983; Rohrer et. al., 1982). 10% of sampled coho salmon and 58% of sampled chinook salmon in the Great Lakes region were reported to exceed FDA action limits of 5.0 mg/kg for total PCBs (Rohrer et. al., 1982). Elevated levels of total PCBs in gonad tissue or eggs were suggested to be responsible for reproductive impairment or failure in several species

of fish, including striped bass, rainbow trout, flounder and Atlantic salmon (Eisler, 1986, and references within).

PCBs bioaccumulate in tissues of aquatic organisms to levels four to five orders of magnitude of PCB levels in water. PCBs sequester in fat and fatty tissues due the lipophilic properties of these compounds. Differences in the level of PCB among fishes may be due to diet, temperature variation, molecular composition of body lipids and metabolic state (Eisler, 1986, and references within). Depuration rates for PCBs can be slow in some fishes. Codfish larvae exposed to PCB mixtures as eggs showed no depuration of the chemical 12 days after hatching (Solbakken et. al., 1984). Adult rainbow trout fed 1,150 mg PCBs/kg body weight had body burdens of 33 mg/kg in liver, and 70 mg/kg in muscle 28 days after treatment (Kiessling et. al., 1983). PCB persistence is a reflection of the extent of metabolic activity. Rates of PCB metabolism appear to occur on a congener-specific basis, such that accumulated PCB profiles in fish tissues are frequently different from the source profile (Boon et. al., 1984).

Toxicity Reference Values (TRV) for Aroclor 1254 and 1260 are the National Ambient Water Quality Criteria (NAWQC) derived by USEPA for the protection of wildlife (Suter et. al., 1992)(Table 21-1). The NAWQC represents ambient CPEC levels in water which result in no adverse impacts on wildlife which consume, feed from , contact or otherwise interact with waters of an aquatic system (USEPA, 1986). In the absence of applicable dose-response data for representative prey species, and in recognition of the potential variation in toxicological response to PCB exposure by different marine organisms, the NAWQC was selected as a TRV in order to establish a conservative threshold for PCB exposure levels. The TRV for individual PCB congeners in aquatic organisms were adopted from the National Ambient Water Quality Criteria for Aroclor 1248 since this level (2.0e-07 mg/L) represents a more conservative toxicity threshold than Aroclors 1260 or 1254 (1.1e-04 mg/L and 2.0e-05 mg/L, respectively).

1.3.3 Amphibians and Reptiles

There is a paucity of information on the presence and effects of PCBs in marine or aquatic reptiles.

1.3.3.1 Exposure Routes

PCB exposure for the reptile target receptor (Green turtle) is probably through dietary intake. The diet of the Green turtle consists mainly of sea grasses and algae. There is apparently no data available on PCB accumulation in sea grasses, and it has been suggested that low PCB concentrations in tissues of Green turtle yearlings reflect low concentrations in plant tissues (McKim and Johnson, 1983). BCF values of 2,100 were calculated for tri-substituted PCBs and 10,750 for Arochlor 1254 in an aquatic vascular plant species, demonstrating the occurrence of PCB bioaccumulation. PCB sorption on macroalgal surfaces and partitioning into algal lipids have been cited as routes of introduction into the aquatic food chain (Rohrer et. al., 1982).

1.3.3.2 Metabolism

There is currently very little information on biological activity of organochlorines in turtles and other reptiles. Presently there is no literature available on the presence of an Ah receptor protein, or an analagous counterpart, which would give some indication of the sensitivity reptiles may have for the persistent coplanar PCBs. Efforts to detect Ah receptors in amphibians have been inconclusive (USEPA, 1993).

1.3.3.3 Acute Effects

There are no available reports on adverse effects from acute PCB exposure to Green turtles or turtles of any other species. Hepatic mixed function oxidase (MFO) enzyme induction was reported in Marsh turtles (*Mauremys caspica rivulata*) after a series of Aroclor 1254 injections, but this effect was not accompanied by any observable toxicological responses (Yawetz et. al., 1993).

1.3.3.4 Chronic Effects

Some studies addressing PCB toxicity in turtles involve tissue disposition analysis of the terrestrial snapping turtles as an ecotoxicological screen (Olafsson et. al., 1983; Bryan, et. al., 1987a, b). Yawetz et. al., (1993) reported on cytochrome P450 induction effects of Aroclor 1254 on hepatic microsomes of the marsh turtle. Adipose tissue levels of PCBs as high as 300 mg/kg which were observed in both snapping turtles and marsh turtles did not have apparent toxic effects on either individual condition or reproductive success (Bryan et. al., 1987a; Yawetz et. al., 1993). However, PCB levels of 57-62 mg/kg in snapping turtle adipose tissue were reported by Bishop et. al., (1991) to be associated with decreased hatching success and developmental impairments in newborn turtles. Bryan et. al., (1987a), reported that snapping turtles from a contaminated area bioaccumulated mono-substituted PCBs to levels 2-3 orders of magnitude higher than in specimens from clean areas. They suggested the ability of turtles to store and sequester high concentrations of PCBs in adipose fat protects them from adverse toxic effects.

Concentrations of several individual PCB isomers were quantified in liver and fat tissues of the Kemp's Ridley sea turtle (Lake et. al., 1994). Measured levels of total PCBs were as high as 0.73 mg/kg in liver and 1.25 mg/kg in fat tissue. These levels were considerably lower than those reported by Bishop et. al., (1991) to be associated with

reproductive impairment in snapping turtles. Postyearlings of the Atlantic green turtle and loggerhead turtle were analyzed for total PCB levels in muscle and liver tissue (McKim and Johnson, 1983). Neither turtle exhibited high levels of PCBs in their tissues. Their herbivorous (green turtle) and omnivorous (loggerhead) diets were cited as probable explanations for the lack of PCB accumulation.

1.3.3.5 Toxicity Reference Value Derivation

Typical toxicity endpoint types (LOAEL, LD_{50}, etc.) were not available to evaluate reptile target receptor (green turtle) responses to PCB exposure due to a lack of laboratory toxicity studies. However, information was frequently available on tissue PCB levels that were observed to be unaccompanied by adverse effects or toxicological responses. By conservatively assuming total assimilation and no depuration of ingested contaminants under steady-state conditions, it was estimated that a NOEL dose was equal to a no observed effect tissue concentration , and these "no-observed-effect" tissue concentrations were used as surrogates for no-observed-effect TRVs (doses). This allowed calculated doses (c.f., Section 4.3.1.4 *et seq.*) to be compared to these NOEL tissue concentrations as a screen for potential effects. In the absence of formally derived effects levels, this approach provides: (a) a means to evaluate the potential for effects in little studied target receptors and (b) a way of reducing uncertainty in the risk estimate by narrowing data gaps. This approach was also applied to TRV derivation for avian and mammalian target receptors for which tissue data was available (Sections 1.3.3.5 and 1.3.4.5, respectively).

Reported CPEC tissue levels in green turtles, or similar sea turtle species, were given priority for TRV derivation. To best represent a no-effects threshold, the highest reported tissue levels not associated with adverse effects were selected. If tissue levels were not available for sea turtles, then reported levels for snapping turtle tissue were selected. Data from the following tissue types were used: liver (PCBs 118, 138, 153, 170, 180,

187), adipose tissue (PCBs 28, 44, 52, 66, 128), egg (PCB 105) and muscle (Aroclor mixtures).

For PCB congeners with no available reported tissue levels TRVs were selected in the following manner:

1) PCB 153 was the highest reported diortho-substituted congener, and was selected to represent all diortho-substituted congeners (PCBs 101, 195, 206 and 209). The TCDD-eq for all diortho-substituted congeners is 0.0002, so the PCB 153 endpoint value was maintained as a replacement value without modification.
2) The PCB 105 value was used as a surrogate for the more toxic congeners, PCB 77 and PCB 126. PCB 105 has a TEF of 0.001, while PCBs 77 and 126 have TEFs of 0.01 and 0.1, respectively. Since toxic congeners tend to be present at lower levels in biotic samples (Faladysz et. al., 1994; Kubiak et. al., 1989; Yamashita et. al., 1991; Daelemans et. al., 1991), the level measured for PCB 105 was corrected by the appropriate factor to account for differences in respective toxicity equivalences for PCBs 77 and 126.
3) Where possible, PCB congeners of similar molecular weight and substitution pattern were used as proxies for lesser substituted congeners with unavailable endpoint values. As a result the endpoint value for PCB 28 was used to represent PCB 8, and that for PCB 52 was used to represent PCB 18.

1.3.4 Birds

There are only a few published reports detailing organochlorine contamination in sea birds of the Northwestern Hawaiian Islands (Fisher, 1973; Ohlendorf and Harrison, 1986; Ryan, at. al., 1988). However, there are ample reports of PCB assimilation, body burdens, and effects in populations of phylogenetically and ecologically similar birds.

Many of the recent ecotoxicological studies on colonial fish-eating water birds (CFEWB) fall into one of two categories: 1) comparisons of organochlorine levels in eggs of reference and exposed clutches in order to investigate relative breeding success in exposed and unexposed species, or 2) quantification of organochlorine levels in tissues of juvenile, subadult or adult subjects toward investigating biological or physiological effects, such as enzyme induction, or body burden tolerance.

1.3.4.1 Exposure Routes

PCB exposure to seabird target receptor species is primarily through ingestion of contaminated prey items. PCBs accumulate in lower trophic level aquatic organisms, including crustaceans, molluscs and fish, which constitute the prey base for high-level consumers. PCB levels in organisms at the apex of the marine food chain with diets consisting of these prey items has been reported to be three to six orders of magnitude greater than ambient (i.e. plankton and sediment) PCB levels (Borlakoglu and Dils, 1990), indicating the high biomagnification potential of these compounds. Seabirds and marine mammals occupy the trophic apex of the marine food chain and thus accumulate high levels of PCBs in their muscle and fatty tissues. To a much lesser extent than through prey ingestion, birds may be exposed to PCBs through incidental ingestion of contaminated soil. Birds may also be exposed to localized contaminated soils through burrowing, foraging and nesting behavior.

1.3.4.1.1 Migratory Patterns

The magnitude of organochlorine accumulation in pelagic species may be related to species-specific behavioral activites such as migration, and location of feeding. The species of birds occupying the region of Northwestern Hawaiian Islands exhibit different breeding patterns, which, for many of these species, determines their annual residence

period in the region. Some species, including the albatrosses, have seasonal migration patterns in which they breed and nest in the southern latitudes of the North Pacific during the winter and spring months and spend summer and fall in the northern latitudes, including the Gulf of Alaska, the Bering Sea, the Aleutian Islands and Siberia (McDermond and Morgan, 1993). The Pacific golden plover leaves the Northwestern Hawaiian Islands comparatively early (April) to breed in the northern latitudes of Alaska and Siberia (Bent, 1929). The Bonin petrel is also migratory, although it maintains residence in the Northwest Hawaiian Islands for all but two or three months of the year, leaving only for the summer months. The regions where these migratory species tend to summer were among those reported by Iwata et. al., (1993) to have high ambient seawater levels of organochlorines, including PCBs. Conversely, shearwaters and terns, among other avian species, spend the entire year in the southern latitudes

1.3.4.2 Metabolism

Bioaccumulation of PCBs through the food chain varies depending on both chemical- and species-specific characteristics. Metabolic fate processes of PCB metabolism in sea birds and mammals are determined by the degree and configuration of chlorine substitution of specific congeners; those which tend to occur commonly in biotic tissues of aquatic organisms are the highly chlorinated planar congeners (non- and mono-ortho substituted) which are not readily transformed through the food chain (Safe, 1989). As a result, the balance of PCB congeners in a mixture (i.e. commercial Aroclors) will change as it moves through the food chain due to differential metabolism of the constituents. These metabolic transformations may contribute to inaccuracies in extrapolating experimental results of PCB toxicity tests from the laboratory to the field. Tillet et. al., (1992) found PCB residues in cormorant eggs of the Great Lakes area to have toxic potency 3 - 4 times greater than Aroclor mixtures 1242, 1248, 1254 and 1260. The toxic differential was attributed to selective metabolism and enrichment of individual congeners of the

Aroclors, with a tendency toward greater resistance to metabolism by the more toxic congeners.

Species-specific physiological characteristics are also responsible for differential levels of PCB bioaccumulation. Organisms with relatively low levels of metabolic enzyme activity (i.e. hepatic microsome monooxygenase) tend to bioaccumulate PCBs to higher levels relative to species with greater enzyme activity. An extensive survey of PCB levels in the adipose tissue of five fish-eating seabirds (i.e. puffin, razorbill, shag cormorant and guillemot) by Borlakoglu et. al., (1990ab), estimated enrichment factors for up to 47 PCB congeners, based on their relative concentrations in Aroclor mixtures (enrichment factors >1 indicated bioaccumulation for that congener was occurring). Congeners with enrichment factors >1 generally adhered to structural guidelines regarding degree and pattern of chlorinated substituents, for metabolism and bioaccumulation (Safe, 1989). Congeners with high TCDD-eq values (PCBs 77, 105, 118, and 156) consistently exhibited significant enrichment.

The extent of PCB congener bioaccumulation can vary significantly from species to species, probably due to differences in detoxification enzyme complexes. Five sea bird species demonstrated 9-10 fold interspecific differences in enrichment factors for some persistent PCB congeners (Borlakoglu et. al., 1990c). Yamashita et. al., (1991) concluded from comparative PCB assays in cormorant and Caspian tern eggs taken from the same area that cormorants have greater metabolic capacity to denature PCBs and other organochlorines. Residual planar PCB levels and differences in the relative capacities for enzyme induction between the black-headed sea gull and the black-tailed sea gull suggested species-specific differences in the relative ability to metabolize PCBs (Yamashita et. al., 1992).

1.3.4.3 Acute Effects

Acute effects of PCB exposure to avian wildlife had not been the central objective of any of the reports reviewed here. Due to the complexities of environmental interactions on the fate and metabolism of contaminant mixtures, it is difficult to use the results of laboratory dose-response studies to predict acute (and chronic) exposures in natural conditions. LD_{50} values of 460 and 750 pg/g TCDD-eq units were reported in laboratory studies of the adult cormorant and Caspian tern embryo, respectively (Giesy et. al., 1994). Brain tissue PCB levels of 310 ppm were reported in corpses of ring-billed gulls whose death was attributed to organochlorine toxicity (Sileo et. al., 1977). Relatively high total PCB levels of 480 ppm were reported in breast muscle of sea eagle corpses whose cause of death was unknown (Falandyz et. al., 1994).

1.3.4.4 Chronic Effects

Much of the recent work on comparisons between exposed and reference populations involves birds of the Great Lakes Region (Giesy et. al., 1994, and references within). Historically, the Great Lakes CFEWB have been exposed to many organochlorine compounds in mixtures including PCDDs, PCDFs, PCBs and insecticides. Studies have generally focused on reproductive success of birds and bird colonies with long-term exposure to contaminants. These studies are particularly valuable in that they characterized reproductive and developmental impairments in relation to the individual constituents of complex organochlorine mixtures. Studies of reproductive impairment in correlation with residue levels in eggs and hatchlings of the Forster's tern identified multiple PCB congeners, in addition to dioxins and insecticides (Kubiak et. al., 1989; Harris et. al., 1993). It was determined from these studies that the great majority of toxic effects (as determined by TCDD-eq) was attributed to two planar PCB congeners (PCB 126 and 105). Similar findings were reported in a study on embryotoxicity of the double-

crested cormorant and the Caspian tern from the Great Lakes Region (Yamashita et. al., 1991). Biological effects of the different classes of organochlorines were discernible in some of the subjects. For example, egg-shell thinning was observed in association with high DDE levels, and Ah-mediated effects (enzyme induction, increase liver weight, low birth weight and chick edema) were observed in embryos in association with high levels of non- and mono-ortho substituted PCBs. The herring gull has been reported to be relatively resistant to reproductive impairment in the Great Lakes area in comparison to the terns and cormorant, demonstrating considerably lower incidences of reproductive impairment in association with higher levels of organochlorines (Mineau et. al., 1984; Weseloh et. al., 1989).

PCB profiles were characterized in pectoral muscle of healthy sea gulls (black-headed gull and black-tailed gull) to investigate correlations with induction of drug-metabolizing enzymes (Yamashita et. al., 1992). There was initially no apparent relationship between total PCB levels and cytochrome P-450 induction in either species. However, when corrected for TCDD-eq there was a significant correlation between enzyme activity and TCDD-eq level. Again, toxicity was attributed to the presence of two coplanar PCB congeners (118 and 126), underscoring the importance of both contaminant profile characterization and overall toxicity equivalence of the contaminant mixture.

Additive, synergistic and/or antagonistic effects of organochlorine compounds encountered naturally by wildlife present difficulties in assessing individual toxicological endpoints (lethal or chronic) for risk analysis. As discussed previously, reproductive impairment in populations or sub-populations of CFEWB has been positively correlated with elevated PCB/organochlorine levels in eggs or hatchling body tissues. Embryotoxic effects including hepatic mixed function oxygenase (MFO) enzyme induction, wasting syndrome, depletion of hepatic reserves of retinoids and vitamin A, deformities in embryos and growth retardation are implicated in contributing to overall decreased fitness

and subsequent population declines (Bosveld et. al., 1993; Kubiak et. al., 1989; van den Berg et. al., 1994; Yamashita et. al., 1991; Yamashita et. al., 1992). In addition to these observable intrinsic impairments, extrinsic effects involving parental in attentiveness are reported to be associated with elevated levels of PCBs. More frequent incidences of negligent parental care and egg abandonment were observed in Forster's terns (Kubiak et. al., 1989) and herring gulls (Fox et. al., 1978) when eggs contained high levels of PCBs, suggesting corresponding high levels in tissues of adults may be responsible for the aberrant behavior resulting in parental in attentiveness.

1.3.4.5 Toxicity Reference Value Derivation

TRV derivation for seabird target receptors was based on tissue PCB levels reported in the literature, and was consistent with the approach described earlier for reptile target receptors (Section 1.3.2.5). Reported endpoint values for PCB CPECs included dose-response levels, tissue levels in healthy adults who exhibited no obvious adverse toxicological effects, and levels in eggs and hatchlings from presumably unexposed reference populations used for comparative toxicity studies. While tissue levels were the predominant available endpoint for all PCB CPECs, selection of CPEC toxicological endpoints were based on the following guidelines:

1) Priority was given to endpoint values in the order: 1) published dose-response studies conducted with representative wildlife species; 2) published dose response studies conducted in the laboratory; 3) tissue levels reported in the literature for organisms or eggs which exhibited no adverse exposure effects. In order to address reproductive effects, preference in tissue selection was given to first to hatchlings, then to eggs if no values for hatchlings were available, and then to metabolically active tissues (muscle or organ), and finally to adipose tissue.

2) Reported PCB tissue levels that were not accompanied by adverse effects were used as surrogate endpoint values for formally derived NOAEL or NOELs. In that the objective was to approach a no-effects tissue level threshold , it was decided to select the highest reported value for a particular CPEC in situations where multiple tissue or dose values were available.
3) CPECs for which there was no CFEWB endpoint values were assigned an endpoint from a PCB congener with a similar chlorine substitution number and pattern. Based on this, the PCB 52 endpoint was used to represent PCB 18, and that for PCB 153 was used to represent PCB 128.

1.3.5 Marine Mammals

Early toxicological analyses of organochlorines in phocids and other marine mammals generally addressed empirical levels of total PCBs in organ or fat tissue. More recent studies have addressed ecotoxicological effects associated with increasing levels of PCB and other organochlorines in mammalian tissue. Kannan et. al., (1989) reported that there is an increasing threat of PCB toxicity from terrestrial to aquatic environments, as a result of transport and distribution processes which favor PCB dispersion in aquatic systems. Tanabe et. al., (1994) has reviewed patterns and levels of organochlorine contamination in the western North Pacific in relation to levels in the tissues of marine mammals from that region. In general, a high degree of amplification has been observed in the marine food chain. PCB and DDT residue levels in the tissues of dolphins and cetaceans have been reported up to seven orders of magnitude greater than the levels measured in the ambient water (less than 1 ng/L) (Tanabe et. al., 1984; Tanabe et. al., 1988). Tanabe et. al., (1988) reported levels of PCBs to be higher in marine mammals (cetaceans) from the open North Pacific than various marine and terrestrial mammals from the vicinity of known pollution sources in Japan. Carnivorous marine mammals are thought to be particularly susceptible to uptake and accumulation, and therefore toxicity,

of PCBs. Currently, PCB concentrations in carnivorous marine mammals are reported to be in ranges where they are suspected to contribute to observed decreases in populations (Kannan et. al., 1989; Storr-Hansen and Spliid, 1993a).

1.3.5.1 Exposure Routes

Bioavailability of organochlorines, including PCBs, is related to the chemical fate and environmental compartmentalization of the compounds, as well as the ecological niche (i.e. trophic level) of the receptors. Marine mammals occupy the trophic apex of the marine food chain and thus accumulate high levels of PCBs in their muscle and fatty tissues. Marine mammal target receptor (seals) exposure to PCBs is primarily through ingestion of contaminated prey items. PCBs accumulate in tissues of lower trophic level aquatic organisms including crustaceans, molluscs and fish. Once consumed, PCBs tend to biomagnify to higher levels in tissues of seals and delphinids than any other mammals (or birds) at the apex of the marine food chain. Because seal diets consist of fish, crustaceans and shellfish, and PCB compounds accumulated in fatty tissues of this prey base will continue to accumulate and biomagnify in their tissues.

Other factors affecting contaminant bioconcentration in marine mammals include age-dependent chemical accumulation in individuals, and temporal trends in environmental organochlorine levels affecting populations. Age-dependent accumulation is observed in many higher animals, as lipophilic compounds sequester and concentrate in fatty tissues. In marine mammals, they tend to accumulate to higher levels due to the high lipid content in the form of blubber, and the role of blubber as a non-metabolized insulating fat layer. Age trends in marine mammals were reported for the Dall's porpoise over the course of a twelve year period (Subramanian et. al., 1988). Male porpoises exhibited continual increases in whole-body burden of DDE and PCBs throughout the twelve year period. Organochlorine levels in female porpoises increased until the onset of sexual maturity,

after which organochlorine concentrations were constant or decreased. This pattern was attributed to organochlorine transfer to offspring by lactation, from which up to 60% of the body burden may be eliminated from the female.

Seals may also be exposed to PCBs by contact with contaminated soils during haul-out periods, or they may be in contact with contaminated sediments while foraging and hunting. Both of these exposure routes are likely to be of much less significance than the direct consumption route.

1.3.5.2 Metabolism

Recent studies addressing specific congener identification and TCDD-eq toxicity characterization demonstrate that significant levels of both coplanar and nonplanar PCBs are deposited in fat and organ tissues of harbour seals (Bernhoft and Skaare, 1994; Haraguchi et. al., 1992; Hong et. al., 1993; Storr-Hansen and Spliid, 1993ab), ringed seals (Daelmans et. al., 1993) and grey seals (Haraguchi et. al., 1992).

As with CFEWB, causal relationships of PCB effects on seal populations are rooted in biological activity at the organismal and cellular levels. Biological effects associated with PCB toxicity observed in mammalian (mostly terrestrial species) laboratory studies, appear to be Ah-mediated symptoms characteristic of coplanar PCB congeners. Some of these effects have been noted in individuals of impacted harbour seal populations possibly exposed to high levels of PCBs (Reijnders, 1986).

Toxicity analysis in harbour seals revealed that total toxicity was dominated by just four PCB congeners (PCBs 118, 156, 157 and 105) (Storr-Hansen and Spliid, 1993a). Hong et. al., (1993) reported that total toxicity in harbour seal and elephant seal blubber was almost entirely dominated by three coplanar PCBs (PCBs 77, 105, 126), and toxicity in

seal serum was based on just one congener (PCB 105). Bernhoft and Skaare (1994) identified eight persistent PCBs (of 26 analyzed) in tissues of the harbour seal, and reported different congener accumulation patterns in the various body tissues. They also reported a positive correlation in levels of tissue accumulation relative to body weight. Haraguchi et. al., (1992) reported species-specific differences in bioaccumulation between the grey, harbour and ringed seals, where lower chlorinated congeners did not accumulate as readily in body tissues of the grey and harbour seals, as they did in the ringed seal.

1.3.5.3 Acute Effects

There were no reports available on the acute effects of PCB ingestion in seals. Reported LD_{50} values for Arochlor mixtures range from 1,000 to 12,000 mg/kg in rat and 750 to 4,000 mg/kg in mink (Eisler, 1986). However, environmental exposure of PCBs to seals usually results from long-term, low level accumulation through the food chain. Thus, acute effects extrapolations from laboratory mammal studies are probably not accurate reflections of acute responses to PCB exposure to seals in the aquatic environment.

1.3.5.4 Chronic Effects

Reproductive failure was reported in harbour seals as a result of ingesting fish contaminated with PCBs over a two year period (Reijnders, 1986). It was determined that reproductive failure was not due to diminished hormone levels or activity and occurs post-ovulatory; however, the actual mechanism was not defined. Other studies with seals have identified PCB mixtures as causative factors in pathological changes in the uterine system, vitaminosis A, thyroid hormone deficiency, hepatic MFO enzyme induction and reduced resistance to microbial infections (Bernhoft and Skaare, 1994). Understanding chronic non-lethal exposure effects are of primary importance since relatively low levels

of PCBs in seals may have adverse sub-lethal effects which are expressed at either the level of the individual or the community.

1.3.5.5 Toxicity Reference Value Derivation

PCB CPEC endpoint values were either: 1) residue levels in tissues of healthy adults seals which exhibited no obvious adverse exposure effects, or 2) reported dose-response relationships from laboratory investigations. The approach and rationale was consistent with that described earlier for reptile target receptors (Section 1.3.2.5). Guidelines for toxicological endpoint value selection for TRV derivation was as follows:

1) Priority was given to an endpoint value for reproductive impairment in harbour for total PCBs and this value was selected to represent Aroclors 1254 and 1260. Second priority was given to tissue levels associated with no observed adverse effects in healthy individuals. Metabolically active organ tissue (liver) was selected over tissue residue levels reported in blubber (adipose), brain or other organs. The highest available reported tissue levels were selected to best represent a no-observable-effects threshold.
2) Diortho-substituted congeners which did not have endpoint values available from the literature (PCBs 195, 206 and 209) were assigned the PCB 180 value, since it was lowest of the diortho-substituted congeners.
3) Lower molecular weight PCB CPECs for which there was no endpoint value available were assigned an endpoint from a PCB congener with a similar chlorine substitution number and pattern. Hence, the PCB 52 endpoint value was used to represent PCB 18, that for PCB 28 was used to represent PCB 8, and that for PCB 44 was used to represent PCB 66.

1.4 Population / Community Effects

No reports were found describing studies designed with the expressed objective of determining exposure-effects levels of PCBs on wildlife at the population level. The ability to analyze effects of toxic compounds in wildlife populations is hindered by the complexities of ecological interactions and the environmental dynamics which regulate biological responses to chemical exposure.

Several reports on colonial fish-eating waterbird species have addressed population effects as a function of reproductive impairment from organochlorine exposure, which in turn results in bird population decreases (Giesy et. al., 1994, and citations within). However, in most cases reproductive impairment is an effect of exposure to organochlorine mixtures, and specific adverse effects (egg-shell thinning, embryonic deformities, reduced growth and fitness) cannot be attributed to an individual compound. One study cited PCBs as the causative agent in a 75% decrease in hatchability in a Forster's tern colony. However, pesticides and dioxins were also detected in tissue and egg samples, suggesting that additive or synergistic effects of other chemicals are contributing causative factors (Kubiak et. al., 1989).

Declines in common seal populations of the Dutch Wadden Sea due to reproductive failure were conclusively attributed to PCB ingestion from contaminated fish. Populations from a reference area were exposed to significantly lower PCB levels from their food sources and did not undergo a decline in size (Reijnders, 1986). Dead or moribund seals found during a viral epidemic in England were found to have higher than average PCB levels in blubber tissues. Although death was not attributed to chemical toxicity, it suggests possible increased susceptibility to diseases (immunosuppression), which in turn will have adverse population effects (Bernhoft and Skaare, 1994).

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2.0 POLYCYCLIC AROMATIC HYDROCARBONS

2.1 Physicochemical Properties

Polycyclic aromatic hydrocarbons (PAH), also referred to as polynuclear aromatic hydrocarbons (PNA), are aromatic hydrocarbons comprised of multiple fused hydrocarbon rings. PAHs range in size and composition from two (naphthalene) to seven (coronene) rings. They exist as unsubstituted rings, or they may have substituted moieties, such as methyl groups, nitrogen, sulfur and oxygen. They generally have low solubility in water, high melting and boiling points, and low vapor pressure. The mobility (i.e. lower solubility and vapor pressure) of PAHs tends to decrease as the molecular weight increases. PAHs of different molecular weights differ accordingly in environmental persistence, metabolic fate, and biological activity (Albers, 1995; Harvey, 1991).

2.2 Environmental Transport and Distribution

PAH production results from pyrolytic breakdown of organic compounds. Atmospheric sources are mostly from industrial combustion, vehicle emmissions and refuse burning. Concentrations in urban and industrial areas are 10-100 times higher than in non-urban areas. Agricultural burning and natural forest and prairie fires contribute a lesser, yet still significant, proportion of total input. Under natural conditions there is a global balance between natural production and degradation (by photodegradation and biological transformation) of PAHs. However, with increased industrial production and reliance on petroleum products, and increased agricultural burning worldwide, PAH production has in the several decades greatly exceeded elimination (Suess, 1976).

Airborne PAHs are generally associated with particulate matter and can thus be dispersed great distances from emmission sources. In addition, they may be scoured from the atmosphere by rainfall, providing a mechanism for chemical distribution in both terrestrial and aquatic systems. Atmospheric deposition is a major input source of PAHs in freshwater and marine systems, although the primary source in aquatic systems may be spillage of petroleum products(Eisler, 1987). Other sources to aquatic systems include runoff from polluted ground sources and industrial and municipal effluent discharges. There are significant regional variations in PAH levels in aquatic environments based on the proximity to sites of deposition, including rivers, estuaries and human population centers (Neff, 1979). PAHs introduced into aquatic systems become associated with particulates and sediments, and then enter the food chain by being taken up by plankton, aquatic plants and fauna. PAHs can be taken up systemically by the target receptor through inhalation, ingestion and dermal exposure.

2.3 Individual Effects

2.3.1 General Toxicology

Low molecular weight PAH species are of major environmental concern because they have greater mobility. Higher molecular weight PAHs tend to have extremely low solubility and volatility and are thus comparatively immobile. The toxicity of PAHs in water tends to increase up to molecular weight 202, above which immobility generally reduces potential environmental concentrations to sublethal levels (Albers, 1995). Transport pathways in aquatic systems include volatilization, solubilization, chemical oxidation, biological transformation, association with particulates or sediments, or bioaccumulation in biotic tissues. PAHs associate strongly with sediments due to their hydrophobicity (high K_{ow} and high K_{oc}). PAH degradation in aquatic sediments generally occurs much slower than in the atmosphere due to the relatively low-oxygen

environment and low levels of penetrating radiation (Suess, 1976). As a result, PAH bioavailability from sediments is a major source of entry into the aquatic food chain.

PAH levels reported in various lower marine organisms indicate that these receptors readily bioaccumulate low environmental PAH concentrations (Suess, 1976). Bioaccumulation of PAHs in organisms is generally a result of an inability to metabolize or depurate the compounds. Non-metabolized PAHs tend to sequester in the lipid fraction of tissues and organs due to their lipophilic properties, and higher molecular weight PAHs tend to bioaccumulate to higher concentrations. Depuration is a species- and chemical-specific process which can vary in time frame from rapid (hours or days) to very slow (years). Metabolism studies in wildlife species have been restricted to lower aquatic organisms (including fishes), so applications to higher species must be considered speculative.

Toxic effects of PAHs can be initiated by either unmetabolized PAHs or pharmacologically active PAH metabolites. Acute toxicity of some PAHs involve impairment of cellular membrane and enzyme functions. PAH toxicity is largely dependent on the molecular weight, ring number and degree of substitution. Unsubstituted, low molecular weight (i.e. two or three ring) compounds tend to have higher acute toxicity, but are non-carcinogenic. Higher molecular weight and more highly substituted PAHs (four or more rings) are less acutely toxic, but have been demonstrated to be carcinogenic or teratogenic to animals of all taxonomic groups. Carcinogenesis is initiated when metabolites formed from oxidation of PAHs react with cellular DNA or proteins and disrupt cellular functions (Eisler, 1987). The main elimination pathways are the hepatobiliary system and the gastrointestinal system. The hepatic mixed function oxidase (MFO) enzyme system metabolizes PAHs to water-soluble compounds for excretion. It is these intermediate metabolites which may be mutagenic or carcinogenic. It

is generally agreed that PAH-induced carcinogenesis is initiated by metabolic activation of the MFO system (Neff, 1979).

There have been few studies on individual PAH exposure to wildlife species. Although many of the PAHs have been individually tested in various studies, the majority of studies have focused on dose-response relationships of one compound, benzo(a)pyrene, since it is considered the most potent carcinogen of the chemical class. Most exposure studies to higher vertebrates have involved oral or dermal administration trials in laboratory rodents. Acute effects observed from PAH exposure by oral ingestion include reproductive and developmental impairments, hepatomegaly, gastrointestinal tumors (carcinomas) and blood disorders. Acute dermal exposures to PAH compounds include dermal hypersensitivity, increased melanocyte production and dermal cell death. Chronic oral exposure effects in laboratory test animals test include gastrointestinal and laryngeal tumors, aplastic anemia, blood disorders, reproductive and developmental impairment. Chronic dermal exposure results in increased melanocyte production, skin tumors and epidermal cell carcinomas (Eisler, 1987; ATSDR, 1993).

2.3.2 Aquatic Invertebrates and Fish

PAH bioaccumulation in aquatic organisms is a function of the inability to metabolize individual compounds. Some fish and bivalves accumulate high levels of PAHs due to their inability to metabolize parent compounds into excretable products, and it has been suggested that this is due to inefficient or absent mixed function oxidase systems (Sirota and Uthe, 1981). Elevated PAH levels in aquatic organisms have been reported in the vicinity of human activity. High levels of benzo(a)anthracene, pyrene, chrysene and other PAH compounds were measured in oyster tissue in the vicinity of boat marinas, and levels tended to be higher still during cooler months, presumably when lipids were being stored (Marcus and Stokes, 1985). In mussels, the lower molecular weight PAHs were

reported to bioaccumulate one to two orders of magnitude higher than higher molecular weight compounds (Mix and Schaefer, 1983). Clams exposed to mixtures PAH compounds demonstrated depuration of 3- and 4-ring compounds and persistent accumulation of the 5-, 6- and 7-ring compounds when placed in clean water for 24 hours (Mix, 1982). American lobster has been demonstrated to bioaccumulate total PAHs as high as 88 mg/kg in hepatopancreas and 2.67 mg/kg in the (edible) tail muscle. These values were reported for animals captured in the vicinity of a coking plant; PAH levels in control lobsters were measured at 1.2 mg/kg in hepatopancreas and 0.2 mg/kg in muscle (Sirota and Uthe, 1981).

PAH bioaccumulation in fish is generally low due to the ability to rapidly transform, metabolize or excrete PAH compounds. High levels of PAHs in tissues of fish correlated positively with sediments heavily contaminated with PAHs (Black et. al., 1981). No carcinogenic effects on fish populations have been directly linked to PAH toxicity, higher incidences of tumors and tissue hyperplasia has been reported in areas of heavy PAH contamination (Baumann et. al., 1982). Chemical-exposure ecological exposure effects have been demonstrated with in which low levels of dissolved fluorene were demonstrated to remain stable in bottom sediments for extended periods of time. Studies with fingerling bluegill demonstrated these levels of dissolved fluorene caused adverse behavioral effects in capturing prey and eluding predators (Eisler, 1987, and references within). Bottomfish such as sole and catfish have been demonstrated to rapidly metabolize benzo(a)pyrene, however high levels of reactive metabolites have been detected in livers of these species. These metabolites have been implicated as mutagenic and carcinogenic agents in mammalian systems (Varanasi and Gmur, 1981). These findings are consistent reports of liver tumors in brown bullheads, hagfish, sole and tomcod in association with PAH-contaminated sediments (Bauman et. al., 1982).

Toxicity Reference Values (TRV) for the PAHs are the National Ambient Water Quality Criteria (NAWQC) derived by USEPA for the protection of wildlife (Suter et. al., 1992; USEPA, 1986)(Table 21-1). The NAWQC represents ambient CPEC levels in water which result in no adverse impacts on wildlife which consume, feed from , contact or otherwise interact with waters of an aquatic system (USEPA, 1986). In the absence of applicable dose-response data for representative prey species, and in recognition of the potential variation in toxicological response to PAH exposure by different marine organisms, they were selected as TRVs in order to establish a conservative threshold for PAH exposure evaluation.

TRVs were selected for the PAHs in aquatic organisms as follows:

1) Available NAWQC values were selected from Suter et. al., 1992 or USEPA,1986.
2) Isomers of parent PAH compounds for which their were no NAWQC values available were assigned the NAWQC available for the parent compound (e.g. NAWQC for fluoranthene was used as a surrogate for all alkyl-substituted fluoranthene compounds).
3) The NAWQC for benzo(a)pyrene (1.3e-06 mg/L; Suter et. al., 1992) was used a surrogate for unavailable PAH NAWQC. Since benzo(a)pyrene is the most toxic of the PAH compounds, it was used in order to maintain a conservative toxicity effects threshold.

2.3.3 Reptiles

There is a paucity of available information on PAH intake, body burdens or effects in wildlife or laboratory specimens.

2.3.3.1 Exposure Routes

Target receptor (green turtle) exposure to PAHs is most likely through oral ingestion or absorption across dermal surfaces. Algae and aquatic vascular plants constitute the majority of the green turtle diet. Some PAH compounds accumulate readily in aquatic plant tissues due to the inability of plants to metabolize PAHs, and accumulation can also be related to the lipid fraction and surface area of the plant. PAH bioavailability to turtles is primarily a result of ingesting PAH-laden aquatic plants and algae. To a lesser extent than ingestion, exposure by dermal absorption can occur from direct contact with contaminated soil and sediment, or immersion in contaminated water.

2.3.3.2 Metabolism

There is very little information available on toxicologically-induced adverse effects of PAHs in reptilian systems. Studies have demonstrated the metabolic transformation of PAH compounds by MFO activity in livers of the garter snake and alligator (Schwenn and Mannering, 1982; Jewell et. al., 1989), and one report demonstrated that mutagenic metabolite formation is activated by PAH induction of the alligator MFO system (Kirchin and Winston, (1992).

2.3.3.3 Acute Effects

There is no available information on adverse acute effects of PAHs in reptiles.

2.3.3.4 Chronic Effects

There is no available information on adverse chronic effects of PAHs in reptiles. As stated above, it was demonstrated that mutagenic metabolites were produced from hepatic

MFO enzyme activity in laboratory reptile studies (Kirchin and Winston, 1992). It can be speculated that these mutagens may produce chronic adverse effects given high exposure concentrations and/or over prolonged exposure periods.

2.3.3.5 Toxicity Reference Value Derivation

There were no formally-derived toxicity endpoints (e.g. NOAEL, LD_{50}) reported for PAH exposure in reptiles to derive TRVs for the reptile target receptor (green turtle). PAH TRVs for green turtles were derived from the reported levels of 3-methylcholanthrene which resulted in MFO enzyme induction in alligator liver, but otherwise no observable adverse effects (Jewell et. al., 1989). The no-effects levels reported here were used as surrogates for no-observed-effect doses, and these levels were used to derive TRVs based on the assumptions and rationale discussed in Section 1.3.2.5. Although 3-methylcholanthrene is not listed as a PAH CPEC for this assessment, it is representative because it is a strongly carcinogenic PAH, in the same class as benzo(a)pyrene and dibenz(a,h)anthracene. (Eisler, 1987). Given the lack of information for other PAH compounds, 3-methylcholanthrene was selected to represent all PAHs to maintain a conservative estimate of exposure-response levels.

2.3.4 Birds

There are no published reports detailing PAH toxicity in seabirds. Reports are available on toxicity endpoints for some PAH compounds for mallard ducks and several passerine bird species (Eisler, 1987; Schafer et. al., 1983).

2.3.4.1 Exposure Routes

PAHs are hydrophobic compounds, which tend to associate with carbon fractions of soils or lipid fractions of biotic systems. Exposure routes of PAHs to seabird target receptors may include one or more of the following: dietary ingestion of contaminated prey items or water; incidental ingestion of contaminated soil; and dermal absorption by direct contact with contaminated soil. PAHs have been reported to readily bioaccumulate to high levels in the tissues of potential prey items including crustaceans, molluscs and fishes, thus providing a major exposure pathway. Foraging birds can be subject to incidental ingestion from contaminated soil, while burrowing and nesting birds may come in direct dermal contact with contaminated soils. Wading and floating birds may come into dermal contact from contaminated waters, but this is thought to be a relatively insignificant exposure route.

2.3.4.2 Metabolism

Although there is little specific information on metabolism of PAHs in avian species, it may be speculated that similar metabolic pathways occur in birds as have been reported in other animal classes. It has been suggested that mallard embryos contain microsomal enzymes which may generate more highly toxic metabolites than tissues of adult birds. This is consistent with the observation that low levels of PAHs result in mallard embryotoxicity while PAH exposures create no adverse effects in adults (Eisler, 1987).

2.3.4.3 Acute Effects

There are no reports of acute biological effects of PAHs in seabirds. Single topical doses of PAH compounds (benzo(a)pyrene and 7,12-dimethylbenz(a)anthracene) to mallard eggs resulted in a variety of sublethal and lethal effects, including developmental

impairments, growth reduction and reduced hatching success (Eisler, 1987). LD_{50} values for some PAH compounds in passerine birds are listed in Table 21.1.

2.3.4.4 Chronic Effects

There are no published reports of chronic effects of PAHs in seabirds. Chronic oral exposure of PAH mixtures to adult mallards (4,000 mg/kg for seven months) resulted in increased liver metabolism and liver enlargement, but no other observable adverse effects (Eisler, 1987).

2.3.4.5 Toxicity Reference Value Derivation

No toxicological data are available specifically for PAHs in aquatic fish-eating birds. A limited number of reported avian exposure endpoint values were available to derive PAH TRVs for avian target receptors. In selecting endpoint values for TRV derivation, priority was given to laboratory dose-response studies for avian species. Median lethal dose (LD_{50}) endpoint values were available for total PAHs for mallard duck (Eisler, 1987) and for several individual PAH compounds in passerine birds (Schafer et. al., 1983). TRVs for the remaining PAH compounds were derived from mammal laboratory test endpoint values, with application of an appropriate uncertainty factor, shown in Table 21.1 and discussed in Section 4.3.2.2.

2.3.5 Marine Mammals

There is a general lack of information on exposure and effects of PAHs in marine mammal systems. Given the importance of PAHs as a contributor to toxicity and carcinogenicity in wildlife populations, concern has been expressed in the scientific community over the need to research effects and effect levels of PAHs in the wild, and

especially in marine ecosystems (Hellou et. al., 1990; Hellou et. al., 1991; Law and Whinett, 1992). To date, only a few studies have profiled the presence and levels of multiple PAH compounds in tissues of marine mammals. One study presents levels of PAHs in tissues of various seals, whales and delphinids yet it is of limited value since PAH levels are presented as chrysene toxicity equivalents rather than absolute PAH levels (Hellou et. al., 1990). Chrysene equivalents may not serve as an accurate standard for ecotoxicological objectives, due to the wide range of acute toxic effects associated with PAH exposure.

2.3.5.1 Exposure Routes

PAHs readily bioaccumulate in the tissues of fish, molluscs and crustaceans, which are the primary prey items of marine mammals. The primary exposure route to the target receptors of concern (seals) is probably ingestion of contaminated food items. Dermal contact through immersion in contaminated waters exposes marine mammals to hydrocarbons and PAHs from petroleum; seals may also come in contact with contaminated soil during haul-out periods. In general, however, dermal contact was judged a relatively insignificant exposure pathway.

2.3.5.2 Metabolism

No studies have focused directly on metabolic pathways for PAHs in marine mammals. The most probable elimination pathways are likely the same as those reported for other mammalian species (Eisler, 1987, and citations within). Primary elimination pathways include direct elimination from the gastrointestinal system, enzymatic transformation and elimination of metabolites, accumulation of unchanged compounds and accumulation of transformed metabolites. Current data are available only on accumulated levels of unchanged compounds in body tissues.

2.3.5.3 Acute Exposure

There are no reports of acute exposure effects of PAHs on marine mammals. Acute petroleum exposure experiments have been performed with seal species (Englehardt, 1983). However, the complex chemical mixtures in petroleum, only a small fraction of which are pure PAH compounds, make it difficult to directly estimate acute biological response to PAH compounds.

2.3.5.4 Chronic Exposure

No reports have directly addressed chronic toxicity from exposure to PAH compounds in marine mammals. Martineau et. al., (1988) reported benzo(a)pyrene adducts of DNA in brain tissue of beluga whales, and benzo(a)pyrene was implicated as a causative factor for tumors in tissues of the whales. However, no tissue levels were reported to further quantify the relationship, or to assess the contribution of benzo(a)pyrene or any other PAHs to tumorogenesis. It can be speculated that long-term exposure effects expressed in marine mammals would parallel those which have been reported for laboratory animals.

2.3.5.5 Toxicity Reference Value Derivation

Few toxicological endpoint values were available for marine mammal species. Table 21.1 presents levels of various PAH compounds which were reported in muscle tissues of porpoises displaying no obvious adverse effects at time of capture and tissue sampling (Law and Whinnett, 1992). For most PAHs, toxicological endpoint values were derived from laboratory mammal studies. The approach and rationale for TRV derivation from tissue levels and experimental dose-response endpoint values was consistent with that described earlier for PCBs (Section 1.3.2.5) and discussed in Section 4.3.2.2. Guidelines for TRV derivation were as follows:

1) Available porpoise tissue PAH levels were selected as endpoint values to derive TRVs for those PAH CPECs.
2) PAH CPEC endpoint values not available as porpoise tissue levels were selected from laboratory rodent studies. Where possible, NOAEL endpoint values were given priority. If no NOAEL endpoint was available for a particular CPEC, priority was given first to LOAEL and then to LD_{50} endpoints.
3) If no laboratory rodent or other mammal endpoint value was available for a PAH CPEC, endpoint values were adopted from avian exposure studies using appropriate uncertainty factors presented in Section 4.3.2.2.

2.4 Population and Community Effects

There was no available information in the reviewed literature on the effects of PAHs on the selected target receptors at the population and community levels.

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3.0 ORGANOCHLORINE PESTICIDES (OCPs)

3.1 Chemical Categories

There are five chemical groupings of organochlorine pesticides (OCP) based on molecular structure. These groupings are notably different from each other structurally, so it is difficult to generalize physicochemical effects and toxicity of OCPs as a chemical species. Four of the chemical groupings are relevant to this assessment: 1) DDT and its analogs or metabolites; 2) benzene hexachlorides (BHCs; commonly referred to as hexachlorocyclohexanes [HCHs]); 3) cyclodienes (chlordanes, endosulfans, endrin, etc.); and 4) caged structures (mirex and photomirex).

3.2 Environmental Transport and Distribution

Environmental persistence, toxicity and bioaccumulation of OCPs are quite variable and, in addition to chemical specificity, are dependent on species-specific parameters (i.e. sex, life history, etc.), mixtures with other chemicals, and other physical or environmental factors. All organochlorines, however, are lipophilic and tend to sequester or accumulate in the lipid fraction of tissues and organs. Temporal trends in DDT and PCB levels demonstrate that usage has dropped in the mid-latitude northern countries, presumably in response to the bans and restrictions. Although restricted or banned in the northern industrialized countries, OCPs and PCBs, are still in use in low-latitude, developing countries of the equatorial regions and the Southern Hemisphere. This is reflected in the comparatively high levels of these compounds associated with oceanic air and water samples from regions proximal to India, China, Indochina and Indonesia (Iwata et. al., 1993). This trend was predicted some 20 years ago for DDT in what was termed a 'southward tilt', a marked and observable transition in the production and usage of pesticides from developed to undeveloped countries, most of which are located in the

tropics and subtropics (Goldberg, 1975). This trend in usage would result in a concomitant temporal shift in contaminant levels from the mid-latitudes to the low-latitude tropics. Iwata et. al. (1993) and other investigators (Bidleman and Leonald, 1982; Bidleman et. al., 1981; Tanabe et. al., 1982; Tanabe et.al., 1983) have demonstrated a temporal southward trend in elevated environmental contaminant levels of several organochlorine compounds, including DDT.

Surveys involving collection and analysis of air and water samples to measure organochlorine content (OCPs and PCBs) have been conducted in order to characterize the comparative roles of oceanic air and surface water in global distribution of contaminants (Iwata et. al., 1993; refer to Section 1.2). OCP and PCB levels were measured in air and water samples collected simultaneously at sites in the Bering Sea, Gulf of Alaska, North Pacific, China Sea, Bay of Bengal, North Atlantic, Mediterranean Sea, Indian Ocean and Southern Ocean (South Pacific) in 1989-1990. There was generally a positive correlation between air and seawater sample levels for most of the organochlorines. On a global scale, HCHs were reported to be the most abundant and widely distributed of the organochlorines. PCBs were widely distributed but in comparatively smaller concentrations than HCHs, and DDT was both distributed less and present in lower concentrations than the HCHs.

Depending on the chemical-specific characteristics of the compound, exposure to wildlife occurs primarily by ingestion, dermal contact or respiration.. Persistence and metabolism of OCPs vary widely from group to group. While some pesticides are quick to metabolize once taken up by an organism, their metabolites may be both persistent and toxic. Examples include heptachlor and aldrin, and their metabolites heptachlor epoxide and dieldrin. Some OCP metabolites are present and toxic in one animal class but rarely found in another. For pesticide compounds which do not metabolize rapidly, the levels of bioaccumulation can be quite high. Fish-eating birds (herring gull and brown pelican)

have been reported to have tissue and egg OCP levels of 30 to 100 times that of prey items (Blus et. al., 1977).

3.3 Individual Effects

3.3.1 General Toxicology

OCPs are neurotoxic agents, affecting either the ion permeability of the axon or mimicing binding substrates of nerve receptors (Matsumura, 1985). As with other organochlorines, some OCPs induce hepatic mixed function oxidase enzyme activity. The extent of induction and metabolic efficiency of the liver varies from species to species, affecting both persistence and toxic effects of the compounds. OCPs including DDT analogs and the cyclodienes affect hormonal activity in test animals. The breakdown by DDT and DDE of sex hormones which mobilize calcium is the mechanism responsible for eggshell thinning in wild bird populations (Peakall, 1967). Other reported adverse effects involve thyroid and adrenal function, immunosuppression, and pathological hepatic conditions (Blus, 1995; Dikshith, 1991).

Wildlife are often exposed to mixtures of organochlorines, complicating the correlation of adverse effects with specific chemical compounds. Additive, synergistic or antagonistic effects may result from multiple chemical exposure. However, some benchmark effects can be associated with high exposure to certain contaminants, the most notable of which is eggshell thinning correlated with high DDT or DDE levels. Dirksen et. al. (1994) summarized low breeding success in organochlorine-contaminated cormorant colonies as a consequence of several factors resulting in high embryonic mortality. High levels of DDE were correlated specifically with eggshell thinning, and high levels of PCBs were correlated with other developmental and reproductive impairments. Conversely, some adverse effects are common among different chemical species. Hepatic MFO induction

and pathomorphological changes have been attributed to OCP compounds from each chemical grouping, as well as the PAHs and PCBs (Dikshith, 1991).

DDT and Analogs (DDE, DDD and methoxyclor): DDT is transformed through microbial and enzymatic pathways in animal tissues to toxic metabolites, with the capacity for transformation varying from species to species (Dikshith, 1991). At high acute and chronic doses, DDT is a potent neurotoxin and has been implicated in population die-offs of wildlife, most notably in birds. (Blus, 1995, and citations within). In low-level, long-term exposures, DDT is implicated in reproductive failure leading to population decline in some wildlife species. DDD and DDE are separate analogs of DDT which are formed from DDT through metabolic pathways. High levels of DDE have been recently implicated in egg shell thinning in several different contaminated aquatic bird colonies (Kubiak et. al., 1989; Harris et. al., 1993), although toxicity from DDT and its metabolites has been recognized in bird and other wildlife populations since the early 1960s. DDT effects have been implicated in overall reproductive failure in many species of fish-eating and raptorial birds, including the double-crested cormorant, osprey, bald eagle, brown pelican, common loon and many others (Blus, 1995, and citations within). It is widely held that DDT burdens are accumulated in tissues of birds and other wildlife through ingestion of contaminated prey.

3.3.1.2 Benzene hexachloride (BHC)

BHC, more commonly known as hexachlorocyclohexane (HCH), is an organochlorine compound with a cyclic chair-conformation. The three isomers of interest are alpha-, beta- and gamma-BHC (lindane). Compared to DDT, BHC is less persistent in the body because it is rapidly metabolized to excretable metabolites, and therefore represents less of a biological hazard. BHC has a relatively short half-life in tissues and eggs compared to other organochlorine pesticides (Cummings et. al., 1966). To date, BHC (lindane) has

not been implicated in any population declines, and it has been reported that residues do not readily bioaccumulate in the food chain (Blus et. al., 1985). In high concentration applications, however, lindane has been demonstrated to increase embryonic mortality and eggshell thinning in birds (Sauter and Steele, 1972).

Acute toxic effects of BHC are primarily neurotoxic and hepatotoxic. However, tumorigenic and hepatocarcinogenic effects from prolonged exposure to BHC has been reported, and also disruption to steroidogenic enzyme activity (Dikshith, 1991).

Cyclodienes: The cyclodienes of interest include chlordane, heptachlor, trans-nonachlor, aldrin, dieldrin, endrin and endosulfan. Some of the compounds are rapidly metabolized to isomers which become the toxic agent. Aldrin is metabolized to dieldrin, endrin is a metabolite of isodrin, and heptachlor is metabolized to heptachlor epoxide.

Aldrin and dieldrin are highly toxic and have been implicated in incidental wildlife mortality related to agricultural application. These include adults and eggs of ring-necked pheasants, bald eagles, golden eagles, pelicans, herons, falcons and various terrestrial mammals, including bats (Blus, 1995, and citations within). The high acute toxicity of aldrin and dieldrin is demonstrated by the fact that population declines associated with these toxic episodes were often related to adult die-off, rather than reproductive failure. Chronic dieldrin exposure results in induced hepatic MFO enzyme activity, hepatomegaly and other hepatotoxic effects (Dikshith, 1991).

Endrin is considered the most acutely toxic organochlorine pesticide. Levels of endrin in brains of pelicans whose death was attributed to endrin toxicity were approximately 8 ppm. Endrin toxicity has been implicated in the deaths of other terrestrial mammalian and avian species in relation to agricultural applications. The chemical is rapidly degraded

and dissipated in nature, so incidents of wildlife mortality have quickly declined after discontinued usage.

Heptachlor was once a widely used pesticide which was gradually phased out in the early 1980's. As with other cyclodienes, it has been implicated in the deaths of terrestrial birds and mammals in relation to agricultural applications. Heptachlor has been demonstrated to biomagnify through the food chain in cases where carnivorous mammals and birds demonstrated mortality in response to eating prey which had ingested heptachlor-contaminated seed (Henny et. al., 1983; Blackmore, 1963).

Mirex and photomirex: Mirex has been used as an insecticide to replace the banned pesticides dieldrin and heptachlor. Mirex has also been used as an industrial fire retardant. Photomirex is a natural degradation product of the mirex parent compound. Mirex has been reported to bioaccumulate in systems of mammal and bird wildlife species (Eisler, 1985). Mirex metabolism is only partial in animal systems, and as a result is implicated in chronic adverse effects in wildlife. It accumulates as a parent compound in fat, muscle, liver and kidney. Chronic exposure to mirex results in hepatomegaly and hepatobiliary misfunction. Acute exposure results in fatty buildup and glycogen depletion in the liver. It has also been demonstrated to produce morphological changes in the thyroid gland (Dikshith, 1991).

3.3.2 Aquatic Invertebrates and Fish

Organoclorine pesticides are lipophilic and tend to accumulate in the lipid fraction of tissues and organs of aquatic organisms. Bioconcentration of organochlorine pesticides in tissues of aquatic organisms is reported to be in the range of five to six orders of magnitude greater than ambient water concentrations (Blus et. al., 1995, and references within). Some evidence suggests food intake is not the primary source of OCP body

burden in aquatic invertebrates and in some fish, as it is in higher trophic consumers and in terrestrial organisms (Moriarity, 1990).

Some OCPs bioaccumulate not as the parent compound in animal tissues, but as metabolites or natural degradation products. However, metabolites are generally as toxic, or nearly as toxic, as the parent compound. DDT accumulates rapidly in tissues of invertebrates, up to thousands of times of ambient exposure levels, and is metabolized to DDE. LC_{50} values for DDT have been reported to range form 0.2 to 7.4 ug/L in various test invertebrates including insects (larvae), amphipods, decapods, isopods, shrimp and crayfish (Johnson and Finley, 1980). DDT LC_{50} values for various sportfish (bass, trout, pike, catfish, bluegill, perch) were reported to range from 1.5 to 21.5 ug/L. By contrast DDE LC_{50}s in sportfish have been reported to range from 32 - 240 ug/L. Some increase in DDT toxicity to bluegill was correlated with increase in ambient temperature. High bioaccumulation of DDT was indicative cumulative toxicity indices of 90 for channel catfish and 250 for bluegill.

The cyclodiene compounds generally demonstrate greater toxicity to aquatic organisms than other OCP compound classes. LC50 values for endrin, perhaps the most toxic of all OCPs, was reported to range from 0.2 to 5 ug/L in most invertebrate test organisms, although values as high as 62 ug/L were reported for some insect larvae. LC_{50} values for sportfish were reported 0.15 to 1.1 ug/L. Bioaccumulation of endrin in fish was reported to be 400 to 2,000 times as high as ambient water concentrations (Johnson and Finley, 1980). Dieldrin is also toxic to fish in low ambient water concentrations. LC_{50} values for sportfish generally ranged from 1.2 to 11 ug/L, however a value of 19 ug/L was reported for the channel catfish. Some test invertebrates (daphnids, amphipods, crayfish) were comparatively resistant to dieldrin toxicity, with reported LC_{50}s ranging from 240 to 740 ug/L (Johnson and Finley et. al., 1980). Invertebrates were reported to bioconcentrate dieldrin two to three orders of magnitude of the ambient water concentrations.

Invertebrate test species were not as sensitive to aldrin as they are to the other highly toxic cyclodienes. Reported LC_{50} values ranged from 18 to 50 ug/L for daphnids and shrimp, but were as high as 4,300 for amphipods. Insect larvae (midge and mayfly) and daphnids were reported to bioconcentrate low concentration of aldrin (16 ug/L) 23,000 and 100,000 times ambient levels (Johnson and Finley, 1980). Aldrin toxicity to fish was approximately on the same order as for dieldrin, with reported LC_{50}s in sportfish ranging from 2.6 to 14.3 ug/L. The LC_{50} for the channel catfish, however, was comparatively high at 53 ug/L.

Mirex does not present a toxic threat to fishes and invertebrates to the same degree as the cyclodienes and DDT. Aquatic organisms are comparatively resistant to acute or short term mirex toxicity. LC_{50} values were not obtained at concentrations less than 1,000 for invertebrates (daphnids, amphipods and insects) and 100,000 for sportfish (perch, trout and bluegill) (Johnson and Finley, 1980). Delayed mortality was demonstrated in crayfish after extended periods of low mirex concentration (1.0 - 5.0 ug/L)(Eisler, 1985). Mirex toxicity is generally from to chronic exposure since it is only partly metabolized and not rapidly eliminated (Norstrom et. al., 1978). Invertebrates and fish have been reported to bioconcentrate mirex two to four orders of magnitude of the ambient water concentrations (Eisler, 1985, and references within).

Toxicity Reference Values (TRV) for the organochlorine pesticides are National Ambient Water Quality Criteria (NAWQC) derived by USEPA for the protection of wildlife (Suter et. al., 1992; USEPA, 1986)(Table 21-1). The NAWQC represents ambient CPEC levels in water which result in no adverse impacts on wildlife which consume, feed from , contact or otherwise interact with waters of an aquatic system (USEPA, 1986). In the absence of applicable dose-response data for representative prey species, and in recognition of the potential variation in toxicological response to OCP exposure by

different marine organisms, they were selected as TRVs in order to maintain a conservative threshold for OCP exposure evaluation.

TRVs were selected for OCP exposure in aquatic organisms as follows:

1) Available NAWQC values were selected from Suter et. al., 1992 or USEPA,1986.
2) Isomers, metabolites or products of OCP compounds for which their were no NAWQC values available were assigned the NAWQC available for the parent compound (e.g. NAWQC for heptachlor was used as a surrogate for heptachlor epoxide, and NAWQC for mirex was a surrogate for photomirex).

3.3.3 Reptiles

Few studies have been conducted on organochlorine pesticide exposure to the reptilian target receptor (green turtle) or similar sea turtle species. McKim and Johnson (1983) reported DDE levels in liver and muscle of green and loggerhead turtles. They reported no adverse exposure effects in response to liver DDE levels of 0.01 mg/kg. Thompson et. al., (1974) reported that total organochlorine levels in green and loggerhead embryos had no deleterious effects on reproductive success.

Several studies have reported OCP levels (DDT and analogs, cyclodienes, BHC and mirex) in tissues of snapping turtles and other terrestrial reptiles including snakes and lizards (Albers et. al., 1986; Bishop et. al., 1994; Niethammer et. al., 1984; Punzo et. al., 1979). Albers et. al., (1986) were unable to correlate growth in snapping turtles to organochlorine and metals exposure levels. Bishop et. al., (1994) concluded there was no correlation between organochlorine levels in eggs and clutch size or age of the mother turtle.

3.3.3.1 Exposure Routes

Organochlorine pesticide exposure to the green turtle is through ingestion of contaminated food items. However, the herbivorous feeding habits of the green turtle probably limit the intake and bioaccumulation of persistent OCPs (DDE, dieldrin, chlordanes) in turtle tissues, since these compounds do not biomagnify in plant tissues to the high levels observed in fish and shellfish. Although no data is available relating OCP levels in plant tissues to uptake by turtles, McKim and Johnson (1983) suggested that low DDE concentrations in turtle tissues reflect low rates of chemical accumulation in plants.

3.3.3.2 Metabolism

There is little information available on metabolic processes of organochlorine pesticides in turtle or other reptilian systems. Levels of DDT and DDT metabolites were measured in the tissues of representative species from several levels of the food web in a freshwater lake (Niethammer et. al., 1984). Two snake species, the cottonmouth and water snake, were observed to contain high residue levels of DDE (41 mg/kg), toxaphene (10 mg/kg) and dieldrin (0.10mg/kg) in their tissues, which compared to residue levels in other high-level consumers such as fish-eating birds. Stafford et. al., (1976) reported species-specific differences in levels of hepatic detoxifying enzymes between the two snake species. These observations suggest that diet, trophicism and species-specific physiology contribute to chemical bioaccumulation in reptiles. Bishop et. al., (1994) concluded that physiological and ecological factors such as prey selection, feeding location and food metabolism were determining factors in egg OCP accumulation in snapping turtles, rather than size or age of the parent.

3.3.3.3 Acute Effects

No reports on adverse effects of acute exposure to organochlorine pesticides by reptiles were reported in the reviewed literature. Albers et. al., (1986) examined blood chemistry parameters as indicators of impaired metabolism in snapping turtles taken from several sites contaminated with organochlorines (including DDT, DDT metabolites and several cyclodiene congeners) and compared them to blood profiles in turtles taken from relatively uncontaminated sites. They reported no indications of physiological impairment related to organochlorine exposure levels (PCBs, DDT and metabolites, dieldrin and chlordanes) up to ten times the levels in reference animals.

3.3.3.4 Chronic Effects

Several of the studies reviewed were designed to address the effects of organochlorine contaminants in brackish and freshwater aquatic organisms, including snapping turtles and other reptiles (Albers et. al., 1986; Bishop et. al., 1994; Niethammer et. al., 1984). No chronic effects were reported in reptilian species at organismal or population levels from exposure to OCPs including DDT and its metabolites, dieldrin, endrin, chlordane compounds, mirex and BHC (lindane). Exposure to organochlorine compounds including OCPs (oxychlordane = 9.3 mg/kg; *cis* + *trans* nonachlor = 7.5 mg/kg; ΣDDT = 2.2 mg/kg) did not alter blood chemistry parameters in snapping turtles relative to reference specimens (Albers et. al., 1986). This study speculated that these low to moderate levels of organochlorine compounds in snapping turtle tissues may contribute to reproductive impairment or other sub-lethal effects, but no support was given to this claim.

Measured levels of DDE were reported in liver and muscle of yearling green and loggerhead turtles were reported (McKim and Johnson, 1983). Neither turtle

demonstrated levels higher than 0.01 mg/kg, and no apparent exposure effects were observed. Thompson et. al., (1974) reported that observed levels of DDE and other organochlorine compounds in green turtle embryos had no adverse effects on hatching success.

3.3.3.5 Toxicity Reference Value Derivation

No standard toxicity endpoint types (LOAEL, LD_{50}, etc.) were available to evaluate reptile target receptor responses to organochlorine pesticide exposure. However, information was frequently available on tissue OCP levels that were observed to be unaccompanied by any adverse effects or toxicological responses. By conservatively assuming total assimilation and no depuration of ingested contaminants under steady-state conditions, it was estimated that a NOEL was equal to a no observed effect tissue concentration, and these "no-observed-effect" tissue concentrations were used as surrogates for no-observed-effect TRVs (as doses). This allowed calculated doses (c.f., Section 4.3.1.4 *et seq.*) to be compared to these NOEL tissue concentrations as a screen for potential effects. In the absence of formally derived effects levels, this approach provides: (a) a means to evaluate the potential for effects in little studied target receptors and (b) a way of reducing uncertainty in the risk estimate by narrowing data gaps.

Toxicity reference values (TRVs) for organochlorine pesticides in the reptile target receptor (green turtle) were predominantly derived from reported OCP tissue levels. Endpoint value selection for the OCPs were based on the following:

1) Tissue levels for green turtles or similar sea turtle species were given primary priority for TRV derivation. Second priority was given to available tissue levels for snapping turtles. In the absence of any available endpoint values for turtles, reported values for other reptilian species were selected. For OCP compounds with no available reptilian

tissue levels, TRVs were derived from avian dose-response endpoint values or tissue levels.

2) Selection priority for tissue type was given to reported tissue OCP levels in turtle liver. If liver OCP levels were not available from the literature, reported levels from an alternative metabolically active tissue were selected. Adipose tissue OCP levels were used if there were no other turtle tissue levels reported. All tissue levels for alternate reptilian species (water snake and cottonmouth) were from visceral tissue.

3) Values adopted from avian studies were the same as those selected for TRV derivation for OCP CPECs for avian target receptors (Section 3.3.4.5).

4) The same endpoint values were used to represent isomeric, metabolite or by-product OCP CPECs (endosulfan/endosulfan sulfate, endrin/endrin ketone, mirex/photomirex, heptachlor/heptachlor epoxide, BHC isomers) for TRV derivation.

3.3.4 Birds

The chronic toxicity of environmental organochlorine compounds to wildlife first became apparent in the early to mid-1960s when declining populations of raptorial and fish-eating birds were attributed to eggshell thinning from DDT and its metabolites. Populations of peregrine falcons from certain regions of Europe and the U.S. exhibited significant deficits to breeding success in comparison to populations in British Columbia and the Arctic. It was demonstrated that eggs and tissue samples from captured peregrines contained significant levels of dieldrin, DDT and PCBs (Risebrough et. al., 1968). These findings first brought attention to the issue of ubiquitous organochlorine deposits in global ecosystems and their infiltration into the food web. Over the next three decades the issue of global organochlorine contamination continued to be addressed with respect

to ambient chemical concentrations in remote regions and their potential exposure to fish, birds and mammals.

Early studies have reported levels of DDT and DDT metabolites in tissues and eggs seabird species similar to those common to the Northwestern Hawaiian Islands (Fisher, 1973; King and Lincer, 1973; Wurster and Wingate, 1967). No conclusions were drawn from these reports relating tissue levels to adverse effects of DDT on individuals or populations. However, there have been numerous reports on the adverse effects of DDT and DDE in other species of colonial, fish-eating water birds (CFEWB) and the impact of these compounds on bird populations (Harris et. al., 1993; Henny, 1977; Kubiak et. al., 1989). Wildlife exposures to organochlorine pesticides is generally not limited to single compounds, but rather to mixtures composed of multiple pesticides and PCBs. Unless significantly high levels of specific compounds are observed in a sample contaminant profile, it may be difficult to discern which compounds of a mixture are causative of the adverse effects expressed by receptors.

Organochlorine pesticide toxicity patterns in wildlife vary depending on dose level and exposure time. In comparison to other chemical insults (i.e. PCBs, PAHs and metals) which are usually accumulated slowly over time in animal systems, OCP exposure to wildlife has often been an incidental occurrence associated with agricultural or horticultural applications. In such cases, population impacts result from massive adult mortality within a short time frame as a result of acute toxic effects, in contrast to low level, long term exposures which result in reproductive impairment.

3.3.4.1 Exposure Routes

Organochlorine pesticides tend to bioaccumulate and biomagnify through the food chain, such that uptake in receptors at high trophic levels is through ingestion of contaminated

prey items. To a lesser extent birds may incidentally ingest contaminated soil, or be exposed to localized contaminated soils through nesting , burrowing or foraging behavior. High dose, short term exposures generally result from incidental ingestion of pesticides deposited on food items, soil or body surfaces.

3.3.4.2 Metabolism

Persistent OCPs are lipophilic and associate with particulate matter such as benthic and suspended sediments in the aquatic environment. At this level they become assimilated with the food chain and bioaccumulate as they move through the trophic levels. Studies on CFEWB species including the shag, cormorant and gannet demonstrated that dieldrin and DDE bioaccumulate to levels 50-fold greater than that of prey items (Robinson et. al., 1967). OCP levels have been demonstrated to biomagnify up to 100-fold in herring gull and brown pelican (Anderson and Hickey, 1976; Blus et. al., 1977)

In vivo studies of OCP metabolism in CFEWB species are few, and much of the current understanding is based on in vitro studies extrapolated to whole-organism systems. Studies on the hepatic mixed function oxygenase (MFO) system using hepatic microsomes of eight CFEWB species demonstrate relatively low levels of metabolic enzyme activity when exposed to dieldrin and DDT metabolites. High concentrations and slow elimination rates of dieldrin and DDE in bird tissues are attributed to low levels of MFO activity (Walker, 1990).

Five species of fish-eating aquatic birds (cormorant, shag, guillemot, razorbill and puffin) demonstrated positive correlations between adipose tissue concentrations of DDE and PCBs (Borlakoglu et. al., 1990). In some situations chemical accumulation levels of the two compounds were similar. This was attributed to the two compound types having

similar molecular structures, and thus similar metabolic activities with respect to the hepatic MFO system.

3.3.4.3 Acute Effects

Most studies concerning adverse OCP effects in aquatic bird receptors have focused on long-term exposure to environmental residue levels. As with other organochlorine compounds, it may be difficult to assess acute toxic effects of OCPs on wildlife species based on laboratory dose-response relationships since contaminant mixtures and environmental conditions often contribute to toxic responses. In high doses, DDT is a potent neurotoxin which affects ion permeability and axon polarity in nerve cells. LD_{50} values ranging from 430 to 4,000 mg/kg are reported for various avian wildlife species (Hudson, 1984). Symptoms include neural abnormalities such as tremors, jerkiness and convulsions, followed by death in a matter of hours or days. Cyclodiene compounds and BHC are nerve receptor agents which interfere with normal neurotransmission. Two of the most potent cyclodienes, dieldrin and endrin, have LD_{50} values that range from 10 to over 1,000 mg/kg, and from 0.5 to 12 mg/kg , respectively. Death from exposure to these compounds occurs in a matter of several days (Hudson, 1984). In high acute dosage situations, incidental ingestion, dermal absorption and respiration are all major exposure routes.

Lethal OCP levels in brain tissues have been reported for aquatic birds. In the absence of other apparent causes of death, concentrations of 9 ppm of dieldrin, 0.8 ppm endrin , 250 ppm DDE or 30 ppm total DDE and DDT in brain tissues are considered lethal (Ohlendorf et. al., 1981). Based on these lethal levels, some heron mortality of otherwise unknown causes has been attributed to dieldrin, endrin, DDE and DDT poisoning. These deaths occurred numerous years after the ban of DDT and dieldrin, demonstrating the environmental persistence of these contaminants (Ohlendorf et. al., 1981). Death by

dieldrin poisoning has been suspected in ospreys with brain tissue levels of 4 ppm (Wiemeyer et. al., 1980) and in bald eagles with brain tissue levels of 5 - 7 ppm (Reichel et. al., 1983). Bald eagle brain tissues also contained DDE at levels up to 120 ppm, but it was concluded that death was not attributed to DDE poisoning (Reichel et. al., 1983). As with the heron study, OCP levels in bald eagles were measured years after the bans on dieldrin and DDT.

3.3.4.4 Chronic Effects

Chronic effects of organochlorine pesticide toxicity focuses primarily on reproductive impairment as a result of low-level, long term exposure. DDT and its metabolites have been implicated in reproductive impairments of two types, eggshell thinning and embryotoxicity. Eggshell thinning (which has been well-documented in wildlife bird species) is caused by an enzymatic alteration of calcium-mobilizing steroids induced by DDT and DDE. Other adverse physiological effects from OCP exposure which have been reported but not extensively studied in wildlife include thyroid function, adrenal function, immunosuppression and behavioral effects (Blus, 1995, and citations within).

Eggshell thinning has been reported in many aquatic bird species, and it has been demonstrated that there are notably different degrees of interspecies sensitivity to DDT. Pelicans have been reported to be one of the most sensitive species, with DDE levels of 3 ppm in eggs resulting in deleterious eggshell thinning resulting in near total reproductive failure (Blus, 1982). The white-faced ibis demonstrated significantly reduced reproductive capacity and increased eggshell thinning associated with egg DDE levels of 8 ppm (Henny and Herron, 1989). Significant declines in osprey (Henny et. al., 1977), bald eagle (Wiemeyer et. al., 1984) and falcon (Peakall et. al., 1975) populations were attributed to egg DDE levels in the range of 15 - 30 ppm which resulted in eggshell thinning and breakage. Conversely, other raptorial or piscivorous species have displayed

no adverse eggshell thinning or embryotoxicity associated with similar or higher egg DDE levels. Kestrels, herons and herring gulls have demonstrated little or no reproductive impairment associated with egg DDE levels greater than 100 ppm (Henny et. al., 1983; Blus et. al., 1980; Keith, 1966). Dietary dosage effects of DDT and DDT metabolites on reproductive impairment has been reported for two piscivorous birds, the brown pelican and American kestrel; reduced reproductive success (hatchability or survivability) resulted from dietary doses as low as 0.15 mg/kg and 3.0 mg/kg, respectively (Anderson, 1975; Lincer; 1975).

Little information is available on whether non-DDT OCPs are implicated in reproductive impairment or failure. Elliot et. al., (1988) reported a positive correlation between levels of dieldrin, chlordanes and other cyclodienes and failure of gannet eggs to hatch.

3.3.4.5 Toxicity Reference Value Derivation

TRVs for seabird target receptors were derived from reported OCP tissue levels or dose-response levels. TRV derivation for seabirds was consistent with the approach described earlier for reptilian target receptors (Section 3.3.3.5). Reported endpoint values for OCP CPECs included dose-response levels, tissue levels in healthy adults which exhibited no obvious adverse toxicological effects, and levels in eggs from impacted populations. Tissue levels were the predominant available test endpoint for the OCP CPECs. The highest available value reported in target tissues was used as a surrogate for analytically determined NOEL or NOAEL values.

Selection of OCP CPEC toxicological endpoints were based on the following guidelines:

1) Priority was given to endpoint values in the order: a) reported laboratory dose-response studies conducted with representative wildlife species; b) tissue levels

reported in the literature for adult seabirds which exhibited no adverse exposure effects ; c) standard LD_{50} dose-response studies conducted on the mallard duck.

2) Preference for tissue type was given first to metabolically active organ tissue (liver or viscera) and second to muscle. One exception to this was the choice of pelican tissue (muscle and egg) over available seabird liver OCP levels for DDT and its metabolites because the pelican has been reported to be the most sensitive aquatic bird to DDT exposure (Blus, 1982). Adipose tissue OCP levels were used if no organ or muscle tissue was available.
3) The same endpoint values were used to represent isomeric, metabolite or by-product OCP CPECs (endosulfan/endosulfan sulfate, endrin/endrin ketone, mirex/photomirex, heptachlor/heptachlor epoxide, chlordane isomers) for TRV derivation.

3.3.5 Marine Mammals

Marine mammals are highly susceptible to organochlorine pesticide accumulation due to their high position on the trophic food chain and their large anatomical lipid pool. Marine mammals also have a high rate of lactational transfer and comparatively lesser capabilities for xenobiotic metabolism than terrestrial mammals (Tanabe et. al., 1993). Organochlorine pesticide exposure usually occurs in combination with other organochlorine compounds (PCBs) or metals, so it is difficult to assess specific OCP effects in marine mammals exposed in the wild (refer to Sections 1.3.5 and 1.3.5.1). Many marine mammal OCP studies involve characterizing environmental persistence of banned pesticides and the time frames of bioavailability in relation to the time period in which their use was terminated (Blomkvist et. al., 1992; Kannan et. al., 1993; Rosewell et. al., 1979; Tanabe et. al., 1994).

3.3.5.1 Exposure Routes

OCPs are strongly lipophilic and not rapidly metabolized in invertebrates and lower vertebrates. As a result, OCPs biomagnify through the food chain, reaching potentially high levels in the fatty tissues of marine mammals, including cetaceans, porpoises and pinnipeds. The primary route of exposure to OCPs by marine mammals is through ingestion of contaminated prey items. It is generally agreed upon that ingestion is the primary route of exposure in marine mammal target receptors; however, the magnitude of accumulation is partially dependent on species-specific dietary preferences or the location of feeding grounds. Blomkvist et. al., (1992) suggested high levels of DDT in grey seals in comparison to ringed seal was due to the inclusion of cod in the diet of grey seals. Cod liver constitutes a large proportion of the fish weight and tends to accumulate lipophilic contaminants.

Temporal trends in environmental organochlorine contaminant levels were reported for the northern fur seal in which adult seals of approximately twenty years of age were sampled for PCBs, DDT and HCHs in their tissues, for the years spanning 1971 - 1988 (Tanabe et. al., 1994). PCB and DDT levels in tissue samples peaked in 1976, and declined at a slow but continuous rate through the 1980's. HCH levels in seal tissues were reported to remain relatively steady throughout the study period. The reported age-dependent accumulation and slow rates of temporal reduction of organochlorine body burden in marine mammal populations, in conjunction with the high magnitude of bioconcentration, demonstrate the potential for long-term persistence of organochlorine residues in marine mammal tissues from ambient chemical levels in seawater.

It is possible that dermal exposure to OCPs could occur with direct contact to contaminated soil during haul-out periods, or with direct contact to contaminated

sediments while hunting or foraging, however this is viewed as a relatively minor exposure route in comparison to ingestion.

3.3.5.2 Metabolism

It is clear that bioaccumulation of OCPs readily occurs in seals and other marine mammals, and that various physiological and environmental factors determine the extent of accumulation. The basis of OCP bioaccumulation is the generally slow rate of metabolism of these compounds in animal systems. OCPs tend to accumulate in most body tissues, although in seals they have much higher levels of accumulation in blubber compared to organ or brain tissues.

Levels of dieldrin, DDT/DDE and PCBs have been reported to correlate positively in harp seals, suggesting similarities in accumulation and metabolism pathways and rates (Ronald et. al., 1984). Bioaccumulation studies on captive harp seals demonstrated 10-fold increases in DDT levels in seal tissue over tissues of the food items (fish). By comparison, dieldrin levels in seal tissue remained lower than those of the food fish, suggesting different biological fate of this compound (Frank et. al., 1973).

Transplacental transfer of OCPs has been demonstrated to be a significant metabolic mechanism in several species of seals in which mother/fetal pairs had comparable tissue levels of DDT and other organochlorine compounds (Ronaldet. al., 1984). Transmammary exchange has been reported to significantly decrease (up to 30%) female DDT loads in the process of transferring it to nursing pups (Addison and Brodie, 1977).

Levels of OCPs (including dieldrin, DDT and DDT metabolites) have been reported to be in decline since widespread applications were curtailed in the 1960s and 1970s (Blomkvist et. al., 1992; Kannan et. al. 1993; Tanabe et. al., 1994). However, HCH

levels have reportedly stabilized or increased in the same time period (Kannan et. al., 1993; Tanabe et. al., 1994).

3.3.5.3 Acute Effects

Effects of acute organochlorine pesticide exposure have not been directly addressed in any of the studies reviewed in this assessment, and it appears that direct lethal or sub-lethal adverse effects have yet to be demonstrated in aquatic mammalian wildlife. Environmental exposure by marine mammals (seals) is generally through low-level chronic doses associated with fish and shellfish ingestion. Acute effects studies involving OCP exposure to laboratory or domestic mammalian species are not likely to be representative of acute dose response by marine mammals in their natural habitat. Necropsy reports noting elevated OCP levels in seals cite complications associated with chronic exposure to organochlorine mixtures, rather than individual pesticide compounds, as the probable cause of death (Menchero et. al., 1994).

3.3.5.4 Chronic Effects

Chronic effects of organochlorine pesticides to marine mammals in the wild is usually associated with exposure to organochlorine mixtures through ingestion. Chronic exposure effects include reproductive impairment or failure and immuno-suppressive responses resulting in susceptibility to pathogenic infection (Blomkvist et. al., 1992; Haraguchi et. al., 1992; Reijnders, 1986). It has been reported that OCP and other organochlorines can disrupt hormone formation (steroidogenesis) which results in infertility or abortion (Jensen et. al., 1979; Reijnders, 1979). Increased incidence of adrenocortical hyperplasia was reported for seals with elevated levels of DDE and other organochlorines in body tissues (Brandt et. al., 1992). Seals suffering from starvation were found to have high tissue levels of DDT and DDT metabolites (Blomkvist et. al., 1992). Hepatic disfunction

related to nutrient metabolism and assimilation has also been demonstrated as a chronic exposure effect in some mammalian species (Yarbrough et. al., 1979). This response in seals could potentially contribute to both starvation and immunosuppressive effects.

3.3.5.5 Toxicity Reference Value Derivation

The approach for TRV derivation for organochlorine pesticides in marine mammal target receptors was the same that reported earlier for reptile target receptors (Section 3.3.3.5). OCP CPEC endpoint values were predominantly reported as residue levels in tissues of healthy adult seals or porpoises which displayed no observable adverse effects. Standard laboratory-derived LD_{50} values for rodents or other mammals were used where marine mammal OCP tissue values were not available. Guidelines for endpoint value selection are as follows:

1) Priority was given to reported OCP levels in seal tissue. Preference for tissue type was given first to metabolically active organ tissues (liver) and second to muscle tissue. OCP levels in blubber were used if liver or muscle tissue levels were not available. OCP levels in porpoise tissue were used for some compounds not reported in seal tissue.
2) Endpoint values (NOAEL, LD_{50}) from laboratory dose-response studies of terrestrial mammals were used for TRV derivation if no marine mammal tissue levels were available.
3) The same endpoint values were used to represent isomeric, metabolite or by-product OCP CPECs (endrin/endrin ketone, mirex/photomirex, heptachlor/heptachlor epoxide) for TRV derivation.

3.4 Population and Community Effects

The effects of organochlorines on populations of avian receptor species has been addressed with respect to reproductive impairment due to eggshell thinning in populations of similar aquatic birds. In most cases reproductive impairment results from a combination of chemical stressors, however eggshell thinning is associated primarily with elevated levels of DDT and its metabolites. DDT has been implicated or suggested in impacts in seabird populations including the pelican (Risebrough et. al., 1969) and Bermuda petrel (King and Lincer, 1973).

Eggshell thinning as an exposure effect to DDT and its metabolites has been demonstrated for a multitude of bird species in at least ten taxonomic orders (Peterle, 1991). However, the extent and severity of its effect on bird population recruitment varies considerably from species to species. The possible effects of DDT metabolites and other OCPs on reproductive impairment of the target receptors of interest remain uncertain from the available literature.

DDT and DDT metabolites have been suggested or implicated in reduced reproductive success or susceptibility to disease in some marine mammals including the sea lion (DeLong et. al., 1973), ringed seals (Helle et. al., 1976), harbour seals (Reijnders, 1979), and Baltic seals (Jensen et. al., 1979). It was concluded that ingestion of organochlorine compounds, including DDE, at relatively low levels in fish was a causative factor in reduced reproductive success in harbour seals in the Dutch Wadden Sea (Reijnders, 1986).

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4.0 OTHER ORGANIC COMPOUNDS

4.1 Semi-Volatile Organics (BTEX)

The organic compounds benzene, toluene, ethylbenzene and xylene (BTEX) are moncyclic hydrocarbons which are readily volatilized in the environment. Persistence of the BTEX in aqueous media are low in comparison to organochlorines. There is some variation among the BTEX compounds in vapor pressure, solubility and sorptive properties, which determine their relative persistence and fate in aquatic systems.

Benzene: Benzene is easily volatilized and transported through the air. It is relatively soluble in water, and does not sorb significantly to sediments and soil. It does not bioaccumulate at a rapid rate in organismal tissues, but due to high lipophilicity it can bioaccumulate to moderately high concentrations. Benzene toxicity is caused by toxic metabolites (phenol and benzene oxide) transformed from the parent compound. Metabolism occurs mostly in the liver, and the rates of bioaccumulation and elimination differ between benzene and its metabolites (US PHS, 1987). Benzene toxicity is associated more with inhalation than dermal contact or ingestion. Acute toxicity levels are relatively high in comparison to other organic toxicants. Adverse health effects include genotoxicity, embryotoxicity, immuosuppression, and neurotoxicity (Clement Associates, 1985).

Toluene: Similar to benzene in its physicochemical properties, toluene is readily volatilized and transported in the vapor phase. Because it is relatively soluble in water, some atmospheric deposition occurs through precipitation. Toluene is moderately lipophilic and bioaccumulates to a limited degree in organismal tissues. The bioconcentration factor (BCF) has been reported to be 10 in fish, which is one to several orders of magnitude less than organochlorine compounds. Metabolic processes in

mammalian systems appear to detoxify and eliminate toluene residues (Clement Associates, 1985). Large doses of toluene have been demonstrated to cause toxic and adverse sublethal effects. Embryotoxicity and fetotoxicity have been reported to result from large doses in laboratory animals. Other adverse effects involve kidney disfunction, growth inhibition and low body and brain weight (US PHS, 1989).

Xylene: Xylene is a monocyclic hydrocarbon which exists commercially as a mixture of three isomers (ortho-, meta-, para-). Xylene is more hydrophobic than the other BTEX compounds, with low water solubility and a tendency to associate with soils and sediments (Clement Associates, 1985). Xylene fate processes in surface and ground water are mostly volatilization and photooxidation. The BCF of xylene has been reported to range from 45 to 105 depending on the isomeric mixture (USEPA, 1984). Xylene has not been demonstrated to be carcinogenic or mutagenic, however fetotoxic effects have been demonstrated in laboratory mice and rats. High acute doses can cause sublethal neurotoxic effects. The oral LD_{50} for rodents is 2,000 mg/kg. (USEPA, 1984). There is limited information available on the toxicity of xylene to wildlife. Decreased hatch rates were reported for quail eggs which had low-level (0.05%) topical applications of xylene (HSDB, 1991). Xylene reportedly has adverse effects on adult trout in concentrations as low as 3.6 mg/L, and the LD_{50} for trout has been reported at 13.5 mg/L (Clement Associates, 1985).

4.2 Dioxins and Furans

Polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) are tricyclic aromatic hydrocarbons with varying degrees of chlorine substitution (Cl_x= 1-8). PCDD/F compounds are by-products of combustion processes of natural (forest fire, volcanic) or anthropogenic (industrial, incineration) origin. Based on sediment and biological records, environmental levels of PCDD/F have increased significantly since the 1940's,

indicating anthropogenic activities are the primary sources of production and input (Zook and Rappe, 1994).

Of the many PCDD/F isomers known to exist naturally (210), the most toxic configuration is 2,3,7,8-TCDD. 2,3,7,8-TCDD is one of the most toxic compounds known, and it is the standard for the Toxicity Equivalency Factor (TEF), which measures toxicity of PCDD/F isomers (and PCBs) as a proportion of 2,3,7,8-TCDD toxicity.

Modern environmental sources of PCDD/F include waste incineration, fossil fuel and wood combustion, and industrial sources including chemical manufacturers and the pulp and paper industry. PCDD/F formation tends to occur in the presence of aromatic carbon and free chlorine precursors and conditions which favor free radical reactions (heat and alkaline media). As a result of these favorable synthesis conditions, PCDD/Fs are often formed as by-product impurities during the synthesis of chemical products such as Aroclor and Clophen mixtures and herbicides (2,4,5-T) (Zook and Rappe, 1994).

PCDD/F profiles differ significantly depending on the source of formation, however most isomers are present at some level in samples from any given source. Treatment processes of the pulp and paper industry (delignification, bleaching) tend to yield higher levels of lower- substituted PCDD/F isomers, including 2,3,7,8-TCDD and -TCDF. Oil refinement, fossil fuel combustion and incineration of some types of waste also yield high levels of the 2,3,7,8-substituted PCDD/F isomers.

Waste combustion usually gives rise to most of the 210 PCDD/F isomers. Chromatography profiles of combustion samples from municipal waste incinerators demonstrate that the higher chlorinated PCDDs (OctaCDD and HeptaCDD) are the predominant dioxin isomers, and the isomeric proportion in the sample progressively decreases with lower levels of chlorine substitution. The predominant dibenzofurans are

the hexa- and hepta-substituted isomers (Marklund et. al., 1990) PCDD/F homologue profiles in air, snow, soil and sediment indicate the same general profile, demonstrating that most environmental PCDD/F input is from atmospheric deposition (Tysklind et. al., 1993; Andersson et. al, 1992).

Because of the presence of many PCDD/F congeners in biological samples, exposure studies in wildlife generally address chemical levels of either 2,3,7,8-TCDD, or total 2,3,7,8-TCDD TEQs of the sample. Although the OCDD and hepta-substituted PCDD/F are among the most predominant isomers in environmental samples, the toxicity levels remain low in comparison to 2,3,7,8-TCDD. TEFs for these PCDD/F isomers are 0.001 for OCDD and OCDF, and 0.01 for HpCDD and HpCDF.

OCDD and HpCDD have been detected in heron eggs at levels as high as 47 and 76 ng/kg, respectively (Elliot et. al., 1989). Levels of 1 to 5 ng/kg of these congeners were detected in regurgitated prey samples, demonstrating the bioavailability and degree of biomagnification of these congeners. PCDD/F accumulation in seals has been reported to be less than what would be expected from contaminant levels in fish, suggesting the presence of metabolic elimination pathways which limit chemical persistence (Bergek et. al., 1993).

Levels of PCDDs (OCDD, TCDD, and HexCDD) were detected in marine mammals (Beluga whale and ringed seal) and polar bear in Northern Canada at levels ranging from 8.0 ng/kg (detection limit) to 44 ng/kg, in blubber and liver tissue (Norstrom et. al., 1990). Polar bear tissue exhibited slightly higher levels of PCDDs than ringed seal. Since ringed seal is a significant part of the polar bear diet, this suggests that PCDD metabolism in polar bears is sufficient to prevent PCDD biomagnification. PCDD levels in Beluga whale tissue were notably lower than in ringed seal, even though other organochlorine levels (PCBs and HCB) were determined to be higher. Ringed seals and Belugas share

the same trophic level, suggesting that diminished levels of PCDDs in Belugas result from more effective or selective metabolism of these compounds (Watanabe et. al. 1989).

4.3 References

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INORGANICS

5.0 ANTIMONY

Antimony (Sb) occurs in the earth's crust at concentrations ranging from 0.1 - 0.2 mg/kg and in seawater at approximately 0.0002 mg/kg. The average range of concentration in soils is 2 to 10 mg/kg (USEPA 1983). The trace element can occur in either a sulfidic or oxide form, but is most common in its trivalent or pentavalent form. Antimony precipitates rapidly as Sb_20_3 or Sb_20_5 or is removed by absorption.

5.1 Invertebrates and Fish

The TRV of 1.6 mg/L was derived from the National Ambient Water Quality Criteria-freshwater chronic criteria (NAWQC-FC) (USEPA, 1986).

5.2 Reptiles

Antimony concentrations of 0.3 mg/L have been reported as the median lethal concentration (LC_{50}) (RTECS, 1994) in amphibian *(Gastrophryne carlinensis)* eggs.

5.3 Birds and Marine Mammals

A concentration of 5.5 mg/kg-d has been reported as a LOEL for rabbits (NRC 1980). Reproductive impairment has been reported to occur in laboratory rats given chronic oral (LOAEL) doses of 0.35 mg/kg body weight/day (USEPA, 1994).

5.4 Toxicity Reference Value Derivation

The toxicity reference values for antimony for reptilian, avian and mammalian target receptors were derived from the reported rat LOAEL value of 0.35 mg/kg body weight/day (USEPA, 1994) by applying appropriate uncertainty factors as described in Section 4.3.2.2.

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6.0 ARSENIC

Arsenic (As) occurs naturally in living organisms, but no confirmed physiological function has been attributed to this metal. Arsenic exhibits two inorganic forms with differing toxic properties. Arsenic III is known to bind to sulfhydryl groups on proteins, disrupting their function. The mechanism of As V toxicity is less well known, as it does not bind to sulfhydryl groups. It does appear to selectively uncouple oxidative phosphorylation, poisoning aerobic ATP generation. Under acidic conditions, As III will slowly oxidize to As V.

6.1 Aquatic Invertebrates and Fish

Little is known about the mechanisms of As toxicity to aquatic organisms; however, As readily forms stable bonds with sulfur and carbon in organic compounds. Enzyme inhibition is probably the primary mode of toxicity when As (III) reacts with sulfhydryl groups of proteins, and As (V) may uncouple oxidative phosphorylation (Fowler et. al, 1977, Schiller et. al, 1977). The chemistry of As in water is complex. Chemical, biochemical, and geochemical reactions control the concentration, oxidation state, and form of As in water (Braman 1983, Callahan et. al, 1979, Holm et. al, 1979, and Scudlark and Johnson 1982). Unlike many other heavy metals, the toxicity of As III in aquatic animals appears to be independent of water hardness ($CaCO_3$ content).

Bioconcentration tests have been conducted on freshwater fish and invertebrates. The highest bioconcentration factor (BCF) was 17, which was obtained for inorganic As (III) with a snail (Spehar et. al, 1980). An early life-stage test on As (V) with the fathead minnow (Defoe 1982) showed that the bioconcentration decreased with increased exposure. Bioconcentration factors were slightly lower (down to 1.2) in exposure concentrations that caused significant adverse effects than those that did not (USEPA

1985). Pretreatment of rainbow trout to As (III) enhanced the elimination of a subsequent dose of As. Additional results indicated that fish retained less As after four weeks of exposure than after two weeks (Oladimeji et. al, 1982). In a number of cases, As toxicity for fish increased with increased duration of exposure (USEPA 1985). The freshwater residue data indicate that As is not bioconcentrated to a high degree but that lower forms of aquatic life may accumulate higher As residues than fish. The low bioconcentration factor and short half-life of As in fish tissue suggest that residues should not be a problem to predators of aquatic life (USEPA 1985).

The TRV of 0.036 mg/L was derived from the Hawaii Water Quality Criteria-saltwater chronic criteria (HWQC-SC), (USEPA, 1986).

6.2 Reptiles

Little information is available on arsenic toxicity and effects of amphibians and reptiles. Tissue levels of 0.2 mg/kg have been reported in the eggs of both crocodiles and alligators (Eisler, 1988). These levels were not reported to have any adverse effects on egg hatchability or reproductive success.

6.3 Birds and Marine Mammals

Little information is available on the effects, toxicity, and bioaccumulation of arsenic in terrestrial vertebrates. Absorption from the gastrointestinal tract is almost complete, as only 6 to 9 percent of orally administered As-labeled trivalent or pentavalent As is eliminated in feces in mice. Approximately 80% of an As dose administered mixed with soil was eliminated in feces (Freeman et. al., 1993). A modest accumulation of As is seen in small mammals from orchards where lead arsenate was used as a fungicide. Detectable levels of arsenic have been reported in tissues of marine mammals including seals (1.4

mg/kg) and fin whales (1.8 mg/kg) but were not accompanied by any observable adverse effects (Eisler, 1988).

White et. al, (1977) reported concentrations in European starling *(Sturnus vulgaris)* whole bodies (less skin, wings, and bill) of 0.019, 0.156, 0.171, and 0.139 mg/kg. Arsenic levels of 1.02 mg/kg were reported in the liver of the brown pelican, without any apparent adverse effects. (Blus et. al., 1977). Arsenic levels of 16.7 mg/kg in the liver of an osprey were suspected to contribute to its mortality (Wiemeyer et. al., 1980).

6.4 Toxicity Reference Value Derivation

TRVs for the target receptor were derived from tissue levels or dose-response studies in accordance with the approach described earlier for PCBs in Section 1.3.2.5. The arsenic endpoint value for the reptile target receptor was the 0.2 mg/kg value reported for crocodile egg (Eisler, 1988). The endpoint value selected for the avian target receptors was the tissue level of 1.02 mg/kg reported for pelican liver. The mammalian target receptor endpoint value was the reported rat LOAEL of 1.2 mg/kg/day, which was adjusted with the appropriate uncertainty factor, as shown in Table 21-1.

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7.0 CADMIUM

The importance of acclimatization to ambient metal concentrations is well illustrated by cadmium (Cd). Many species may occur in areas where naturally occurring Cd concentrations fall within the range of acute toxicity values derived from laboratory toxicity testing (Eisler 1985). However, sublethal effects of Cd on individual organisms, populations, and communities are also documented. Heavy metal ratios in native fauna are inconsistent with those of indigenous soil and vegetation, reflecting differences in relative mobilities. For both carnivores and herbivores, Cd is accumulated at rates greater than lead and zinc (Roberts and Johnson 1978) and therefore appears to bioconcentrate.

7.1 Aquatic Invertebrates and Fish

Mortality resulting from acute exposure to Cd has been measured in several species of aquatic invertebrates and fish. Acute (96 hr) LC_{50} values for adult warmwater fish species range from 0.8 to 5 ppb (Eisler 1985). The maximum LC_{10} (200 hr) for a similar group of species was 1.5 ppb. Immature and larval fish tended to be slightly more sensitive, but within the same range of concentrations. In addition to the chemical form of Cd, the sensitivity of invertebrate species to toxicants is heavily dependent upon feeding ecology, life history stage, acclimation to ambient conditions, and available food sources. More extensive work with marine organisms indicates that Cd toxicity caused reduced growth rates in marine fish and annelids, affected molting in crustaceans, and reduced the life span of the Fl generation of the crab Pontoporeia affinis (Eisler, 1985).

Cd accumulates differentially in tissues of freshwater fish. Rainbow trout exposed to 10 ppb Cd accumulated to 1740 ppb in gill, 4900 ppb in liver, and 740 ppb in kidney tissue (Roberts and Johnson, 1978) When exposed to 5 ppb Cd, whole body burdens of Cd in mosquitofish were 2,213 times that of the medium. Mollusks also accumulate Cd and

many other metals in soft tissues. Oysters exposed to 5 ppb Cd in seawater concentrated Cd 2,000 times (Eisler, 1985).

Elimination of Cd depends on the source of the contaminant. Free Cd^{+2} absorbed from the water column is eliminated more slowly than organically complexed Cd ingested with food. Consequently, bioaccumulation appears to result mostly as a result of bioconcentration from ambient water and not food chain transfer. Daphnia magna concentrated Cd only seven-fold from contaminated algae, and fish (Leucospius delineatus) fed the daphnids did not concentrate Cd any further. This pattern is generally the case for heavy metal contamination.

The TRV of 9.3e-03 mg/L was derived from the National Water Quality Criteria-saltwater chronic criteria (NAWQC-SC) (USEPA, 1986).

7.2 Reptiles

There have been few reported studies on heavy metal exposure and effects in reptiles. Cadmium levels of 0.10 mg/kg were measured in livers of snapping turtles from sites contaminated by various heavy metals (Albers et. al., 1986). Cadmium levels were reported to range from 0.06 to 17 mg/kg in livers of snapping turtles taken from sites along the Hudson River (Stone et. al., 1980). Levels of 10 mg/kg were reported in kidneys of softshell turtles taken from river sites below a metal plating facility (Robinson and Wells, 1975). These tissue levels were not reported to result in adverse toxicological effects.

7.3 Birds and Marine Mammals

Wildlife are exposed to Cd primarily via ingestion of contaminated food and drinking

water. Birds and mammals appear to be less sensitive to Cd than are aquatic organisms. Cadmium accumulates with age (Hunter et. al, 1981) and is seen at higher concentrations in insectivores such as common shrews (*Sorex araneus*) than in herbivores such as field voles (*Microtus agrestis*) (Roberts and Johnson 1978, Scanlon 1979).

Sublethal effects of Cd on birds and mammals include reduced growth rate, anemia, hypoplasia in bone marrow and gonads, enlarged heart, and behavioral impacts to adults and progeny. Lowest concentrations of Cd producing significant effects include cardiovascular disease in domestic pigeons (*Columba livia*) exposed to 600 ppb Cd in drinking water and behavioral alterations of progeny after female black ducks *(Anas rubripes*) were fed 4 ppm Cd in their diets (Eisler 1985). Threshold concentrations of dietary Cd having significant physiological effects appear to be around 20 ppm for mallard (*Anas platyrhynchos*) ducklings, with exposures of adult birds ranging up to 75 ppm. Male and female mallards fed 200 ppm dietary Cd survived with no weight loss, but egg production was decreased in females (White and Finley 1978, cited in Eisler 1985).

Cadmium levels have been reported in the livers of several piscivorous seabirds. Cd levels of 56 mg/kg were reported in great shearwater, 18 mg/kg in the grey-backed petrel and 33 mg/kg in the sooty albatross (Renzoni et. al., 1986; Muirhead and Furness, 1988). The California pelican had reported levels of 14 mg/kg in liver tissue (Eisler, 1985). There were no observable adverse effects reported in association with these tissue levels.

Bone marrow and hematopoietic effects on rodents are known from dietary exposures of less than 2 ppm (Siewicki et. al., 1983). The lowest oral dose causing mortality in laboratory rats and guinea pigs was 250 and 150 mg Cd per kg body weight, respectively. A maximum dietary Cd content of 100 μg Cd/kg is recommended to avoid acute toxicity and effects of accumulation of Cd in tissues (USEPA 1980, cited in Eisler 1985).

Cd accumulates in liver and kidneys of vertebrates (Anderson and Van Hook 1973, Johnson et. al, 1978). Cadmium associated with liver and kidney of the chipping sparrow (*Spizella passerina*) was eliminated with a half-life of about 100 days. Mallard ducklings fed 20 ppm dietary Cd had accumulated 42 ppm Cd in liver tissue after 12 weeks. Mallards and chickens tolerated 200 ppm Cd in the diet for long periods, producing kidney concentrations of 130 ppm fresh weight.

Cadmium residues in vertebrate kidneys or livers that exceed 10.0 mg/kg fresh weight or 2.0 mg/kg in whole body fresh weight should be considered probable Cd contamination. Levels of 13.0 and 15.0 ppm Cd tissue fresh weight probably represent a significant hazard to animals at higher trophic levels. Residues of 200 ppm fresh weight kidney or more than 5.0 ppm whole animal fresh weight should be considered life-threatening (Eisler 1985).

Cadmium levels of 12 mg/kg and 0.5 mg/kg were reported in liver and muscle tissues of the harp seal (Ronald et. al., 1984). Levels of 16 mg/kg and 42 mg/kg have been reported in kidney tissues of the fur seal and pilot whale, respectively (Eisler, 1985). There were no observable adverse effects reported in association with these tissue levels.

7.4 Toxicity Reference Value Derivation

TRVs for cadmium were derived from reported liver residue levels for the three target receptors. Selected endpoint values for TRV derivation were 0.1 mg/kg for the reptile target receptor (Albers et. al., 1986), 56 mg/kg for the avian target receptor (Renzoni et. al., 1986), and 12 mg/kg for the mammalian target receptor (Ronald et. al., 1984).

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8.0 CHROMIUM

Chromium (Cr) is an abundant element in the earth's crust. It occurs in many oxidation states, but only trivalent and hexavalent forms are biologically significant. Chromium in ambient air originates from industrial sources such as ferrochrome production, cement production, ore refining, chemical and refractory processing, and combustion of fossil fuels. Chromium values in air are less than 0.1 μg/m3 and range from 0.01 to 0.03 μg/m3 in industrial areas (Goyer 1986).

8.1 Aquatic Invertebrates and Fish

Hexavalent Cr was associated with adverse effects in invertebrates of widely separated taxa: reduced survival and fecundity of the cladoceran Daphnia magna at a concentration of 10 ppb and exposure for 32 days (USEPA 1980); growth inhibition of the protozoan Chilomonas paramacium at 1,100-3,000 ppb during exposures of 19-163 hours (Honig et al., 1980); abnormal movement patterns of larvae of the midge Chironomus tentans at 100 ppb in 48 hours (Catalan 1982); and a temporary decrease in hemolymph glucose levels in the freshwater prawn Macrobrachium lamarrei surviving 1,840 ppb Cr VI for 96 hours (Eisler 1986).

Long-term exposure of rainbow trout for 180 days to high, but environmentally realistic, concentrations of 0.2 ppm Cr VI resulted in elevated levels of Cr in kidney (3.5 mg/kg/ fresh weight), liver (2.0 mg/kg), and muscle (0.6 mg/kg); after 90 days in Cr-free media, Cr levels were 1.6, 1.3, and 0.5, respectively (Calamari et al 1982, Eisler 1986). Sublethal effects were observed in freshwater teleosts following exposure to Cr VI. In the snakehead (*Channa punctatus*), enzyme activities were altered in a wide variety of organs and tissues after exposure for 30 days to 2.6 ppm (Sastry and Sunita 1984); the effects became life threatening after exposure for 120 days (Sastry and Tyagi 1982,

Sastry and Sunita 1982, 1983). Adverse effects of Cr to sensitive species have been documented at 10.0 μg/l (ppb) of Cr VI and 30.0 μg/l of Cr III in freshwater (Eisler 1986).

The TRV value of 0.05 mg/L was derived from NAWQC-saltwater chronic criteria (USEPA, 1986).

8.2 Reptiles

Chromium levels ranging from 0.32 to 1.97 mg/kg were reported in the liver of snapping turtles from sites contaminated by metals and uncontaminated reference sites (Albers et. al., 1986). These levels were not reported to result in adverse toxicological effects.

8.3 Bird and Marine Mammals

Chromium is an essential trace element in humans and at least some laboratory animals; data are lacking for wild populations. Adverse effects have been documented at 5.1 and 10.0 mg of Cr^{+6} and Cr^{+3}, respectively, per kilogram of diet (Eisler 1986). High concentrations of Cr are normally found in RNA, but its role is unknown. Trace quantities are essential for carbohydrate metabolism in mammals as well as insulin action. In humans, a diet lacking Cr can lead to Cr deficiency (Goyer 1986). Half-life for elimination of Cr from rats is 0.5, 5.9, and 83.4 days (Mertz 1969).

Chromium levels of 1.4 mg/kg and 2.8 mg/kg were reported in spleen and brain tissues of the harbor seal (Eisler, 1986). Cr levels of 0.2 mg/kg have been reported in liver of the osprey (Wiemeyer et. al., 1980). These reported tissue levels were not accompanied by observable adverse effects.

8.4 Toxicity Reference Value Derivation

RVs for chromium were derived from reported liver tissue levels for reptilian and avian target receptors, and from spleen tissue for the mammalian target receptor. Selected endpoint values for TRV derivation were 0.6 mg/kg for the reptile target receptor (Albers et. al., 1986), 0.2 mg/kg for the avian target receptor (Wiemeyer et. al., 1980), and 1.4 mg/kg for the mammalian target receptor (Eisler, 1986).

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9.0 COBALT

Cobalt (Co) is nutritionally essential as a cofactor in cyanocobalamin (vitamin B12) (U.S. EPA, 1992). The element is ubiquitous and universally present in the diet. Important target organs in orally exposed humans are the heart, erythrocyte and thyroid. Target organs for occupational exposure are the skin, lungs and heart.

9.1 Aquatic Invertebrates and Fish

The TRV of 2.9e-04 mg/L was derived from an Ambient Water Quality Criteria-freshwater chronic criteria advisory value estimated by Suter et. al. (1992).

9.2 Reptiles

There were no available reports of cobalt exposure or effects in reptiles.

9.3 Birds and Marine Mammals

There were no available reports of cobalt exposure or effects in marine mammals or aquatic birds. Acute high oral or parenteral doses of cobalt in humans or animals induce myocardial degeneration often leading to mortality, erythropoiesis, enlarged thyroid, and, in animals, renal tubular degeneration (Elinder and Friberg, 1986).

The developmental toxicity of cobalt was tested in rodents treated orally with cobalt chloride (U.S. EPA, 1992a). Maternal effects (unspecified) were reported in rats treated with 5.4 to 21.8 mg cobalt/kg-day from gestation day 14 through lactation day 21. Effects on the offspring included stunted growth at 5.4 mg cobalt/kg-day and reduced survival at 21.8 mg cobalt/kg-day. In rats treated with 6.2, 12.4 or 24.8 mg cobalt/kg-day

on gestation days 6-15, maternal effects included reduced food consumption and body weight gain and altered hematologic parameters, although it is unclear at what dose level(s) these effects occurred. There were no effects on fetal survival, although a nonsignificant increase in fetal stunting was observed in rats treated with ^{3}12.4 mg cobalt/kg-day. In mice, treatment with 81.7 mg cobalt/kg-day caused reduced maternal weight gain, but had no fetal effects. Several studies reported testicular degeneration and atrophy in rats treated with cobalt chloride in the diet or drinking water at concentrations equivalent to doses of 5.7 to 30.2 mg cobalt/kg-day (U.S. EPA, 1992).

9.4 Toxicity Reference Value Derivation

The TRVs for cobalt for reptilian, avian and mammalian target receptors were derived from the reported rat LOAEL value of 5.4 mg/kg body weight/day (USEPA, 1994) by applying appropriate uncertainty factors as described in Section 4.3.2.2.

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10.0 COPPER

Copper (Cu) is a common trace element and an essential micronutrient necessary for a wide range of metabolic processes (Flemming and Trevors 1989). Copper is widespread and moderately soluble. Its bioavailability depends on a number of factors, such as pH, redox potential, soil and sediment type, water hardness, and organic content. Copper contamination may enter soils and sediments as a result of smelting, mining, industrial activities, domestic waste emission, and the application of fertilizers, sewage sludge, algicides, fungicides, and molluscicides.

10.1 Aquatic Invertebrates and Fish

Copper occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (Callahan et al., 1979). The cupric ion is highly reactive and forms moderate to strong complexes and precipitates with many inorganic and organic constituents of natural waters, like carbonates and phosphates. Free cupric ions are more toxic than most organic and inorganic Cu complexes, which tend to reduce toxicity attributable to total Cu (Andrew, 1976; Borgmann and Ralph, 1983). With this in mind, the interpretation of available toxicity data becomes complicated, because the proportion of free cupric ion present is highly variable and is difficult to measure except under carefully controlled laboratory conditions. Usually, data on Cu toxicity are reported using measurements other than total or dissolved Cu.

Copper is toxic to aquatic life at concentrations only slightly higher than those for plants and animals. Copper is known to act at cell surfaces to exert a toxic effect (MacLeod et. al, 1967; Lamb and Tollefson, 1973). Most of the available tests on the toxicity of Cu to freshwater animals have been conducted with four salmonid (trout) species, fathead and bluntnose minnows, and bluegills. Acute values range from 6.5 μg/l for *Daphnia magna*

in hard water to 10,200 μg/l for the bluegill in hard water (Cairns et al., 1978). Several factors are key contributors to the level at which Cu becomes toxic. These factors include water hardness, pH, and total organic carbon (TOC) level. As a general rule, Cu toxicity decreases with increases in alkalinity and TOC.

Chronic toxicity values are available for fifteen freshwater species. Values range from 3.873 μg/l for brook trout to 60.36 μg/l for northern pike (*Esox lucius*). Fish and invertebrate species seem to be about equally sensitive to the chronic toxicity of Cu (USEPA, 1984). The TRV of 2.90e-03 mg/L for copper was derived from the NAWQC-saltwater chronic criteria (USEPA, 1986).

10.2 Reptiles

Copper levels ranging from 1.28 to 9.72 mg/kg were reported in the liver of snapping turtles from sites contaminated by metals and uncontaminated reference sites (Albers et. al., 1986). These levels were not reported to result in adverse toxicological effects.

10.3 Birds and Marine Mammals

Copper levels have been reported in the livers of several piscivorous seabirds. Cu levels of 8.4 mg/kg were reported in great shearwater, 15 mg/kg in the grey-backed petrel and 8.5 mg/kg in the sooty albatross (Muirhead and Furness, 1988). The osprey had reported levels of 452 mg/kg in liver tissue (Wiemeyer, 1985). These avian tissue levels were not associated with observable adverse effects.

Copper is relatively nontoxic to mammals, and tolerance limits are generally 10- to 100-fold higher than for aquatic fauna. Rabbits, ponies, and pigs can tolerate high levels, 300 to 800 μg/g dry weight feed in their diets, with no toxicosis (Flemming and Trevors

1989). EPA levels acceptable in drinking water are 1.0 mg/L. Copper levels of 30.7 mg/kg and 2.1 mg/kg were reported in liver and muscle tissues of the harp seal (Ronald et. al., 1984). There were no observable adverse effects reported in association with these tissue levels.

10.4 Toxicity Reference Value Derivation

TRVs for copper were derived from reported liver residue levels for the three target receptors. Selected endpoint values for TRV derivation were 9.72 mg/kg for the reptile target receptor (Albers et. al., 1986), 8.4 mg/kg for the avian target receptor (Muirhead and Furness, 1988), and 30.7 mg/kg for the mammalian target receptor (Ronald et. al., 1984).

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11.0 LEAD

Lead is ubiquitous in the earth's crust with an average distribution of 16 mg/kg. Primary lead is processed by smelting and refining mined lead ore. Over four million metric tons of lead are produced annually worldwide, about a third of which is produced and consumed domestically. In recent years, more domestic lead has been produced from secondary sources (i.e. scrap or recycled) than from primary sources. About half of the domestically produced lead is used in the manufacture of storage batteries. Historically, a significant proportion of domestic lead has been utilized as an additive in gasoline and subsequently an estimated 98% of lead in the biosphere originates from automobile emissions (Smith, 1980). Other common uses for lead include, or have included, paint products, ceramics, metal alloys, and ammunition. Globally, the primary route of lead exposure to the environment is through atmospheric deposition, mostly in the form of emissions from smelting operations and in the form of vehicle exhaust. Atmospheric lead associates with minute aerosol particulates, and may be transported far from the point of origin before deposition. Lead is efficiently scavenged from the air column by precipitation, which is the primary air-to-water flux pathway. Residence time for airborne lead has been reported to range from a few days to 14 weeks (Eisler, 1988, and citations within).

Lead levels in marine environments have been reported to range from 3 mg/kg in uncontaminated sediments high in carbonate to 11,000 mg/kg in sediments from regions highly exposed to industrial wastes and runoff. Lead concentrations in marine corals have been reported to increase significantly in the years spanning 1954 to 1980, indicating the increased global availability of lead in that time frame (Dodge and Gilbert, 1984). Lead profiles in dated cores of marine, estuarine and freshwater sediments generally reflect the usage trends in leaded gasoline, with deposits peaking in the early 1970's and steadily decreasing in the years following (Eisenreich et. al., 1986).

The complex chemistry of lead is determinative in its environmental bioavailability. In aquatic systems, lead is most soluble (and therefore bioavailable) in low pH conditions, low organic content, low levels of total suspended solids and low levels of mineral salts. As a result, lead solubility is generally low in most aquatic systems, except in the immediate vicinity of discharges. pH-dependent solubility of lead in water ranges from 10 ug/L at pH 5.5 to 1 ug/L at pH 9.0. Water alkalinity (mineral salt content) and valence of the lead compounds are also determining factors in site-specificity of lead solubility and bioavailability, and may effect the degree of solubility by 2-3 orders of magnitude (Eisler, 1988, and citations within).

Important exposure pathways specific to aquatic and terrestrial wildlife include direct ingestion of spent ammunition or its leachates, incidental ingestion of leachates from mining wastes and ingestion of lead-based paint chips (Eisler, 1988, and citations within). Wildlife inhabiting areas near heavily traveled roads or lead processing operations (smelters, recycling plants) and aquatic life in the vicinity of mining operations are at particularly high risk.

Lead toxicity affects neurological, vascular, reproductive, renal and other physiological systems in both humans and wildlife. Nervous damage by lead is functional as well as structural, effecting the brain (cerebellum) and spinal cord in addition to individual nerve cell axons and nerve ganglia. Brain lead concentrations are among the lowest in organs of lead-poisoned animals, although it is the primary site of toxic action. In humans neurological damage is manifest as aberrations in intellectual, psychological, sensory and neuromuscular functions. Lead exposure has been demonstrated to result in retarded brain growth in experimentally poisoned rats, brain lesions in cattle and chickens, and to affect learning behavior in lamb offspring of exposed sheep. One neurotoxicological mode of acute toxicity action for lead, the demyelineation of axons, is harmful in

vertebrates, but may not be considered significantly toxic to invertebrates. Lead, however, also interferes with the activity of ATP-ase and thus is potentially toxic to all organisms (Jernelov et al., 1978). In vascular plants, lead toxicosis includes reduced photosynthesis, mitosis and absorption of water (Demayo et. al., 1986).

11.1 Aquatic Invertebrates and Fish

Adverse effects were noted on Daphnid magna reproduction at 1.0 μg Pb II/L. The exposure duration was 19 days and the reproductive impairment affected 10 percent of the study population (Eisler 1988). At concentrations of 10 μg Pb II/L 50 percent of the study population of *Daphnia magna* showed reproductive impairment.

Rainbow trout survival diminished at 3.5 μg of tetraethyllead per liter. The exposure duration for this experiment was 72 hours. An LC_{50} was reached at the above concentration (Eisler 1988). Fathead minnows were not as sensitive to Pb as rainbow trout. An LC_{50} was reached in 96 hours at a concentration of 6,500 μg Pb II/L (Eisler 1988).

Lead is concentrated by aquatic plants, algae and invertebrates from water, but tends to have lower concentrations in higher aquatic organisms. It appears that lead does not transfer through food chains, and lead concentrations have been reported to decrease markedly with increasing trophic level in both detritus-based and grazing aquatic food chains (Wong et. al, 1978; Branica and Konrad, 1980; cited in Eisler 1988). In the freshwater food chain of an alga (*Selenastrum capricornutum*), to a daphnid (*Daphnia magna*), to the guppy (*Poecilia reticulata*), Pb accumulation progressively decreased from the alga to the guppy (Vighi 1981, cited in Eisler 1988).In marine biota, some accumulation of lead in hard tissues of fishes with size and age has been reported (Eisler 1981, 1984; in Eisler 1988). Conversely, lead levels were reported to be independent of size (weight, length and girth) in the black marlin (Mackay et. al., 1975). In general fish

tissue lead levels are highest in fishes of coastal areas near anthropogenic inputs of lead. In the open ocean lead levels tend to be low due to both nonavailability and low rates of bioaccumulation in fish tissues.

The TRV of 5.60e-03 mg/L for lead was derived from the NAWQC-saltwater chronic criteria (USEPA, 1986).

11.2 Reptiles

Lead levels in livers of box turtles captured near industrial lead sources were reported to range from 1.2 to 21.6 mg/kg (Beresford et. al., 1981). Low lead levels (0.07 mg/kg) have been reported in livers of snapping turtles from uncontaminated sites (Albers et. al., 1986).No toxicological effects were reported in association with these residue levels.

11.3 Birds and Marine Mammals

The toxicity of lead in mammalian and avian systems is widely recognized. In both mammals and birds, lead tends to accumulate in bone more than any other tissue, but it also readily accumulates in the kidney and liver. Normal background concentrations (uncontaminated) of lead in these tissues in birds are reported to range from 2 - 15 mg/kg in bone, 1 - 10 mg/kg in kidney and 0.5 - 5 mg/kg in liver (Connors et. al., 1975; Custer, et. al., 1984; Kendall and Scanlon, 1981; cited in Scheuhammer, 1987). Lead accumulations of up to 50 times these levels have been reported in avian species inhabiting impacted or urban areas, and were often associated with observed toxicosis. Organs of ducks and swans whose deaths were attributed to lead poisoning contained levels of lead up to 500 mg/kg in kidney tissue and up to 200 mg/kg in liver

(Scheuhammer, 1987).

The toxicity of lead is dependent on the form in which it is ingested. The most common toxicity in avian species is from ingestion of lead shot. Lead shot is swallowed incidentally by birds foraging in hunter-impacted areas. Ingested lead shot is retained in the crop and erodes by crop action and solubility in the low-pH stomach milieu. Lead body burdens in marsh birds containing lead in their crops has been reported to be 2 - 3 times higher than in control birds (Hall and Fisher, 1985; Stendell et. al., 1980). In sensitive avian species, a single lead pellet can cause fatal toxicosis. More than 2.4 million ducks and geese are estimated to die annually worldwide as a result of such ingestion (Wobeser, 1981, cited in Eisler, 1988). Secondary lead poisoning occurs in raptorial birds (eagles, kestrels) which feed on lead-poisoned (or lead-embedded) birds in weakened conditions. It is thought that lead poisoning in raptorial birds is more a factor of ingesting and concentrating multiple lead pellets in a short time, rather than assimilating biologically incorporated lead from tissues of prey items (Custer et. al., 1984). Lead toxicosis in birds may also occur from consumption of lead-based paint chips. This has been reported to occur in captive parrots in association with ingestion of flaking paint on cage bars, and in fledgling Laysan albatrosses on Midway Island after ingestion of peeling paint from abandoned, unmaintained structures (NRCC, 1973; Sileo and Fifer, 1987).

The magnitude of lead toxicity to a particular species or individual may be modified by factors including age, sex, and the general state of health of the bird. Studies demonstrate the susceptibility to lead toxicity in young birds is higher than in adults. Dietary lead levels of 448 mg/kg were demonstrated to cause growth reduction and increased mortality in kestrel nestlings but not in adults (Hoffman et. al., 1985). Young quail and cockerel were reported to have blood disorders (anemia) and reduced growth rates resulting from dietary lead levels ranging from 500 - 1850 mg/kg (Morgan et. al., 1975; Franson and

Custer, 1982; cited in Scheuhammer, 1987).

Adult female birds accumulate lead at higher rates than males, as a result of calcium mobilization processes associated with eggshell formation. This high rate of skeletal calcium turnover by females ultimately results in increased lead uptake across the intestinal wall concomitant with increased calcium uptake (Edelstein et. al., 1984). Bone tissue of female ring-tailed doves and mallards were reported to assimilate up to ten times as much lead in bone of males dosed with the same levels of lead (Kendall and Scanlon, 1981; Finley and Dieter, 1978; cited in Scheuhammer, 1987). In addition, female mallards of laying age were demonstrated to accumulate lead in bone tissues up to five times the levels of non-laying females. Johnson et. al., (1982) compared lead levels in kidneys and bone of female and male rock doves from both urban and rural environments. Both sexes from rural environments exhibited low lead levels in bone (16 - 19 mg/kg) and kidney (6 - 8 mg/kg) when compared to lead accumulation in tissues of urban birds. Lead levels of 338 mg/kg were measured in bone and 204 mg/kg were measured in kidneys of females from urban environments. These levels were 2 - 2.5 times higher than the levels measured in tissues of males from the same urban areas.

Mallards on a balanced commercial duck ration exhibited significantly less toxic effects to ingested lead shot than birds on a strict corn diet, suggesting that nutritional deficiencies may contribute to toxicosis (Carlson and Nielsen, 1985; Wobeser, 1981). Calcium-deficient diets have been reported to significantly increase the rate of lead absorption and assimilation in both mammals and birds. This is thought to be related to the increased production of calcium-binding protein, a transport protein, in response to decreased calcium dietary levels, and the compatibility of lead with the calcium binding site on the transport protein (Barton et. al.,1978).

Lead toxicity in avian species is marked by outward signs of emaciation, muscle tremors

lethargy, weakness, impaired neuro-motor functions, and isolation from other birds. Histopathological effects include lesions of the kidney, osteocytes, liver, brain and muscle. Physiological and developmental impairments include decreased levels of heme-forming enzymes in the blood, liver and brain tissues, enlarged spleen, abnormal skeletal development and reduced brain weight (Eisler, 1988). Lethal lead poisoning in avian species have been associated with concentrations in liver tissue (wet wt.) of 23 to 38 mg/kg in bald eagles, 10 to 14 mg/kg in seagulls, and 40 mg/kg in starlings. Recovered corpses of seagulls whose death was attributed to chemical poisoning were found to have liver lead levels up to 10 mg/kg and demonstrated other pathological conditions consistent with experimentally induced lead toxicosis in gulls (Osburn et. al., 1983).

Seabirds, when compared to avian species in hunter-impacted or urban regions, demonstrate relatively low body burdens of lead, generally not in exceedance of 1 mg/kg wet weight in body tissues, with the exception of those species which frequent coastal regions near anthropogenic lead sources. Low lead body burdens in oceanic seabirds are attributed to the low rates of lead bioaccumulation in marine fishes and invertebrates (body burdens usually less than 2 mg/kg) that constitute the prey base. Comparative exposure levels of lead to several species of tropical seabirds, as determined by lead levels measured in feathers, demonstrated species-specific and locational differentials in exposure and/or accumulation. Sooty terns from Johnston Island were demonstrated to have significantly lower lead levels than specimens from the Hawaiian Islands, while the opposite was true for the wedge-tailed shearwater (Burger et. al., 1992).

High lead doses induce abortion, reduce or terminate pregnancy, result in stillbirths, or increase skeletal malformations in most vertebrates. Lead toxicosis in mammals has been studied mostly in livestock and laboratory animals. Survival was reduced under the following regimens: acute oral doses of 5 mg/kg body weight in rats, chronic oral doses of 0.3 mg/kg body weight in dogs, and dietary levels of 1.7 mg/kg body weight in horses

(Eisler, 1988).

Although ingestion of food containing biologically incorporated lead is unlikely in itself to cause lead poisoning (Custer, 1984), the effects of lower exposure levels are not well known (Nriagu, 1978). While the use of lead arsenate as an insecticide in orchards has decreased, residues remain in upper soil surfaces and will be bioavailable almost indefinitely (Gilmartin et al., 1985, cited in Eisler, 1988). Sublethal effects such as a delayed impairment of learning and abnormal social behavior were seen in monkeys administered 0.1 mg lead/kg BW daily or fed diets containing 0.5 mg lead/kg.

Lead has been measured in tissues of marine mammals at non-deleterious levels. Levels have been reported for liver tissue of sea lions (1.3 mg/kg), fur seals (0.8 mg/kg) and harp seals (0.77 mg/kg) (Anas, 1974; Braham, 1973; Ronald et. al., 1984). Among the highest reported lead levels in soft tissues of marine mammals was 5 mg/kg in the liver of a harbour porpoise off the coast of Denmark (Kemper, et. al., 1994). A study of lead levels in tissues of marine mammals in Australian waters examined 174 specimens of 16 different species and concluded that lead does not bioaccumulate to high levels in soft tissues of these mammals, generally less than 1 mg/kg. Exceptions included moderately elevated levels in liver (3 mg/kg) and blubber (3.4 mg/kg) of dolphins. As with other aquatic vertebrates and avian species, bone tissue was reported to have higher lead levels than other body tissues.

11.4 Toxicity Reference Value Derivation

TRVs for lead were derived from reported liver residue levels for the three target receptors. Selected endpoint values for TRV derivation were 21.6 mg/kg for the reptile target receptor (Beresford et. al., 1981), 0.84 mg/kg for the avian target receptor (Renzoni et. al., 1986), and 0.77 mg/kg for the mammalian target receptor (Ronald et. al., 1984).

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12.0 MANGANESE

As an essential element for both plants and animals, manganese (Mn) might be expected to concentrate in biomass. In ecosystems, mobilization of Mn, like that of many other metals, increases with pH decrements. Potentially toxic concentrations might result; toxicity in humans is well documented. Manganese also has the potential to exert mutagenic effects via its ability to complex with DNA nucleotides.

12.1 Aquatic Invertebrates and Fish

Lewis et. al, (1979) reported that manganese toxicity can be affected by hardness and pH in aquatic systems. They also reported antagonism of Mn with nickel toxicity, as well as synergistic effects with some other metals. Unfortunately, limited information is available on the toxicity of Mn to freshwater aquatic organisms. No ambient water quality criteria for the protection of freshwater aquatic life have been established for Mn by EPA. Reported tolerance values indicate that 1.0 mg/L is protective of freshwater species (Davies and Goettl, 1977, cited in Lewis 1979). Dawson (1974, cited in Lewis 1979) has developed a criterion of 0.1 mg/L.

Acute toxicity for eels has been reported at concentrations of 2.2 to 4.1 mg/L over a time period of 8 to 18 hours. A 24-hour LC_{50} was determined at a concentration of 6045 mg/L for Orizias sp. (McKee and Wolf, 1963, cited in Lewis 1979). England and Cummings (1971, cited in Lewis 1979) reported a 96-hour LC_{50} for Mn in young rainbow trout of 16 mg/L. Davies (1980) reported that the acute toxicity of Mn decreases with increased hardness, as well as increased fish size.

Little information was found concerning Mn bioaccumulation in a food chain or food web. Davies (1980) reported that the relationship between size and toxic effects is

pronounced. When smaller fish are consumed by larger fish, the impact of toxic effects decreases. Therefore, Mn does not appear to be biomagnified between trophic levels

The TRV of 0.11 mg/L was derived from the National Ambient Water Quality Criteria-freshwater chronic criteria advisory value estimated by Suter et. al., (1992).

12.2 Reptiles

There were no available reports for manganese exposure or effects in reptiles.

12.3 Birds and Marine Mammals

There were no available reports for manganese exposure or effects in birds or marine mammals. In humans, the principal route of excretion of Mn is in the feces. Large doses of Mn salts cause gastrointestinal irritation, and systemic toxicity does not seem to result following oral administration of Mn (Goyer 1986). Scant information was found on toxicity and effects of Mn in terrestrial vertebrates. There is no evidence of biomagnification. The acute LD_{50} dose in laboratory rats is reported to be 9000 mg/kg body weight (RTECS, 1994).

12.4 Toxicity Reference Value Derivation

The TRVs for manganese for reptilian, avian and mammalian target receptors were derived from the reported rat LOAEL value of 5.4 mg/kg body weight/day (USEPA, 1994) by applying appropriate uncertainty factors as described in Section 4.3.2.2.

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13.0 MERCURY

Mercury (Hg) compounds have no known role in normal physiology, and their presence in the cells of living organisms apparently represents contamination from natural and anthropogenic sources. Researchers have had difficulty specifying threshold levels or toxic effects on the basis of present knowledge (NAS 1978).

13.1 Aquatic Invertebrates and Fish

Depending on the level of pollution, many invertebrate organisms tolerate and magnify various mercurials to some degree (Hannerz, 1968; cited in NAS 1978). The extent to which organisms concentrated Hg from water varied from <100 to >12,000-fold, depending on such factors as the form of the mercury, time of exposure, nature of the food consumed, feeding habits, and metabolic rates.

In *Daphnia*, methyl mercury chloride accumulates more readily than mercuric chloride. Incorporation into the food chain is facilitated at temperatures of 18° C compared to 10° C (Boudou and Ribeyre 1981). Pelagic fish caught in remote oceanic regions with up to 120 ppb Hg in muscles are evidence of the ability of Hg to bioconcentrate.

The TRV of 3.0e-05 mg/L for mercury was derived from the NAWQC-saltwater chronic criteria (USEPA, 1986).

13.2 Reptiles

Mercury levels ranging from 0.46 to 1.28 mg/kg have been reported the liver of the snapping turtle (Albers et. al., 1986). Hg levels up to 7.6 mg/kg were reported for the diamondback terrapin liver (Galluzi, 1981). No toxicological effects were reported in

association with these residue levels.

13.3 Birds and Marine Mammals

Chronic exposure of laboratory rats to inorganic Hg has resulted in decreased body weight and increased kidney weight. The central nervous system is a major target for organic Hg compounds. Adverse effects in humans to subchronic and chronic oral exposures include brain lesions, brain cell destruction, hearing and visual impairment, and loss of sensation to extremities.

Mercury has been reported in the livers of several piscivorous seabirds. Hg levels of 86.2 mg/kg were reported in great shearwater, 53 mg/kg in the Atlantic petrel and 227 mg/kg in the sooty albatross (Muirhead and Furness, 1988; Renzoni et. al., 1986). These avian tissue levels were not associated with any observable adverse effects.

Mercury was detected in liver tissues of the bearded seal and ringed seal at levels of 143 and 27.5 mg/kg, respectively. Muscle tissue levels of Hg in the bearded and ringed seals were reported to be 0.53 and 0.72 mg/kg, respectively (Koemann et. al., 1975). Beluga whale liver was reported to contain Hg liver levels of 43 mg/kg (Wagemann et. al., 1990). These Hg levels reported for marine mammalian tissue were not associated with observable adverse effects.

13.4 Toxicity Reference Value Derivation

TRVs for mercury were derived from reported liver tissue levels for the three target receptors. Selected endpoint values for TRV derivation were 1.28 mg/kg for the reptile target receptor (Albers et. al., 1986), 86.2 mg/kg for the avian target receptor (Renzoni et. al., 1986), and 27.5 mg/kg for the mammalian target receptor (Koemann et. al., 1975).

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14.0 NICKEL

Nickel (Ni) commonly occurs in the 0, +1, +2, and +3 valences with a molecular weight of 58.71. Elemental nickel is insoluble in water, although many nickel compounds are highly soluble in water (USEPA, 1980).

14.1 Aquatic Invertebrates and Fish

In a freshwater media, nickel tends to be more toxic in softer water (USEPA, 1980). Acute values for exposure to a variety of nickel salts, expressed as nickel, range from 510 ug/L for *Daphnia magna* to 46,200 ug/L for banded killifish at comparable hardness levels. Chronic values range from 14.8 ug/L for *Daphnia maqna* in soft water to 530 ug/L for the fathead minnow in hard water (USEPA, 1980). Residue data for the fathead minnow indicate a bioconcentration factor of 61 (USEPA, 1980).

The TRV of 8.3e-03 mg/L for nickel was derived from the NAWQC-saltwater chronic criteria (USEPA, 1986a).

14.2 Reptiles

Nickel levels ranging from 0.13 to 0.99 mg/kg were reported in the liver of snapping turtles captured from sites contaminated by metals and from uncontaminated reference sites (Albers et. al., 1986). These levels were not reported to result in adverse toxicological effects.

14.3 Birds and Marine Mammals

Nickel can enter the body via ingestion, inhalation or skin contact. Gastrointestinal

absorption of nickel in humans is about 1 to 10% (USEPA, 1986b). Nickel can also penetrate human skin. An applied dose of 0.23% aqueous nickel chloride was reported to permeate the human skin, and about 3.5% of aqueous nickel chloride passed through the skin when occluded (Fullerton et. al, 1986).

Exposure of animals to nickel salts is associated with delayed fetal development and increased resorptions (Lu et. al, 1979). There are no studies regarding the teratogenicity or fetotoxicity of nickel in humans. Mammalian cell transformation data indicate that several nickel compounds are mutagenic and can cause chromosomal alterations (Larremendy et. al, 1981; Lechner et. al, 1984).

The oral LD_{50} in rats that have been reported for various nickel compounds include: 355 mg/kg for nickel acetate (118 mg/kg nickel); 1600 mg/kg for nickel hydroxide (1021 mg/kg nickel); 300 mg/kg for nickel sulfate hexahydrate (67 mg/kg nickel); >5000 mg/kg for nickel oxide (>3292 mg/kg nickel), nickel sulfide (>3233 mg/kg nickel); and nickel subsulfide (>3666 mg/kg nickel) (Mastromatteo, 1986). It appears that the soluble nickel compounds are more toxic than insoluble compounds by the oral route.

Chronic toxicities were determined by American Biogenics (1986), who dosed groups of male and female rats by gavage with nickel chloride at 0, 5, 35, or 100 mg/kg nickel per day for 91 days. High rates of mortality occurred at the 35 and 100 mg/kg doses (FELs) but not at 5 mg/kg (NOAEL). The 35 mg/kg and 5 mg/kg doses are the LOAEL and NOAEL, respectively, for lethality due to oral exposure. In a series of studies, rats and mice were exposed by inhalation to nickel sulfate, nickel subsulfide, or nickel oxide (Dunnick et. al, 1985, 1987; Benson et. al, 1987). When exposure concentrations of individual compounds are expressed in terms of nickel content, nickel sulfate was found to be the most toxic. In the animals exposed to nickel sulfate, the lowest concentrations of nickel that resulted in reduced survival were 1.7 mg/m^3 for mice and 3.3 mg/m^3 for

rats (LOAEL) (The animals died following the development of pulmonary inflammation.) 0.8 and 1.7 mg/m^3 (NOAEL) did not result in reduced survival in mice and rats, respectively.

A NOAEL value of 77.4 mg/kg/day was reported for mallard duckling (Opresko et. al., 1994).

14.4 Toxicity Reference Value Derivation

The endpoint value for nickel TRV derivation for the reptile target receptor was 0.99 mg/kg reported for snapping turtle liver (Albers et. al., 1986). The endpoint value selected for the avian target receptors was the NOAEL value of 77.4 mg/kg/day reported for mallard duckling (Opresko et. al., 1994). The mammalian target receptor endpoint value was the reported rat NOAEL of 5 mg/kg/day (American Biogenics, 1986).

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15.0 SELENIUM

Selenium (Se) is widely distributed in nature, usually occurring in the sulfide ores of heavy metals such as copper iron and lead. Soils around volcanoes tend to have enriched selenium concentrations (HSDB, 1995). The primary environmental source of selenium is weathering of natural rock containing selenium deposits. Coal combustion is the major anthropogenic source of selenium deposition in the environment (Eisler, 1985).

Selenium chemistry is complex. It exists in five different valence states, and the changes in valence states determine geologic, environmental, and biological distribution and fate. Selenium can persist in waters and soil as a free anion (selenate), where it is reduced to selenites and can be taken by plants. Selenites are the predominant selenium chemical specie in seawater (Eisler, 1985). Selenite can be reduced to elemental Se, which is insoluble and essentially non-bioavailable. Elemental selenium can be reduced further to hydrogen selenide, which is acidic, unstable and highly toxic. The alkalinity of soils and water is positively correlated with the levels of solubilized selenium (Eisler, 1985).

15.1 Aquatic Invertebrates and Fish

Concentrations of 2.0 ppm have been shown to be toxic to goldfish. All reported levels of selenium in tissues of marine plants and invertebrates have been less than 2 mg/kg (wet wt.) (Eisler, 1985). Fish from streams in industrialized areas have elevated (near 2 ppm) whole-body selenium levels (Ohlendorf et. al., 1986). In agricultural regions, elevated selenium in bird and fish tissues is attributed to both natural deposition from weathering and residual soil concentrations from past use (1960's) of selenium pesticides (Ohlendorf et. al., 1986). Selenium is still used as a pesticide in controlled applications (greenhouses).

Death is observed in aquatic organisms at selenium levels between 0.06 and 0.6 mg/L. Zebrafish (*Brachydanio rerio*) embryos were demonstrated to survive hatching but shortly thereafter succumb to selenium levels of 3 mg/L (Niimi and LaHam, 1975). LC_{50} values for marine organisms have been reported for Dungeness crab (*Cancer magister*) larvae (1.04 mg/L), brown shrimp (*Penaeus azteca*) (1.8 mg/L), and winter flounder (*Pseudopleuronectus americanus*) larvae (15.1 mg/L) (Glickstein, 1975; USEPA, 1980; Ward et. al., 1981, cited in Eisler, 1985).

The TRV of 3.0e-05 mg/L for mercury was derived from the NAWQC-SC (USEPA, 1986).

15.2 Reptiles

Selenium levels of 0.5 mg/kg have been reported in whole-body tissues of the water snake (*Natrix* sp.) (Winger et. al., 1984).

15.3 Birds and Marine Mammals

Selenium in marine vertebrates including marine mammals and birds is routinely observed at greater levels than in plants and invertebrates. Selenium levels have been reported in liver tissues of sea lions (260 mg/kg), ringed seal (170 mg/kg), pilot whale (62 mg/kg) and harbor seal (109 mg/kg) (Kari and Kaurenen 1978; Reijnders, 1980; Stoneburner, 1978,). Selenium levels appear to be positively correlated with age in marine mammals; sea lion mothers with normal pups had selenium liver levels as high as 260 mg/kg, while liver Se levels in pups were 4.1 mg/kg (Martin et. al., 1976, cited in Eisler, 1985). Reported selenium levels in marine mammalian liver tissue were not associated with observable adverse effects.

Selenium levels have been reported in tissues of piscivorous seabirds. Seabirds do not bioaccumulate Se in their tissues to the levels reported for marine mammals. Liver residue levels have been reported for the brown pelican (4.2 mg/kg), herring gull (9.3 mg/kg), and the great skua (35 mg/kg) (Blus et. al., 1977; Hutton et. al., 1981, cited in Eisler, 1985). An exception to the comparatively low Se tissues reported in the seabirds is a value of 108 mg/kg measured in the liver of the great shearwater (Renzoni et. al., 1986). There were no adverse toxicological effects associated with these reported avian liver selenium levels.

15.4 Toxicity Reference Value Derivation

The toxicity reference value for selenium for the reptilian target receptors was derived from the reported mouse NOAEL value of 0.075 mg/kg body weight/-d (Opresko, 1994) by applying appropriate uncertainty factors as described in Section 4.3.2.2. TRVs were derived from reported liver residue levels for the avian and mammalian target receptors. Selected endpoint values for TRV derivation were 108 mg/kg for the avian target receptor (Renzoni et. al., 1986), and 170 mg/kg for the mammalian target receptor (Eisler, 1985).

15.5 References

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16.0 SILVER

Silver (Ag) is a white, ductile metal occurring naturally in the pure form and in ores. Bowen (1979) suggested that Ag shows a close relationship between parent material and soil concentrations. Although highly toxic to plants, there appear to be no relevant data concerning its chemistry or mobility in soils (Coughtrey and Thorne 1983).

16.1 Aquatic Invertebrates and Fish

Silver exhibits oxidation states of 0, +1, +2, and +3, but only the 0 and +1 states occur to any extent in the environment. In natural water, the monovalent species is the form of environmental concern. Monovalent Ag ions may exist in various degrees of association with a large number of inorganic ions, such as sulfate, bicarbonate, and nitrate, to form numerous compounds with a range of solubilities and potentials for hydrolysis or other reactions (USEPA 1980). Most of the toxicity studies have been conducted with Ag nitrate, which is an excellent source of free soluble Ag ions.

The data concerning acute toxicity of Ag to freshwater organisms include 82 values for 10 species from nine different taxonomic families (USEPA 1980). Water hardness and chloride concentration are the two factors involved with acute Ag toxicity in aquatic organisms. For invertebrate species, acute values for Ag range from 0.25 μg/L for the water flea *Daphnia magna* to 4,500 μg/l for the scud *Gammarus pseudolimnaeus* (USEPA 1980). Acute values for fish range from 3.9 μg/L for the fathead minnow in soft water to 280 μg/l for rainbow trout in hard water. It appears that Ag is more toxic in soft water.

The available data indicate that acute toxicity to freshwater aquatic life may occur at concentrations of 1.2 μg/l in solution (water hardness of 50), and chronic toxicity at

concentrations as low as 0.12 μg/l (USEPA 1980). Chronic values as high as 29 μg/l were determined in the laboratory. No information was found concerning the relationship between water hardness and chronic Ag toxicity.

Silver seems to bioaccumulate to some degree in food chains. The bioconcentration factors for Ag range from less than one for bluegills to 240 for insect larvae (USEPA 1980). Little information for bioaccumulation of Ag in food web matrixes exists. Limited information is available concerning the relationship of various forms of Ag and toxicity to aquatic animals.

The TRV of 1.0e-03 mg/L was derived from the Hawaii Water Quality Criteria-saltwater chronic criteria (HWQC-SC).

16.2 Reptiles

There were no available reports on silver exposure levels and effects in reptiles.

16.3 Birds and Marine Mammals

Silver does not occur regularly in animal tissues. The major effect of excessive absorption of Ag is local or generalized impregnation of the tissues, where it remains as Ag sulfide. This forms an insoluble complex in elastic fibers, resulting in argyria (Goyer, 1986). Although the data for the systemic distribution of stable Ag are variable, they do not suggest that any organ or tissue, except perhaps the spleen, concentrates the element to any great extent (Coughtrey and Thorne, 1983).

There is a paucity of reported exposure effects or tissue levels for silver in mammals and birds. A NOEL of 100 mg/kg/day was reported from dose-response studies conducted on

laboratory rats (NRC, 1980).

16.4 Toxicity Reference Value Derivation

The TRVs for silver for reptilian, avian and mammalian target receptors were derived from the reported rat NOEL value of 100 mg/kg body weight/day (NRC, 1980) by applying appropriate uncertainty factors as described in Section 4.3.2.2.

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17.0 THALLIUM

Thallium has been detected naturally in volcanic soils and rocks. It can bioaccumulate, with factors of 100,000 for marine and freshwater fish. Thallium is toxic to plants and inhibits chlorophyll formation and seed generation (OHM/TADS, 1995).

17.1 Aquatic Invertebrates and Fish

The TRV of 0.04 mg/L was derived from the National Ambient Water Quality Criteria-freshwater chronic criteria (USEPA, 1986).

17.2 Reptiles

There were no reports available addressing levels of exposure or effects of thallium in reptiles.

17.3 Birds and Marine Mammals

There were no available reports on thallium exposure levels or effects in marine mammals or birds. An LD_{50} of 15.8 mg/kg body weight was reported for laboratory rats, and an LD_{50} of 16 - 29 mg/kg body weight was reported for mice (OHM/TADS 1995). A NOAEL value of 7.4e-03 mg/kg/day was reported for thallium in laboratory rats (Opresko, 1994). An LD_{50} of 120 mg/kg was reported for thallium intake by the adult golden eagle (Hudson et. al, 1984).

17.4 Toxicity Reference Value Derivation

The toxicity reference value for thallium for the reptilian and mammalian target receptors

was derived from the reported rat NOAEL value of 7.40e-03 mg/kg body weight/day (Opresko, 1994). The endpoint value for TRV derivation for the avian target receptor was the LD_{50} value of 120 mg/kg (Hudson et. al., 1984). Appropriate uncertainty factors were applied to derive TRVs for all target receptors, as described in Section 4.3.2.2.

17.5 References

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18.0 TIN

Tin occurs naturally as the mineral casserite (stannic oxide), which has wide industrial application. Inorganic tin is not highly toxic due to poor absorption, relative insolubility of tin oxides and rapid tissue turnover rate (Eisler, 1989). Elimination of tin from the vascular system is rapid, and the main site of deposition is bone, followed by lung liver and kidney. Tin is excreted in the urine and, to a lesser extent, in bile. Systemic tin toxicity involves growth retardation, limb weakness, and paralysis. At extremely high doses pancreatic atrophy, testicular degeneration and kidney necrosis may result. High levels of tin exposure have not been shown to result in teratogenicity, carcinogenicity or mutagenicity (Eisler, 1989).

In aquatic systems tin tends to concentrate in surface microlayers to levels up to 10,000 times greater than dissolved concentrations. Tin levels of 15.5 mg/kg have been reported in sediments of the Great Lakes (Bryan et. al., 1986). Biotransformation of tin to more toxic methyltin compounds by microorganisms in aquatic systems has been reported (Tugrul et. al., 1983). Tin concentrations in marine plants and algae have been measured between 0.5 and 101 mg total tin/kg tissue, demonstrating tin biomagnification by aquatic flora. Aquatic plants are important in the fate of tin in the aquatic environment by accumulating and immobilizing inorganic and organic tin compounds (Donard et. al., 1987).

18.1 Aquatic Invertebrates and Fish

Inorganic tin levels of 0.04 mg/kg were reported in whole-body tissue of the Pacific herring (Maguire et. al., 1984). Total tin levels of 7.0 mg/kg were measured in soft tissue of Pacific oyster, with 1.6 mg/kg of total tin measured as organotin compounds and the balance inorganic tin. Tin levels in limpet soft tissue were measured at 0.075 mg/kg, less

than one-half of which was organic tin compounds (Alzieu et. al., 1986; Tugrul et. al., 1983).

Inorganic tin levels of .035 mg/L did not cause any lethal or deleterious effects in the dab (fish) (*Limanda limanda*) (Eisler, 1989). This residue level was taken as the tin endpoint value (NOEL) for derivation of the invertebrate target receptor TRV.

18.2 Reptiles

There were no available reports on exposure levels or effects of tin on reptiles.

18.3 Birds and Marine Mammals

There is very little information available on the exposure levels and effects in marine mammals and none for seabirds. Measured total tin levels in tissues of the harbor seal were detectable, but less than 0.1 mg/kg (Jenkins, 1980).

Total tin levels of 0.5 mg/kg were detected in the liver of the ruffed grouse (*Bonasa umbellus*) (Jenkins, 1980). An LD_{50} of 700 mg/kg was reported for dose studies conducted on laboratory rats (Eisler, 1989).

18.4 Toxicity Reference Value Derivation

The toxicity reference value for tin for the reptilian and mammalian target receptors was derived from the reported rat LD_{50} value of 700 mg/kg body weight/day (Eisler, 1989) by applying appropriate uncertainty factors as described in Section 4.3.2.2. TRV derivation for the avian target receptors was based on the endpoint value of 0.5 mg/kg reported for tin levels in grouse liver .

18.5 References

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19.0 VANADIUM

Vanadium is ubiquitous in the earth's crust. It rarely exists as a free metal, rather it is complexed as insoluble minerals or organo-metallic compounds. Levels of vanadium are generally low in natural waters, and its role as a water pollutant is not currently well known (Stendahl and Sprague, 1982). Anthropogenic deposition of vanadium has been estimated to account for a doubling of the environmental levels and cycling . It is major trace metal in fossil fuels, and is primarily released from burning fossil fuels. Other anthropogenic sources include crude oil spills, coal combustion and mining leachates and effluents (Holdway et. al., 1983).

19.1 Aquatic Invertebrates and Fish

Vanadium exposure levels and effects to fish and invertebrates have been addressed in several studies. LC_{50} values have been reported of 2.5 - 5 mg/L for scorpionfish (*Scorpaena porcus*) (Unsal, 1978, cited in Miramand et. al., 1992), 26.8 mg/L for the dab (*Limanda limanda*) (Taylor et. al., 1985), and 1.9 - 6.0 mg/L for rainbow trout (Stendahl and Sprague, 1982). Bioaccumulation levels of vanadium were reported to be low in the goby (*Gobius minutus*), at only 2-3% of ingested vanadium from prey items retained in body tissues. Bioaccumulation has been reported in mussel (*Mytilus edulis*) tissues as high as 17 mg/kg in response to dosed water concentrations of 0.5 mg/L (Edel and Sabbioni, 1993).

The TRV of 3.0e-03 mg/L was derived from the an Ambient Water Quality Criteria-freshwater chronic criteria advisory value estimated by Suter et. al., (1992).

19.2 Reptiles

There were no available reports on exposure levels and effects of vanadium in reptiles.

19.3 Birds and Marine Mammals

There were no available reports on exposure levels and effects of vanadium in marine mammal or birds.

19.4 Toxicity Reference Value Derivation

The TRV for vanadium for mammalian target receptors was derived from a reported NOAEL value of 5.4 mg/kg body weight/day based on dose-response feeding trials conducted on laboratory rats (Opresko et. al. 1994) The TRV for avian and reptilian target receptors was derived from a NOAEL value of 11.38 mg/kg/day for mallard duck.

19.5 References

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20.0 ZINC

Zinc (Zn) is an essential trace element for animals and is important to cell growth and differentiation and the formation of a number of metalloenzymes (NAS, 1980; Rand and Petrocelli, 1985). Thus, it is not surprising that many organisms have systems to accumulate and store Zn. However, at concentrations above the micronutrient level required, Zn exerts toxic effects. Zinc may enter a food chain through aerial deposition on foliage or through uptake by plant roots. Although Zn is extremely soluble, uptake by roots is limited.

20.1 Aquatic Invertebrates and Fish

In aquatic systems, acute toxicity to fish includes gill destruction and hypoxia (Rand and Petrocelli, 1985). Exposure of fish to sublethal concentrations of Zn can cause extensive edema and necrosis of liver tissue (Rand and Petrocelli, 1985). Water quality criteria have been developed by USEPA (1986) based on the relationship of decreasing Zn toxicity with increasing water hardness.

Cladocerans are the most sensitive aquatic animal species to Zn (USEPA, 1987). The mean acute value determined, at a water hardness of 50 mg/L, was 93.95 μg/L. *Daphnia* sp. had a mean acute 3 toxicity value of 299.8 μg/l. *Argia* sp. were the most tolerant animal, with an acute value of 88,960 μg/l (USEPA, 1987). Trout are among the most sensitive fish tested in acute assays with Zn (USEPA, 1987). The mean acute value, at water hardness of 50 mg/L, for rainbow trout is 689.3 μg/l (USEPA, 1987). Davies (1980) has reported a 96-hour LC_{50} for rainbow trout (170 mm) of 105 μg/l (water hardness was 36.7 mg/L) and 186 μg/l (water hardness was 39.2 mg/L) in aerated and nonaerated tests, respectively.

A concentration of 47 µg/l was the lowest maximum acceptable toxicant concentration (MATC) for *Daphnia magna* at a water hardness of 104 mg/L (USEPA 1986). The flagfish (*Jordanella floridae*) had an MATC of 36.4 µg/l (water hardness of 44 mg/L) and was the most sensitive of seven fish species tested (USEPA 1986). Trout are apparently not as sensitive to the chronic effects of Zn as the flagfish. The chronic value for brook trout was 854.7 µg/l at water hardness of 45.9 mg/L (Holcombe et. al, 1979, cited in USEPA 1987). Chronic values based on early life cycle tests with rainbow trout are 276.7 µg/l (water hardness = 26 mg/L) (Sinley et. al, 1974, cited in USEPA 1987) and 603.0 µg/l (hardness = 25 mg/L) (Cairns et. al, 1982, cited in USEPA 1987).

Zinc has shown bioconcentration factors of 51 to 1,000 in freshwater fish (USEPA 1986, 1987), although limited information is available. A whole body bioconcentration factor of 417.3 was reported for *Jordanella floridae* following 100 days of exposure (Spehar 1978, cited in USEPA, 1987).

The TRV of 0.086 mg/L for zinc was derived from the NAWQC-saltwater chronic criteria (USEPA, 1986).

20.2 Reptiles

Zinc levels ranging from 27.27 to 50.38 mg/kg were reported in the liver of snapping turtles captured from sites contaminated by metals and from uncontaminated reference sites (Albers et. al., 1986). These levels were not reported to result in adverse toxicological effects.

20.3 Birds and Marine Mammals

Zinc absorption is affected by numerous dietary factors. These interactions, and the

uptake mechanisms, are generally not well understood. In a laboratory study, Zn was administered in drinking water (200 mg/L) by itself and in combination with other metals (Cooke et. al, 1990). Resultant Zn concentrations in the kidneys were higher than liver and femur concentrations. However, this was also the case when the combinations zinc/cadmium and iron/lead/zinc/cadmium were administered. In fact, the highest kidney concentrations occurred in the high Cd-only treatments. This may reflect the induction of metalliothioneins, which can bind Zn and Cd, and subsequent redistribution and accumulation in the kidney (Cooke et. al, 1990).

Zinc levels have been reported in the livers of several piscivorous seabirds. Zn levels of 118 mg/kg were reported in great shearwater, 77 mg/kg in the grey-backed petrel and 86 mg/kg in the sooty albatross (Renzoni et. al., 1986; Muirhead and Furness, 1988). The osprey had reported levels of 132 mg/kg in liver tissue (Wiemeyer, 1980). These avian tissue levels were not reported to be associated with observable adverse effects.

Zinc levels of 84 mg/kg and 1101 mg/kg were reported in liver tissues of grey seals and sirenians (Eisler, 1993). There were no observable adverse effects reported in association with these tissue levels.

20.4 Toxicity Reference Value Derivation

TRVs for zinc were derived from reported liver residue levels for the three target receptors. Selected endpoint values for TRV derivation were 50.38 mg/kg for the reptile target receptor (Albers et. al., 1986), 118 mg/kg for the avian target receptor (Renzoni et. al., 1986), and 84 mg/kg for the mammalian target receptor (Eisler, 1993).

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21.0 TOXICITY REFERENCE VALUES

See following Table 21-1.

Appendix K

APPENDIX K

TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN FOR HUMAN HEALTH

APPENDIX K

TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN FOR HUMAN HEALTH

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APPENDIX K

TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN FOR HUMAN HEALTH

1.0 ANTIMONY

Antimony is a silvery white metal of medium hardness that breaks easily. Small amounts of antimony are found in the earth's crust. Antimony ores are mined and then either changed into antimony metal or combined with oxygen to form antimony oxide.

Antimony oxide is a white powder that does not evaporate. Only a small amount of it will dissolve in water. Most antimony oxide produced is added to textiles and plastics to prevent their catching on fire.

Antimony metal is too easily broken to be used much by itself. To make it stronger, a little antimony is usually mixed with other metals such as lead and zinc to form mixtures of metals called alloys. These alloys are used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, type metal, ammunition, and pewter.

Antimony enters the environment during the mining and processing of its ores and in the production of antimony metal, alloys, antimony oxide, and combinations of antimony with other substances. Little or no antimony is mined in the United States. Antimony ore and impure metals are brought into this country from other countries for processing. Small amounts of antimony are also released into the environment by incinerators and coal-burning power plants. The antimony that comes out of the smoke stacks of these plants is attached to very small particles that settle to the ground or are washed out of the air by rain. It usually takes many days for antimony to be removed from the air. Antimony attached to very small particles may stay in the air for more than a month. Antimony cannot be destroyed in the environment. It can only change its form or become attached to or separated from particles. Most antimony will end up in the soil or sediment, where it attaches strongly to particles that contain iron, manganese, or aluminum.

Antimony is found at very low levels in the environment, so low that we often cannot measure it. You may be exposed to antimony by breathing air, drinking water, and eating

foods that contain it. You also may be exposed by skin contact with soil, water, and other substances that contain antimony. The analytical methods used by scientists testing for the presence of antimony in the environment do not determine the specific form of antimony present. Therefore, we do not always know what form of antimony persons may be exposed to. Similarly, we do not know what forms of antimony are found in hazardous waste sites. Much of the antimony found in sediment, soil, and rock is so strongly attached to dust and dirt or buried in minerals that it cannot easily affect your health. Some antimony in the environment is less tightly attached to particles and may be taken up by plants and animals.

The concentration of antimony in air ranges from a very small part of a nanogram (1 nanogram equals a billionth of a gram) in a cubic meter (m^3) of air (ng/m^3) to about 170 ng/m^3. However, near companies that change antimony ores into metal or make antimony oxide, concentrations may be more than 1,000 ng/m^3. One may breathe high levels of antimony in dust if one lives or works near antimony mines or processing companies.

The concentration of antimony that is dissolved in rivers and lakes is very low, usually less than 5 parts of antimony in 1 billion parts of water (ppb). One cannot measure such small amounts without special equipment. Antimony does not appear to accumulate in fish and other aquatic animals. The concentration of antimony dissolved in one polluted river where wastes from antimony mining and processing had been dumped was as high as 8 ppb. Most of the antimony in the river, however, was not dissolved, but was attached to particles of dirt. Although antimony is used in solder for water pipes, it does not seem to get into the drinking water.

Soil usually contains very low concentrations of antimony, less than 1 part of antimony in a million parts of soil (ppm). However, concentrations close to 9 ppm have been found. The highest soil concentrations found at hazardous waste sites on the National Priorities List (NPL) and at antimony-processing sites range from 109 to 2,550 ppm. High concentrations of antimony may be found in soil because dust sent out during processing settles out from the air. Also, waste from antimony-processing and other antimony-using industries is usually dumped onto the soil. Much of the antimony in antimony-processing wastes is strongly attached to soil. One may be exposed to this antimony by skin contact. Children may also be exposed to this antimony by eating the dirt.

Food usually contains small amounts of antimony. A person eats and drinks about 5 micrograms (5 millionths of a gram) of antimony every day. The average concentration of antimony in meats, vegetables, and seafood is 0.2-1.1 ppb. The antimony oxide that is added to many materials for fire protection is very tightly attached to these materials and does not expose people to antimony.

One may also be exposed to antimony in the workplace. If a person works in an industry that processes antimony ore and metal or makes chemicals that contain antimony, such as antimony oxide, one may be exposed to antimony by breathing dust or by skin contact.

The Environmental Protection Agency (EPA) has set a limit of 145 ppb in lakes and streams to protect human health from the harmful effects of antimony taken in through water and contaminated fish and shellfish. EPA has also set limits on the amount of antimony that industry can release.

The Occupational Safety and Health Administration (OSHA) has set a limit of 0.5 mg/m^3 of antimony in workroom air to protect workers during an 8-hour work shift (40-hour workweek). The National Institute of Occupational Safety and Health (NIOSH) also recommends that the concentration in workroom air be limited to 0.5 mg/m^3 for antimony, averaged over an 8-hour shift.

1.1 Toxicokinetics

Antimony can enter the body when a person drinks water or eats food, soil, or other substances that contain antimony. Antimony can also enter the body if air or dust containing antimony is breathed. It is not known if antimony can enter the body when it is placed on the skin.

A small amount of the antimony that a person eats or drinks enters the blood after a few hours. The amount and the form of antimony in the food or water will affect how much antimony enters the blood. After eating or drinking very large does of antimony, one may vomit. This will prevent most of the antimony from entering through the stomach and intestines into the blood. Antimony in the lungs will enter the blood after several days or weeks. The amount of antimony that will enter the blood from the lungs is not known.

After antimony enters the blood, it goes to many parts of the body. Most of the antimony goes to the liver, lungs, intestines, and spleen. Antimony will leave the body in feces and urine over several weeks.

Exposure to 9 milligrams per cubic meter of air (mg/m^3) of antimony for a long time can irritate the eyes, skin, and lungs. Breathing 2 mg/m^3 of antimony for a long time can cause problems with the lungs (pneumoconiosis), heart problems (altered electrocardiograms), stomach pain, diarrhea, vomiting and stomach ulcers. People who drank over 19 ppm of antimony once, vomited. It is not known what other health effects would occur to people who swallow antimony. It is not known if antimony can cause cancer or birth defects, or affect reproduction in humans. Antimony can have beneficial effects when used for medical reasons. It has been used as a medicine to treat people infected with parasites. Persons who have had too much of this medicine or are sensitive to it when it was injected into their blood or muscle have experienced adverse health effects. These health effects include diarrhea, joint and/or muscle pain, vomiting, problems with the blood (anemia) and heart problems (altered electrocardiograms).

Rats and guinea pigs that breathed very high levels of antimony for a short time died. Rats breathing high levels of antimony for several days had lung, heart, liver, and kidney damage. Breathing very low levels of antimony for a long time has resulted in eye irritation, hair loss, and lung damage in rats. Dogs and rats that breathed low levels of antimony for a long period had heart problems (changes in EKGs). Problems with fertility have been observed in rats that breathed very high levels of antimony for a couple of months. Lung cancer has been observed in some studies of rats breathing high concentrations of antimony. Antimony has not been classified for cancer effects by the Department of Health and Human Services, the International Agency for Research on Cancer or the Environmental Protection Agency.

Dogs that drank very high levels of antimony for several weeks lost weight and had diarrhea. Rats that drank very low levels of antimony for most of their lives died sooner than rats not drinking antimony. Rats eating high levels of antimony for a long time had liver damage and fewer red blood cells.

Rabbits that had very small amounts of antimony placed on their skin for less than 1 day had skin irritation. Small amounts of antimony placed in rabbit eyes resulted in eye irritation. Large amounts of antimony placed on rabbit's skin resulted in death.

Quantitative data on the absorption of antimony from the lungs in humans were not located. Elevated blood and urine antimony levels were observed in workers exposed to antimony, suggesting that antimony is absorbed. However, there is a possibility that some of the antimony detected in the urine and blood was swallowed.

The International Commission on Radiological Protection (ICRP) considers oxides, hydroxides, halides, sulfides, sulfates, and nitrates of antimony to be class W chemicals. All other common compounds of antimony are assigned to class D. Class W and D chemicals are considered to have respiratory tract clearance rates of weeks and days, respectively. The ICRP classifications are based on animal data. Data from decreased antimony smelter workers suggest that the elimination half-time of some forms of antimony in the lungs may be longer than weeks.

The absorption of antimony from the respiratory tract is a function of particle size. Exposure to antimony tartrate with a particle size of 1.6 Φm resulted in a greater deposition of antimony in the upper respiratory tract than exposure to 0.7 or 0.3 Φm particles. Furthermore, the antimony deposited in the upper respiratory tract was cleared after several hours via mucociliary clearance. Particles of the two smaller sizes were relatively insoluble in the lung and were slowly absorbed over several weeks.

No quantitative data on the absorption of antimony from the gastrointestinal tract in humans were located. However, results of studies in animals suggest that at least certain forms of antimony are probably absorbed from the gastrointestinal tract. Estimates of the absorption of antimony tartrate and antimony trichloride in animals range from 2% to 7%, suggesting that absorption of trivalent antimony salts in humans is probably less than 10%. Gastrointestinal absorption of antimony is likely to be affected by numerous factors, including chemical form of the ingested antimony, particle size and solubility, age, and diet. Although quantitative information on the absorption of antimony is not available for all forms, ICRP has recommended 10% for antimony tartrate and 1% for all other forms of antimony as reference value for gastrointestinal absorption in humans.

No studies were located regarding absorption of antimony in humans following dermal exposure.

Exposure to high levels of antimony trioxide or a mixture of antimony trioxide and pentoxide resulted in death in rabbits. The application area was occluded, suggesting that at least some forms of antimony can be absorbed through the skin.

The EPA-derived subchronic and chronic oral RfD for antimony is 4E-04 mg/kg-day. These values are based on a study by Schroeder and Mitchner in which a group of 50 male and 50 female rats was administered potassium antimony tartrate in water. Shortened longevity, decreased glucose levels, altered cholesterol levels, and no increase in tumors were observed. An uncertainty factor of 1000 was used to account for interspecies conversion, protect sensitive individuals, and because the effect level was a LOAEL of 0.35 mg/kg bw/day and no NOEL was established. On the basis of available information, EPA assigned a low confidence level to the oral RfD, study, and data base because only one species was used, only one dose level was used, no NOEL was determined, gross pathology and histopathology were not well described, and lack of adequate oral exposure investigations (IRIS 1995).

1.2 Fate And Transport

Antimony is released to the atmosphere in the form of particulate matter or adsorbed to particulate matter. It is dispersed by wind and removed by gravitational settling and dry and wet deposition. The removal rate and distance traveled from the source will depend on source characteristics (e.g., stack height), particle size and density, and meteorological conditions.

Gravitational settling governs the removal of large particles (greater than 5 Φm), whereas smaller particles are removed by the other forms of dry and wet deposition. Removal of coarse particles may occur in a matter of hours. Very small particles may have an atmospheric half-life as long as 30 days. Antimony is predominantly associated with small, submicron particles. This is frequently the case with the more volatile metals, such as antimony, that may volatilize during combustion and condense when cooled. A model which relates particle size to volatility estimates an average atmospheric half-life for antimony of 1.9 days; for the more volatile antimony trioxide, the estimated half-life is 3.2 days. With such an atmospheric half-life, antimony may be transported far from its source.

Metal deposition is characterized by large temporal and spatial variability. Estimated antimony deposition rates in urban areas are 0.006 and 0.004 kg/hectare/year (60 and 40

ng/cm^2/year) for dry and wet deposition, respectively. For remote areas, bulk (wet plus dry) deposition may be as little as 0.00016 kg/hectare/year (1.6 ng/cm^2/year). Rates of air-sea transfer of antimony are similar to the rates of accumulation of antimony in sediment.

The partitioning between dry and wet deposition depends on the intensity and duration of precipitation, the element in question, its form in the particulate matter, and its particle size. The ratio of wet to dry deposition generally increases with decreasing particle size; therefore,, a larger proportion of antimony will be found in rain compared with most other metals. A study of the wet and dry deposition over an 8-week period on an island in the German Bight, which was presumably far from sources, found 87 percent of deposited antimony dissolved in rain, 11 percent in particulate matter in rain, and only 2 percent as dry deposition. In other studies conducted in areas removed from sources of antimony emissions, half of the antimony deposition was in the form of wet deposition. The total antimony deposition annualized from a 6-month study in an industrial area of England where a number of ferrous and nonferrous metal smelting and manufacturing works were concentrated was 1,000 ng/cm^2-year (a factor of 20-40 above nonurban deposition rates). Of this, 42% represented wet deposition, of which 58% was dissolved antimony.

Antimony released into waterways is generally associated with particulate matter; it is transported to and settles out in areas of active sedimentation such as where a river empties into a lake or bay. Similarities in the composition of suspended river sediment and the sediment in bays indicate that the rivers transport the suspended sediment and deposit it in the bottom sediment. Additionally, when a river feeds into an estuary, the salinity changes that are encountered may affect adsorption to sediment and particulate matter, complexation, and coprecipitation.

Little is known of the adsorptive behavior of antimony, its compounds, and ions. The binding of antimony to soil is determined by the nature of the soil and the form of antimony deposited on the soil. Some forms of antimony may bind to inorganic and organic ligands. On the other hand, a mineral form would be unavailable for binding. Some studies suggest that antimony is fairly mobile under diverse environmental conditions, while others suggest that it is strongly adsorbed to soil. Since antimony has an anionic character, it is expected to have little affinity for organic carbon. No information could be found about antimony's adsorption to clay minerals. It is not expected that cation exchange, which generally dominates adsorption to clay, would be important for

anionic antimony. Antimony is known to form coprecipitates with hydrous iron, manganese, and aluminum oxides in soil and sediment.

The capacity of soil to adsorb antimony and the nature of the bound antimony were evaluated by incubating 200 ppm of antimony potassium tartrate with 5 g samples of soils for 6 days. Thirteen soils and subsoils (21 samples) from the southeastern United States (10 mineral and 3 organic) were included in the study. Antimony adsorbed strongly to most soils. The amount of adsorbed antimony ranged from 50% in Lakeland surface soil to 100% in several soils; the median percent adsorption was 93%. The percentage of nonexchangeable (i.e., that not removed with KC1) antimony adsorbed paralleled that of total antimony and ranged from 57% to 99%. Both sorbed and nonexchangeable antimony were negatively correlated to sand content in mineral soil. The soil/water partition coefficient (mmol/kg soil)/(mol/m^3) was 81 and greater than 185 for organic and mineral soils, respectively. Several mineral soils adsorbed 100% of the antimony and were excluded from the averaging. It is not clear what species of antimony was adsorbed in this study. If it was the antimony tartrate ion, the study may not be particularly relevant to other forms of antimony. The mobility of antimony in clay, sandy loam, silt loam, and sand soils was investigated using soil thin-layer chromatography (TLC). The antimony was applied as antimony trioxide in a water 1% HC1 suspension and developed with water in 8 hours or less. Despite experimental difficulties, the results demonstrated that there is no general mobility of antimony in any soil. The experimental problems and the fact that small amounts of antimony were found in all zones is possibly due to an unsuitable soil digestion.

A Superfund site study at a battery reclamation plant showed that while soil and sediment contained high levels of antimony, an aquifer 3 m below the surface contained 0.1 ppm of antimony; no antimony was detected in two deeper aquifers. Antimony adsorbs strongly to colloidal material in soil. The partition coefficient of antimony to 0.05-0.003 Φm colloids was 1,300. Antimony adsorbed to such material can be transported with the colloids in groundwater.

Leaching experiments performed with river sediment samples from a mining district in Idaho indicated that Sb(V) was the major species released during leaching. The fraction of antimony leached from sediment with deionized water after 10 days was highly correlated with the free iron and manganese oxide content of the sediment (correlation coefficients of 0.90 and 0.75). Experiments were also performed in which the pH

dependence of leaching was determined. The release of antimony from the sediment increased at low pH and increased sharply at high pH. The form of released antimony was also sensitive to pH. At pH 2.7, the bulk of antimony released was as Sb(III); at pH 4.3, the concentrations of tri- and pentavalent antimony were comparable; and at pH 6.3 and above, Sb(V) was the predominant species.

In order to evaluate the potential for leaching of elements from land-spread sewage sludge, the adsorption of elements from water, salt solutions, and sludge solutions to sandy and sandy loam top soils was studied. Metal levels that occur in the solution phase of sewage sludge was used, 10-100 ppb in the case of antimony. The results indicate that antimony is fairly mobile in these soils. The adsorption constants were approximately 2-16 in the sandy soil and 20 in the sandy loam soil. Although the presence of sludge increases the mobility of many trace elements because of complexation with dissolved organic compounds or increased ionic strength, this did not appear to be the case with antimony. Other studies indicated that antimony deposited on the soil surface accumulates primarily in the surface layer, and that aquifers beneath antimony waste piles are not grossly contaminated.

Mobilization of elements deposited on soil in fly ash is a potential source of terrestrial and aquatic pollution. When the alkaline fly ash from a coal-fired power plant was packed in a column and subject to leaching with dilute sulfuric acid, antimony was partially dissolved and removed from the upper layers of ash and deposited and retained on lower sections of ash in the column. It was thought that extractable, surface-adsorbed antimony in the upper layers of ash was removed by the acid, subsequently precipitated by iron oxyhydroxides, and retained lower down in the column. Other column leaching and shake-flask experiments with coal ash are too complex to summarize; they basically indicate that leaching of antimony is low. Low concentrations of antimony found in ground water beneath precipitator ash ponds lend field confirmation to the laboratory results.

When saline sediment is oxidized, such as when dredged sediment is exposed to oxygen, the pH can become very low (pH 3.1 in a lab experiment), and antimony and other toxic metals may be released. This occurs because sediments in estuaries often contain pyrite and other readily oxidizable sulfur compounds; sulfuric acid may be produced and overwhelm the buffering capacity of the sediment. An analogous pH decrease following oxidation was not observed in a freshwater sediment.

Antimony does not appear to bioconcentrate appreciably in fish and aquatic organisms. No detectable bioconcentration occurred during a 28-day test in bluegills. Only low levels of antimony have been reported in fish and aquatic organisms collected off the coast of Africa, Australia, and the Danube River in Austria. Bioconcentration factors for antimony ranged from 0.15 to 390. A study of the distribution of antimony around a smelter site indicated that antimony occurring in plants results from surface deposition. Uptake from soil is minor and appears to be correlated with the amount of available antimony (that which is soluble or easily exchangeable). Antimony bioconcentration was measured in voles, shrews, rabbits, and invertebrates around a smelter. Analysis of antimony in organs of the small mammals, compared with estimates of their antimony intake from food, showed that, although the amount of antimony in the organs was elevated, it was low compared to the amount ingested. The results suggest that antimony does not biomagnify from lower to higher trophic levels in the food chain.

1.3 Interactions with Other Chemicals

No information on the influence of other compounds on the toxicity of antimony was located.

1.4 References

ATSDR Toxicological Profile for Antimony. Update, September 1992.

Integrated Reference Information System (IRIS). 1995

2.0 POLYCHLORINATE BIPHENYLS AROCLOR - 1260, 1254

Polychlorinated biphenyls (PCBs) are a group of man-made organic chemicals that contain 209 individual compounds (known as congeners) with varying harmful effects. There are no known natural sources of PCBs in the environment. PCBs are either oily liquids or solids and are colorless to light yellow in color. They have no known taste or smell. PCBs enter the environment as mixtures containing a variety of individual components and impurities. Because the health effects of PCBs are difficult to evaluate, this document contains information on mainly seven types of commercially available PCB mixtures. These seven types of PCB mixtures include 35% of all the different PCBs commercially produced and 98% of PCBs sold in the United States since 1970. Some commercial PCB mixtures are known in the United States by their trade name, Aroclor. Aroclor 1254, for example, signifies that the molecule contains 12 carbon atoms (the first two digits) and approximately 54% chlorine by weight (second two digits). Because they do not burn easily, PCBs have been used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. The manufacture of PCBs stopped in the United States in October 1977 because of evidence that PCBs build up in the environment and cause harmful effects. Consumer products that may contain PCBs are old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors made before PCB use was stopped, old microscope oil, and hydraulic fluids.

Aroclors are no longer produced (except under exemption; e.g., small quantities for research and development and as a microscope mounting medium) in the United States and are no longer used in the manufacture of new products. Today, the major source of ambient PCB exposure seems to be environmental cycling of PCBs previously introduced into the environment. This process involves volatilization of PCBs from terrestrial and aquatic surfaces into the atmosphere with subsequent removal from the atmosphere via wet/dry deposition and then revolatilization. PCBs have been identified in 349 of the 1,300 National Priorities List (NPL).

The PCB mixtures reaching the environment as Aroclor or other commercial mixtures may contain as many as 209 PCB congeners. The environmental fate and transport and the toxic properties of PCBs as a result of environmental contamination are determined by the properties of the individual congeners. Therefore, characterizing individual congeners, as opposed to identifying the commercial product, has become more important in recent years, but it is still rarely done due to the cost involved.

PCBs, which adsorb strongly to soil and sediment, usually persist in the environment. The half-life of PCBs in soil is several years. Adsorption of PCBs generally increases as chlorination of the compound and organic carbon content of the soil and sediment increases. As a result, the leaching of PCBs from soil is generally slow, and leaching is slower for higher chlorinated PCBs than lower PCBs. The highly chlorinated Aroclors (1248, 1254, and 1260) resist both chemical and biological degradation in the environment. Although they are slow processes, volatilization and biodegredation account for the major routes of removal of PCBs from water and soil. PCBs are persistent in the atmosphere and will undergo long range transport in the air. Removal of vapor-phase PCBs from the atmosphere occurs mainly by photolysis and of particulate-phase PCBs via wet and dry deposition. The chemical composition of the original Aroclor mixtures released to the environment will change over time since the individual congeners degrade and partition at different rates.

PCBs partition significantly from water to aquatic organisms such as fish. The bioconcentration factors (BCFs) of various Aroclors in aquatic animals vary from 26,000 to 660,000. There is evidence that PCBs will biomagnify within the food chain.

The concentrations of PCBs in air and food have declined since early 1980s. The typical mean atmospheric concentration of PCBs in urban, rural, and remote locations in the United States during 1975-1979 were 5-10, 0.8, and 0.1 nanograms per cubic meter, respectively. The average PCB concentration in waters of the Great Lakes range from 0.5 to 3.3 nanograms per liter (ng/L), although a value as high as 17 ng/L was reported in water from Lake Huron. The concentrations are generally higher in water near sites of anthropogenic input and water near shorelines. Concentrations of PCBs in drinking water and soil are generally <0.1 microgram per liter and <100 microgram per kilogram (Φg/kg), respectively. PCB levels in contaminated soils can be several orders of magnitude higher than in other soils. In a 1980-1981 survey by the U.S. Fish and Wildlife Service, the geometric mean concentration of PCBs in whole freshwater fish was found to be 0.5 microgram per gram (Φg/g).

The general population may be exposed to PCBs by inhaling contaminated air and ingesting contaminated water and food. Food consumption accounted for the major body burden for PCBs in the past. Both inhalation of indoor air and consumption of fish have been identified as primary sources of human exposure to PCBs at the present time. The

estimated adult dietary intake of PCBs during 1981-1982 was 210 ng/day. The detection of PCBs in blood, adipose tissue, and breast milk samples form the general population indicates widespread exposure to PCBs from environmental sources. People who live near PCB-containing hazardous waste site may be exposed to PCBs primarily by breathing air that contains PCBs and consuming contaminated fish from local waters. Children playing inside these sites may be exposed to additional PCBs by dermal absorption and eating soil that contains PCBs. Despite the prohibition and restriction regarding PCB usage, occupational exposure to PCBs remain several orders of magnitude higher than general population exposure.

For the maximum protection of human health from the possible cancer effects of drinking water or eating fish or shellfish that contain PCBs over a lifetime, the Environmental Protection Agency (EPA) recommends that the level of PCBs in lakes and streams not be more than 0.001 parts of PCBs per billion parts of water (0.001 ppb). For exposure through drinking water, EPA recommends that at 0.004 milligrams of PCBs per liter of water (0.004 mg/L) for adults, and 0.001 mg/L of water for children, noncancer harmful health effects would not be expected.

The food and drug administration (FDA) requires that milk, eggs, other dairy products, poultry fat, fish, shellfish, and infant foods should contain not more than 0.2 to 3 ppm of PCBs to protect from noncancer harmful health effects.

The National Institute for Occupational Safety and Health (NIOSH) recommends that workers not breathe air containing more than 0.001 milligrams of PCBs per cubic meter of air (0.001 mg/m^3) for a 10-hour workday, 40-hour workweek. The Occupational Safety and Health Administration (OSHA) requires workplace exposure limits of 0.5 mg/m^3 (54% chlorine) or 1 mg/m^3 (42% chlorine) for different types of PCBs for an 8-hour workday to protect workers from noncancer harmful health effects.

The EPA requires that companies that transport, store, or dispose of PCBs follow the rules and regulations of the federal hazardous waste management program. The EPA also limits the amount of PCBs put into publicly owned waste water treatment plants. To minimize exposure to PCBs by people, EPA requires that industry tell the National Response Center when 10 pounds or more of PCBs have been released to the environment.

2.1 Toxicokinetics

Skin irritation, such as acne and rashes, can occur in people exposed to PCBs. Studies in the workplace suggest that exposure to PCBs may also cause irritation of the nose and lungs. The concentrations of PCBs in the workplace are usually much higher than at other places, such as in air in buildings that have electrical parts that contain PCBs or in outdoor air, including air at hazardous waste sites. It is not known the possible effects in persons exposed to high levels of PCBs for a short period.

Rats that ate food containing large amounts of PCBs for a short period had mild liver damage, and some died. Animals that ate smaller amounts of PCBs in their food over several weeks or months had many serious health effects, including liver, stomach, and thyroid gland injuries; anemia; acne; and damaged reproduction. These effects have been seen in many different kinds of animals, including monkeys, as well as in the offspring of animals that ate PCBs. No birth defects have been found. Only a small amount of information exists on the health effects in animals exposed to PCBs by skin contact or breathing. This information indicates that liver, kidney, and skin damage occurred in rabbits following repeated skin exposure, and that a single exposure to a large amount of PCBs on the skin caused death in rabbits and mice. Breathing PCBs over several months also caused liver and kidney damage in rats and other animals, but the levels necessary to produce these effects were very high. It is not known if the same effects would happen in people if they were exposed in the same way.

Studies of workers do not provide enough information to determine if PCBs cause cancer (are carcinogenic) in humans. Rats that ate certain PCB mixtures throughout their lives developed cancer in their livers. Based on the cancer in animals, the Department of Health and Human Services has determined that PCBs may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer has determined that PCBs are probably carcinogenic to humans. The EPA has determined that PCBs are probable human carcinogens.

If air that contains PCBs is breathed, they can enter the body through the lungs and pass into the blood stream, but it is not known how fast or how much of the PCBs will pass into the blood stream. If PCBs are swallowed in contaminated food, water, or soil, most of the PCBs will probably enter the body and pass from the stomach into the bloodstream quickly (in minutes). If there is dermal exposure to PCB contaminated soil, some of the

PCBs will pass through the skin into the bloodstream. It is unknown how much or how fast. A common way for PCBs to enter the body is by ingestion of contaminated fish and shellfish. PCBs can enter the body through inhalation of in indoor air in buildings that have electrical parts containing PCBs. Exposure from drinking water is less than from food. Once PCBs enter the body, some may change into other related chemicals called metabolites. Some metabolites of PCBs may have the potential to be as harmful as unchanged PCBs, but there is no conclusive experimental evidence to support this assumption. Some of the metabolites may leave the body in the feces in a few days, but others may stay in the body fat for months. Unchanged PCBs may also stay in the body and be stored for years in the body fat. PCBs build up in milk fat and can enter the bodies of infants through breastfeeding.

Inhalation exposure is considered to be a major route of occupational exposure to PCBs. Indirect evidence of absorption of PCBs by this route in humans is based on the fact that individual congeners have been detected in tissues and body fluids of subjects exposed in occupational settings. From data it can be assumed that a maximum of 80% of the levels commonly seen in adipose tissue of exposed capacitor workers may have been absorbed by the inhalation route. A maximum of 20% would have been derived from dermal exposure. Exposure to PCBs was positively related to mean serum PCB levels in subjects involved in clean-up operations following a PCB transformer fire; the relative contribution of the dermal route was not determined.

Information regarding absorption of PCBs in animals following inhalation exposure is limited. Male rats were exposed (whole body) to an aerosol of a PCB mixture, Pydraul A 200 (42% chlorine), at a concentration of 30 g/m^3 (0.5-3 Φm particle diameter) for $\leq$2 hours. After a 15-minute exposure, the PCB concentration in the liver was approximately 40 Φg/g tissue, and reached a maximum of 70 Φg/g after 2 hours of exposure. These results provide qualitative information regarding absorption of this specific PCB mixture, but the data were not sufficient for estimating the amount or rate of absorption. It must be also mentioned that since exposure was not head-only, the dermal route may have contributed to absorption.

Oral exposure through consumption of contaminated food is presumed to be the major route of exposure to PCB mixtures for the general population. Furthermore, oral exposure through ingestion of contaminated water or soil represents a major source of exposure for populations in the vicinity of hazardous waste sites.

Direct evidence of absorption of PCBs in humans after oral exposure was provided in a study in which a volunteer ingestion 329 Φg of a ^{13}C-PCB mixture/kg body weight. The PCB mixture, which was prepared by the investigators, contained 54% chlorine (mainly penta-, hexa-, and heptachlorobiphenyls). Blood samples obtained over 260 days after dosing revealed the presence of mostly penta- and hexachlorobiphenyl and smaller amounts of hepachlorobiphenyls. Concentrations of PCBs in whole blood reached a maximum 120 days after intake. The investigators estimated that an intake of 26 Φg/kg of 2,2',4,4',5,5'-hexachlorobiphenyl would lead to a total concentration in whole blood of 0.5 ppb 1 month later.

Indirect evidence of absorption results from studies regarding ingestion of contaminated food by the general population. Elevated levels of PCBs were found in the serum and breast milk of women who ate PCB-contaminated fish from Lake Michigan. Blood levels of PCBs were positively correlated with the amount of fish consumed. Two volunteers who consumed a total of 0.181 mg and 0.128 mg, respectively, of PCBs (mixture of 42, 48, 54, and 60% chlorine content) in contaminated fish showed a maximum 52-60% increase (2.5-4.0 and 2.3-3.5 ppb) in blood levels of total PCBs approximately 5 hours after ingesting the meal. The concentration of PCBs in blood returned to premeal levels 17 hours later. Levels of PCBs in adipose were not determined.

In experimental animals, the absorption of PCBs by the gastrointestinal tract is well documented; however, few studies provided quantitative estimates. In rats, individual cogeners (mono- to hexachlorobiphenyls) were readily absorbed when administered by gavage (vehicle not reported) in doses between 5 and 100 mg/kg. Retention was >90% of the administered dose over a 4-day period, and was apparently dose-independent. No relationship between substitution pattern and degree of absorption could be established due to the low levels of excretion, although a later study reported that absorption efficiency decreased in rats as the number of chlorine atoms increased such that dichlorobiphenyls were absorbed with a 95% efficiency, whereas octachlorobiphenyls has an absorption efficiency of only 75%. Results similar to those obtained in rats were reported in monkeys administered a single dose of 1.5 or 3.0 g Aroclor 1248/kg by gavage and in ferrets given 0.05 mg ^{14}C-labeled Aroclor 1254 in the food on days 14 and 35 of gestation. Retention was estimated to be >90% and 85.4% of the administered dose in the monkeys and ferrets, respectively. In mice, absorption of a gavage dose of 8 mg/kg 2,2',5,5'-tetrachlorobiphenyl or 100 mg/kg of 3,3',4,4'-tetrachlorobiphenyl was rapid,

with serum concentrations increasing four-to seven-fold in 30-60 minutes; peak serum concentrations were achieved approximately 2 hours after dosing. Further evidence, although indirect, regarding absorption of PCBs after oral exposure in several species can be found in studies on tissue distribution of these chemicals.

The dermal route of exposure has been recognized as a significant contributor to the accumulation of PCBs in adipose tissue of workers in the capacitor manufacturing industry. For example, it was reported that the concentration of PCBs in wipe samples from the face and hands of two employees at a private utility company varied from 0.05 to 5 $\Phi g/cm^2$. Assuming 100% dermal absorption into the main body reservoir (10 kg adipose), it is estimated that the figure of 5 $\Phi g/cm^2$ would represent 0.2-20% of a 50-$\Phi g/g$ adipose level, which is commonly seen among capacitor workers. This represents a maximum estimate and is not necessarily representative of levels found in occupationally exposed subjects.

In addition to contributing to exposure in occupational settings, the dermal route, through skin contact with contaminated water or soil, represents a major route of exposure to PCB mixtures for populations in the vicinity of hazardous waste sites.

Dermal absorption of PCBs has been measured in monkeys and guinea pigs. Single doses of ^{14}C-labeled PCBs (42% chlorine content) in benzene/hexane were applied to the abdominal skin of four rhesus monkeys and to the lightly clipped skin behind the ear of three guinea pigs. To an additional group of three guinea pigs, PCB with 54% chlorine content was applied. The application amount ranged between 4.1 and 19.3 $\Phi g/cm^2$ skin. The application sites were washed with water and acetone after 24 hours, and radioactivity was monitored in the urine for several weeks post-dosing. Absorption efficiency ranged from approximately 15% to 34% of the applied radioactivity in the monkeys and averaged approximately 33% (42% chlorine) and 56% (54% chlorine) of the applied radioactivity in the guinea pigs. Washing the skin immediately after PCB application removed 59% of the applied dose. However, only 1% of the applied label from the PCB containing 42% chlorine and 20% of the label from the PCB containing 54% chlorine could be recovered from the application site when the skin was washed 24 hours after dosing. A recent report showed that percutaneous absorption of Aroclor 1242 by abdominal skin of monkeys amounted to 20.4% of the applied was used as solvent. With Aroclor 1254 (4.8 $\Phi g/cm^2$ doses), percutaneous absorption was 28.8% from mineral oil and 14.6% from trichlorobenzene. Following a 15-minute application of Aroclor 1242

in trichlorobenzene to four different groups of monkeys, soap and water, trichlorobenzene, and mineral oil were able to remove >90% of the applied dose with five consecutive washes, whereas ethanol removed 63% of the dose suggesting that little difference exists regarding decontaminant properties among the different solvent systems. Skin washing 24 hours after dosing removed only 25-45% of the applied dose indicating that removal is no longer possible after a certain period of PCB-skin contact. Dermal absorption of PCBs (48% chlorine) has also been demonstrated in rats.

The EPA-derived subchronic and chronic oral RfDs for Aroclor 1254 are both 2E-05. These values are based on studies conducted by Arnold and others in which adult female rhesus monkeys ingested gelatin capsules containing Aroclor 1254. Ocular exudate, inflamed and prominent Meibomian glands, and distorted growth of finger and toe nails were observed. On the basis of these studies, a NOAEL could not be assessed and the LOAEL was determined to be 5E-03 mg/kg-day. On the basis of available information, EPA has determined a medium level of confidence in the principle study. The data base is rated medium due to extensive research and that human occupational and environmental data is available for commercial PCB mixtures in general. Overall confidence in the RfD is medium (IRIS 1995).

The EPA-derived oral slope factor for PCBs is 7.7 mg/kg-day. This value is based on studies in which there were hepatocellular carcinomas in three strains of rats and two strains of mice and inadequate yet suggestive evidence of excess risk of liver cancer in humans by ingestion and inhalation or dermal contact. Based on the available scientific information, EPA assigned a weight-of-evidence Group B2 to PCBs (probable human carcinogen) (IRIS 1995).

2.2 Fate And Transport

In water, adsorption to sediment or other organic matter is a major fate for PCBs. Experimental and monitoring data have shown that PCB concentrations are higher in sediment and suspended matter than in the associated water column, although about 75% of PCBs in a water column of Lake Superior exist in the dissolved phase and about 25% in the suspended particulate phase. Based on their water solubilities and octanol-water partition coefficients, the less chlorinated components of the Aroclors will sorb less strongly than the highly chlorinated components. Although adsorption and subsequent sedimentation may immobilize PCBs for relatively long periods of time in aquatic systems,

redissolution (due to loss from the aquatic phase as a result of, for example, volatilization and subsequent release from sediment) into the water column has been shown to occur in the environment. The substantial quantities of PCBs contained in aquatic sediments can therefore act as an environmental reservoir from which PCBs may be released slowly over a long period of time. Environmental redistribution from aquatic sediments should be most significant for the PCBs contained in the top layers of the sedimentary deposit. PCBs reaching the lower layers of sedimentary deposits may be effectively sequestered from environmental redistribution. The redistribution of PCBs from the uppermost sediment layer and the lower atmospheric deposition of PCBs in the upper sediment layer since 1977 may be the reason for the observed lower PCB concentration in the upper sediment layer compared to the lower sediment layers in the Great Lakes. The depth distribution of PCBs in lake sediments provides a record of changes in PCB accumulation with time.

Volatilization is a significant environmental transport process for PCBs dissolved in natural water, even though Aroclors occur as a mixture in natural water. A study conducted on Lake Michigan indicates that volatilization may be the major removal process for PCBs from lakes. PCBs may volatilize even more significantly from dams, waterfalls, and other waterways that have markedly higher aeration rates. Nonetheless, adsorption to sediment significantly decreases the volatilization rate of highly chlorinated Aroclors from the aquatic phase. The rate of redissolution of PCBs from sediment to water will always be greater in summer than in winter because of more rapid volatilization from water. Studies of PCB concentration profiles in the water column with increasing water depth in lakes suggest that air/water and sediment exchanges lead to higher PCB concentrations in surface and bottom waters, respectively. While the loss of PCBs from lake water due to volatilization and sedimentation is about the same, the contribution of outflow (to other water bodies) to the total loss of PCBs is significantly less. The distribution of PCBs in various compartments of Lake Michigan, resulting from the release of accumulated PCBs in the bottom sediments at time zero, is estimated to be 2.3% in water; 0.084% in fish; 97.5% in sediment; and 0% in air. A fugacity model estimated the input and loss of PCBs in Lake Ontario over the period 1940 - 2000. The model estimates that the concentration of PCBs rose steadily in water, sediment, fish, and gull eggs, reaching a maxima during 1968 - 1972 and decreasing thereafter relatively more rapidly in water and sediment and less rapidly in fish and gull eggs. The model also suggests that about 1985, the loss due to volatilization exceeded the sum of all deposition and absorption processes.

The low water solubility, high octanol-water partition coefficients of the PCBs, and demonstrated strong adsorption of PCBs to soils and sediment indicate that leaching should not occur in soil under most conditions. The tendency to leach will be greatest among the least chlorinated congeners. Since the sorption of PCBs to soil is proportional to soil organic carbon content, leaching is expected to be greatest from soils with low organic carbon. PCBs in soil leach significantly in the presence of organic solvents, as might occur at a hazardous waste site. The measured atmospheric concentration of PCBs in the vicinity of Superfund hazardous waste sites was found to be much higher than atmospheric concentrations 15 kilometers from the site, suggesting that PCBs may be transported (via volatilization) from soil to air. The volatilization rate will be greater from soil with low organic carbon, due to the weaker sorption of PCBs. The volatilization rates also will be greater in moist soils due to the codistillation of PCBs with water. Storm water runoff will also transport PCBs from soil to surface water.

According to a summary of experimentally determined BCFs (ration of concentration in the organism over the concentration in water) of various Aroclors (1016, 1248, 1254, and 1260) in aquatic species (fish, shrimp, oyster), BCFs range from 26,000 to 660,000. The estimated BCFs for the same Aroclors in the fathead minnow is 43,000 - 200,000. Nevertheless, the BCF in aquatic animals may depend on the water zone in which they predominantly reside. When airborne PCBs are deposited onto the surface of water, they become enriched in the surface microlayer, and the concentrations of PCBs in the surface microlayer is about 500 times higher than in deeper water. As a result, bioconcentration by fish was several orders of magnitude higher in this zone. Conversely, since the concentration of PCBs in the sediments is several orders of magnitude higher than in water, the bioconcentration of PCBs in bottom feeding species is also expected to be high. The BCFs will generally be higher as the degree of chlorination of Aroclor increases. There is evidence that PCBs will biomagnify within the food chain as indicated by the PCB levels in higher tropic levels of aquatic organisms and in several species of fish-consuming birds and seals. The biotransfer factors of Aroclor 1254 (concentration in food [mg/kg]/daily intake of PCBs [mg/day]) for beef and milk were estimated to be 0.052 and 0.011 day/kg, respectively. The estimated BCF (the concentration in tissue over the concentration in the diet) of PCBs in human fat (wet weight basis) is 175.

Accumulation of PCBs in terrestrial vegetation can occur in the following ways: uptake from soil through the root and translocation to the aerial parts of plants; deposition of

atmospheric particulates on aerial plant surfaces; and uptake of airborne vapors by aerial plant parts. the BCF for the first process is <0.02, indicating translocation from soil to aerial plant parts is not important for PCBs. The BCF in carrot peels was slightly higher than in other plant parts possibly due to adsorption from soil. However, the BCF for air to vegetation transfer of gaseous PCBs (concentration of PCBs in aerial plant parts [ng/g]/concentration of PCB vapor in air [ng/g, air density 1.19 g/L] is reported to be 85,000. Therefore, the transfer of vapor-phase PCBs from air to aerial plant parts may be the main source of vegetation contamination.

Organic compounds with vapor pressures $>10^{-4}$ mmHg should exist almost entirely in the vapor phase in the atmosphere, while organic compounds with vapor pressures $<10^{-8}$ mmHg should exist almost entirely in the particulate phase. Monitoring data indicate that between 87% and 100% of the PCBs in the atmosphere are present in the vapor phase, and that the atmosphere may effectively disperse PCBs within short distances from sources. However, the tendency of PCBs to adsorb to airborne particulates will increase as the degree of chlorination increases. The fact that the PCBs have been detected in remote locations indicates these compounds will be transported long distances from their source of emission.

PCBs in the atmosphere are physically removed by wet and dry deposition. Dry deposition occurs only for PCBs in the particulate phase. The PCB concentration in rain anywhere in the world will usually range between 1 and 250 ng/L, which indicates the importance of wet deposition. Most wet deposition is due to particulate washout, which was found to be 99%, compared to vapor washout which was found to be only 1%.

The ability of PCBs to be degraded or transformed in the environment depends on the degree of chlorination of the biphenyl molecule as well as on the isomeric substitution pattern. In general, the persistence of PCB congeners increases as the degree of chlorination increases.

2.3 Interactions with Other Chemicals

Many of the interactive affects of PCBs with other chemicals are related to the capacity of PCBs for enzyme induction. In these cases, the effects of PCBs on toxicity of other compounds depend on the role of oxidative metabolism in the toxicity of those compounds. Reported effects of PCB pretreatment include increased metabolism and

excretion of pentobarbital and decreased pentobarbital sleeping times, increased genotoxicity of numerous carcinogens (e.g., benzo(a)pyrene) in vitro, increased duodenal ulcerogenic action of acrylonitrile, and renal dysfunction of trichloroethylene. The capacity of PCB mixtures to induce cytochrome P-450 has resulted in increased toxicity of widely used solvents and numerous other chemicals commonly found at hazardous waste sites. For example, pretreating animals with PCB mixtures resulted in increased hepatotoxicity due to halothane, vinylidene fluoride, diethylnitrosamine, tricloroethylene, carbon tetrachloride, 1,1,2-trichloroethane, tetrachloroethylene, and 2,2,2-trifluoroethylvinyl ether.

Simultaneous exposure of rats to Aroclor 1254 or 1260 and chemicals of environmental concern such as the pesticide mirex, photomirex, and/or kepone in the diet resulted in increased severity of the liver lesions attributed to exposure to chlorinated biphenyls alone. Induction of hepatic arylhydrocarbon hydroxylase (AHH) activity by Aroclor 1254 in the diet of lactating rats was increased in additive manner by simultaneous dietary exposure to polybrominated biphenyls such as Firemaster BP-6.

Pretreatment of rats with Aroclor 1254 protected against hepatotoxicity due to inhalation of 1,1-dichloroethylene, suggesting that MFO induction by PCBs may be responsible for detoxification of 1,1-dichloroethylene. This detoxification might occur if the epoxide of 1,1-dichloroethylene isomerizes rapidly to an aldehyde before reacting with tissues.

Increased dietary ascorbic acid may protect against some of the toxic effects of PCBs, such as altered enzyme activity and liver histopathology, perhaps by inhibiting lipid peroxidation. The exact mechanism is not known.

Co-administration of cadmium and Aroclor 1248, resulted in a significant increase in growth retardation and plasma cholesterol, compared to controls or rats fed a diet containing cadmium or Aroclor 1248 alone. The effects were found to be additive.

The most active PCB congeners (3,3',4,4'-tetra-, 3,3',4,4',5-penta-, and 3,3',4,4',5,5'-hexachlorobiphenyl) can assume copolar conformations. The coplanar PCBs are approximate stereoisomers of 2.3.7.8-TCDD and have been shown to be potent aryl hydrocarbon hydroxylase (AHH) inducers. The di-ortho substituted PCBs (e.g., 2,2',4,4',5,5'-hexachlorobiphenyl) have been shown to be inactive as AHH inducers. However, 2,2',4,4',5,5'-hexachlorobiphenyl has been shown to competitively displaced

2,3,7,8-TCDD from the Ah receptor protein and thus acts as a 2.3.7.8-TCDD antagonist. Co-administration of 2,2',4,4',5,5'-hexachlorobiphenyl or Aroclor 1254 with 2,3,7,8-TCDD resulted in antagonism of 2,3,7,8-TCDD mediated teratogenicity (i.e., cleft palate) and immunotoxicity (i.e., suppression of the splenic plaque-forming cell response to sheep and red blood cells) in C57BL/6J mice. Similar results were found when 2,2',5,5'-tetrachlorobiphenyl (also lacking Ah receptor binding capacity) and 2,3,7,8-TCDD were administered to C57BL/6J mice.

PCBs can interact with structurally diverse carcinogens in various ways. Oral studies have shown that Aroclor 1254 and other PCBs of similar diverse carcinogens in various ways. Oral studies have shown that Aroclor 1254 and other PCBs of similar percent chlorine by weight (e.g., Kanechlor 500, Clophen A-50) promote the development of liver preneoplastic foci, liver tumors, and lung tumors in rats or mice that have been treated with other carcinogens as initiators, including nitrosamines and 2-acitylaminofluorene. PCBs also can enhance or inhibit the activity of other hepatocarcinogens when simultaneously administered orally. There is no conclusive evidence that Aroclor is a skin tumor promoter when repeatedly applied to the skin of mice that were initiated with DMBA or MNNG, but a single dermal application of Aroclor 1254 to mice showed a weak initiator activity when promoted with TPA. Pretreatment with a single dermal dose of Aroclor 1254 inhibited skin tumor initiation by DMBA in mice. Intraperitoneal injection of Aroclor 1254 to mice of day 19 of gestation protected the offspring from lung tumors, but increased the incidence of liver tumors, following injection of N-nitrosodimethylamine on postnatal day 4 or 14. The genotoxicity of numerous carcinogens is potentiated in vitro by PCBs, but this does not indicate that PCBs should be regarded universally as tumor promoters because of the protective role of PCBs against carcinogenicity of many genotoxic carcinogens in vitro.

2.4 References

ATSDR Toxilogical Profile for Selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016). Update, April 1993.

Integrated Reference Information System (IRIS). 1995.

3.0 ARSENIC

Arsenic is an element that occurs naturally in a variety of sulfidic ores. Arsenic can be released to the environment from natural sources (e.g., volcanoes, erosion of mineral deposits), but releases from human activities (e.g., metal smelting, chemical production and use, coal combustion, waste disposal) can lead to substantial environmental contamination. Most human releases of arsenic are to land or soil, primarily in the form of pesticides or solid wastes. However, substantial amounts are also released to air and to water.

Arsenic releases to land is relatively nonmobile, due to binding to soil particles. However, rainwater or snowmelt may leach soluble forms into surface water or groundwater, and soil microorganisms may reduce a small amount to volatile forms (arsines). Arsenic dissolved in water can undergo either reduction or oxidation, depending on conditions. Poorly soluble forms tend to adsorb to organic material in sediments or soils, while the soluble species tend to move with water. Arsenic released to air exists mainly in the form of particulate matter. These particles are dispersed by the wind as a function of their size, and the particles are then returned to the earth by wet or dry deposition. Arsines that are releases from microbial sources in soils or sediments undergo oxidation in the air, reconverting the arsenic to nonvolatile forms that settle back to the ground.

Because arsenic is a natural component of the earth's crust, low levels are found in all environmental media. Concentrations in air in remote locations (away from human releases) range from 20 to 100 nanograms per cubic meter. Concentrations in water are usually less than 10 parts per billion (ppb), although higher values can occur near natural mineral deposits or man-made sources. Natural levels of arsenic in soil usually range from 1 to 40 parts per million (ppm), but pesticide application or waste disposal can produce much higher values. Arsenic is also found in many foods, at concentrations that usually range from 20 to 140 ppb. Concentrations may be substantially higher in certain seafoods, although much of this is in a nontoxic form.

For most people, the diet is the largest source of exposure, with average intakes of about 50 micrograms per day. Intake from air, soil, and water are usually much smaller, but exposure from these media may become significant in areas of arsenic contamination. People who produce or use arsenic compounds in occupations such as nonferrous metal smelting, pesticide manufacturing or application, wood preservation, semiconductor

manufacturing, or glass production can be exposed to substantially higher levels of arsenic, mainly from dusts or aerosols in air. The government estimates that in the early 1980s, about 55,000 workers were exposed in these occupations.

Hazardous waste sites are another possible source of human exposure to arsenic. Arsenic has been identified at 781 of the 1,300 hazardous waste sites that have been proposed for inclusion on the National Priorities List (NPL). Of these sites 774 are located in the United States and 7 are located in the Commonwealth of Puerto Rico. Exposure at waste sites may occur by a variety of pathways, including inhalation of dusts in air, ingestion of contaminated soil of water, or through the food chain. The magnitude of the exposures may be substantial, but this can only be evaluated on a site-by-site basis.

The federal government has taken several steps to protect humans from arsenic. First, the Environmental Protection Agency (EPA) has set limits on the amount of arsenic that industrial sources can release into the environment. Second, EPA has restricted or canceled many of the uses of arsenic in pesticides and is considering further restrictions. Third, EPA has set a limit of 50 ppb for arsenic in drinking water. EPA is currently reviewing this value and may lower it. Finally, the Occupational Health and Safety Administration (OSHA) has established a maximum permissible exposure limit to 10 micrograms per cubic meter for airborne arsenic in various workplaces that use inorganic arsenic.

3.1 Toxicokinetics

Inorganic arsenic has been recognized as human poison since ancient times, and large oral dosed (above 60,000 ppb in food or water) can produce death. If lower levels are swallowed of inorganic arsenic (ranging from about 300 to 30,000 ppb in food or water), irritation of the stomach and intestines, with symptoms such as pain, nausea, vomiting, and diarrhea may be experienced. Other effects from swallowing arsenic may include decreased production of red and white blood cells, abnormal heart rhythm, blood-vessel damage, and impaired nerve function causing "pins and needles" sensation in the hands and feet. Although there is no good evidence that arsenic can injure pregnant women or their fetuses, studies in animals show that doses of arsenic that are large enough to cause illness in pregnant females may cause low birth weight, fetal malformations, or even fetal death.

If arsenic in water, soil, or food is swallowed, most of the arsenic quickly enters into the body. This is the most likely way of exposure near a waste site. If arsenic dust particles are breathed, many of the dust particles settle into the lining of the lungs. Most of the arsenic in these particles is then taken up from the lungs into the body. If arsenic-contaminated soil or water contacts the skin, only a small amount will go through the skin and into the body, so this is usually not of concern.

Perhaps the single most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. This includes a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. While these skin changes are not considered to be a health concern in their own right, a small number f the corns may ultimately develop into skin cancer. Swallowing arsenic has also been reported to increase the risk of cancer in the liver, bladder, kidney, and lung. The Department of Health and Human Services determined that arsenic is known carcinogen. The International Agency for Research on Cancer (IARC) has determined that arsenic is a human carcinogen. Both the EPA and the National Toxicology Program (NTP) have classified arsenic as a known human carcinogen.

The most common inorganic arsenic in air is arsenic trioxide (As_2O_3), while a variety of inorganic arsenates (AsO_4^{-3}) or arsenites (AsO_2) occur in water, soil, or food. A number of studies have noted differences in the relative toxicity of these compounds, with trivalent arsenites tending to be somewhat more toxic than pentavalent arsenates. However, these distinctions have not been emphasized in this profile, for several reasons: (1) in most cases, the differences in the relative potency are reasonably small (about 2-3 fold), often within the bounds of uncertainty regarding no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs); (2) different forms of arsenic may be interconverted, both in the environment and the body; and (3) in many cases of human exposure (especially those involving intake from water or soil, which are of greatest concern to residents near waste sites), the precise chemical speciation is not known. Thus, for the purposes of simplicity and practicability, it is convenient to consider the arsenates and arsenites as approximately equitoxic.

If high levels of arsenic are breathed, a sore throat and irritated lungs are likely to be experienced. Skin effects may develop. The exposure level that produces these effects is uncertain, but is probably above 100 micrograms per cubic meter. However, these effects are usually not serious. Of much greater concern is the ability of inhaled inorganic arsenic

to increase the risk of lung cancer. This has been seen mostly in humans exposed to arsenic in or around smelters. People who live near smelters, chemical factories, or waste sites with arsenic may have increased risk of lung cancer as well.

Since arsenic exists in air as particulate matter, absorption across the lung involves two processes: deposition of the particles onto the lung surface, and absorption of arsenic from the deposited material. In lung cancer patients exposed to arsenic in cigarette smoke, deposition was estimated to be about 40% and absorption was 75-85%. Thus, overall absorption (expressed as a percentage of inhaled arsenic) was about 30-34%. In workers exposed to arsenic trioxide dusts in smelters, the amount of arsenic excreted in the urine (the main route of excretion) was about 40-60% of the estimated inhaled dose. Although the percent deposition was not measured in these cases, it seems likely that nearly all of the deposited arsenic was absorbed. This conclusion is supported by intratracheal instillation studies in rats and hamsters, where clearance of oxy compounds of arsenic (sodium arsenite, sodium arsenate, arsenic trioxide) from the lung was rapid and nearly complete (60-90% within 1 day). In contrast, arsenic sulfide and lead arsenate were cleared more slowly, indicating that the rate of absorption may be lower if the inhaled arsenic is in a highly insoluble form.

No studies were located regarding absorption of organic arsenicals in humans or animals after inhalation exposure. However, DMA instilled in the lungs of rats was very rapidly (half-time = 2.2 minutes) and nearly completely (at least 92%). This indicates that organic arsenicals are likely to be well-absorbed by the inhalation route.

Several studies in humans indicate that arsenates and arsenites are well absorbed across the gastrointestinal tract. The most direct evidence is from measurement of fecal excretion in humans given oral doses of arsenite, where less than 5% was recovered in the feces. This indicates absorption was at least 95%. This is supported by studies in which urinary excretion in humans was found to account for 55-80% of daily oral intakes of arsenate or arsenite. In contrast, ingestion of arsenic triselenide (As_2Se_3) did not lead to a measurable increase in urinary excretion, indicating that gastrointestinal absorption may be much lower if highly insoluble forms of arsenic are ingested.

These observations in humans are supported by a number of studies in animals. Fecal excretion of arsenates and arsenites ranged from 2-10% in monkeys and mice, with 70% or more appearing in urine. Hamsters appear to absorb somewhat less, since fecal

excretion usually ranges from 10-40%. As in humans, when highly insoluble arsenic compounds are administered, gastrointestinal absorption is reduced.

Based on urinary excretion studies in volunteers, it appears that both MMA and DMA are well-absorbed (at least 75-85%) across the gastrointestinal tract. This is supported by studies in animals, where at least 75% absorption has been observed for DMA and MMA.

If exposed to arsenic, the liver changes some of the arsenic to a less harmful organic form. Both the inorganic and organic forms leave the body in the urine. Most of the arsenic will be gone within several days, although some will remain in the body for several months or longer.

If direct skin contact with inorganic arsenic compounds occurs, the skin may become irritated with some redness and swelling. However, it does not appear that skin contact is likely to lead to any serious internal effects.

No quantitative studies were located on absorption of inorganic arsenicals in humans after dermal exposure. Uptake of arsenic into blood or tissues was undetectable for up to 24 hours in rats whose tails were immersed in solutions of sodium arsenate for 1 hour. However, arsenic began to increase in blood, liver, and spleen over the next 5 days. The rate of uptake was estimated to be 1-33 Φg/cm2/hr. These findings suggest that dermal exposure leads initially to arsenic binding to skin, and that the bound arsenic may slowly be taken up into the blood, even after exposure ends.

No studies were located on absorption of organic arsenicals in humans or animals after dermal exposure.

Almost no information is available on the effects of organic arsenic compounds in humans. Studies in animals show that most arsenic compounds are less toxic than the inorganic forms. However, high doses can produce some of the same effects. Thus, if there is exposure to high doses of an organic arsenic compound, there may develop nerve injury, stomach irritation, or other effects, but this is not known for certain.

Despite all the adverse effects associated with inorganic arsenic exposure, there is some evidence that the small amounts of arsenic in the normal diet (10 to 50 ppb) may be beneficial to the health. For example, animals fed a diet with unusually low concentrations

of arsenic did not gain weight normally. They also became pregnant less frequently than animals fed a diet containing a normal amount of arsenic. Further, the offspring from these animals tended to be smaller than normal, and some died at an early age. However, no cases of arsenic deficiency in humans have ever been reported.

The EPA-derived subchronic and chronic oral RfDs for inorganic arsenic are both 3E-04 mg/kg-day. These values are based on epidemiological studies conducted by Tseng and others with the NOAEL and LOAEL of 8E-04 mg/kg-day and 14E-03 mg/kg-day, respectively. Hyperpigmentation, keratosis, and vascular complications were the observed adverse health effects in these studies. An uncertainty factor of 3 was used to account for the lack of data that would preclude reproductive toxicity as a critical effect and for some uncertainty as to whether the NOAEL identified in the study addressed all sensitive individuals. The EPA-verified oral RfD for arsenic also includes estimation of arsenic from food. On the basis of the available information, EPA assigned a medium confidence level to the oral RfD and the study (doses were not well characterized and other contaminants were present) and medium confidence in the database (there were problems with the available epidemiological data) (IRIS 1995).

The EPA-derived oral slope factor for inorganic arsenic is 1.75 $(mg/kg\text{-}day)^{-1}$. This value is based on the epidemiological study of Tseng who reported an increased prevalence of skin cancer following exposure to arsenic in drinking water. Based on the available scientific information, EPA assigned a weight-of-evidence Group A to arsenic (known human carcinogen) (IRIS 1995).

3.2 Fate And Transport

Most arsenic in the environment exists in soil or rock. This material may be transported by wind or water erosion of small particles, or may be transported by leaching into rainfall or snowmelt. However, because many arsenic compounds tend to adsorb to soils or sediments, leaching usually results in transportation over only shorts distances in soil.

Transformation of arsenic in soil are similar to those occurring in aquatic systems, with As(+5) predominating in aerobic soils, As(+3) in slightly reduced soils (e.g., temporarily flooded), and arsine, methylated arsenic, and elemental arsenic in very reduced conditions (e.g., swamps and bogs). Organoarsenical pesticides (e.g., MMA, DMA) applied to soil are metabolized by soil bacteria to alkylarsines, arsenate and MMA. The half-life of DMA

in soil is about 20 days.

Transport and partitioning of arsenic in water depends upon the chemical form (oxidation state and counter ion) of the arsenic and on interactions with other materials present. Soluble forms move with the water, and may be carried long distances through rivers. However, arsenic may be adsorbed from water onto sediments or soils, especially clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material. Sediment-bound arsenic may be released back into the water by chemical or biological interconversions of arsenic species.

Arsenic in water can undergo a complex series of transformations, including oxidation-reduction reactions, ligand exchange, and biotransformation. Rate constants for these various reactions are not readily available, but factors most strongly influencing fate processes in water include Eh (the oxidation-reduction potential), pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, and distribution and composition of the biota. The predominant form of arsenic in surface waters is usually arsenate, but aquatic microorganisms may reduce the arsenate to arsenite and a variety of methylated arsenicals. Arsenate also often predominates in groundwater, but arsenite may be an important component, depending upon the characteristics of the water surrounding the geology.

Arsenic in the atmosphere exists as particulate matter, mostly as particles less than 2 micrograms in diameter. Theses particles are transported by wind and air currents until they are returned to earth by wet or dry deposition. The residence time of particulate-bound arsenic depends on particle size and meteorological conditions, but a typical value is about 10 days.

Arsenic is released into the atmosphere primarily as arsenic trioxide or, less frequently, in one of several volatile organic compounds, mainly arsines. Trivalent arsenic and methyl arsines in the atmosphere undergo oxidation to the pentavalent state, and arsenic in the atmosphere is usually a mixture of the trivalent and pentavalent forms. Photolysis is not considered an important fate process for arsenic compounds.

Bioconcentration of arsenic occurs in aquatic organisms, primarily in algae and lower vertebrates. Bioconcentration factors (BFCs) measured in freshwater invertebrates and fish for several arsenic compounds ranged from 0 to 17, but a BFC of 350 was observed in

marine oysters. Biomagnification in aquatic food chains does not appear to be significant, although some fish and invertebrates contain high levels of arsenic compounds. Terrestrial plants may accumulate arsenic by root uptake from the soil or by absorption of airborne arsenic deposited on the leaves, and certain species may accumulate substantial levels.

3.3 Interactions With Other Chemicals

A number of researchers have found that arsenic compounds tend to reduce the effects of selenium. Conversely, selenium can decrease the effects of arsenic, including clastogenicity, cytotoxicity, and terarogenicity. The mechanism of this mutual inhibition of effects is not known, but may be related to formation of a complex that is excreted more rapidly than either arsenic or selenium alone. There is little direct evidence that variations in selenium exposure to humans lead to significant increases or decreases in arsenic toxicity, although workers who develop lung cancer in a copper smelter had lower tissue levels of selenium than workers who did not develop lung tumors. This suggests that selenium deficiency could significantly increase the risk of lung cancer following inhalation exposure to arsenic, but it is difficult to distinguish cause from effect in such a study.

The interactions between cigarette smoking, inhalation of arsenic, and the risk of lung cancer has not been extensively investigated. Smoking appeared to increase lung cancer risk synergistically (multiplicatively) in one study of smelter workers, although the data are not adequate to exclude a simple additive interaction. Suggestive evidence of a positive interaction between arsenic and benzo(a)pyrene has also been noted for induction of lung adenocarcinomas in hamsters.

Interactions between arsenic and other metals have been investigated, but no clear evidence for toxicologically significant effects has emerged. For example, studies of rats exposed to arsenic, lead, and cadmium, alone or in combination, revealed mainly additive or sub-additive effects of body weight, hematological parameters, and enzymes of heme synthesis. Similarly, studies of the tissue levels of arsenic in rats fed arsenic with or without lead or cadmium revealed only limited evidence of any toxicokenetic interactions. These data do not suggest that arsenic toxicity is likely to be significantly influenced by concomitant exposure to other metals.

Since methylation of arsenic is a detoxification mechanism, it is possible that chemicals which interfere with the methylation process could increase toxicity. This is supported by studies in animals in which reagents that inhibit methylation enzymes (e.g., periodate-oxidized adenosine) caused an increase in tissue levels of inorganic arsenic. Similarly, cellular glutathione levels appear to play a role in the methylation process, and treatment with reagents (e.g., phorone) that decrease glutathione levels increases arsenic toxicity. It is not known if chemicals likely to be encountered in the environment cause significant effects on the methylating capacity of humans.

3.4 References

ATSDR Toxicological Profile for Arsenic. Update, April 1993.

Integrated Reference Information System (IRIS). 1995.

4.0 CHLORDANE

Chlordane is a manmade chemical that was used as a pesticide in the United States from 1948 to 1988. It is sometimes referred to by the trade names Octachlor and Velsicol 1068. It is a thick liquid whose color ranges from colorless to amber, depending on its purity. It may have no smell or a mild, irritating smell. The taste is unknown. Chlordane is not a single chemical, but is a mixture of many related chemicals, of which about 10 are major components. Some of the major components are *trans*-chlordane, *cis*-chlordane, *B*-chlordane, heptachlor, and *trans*-nonachlor. Chlordane does not dissolve in water. Therefore, before it can be used as a spray, it must be placed in water with emulsifiers (soap-like substances), which results in a milky-looking mixture.

From 1983 until 1988, chlordane's only approved use was to control termites in homes. The pesticide was applied underground around the foundation of homes. When chlordane is used in the soil around the house, it kills termites that come into contact with it.

Before 1978, chlordane was also used as a pesticide in agricultural crops, lawns, and gardens and a fumigating agent. Because of concerns over cancer risk, evidence of human exposure and build up in body fat, persistence in the environment, and danger to wildlife, the EPA canceled the use of chlordane on food crops and phased out other aboveground uses over the next five years. In 1988, when the EPA canceled chlordane's use for controlling termites, all approved use of chlordane in the United States stopped. Manufacture export continues.

When used as a pesticide on crops, on lawns and gardens, and to control termites in houses, chlordane enters into the environment. Although it is no longer used in the United States, it may be used in other countries. In soil, it attached strongly to particles in the upper layers of soil and is unlikely to enter the groundwater. It is not known whether chlordane breaks down in most soils. If a breakdown occurs, it does not leach significantly. Chlordane is known to remain in some soils for more than 20 years. Persistence is greater in heavy, clayey or organic soil than sandy soil. Most chlordane is lost from soil by evaporation. Evaporation is more rapid from light, sandy soils than from heavy soils. Half of the chlordane applied to the soil surface may evaporate in two to three days. Evaporation is much slower after chlordane penetrates into the soil. In water, chlordane may attach strongly to sediment and particles in the water column and it may be lost by evaporation. It is not known how much chlordane breaks down in water or in

sediment. Chlordane breaks down in the atmosphere by reacting with light and with some chemicals in the atmosphere. However, it is sufficiently long lived that it may travel long distances and be deposited on land or in water far from its source. Chlordane or the chemicals that chlordane changes into accumulate in fish, birds, and mammals. Chlordane stays in the environment for many years and is still found in food, air, water, and soil. Chlordane is still commonly found in some form in the fat of fish, birds, mammals, and almost all humans.

The Environmental Protection Agency (EPA) guidelines for drinking water suggest that no more than 60 ppb chlordane should be present in drinking water that children consume for loner than 10 days. Drinking water should contain no more than 0.5 ppb for children or 2 ppb for adults if they drink the water for longer periods.

EPA stopped all use of chlordane of chlordane on food crops, effective March 1978. Until 1988, EPA permitted chlordane use for termite control or dipping the roots or tops of nonfood plants. On April 14, 1988, however, EPA stopped all sales and commercial use for chlordane.

Federal regulations limit the amount of chlordane that factories can release into waste water. The EPA requires industry to report release or spills of 1 pound or more. A temporary guideline of the National Research Council indicated that 0.005 mg/m^3 should be the maximum amount allowed in the air of military housing.

The Occupational Safety and Health Administration (OSHA) regulates chlordane levels in the workplace. The maximum allowable level in workplace air is 0.5 mg/m^3 for a person who is exposed for 8 hours per workday and 40 hours per workweek.

4.1 Toxicokinetics

Chlordane can enter the body through the skin if skin contact occurs with contaminated soils, through the lungs if breathed in with contaminated air, and through the digestive tract if swallowed. Uptake through the skin and digestive tract increases if chlordane is in an oily mixture, which might occur at hazardous waste sites. The importance of each of these ways for chlordane to enter the body depends of the kind of exposure. For example, people living in houses that have been treated with chlordane will be exposed mostly by breathing the vapor in the air. Workers who sprayed chlordane as a pesticide were

exposed mostly by breathing the compound in the air and by contact with the skin. Other people may be exposed to small quantities by eating food or drinking water that contains chlordane. People at or near waste sites may be exposed by touching chlordane in the soil, by breathing chlordane that evaporates into the air, by drinking water that contains chlordane or by eating contaminated fish or crops. The amount of chlordane that enters the body depends on the amount of air, food, or water, and the length of time a person is exposed to it. Most chlordane that enters the body leaves in a few days, mostly in the feces, and a much smaller amount leaves in the urine. Chlordane and its breakdown products may be stored in body fat, where they cause no bad effects, unless released from the fat in large amounts. It may take months or years before the chlordane and the breakdown products that are stored in fat are able to leave the body.

Most health effects in humans that may be linked to chlordane exposure are on the nervous system, the digestive system, and the liver. These effects were seen mostly in people who swallowed chlordane mixtures. Large amounts of chlordane taken by mouth can cause convulsions and death. Convulsions occurred in a man who had a long-term skin contact with soil containing large amounts of chlordane. Swallowing small amounts or breathing air containing high concentrations of chlordane vapors can cause a variety of nervous system effects, including headaches, irritation, confusion, weakness, and vision problems, as well as upset stomach, vomiting, stomach cramps, diarrhea, and jaundice.

No harmful effects on health have been confirmed in studies of workers who made chlordane. One study found major changes in liver function in workers in Japan who used chlordane as a pesticide. There are indications that chlordane may cause anemia and other changes in the blood cells, but the evidence is not very strong.

Animals given high levels of chlordane by mouth for short periods of time or had convulsion. Long-term exposure of animals to chlordane in their food caused harmful effects in the liver. It is not known whether chlordane will cause cancer in humans after long-term exposure. Studies of workers who made or used chlordane do not link exposure with cancer, but the information is not sufficient to know for sure. Mice fed low levels of chlordane in their food for most of their lifetimes developed liver cancer. The International Agency for Research on Cancer (IARC) has determined that chlordane is not classifiable as to its carcinogenicity to humans. It is not known whether chlordane will cause reproductive or birth defects in humans. Studies of workers who made or used chlordane do not link exposure to the chemical with birth defects, but there are not

enough studies in humans to know for sure. There is some evidence that animals exposed before birth or while nursing develop behavioral effects while growing up.

Data obtained from humans exposed via inhalation to chlordane in the air of termite-treated homes in Japan or as the result of pesticide spraying indicate that blood or tissue levels of chlordane and/or its metabolites increase with exposure duration. Although these data are not sufficient to quantify absorption from the respiratory tract, the confirm qualitatively that absorption occurs.

An intratracheal study suggests that absorption of chlordane by the respiratory system of rats is rapid. A peak blood concentration of radioactivity equivalent to about 4% of an intratracheal dose of radiolabeled chlordane was reached in <5 minutes. The value of this study was limited by the mode in which the chlordane was delivered, the use of ethanol as a vehicle, and the unknown impact of anesthesia and surgical preparation on uptake from the respiratory tract. In reviewing the data from this study, it was noted that about 24% of the dose of radioactivity was present in the lungs 1 hour after treatment and concluded that about 76% of the dose had been absorbed from the respiratory tract.

Information on the absorption of chlordane following oral exposure in humans comes largely from case reports involving accidental ingestion. A chlordane level of 2.71 mg/L was measured in the blood of a 20-month-old boy 2.75 hours after he had ingested an unknown amount of technical grade (74%) chlordane. A chlordane concentration of 3.4 mg/L was measured in a serum sample taken from a 4-year old girl at an unspecified time following the ingestion of an unknown amount of a 45% chlordane formulation. Chlordane was found in the blood plasma (concentration of 4.87 Φg/g) and in several tissues (adipose, 22.00 Φg/g; spleen, 19.15 Φg/g; brain, 23.27 Φg/kg; liver, 59.93 Φg/g) of a 59-year-old male about 2 hours after he ingested an unknown amount of chlordane. A whole blood chlordane concentration of 5 mg/L was measured in a 62-year-old male 3.5 hours after he had ingested 300 mL of a 75% chlordane solution (215 g). While these case reports do not provide information on the rate and extent of absorption in humans after oral exposure to chlordane, they indicate that the compound is absorbed from the gastrointestinal tract.

Excretion of radioactivity in the urine of rats given a single oral dose of radiolabeled chlordane accounted for about 2-8.5% if the administered dose. The chlordane doses used in this study were 0.05-1.0 mg/kg of a 3:1 mixture *cis*- and *trans*-chlordane, or 0.2

mg/kg of each isomer separately. Based on these urinary excretion data, EPA stated that chlordane from the gastrointestinal tract of rats was at least 2-8.5% of the administered dose. More recent information , however, indicates that absorption from the gastrointestinal tract of rats and mice may be substantially higher than previously estimated. Biliary excretion of chlordane (and/or its metabolites) played a significant role in the elimination of this compound in both species, suggesting that a large amount of the radioactivity found in the feces following oral administration of radiolabeled chlordane represents absorbed material. A first-order absorption model suitably described the experimental data in rats. The extent of chlordane absorption after oral exposure was estimated by comparing areas under the plasma concentration versus time curves (AUC) of radioactive equivalents of chlordane after oral or intravenous dosing at 0.1-1.0 mg/kg. Absorption was estimated to be about 80% of the administered dose in rats, and this percentage did not vary significantly over the dose range tested.

Chlordane appears to be rapidly absorbed from the gastrointestinal tract of rats; peak blood levels of radioactivity occurred about 2-4 hours following administration of oral doses ranging from 0.1 to 1.0 mg/kg. Peak blood levels of radioactivity following a 1.0 mg/kg dose of ^{14}C-chlordane were between approximately 81 ng chlordane equivalents/mL for the *cis* isomer and 175 ng chlordane equivalents/mL for the *trans* isomer.

Absorption in the mouse was slower than in the rat after oral exposure to chlordane; a peak blood level of 113 ng equivalents/mL of blood was observed in the mouse 8 hours after administration of a 1 mg/kg dose of ^{14}C-*cis*-chlordane. Absorption was not quantified following oral dosing in the mouse, but intraperitoneal studies indicated that a significant degree of biliary excretion also occurs in this species. The mouse may be similar to the rat in that a large percentage of an oral dose of chlordane is absorbed in the gastrointestinal tract of both species.

In rabbits, the estimated absorption of chlordane following various repeated oral dosing regimens with radiolabeled compound had been between 30% and 50% of the cumulative ^{14}C dose, based on radioactivity eliminated in the urine. The various dosing regimens used in these studies included: radiolabeled *trans*-chlordane given to male rabbits at approximately mg/kg/day for 10 weeks, 25 ppm of a mixture of *cis*- and *trans*-chlordane fed to a male rabbit for 2 days (approximately 1.22 mg/kg/day), and *cis*- or *trans*-chlordane(30 and 67 mg/kg/day, respectively) given in gelatin capsules to male rabbits for

4 days. Bilary excretion was not studied in the rabbit, and the estimation of 30-50% absorption (based on urinary excretion) must be considered a minimum estimate.

No quantitative data regarding absorption in humans after dermal exposure to chlordane were located. It was reported that chlordane tends to persist in the hands of pest control operators (exposure duration not reported) for at least 2 years after exposure to the pesticide has been terminated. This claim is questionable, however, because the subject in the study was not followed closely enough to determine the absence of chlordane exposure during the 2-year period. It is possible, for example, that chlordane may have been present on the subject's clothing or shoes, resulting in continued exposure. A case was reported of accidental death preceded by neurological signs typical of chlordane toxicity in a woman who was dermally exposed to a mixture of chlordane and other chemicals. These data suggest that chlordane is absorbed through human skin.

The dermal route of exposure is relatively significant for chlordane. It has been indicated that a topical dose of chlordane in rats (50 mg/kg) is more readily absorbed when the compound is administered in an oil vehicle instead of ethyl alcohol. In an in vitro study using diffusing cells in which ^{14}C-chlordane (0.0027-0.003 mg/cm^2/day) was applied to human skin from cadavers for 24 hours, the amount of the applied dose of radioactivity recovered from the receptor fluid (human plasma) was 0.04% when the application medium was soil and 0.07% when the application medium was acetone. Much larger proportions (0.34% from soil and 10.9% from acetone) were retained within the layers of the skin. In an in vitro study, ^{14}C-chlordane in soil or acetone was applied to the skin of monkeys for 24 hours. Absorption accounted for 4.2% of the dose in soil and 6% of the dose in acetone, based on recovery of ^{14}C in the urine following dermal, compared with intravenous, dosing.

The EPA-derived subchronic and chronic oral RfDs for chlordane are both 6E-05 mg/kg-day. These values are based on studies conducted by Velsicol Chemical Company in which 344 rats of both sexes were fed technical chlordane for 130 weeks. Liver lesions were observed in the female rats only, therefore the LEL for female rats is 2.73E-01 mg/kg-day and 1.175E-01 mg/kg-day for male rats. A NOEL of 5.5E-02 was established for female rats. An uncertainty factor of 100 was used to account for the inter- and intraspecies differences. An additional uncertainty factor of 10 was used to account for the lack of an adequate reproduction study and adequate chronic study in a second mammalian species, and the generally inadequate sensitive endpoints studied in existing

studies, particularly since chlordane is known to bioaccumulate over a chronic duration. On the basis of the available information, EPA determined that the critical study is of adequate quality and is given a medium rating. The data base is given a low confidence rating because of 1) the lack of an adequate reproduction study and adequate chronic study in a second mammalian species and 2) inadequate sensitive endpoints studied in existing studies, particularly since chlordane is known to bioaccumulate over a chronic duration. Low confidence in the RfD follows (IRIS 1995).

The EPA-derived oral slope factor for chlordane is 1.3 $(mg/kg/day)^{+0}$. This value is based on studies in which benign and malignant liver tumors were induced through diet in four strains of mice of both sexes and in male rats; namely heptocellular carcinomas in mice and hepatocellular adenomas in rats. Based on the available scientific information, EPA assigned a weight-of-evidence Group B2 to humans (probable human carcinogen) (IRIS 1995).

4.2 Interactions with Other Chemicals

Chlordane, like those other organochlorine insecticides, functions as a potent inducer of hepatic microsomal enzymes. Induction of these enzymes following chlordane administration is associate with an increased rate of metabolism of many endogenous and xenobiotic compounds, including therapeutic drugs and hormones. Health practitioners should be aware that doses of therapeutic drugs and hormones may require adjustment in patients exposed to chlordane, although data regarding enzyme induction in humans exposed to chlordane were not located.

Health practitioners should also be aware that exposure to other pesticides or chemicals that induce hepatic microsomal enzymes may increase the toxicity of chlordane, probably enhancing the transformation of chlordane to more highly toxic metabolites. For example, previous exposure to aldrin, dieldrin, or DDT increases the acute toxicity of chlordane to rats by approximately 2.3 to 4.6 times. When given simultaneously to rats or mice, the acute lethal effects of chlordane in combination with most pesticides appeared to be roughly additive, except that aldrin or endrin and chlordane, and methoxychlor and chlordane were more than additive in mice.

The acute toxicity of chlordane in rats increased when rats were fed protein deficient diets. Chlordane treatment has also been demonstrated to enhance the hepatotoxic effects

produced by carbon tetrachloride in rats, as indicated by its effect on SGPT levels, presumably by inducing the metabolism of carbon tetrachloride to its toxic metabolite. On the other hand, chlordane provided some protection against carbon tetrachloride-induced liver necrosis in rats, possibly by inducing a type of cytochrome P-450 with diminished ability to metabolize carbon tetrachloride to its toxic metabolite. Pretreatment of rats with chlordane accelerated the metabolism of lindane, presumably by the same mechanism.

4.3 References

ATSDR Toxicological Profile for Chlordane. Update Draft for Public Comment, October 1992.

Integrated Reference Information System (IRIS). 1995.

5.0 4,4'-DDT, 4,4'-DDE, 4,4'-DDD

DDT (1,1,1-trichloro-2,2-bid(*p*-chlorophenyl)ethane) was one of the most widely used chemicals for controlling insects on agricultural crops and controlling insects that carry such diseases as malaria and typhus. Technical DDT is a mixture of three forms, *p,p'*-DDT (85%), *o,p'*-DDT (15%), and *o,o'*-DDT (trace amounts), all of which are white, crystalline, tasteless, and almost odorless solids. Technical DDT is made from chloral hydrate, chlorobenzene, and sulfuric acid. In addition, DDE (1,1-dichloro-2,2-*bid(p*-chlorophenyl)ethylene) and DDD (1,1-dichloro-2,2-*bis(p*-chlorophenyl)ethane) are found in small amounts as contaminants in technical DDT. DDD was also used to kill pests, and one form of DDD (*o,p'*-DDD) has been used medically to treat cancer of the adrenal gland.

DDT does not occur naturally in the environment. DDT can no longer be used as a pesticide in the United States except in cases of public health emergency. It is, however, still used in several other areas of the world. In addition, the use of DDD to kill pests has also been banned.

DDT entered the environment as a result of its production and use as an insecticide. DDT is present at many waste sites, including National Priorities List (NPL) sites, and releases from these sites might be additional sources of environmental contamination. Most DDT in the environment entered as a result of its past use. DDT still enters the environment because of its current use in other areas of the world. DDE and DDD are only found in the environment as a result of contamination or breakdown of DDT. Large amounts of DDT were released to soil because of direct application. Some DDT may have entered the soil when it was stored or disposed of in waste sites. DDT has entered surface water either by direct spraying of the water during insecticide use or indirectly when rain-washed soil containing DDT enters surface waters. In the past, DDT entered the air directly when used as an insecticide. Small amounts may still be released to air from the manufacture of DDT and from its use as an insecticide in other countries. Once in the environment, DDT in soil lasts for a very long time. Some studies show that half the DDT present in soil is broken down within 2 years, but other studies show that this breakdown takes more than 15 years. Some DDT may evaporate from soil and enter the air, and some may be broken down by the sun or by microorganisms. DDT in soil is usually broken down to form DDE or DDD. DDT in surface water may also evaporate into the air, and some of it is broken down by the sun or by microorganisms in water. DDT in air lasts for only a short time.

Half of the DDT in air is gone within 2 days. DDT does not readily move from place to place in the environment. DDT attaches tightly to soil and does not move down through the soil quickly to underground water supplies. DDT may attach to small particles and be carried by the wind. In surface water, DDT may also bind to soil particles mixed in water and settle to the bottom of the water. DDT in soil can be taken up by some growing plants and by the animals or people that eat those crops. Also, DDT in water can be taken up by small aquatic organisms and then concentrate in the fish which eat these organisms. The levels of DDT in animals or fish can be higher than those found in the environment because DDT is stored in fat and because the breakdown of DDT takes a long time.

People can be exposed to DDT, DDE, and DDD primarily by eating foods containing small amounts of these compounds. Even though DDT has not been used in this country since 1972, small amounts of DDT and DDE are found in soil and, under certain conditions, may be transferred to crops grown in contaminated soil. In addition, imported foods may have been directly exposed to DDT. The amount of DDT in crops has been decreasing and is expected to continue to decrease. In the United States, an average of 0.001 parts of DDT and DDE per million parts of food (ppm) was eaten daily in 1981, with root and leafy vegetables containing the highest amount. Meat, fish, and poultry also contain very low levels of these compounds. Infants may be exposed by drinking breast milk.

DDT or its breakdown products are still present in some air, water, and soil samples. Levels in most air and water samples are low, however, and exposure by these pathways is of little concern. Air samples in the United States have shown levels of DDT ranging from 0.0000007 to 0.1 parts DDT per million parts (ppm) of air, depending on the location and year of sampling. Most reported samples were collected in the mid-1970s, and present levels are probably much lower. DDT and DDE have been reported in surface waters at levels of 0.001 parts DDT per trillion parts (ppt) of water, while DDD generally is not found in surface water. DDT was found in 45% of the surface water samples tested. National soil testing programs in the early 1970s reported levels in soil ranging from 0.2 to 6 ppm. Persons who work or live around NPL sites would most likely be exposed by accidentally taking in soil through the mouth or by breathing in DDT on dust or soil particles.

EPA banned all uses of DDT, except in cases of public health emergencies, in 1972 primarily because amounts were building up in the environment and because some cancer

tests in laboratory animals showed positive results. Although DDT is no longer used in the United States, there are still federal regulations concerning the amounts of DDT that are allowed in food and water.

The Occupational Safety and Health Administration (OSHA) states that workers may not be exposed to amounts of DDT greater than 0.07 ppm (1 mg/m^3) of air for an 8-hour workday, 40-hour work week. EPA estimates that drinking 2 liters of drinking water containing 0.024 nanograms of DDT per liter of water (1 nanogram is one billionth of a gram) and eating 6.5 grams (g) of fish and shellfish per day (from waters containing 0.024 nanograms DDT) would be associated with an increased risk of one extra cancer case for every one million persons exposed. Fish and shellfish tend to concentrate DDT in tissues from the surrounding water. In addition, standards are set for almost all foods.

5.1 Toxicokinetics

DDT, DDE, or DDD enter the body mainly when a person eats foods contaminated with these compounds. The actual amount of DDT, DDE, and DDD from foods depends on both the concentration of chemical in the food and the amount of the contaminated food eaten. Small amounts of DDT, DDE, and DDD may also be breathed in and passed through the lungs into the body. Because DDT, DDE, or DDD particles are usually too large to pass through the lungs into the body after breathing air containing them, they are more likely to be coughed up and swallowed. These compounds do not enter the body through the skin very easily.

Once inside the body, DDT can be broken down to form DDE or DDD. DDT, DDE, and DDD in turn are broken down to other metabolites that are excreted in the urine. These compounds are stored most readily in fatty tissue. Stored amounts leave the body very slowly. Levels in fatty tissues may either remain relatively the same over time or even increase with continued exposure. However, amounts of DDT in the body will decrease with decreasing exposure. DDT metabolites leave the body primarily in urine, but breast milk is another way they may leave the body.

Short-term exposure to high does of DDT (571 ppm in food) primarily affects the nervous system. People who either voluntarily or accidentally swallowed these amounts of DDT experienced excitability, tremors, and seizures. These effects on the nervous system appeared to go away once exposure stopped. Tests in laboratory animals confirm the

effect of DDT on the nervous system at concentrations of 210 ppm in food. Some people who came in contact with DDT complained of rashes or irritation of the eyes, nose, and throat. No effects have been reported in people exposed to concentrations as high as 22 ppm for 18 months. People exposed for a long time to small amounts, such as people who made DDT, had some changes in the levels of live enzymes. However, there was no indication that DDT caused permanent harmful (noncancer) effects. Animal studies also show that long-term exposure to DDT may affect the liver. Tests in animals also suggest that short-term exposure to DDT at concentrations of 20 ppm in food may have a harmful effect on reproduction.

Studies in animals have shown that oral exposure to DDT can result in an increased occurrence of liver tumors. In studies of DDT-exposed workers, results did not show increases in the number of deaths or cancers. However, these studies had problems or flaws so that possible increases in cancer may not have been detected. Because DDT caused cancer in laboratory animals, it is assumed that DDT could have this effect in humans. The Department of Health and Human Services has determined that DDT may reasonably be anticipated to be a human carcinogen. The International Agency for Research on Cancer (IARC) has determined that DDT, DDE, and DDD are possibly carcinogenic in humans. EPA has determined that DDT, DDE, and DDD are probable human carcinogens.

Absorption of DDT by the lung is considered to be a minor route of entry. It is assumed that the large particle size of DDT (crystalline) prevents it from entering the deeper, smaller spaces of the lung, and that it is deposited on the upper respiratory tract mucosa and then eventually swallowed because of the action of the mucociliary apparatus. Some crystalline DDT, however, could be small enough to pass through the tracheal-bronchial passages. In occupational settings, human exposure has occurred by a mixture of routes, including inhalation with subsequent oral ingestion and dermal absorption. Evidence of DDT absorption was indicated by the appearance of DDA (a DDT metabolite) in the urine and plasma or serum. However, no studies were located that quantify the rate or extent of absorption of DDT, DDE, or DDD in humans after inhalation exposure. No studies were located regarding the absorption of DDT, DDE, or DDD after inhalation exposure in animals.

Absorption following ingestion of DDT, DDE, and DDD is evident in humans both from measurements of serum and adipose tissue concentrations of these chemicals and from

measurements of DDA in the urine. Indirect evidence of absorption is the development of toxicity following accidental or intentional (suicidal) ingestion of DDT. In subjects chronically exposed to oral doses of DDT up to 20 mg/day (approximately 0.3 mg/kg/day), DDT appeared in the serum and reached peak serum concentrations 3 hours after ingestion. Serum levels remained elevated, but returned to normal values 24 hours after dosing.

Gastrointestinal absorption can be inferred in animals. The presence of urinary metabolites in mice, rats, and hamsters, the presence of DDT and its metabolites in bile collections, and the induction of tumors and other toxic effects in animals after oral administration of DDT, DDE, or DDD provide evidence of gastrointestinal absorption. In animals, absorption of orally administered DDT is enhanced when it is dissolved in digestible oils. Approximately 70-90% of the administered dose is absorbed after oral exposure to DDT in vegetable oils. DDT is absorbed 1.5-10 times more effectively when given in digestible oils than when dissolved in nonabsorbable solvents.

Gastrointestinal absorption by way of the intestinal lymphatic system plays a major role in the uptake of DDT in animals. However, portal blood absorption has been demonstrated that 20% of the administered dose appeared in the lymph of thoracic duct-cannulated rats. Other studies indicate that little DDT is absorbed from the gastrointestinal tract into the blood.

Dermal absorption of DDT in humans and animals is considered to be limited, but can be inferred by observation of toxicity after dermal application of DDT. Acute toxicity studies in several species demonstrate that toxicity, expressed as an LD_{50}, is less when DDT is applied dermally than when given by gavage or by injection, which reflects the difference in the amount of DDT absorbed by the dermal route.

The data indicate that DDT is four times more toxic when given by intraperitoneal injection than when administered orally and 40 times more potent when given by intraperitoneal injection than when administered by the dermal route. Absorption of DDT from soil applied to the abdomen of monkeys, as extrapolated from urinary excretion data, was 3.3% of the applied dose in 24 hours.

The EPA-derived subchronic and chronic oral RfDs for DDT are both 5E-04 mg/kg-day. These values are based on studies conducted by Laug and others in which weanling rats

were fed commercial DDT. Liver lesions were observed and a NOEL of 0.05 mg/kg bw/day was established. A minimal effect occurred at 5 ppm (LOAEL). An uncertainty factor of 100 was used to account for the lack of data. A factor of 10 each was applied for the uncertainty of interspecies conversion and to protect sensitive human subpopulations. An uncertainty factor for subchronic conversion was not included because of the corroborating chronic study in the data base. On the basis of the available information, the principle study has a medium to low confidence level. The data base is only moderately supportive and lacks a clear NOEL for reproductive effects; therefore, confidence in the data base can also be considered medium to low. Medium to low confidence in the RfD follows (IRIS 1995).

The EPA-derived slope factor for DDE and DDT is 3.4 $(mg/kg\text{-}day)^{-1}$. The value for DDE is based on studies in which increased incidence of liver tumors including carcinomas in two strains of mice and in hamsters and of thyroid tumors in female rats by diet. The value for DDT is based on studies in which there were observations of tumors (generally of the liver) in seven studies in various mouse strains and three studies in rats. DDT is structurally similar to other probable carcinogens, such as DDD and DDE. Based on available scientific information for DDE and DDT, EPA assigned a weight-of-evidence Group B2 to humans (probable human carcinogen)(IRIS 1995).

5.2 Fate And Transport

DDT and its metabolites may be transported from one medium to another by the processes of solubilization, adsorption, bioaccumulation, or volatilization.

Studies of DDT transformations in soils indicate prolonged persistence. During these extended periods of time, these compounds undergo extensive adsorption to soil particles, as predicted by their organic carbon partition coefficients (K_{oc}) of 2.4×10^5, 4.4×10^6, and 7.7×10^5 for DDT, DDE, and DDD, respectively. DDT, DDE, and DDD are only slightly soluble in water, with solubilities of 0.0034, 0.12, and 0.160 mg/L at 25°C, respectively. Therefore, loss of these compounds in runoff is primarily due to transport of particulates to which these compounds are bound. Since they are bound strongly to soil, they are not easily displaced from their site of application (except by erosion), nor do they tend to leach to groundwater, and appreciable amounts may remain in the soil for extended periods of time. DDT in excess of water solubility limits is adsorbed onto sediments

which act as the primary reservoir for excess quantities of DDT. There it is available for ingestion by organisms, such as bottom feeders.

Volatilization of DDT and DDE is known to account for considerable losses of these compounds from soil surfaces and water. Their tendency to volatilize from water can be predicted by their Henry's law constants, 4.13×10^{-4} and 6.8×10^{-5} atm-m^3/mol, respectively, and from soil surface by their vapor pressures, 5.5×10^{-6} and 6.5×10^{-6} Torr, respectively, and the organic content of the soil. The tendency of DDD to volatilize is approximately three fold less than that of DDT or DDE. Estimates of the rate of volatilization loss of DDT from water range from several hours to 50 hours. Laboratory studies of the air/water partition coefficient of DDE indicate that it will volatilize from seawater 10-20 times faster than from freshwater. This process may be related to interaction at the bubble-water surface. DDT in soils is subject to volatilization, with an estimated half-life of 100 days.

Small particles that carry DDT or its degradation products may also be distributed through the atmosphere. Once volatilized or airborne, transport of these compounds into the ambient atmosphere of North America is facilitated by a circulation pattern that brings moisture from the Gulf of Mexico into the Midwest and airflow patterns across the eastern seaboard. Residues are removed from the atmosphere by precipitation, diffusion into large bodies of water, and chemical transformation. Precipitation is believed to account for the greatest rate of removal from the atmosphere. When DDT is released to water, it quickly adsorbs to particles and is subject to sedimentation, may bioconcentrate in microorganisms, and can become part of the food chain.

DDT, DDE, and DDD are highly lipid soluble, as reflected by their log octanol-water partition coefficients (log K_{ow}) of 6.19, 7.00, and 6.20, respectively. This lipophilic property, combined with an extremely long half-life, has resulted in bioaccumulation (levels in organisms exceed those levels occurring in the surrounding environment). When they are present in ambient water, DDT and its metabolites are bioconcentrated in freshwater and marine plankton, insects, mollusks, other invertebrates, and fish. As these organisms become part of the food chain, a progressive biomagnification of residues may result in high levels of residues in organisms at the top of the food chain. In some cases, humans may be the ultimate consumer of these contaminated organisms. The bioconcentration factor (BCF) is defined as the ratio at equilibrium between the concentration of the chemical in the organism and the concentration of the chemical in the

surrounding media. There are numerous measurements and estimates of BCF values in fish. One study estimated the steady-state BCF in rainbow trout as 12,000. Another study reported a BCF of total DDT in humans to be 1,646 (on lipid basis, mg/kg).

5.3 Interactions with Other Chemicals

This section discusses the potential for DDT to act synergistically and/or antagonistically with other chemicals to cause physiological harm. DDT may have broad effects by changing the metabolism of other chemicals, both xenobiotics and endogenous macromolecules. DDT induces microsomal mixed function oxidases which are involved in the catabolism of both of xenobiotics and many endogenous hormones, such as cortisol. DDE has also caused the induction of hepatic enzymes, including cytochrome P-450 microsomal enzymes. In most cases this biotransformation results in compounds that are less toxic than the parent and more readily excreted from the body. For some chemicals this metabolism results in the production of metabolites that are more toxic than the parent and that may be carcinogenic. One interaction of concern is the enhanced conversion of other chemicals to the active, carcinogenic form through the action of DDT. Several investigations indicate that DDT administered to animals along with a known carcinogen sometimes results in more, sometimes in less, tumor production than when that carcinogen is tested without DDT. Also, DDT alone is thought to produce hepatic tumors both through the formation of DNA adducts and through promotional mechanisms involving cytotoxicity and compensatory cell proliferation. It is possible that DDT could also promote the formation of hepatic tumors initiated by other carcinogens.

DDT is reported to promote the tumorigenic effects of several known carcinogens, such as 3-methyl(4-dimethylamine)-azobenzene, 2-acetylaminofluorene (2-AAF), diethylnitorsamine (DEN), and carbon tetrachloride ($CC1_4$) when given after the putative carcinogen. The promoting effect of DDT in rats is reported to act in a dose-dependent fashion, with DDT decreasing the latency period of tumor development and increasing the incidence and yield of hepatic tumors, mainly hepatocellular carcinomas.

Pretreatment of animals with DDT is reported to decrease the tumorigenic effects of some previously determined carcinogens. Pretreatment of rats with DDT significantly lowered the incidence of mammary tumors per rat after treatment with 7,12-dimethylbenz[a]anthracene (DMBA), versus DMBA-treated controls. It was suggested that DDT may inhibit DMBA-induced mammary tumors by stimulating hepatic

metabolism and accelerating the excretion of DMBA, so that less carcinogen is available to peripheral tissues. Other studies also have reported the induction of microsomal enzymes of the liver by DDT, which reduced the carcinogenicity of azo dyes and similar carcinogens.

The effects of DDT on the nervous system are altered when DDT is given in combination with certain neuronally active pharmacological agents. Some pharmacological agents (hydantoin, phenobarbital, mephenesin) prevent some or all of the neurological effects seen in animals treated with DDT, while other agents (trihexyphenidyl, haloperidol, propranolol) enhance DDT-induced neurotoxicity. One of the effects of DDT is to hold sodium channels open, which probably contributes to DDT-induced neurological effects (tremors and hyperexcitability). Chemicals that reduce the neurotoxic effects of DDT may block repetitive firing of nerves by binding to and interfering with the alteration of sodium channels caused by DDT or by interfering with neurotransmitter systems associated with DDT-induced neurotoxicity.

5.4 References

ATSDR Toxicological Profile for 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD. Update, October 1992.

Integrated Reference Information System (IRIS). 1995.

6.0 ALDRIN/DIELDRIN

Aldrin and dieldrin are the common names of two structurally similar compounds that are used as insecticides. They are chemicals that are made in the laboratory and do not occur naturally in the environment. The scientific name for aldrin is 1,2,3,4,10,10-hexachloro-1,4,4∀, 5,8,8∀-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene. The abbreviation for the scientific name for aldrin is HHDN. Technical-grade aldrin contains not less than 85.5% aldrin. The trade names used for aldrin include Aldrec, Aldrex, Drinox, Octalene, Seedrin, and Compound 118. The scientific name for dieldrin is 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4∀, 5, 6, 7, 8, 8∀-octahydro-1, 4-endo, exo-5, 8-dimethanonaphthalene. The abbreviation for the scientific name for dieldrin is HEOD. Technical-grade dieldrin contains not less than 85% dieldrin. The trade names used for dieldrin include Alvit, Dieldrix, Octalox, Quintox, and Red Shield.

Pure aldrin and dieldrin are white powders. Technical-grade aldrin and dieldrin are tan powders. Aldrin and dieldrin slowly evaporate in the air. Aldrin evaporates more readily than dieldrin. Both aldrin and dieldrin have mild chemical odors. You might find aldrin and dieldrin in the soil, in water, or in the air near hazardous waste sites. You might also find aldrin and dieldrin in plants and animals near hazardous waste sites.

Aldrin and dieldrin are no longer used. From the 1950s until 1970, aldrin and dieldrin were used extensively as insecticides on crops such as corn and cotton. The U.S. Department of Agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved aldrin and dieldrin for killing termites. Use of aldrin and dieldrin to control termites continued until 1987. In 1987, the manufacturer voluntarily canceled the registration for use in controlling termites.

In this profile, the two chemicals are discussed together because aldrin readily changes into dieldrin once it enters either the environment or the body.

Aldrin and dieldrin can enter the environment from accidental spills or leaks from storage containers at waste sites. In the past, aldrin and dieldrin entered the environment when farmers used them to kill pests on crops and when exterminators used them to kill termites. Aldrin and dieldrin are still present in the environment from these past uses. Sunlight and bacteria in the environment can change aldrin to dieldrin. Therefore, you can find dieldrin in places where aldrin was originally released. Dieldrin in soil or water breaks

down slowly. Dieldrin sticks to soil very strongly and may stay there unchanged for many years. Water does not wash dieldrin off of soil easily. Dieldrin does not dissolve in water very well; thus, you can find very little dieldrin in water. Most dieldrin in the environment attaches to soil. It also attaches to sediments at the bottoms of lakes, ponds, and streams. Dieldrin can travel large distances by attaching to dust and traveling in the wind. Dieldrin can evaporate slowly from surface water or soil. Dieldrin in the air changes to photodieldrin within a few days. We know very little about the harmful health effects of photodieldrin. Plants take up dieldrin from the soil. Most of the dieldrin in plants is in the roots. Fish or animals that eat dieldrin-contaminated materials store a large amount of the dieldrin in their fat. Animals or fish that eat other animals have levels of dieldrin in their fat many times higher than animals or fish that eat plants.

For most people, exposure to aldrin and dieldrin occurs when they eat contaminated foods. Contaminated foods might include fish or shellfish from contaminated lakes or streams, root crops, dairy products, and meats. Exposure to aldrin and dieldrin also occurs when drinking water, breathing air, or touching contaminated soil at hazardous waste sites. Skin contact and breathing of aldrin and dieldrin by workers who used these chemicals to kill insects were at one time common. However, aldrin and dieldrin are no longer used to kill insects. Some people who live in homes that were treated for termites with aldrin or dieldrin may breathe in these chemicals several years after the houses were treated.

Exposure to aldrin is limited because aldrin is changed very quickly to dieldrin in the environment. Dieldrin stays in the environment for a long time. Most dieldrin in the environment is in soil or in animal fat. Levels of aldrin and dieldrin in air and water are very low. Levels in air and water are about 0.000001 part of aldrin or dieldrin in 1 million parts of air or water (ppm). Background levels of dieldrin in soil are about 0.01 ppm. This is 1,000 times higher than background levels in air and water. Contamination of groundwater and soil at hazardous waste sites is limited. Only 0.71% of groundwater samples and 1.42% of soil samples had levels of aldrin or dieldrin above background. The average level of dieldrin in contaminated groundwater was 0.0004 ppm. The average level of dieldrin in contaminated soil was 0.057 ppm. The average level of aldrin in contaminated soil was 0.019 ppm. Contaminated fish contained about 0.030-0.050 ppm of dieldrin. The estimated average daily human intake of dieldrin from the air is 0.02 nanograms per kilogram of body weight (ng/kg/day). The 1982-1984 estimated daily intake from food is 10 ng/kg/day for infants and 16 ng/kg/day for young children. The

estimated daily food intake for adults is 7-8 ng/kg/day. One nanogram is one million times less than 1 milligram.

The federal government has developed regulatory standards and guidelines to protect people from the harmful health effects of aldrin and dieldrin. In 1974, EPA banned all uses of aldrin or dieldrin except as a termite killer. In 1981, the Environmental Protection Agency (EPA) required labeling changes to warn against applying these chemicals near water supplies, heating ducts, or crawl spaces. They also warned against applying them too frequently.

EPA concludes that the maximum amount of aldrin and dieldrin present in bodies of water from which you drink water and eat seafood should not exceed 74 picograms per liter (pg/L, one billion times less than 1 mg/L) of aldrin or 71 pg/L of dieldrin. In theory, this would limit the risk for developing cancer to one in a million. If you do not drink water from the same source as you get seafood, the maximum amount of aldrin and dieldrin present in the water from which you get the seafood should not exceed 79 pg/L for aldrin or 76 pg/L for dieldrin.

The Food and Drug Administration (FDA) regulates the residues of aldrin and dieldrin in raw foods. The allowable range for residues is from 0 to 0.1 ppm depending on the type of food product. This limits the intake of aldrin and dieldrin in food to levels considered to be safe.

EPA has named aldrin and dieldrin as hazardous solid waste materials. If quantities greater than 1 pound enter the environment, the National Response Center of the federal government must be told immediately.

The Occupational Safety and Health Administration (OSHA) recommended a maximum average amount of aldrin and dieldrin in the air in the workplace to protect workers. This amount is 250 micrograms in a cubic meter of air ($\Phi g/m^3$) for an 8-hour workday over a 40-hour workweek. The National Institute for Occupational Safety and Health (NIOSH) recommended that exposure to aldrin and dieldrin be limited to the lowest amount that can be reliably measures.

6.1 Toxicokinetics

Aldrin can enter the bloodstream through the lungs when air is breathed. It can also enter through the stomach after eating food or drinking water containing it, or it can enter through the skin. Dieldrin can enter the bloodstream through the lungs, stomach, or skin. Exposure to aldrin or dieldrin around hazardous waste sites can occur by breathing contaminated air or touching contaminated soil. Exposure around hazardous waste sites can also occur by eating contaminated food or drinking contaminated water. Exposure of the general population most likely occurs through eating food contaminated with aldrin or dieldrin. Exposure of some infants occurs by drinking mother's milk containing aldrin or dieldrin. Studies in animals show that both aldrin and dieldrin enter the body quickly after exposure. Once aldrin is inside the body, it quickly breaks down to dieldrin. Dieldrin then stays in your fat for a long time. Dieldrin can break down to other products. Most dieldrin and its breakdown products leave the body in the feces. Some breakdown products can also leave in the urine. It can take many weeks or years for all of the compound to leave the body.

Aldrin and dieldrin cause similar adverse health effects. Exposure to very high levels of aldrin or dieldrin for a short time causes convulsions or kidney damage. One very young child died from drinking a solution containing a very high level of dieldrin. Another very young child died after eating food contaminated with aldrin. Exposure for a long time to somewhat lower levels of aldrin or dieldrin also causes convulsions. This occurs because aldrin and dieldrin build up in our bodies. Exposure to moderate levels of aldrin or dieldrin for a long time also causes headaches, dizziness, irritability, vomiting, or uncontrollable muscle movements. Some sensitive people develop a condition in which aldrin or dieldrin causes the body to destroy its own blood cells. It is not known whether aldrin or dieldrin affects the ability of men to father children. It is also not known whether aldrin or dieldrin causes birth defects or cancer in people. The International Agency for Research on Cancer (IARC) has determined that aldrin and dieldrin are not classifiable as to their carcinogenicity to humans. The EPA has determined that aldrin and dieldrin are probably human carcinogens.

Animal studies show effects of aldrin and dieldrin on the nervous system and on the kidneys similar to those seen in people. Results from animal studies also show additional effects of aldrin and dieldrin. We do not know whether these effects also occur in people. Animal studies show that aldrin and dieldrin cause increases in liver enzymes and liver

weight. Also, animal studies show that exposure to moderate levels of aldrin and dieldrin for a short time causes decreased ability to fight infections. In addition, animals born to mothers who have eaten aldrin or dieldrin do not live very long. This results, in part, from the newly born animals being poisoned by aldrin or dieldrin in the mother's milk. Studies in animals give conflicting information about whether aldrin and dieldrin causes birth defects. Studies in animals also give conflicting information about whether aldrin and dieldrin make it more difficult for male animals to reproduce. Some studies show that aldrin and dieldrin may damage sperm. Studies in animals show that mice that eat aldrin or dieldrin develop liver tumors.

Studies directly measuring absorption of aldrin or dieldrin in humans following inhalation exposure of known amounts of these pesticides were not located. However, results of a survey of women in pesticide-treated homes showed a correlation between the treatment and dieldrin levels in human breast milk. Inhalation was suggested as the most probable route of exposure because absorption by skin contact with pesticide-treated surfaces was not believed to contribute significantly to the exposures. Measurable levels of aldrin and dieldrin in indoor air have been detected several years after pesticide treatment of homes.

In vitro studies on absorption following inhalation exposure of animals to aldrin/dieldrin were not located. In an in vitro study using isolated perfused rabbit lungs, aldrin (0.25, 0.50, 1.0, 1.5, 2.0, 2.5, and 3.0 Φmol) was taken up by simple diffusion and then metabolized at a slower rate to dieldrin in the lung. Dieldrin was detected 3 minutes after initiation of the experiment. The rate of uptake of aldrin by the lung was biphasic consisting of a rapid phase followed by a slower phase, which could be related to the metabolic turnover of aldrin to dieldrin.

Volunteers were fed dieldrin at concentrations of 0.0001, 0.0007, and 0.003 mg/kg/day for 18-24 months. A dose-related increase in blood and adipose tissue levels of dieldrin was found. However, no quantitative data specifically describing absorption of aldrin/dieldrin following oral exposure were found.

Several metabolic studies indicate that dieldrin is absorbed from the gastrointestinal tract and is transported via the hepatic portal vein. Following dosing with radiolabeled aldrin and dieldrin, high levels of radioactivity were detected in the liver, blood, and stomach and/or duodenum of dosed rats within 1-5 hours. Twenty-four hours following a single oral administration to rats of 10 mg/kg, 50% of the dose was found in fat.

Although data are limited regarding absorption of aldrin and dieldrin following dermal exposure in humans, it appears to occur rapidly. Aldrin and dieldrin were first detected in urine 4 hours after dermal application of a single dose (0.004 mg/cm^2) of aldrin and dieldrin, radiolabeled with carbon 14 (^{14}C), to the forearm of six volunteers. Based on urinary ^{14}C excretion, it was estimated that 7.8% of aldrin and 7.7% of dieldrin was absorbed over a 5-day period. The accuracy of these values is questionable since the dose used was small, the ^{14}C recovery in the urine was low, the major route of excretion was in the feces (not the urine), and a large individual variation in data was reported.

Aldrin was rapidly absorbed into the skin of female rats following dermal application at does of 0.006, 0.06, and 0.6 mg/cm^2. Aldrin and dieldrin were detected in the skin 1 hour after aldrin application for all three dose levels. The amount absorbed was proportional to the dose applied. In vitro studies of rat skin strips incubated with aldrin showed absorption of aldrin was complete by 80 minutes. Absorption from fabric that had been impregnated with up to 0.04% dieldrin was also demonstrated in rabbits.

The EPA-derived subchronic and chronic oral RfDs for dieldrin are both 5E-05 mg/kg-day. These values are based on studies by Walker and others with the LOAEL and NOAEL of 5E-03 mg/kg-day and 5E-02 mg/kg-day, respectively. Convulsions, tremors, irritability, increased liver weights, and increased liver-to-body ratios were observed. An uncertainty factor of 100 was used to account for the uncertainty in the extrapolation of dose levels from laboratory animals to humans and uncertainty in the threshold for sensitive humans. On the basis of this information, EPA assigned a medium confidence level to the oral RfD and the data base because of the support for the critical effect from other dieldrin studies, and from the studies on organochlorine insecticides in general. The study has a low confidence level because the principle study is an older study for which detailed data are not available and in which a wide range of doses was tested (IRIS 1995).

The EPA-derived oral factor for dieldrin is 1.6 (mg/kg-day)$^{+1}$. This value is based on studies in which dieldrin is carcinogenic (liver carcinoma) in seven strains of mice when administered orally. Dieldrin is structurally related to compounds (aldrin, chlordane, heptachlor, heptachlor epoxide, and chlorendic acid) which produce tumors in rodents. Based on available scientific information, EPA assigned a weight-of-evidence Group B2 to humans (probable human carcinogen) (IRIS 1995).

6.2 Fate And Transport

The leaching potential (concentration in soil water/concentration in soil) for aldrin in soil is 9.0×10^{-3}, and the volatilization potential (concentration in soil air/concentration in soil) is 2.0×10^{-5}, suggesting that aldrin is unlikely to leach appreciably from soil to water or volatilize from soil particles to the atmosphere. Volatilization of aldrin is more rapid when it is applied to the soil surface rather than incorporated into the soil. A loss of 50% from a surface application was estimated to occur within 1-2 weeks after application compared to 10-15 weeks for soil-incorporated aldrin. The relatively rapid loss of both aldrin and dieldrin from soil during the first few months after application has been attributed to loss by volatilization. The half-lives of aldrin applied to clay loam soil at a rate of 3, 9, and 15 kg per hectare in 1974 were 79.21, 97.09, and 88.53 days , respectively . The half-lives of aldrin applied to sandy loam soil at a rate of 3, 9, and 15 kg/hectare were 41.69, 36.48, and 45 days, respectively. The loss of aldrin residues was more from sandy loam soil as compared to clay loam soil. The volatilization potential of field-applied dieldrin (10 ppm) was studied for 5 months using three different soil moisture regimes. The three soil moisture regimes included: (1) flooded to a depth of 10 cmp; (2) moist; and (3) nonflooded with no water added except for natural rainfall. The results showed that the soil moisture had an effect on the volatilization rate. About 18% of the applied dieldrin volatilized from a moist plot in 5 months, but only 2% and 7% volatilized from the flooded and nonflooded plots, respectively. Flooding retarded the volatilization potential of surface-applied dieldrin. Volatilization of dieldrin from the nonflooded plot tended to increase with increasing precipitation.

The logarithm of the n-octano/water partition coefficient (log K_{ow}) is a useful preliminary indicator of potential bioaccumulation of a compound. The log K_{ow} value for aldrin ranges from 5.68 to 7.4, indicating a high potential for bioaccumulation. In modeling ecosystem tests, bioconcentration factors for aldrin of 3,140 in fish and 44,600 in snails have been reported.

Experimental evidence indicates that aldrin is rapidly converted to dieldrin, which readily bioconcentrates and biomagnifies. Radiolabeled aldrin added to a model ecosystem was rapidly converted to dieldrin. Of the radiolabel stored in organisms, 95.9% of the total stored in the fish Gambusia affinis, 91.6% stored in the snails of the genus Physa, and 85.7% stored in the algae Oedogonium cardiacum were in the form of dieldrin.

Aldrin also bioconcentrates in terrestrial ecosystems. In a model ecosystem study, 2 weeks after corn planting, the concentration of aldrin residues was 27% greater in plants than in the preplanting soil. Approximately 78% of the plant residue was in the roots and was composed of 33% aldrin and 49% dieldrin. On day 15, a prairie vole (Microtus ochrogaster) was introduced to the model ecosystem. After 5 days, the concentration of residue in the vole was 70% greater than the initial soil concentration and consisted of 2% aldrin and 89% dieldrin.

Biotransfer factors (BTFs) for beef and cow's milk have been determined for aldrin. The concept of biotransfer is useful since it takes into account exposure through both food and water pathways. Biotransfer factors for beef and milk are defined as the concentration of a compound in beef or milk (mg/kg) divided by the daily intake of the compound by the animal (mg/day). The biotransfer values for beef and milk were estimated to be 0.085 and 0.023, respectively. Biotransfer factors for aldrin in beef and milk are directly proportional to octanol-water partition coefficients (K_{ow}). In addition, a bioconcentration factor (BCF) for aldrin in vegetables was also determined. The bioconcentration factor was defined as the ratio of the concentration in aboveground parts (mg of compound/kg of dry plant) to the concentration in soil (mg of compound/kg of dry soil); the bioconcentration factor was estimated to be 0.021. The vegetation bioconcentration factor is inversely proportional to the square root of K_{ow}. The regression equations for beef, milk, and vegetation provide a technique for predicting a chemical's BTF in beef and milk and BCF in vegetation. Consequently, regression analyses will be of value in more precisely quantifying human exposure to organics through the terrestrial food chains.

Dieldrin may be transported great distances in the atmosphere and be removed by wet or dry deposition. Snowpack samples were collected at 12 sites in the Northwest Territories, Canada, in the winter of 1985-1986; dieldrin was found in all 21 samples at a mean concentration of 0.75 ng/L. There were no known local sources of dieldrin in the Canadian Arctic snow.

Dieldrin has an estimated half-life of 723 days for evaporation at 25°C from a column of water of 1-meter depth. Dieldrin has a low water solubility as well (186 Φg/L at 25°C). Dieldrin, when compared to other chlorinated hydrocarbons, has the longest evaporation half-life in water 1 meter in depth; it was estimated to be 72.3 days compared to 3.7 days for DDT.

Dieldrin is extremely nonpolar and, therefore, has a strong affinity for organic matter such as animal fat and plant waxes; it also sorbs tightly to soil particulates. Volatilization if the principal route of loss of dieldrin from soil; however, the process is relatively slow because of the low vapor pressure of dieldrin. It may also be impeded by low soil moisture or incorporation of the compound into the soil. Volatilization of dieldrin from soil is slower than aldrin (<10 g/hectare/day) based on its vapor pressure of 1.78×10^{-7} mmHg at 20°C. The volatilization rate decreases with time and increases with increasing temperature to a maximum at 25°C. After 11 days in a microagroecosystem, 35% of the applied dieldrin had volatilized, while 73% remained on the soil surface. Movement of dieldrin in solution through the soil is extremely slow, indicating little potential for groundwater contamination. Using a low pollution potential scenario (soil with a high organic content and a high average water content), it is estimated that it will take 2,594 years for dieldrin to travel to a depth of 3 meters. Even with a high pollution potential scenario (soil with a low organic content and a low water content, it would still take an estimated 270 years for dieldrin to reach a depth of 3 meters. Dieldrin has been estimated to have a sorption coefficient on mixed-liquor solids (typical of municipal waste-water treatment plants) of 38.9 mg/g at an equilibrium concentration of 1.0 mg/L.

Movement of dieldrin in waterborne sediment is a major pathway of loss from treated soil. Leaching is minimal.

Like aldrin, dieldrin has a potential for high bioaccumulation as indicated by a log K_{ow} value that ranges from 4.32 to 6.2. Measured bioconcentration factors for dieldrin are 2,700 in fish and 61,657 in snails. A second study using the same model ecosystem found bioconcentration factors for dieldrin to be 6,145 in fish, 7,480 in algae, 247 in crabs (Uca minax), 1,015 in clams (Corbicula manilensis), 1,280 in the water plant Elodea, and 114,935 in snails. A bioconcentration factor of 2,095 has been determined for the ciliate Tetrahymena pyriformis exposed to 1 Φg/mL dieldrin for 12 hours. A biomagnification factor of 1.0 has been determined for dieldrin for rainbow trout on a lipid weight basis; the average wet weight bioconcentration factor is 2.3. Channel catfish, exposed to varying concentrations of dieldrin, were used to determine when equilibrium was reached between uptake of dieldrin and elimination from muscle tissue. At 13 ppt, equilibrium was reached after 56 days, whereas, at 49 ppt, equilibrium was not reached even after 70 days of exposure.

Biotransfer factors for beef and cow milk and a bioconcentration factor for vegetables have been determined for dieldrin as well as aldrin. The biotransfer values for dieldrin in beef and milk were estimated to be 0.008 and 0.011, respectively, while the bioconcentration factor for vegetables was estimated to be 0.098.

Data indicate that dieldrin is taken up by various crops. To determine whether foliar contamination of soybean plants occurred via root sorption or vapor sorption, 20 ppm ^{14}C-dieldrin was applied to surface or subsurface soil, and residue levels in soybean plants were determined. The results indicated that foliar contamination by dieldrin occurred by both root sorption (10.8 ppm) and vapor sorption (8.5 ppm). In a greenhouse experiment, various crop seedlings took up dieldrin from soils treated with 0.5 or 5.0 ppm dieldrin. Mean concentrations of dieldrin found in soybeans, wheat, corn, alfalfa, brome grass, and cucumber treated with 0.5 ppm dieldrin were 0.017, 0.147, 0.017, 0.031, 0.075, and 0.070 ppm (dry weight). Mean concentrations of dieldrin found in soybeans, wheat, corn, alfalfa, brome grass, and cucumber treated with 5.0 ppm dieldrin were 0.194, 1.385, 0.171, 0.350, 0.808, and 0.185 ppm (dry weight).

6.3 Interactions With Other Chemicals

Limited information is available regarding the influence of other chemicals on the toxicity of aldrin and dieldrin. Administration of the pesticides Aramite, DDT, and methoxychlor with aldrin to rats did not cause an increase over the incidence of cancer observed in the presence of aldrin alone. However, no increase in cancer incidence was observed with any of these substances administered singly. Thus, it is unclear whether the conditions of this assay were adequate to detect an additive or synergistic effect if it existed.

Induction of microsomal enzymes by ochratoxin, a mycotoxin, was observed to enhance conversion of aldrin to dieldrin. Also, induction of microsomal enzymes by the pesticides hexachlorobenzene and DDT caused a decrease in storage in adipose tissue and/or an increased rate of excretion of the metabolites of aldrin and dieldrin in the feces and urine. However, these studies did not present information regarding the effects of these interactions on the toxicity of aldrin or dieldrin. Thus, it is unknown whether the changes in the pharmacokinetics of aldrin and dieldrin affected their toxicity.

6.4 References

ATSDR Toxicological Profile for Aldrin/Dieldrin. Update, April 1993.

Integrated Reference Information System (IRIS). 1995.

7.0 CHLORINATED DIBENZO -P-DIOXIN

The chlorinated dibenzo-p-dioxins are a class of compounds that are loosely referred to as dioxins. The one with four chloride atoms at positions 2, 3, 7, and 8 of the dibenzo-p-dioxine chemical structure is called 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). It is a colorless solid with no known color. 2,3,7,8-TCDD does not occur naturally not is it intentionally manufactured by any industry, except as a reference standard. It can be inadvertently produced in very small amounts as an impurity during the manufacture of certain herbicides and germicides and has been detected in products of incineration of municipal and industrial waste. At the present time, 2,3,7,8-TCDD is not used for any purpose other than scientific research.

Although 2,4,5-T, 2,4,5-trichlorophenol and hexachlorophene are no longer produced commercially (except for certain medical purposes), disposal sites of past production wastes are still sources of present exposure. 2,3,7,8-TCDD has been found in at least 28 of 1,117 hazardous waste sites on the National Priorities List (NPL). Very low levels of 2,3,7,8-TCDD have been detected in ambient air. Detection of 2,3,7,8-TCDD in drinking water has not been reported. 2,3,7,8-TCDD has not been detected in most rural soils examined, but it can be present at trace levels in urban soils. The highest concentration of 2,3,7,8-TCDD was detected in a waste-oil-contaminated soil in Missouri that contained a 2,3,7,8-TCDD level more than one million times higher than soils from normal urban areas. 2,3,7,8-TCDD was detected in fish obtained from the contaminated sections of Lake Ontario, Saginaw Bay, the Michigan rivers, and several watersheds including those from Maine, Wisconsin, and Minnesota. In human milk, minute amounts of 2,3,7,8-TCDD have been detected in the United States and in several European countries.

2,3,7,8-TCDD can enter the body by absorption through the skin from contaminated soils and other materials. Ingestion of 2,3,7,8-TCDD can occur through the consumption of contaminated fish, cow's milk, foodstuffs, and , in the case of small children, by soil. Inhalation of contaminated ambient air may contribute to very small amounts to total body intake. However, particulates such as fly ash from municipal and industrial incineration may constitute a major source of exposure.

In humans, 2,3,7,8-TCDD causes chloracne, a severe skin lesion that usually occurs on the head and upper body. Unlike common acne, chloracne is more disfiguring and often lasts for years after initial exposure. There is suggestive evidence that 2,3,7,8-TCDD causes

liver damage in humans, as indicated by an increase in levels of certain enzymes in the blood, although these effects might also have resulted from the concomitant exposure to the chemicals contaminated with 2,3,7,8-TCDD or to the solvents in which these chemicals are usually dissolved. Animal studies have demonstrated severe liver damage in some species. There is also suggestive evidence that 2,3,7,8-TCDD causes loss of appetite, weight loss, and digestive disorders in humans, although these effects might have resulted from the concomitant exposure to the chemicals contaminated with 2,3,7,8-TCDD or to the solvents in which these chemicals are usually dissolved. Animal exposure to 2,3,7,8-TCDD results in severe loss of body weight prior to death. The human evidence for 2,3,7,8-TCDD alone is inadequate to demonstrate or reflect a carcinogenic hazard, although certain herbicide mixtures containing 2,3,7,8-TCDD as an impurity provide limited evidence of causing cancer in exposed humans. Based on the positive evidence in animal studies, 2,3,7,8-TCDD is probably carcinogenic in humans. Both the Environmental Protection Agency (EPA) and the International Agency for Research on Cancer (IARC) have concluded that 2,3,7,8-TCDD causes cancer in animals and probably causes cancer in humans.

The EPA calculated health advisories (HAs) for 2,3,7,8-TCDD in drinking water, that is, estimates of levels below which adverse health effects are not expected to occur. The 1-day HA is 1 part of 2,3,7,8-TCDD per trillion parts of waste (1 ppt) for a child; the 10-day HA is 0.1 ppt for a child. The longer-term HA is 0.01 ppt for a child and 0.035 ppt for an adult; the lifetime HA is also 0.035 ppt for adults. These are very small amounts. The EPA also calculated the amount of 2,3,7,8-TCDD in ambient water (lakes and rivers) that would associated with increases in one additional incidence of cancer over background cancer incidence in a population of 1,000,000 to be 0.013 parts per quadrillion, an extremely small amount. This calculated measurement takes into account that 2,3,7,8-TCDD concentrates in fish; hence, exposure may occur through both the drinking of water and the eating of fish. With regard to advisories based on EPA's cancer risk estimate for 2,3,7,8-TCDD, it should be noted that EPA is in the process of revising this risk estimate.

7.1 Toxicokinetics

Human and animal data indicate that 2,3,7,8-TCDD can be absorbed following ingestion, and although bioavailability is affected by binding to soils, the extent of absorption is only decreased by about 50%. In addition, animal data indicate that 2,3,7,8-TCDD may be absorbed well through the skin depending on such variables as the dose or the material to

which 2,3,7,8-TCDD is adsorbed. Following absorption, 2,3,7,8-TCDD is distributed to tissues in proportion to the lipid content. 2,3,7,8-TCDD can cross the placenta with subsequent exposure to the fetus, and the newborn can be exposed following redistribution of 2,3,7,8-TCDD during lactation. Metabolism of 2,3,7,8-TCDD is currently thought to result primarily in detoxification and relatively rapid removal of the metabolites through lactation. There are species and strain differences in both metabolism and elimination rates, with elimination half-lives varying from 11 days in the hamster, which is relatively resistant to 2,3,7,8-TCDD toxicity, to >1 year in the monkey, which is sensitive to the toxicity of 2,3,7,8-TCDD. There is, however, no clear correlation between toxicity and the elimination half-life for 2,3,7,8-TCDD.

Although humans have been exposed to 2,3,7,8-TCDD as a contaminant of herbicides and industrial chemicals, there have been no reported deaths from acute exposure. Lethal oral doses of 2,3,7,8-TCDD vary from 0.6 to 5,000 micrograms per kilogram (Φg/kg) for guinea pigs and hamsters, respectively, with other species tested having LD_{50} values between these two extremes. Subchronic LD_{50} values for cumulative (total) exposure during the 90-day oral study with guinea pigs were essentially the same as those observed after acute exposure. A 9-month feeding study of a small number of monkeys indicated that a dose of 2 to 3 micrograms per kilogram resulted in death. The acute dermal LD_{50} value for 2,3,7,8-TCDD in rabbits has been reported to be 275 (Φg/kg); however, no other species have been tested, and rabbits are only intermediate in sensitivity to 2,3,7,8-TCDD in oral toxicity studies. Inhalation experiments have not been conducted.

The only effect clearly demonstrated to be produced in humans following 2,3,7,8-TCDD exposure is chloracne. This lesion is systemic toxic effect and not solely a dermal effect. Although animal models are available to study chloracne, there are limitations in investigating this toxicological end point. The lesions produced in animals are different from the lesions in humans, and the expression of this lesion may be limited to monkeys, specific strains of mice, and rabbits (observed only in the ears after dermal application).

In animals, the toxic effect of 2,3,7,8-TCDD exposure most often observed is the wasting syndrome, in which the animals progressively lose body weight prior to death, although no one organ is altered to such an extent that it can be associated with the overt signs of toxicity. Although this syndrome is observed in all species of chorduta tested, it occurs predominantly only at dosed that are lethal. The wasting syndrome has not been

confirmed in humans, although loss of weight has been included in the list of effects associated with acute exposure to chemicals contaminated with 2,3,7,8-TCDD.

Immunotoxicity has also been observed in a variety of animal species and may be one of the most sensitive effects of 2,3,7,8-TCDD. Immunotoxicity, however, has not been directly related to 2,3,7,8-TCDD exposure in humans.

Hepatotoxicity has been observed in a variety of animal species, and there is suggestive evidence that this effect also occurs in humans. The human data are not completely clear, however, since mixed exposure to other potentially hepatotoxic chemicals occurred. In addition, species variations in induction of hepatoxic effects indicate that the two most sensitive species, guinea pigs and monkeys, develop relatively less severe hepatic lesions than many other species.

Other organ systems are also affected by 2,3,7,8-TCDD. There is suggestive evidence in humans that the nervous system may be affected; in animals, there are data on effects on the digestive system and the kidney. These additional organ systems have not been investigated as extensively as those described later. Also, they do not appear to be prime indicators of 2,3,7,8-TCDD toxicity or provide any special insight into extrapolating effects observed in animals to those in man.

Many of the toxic end points discussed have been observed to have extensive species and strain differences in sensitivity. These differences may be related to the receptor-mediation mechanism of toxicity proposed for 2,3,7,8-TCDD. This mechanism follows the scheme of 2,3,7,8-TCDD binding to a soluble cytoplasmic receptor protein, which subsequently migrates into the nucleus of the cell as a receptor-2,3,7,8-TCDD complex. Once in the nucleus, it is proposed that both transcription and translation of DNA may be affected. The receptor protein is known genetically to segregate with the Ah locus, and many of the strain differences in toxicity observed in mice are explained by this segregation. The receptor protein is known to be widely dispersed in different organ systems and in different species, although quantitative levels differ. These quantitative differences may help explain some of the species differences in sensitivity. The receptor mechanism cannot explain all the species and strain differences in 2,3,7,8-TCDD toxicity, because some toxic responses segregate with the Ah receptor while others do not.

The data from human populations exposed to herbicides and other industrial chemicals contaminated with 2,3,7,8-TCDD are not adequate to determine if 2,3,7,8-TCDD adversely affects reproductive health in humans. Animal studies clearly demonstrate that 2,3,7,8-TCDD is fetotoxic in several species, causing several effects including spontaneous abortions. There is additional evidence that 2,3,7,8-TCDD affects male hormone levels and the function of male reproductive organs.

Although 2,3,7,8-TCDD has not consistently produced positive results in genotoxicity assays, there are positive results in diverse bioassay systems which may suggest that 2,3,7,8-TCDD is a genotoxic agent; however, the large numbers of negative results in assays usually predictive of genotoxic agents suggest that 2,3,7,8-TCDD is not a genotoxic agent.

The human evidence that 2,3,7,8-TCDD us a carcinogen is conflicting, with both positive associations and nonassociations observed for the induction of cancer in cohorts exposed to herbicides and other chlorinated chemicals known to be contaminated with 2,3,7,8-TCDD. As a result, the human data only provide inadequate evidence that 2,3,7,8-TCDD is a human carcinogen. The animal data, however, provide clear evidence that 2,3,7,8-TCDD is carcinogenic to animals.

Pertinent data regarding the absorption of 2,3,7,8-TCDD by humans or animals following inhalation exposure were not found in the available literature

The absorption data available are from an elimination study of 2,3,7,8-TCDD in which a male volunteer ingested ^{3}H-2,3,7,8-TCDD in corn oil at a dose of 1.14 nanogram per kilogram (ng/kg). Measurements of cumulative elimination in the feces and urine, as well as a determination of sequestering in fat via biopsy samples, indicated that >87% of the dose was absorbed. Following absorption, the half-life for elimination was calculated to be 2,120 days. CDC determined a half-life of 2,595 days by measuring the decrease in serum levels of 2,3,7,8-TCDD in Vietnam veterans.

Studies show that 2,3,7,8-TCDD is generally well absorbed (50 to 80%) when administered to rats, guinea pigs, or hamsters in a lipophilic vehicle by gavage. There appeared to be no change in absorption rates with repeated dosing, but there was some decrease in absorption at higher dose levels. Absorption of 2,3,7,8-TCDD when administered in the diet was also between 50 and 60%.

The vehicle in which 2,3,7,8-TCDD is administered has substantial effects on its gastrointestinal absorption. A decrease in the absorption of 2,3,7,8-TCDD was observed in a soil suspension compared with a solution in 50% ethanol, whereas no absorption occurred when the compound was administered as a suspension of activated carbon. Since 2,3,7,8-TCDD in the environment is likely to be absorbed to soil, a comparison of the absorption of contaminated soil with that from 2,3,7,8-TCDD administered in corn oil. As indicated by biological effects and the amount of 2,3,7,8-TCDD in the liver, the absorption was about 50% less from soil than from corn oil. 2,3,7,8-TCDD-contaminated soil is less toxic than an equivalent amount of 2,3,7,8-TCDD, suggesting that binding to soil had an influence n bioavailability. Other effects on the observed bioavailability, species (rats, hamsters, and guinea pigs), and specific congener may have resulted from differences in metabolism or distribution, since 2,3,7,8-TCDD bioavailability was measured by retention of the compounds in the liver. These data indicate that substantial absorption occurs from contaminated soil; however, soil type and duration of contact, as suggested from the data that demonstrated decreased extraction efficiency with increasing contact time between soil and 2,3,7,8-TCDD, may substantially affect the absorption of 2,3,7,8-TCDD from soils obtained from different contaminated sites. Bioavailability appears to be low from fly ash; however, studies have been very limited, and factors such as source of the fly ash, moisture content, or the coingestion of lipophilic material may affect bioavailability.

Pertinent at regarding the absorption of 2,3,7,8-TCDD following dermal exposure in humans were nor found in the availability literature.

Data regarding dermal absorption is animals are limited. 2,3,7,8-TCDD is absorbed well through the skin, although as with oral absorption the vehicle can substantially affect absorption. It is estimated that 40% of the dose was absorbed by rats when the compound was applied in methanol, whereas application in vaseline or polyethlene glycol resulted in 1.4 and 9.3% absorption, respectively. Applying 2,3,7,8-TCDD as a paste in soil or activated carbon resulted in poorer absorption than observed in oral studies, with absorption of <2% and nondetectable, respectively.

7.2 Fate And Transport

The fate of 2,3,7,8-TCDD in air, water, and soil is not understood with certainty. Although some experimental efforts have been directed in recent years to elucidate its fate in different media, a substantial data gap exits in this area. In air, 2,3,7,8-TCDD is likely to be present partly in the gas phase and predominantly in the particle-sorbed phase. The two important processes that may remove 2,3,7,8-TCDD from the atmosphere are photochemical degradation and wet deposition. The photodegradation of gas phase 2,3,7,8-TCDD with an estimated half-life of a few hours is expected to be much faster than particle-sorbed chlorinated dibenzodioxins. Even an estimate of the atmospheric half-life of 2,3,7,8-TCDD is not available. On the basis of photochemical experiments with 2,3,7,8-TCDD coated on silica gel, the half-life of atmospheric particulate 2,3,7,8-TCDD may be a few days. The lifetime of atmospheric 2,3,7,8-TCDD is such that it can be transported long distances in the air, although this transport will be of shorter distances compared with the transport of higher chlorinated dibenzodioxins. The ultimate environmental sink of airborne particulate 2,3,7,8-TCDD is likely to be sediments of surface waters.

The biodegradation of 2,3,7,8-TCDD in water is probably slow. The two processes that may be important for the removal of 2,3,7,8-TCDD are volatility and photodegradation. Although the photolysis of 2,3,7,8-TCDD in hydrogen-donating solvents is a fast process, a suspension of 2,3,7,8-TCDD in distilled water showed no appreciable photodegradation. In natural waters, the presence of small amounts of hydrogen-donating substrate or the presence of photosensitizers may account for its observed photodegradation; however, the photochemical degradability of 2,3,7,8-TCDD in water, as provided by model ecosystem studies, has not provided definite evidence through mass balance that the observed loss of 2,3,7,8-TCDD attributed to photolysis was not due to its sorption on sediment and biota. The estimated half-lives for dissolved 2,3,7,8-TCDD in sunlight may range from 118 hours in winter to 21 hours in clear near-surface water under clear skies. The photodegradation is usually a dechlorination process leading to the formation of tri- and dichlorinated dibenzo-p-dioxins. In sediment-containing lake water, the estimated half-life of 2,3,7,8-TCDD is >1.5 years. In lake water alone, the estimated half-life is >1 year. The ultimate sink of aquatic 2,3,7,8-TCDD is the sediment. Recent flow-through experiments with fathead minnows have shown that the bioconcentration factor for 2,3,7,8-TCDD in this species is 7,900 to 9,300 on a wet-weight basis. Recently, the steady-state

bioconcentration factor for 2,3,7,8-TCDD in rainbow trout as extrapolated from experimental data has been estimated to be 39,000.

2,3,7,8-TCDD is expected to be immobile in most soils by irrigation and rainfalls. A downward movement of 10 centimeters in 12 years was observed with soil from Eglin Air Force Base. Although 2,3,7,8-TCDD usually does not leach through soil, leaching is possible in some instances from soils of very low organic carbon content as a result of 2,3,7,8-TCDD solvation with organic solvent or biotic mixing by earthworms or other soil invertebrates. A white rot fungus (Phanerochaete chrysosporium) has been shown to degrade 2,3,7,8-TCDD. This biodegradation does not occur significantly in natural soils, probably because of the lack of this or other degrading microorganisms. Both volatilization and photoreaction may remove some 2,3,7,8-TCDD from soil surfaces.. The photoreaction on soil surfaces can be greatly enhanced by the presence of hydrogen-donating substrates (e.g., olive oil or arachis oil) in soil. The photoreaction will be insignificant beyond the surface soil layers. The environmental half-life of 2,3,7,8-TCDD is highly dependent upon soil characteristics, the mode of contamination, and climatological conditions. The estimated half-life in the interior of soil may be 10 to 20 years.

2,3,7,8-TCDD present on leaves of plants as a result of spraying herbicides will photolyze with a half-life of a few hours. The chemical is absorbed by higher plants and is probably translocated, but it is not accumulated. The absorption by underground parts may be at the same level as soil, but the aerial part contains about 50% lower concentrations. Consumption of foods derived from contaminated areas (e.g., near municipal incinerators), could represent a significant dietary source. However, it was observed that no significant uptake in mature oats and soybeans, and edible parts of roots vegetables contained much less 2,3,7,8-TCDD than the surrounding soil.

7.3 Interactions with Other Chemicals

There are few data on the interactions of 2,3,7,8-TCDD with other chemicals. However, 2,3,7,8-TCDD is a strong inducer of microsomal enzymes; hence, prior exposure to 2,3,7,8-TCDD will alter the rate of metabolism and toxicity of many compounds that are either detoxified or activated by this enzyme system. The observed inhibition by 2,3,7,8-TCDD of the tumorigenic response of known tumorigens in the mouse skin bioassay may

be an example of 2,3,7,8-TCDD-induced enzyme changes altering the metabolic fate and toxicity of another compound.

The only other interactions that have been observed are the additive effect of 2,3,7,8-TCDD and similar polychlorinated dibenzofurans and polychlorinated biphenyls on the induction of cleft palate in mice and the increased sensitivity of mice to 2,3,7,8-TCDD-induced cleft palate with the co-administration of the hormones thyroxine and triiodothyroxine. With regard to environmental exposure, the relevance of interactions of 2,3,7,8-TCDD and the high levels of hormones used in the latter study is unclear.

7.4 References

ATSDR Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin. Update, June 1989.

8.0 HEPTACHLOR/HEPTACHLOR EPOXIDE

Heptachlor is a synthetic chemical that was used in the past for killing insects in homes, buildings, and on food crops. It has not been used for these purposes since 1988. There are no natural sources of heptachlor or heptachlor epoxide. Trade names for heptachlor include Heptagran, Heptamul, Heptagranox, Heptamak, Basaklor, Drinox, Soleptax, Gold Crest H-60, Termide, and Velsicol 104. Heptachlor is both a breakdown product and a component of the pesticide chlordane (approximately 10% by weight). Pure heptachlor is a white powder. Technical-grade heptachlor is a tan powder and has a lower level of purity than pure heptachlor. Technical-grade heptachlor was the form of heptachlor used most often as a pesticide. Heptachlor smells somewhat like camphor. Heptachlor does not burn easily and does not explode. It does not dissolve easily in water.

Heptachlor epoxide is a breakdown product of heptachlor. It was not manufactured and was not used as an insecticide like heptachlor. Like pure heptachlor, heptachlor epoxide is a white powder that does not explode easily. Heptachlor epoxide is made by bacteria in the environment. Animals and people also make heptachlor epoxide when heptachlor enters their bodies. This profile describes these two chemicals together because about 20% of heptachlor is changed within hours into heptachlor epoxide in the environment and in the body.

One might find heptachlor or heptachlor epoxide in the soil or air of homes treated for termites, dissolved in surface water or groundwater, or in the air near hazardous waste sites. One might also find heptachlor or its by-product, heptachlor epoxide, in plants and animals near hazardous waste sites. Heptachlor can no longer be used to kill insects on crops or in homes and buildings. However, heptachlor is still approved by the Environmental Protection Agency (EPA) for killing fire ants in power transformers.

From 1953 to 1974, heptachlor entered the soil and surface water when farmers used it to kill insects in seed grains and on crops. It also entered the air and soil when professional insect exterminators and homeowners used it to kill termites. Today heptachlor is no longer used by homeowners to kill termites or other insects. However, exterminators can still use existing stocks of heptachlor to kill fire ants in power transformers. Heptachlor and heptachlor epoxide can enter the air, soil, groundwater, and surface water from leaks at hazardous waste sites or landfills. Heptachlor sticks to soil very strongly and evaporates slowly into the air. Heptachlor does not dissolve easily in water. Heptachlor

epoxide dissolves more easily in water than heptachlor does and evaporates slowly from water. Like heptachlor, heptachlor epoxide sticks to soil. Both heptachlor and heptachlor epoxide can travel long distances in the wind from places where they are released, such as treated fields or manufacturing sites. In soil and water, heptachlor is changed by bacteria into the more harmful substance, heptachlor epoxide, or into other less harmful substances. Heptachlor in the soil can be taken up by plant roots. Heptachlor in the air can be deposited on plant leaves and enter the plant from contaminated soil. Animals that eat plants containing heptachlor can also absorb it. Animals can also change heptachlor to heptachlor epoxide in their bodies. Heptachlor epoxide breaks down very slowly in the environment. It can stay in soil and water for many years. Both heptachlor and heptachlor epoxide build up in fish and in cattle. People store heptachlor epoxide in their fatty tissue. Some studies show that heptachlor epoxide can still be measured in fatty tissue 3 years after a person is exposed.

Most of the breakdown products of heptachlor are thought to be less harmful than heptachlor itself. However, in laboratory animals, heptachlor epoxide is more harmful than heptachlor.

Exposure to heptachlor and heptachlor epoxide most commonly occurs when you eat contaminated food. Contaminated foods might include fish, shellfish (e.g., clams), dairy products, meat, and poultry. Children and toddlers drink large amounts of milk and may have greater exposure if the milk is contaminated with heptachlor or heptachlor epoxide. Infants can be exposed to these compounds from consumption of contaminated maternal or cow's milk. Exposure can also occur when drinking water, breathing air, or touching contaminated soil at hazardous waste sites that contain heptachlor or heptachlor epoxide. People whose homes have been treated with heptachlor to kill termites can be exposed by breathing heptachlor in the air. After heptachlor is changed to heptachlor epoxide in the soil, it can get into the air. People who breathe this air will be exposed to heptachlor epoxide. Workers who use heptachlor to kill fire ants are also exposed if they breathe in the heptachlor or get it on their skin.

Background levels are levels found in the environment that cannot be traced to a specific source. Information on background level of heptachlor and heptachlor epoxide in the air was not found. In a survey conducted more than 4 years ago, the background levels of heptachlor in drinking water and groundwater in the United States ranged from 20 to 800 parts of heptachlor in one trillion parts of water (ppt). Heptachlor was found in less than

2% of U.S. groundwater samples that are known to be contaminated from pesticide application. The average level of heptachlor in the contaminated groundwater samples was 800 ppt. No information was found for levels of heptachlor epoxide in groundwater or drinking water. Current information on background levels of heptachlor and heptachlor epoxide in groundwater or drinking water was not found. Heptachlor epoxide has been found in surface water (river, lakes) at levels between 0.1 and 10 parts of heptachlor epoxide in one billion parts of water (ppb, 1 ppb is 1 thousand times more than 1 ppt). Heptachlor and heptachlor epoxide stick to sediment and soil. The sediment in stream beds usually contains a lot of the heptachlor that enters the water. Heptachlor has been found in less than 1% of U.S. soil samples that are known to be contaminated. The average level of heptachlor detected in contaminated soil samples was 4 ppb. Heptachlor epoxide was not found in any of the contaminated soil samples. Contaminated fish and shellfish have been found to contain 2-750 ppb heptachlor and 0.1-480 ppb heptachlor epoxide. Heptachlor epoxide has been found in human milk samples at levels ranging from 0.13 to 128 ppb. The Food and Drug Administration (FDA) estimated that for 1982-1984, the daily intake of heptachlor and heptachlor epoxide from food was 2.7 ppt for infants (up to 12 months of age), 6.1 ppt for toddlers (1-3 years of age), and 1.5 $\pm$2.8 ppt for adults.

The federal government has developed regulatory standards and guidelines to protect people from the harmful health effects of heptachlor and heptachlor epoxide. EPA has banned the sale of all heptachlor products and has restricted the use of heptachlor. EPA allows companies to use heptachlor only to kill fire ants in power transformers. However, people who bought heptachlor before it was banned can still use it for killing termites.

EPA concludes that the maximum amounts of heptachlor and heptachlor epoxide present in your drinking water and in the seafood you eat each day through your lifetime should not exceed 7.78 ppt. In theory, this would limit the risk of developing cancer to one in 100,000. For contaminated seafood alone, the maximum amounts of heptachlor and heptachlor epoxide that may be consumed each day throughout the lifetime should not exceed 2.85 ppt. This recommendation is made because harmful effects may occur in people after exposure to heptachlor. Because the exact levels that might cause these effects are not known, EPA has set a very low limit as a safety factor.

For short-term exposures of up to 10 days, EPA recommends that a child weighing 22 pounds or less not drink water containing levels of heptachlor greater than 10,000 ppt.

For longer exposures, EPA recommends that a child not drink water containing levels of heptachlor greater than 5,000 ppt or water containing levels of heptachlor epoxide greater than 150 ppt.

FDA controls the amount of heptachlor and heptachlor epoxide on raw food crops and on edible seafood. The limit on food crops is from 0 to 10 ppb depending on the type of food product. The limit on edible seafood is 300 ppb. FDA limits the amount of heptachlor and heptachlor epoxide in the fat of food-producing animals to 200 ppb.

EPA has named heptachlor as a hazardous solid waste material. If quantities of heptachlor or heptachlor epoxide of greater than 1 pound enter the environment, the National Response Center of the federal government must be told immediately.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA) recommend that the highest average amount of heptachlor in workplace air over an 8-hour workday for a 40-hour workweek not be more than 0.5 mg/m^3.

8.1 Toxicokinetics

When breathing air containing heptachlor or heptachlor epoxide, both can enter the bloodstream through the lungs. It is not known how fast these compounds enter and remain in the bloodstream. Both heptachlor and heptachlor epoxide can also enter the body through the stomach after eating food or drinking water or milk containing them. Most of the heptachlor that is swallowed passes through the stomach into the blood. It can also enter the body through the skin, although it is not known how fast this happens and the exact amount has not been measured. Heptachlor and heptachlor epoxide can pass directly from a mother's blood to an unborn baby through the placenta.

Near a hazardous waste site, heptachlor and heptachlor epoxide can enter the body if by breathing contaminated air, drinking contaminated water, or touching contaminated soil. Exposure around hazardous waste sites can also occur by eating plants or animals that have been contaminated with heptachlor or heptachlor epoxide. Sometimes small children eat soil. If the soil is contaminated with heptachlor or heptachlor epoxide, they will be exposed in this way. Heptachlor epoxide can enter an infant's body in mother's milk after

the mother has been exposed to heptachlor or heptachlor epoxide. Heptachlor can enter the bodies of people who make it in factories if they breathe it in or get it on their skin.

Once inside the body, heptachlor is changed to heptachlor epoxide and other related chemicals. Heptachlor epoxide is more harmful than heptachlor. The other breakdown products are generally less harmful. Most of the heptachlor, heptachlor epoxide, and other breakdown products leave the body in the feces within a few days after exposure. Some breakdown products can also leave in the urine. Some heptachlor and heptachlor epoxide are stored in the body fat for long periods after exposure has occurred. Heptachlor can go from fat to other tissues in the body. Effects can thus be seen immediately as well as at a later time. The heptachlor and heptachlor epoxide that have been stored in fat leave the body much more slowly.

People can begin to smell heptachlor or heptachlor epoxide at around 0.3 milligrams in a cubic meter of air (0.3 mg/m^3). No reliable studies in humans were found that show whether harmful health effects occur as a result of breathing heptachlor or heptachlor epoxide. Also, no reliable human studies were found that show whether harmful effects occur from eating contaminated foods, drinking contaminated liquids, or from the chemicals passing through the skin. Blood tests suggest that these chemicals may cause mild liver changes. A few human cases show that breathing pesticide mixtures containing heptachlor may affect the nervous system causing dizziness, fainting, or convulsions. We do not know if the health effects were from heptachlor or other chemicals in the mixture. Studies of people who made or used pesticides that included heptachlor found no serious health effects. An accurate measure of how much heptachlor the workers were exposed to could not be determined. Heptachlor can cross the placental barrier and has also been detected in breast milk. However, it is not known if it affects the ability of men or women to reproduce.

We do not know if animals would have harmful effects after breathing in air that contains heptachlor or heptachlor epoxide for short or long periods. Studies have shown a number of harmful health effects when animals were fed heptachlor or heptachlor epoxide. These effects were more harmful when the exposure levels were high or when exposure lasted many weeks. When rats were fed high levels of heptachlor or heptachlor epoxide one time, half of them died. At these high levels, tremors and convulsions were seen. Some changes in the kidneys were also seen after rats were fed a very large amount of heptachlor one time. When mice were fed lower levels of heptachlor for several weeks,

they had damage to their liver and adrenal glands. When exposures were low or when the exposure period was short, the changes in the liver disappeared. We do not know whether these effects also occur in people exposed to heptachlor or heptachlor epoxide in the same way. However, heptachlor kills insects by causing damage to their nervous systems. The effect of the substance on insects is in agreement with the tremors and convulsions seen in both animals and humans exposed to pesticides containing heptachlor. Therefore, human exposure to large amounts of heptachlor could probably affect the nervous system, at least in the short term.

Animals that ate food containing heptachlor before and/or during pregnancy, had smaller litters. Some of the offspring of these animals had damage to their eyes known as cataracts, and some of the offspring did not live very long after birth. Some animals that ate heptachlor for several weeks were unable to have offspring. We do not know whether these effects would also occur in people exposed to heptachlor in the same way.

Animals fed heptachlor throughout their lifetime had more liver tumors than animals that ate food without heptachlor. The International Agency for Research on Cancer has determined that heptachlor and heptachlor epoxide are not classifiable as to their carcinogenicity to humans.

The levels of heptachlor or heptachlor epoxide that cause death in animals when placed one time on their skin are much higher than the levels that cause death after being eaten one time.

No studies were located regarding absorption in humans after inhalation exposure to heptachlor or heptachlor epoxide.

Although the database is extremely limited, one study has examined inhalation exposure in rabbits under environmental conditions. One group of 20 white rabbits (10 male, 10 female, strain not reported) was housed outdoors in an area of high pesticide use, in cages under an aluminum roof allowing free air movement. A second, equal-sized group was housed inside a building in an area of low pesticide use. During the 3-month exposure, weekly air sampling revealed the heptachlor epoxide concentration to be 1.86 ng/m^3 in the high-exposure area. Heptachlor epoxide was not measured in the indoor area and was assumed negligible based on previous low measures of DDT. Respiratory intake of heptachlor epoxide was calculated to be 0.002 Φg/day; heptachlor epoxide was not

detectable in the feed. At the end of the exposure period, serum and fat concentrations of heptachlor epoxide were measured. It was found that heptachlor epoxide in the fat of exposed rabbits was significantly higher than that measured in control animals (0.039±0.002 versus 0.016±0.001). No heptachlor epoxide was detected in any serum sample.

In order to assess the potential extent of human exposures and health effects, members of dairy farm families who consumed raw dairy products known to be contaminated with heptachlor epoxide were studied. These individuals and an unexposed urban reference population were compared with regard to serum pesticide levels and liver toxicity. The farm family members had significantly higher mean serum levels of heptachlor epoxide (0.81±0.94 ppb), oxychlordane (0.70±0.75 ppb), and transnonachlor (0.79±0.60 ppb) than the unexposed population. This study is limited because exposure level, duration, and frequency of exposure are not known. There was no increase in prevalence of abnormal liver function tests in the dairy farm families compared to the urban population. There are insufficient data to make a quantitative estimate for absorption of heptachlor in humans following oral exposure.

Heptachlor is absorbed from the gastrointestinal tract of rats and cattle as indicated by the presence of heptachlor and/or its metabolites in serum, fat, liver, kidney, and muscle and by its oral toxicity in several animal species including rats, mice, hamsters, guinea pigs, and rabbits (LD_{50}, 40-162 mg/kg/day). Heptachlor epoxide is also absorbed after oral administration to rats. However, no quantitative data that specifically describe absorption of heptachlor epoxide following oral exposure were found in the literature.

Only 6% of the radioactivity from radiolabeled (^{14}C) heptachlor was found in the urine while 60% was found in the feces of male rats 10 days after a single oral dose indicating that most of the radioactive material was not absorbed and was excreted in the feces. These data strongly suggest that a large percentage of heptachlor is absorbed from the gastrointestinal tract and eliminated via the bile into the feces. More than 72% of the radioactivity eliminated in the feces was present as metabolites of heptachlor (heptachlor epoxide, 13.1%; H-2, <0.1%; 1-OH-chlordene, 19.5%; 1-OH-chlordene epoxide, 17.5%; 1,2-OH-chlordene, 3.5%; H-6, 19.0%).

Three groups of four Australian Hereford steers were placed in a paddock that had been previously treated twice, 3 years earlier, with 0.275 kg heptachlor/hectare. The mean

heptachlor and heptachlor epoxide residues measured in soil samples averaged 0.136 ppm and 0.117 ppm, respectively. Soil samples showed substantial variability about the mean with no relation to date of sampling; this was attributed to uneven applications of heptachlor to the pasture, resulting in "hot spots' which were not always sampled. Biopsies of fat from the steers were taken to monitor heptachlor uptake. Within 4 weeks of grazing in the contaminated paddock, one group of animals had heptachlor epoxide present in their body fat at levels that exceeded the Australian maximum residue limit of 0.2 mg/kg. In all groups of cattle, adipose tissue levels of heptachlor epoxide were inversely related to pasture grass length. It is believed that when pasture grasses are shorter than 50 mm, ruminants ingest a great amount of pasture soil through close grazing, thus accounting for the relationship between pasture grass length and heptachlor and heptachlor epoxide intake. Although this study supports oral absorption of heptachlor and/or heptachlor epoxide in cattle, there are insufficient data to make a quantitative estimate of absorption fraction or absorption rate.

No studies were located regarding absorption in humans after dermal exposure to heptachlor or heptachlor epoxide.

Heptachlor is absorbed through the skin following topical application as indicated by its dermal toxicity in rats (LD_{50}, 195-250 mg/kg), but quantitative data are not available. Rats were given heptachlor dissolved in xylene (concentration of heptachlor unspecified), formulated to give a dose at a rate of 0.0016 mL/g body weight. The rats were not restrained and no attempt was made to remove the heptachlor from the shaved area of skin following the exposure, and therefore, some absorption following ingestion may also have occurred.

The EPA-derived subchronic and chronic oral RfDs of heptachlor epoxide are both 1.3E-05 mg/kg-day. These values are based on studies conducted by Dow Chemical Company in which beagle dogs from 23 to 27 weeks of age were divided into five groups and given heptachlor epoxide through diets for 60 weeks. Liver-to-body ratios were significantly increased. Effects were noted for both male and females at the LEL of 0.5 ppm. A NOEL was not established. The uncertainty factor of 1000 was determined to account for inter- and intraspecies differences and to account for the fact that a NOEL was not attained. The principle study is of low quality and is given a low confidence rating. Since the data base on chronic toxicity is complete but consists of low-quality studies, the data

base is given a medium to low confidence rating. Low confidence in the RfD follows (IRIS 1995).

The EPA-derived oral slope factor for heptachlor epoxide is 9.1 $(mg/kg\text{-}day)^{+0}$. This value is based on studies in which liver carcinomas were induced through diet in two strains of mice of both sexes and in female rats and compared with controlled groups. Based on the available information, EPA assigned a weight-of-evidence group B2 to humans (probable human carcinogen) (IRIS 1995).

The EPA-derived oral slope factor for heptachlor is 4.5 $(mg/kg\text{-}day)^{+0}$. This value is based on studies which benign and malignant liver tumors were induced in three strains of mice of both sexes. Several structurally related compounds are liver carcinogens. Based on the available scientific information, EPA assigned a weigh-of-evidence Group B2 to humans (probable human carcinogen) (IRIS 1995).

8.2 Fate And Transport

Heptachlor has a low vapor pressure (3.0×10^{-4} mmHg at 25°C) and a low water solubility (0.056 mg/L). The experimental value for Henry's law constraint is 1.48×10^{-3} suggesting that heptachlor partitions somewhat rapidly to the atmosphere from surface water and that volatilization is significant. Heptachlor is also subject to long-range transport and wet deposition.

The log soil organic carbon adsorption coefficient (log K_{oc}) for heptachlor was estimated to be 4.34. The log K_{oc} value indicates a very high sorption tendency, suggesting it will adsorb strongly to soil and is not likely to leach into groundwater in most cases. The leaching potential at 15 cm (concentration in soil water/concentration in soil) for heptachlor is 0.06, and the volatilization potential at 15 cm (concentration in soil air/concentration in soil) determined in laboratory studies is 5.5×10^{-3}, again suggesting that heptachlor is unlikely to leach appreciably in soil but has some volatilization potential. These are important properties since heptachlor can remain deep in soil for years. The organic matter content of the soil is another factor affecting mobility. Heptachlor is less likely to leach from soil with a high organic matter content. When released into water, it adsorbs strongly to suspended and bottom sediment.

Volatilization from soil particles to the atmosphere is possible. Volatilization is an important mechanism of transport of heptachlor from land surfaces. When heptachlor was applied to orchard grass, approximately 90% was lost in 7 days. When it was applied to moist soil surfaces, 50% was lost in 6 days. When it was applied to dry soil surface, 14-40% was lost in approximately 2 days (50 hours). Volatilization was much less--only 7% in 167 days--when incorporated to a shallow depth of 7.5 cm. Temperature and humidity affect the persistence of heptachlor and total heptachlor (heptachlor plus heptachlor epoxide) in soil. An increase in temperature resulted in a decrease in the volatilization half-lives of heptachlor and total heptachlor. For example, at 18±1°C (90±5% relative humidity [RH]) and 35±1°C (90±5% RH), the half-lives of heptachlor (6 ppm) were 44.8 days and 38 days, respectively. Persistence of heptachlor and total heptachlor was found to be greater at higher humidity, irrespective of temperature. At the combination of higher temperature (25±1°C) and low humidity (55±5% RH), faster dissipation of heptachlor occurred (half-life = 24.67 days). At lower temperatures (18±1°C) and low humidity (55±5% RH), greater persistence of heptachlor was found (40.67 days). Half-lives of total heptachlor (6 ppm) were longer because of the more persistent nature of heptachlor epoxide.

The logarithm of the n-octanol/water partition coefficient (log K_{ow}) is a useful preliminary indicator of bioconcentration potential of a compound. The log K_{ow} for heptachlor is 5.44, suggesting a high potential for bioaccumulation and biomagnification in the aquatic food chain. The bioconcentration factor for heptachlor was 10,630 in Asiatic clam fat (*Corbicula manilensis*), 2,570 in soft clams (*Mya arenaria*), and 8,511 in oysters (*Crassostrea virginica*).

Heptachlor epoxide is soluble in water at a concentration of 0.275 mg/l. The experimental value for Henry's law constant is 3.2×10^{-5}, suggesting that heptachlor epoxide partitions slowly to the atmosphere from surface water. Based on regression equations, the log K_{oc} for heptachlor epoxide was estimated to range between 3.34 and 4.37. These log K_{oc} values suggest a high sorption tendency, meaning that this compound is not mobile in soil and has a low potential to leach. The organic matter content of soil affects the mobility of heptachlor epoxide. Heptachlor epoxide is less likely to leach from soil with a high organic matter content. If released into water, it adsorbs strongly to suspended and bottom sediments.

Heptachlor and heptachlor epoxide are subject to long-range transport and removal from the atmosphere by wet deposition. Snowpack samples were collected at 12 sites in the Northwest Territories, Canada, in the winter of 1985-1986. Heptachlor epoxide was present in 20 of 21 samples at a mean concentration of 0.18 ng/l ($1.8x10^{-4}$ ppb) with reported concentrations ranging from 0.02 to 0.41 ng/L (from $2x10^{-5}$ to $4.1x10^{-4}$ ppb). No data for heptachlor were reported. There were no known local sources for heptachlor in the Canadian Arctic snow.

Heptachlor and heptachlor epoxide are also taken up by plants (translocated into plants by absorption through the roots). Loamy soils were treated with heptachlor at a total of 25 pounds per 5-inch acre over a 5-year period (1958-1962). The commercial formulation of heptachlor used also contained (-chlordane and nonachlor. Insecticide residues were absorbed by crops grown in these soils, with carrots absorbing the largest amounts. Although residue levels in soils increased up to 1962, the residue concentrations in both carrots and potatoes peaked during the 1960 growing season. During that year, the concentration of total heptachlor in carrots was 1,900 ppb. Residue levels of total heptachlor on potatoes never exceeded 540-510 ppm (1960-1962). Apparently a threshold had been reached beyond which the content of insecticidal residues remained constant in these two crops. When insecticide residue levels in soil started to decline (1963), both carrots and potatoes also contained proportionally smaller amounts of residue. In the fall of 1968, residues of total heptachlor were found in the following crops: carrots--413 ppb (92% heptachlor epoxide), potatoes--70 ppb (98% heptachlor epoxide), beets--60 ppb (100% heptachlor epoxide), radishes--140 ppb (100% heptachlor epoxide), and cucumbers--90 ppb (95% heptachlor epoxide).

The log K_{ow} for heptachlor epoxide is 5.40, indicating a high potential for bioconcentration and biomagnification in the aquatic food chain. Estimated bioconcentration factors for heptachlor epoxide are 1,698 in mussels (Mytilus edulis), 851 in oysters (Crassostrea virginica), and 2,330 in Asiatic clam fat (Corbicula manilensis). The bioconcentration potentials of heptachlor and heptachlor epoxide differ, with the more polar epoxide being concentrated to a lesser degree than the parent compound. Biomagnification of heptachlor and heptachlor epoxide in aquatic food chains is significant. Because heptachlor is readily metabolized to heptachlor epoxide by higher trophic level organisms, biomagnification of heptachlor itself is not significant. because of the more persistent nature of heptachlor epoxide and its lipophilicity, biomagnification of heptachlor epoxide in terrestrial food chains is significant.

8.3 Interactions with Other Chemicals

Dietary administration of heptachlor (97.6% purity) at 0.65 or 1.3 mg/kg/day in diet for 25 weeks promoted the development of hepatocellular foci and hepatocellular neoplasms in male $B6C3F_1$ mice previously initiated with 3.8 mg/kg/day diethylnitrosamine given in the drinking water for 14 weeks.

Nutritional factors may influence the toxicity of pesticides. Research in this area has primarily focused on the role of dietary proteins, particularly sulfur-containing amino acids, trace minerals, and vitamins A, C, D, and E. Studies in rats show that inadequate dietary protein enhances the toxicity of most pesticides but decreases, or fails to affect, the toxicity of a few. The results of these studies have shown that at one-seventh or less normal dietary protein, the hepatic toxicity of heptachlor is diminished as evidenced by fewer enzyme changes. The lower-protein diets may decrease metabolism of heptachlor to heptachlor epoxide.

Male weanling rats were fed a 5%, 20%, or 40% casein diet for 10 days and then given heptachlor intraperitoneally. The animals receiving the 5% casein diet showed a three-fold tolerance to heptachlor toxicity, but the toxicity of heptachlor epoxide was not affected. This was probably due to inability of weanling rats to metabolically convert heptachlor to the more toxic heptachlor epoxide. This fact is further supported by the observation that changes in protein percentage in diet did not affect the toxicity of heptachlor epoxide itself.

Walter Reed-Wistar and Charles River male adult rats were exposed to oral does of turpentine or to turpentine vapors, which consisted of ∀ and ∃-pinene. These exposures were followed by oral administration of heptachlor epoxide or of one of three pesticides, paraoxon, heptachlor, or parathion, or by an intraperitoneal injection of hexobarbital. The studies revealed that pretreatment with turpentine reduced hexobarbital sleeping time, reduced the parathion LD_{50}, and increased the heptachlor LD_{50}. The paraoxon and heptachlor epoxide LD_{50} values were unchanged. ∀-Pinene and ∃-pinene vaporized from turpentine had no effect on either hexobarbital sleeping time or parathion, paraoxon, or heptachlor epoxide mortality but did increase the heptachlor LD_{50}. It is speculated that increases in hepatic microsomal enzyme activity are responsible for these differences.

8.4 References

ATSDR Toxicological Profile for Heptachlor/Heptachlor Epoxide. Update, April 1993.

Integrated Reference Information System (IRIS). 1995.

9.0 LEAD

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It has no characteristic taste or smell. Metallic lead does not dissolve in water and does not burn. Some natural and man-made substances contain lead, but do not look like lead in its metallic form. Some of these substances can burn.

Lead has many different uses. Its most important use is in the production of some types of batteries. Other uses include the production of ammunition, in some kinds of metal products (such as sheet lead, solder and pipes) and in ceramic glazes. Some chemicals containing lead, such as tetraethyl lead and tetramethyl lead, are used as gasoline additives. However, the use of these lead-containing chemicals in gasoline is much less than it used to be because the last producer of these additives in the United States stopped making then in early 1991. Other chemicals containing lead are used in paint. The amount of lead added to paints and to ceramic products, caulking, gasoline additives, and solder has also been reduced in recent years because of lead's harmful effects in humans and animals. However, the use of lead in ammunition and roofing has actually increased in recent years. Lead is also used for radiation shields for protection against X-rays and in a large variety of medical (electronic ceramic parts of ultrasound machines, intravenous pumps, fetal monitors, and other surgical equipment) scientific (circuit boards for computers and other electronic circuitry), and military equipment (jet turbine engine blades, military tracking systems).

Most lead used by industry comes from mined ores ("primary") or from recycled scrap metal or batteries ("secondary"). Human activities (such as use of "leaded" gasoline) have spread lead and substances that contain lead to all parts of the environment. For example, lead is in air, drinking water, rivers, lakes, oceans, dust, and soil. Lead is also in plants and animals that humans may eat.

People living near hazardous waste sites can be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing or touching dust or dirt that contains lead. For people who do not live near hazardous waste sites, most exposure to lead occurs by eating foods that contain lead, occupationally in brass/bronze foundries, or in areas where leaded paints exist. Foods such as fruits, vegetables, meats, grains, seafoods, soft drinks, and wine may have lead in them. Cigarettes also contain small amounts of lead. In general, very little lead is in drinking water. More than 99% of all

drinking water contains less than 0.005 part of lead per million parts of water (ppm). However, the amount of lead taken into your body through drinking water can be higher in communities with acidic water supplies. Acidic water can make the lead found in lead pipes, solder, and brass faucets enter water. Eating lead-based paint chips or dust is another way to be exposed to lead. These two latter routes are particularly relevant to children in lower-income urbanized populations. For occupationally exposed individuals, the predominant route of exposure is the inhalation of lead particles.

Exposure to gasoline additives that contain lead can happen while pumping leaded gasoline, from sniffing leaded gasoline, and possibly during the use of some do-it-yourself fuel additives. For people who are exposed to lead at work, the largest source of exposure comes from breathing air that contains lead. Breathing or swallowing dust and dirt that has lead in it is another way to be exposed to lead. Children, especially those who are preschool age, can have a lot of lead exposure because they put many things into their mouths. Their hands, toys, and other items may have lead-containing dirt on them. In some cases, children swallow nonfood items such as paint chips and dirt ("pica"). These items may contain very large amounts of lead , particularly in and around older houses that were painted with lead-based paint. The paint in these houses often chips off and mixes with dust and dirt. Some old paint (when it is dry) is 5-40% lead. Skin contact with dust and dirt containing lead occurs every day. However, not much lead can get into the body through the skin. During normal use of lead-containing products, very little lead gets on the skin.

The burning of gasoline has been the single largest source (90%) of lead in the atmosphere since the 1920s. A lot less lead in the air comes from gasoline now because the Environmental Protection Agency (EPA) reduced the amount of lead that can be used in gasoline. Less than 35% of the lead released to the air now comes from gasoline. Other sources of lead in the air include releases to the air from industries involved in iron and steel production, lead-acid-battery manufacturing, brass foundries, and manufacturing of tetraethyl and tetramethyl lead, the latter two being very volatile. Lead released into air may also come from burning of solid waste, windblown dust, volcanoes, exhaust from workroom air, burning or weathering of lead-painted surfaces, and cigarette smoke.

Sources of lead in drinking water include lead that can come out of lead pipes, faucets, and solder used in plumbing. Lead-containing plumbing may be found in public drinking water systems, in houses, apartment buildings, and public buildings. Sources of lead in

surface water or sediment include deposits of lead-containing dust from the atmosphere, waste water from industries that handle lead (primarily iron and steel industries and lead producers), and urban runoff.

Sources of lead in food and beverages include deposition of lead-containing dust from the atmosphere in crops and during food processing and uptake of lead from soil by plants. Lead may also enter foods when foods are put into improperly glazed pottery and ceramic dishes and leaded-crystal glassware. Illegal whiskey made using stills that contain lead-soldered parts (such as radiators) may also contain lead. The potential for exposure to lead in canned food from lead-soldered containers is greatly reduced because the content of lead in canned foods has decreased 87% from 1980 to 1988. Lead may also be released from soldered joints in kettles used to boil water for beverages.

Sources of lead in dust and soil include deposition of atmospheric leads and weathering and deterioration of lead-based paint. Lead in dust may also come from windblown soil. Disposal of lead in municipal and hazardous waste dump sites also adds lead to soil.

The Centers for Disease Control and Prevention (CDC) recommends that all children should be screened for lead poisoning at least once a year. This is especially important for children between the ages of 6 months and 6 years. A child with an EP level of 35 Φg/dL or greater should be tested for blood lead level. A child with a blood level of 20 Φg/dL or greater should be tested by their doctors for symptoms of lead poisoning.

EPA requires that the concentration of lead in air that the public breathes shall not exceed 1.5 micrograms per cubic meter ($\Phi g/m^3$) averaged over 3 months. EPA regulations now limit the level of lead in leaded gasoline to 0.1 grams per gallon (0.1 g/gal) and the level in unleaded gasoline to 0.05 g/gal. According to the Clean Air Act Amendments (CAAA) of 1990, the sale of leaded gasoline will be illegal as of December 31, 1995.

EPA regulations also limit lead in drinking water to 0.015 milligrams per liter (mg/L). The Consumer Product Safety Commission (CPSC), EPA, and the states are required by the 1988 Lead Contamination Control Act to deal with the problem of lead in drinking water coolers by requiring that water coolers containing lead be recalled or repaired and that new coolers be lead-free. In addition, drinking water in schools must be tested for lead and the sources of lead in this water must be removed.

To help protect small children, the CPSC requires that the concentration of lead in most paints available through normal consumer channels be not more than 0.06%. The CDC recommends that inside and outside painted surfaces of dwellings be tested for lead, and that surfaces containing lead equal to or greater than 0.7 milligram per square centimeter (mg/cm^2) of surface area be stripped and repainted according to a four-step paint removal and replacement protocol. This is necessary because stripping can release fine particles of lead that can cause lead poisoning.

The Department of Housing and Urban Development (HUD) requires that federally funded housing and renovations, public housing , and Indian housing be tested for lead-based paint hazards and that such hazards be fixed by covering the paint or removing it. HUD is carrying out demonstration projects to determine the best ways of covering or removing this paint in housing.

The Occupational Safety and Health Administration (OSHA) regulations limit the concentration of lead in workroom air to 50 $\Phi g/m^3$ for an 8-hour workday. If a worker has a blood level of 40 $\Phi g/dL$, then OSHA requires that worker be removed from the workroom where lead exposure is occurring.

9.1 Toxicokinetics

Some of the lead that enters the body comes from breathing in lead dust or chemicals that contain lead. Once the lead is in the lungs, it goes quickly to other parts of the body in the blood.

Most of the lead that enters the body comes through swallowing, even though very little of the amount swallowed actually enters the blood and others parts of the body. The amount that gets into the body from the stomach partially depends on when last a meal was eaten. It also depends on how old the person is and how well the lead particles eaten dissolved in the stomach juices. Experiments in adult volunteers showed that the amount of lead that got into the body from the stomach was only about 6% in adults who had just eaten. In adults who had eaten for a day, about 60-80% of the lead from the stomach got into the blood. On the other hand, 50% of the lead swallowed by children enters the blood and other body parts even if their stomachs are full.

Frequent skin contact with lead in the from of lead-containing dust and soil can result in children swallowing lead through hand-to-mouth behavior. In adults, only a small portion of the lead will pass through the skin and enter the body if it is not washed off after skin contact. More lead can pass through the skin if it is damaged. Certain types of lead compounds, however, may penetrate the skin .

Shortly after lead gets into your body, lead travels in the blood to the "soft tissues," (such as the liver, kidneys, lung, brain, spleen, muscles, and heart). After several weeks most of the lead then moves into your bones and teeth. In adults, about 94% of the total amount of lead in the body is contained in their bones and teeth. Children, on the other hand, have only about 73% of lead in their bodies stored in their bones. The rest is in their soft tissues and blood. Part of the lead can stay in the bones for decades. Part of the lead can leave the bones and may reenter the blood and organs at a later time.

The body does not change lead atoms into any other form. Once it is taken in and distributed to the organs, the lead that is not stored in the bones leaves the body in the urine or feces. About 99% of the amount of lead that in taken into the body will leave in the waste within a couple of weeks, but only about 32% of the taken into the body of children will leave in the waste.

Exposure to lead can be particularly dangerous for unborn children because of their great sensitivity during development. Exposure to lead can also be dangerous for young children because they swallow more lead through normal mouthing activity, take more of the lead that they swallow into their bodies, and are more sensitive to its effects. Unborn children can be exposed to lead through their mothers. This may cause premature births, smaller babies, and decreased mental ability in the infant. Lead exposure may also decrease intelligence quotient (IQ) scores and reduce the growth of young children. These effects have been seen more often following exposure to high levels of lead, than following exposure to low levels of lead.

In adults, lead exposure may decrease reaction time and possibly affect the memory. Lead exposure may also cause weakness in the fingers, wrist, or ankles. Lead exposure may increase blood pressure in middle-aged men. It is not known whether lead has an effect on blood pressure in women. Lead exposure may also cause anemia, a disorder of the blood. The connection between the occurrence of these effects and low lead exposures is not certain. At high levels of exposure, lead can severely damage the brain and kidneys in

adults or children. In addition, high levels of exposure to lead may cause abortion and damage the male reproductive system (the organs responsible for sperm production). The effects of lead are the same regardless of whether it enters the body through breathing or swallowing.

Kidney tumors have developed in rats and mice given large doses of lead. There is no proof that lead causes cancer in humans. Furthermore, the animal studies have been criticized by a panel of EPA scientists because of the very high doses used, among other things, and should not be used to predict what may happen in humans. The Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably be anticipated to be carcinogens based on these studies in animals, but that there is inadequate evidence for the carcinogenicity of these lead compounds in humans.

Prior to the actual absorption of inorganic lead by the lungs, some fraction of inhaled airborne inorganic lead must be deposited in the respiratory tract. The rate of deposition of particulate airborne inorganic lead in adult humans is approximately 30-50% and is modified by factors such as particle size and ventilation rate. Once deposited in the lower respiratory tract, particulate inorganic lead is almost completely absorbed, and all chemical forms of lead also appear to be absorbed. After subjects breathed lead chloride, with an MMAD of 0.24 Φm, through a standard respiratory mouthpiece for 5 minutes, 23% and 26%, respectively, of the aerosol was deposited in the lungs and respiratory tract.

Absorption is suggested by elevated blood lead concentrations in subjects who were continuously (23 hours per day) exposed to 0.0032-0.011 mg lead/m^3 for 18 weeks (the species of inorganic lead to which the subjects were exposed was not specified). Elevated blood and urinary lead concentrations were also found in volunteers exposed to 0.15 mg lead/m^3 for 7.5 hours per day, 5 days per week for 16-112 weeks. Blood lead concentrations as high as 45 Φg/dL were observed in one subject exposed at that rate for 2 years. Daily lead absorption of 14 Φg was reported for five male volunteers who inhaled ambient air (0.002 mg lead/m^3). Some evidence for complete absorption of inorganic lead from the respiratory tract may be the lack of inorganic lead found at autopsy in the lung tissues of occupationally exposed lead workers and nonoccupationally exposed subjects.

Following a single exposure to vapors of tetraalkyl organic lead compounds (approximately 1 mg/m^3 breathed through a mouthpiece, 10-40 breaths of approximately 1

L volume) in four male subjects, 37% and 51% of inhaled tetraethyl and tetramethyl lead, respectively, were initially found in the respiratory tract, but a considerable percentage of these compounds was lost through exhalation. Approximately 60-80% of the deposited tetraalkyl organic lead was absorbed by the lungs. In a case reported of a 22-year-old male exposed to tetramethyl organic lead, absorption was evident because of elevated urinary lead levels for 4 days after exposure.

Limited experimental data suggest that inhaled organic lead is absorbed rapidly by animals. One hour after female Wistar rats breathed total organic lead concentrations of 0.01 mg lead/m^3 as tetraethyl lead in the form of aerosolized leaded gasoline labeled with lead-210 (^{210}Pb) tracer for 30-45 minutes, lead clearance in the lungs was 30%; the majority of the particles were 0.1-0.5 Φm in diameter. Immediately after nose-only breathing of engine exhaust aerosols containing 6 mg lead/m^3 as lead-203 (^{203}Pb)-labeled tetraethyl lead for 40 or 60 minutes, 25% of the dose was accounted for in tissues other than the lung and gastrointestinal tract in rats. Initially, the organic lead content in lungs decreased quite rapidly; only 7.5% of the dose was retained in the lungs after 48 hours, followed by a slower decline in which less than 2% of the dose remained in the lungs after a week. The lung had the lowest tissue lead content in rats and rhesus monkeys who inhaled 0.0215 mg lead/m^3 continuously for a year.

Although there were limited data, oral absorption of lead appears to be low in humans, except in children. The extent and rate of gastrointestinal absorption are affected by fasting and the solubility of a particular lead salt in gastric acid. Male subjects were fed diets supplemented with 0.0008-0.003 mg/kg/day of lead-204 (^{204}Pb)-labeled lead nitrate for up to 124 days in which 6.5-10.9% of the tracer was absorbed. Absorption can be as high as 45% in adults under fasting conditions to as low as 6% with food. It was reported that intestinal absorption of lead chloride was 3% with meals but increased to 60% when subjects were fasted. Interindividual variability of oral absorption in which intestinal absorption ranged from 10% to 80% in eight fasted volunteers receiving a single exposure of 0.007 or 0.02 mg/kg/day in drinking water.

There is indirect evidence from autopsies which reveal high lead content in tissues, occurring from life-time exposure. Oral intake of lead can result from consuming lead-containing food and beverages and from swallowing lead deposited in the upper respiratory tract after inhalation exposure. In addition, the ingestion of lead in children may occur through normal mouthing activity and pica, which is the ingestion of material

not fit for food, such as soil, clay, ashes, paint chips, or plaster. The primary site of lead absorption in children is the gastrointestinal tract. For dietary lead, absorption in children is approximately 50% compared with 15% gastrointestinal lead absorption measured in adults. When daily intake was greater than 0.005 mg lead/kg, absorption was increased from 26.2% to 41.5% in infants, 2 weeks to 2 years of age, who ere exposed for 72 hours to lead in milk and commercially prepared strained food. However, at lower lead levels there was difficulty in controlling lead intake.

There is evidence to suggest that gastrointestinal absorption in animals is controlled by a saturation phenomenon, as well as influenced by fasting. In fasted rats, absorption was estimated at 42% and 2% following single oral administration of 1 and 100 mg lead/kg, respectively, as lead acetate. In mice, absorption was 14% in fasted mice versus 7.5% in fed mice 4 hours following an oral gavage dose of 0.003 mg lead/kg as lead acetate. However, no difference in absorption (4-5%) was observed in fasted and nonfasted mice receiving 2 mg lead/kg.

The extent of gastrointestinal absorption of lead in experimental animals is age dependent. The rat pup absorbs 40-50 times more lead via the diet than does the adult rat. In rats receiving an oral dose of 1 mL lead-212 (^{212}Pb)-labeled tracer, absorption was approximately 74-89% for animals 16-22 days of age, 15-42% in animals 24-32 days old, and only 16% at 89 days old. A single dose of lead resulted in 52% absorption in 1-2 week-old suckling rats compared to 0.4% in adults. Age differences in absorption rate were evident in rat pups who had slightly higher tissue levels compared to adult rats following a single gavage dose of 1 or 10 mg lead/kg as lead acetate. Absorption was 37.9% for young monkeys versus 26.4% in adults following a single radiolabeled gavage dose of 6.37 mg lead/kg as lead acetate. This age difference may be due, in part, to dietary differences and to the presence of an undeveloped, selective intestinal barrier to lead in the rat neonate.

Particle size also influences the degree of gastrointestinal absorption. An inverse relationship was found between diets containing metallic lead of particle sizes $\leq$250 Φm and absorption in rats. There was a 2.3-fold increase in tissue lead concentration when animals ingested an acute dose of 37.5 mg/kg with a particle size of <38 Φm (diameter) compared to a particle diameter of 150-250 Φm.

Limited information is available regarding absorption after dermal exposure in humans. Dermal absorption of inorganic lead compounds is reported to be much less significant than absorption by inhalation or oral routes of exposure, because of the greatly reduced dermal absorption rate. Following skin application of ^{203}Pb-labeled lead acetate in cosmetic preparations (0.1 mL of a lotion containing 6 mmol lead acetate/L or 0.1 g of a cream containing 9 mmol lead acetate/kg) to eight male volunteers for 12 hours, absorption was $\leq$0.3%, but expected to be 0.06% during normal use of such preparations. Most of the absorption took place by 12 hours of exposure.

No studies were located regarding dermal absorption of inorganic lead in animals; however, tetraalkyl lead compounds have been shown to be rapidly and extensively absorbed through the skin of rabbits and rats. A 0.75-mL amount of tetraethyl lead, which was allowed to spread uniformly over an area of 25 cm^2 on the abdominal skin of rabbits, resulted in 10.6 mg of lead in the carcass at 0.5 hours and 4.41 mg at 6 hours. Tetraethyl lead was reported to be absorbed by the skin of rats to a much greater extent than lead acetate, lead oleate, and lead arsenate.

A slope factor is not available under the recommendation of the Carcinogen Assessment Group due to the many uncertainties of quantifying lead's cancer risk. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. In addition, current knowledge of lead pharmacokinetics indicates that an estimate derived by standard procedures would not truly describe the potential risk. However, an assigned Group B2 to humans (probable human carcinogen) has been assessed based on available information (IRIS 1995).

9.2 Fate And Transport

In the atmosphere, lead exists primarily in the particulate form. Upon release to the atmosphere, lead particles are dispersed and ultimately removed from the atmosphere by wet or dry deposition. Approximately 40-70% of the deposition of lead is by wet fallout; 20-60% of particulate lead emissions from automobiles are deposited near the source. An important factor in determining the atmospheric transport of lead is particle size distribution. Large particles, particularly those with aerodynamic diameters of >2 Φm, settle out of the atmosphere fairly rapidly and are deposited relatively close to emission sources (e.g., 25 meters from the roadway after being emitted in motor vehicle exhaust), whereas smaller particles may be transported thousands of kilometers. Wet deposition is

more important than dry deposition for removing lead from the atmosphere; the ratio of wet to dry deposition was calculated to be 1.63, 1.99, and 2.50 for sites in southern, central, and northern Ontario, Canada, respectively. Lead has been found in sediment cores of lakes in Ontario and Quebec, Canada, that were remote from any point sources of lead releases, indicating that long-range atmospheric transport was occurring.

The amount of lead that remains in solution in surface waters depends upon the pH of the water and the dissolved salt content. Equilibrium calculations show that at pH >5.4, the total solubility of lead is approximately 30 Φg/L in hard water and approximately 500 Φg/L in soft water. In most surface waters and ground waters, the concentration of dissolved lead is low because the lead will form compounds with anions in the water such as hydroxides, carbonates, sulfates, and phosphates that have low water solubilities and will precipitate out of the water column.

The fate of lead in soil is affected by the specific or exchange adsorption at mineral interfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. These processes are dependent on such factors as soil pH, and organic matter content of soil, the presence of inorganic colloids and iron oxides, ion-exchange characteristics, and the amount of lead in soil. The accumulation of lead in most soils is primarily a function of the rate of deposition from the atmosphere. Lead is strongly sorbed to organic matter in soil, and although not subject to leaching, it may enter surface waters as a result of erosion of lead-containing soil particulates. Lead may be converted to lead sulfate at the soil surface which is relatively soluble when compared with lead carbonate or phosphate. Lead complexes and precipitates in soil and their transformation depend on the soil type. In soil with a high organic matter content and a pH of 6-8, lead may form insoluble organic lead complexes; if the soil has less organic matter at the same pH, hydrous lead oxide complexes may form or lead may precipitate out with carbonate or phosphate ions. At a pH of 4-6, the organic lead complexes become soluble and leach out or may be taken up by plants. Entrainment of soil particles is another route of lead transport. This latter process may be important in contributing to the atmospheric burden of lead around some lead smelting facilities and NPL sites that contain elevated levels of lead in soil.

The downward movement of lead from soil to groundwater by leaching is very slow under most natural conditions except for highly acidic situations. The conditions that induce

leaching are the presence of lead in soil at concentrations that either approach or exceed the cation exchange capacity (CEC) of the soil, the presence of materials in soil that are capable of forming soluble chelates with lead, and a decrease in the pH of the leaching solution (for example, acid rain). Partial favorable conditions for leaching may be present in some soils near lead smelting and National Priorities List (NPL) sites. Leaching of soluble lead from contaminated soils into groundwater may be minimized by the presence of lead carbonate in the soil and maintaining a soil pH of 8-10.

9.3 Interactions With Other Chemicals

The toxicokinetic and toxicological behavior of lead can be affected by interactions with essential elements and nutrients. In humans, the interactive behavior of lead and various nutritional factors is appropriately viewed as particularly significant for children, since this age group is not only particularly sensitive to the effects of lead, but also experiences the greatest changes in relative nutrient status. Nutritional deficiencies are especially pronounced in children of lower socioeconomic status; however, children of all socioeconomic strata are affected.

Available data from a number of reports document the association of lead absorption with suboptimal nutritional status. In infants and children 1-6 years of age, lead retention (as measured by blood lead content) was inversely correlated with calcium intake, expressed either as a percentage of total or in a weight basis. Dietary intakes of calcium and vitamin D were significantly ($p<0.001$) lower in children with blood levels >60 micrograms per deciliter (Φg/dL). The gastrointestinal uptake of ^{203}Pb was monitored in eight adult subjects as a function of dietary calcium and phosphorus intakes. The label absorption rate was 63% without supplemented with 200 milligrams (mg) calcium plus 140 mg phosphorus, the amounts present in an average meal. Calcium and phosphorus alone reduced lead uptake by a factor of 1.3 and 1.2 respectively; both together yielded a reduction factor of 6. Copper, iron, and zinc have also been postulated to affect lead absorption.

Children with elevated blood lead (12-120 Φg/dL) were found to have significantly lower serum concentrations of the vitamin D metabolite 1,25-dihydroxyvitamin D compared with age-matched controls ($p<0.001$), and showed a negative correlation of serum 1,25-dihydroxyvitamin D with lead over the range of blood lead levels measured.

Zinc appears to be an important element in the ALAD system and may play a protective role in lead intoxication by reversing the enzyme-inhibiting effects of lead. Children with high blood lead levels (50-67 Φg/dL) were reported to consume less zinc than children with lower levels (12-29 Φg/dL). In a group of 13 children, the mean serum zinc levels in children with plumbism were significantly below the values seen in normal children; chelation therapy reduced the mean level even further. An inverse relationship between ALA in urine and the amount of chelatable or systemically active zinc was reported in 66 children challenged with EDTA and having blood levels ranging from 45-60 Φg/dL. Zinc sulfate administration to a lead-intoxicated man following calcium disodium EDTA therapy restored the erythrocyte ALAD activity that was inhibited by lead. This suggests that zinc is an important requirement in the ALAD system.

Forty-three children with elevated blood lead (>30 Φg/dL) and EP (>35 Φg/dL) had an increased prevalence of iron deficiency as these two parameters increased. An inverse relationship between chelatable iron and chelatable body lead levels as indexed by urinary ALA levels has been demonstrated in 66 children with elevated blood lead. Another study reported that the lead absorption rate was 2 to 3 times greater in iron-deficient adults compared to subjects who were iron replete. Daily nutritional intake of dietary fiber, iron, and thiamin were negatively correlated with blood lead levels in male workers occupationally exposed to lead in a steel factory. An in vitro study demonstrated that cadmium and zinc have an antagonistic effect on the inhibitory effects of lead in human ALAD activity. Cadmium was 40-100 times more potent than zinc in activating ALAD. Furthermore, the combined effects of cadmium and lead in tissue resulted in an additively increased risk morality related to cardiac failure in humans with significant relation to age in 80% of the cases.

Reports of lead-nutrient interactions in experimental animals have generally described such relationships in terms of a single nutrient, using relative absorption or tissue retention in the animal to index the effect. Most of the data are concerned with the impact of dietary levels of calcium, iron, phosphorus, and Vitamin D.

Cadmium also affects the toxicity of lead. A synergistic effect of these metals was found on prostatic cytology and testicular damage in male rats following intraperitoneal injection. Rats fed lead and cadmium or zinc has a marked reduction of reticulocytosis compared with rats fed lead alone. Mice exposed simultaneously to lead and cadmium for

10 weeks had higher mortality rates than mice exposed to either metal alone. In addition, interactions between cadmium and lead have been reported at the behavioral level .

Interactions of lead and iron have been documented in animals. Low dietary iron tends to increase the susceptibility to lead intoxication because of enhanced gastrointestinal absorption, suggesting a common pathway for these two elements. There is a synergistic action between lead intoxication and iron deficiency on impairment of hematopoiesis, specifically on hemoglobin level and red blood cell size. Iron appears to reduce the effects of orally or subcutaneously administered lead on blood enzyme and liver catalase activity. Another study demonstrated that iron and lead were synergistic in reducing liver and kidney iron levels, but nor copper levels.

Dietary copper also appears to be antagonistic to the adverse effects of lead in the hematopoietic system, growth depression or tissue hypertrophy. The reduction in uptake of lead and decrease of lead-induced ALAD inhibition upon administration of copper may be achieved through a competition between the two metals for binding to proteins.

Zinc may have a effect against lead toxicity. Zinc added in the diet has been found to protect horses grazing on lead-contaminated pastures from clinical signs of lead toxicity. The protective action of zinc on lead toxicity is thought to be mediated by an inhibition of gastrointestinal absorption via an intestinal metallothionein mechanism, which binds lead.

Evidence suggest that lead exacerbates the toxic effects of mercury. In the rat, the administration of lead nitrate increased kidney and liver glutathione content and resulted in increased mercury deposition in the kidney, along with increased lethality in rats.

The interaction of lead and ethanol suggests that rats exposed to lead and ethanol are mire susceptible to the neurological and hepatotoxic effects of lead. In this study, the simultaneous exposure of rats to lead and ethanol resulted in a significantly higher concentration of lead in blood, brain, and liver tissues compared to rats treated with lead alone.

9.4 References

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10.0 MANGANESE

Manganese is a naturally occurring substance found in many types of rock. Pure manganese is a silver-colored metal, somewhat like iron in its physical and chemical properties. Not occurring in the environment as the pure metal, manganese combines with other chemicals such as oxygen, sulfur, and chlorine. These solid compounds do not evaporate. However, small dust particles of the solid material can become suspended in air. Some manganese compounds are soluble in water, and low levels of these compounds are normally present in lakes, streams, and the ocean. Manganese can change from one compound to another (either by natural processes or human activities), but it does not break down or disappear in the environment. Rocks containing high levels of manganese compounds are mined and used to produce manganese metal. The manganese metal is mixed with iron to make various types of steel. Some manganese compounds are used in the production of batteries, as a component of some ceramics, pesticides and fertilizers, and in nutritional supplements.

10.1 Toxicokinetics

No studies were located regarding the amount of manganese that is absorbed by humans or animals following inhalation exposure. Studies on the clearance of inhaled manganese particles from the lung reveal that a significant fraction of the particles initially deposited in the lung are transported via mucociliary transport to the gastrointestinal tract. Thus, manganese may be absorbed both in the lungs and in the gastrointestinal tract following inhalation of manganese dust. The amount of manganese absorbed across the gastrointestinal tract in humans is rather variable, but typically averages about 3% to 5%. One of the key determinants of absorption appears to be dietary iron intake, with low iron levels leading to increased manganese absorption and vice versa. Manganese is a normal component of human and animal tissues. In humans, most tissue concentrations range between 0.1 and 1Φg manganese/g wet weight, with highest levels in liver, pancreas, and kidney, and lowest levels in bone and fat. Manganese is capable of existing in a number of oxidation states, and limited data suggest that manganese may undergo changes in valence within the body. Circumstantial support for this hypothesis comes from the observation that the valence of the manganese ion in several enzymes appears to be +3, while most manganese intake from the environment is either +2 or +4. Another line of evidence is based on measurements of manganese in tissues and fluids using electron spin resonance (ESR), which detects only the +2 oxidation state of manganese.

Studies in animals and humans indicate that inorganic manganese compounds have very low acute toxicity by any route of exposure. An exception is $KMnO_2$, which is a powerful oxidant that can cause severe corrosion of skin or mucosa at the point of contact. Acute inhalation exposure to high levels of manganese dust (MnO_2,Mn_3O_4) can cause an inflammatory response in the lung, which can lead to impaired lung function. However, this response is characteristic of nearly all inhalable particulate matter, and is not dependent upon the manganese content of the particle. Intermediate-duration exposure of humans and animals to manganese compounds can lead to central nervous system effects. Studies in humans have made clear that the main health effect following chronic inhalation exposure is also nervous system toxicity. Chronic inhalation studies in animals confirm that the nervous system is the most sensitive target tissue, but it does not appear that animals are as sensitive as humans.

No studies were located regarding carcinogenic effects in humans or animals following inhalation or dermal exposure, and EPA has not given manganese any classification. Chronic oral exposure of rats and mice to high does of manganese sulfite has provided marginal evidence of carcinogenic potential.

Very little information is available on the developmental effects of manganese. In animals, exposure of mice to an average of 61 mg manganese/m^3 (as MnO_2) for 16 weeks prior to gestation led to a decrease in average pup weight at birth and decreased activity levels (rearing, exploration) in the pups. This suggests that maternal exposure to manganese may lead to neurological effects in the fetus or the neonate, but the data are too limited to define the dose-response curve or to evaluate the biological significance of this effect. Impotence and loss of libido are common systems in male workers afflicted with clinically identifiable signs of manganism. Intratracheal instillation studies in rabbits indicate that high doses of manganese (160 mg/kg, as MnO_2) can cause severe degenerative changes in the seminiferous tubules and lead to sterility. No studies were located regarding effects on women or female animals following inhalation exposure to manganese, but the adverse effects observed in male workers and male animals indicate this might be of concern. No studies were located regarding reproductive effects in humans following oral exposure to manganese. However, several intermediate-duration studies in rats and mice indicate that manganese ingestion can lead to delayed maturation of reproductive function in males.

No studies were located regarding genotoxic effects in humans or animals following inhalation of manganese. In male rats, repeated oral doses of 0.014 mg manganese/kg/day (as $MnCl_2$) for 80 days did not produce any significant chromosomal damage either in bone marrow or spermatogonial cells.

There is no EPA-derived oral slope factor for manganese. Manganese is an element essential to human health and existing studies are inadequate to assess the carcinogenicity of manganese. Based on available scientific information, EPA assigned a weight-of-evidence Group D to humans (not classifiable as to human)(IRIS 1995).

The EPA-derived chronic oral RfD for manganese is 5E-3 mg/kg-day. This value is based on studies by the World Health Organization (WHO) with manganese concentrations for the NOAEL and LOAEL are 167 Φg/L and 1950 Φg/L, respectively. Assuming a water consumption of 2L/day and a body weight of 70 kg, these are equivalent to 0.005 mg/kg-day and 0.06 mg/kg-day respectively. The water RfD assumes a separate dietary intake of manganese, as this essential element is found in varying amounts in all diets. The NOAEL of 10 mg/day (0.14 mg/kg-day for 70 Kg adult) for chronic human consumption of manganese in the diet is based on a composite of data from three references. This available information, taken in conjunction with the essentiality of manganese, warrants an uncertainty factor of 1. On the basis of available information, EPA has assigned a confidence level of not applicable to the RfD, study, and data base. There is no one study used to derive the dietary RfD for manganese. While several studies have determined average levels of manganese in various diets, no quantitative information is available to indicate toxic levels of manganese in the diets of humans.

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11.0 POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. PAHs can either be man-made or occur naturally. Most of these chemicals have no known use except for research purposes. A few of the PAHs are used in medicines and to make dyes, plastics, and pesticides, while others are contained in asphalt used in road construction. They are found throughout the environment in the air, water, and soil. There are more than 100 different PAH compounds. Although the health effects of the individual PAHs are not exactly alike, the following 17 PAHs are considered as a group in this profile:

- acenaphthene
- acenaphthylene
- anthracene
- benz(a)anthracene
- benzo(a)pyrene
- benzo(e)pyrene
- benzo(b)fluoranthene
- benzo (g,h,i)perylene
- benzo(j)fluoranthene
- benzo(k)fluoranthene
- chrysene
- dibenz(a,h)anthracene
- fluorene
- indeno(1,2,3-c,d)pyrene
- phenanthrene
- pyrene

These 17 PAHs were chosen to be included in this profile because (1) more information is available on these than the others; (2) they are more harmful than many or most of the

others; (3) there is a greater chance of exposure to these PAHs than to the others; and (4) they were the ones most frequently identified at the National Priorities List (NPL) hazardous waste sites.

As pure chemicals, PAHs generally exist as colorless, white, or pale yellow-green solids. They can have a faint, pleasant odor. Most PAHs do not occur alone in the environment (including those found at hazardous waste sites). They are found as parts of complex mixtures of chemicals. They can occur in the air either attached to dust particles or as solids in soil or sediment. They can also be found in substances such as crude oil, coal, coal tar pitch, creosote, and road and roofing tar.

PAHs enter the environment largely as releases to air from volcanoes, forest fires, residential wood burning, and automobile and truck exhausts. They can also enter surface water through discharges from industrial plants and waste water treatment plants, and they can be released to soils at hazardous waste sites. The movement of PAHs in the environment depends on properties like their water solubility, vapor pressure, and molecular weight. PAHs in general do not easily dissolve in water. They are present in air as vapors or stuck to the surfaces of small solid particles and can travel long distances before they are removed through washout in rainfall or particle settling. From surface waters, some PAHs can evaporate into the atmosphere, but most will stick to solid particles and settle to the bottoms of rivers or lakes. In soils, the compounds are most likely to stick tightly to particles. Some PAHs can evaporate from surface soils to air. Certain PAHs in soils can also contaminate underground water. The PAH content of plants and animals living on the land or in water can be many times higher than the content of PAHs in soil or water. PAHs can break down to less short-lived products by reacting with sunlight and other chemicals in the air, generally over a period of days to weeks. Breakdown in soil and water generally takes weeks to months and is due mostly to the actions of microorganisms.

PAHs are present throughout the environment, and exposure may occur at home, while outside, or at the workplace. Typically, exposure does not occur to an individual PAH alone, but to a mixture of PAHs.

In the environment, exposure will most likely occur to PAH vapors or PAHs that are attached to dust and other particles in the air. Sources include cigarette smoke, vehicle exhaust, asphalt roads, coal, coal tar, wild fires, agricultural burning, residential wood

burning, and hazardous waste site. Background levels of some representative PAHs in the air are reported to be 0.02 -1.2 nanograms per cubic meter (ng/m^3) in rural areas and 0.15-19.3 ng/m^3 in urban areas. Exposure to PAHs may occur in soils near areas where coal, wood, gasoline, or other products have been burned. Exposure may occur to PAHs in the soil on or near hazardous waste sites, such as former manufactured-gas sites and wood-preserving facilities. PAHs have been found in some drinking water supplies in the United States. Background levels of PAHs in drinking water range from 4 to 24 nanograms per liter (ng/L).

In the home, PAHs are present in tobacco smoke, smoke from home burning of wood, creosote-treated wood products, cereals, grains, flour, bread, vegetables, fruits, meats, processed or pickled foods, and contaminated cow's milk or human breast milk. Food grown in contaminated soil or air may also contain PAHs. Cooking meat or other food at high temperatures, which happens during grilling or charring, increases the amount of PAHs in the food. The level of PAHs in the typical U.S. diet is less than 2 part of total PAHs per billion parts of food (ppb), or less than 2 micrograms per kilogram of food (Φg/kg).

The primary sources of exposure to PAHs for most of the U.S. population are inhalation of the compounds in tobacco smoke, wood smoke, and ambient air, and ingestion of PAHs in foods. For some people, the primary exposure to PAHs occurs in the workplace. PAHs have been found in coal tar production plants, coking plants, bitumen and asphalt production plants, coal-gasification sites, smoke houses, aluminum production plants, coal tarring activities, and municipal trash incinerators. PAHs have also been found in other facilities where petroleum, petroleum products, or coal are used or where wood, cellulose, corn, or oil are burned. Populations living near waste sites containing PAHs may be exposed through contact with contaminated air, water, and soil.

The federal government has set regulations to protect individual from the possible health effects of eating, drinking, or breathing PAHs. EPA has suggested that taking into the body each day the following amounts of individual PAHs are not likely to cause significant (noncancer) harmful health effects: 0.3 milligrams (mg) of anthracene, 0.06 mg of acenaphthene, 0.04 mg of fluoranthene, 0.04 mg of fluorene, and 0.03 mg of pyrene per kilogram (kg) of the body weight (one kilogram is equal to 2.2 pounds).

Based on data on benzo(a)pyrene, the federal government has developed regulatory standards and guidelines to protect individuals from the potential health effects of PAHs in drinking water. EPA has provided estimates of levels of total cancer-causing PAHs in lakes and streams associated with various risks of developing cancer in humans. If the following amounts of individual PAHs are released to the environment, EPA must be notified: 1 pound of benzo(b)fluoranthene, benzo(a)pyrene, or dibenz(a,h)anthracene; 10 pounds of benzo(a)anthracene; 100 pounds of acenaphthene, chrysene, fluoranthene, or indeno(1,2,3-c,d)pyrene; or 5,000 pounds of acenaphthylene, anthracene, benzo(k)fluoranthene, benzo(g,h,i)perylene, fluorene, phenanthrene, or pyrene.

PAHs are generally not produced commercially in the United States except as research chemicals. However, PAHs are found in coal, coal tar, and in the creosote oils and pitches formed from the distillation of coal tars. The National Institute for Occupational Safety and Health (NIOSH) concluded that occupational exposure to coal products can increase the risk of lung cancer and skin cancer in workers and established a recommended occupational exposure limit (REL-TWA) for coal tar products of 0.1 milligram of PAHs per cubic meter of air (0.1 mg/m^3) for a 10-hour work day, 40-hour work week. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends an occupational exposure limit for coal tar products of 0.2 mg/m^3 for and 8-hour work day, 40-hour work week. The Occupational Safety and Health Administration (OSHA) has established a legally enforceable limit of 0.2 mg/m^3 averaged over an 8-hour exposure period.

11.1 Toxicokinetics

PAHs can enter the body through the lungs when breathing air that contains them (usually stuck to particles or dust). This is one of the routes of exposure for people living near hazardous waste sites. However, it is not known how rapidly or completely uptake by the lungs occur. Drinking water and swallowing food, soil, or dust particles that contain PAHs are other routes for these chemicals to enter the body, but uptake is generally slow when PAHs are swallowed. Under normal conditions of environmental exposure, PAHs could rapidly enter the body if the skin comes into contact with soil that contains high levels of PAHs (this could occur near a hazardous waste site) or with used crankcase oil or other products (such as creosote) that contain PAHs. The rate at which PAHs enter the body by ingestion or through the skin is increased when they are present in certain oily mixtures; other oily mixtures decrease absorption into the body.

PAHs can enter all the tissues of the body that contain fat and tend to be stored mostly in the kidneys, liver, and fat, with smaller amounts in the spleen, adrenal glands, and ovaries. PAHs are changed by all tissues in the body into many different substances. Some of these substances are more harmful and some are less harmful than the original PAHs. Results from animal studies show that PAHs do not tend to be stored in your body for a long time. Most PAHs that enter the body leaves within a few days, primarily in the feces and urine.

PAHs can be harmful to the health. Several of the PAHs, including benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)flouranthene, benzo(k)flouranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene, have caused tumors in laboratory animals when they breathed them in air, when they ate them, or when they had long periods of skin contact with them. Reports in humans show that individuals exposed by breathing or skin contact for long periods to mixtures that contain PAHs and other compounds can also develop cancer.

Mice fed high levels of benzo(a)pyrene during pregnancy had difficulty reproducing and so did their offspring. The offspring from pregnant mice fed benzo(a)pyrene also showed other harmful effects, such as birth defects and decreased body weight. Similar effects could occur in humans, but there is no information to show that these effects do occur.

Studies in animals have also shown that PAHs can cause harmful effects on skin, body fluids, and the body's system for fighting disease after both short- and long-term exposure. These effects have not been reported in humans.

Absorption of PAHs in humans following inhalation exposure can be inferred from the presence of urinary metabolites of PAHs in workers exposed to these compounds in an aluminum plant. The high concentration of PAHs in the occupational setting did not correspond to the amount of PAHs deposited, metabolized, and excreted in the urine in this study. It is suggested that PAHs adsorbed to airborne particulate matter may not be bioavailable and that the dose-uptake relationship may not be linear over the entire PAH range.

Animal studies on inhalation absorption of PAHs are limited to benzo(a)pyrene exposure. Rapid absorption was evident following inhalation exposure of low and high levels of benzo(a)pyrene to rats. Acute and intermediate-duration exposure to 4.8 mg/m^3 [^{14}C]-

benzo(a)pyrene by nose-only inhalation in rats resulted in elevated levels of radioactivity in tissues and excreta within 3 hours of exposure. High levels of radioactivity were detected in the gastrointestinal tract, which may be due to biliary excretion or mucociliary clearance of benzo(a)pyrene from the upper respiratory tract. Intratracheal administration of 0.001 mg/kg [^{3}H]-benzo(a)pyrene to rats also resulted in rapid absorption through the lungs. Radioactivity in the liver reached a maximum of 21% of the administered dose within 10 minutes of instillation. Presence of radioactivity in other tissues and the bile was also indicative of its absorption in rats. Similar results were also seen in guinea pigs and hamsters following intratracheal exposure to benzo(a)pyrene.

Inhalation absorption of benzo(a)pyrene may be affected by the size of particles on which benzo(a)pyrene is adsorbed. The elimination of benzo(a)pyrene from the lungs was studied following intratracheal administration of pure benzo(a)pyrene crystals or benzo(a)pyrene coated on carbon particles in two size ranges (0.5-1.0 Φm and 15-30 Φm). Fifty percent of the pure benzo(a)pyrene crystals was cleared from the lungs within 1.5 hours and >95% cleared within 24 hours, while only 50% of the benzo(a)pyrene adsorbed to the small carbon particles cleared within 36 hours. Elution of benzo(a)pyrene was even slower with the larger particle size (approximately 4-5 days). These results indicate that the bioavailability of benzo(a)pyrene is altered by the particle size of the carrier. The initial lung deposition of [^{3}H]-benzo(a)pyrene adsorbed onto gallium oxide(Ga_2O_3) particles was 4.9 Φg of which 3.1% remained after 30 minutes. A control study, conducted without the Ga_2O_3 particles at a concentration of 1 mg/m^3, found that 8.2 Φg was inhaled, of which 0.9% remained in lungs after 30 minutes. The excretion of hydrocarbon was monitored for over 2 weeks at which time nearly all the initial lung burden was recovered in the excreta, indicating complete absorption of the instilled hydrocarbon. Significant differences in the clearance of benzo(a)pyrene coated with Ga_2O_3 and pure benzo(a)pyrene suggested that a substantial amount of benzo(a)pyrene/Ga_2O_3 particles was removed from the lungs by mucociliary clearance and subsequent ingestion.

The above results corroborate findings in an <u>in vitro</u> experiment. It was concluded that the release rate of PAHs from carrier particles is the rate-determining step in the transport of PAHs from these particles to the bronchial epithelium.

The absorption of benzo(a)pyrene may also be affected by the solubility of the vehicle used in administration. Approximately 70% of benzo(a)pyrene administered with

triethylene glycol was excreted 6 hours following intratracheal instillation. Excretion rates of benzo(a) pyrene were only 58.4% and 56.2% with ethyl laurate and tricaprylin, respectively, within a 6-hour period. The small volume of benzo(a)pyrene instilled is probably deposited in the bronchial region which allows more water-soluble materials (triethlene glycol) to pass the mucous layer lining than water-insoluble compounds (ethyl laurate and tricaprylin).

Nasal instillation of [^{3}H]-benzo(a)pyrene (0.13 mg/kg) to hamsters resulted in the metabolism of [^{3}H]-benzo(a)pyrene in the nasal cavity. A large fraction of the metabolites was recovered from the epithelial surface, indicating that benzo(a)pyrene was first absorbed in the mucosa, metabolized, and returned to the mucus. Monkeys and dogs received nasal instillation of [^{14}C]-benzo(a)pyrene at doses of 0.16-0.21 mg/kg. Radiolabeled metabolites were detected in the nasal cavity, but little or no activity was detected in the blood and excreta of either species during the 48 hours after exposure. These results indicate that absorption of benzo(a)pyrene and/or its metabolites was very poor or very slow following nasal instillation in monkeys and dogs.

There is evidence suggesting that benzo(a)pyrene is orally absorbed in humans. Following ingestion of diets containing very low levels of benzo(a)pyrene, the metabolite, 1-hydroxypyrene, was detected in the urine. No quantitative data on the excretion of the benzo(a)pyrene were provided. The concentration of benzo(a)pyrene in human feces was examined in eight volunteers who ingested broiled meat that contained approximately 9 Φg of benzo(a)pyrene. The feces of these individuals contained undetectable levels of benzo(a)pyrene (<0.1 Φg/person), which is similar to what was seen following consumption of control meat that contained undetectable amounts of benzo(a)pyrene by these same volunteers, suggesting that most of the ingested benzo(a)pyrene was absorbed.

Oral absorption of benzo(a)pyrene in rats is incomplete and may be influenced by the presence of oils and fat in the gastrointestinal tract. Oral absorption of benzo(a)pyrene was estimated to be 40%, with a bioavailability of 7.8-11.5%, in Sprague-Dawley rats infused intaduodenally to a total dose of approximately 0.0005 mg/kg for 90 minutes. Nearly 80% of gavage dose of 0.0527 mg/kg [^{14}C] benzo(a)pyrene in peanut oil was detected in the excreta of rats 48 hours after exposure; however, some of the recovered radioactivity may have been unabsorbed . Radioactivity found in the liver, lungs, kidneys, and testis following a low dose of [^{3}H]-benzo(a)pyrene to Sprague-Dawley rats provides supporting evidence of oral absorption. The extent of oral absorption in rats is enhanced

when benzo(a)pyrene is solubilized in a vehicle (triolein, soybean oils, high-fat diet) that is readily absorbed following low-and high-dose levels.

Oral absorption of benzo(a)pyrene was estimated to be 38-58% following dietary or gavage exposure to high levels in rats. Anthracene was absorbed at a slightly higher extent (53-74%) than benzo(a)pyrene in rats while phenanthracene was poorly absorbed (4-7%). However, the data were limited because an inadequate number of rats was used and study details were lacking.

In general, the oral absorption of chrysene, dibenz(a,h)anthracene, and pyrene was high following exposure to high doses in rats. Following dietary or gavage administration of chrysene in rats, 64-87% of the dose was excreted in the feces. Recovery of chrysene in excreta of Wistar rats was 74% four days after a single gavage dose of 22 mg/kg chrysene in corn oil. Administration of dibenz(a,h)anthracene in the diet (250 mg) or by stomach tube (200 mg) resulted in greater than 90% of the dose being excreted in the feces of white rats. As with chrysene, absorption of dibenz(a,h)anthracene could not be quantified. Male Wistar rats administered 2-15 mg/kg of [^{14}C]-pyrene recovered 68-92% of the dose in the excreta by 6 days postexposure. Bioavailability of pyrene and its metabolites was 65-84% over a period of 8 hours following administration.

The intestinal absorption of PAHs is highly dependent on the presence of bile. To study the role of bile in the absorption of PAHs, conscious rats with bile duct and duodenal catheters were given [^{3}H]-benzo(a)pyrene, phenanthrene, anthracene, 2,6-dimethynaphthalene (DMN), and 7,12-dimethylbenz(a)anthracene (DMBA) with or without exogenous bile. The efficiency of PAH absorption was estimated from the cumulative recovery of radioactivity in the bile and urine over 24 hours. The efficiencies of absorption without bile (as a percentage of absorption with bile) were benzo(a)pyrene, 22.9%; phenanthrene, 96.7%; anthracene, 70.8%; DMN, 91.6%; DMBA, 43.4%. Absorption of the four- or five-membered rings (DMBA and benzo[a]pyrene) was strongly dependent on the presence of bile in the intestinal lumen. The absorption of the tricyclic PAHs (phenanthrene and anthracene) differed with respect to their dependency on bile for efficient absorption. This difference correlated with a difference in water solubility, with anthracene being 18 times less water-soluble than phenanthrene. Those products with low water solubility are dependent on the creation of an intermediate phase of lipolysis and bile salts. These reactions occur during the normal process of lipid digestion and absorption in the intestine.

Application of 2% crude coal tar to the skin of humans for 8-hour periods on 2 consecutive days yielded evidence of PAHs absorption. Phenanthrene, anthracene, pyrene, and fluoranthene were detected in the blood, but benzo(a)pyrene (which is present in coal tar) was not detected. This difference was attributed to differences in percutaneous absorption, rapid tissue deposition after absorption, or metabolic conjugation with rapid urine excretion. An in vitro study using human skin revealed that the extent of permeation across viable human skin after 24 hours was estimated to be 3% of the total applied radioactivity from [^{14}C]-benzo(a)pyrene (10 Φg/cm^2). Using human cadaver skin, it was shown that 23.7∀9.7% of the applied benzo(a)pyrene penetrated into the skin. These results suggest that substantial metabolism and/or binding of benzo(a)pyrene takes place in viable human skin which limits the amount of PAH available to penetrate the skin into the systemic circulation.

Percutaneus absorption of [^{14}C]-benzo(a)pyrene in mice, rats, monkeys, and guinea pigs is rapid and high. A single dose of 7Φ/cm^2 [^{14}C]-benzo(a)pyrene in acetone was applied to a 4-cm^2 area of the dorsal skin of female hairless guinea pigs for 24 hours. Approximately 73% of the administered dose was absorbed dermally by 7 days postexposure; most of the dose was absorbed by day 3. The skin wash at 24 hours of exposure contained about 10.6% of dose. In vitro absorption of benzo(a)pyrene through guinea pig skin demonstrated similar results; 67% absorption in a 24-hour exposure. Seven days after exposure to 125Φg/cm^2 benzo(a)pyrene, 80% of the total recovered radioactivity was eliminated in the feces of mice. The site of application still retained 7% of the recovered radioactivity after 7 days. However, the area of application was not covered to prevent animals from licking the test material which may have lead to ingestion of benzo(a)pyrene.

Dermal absorption of benzo(a)pyrene in rats and monkeys may be affected by the vehicle of administration. Following application of 10 ppm benzo(a)pyrene on the skin of rhesus monkeys, an average absorption of 51∀22% was reported with acetone vehicle and 13.2∀3.4% with soil, however, absorption data were based on radioactivity recovered in urine only. The great variation in the absorption with the acetone vehicle limits these results. This may be related, in part, to the dependence on monitoring radioactivity recovered in urine only as opposed to monitoring radioactivity recovered in urine and feces. Disappearance of the applied dose from the application site was 40% at 24 hours following administration. Sprague-Dawley rats absorbed 1 ppm benzo(a)pyrene 4-5 times higher when administered with crude oil than with soil-sorbed crude oil. The greater

lipophilicity of the crude oil alone probably increases the rate of dermal uptake of the test material, however, no quantitative data were available.

Female Sprague-Dawley rats were exposed dermally to [^{3}H]-benzo(a)pyrene (1 ppm) containing petroleum crude oil alone or in fortified soil matrix for 4 days. Recovery of radioactivity was 35.3% of the dose applied in oil, as follows: (5.3% of dose), feces (27.5%), and tissues (2.5%) 96 hours after beginning of exposure. Recovery was 9.2% of applied dose with benzo(a)pyrene from petroleum crude-fortified soil; recoveries in urine, feces, and tissues were 1.9%, 5.8%, and 1.5%, respectively, at 96 hours. Benzo(a)pyrene (10 ppm) with acetone vehicle or in soil was applied to a 12-cm^2 area of abdominal skin of female rhesus monkeys for 24 hours. Urine contained 51∀22% of the dose with acetone vehicle and 13.2∀3.4% with soil.

The percutaneous absorption of [^{14}C]-anthracene (9.3 Φg/cm^2) was 52.3% in rats, estimated from radioactivity in urine, feces, and tissues over a 6-day period. Over time, the permeation of anthracene significantly decreased suggesting that anthracene was dermally absorbed in a dose-dependent manner. Diffusion of anthracene through the skin (stratum corneum) depended on the amount of anthracene on the skin's surface.

In guinea pigs applied with 6.25 Φg/cm^2 [^{14}C]-phenanthrene and pyrene, dermal absorption was 80% and 94%, respectively. In vitro absorption of phenanthrene and pyrene in guinea pig skin was about 79-89% and 70%, respectively.

Monitoring the removal of compounds from the epidermis is indicative of measuring the compound's dermal absorption. The disappearance of radiolabeled benzo(a)pyrene and its metabolites from the epidermis was monophasic, following first order kinetics with a half-life of approximately 2 hours. Recovery of the radiolabel was 99-100% throughout the period of the experiment (8 hours), indicating that volatilization of benzo(a)pyrene from the skin was not a confounding factor. In contrast, removal of one of its metabolites, 7,8-dihydroxy-9,10-epoxy-7,8,9,10-tetrahydrobenzo(a)pyrene (anti-BPDE), from the epidermis was biphasic. The second, slower phase of removal suggested that the stratum corneum, the outermost layer of skin which consists of several layers of inactive, keratinized cells surrounded by extracellular lipids, may act as a reservoir that can retain and slowly release topically applied lipophilic substances such as benzo(a)pyrene but is penetrated rapidly by more compounds such as anti-BPDE.

The Department of Health and Human Services (DHHS) has determined that benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer (IARC) has determined the following: benzo(a)anthracene and benzo(a)pyrene are probably carcinogenic to humans; benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-c,d)pyrene are possibly carcinogen to humans; and anthracene, benzo(g,h,i)perylene, benzo(e)pyrene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene are not classifiable as to their carcinogenicity to humans. EPA has determined that benz(a)anthracene, benz(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene are probable human carcinogens and that acenaphthylene, anthracene, benzo(g,h,i)perylene, fluoranthene, flourene, phenanthrene, and pyrene are not classifiable as to human carcinogenicity. Acenaphthene has not been classified for carcinogenic effects by the DHHS, IARC, or EPA.

The EPA-derived slope factor for benzo(a)pyrene is 7.3 $(mg/kg\text{-}day)^{+0}$. This value is based on multiple animal studies in many species demonstrating benzo(a)pyrene to be carcinogenic following administration by numerous routes. Benzo(a)pyrene produced positive results in numerous genotoxicity assays. However, human data linking benzo(a)pyrene to a carcinogenic effect are lacking. Based on available scientific information, EPA assigned a weight-of-evidence Group B2 to benzo(a)pyrene (probable human carcinogen). There is no EPA-derived slope factors for benzo(e)pyrene, benzo(b)fluoranthene, or dibenz(a,h)anthracene. This is based on no human data and sufficient data from animal bioassays. Based on available scientific information, EPA assigned a weight-of-evidence Group B2 for benzo(b)flouranthene and dibenz(a,h)anthracene (probable human carcinogen). Benzo(e)pyrene has not been assigned a weight-of-evidence (IRIS 1995).

11.2 Fate And Transport

The global movement of PAHs can be summarized as follows: PAHs released to the atmosphere are subject to short- and long-range transport and are removed by wet and dry deposition. In surface water, PAHs can volatilize, photodegrade, oxidize, biodegrade, bind to particulates, or accumulate in plants; PAHs can enter groundwater and be transported within an aquifer.

Transport and partitioning of PAHs in the environment are determined to a large extent by physical/chemical properties such as water solubility, vapor pressure, Henry's law constant, octanol-water partition coefficient (K_{ow}), and organic carbon partition coefficient (K_{oc}). In general, PAHs have low water solubilities. The Henry's law constant is the partition coefficient that expresses the ratio of the chemical's concentrations in air and water are equilibrium and is used as an indicator of a chemical's potential to volatilize. The K_{oc} indicates the chemical's potential to bind to organic carbon in soil and sediment. The K_{ow} is used to estimate the potential for an organic chemical to move from water into lipid and has been correlated with bioconcentration in aquatic organisms.

PAHs are present in the atmosphere in the gaseous phase or sorbed to particulates. The ratio of particulate to gaseous PAHs in air samples collected in Antwerp, Belgium, was 0.03 for anthracene, 0.49 for pyrene, 3.15 for summed benz(a)anthracene and chrysene, and 11.5 for summed benzo(a)fluoranthene and benzo(b)fluoranthene. Atmospheric residence time and transport distance depend on the size of the particles to which PAHs are sorbed. Larger particles emitted from urban sources tend to settle onto streets and become part of urban runoff. PAHs in urban air are primarily associated with submicron-diameter soot particles that have residence times of weeks and are subject to long-range transport. Long-range transport of PAHs was examined and it was found that PAHs originating in Great Britain could be collected in Norway and Sweden. PAHs are removed from the atmosphere by both water and dry deposition; the relative importance of each process varies with the individual PAH. For example, it is estimated that a total of 23% of benzo(a)pyrene release to the atmosphere is deposited on soil and water surfaces. Dry deposition of benzo(a)pyrene adsorbed to atmospheric aerosols accounts for most of the removal; wet deposition is less significant by a factor of 3-5. In a mass balance study of the atmospheric deposition of PAHs to Siskiwit Lake, which is located on a wilderness island in northern Lake Superior, dry aerosol deposition of particulate phase PAHs was found to be the predominant form of input to surface waters by an average ratio of 9:1 over wet deposition.

PAH compounds tend to be removed from the water column by volatilization to the atmosphere, binding to particulates or sediments, or by being accumulated by or sorbed onto aquatic biota. The low molecular weight PAHs have Henry's law constants in the range of 10^{-3} to 10^{-5} atm-m^3/mol; medium molecular weight PAHs have constants in the 10^{-6} range; and higher molecular weight PAHs have values in the range of 10^{-5} to 10^{-8}.

Compounds with values ranging from 10^{-3} to 10^{-5} are associated with significant volatilization, while compounds with values less than 10^{-5} volatilize from water only to a limited extent. Half-lives for volatilization of benz(a)anthracene and benzo(a)pyrene (high molecular weight PAHs) from water have been estimated to be greater than 100 hours. Lower molecular weight PAHs could be substantially removed by volatilization if suitable conditions (high temperature, low depth, high wind) were present. It was estimated that the half-lifes for volatilization of anthracene (a low molecular weight PAH) of 18 hours in a stream with moderate current and wind, versus about 300 hours in a body of water with a depth of 1 meter and no current.

Because of their low solubility, PAHs in aquatic systems are primarily found sorbed to particles that either have settled to the bottom or are suspended in the water column. In an estuary, volatilization and adsorption to suspended sediments with subsequent deposition are the primary removal processes for medium and high molecular weight PAHs, whereas volatilization and microbial degradation are the major removal processes for low molecular weight compounds. In an enclosed marine ecosystem study, less than 1% of the original amount of radiolabeled benz(a)anthracene added to the system remained in the water column after 30 days; losses were attributed to adsorption to settling particles and to a lesser extent to photodegradation.

The K_{oc} indicates the chemical's potential to bind to organic carbon in soil and sediment. The low molecular weight PAHs have K_{oc} values in the range of 10^3 to 10^4, which indicates a moderate potential to be adsorbed to organic carbon in the soil and sediments. The medium molecular weight compounds have K_{oc} values in the 10^4 range. High molecular weight PAHs have Koc values in the range of 10^5 to 10^6 which indicates stronger tendencies to adsorb to organic carbon. PAHs from lands cleared by slash and burn methods have been found to be deposited in charred litter and to move into soils by partitioning and leaching. Phenanthrene and fluoranthene (low and medium molecular weight PAHs, respectively) from these areas were incorporated into soil to a greater extent than high molecular weight PAHs such as benzo(g,h,i)pyrene and indeno(1,2,3-c,d)pyrene.

Sorption of PAHs to soil and sediments increases with increasing organic carbon content and is also directly dependent on particle size. Absorption coefficients for sorption of pyrene to sediments are as follows: sand--9.4 to 68; silt--1,500 to 3,600; and clay--1,400 to 3,800. It was discovered that from three to four times more anthracene and about two

times more fluoranthene, benz(a)anthracene, and benzo(a)pyrene were retained by marsh sediment than by sand. PAHs may also volatilize from soil. Volatilization of acenaphthene, anthracene, fluorene, and phenanthrene (low molecular weight PAHs) from soil may be substantial. Of 14 PAHs studied in two soils, volatilization was found to account for about 20% of the loss mechanism for the other compounds. Lower molecular weight compounds may also volatilize from sediments; this process is not significant for the higher molecular weight compounds.

PAHs have been detected in groundwater either as a result of migration directly from contaminated surface waters or through the soil. Fluorene from an abandoned creosote pit migrated through sand and clay into groundwater. PAHs have also been shown to be transported laterally within contaminated aquifers.

PAHs can be accumulated in aquatic organisms from water, sediments, and food. Bioconcentration factors (BCFs) of PAHs in fish and crustaceans have frequently been reported to be in the range of 100-2,000. In general, bioconcentration was greater for the higher molecular weight compounds than for the lower molecular weight compounds. Bioconcentration experiments performed with radiolabeled compounds may overstate the bioconcentration of parent compounds. It is estimated BCFs of 900 for anthracene and 4,900 for benzo(a)pyrene in bluegills (whole body) based on total radiolabeled carbon (^{14}C) activity. The estimated BCFs based only on the parent compounds were 675 and 490, respectively. Thus, biotransformation of the parent compounds occurred in addition to bioconcentration. Biotransformation by the MFO system in the fish liver can result in the formation of carcinogenic and mutagenic intermediates; exposure to PAHs has been linked to the development of tumors in fish. The ability of fish to metabolize PAHs may explain why benzo(a)pyrene is frequently not detected or found only at very low levels in fish from environments heavily contaminated with PAHs. The breakdown products (polyhydroxy compounds) are eliminated in feces (via bile) and urine. Half lives for elimination of PAHs in fish ranged from less than 2 days to 9 days.

Fish and crustaceans readily assimilate PAHs from contaminated food, whereas mollusks and polychaete worms have limited assimilation. Biomagnification (a systematic increase in tissue concentrations moving up a food chain) has not been reported because of the tendency of many aquatic organisms to eliminate these compounds rapidly. In general, PAHs obtained from the diet can contribute to total tissue concentrations to a limited extent. For example, food chain uptake of anthracene by fathead minnows consuming

water fleas was estimated to be about 15% of the amount accumulated from the water. In a simple aquatic food chain involving seston (i.e., organic and inorganic particulate matter >0.45 Φm), blue mussels, and the common eider duck, significant changes were observed in the composition of 19 PAHs moving through the tropic levels. Decreasing PAH concentrations were found with increasing trophic level, probably as a result of the selective biotransformation capacity of the organisms for different PAHs. The high theoretical flux of PAHs through the food chain did not result in increasing concentrations with increasing trophic level (i.e., biomagnification was not observed), indicating rapid biotransformation of the compounds.

Sediment-associated PAHs can be accumulated by bottom-dwelling invertebrates and fish. For example, Great Lakes sediment containing elevated levels of PAHs were reported to be the source of the body burdens of the compounds in bottom-dwelling invertebrates. It was found that benzo(a)pyrene was accumulated in fish, amphipod crustaceans, shrimp, and clams when estuarine sediment was the source of the compound. Approximate tissue to sediment ratios were 0.6-1.2 for amphipods, 0.1 for clams, and 0.05 for fish and shrimp.

Some terrestrial plants can take up PAHs via the roots or foliage; uptake rates are dependent on the concentration, solubility, and molecular weight of the PAH and on the plant species. Mosses and lichens have been used to monitor atmospheric deposition of PAHs. Ratios of PAH concentrations in vegetation to those in soil ranged from 0.001 to 0.18 for total PAHs and from 0.002 to 0.33 for benzo(a)pyrene. About 30-70% of atmospheric PAHs (indeno[1,2,3-c,d]pyrene, fluoranthene, and benzo[a]pyrene) deposited on a forest were sorbed onto tree foliage (i.e., leaves and needles) and then deposited as litterfall. Atmospheric deposition on leaves often greatly exceeds uptake from soil by roots as a route of PAH accumulation. In a study of PAH uptake from cropland soils conducted in the United Kingdom, elevated concentrations of PAHs in soils were not correlated with concentrations in plant tissues. The cropland soils had received repeated applications of PAHs in sewage sludge that was applied to the soils over a number of years. PAH content of the soils substantially increased as a result of the sludge amendments, and residues of some PAHs persisted in the soils for years. Tissues from plants grown in the treated soils were relatively enriched with low molecular weight PAHs (e.g., acenaphthene, fluorene, phenanthrene), but increased PAH concentrations (relative to tissues from plants grown in control plots that did not receive sludge amendments) were not consistently detected. The PAH concentrations in aboveground plant parts were not strongly related to soil PAH levels but were probably the result of atmospheric

deposition. The presence of PAHs in root crop tissues was probably due to adsorption of the compounds to root surfaces.

PAHs may accumulate in terrestrial animals through the food chain or by ingestion of soil. The environmental fate of creosote coal tar distillate (which contained 21% phenanthrene and 9% acenaphthene) was studied in a terrestrial microcosm containing soil, rye grass, insects, snails, mealworm larvae, and earthworms. Two gray-tailed voles were added 54 days after the start of the experiment, which continued for 19-26 more days. Average surface soil concentrations (measured on an unspecified day) were 0.60 ppm (phenanthrene) and 1.19 ppm (acenaphthene). During the last 3 days of the experiment, the following phenanthrene concentrations were measured: snail--3.27 ppm; pill bugs--1.72 ppm; and earthworm--18.30 ppm. The acenaphthene concentrations measured were as follows: snail--11.2 ppm (day 37); pill bugs--0.99 ppm (day 75); and earthworm--71.9 ppm (days 72-75). The whole body concentrations in the vole analyzed for phenanthrene was 7.20 ppm; in the vole analyzed for acenaphthene it was 37.00 ppm. It was found that these compounds were not metabolized in this system. Whole body concentrations in the vole exceeded soil concentrations by a factor of 12 for phenanthrene and 31 for acenaphthene; however, most of the radiolabeled acenaphthene was found as bound residues in the gastrointestinal tract of the animal and, therefore, was not accumulated.

11.3 Interactions With Other Chemicals

Because humans are usually exposed to PAHs in complex mixtures rather than to individual PAHs, it is important to understand the potential interactions between the PAHs and other components of the mixture. Interactions may occur among chemicals in a mixture prior to exposure, or may occur after exposure as a result of differing effects of the mixture components on the body. Synergistic and/or antagonistic interactions with regard to the development of health effects, particularly carcinogenesis, may occur.

The extent of human exposures to PAH mixtures in occupational settings is generally not known in quantitative terms. However, exposures to complex chemical mixtures that include PAHs, such as use of tobacco products and exposure to roofing tar emissions, coke oven emissions, coal tar, and shale oils, have been associated with adverse health effects in humans. The biological consequences of human exposure to complex mixtures of PAHs depend on the interaction of the various strongly carcinogenic, weakly carcinogenic, or noncarcinogenic PAHs. For example, there is evidence to suggest that

PAHs in cigarette smoke require other components in the smoke in order to exert their tumorigenic effect.

The interaction between noncarcinogenic and carcinogenic PAHs has been extensively examined in animals. Noncarcinogenic PAHs exhibit cocarcinogenic potential and tumor-initiating and promoting activity when applied with benzo(a)pyrene to the skin of mice. Simultaneous administration of weakly carcinogenic or noncarcinogenic PAHs including benzo(e)pyrene, benzo(g,h,i)perylene, fluoranthene, or pyrene significantly elevated the benzo(a)pyrene-induced tumor incidence. Benzo(e)pyrene, fluoranthene, and pyrene were more potent cocarcinogens than benzo(g,h,i)perylene. Benzo(e)pyrene, fluoranthene, and pyrene have also demonstrated weak tumor-promoting activity following initiation with benzo(a)pyrene, and these compounds increased benzo(a)pyrene-DNA adduct formation.

Interactions between selected noncarcinogenic PAHs and carcinogenic benzo(a)pyrene have also been documented to reduce the carcinogenic potential of benzo(a)pyrene in animals. Benzo(a)fluoranthene, benzo(k)fluoranthene, chrysene, perylene, and a mixture of anthracene, phenanthracene, and pyrene significantly inhibited benzo(a)pyrene-induced injection-site sarcomas. However, other PAHs including anthracene, benzo(g,h,i)perylene, fluorene, and indeno(1,2,3-c,d)pyrene had no antagonistic effects. Coexposure of tracheal explants to benzo(e)pyrene and benzo(a)pyrene resulted in an increased incidence of tracheal epithelial sarcomas over that seen with either PAH along. Phenanthrene administration with benzo(a)pyrene decreased the DNA adduct formation in mice.

There is evidence to suggest that benz(a)anthracene may serve as an anticarcinogen when administered with benzo(a)pyrene. Coadministration of benz(a)anthracene and benzo(a)pyrene decreased benzo(a)pyrene metabolism, benzo(a)pyrene-DNA adduct formation, and reduced the mutagenic activity of benzo(a)pyrene on hamster embryo cells. It has been postulated that the antimutagenic effect of benz(a)anthracene results from competition with benzo(a)pyrene for MFO enzymes, rather than the induction of detoxifying enzymes.

The synergistic effect of individual PAHs on the mutagenicity of benzo(a)pyrene has also been demonstrated. Anthracene and benzo(e)pyrene enhanced the mutagenicity of benzo(a)pyrene, the maximal increase being obtained with anthracene. Benzo(e)pyrene (at a ratio of 2:1) had no effect on benzo(a)pyrene-induced mutation frequencies in V79 cells, but at a ratio of 15:1, benzo(e)pyrene inhibited the benzo(a)pyrene-induced mutations by

approximately 10-fold. Benzo(e)pyrene inhibited the metabolism of benzo(a)pyrene by cultured hamster embryo only at high does, but at both low and high does, the proportion of metabolites formed was altered by benzo(e)pyrene. The percentage of water-soluble metabolites was decreased, whereas the percentage of diols was increased. It is postulated that benzo(e)pyrene alters the activity of other PAHs by inhibiting the conversion of the proximate carcinogenic diol of a particular PAH to a diol epoxide.

Benzo(a)pyrene and dibenz(a,h)anthracene in combination with 10 noncarcinogenic PAHs were less potent tumor-inducers than was dibenze(a,h)anthracene alone or in combination with benzo(a)pyrene. The noncarcinogenic or weakly carcinogenic PAHs include benzo(e)pyrene, phenanthrene, anthracene, pyrene, fluoranthene, chrysene, perylene, benzo(g,h,i)pyrene, and coronene. Dose-response relationships for tumor incidences were observed for benzo(a)pyrene and dibenz(a,h)anthracene either alone or in combination with the 10 noncarcinogenic PAHs; however, no treatment-related sarcoma incidences were observed for any of the 10 noncarcinogenic PAHs.

Phenanthrene, a noncarcinogenic PAH, demonstrated a dose-related inhibition on dibenz(a,h)anthracene-induced carcinogenicity in mice. Phenanthrene significantly reduced the incidence of injection-site sarcomas elicited by dibenz(a,h)anthracene, especially at low doses. However, when triethylene glycol was the vehicle administered in combination with phenanthrene and dibenz(a,h)anthracene, a substantial increase (50%) in the rate of tumor induction was observed.

Several experiments have shown that most PAH mixtures are considerably less potent than individual PAHs. Various combustion emissions and benzo(a)pyrene have been examined for carcinogenic potency and tumor initiation activity on mouse skin. In all cases, PAH mixtures were much less potent than benzo(a)pyrene. The authors calculated relative potency estimates that ranged from 0.007 for coke oven emissions extract to less than 0.002 for diesel engine exhaust extract, using papillomas per mouse per milligram of the mixture as the end point. Another study demonstrated that the relative tumorigenicities, as compared to benzo(a)pyrene, of automobile exhaust condensate (AEC), diesel emission condensate, and a representative mixture of carcinogenic PAHs were 0.0053, 0.00011, and 0.36, respectively, following chronic application to mouse skin. AEC has also exhibited an antagonistic influence on benzo(a)pyrene carcinogenicity when subcutaneously administered to mice; this effect was particularly augmented at higher benzo(a)pyrene concentrations.

Predicting the toxicity of a complex mixture on the basis of one of several of its components may be misleading, because the interactions among the components may modify toxicity. Since PAHs require metabolic activation by monoxygenases to elicit carcinogenic effects, any alteration in these metabolic pathways will influence the observed toxicity. There are two primary mechanisms by which chemicals interact with PAHs to influence toxicity. A compound may compete for the same metabolic activating enzymes and thereby reduce the toxicity of carcinogenic PAHs or it may induce the metabolizing enzyme levels to result in a more rapid detoxification of the carcinogenic PAHs. Alternatively, compounds may compete for a deactivating pathway, thereby increasing the toxicity of PAHs. Many monooxygenase inducers are ubiquitous in the environment, and they may have an effect on the toxicity of PAHs. For example, environmental contaminants such as tetrachlorodibenzo-*p*-dioxin (TCDD), polychlorinated biphenyls (PCBs) and 3,3',4,4'-tetrachlorobiphenyl (TCBP) can increase microsomal enzyme activity and consequently affect PAH toxicity. The dermal absorption of benzo(a)pyrene was measured in the presence or absence of complex organic mixtures derived from coal liquefaction processes. The dermal half-life of benzo(a)pyrene was 3.0 hours when applied alone, 6.7 hours when measured as a component of a mixture, and ranged from 7.8 to 29.7 hours in the presence of different mixtures. The authors proposed that these mixtures inhibit the dermal absorption of benzo(a)pyrene by inhibiting the metabolism of benzo(a)pyrene at the application site. Interactions can thus play important modulatory roles in the expression of PAH toxicity that may not be adequately reflected based on the toxicity of a single PAH.

The majority of human exposures to PAHs occur in the presence of particles that affect the pharmacokinetics of PAHs in a manner that can enhance their carcinogenicity. Coadministration of benzo(a)pyrene and particulate material, such as hematite (Fe_2O_3) and arsenic trioxide (As_2O_3), greatly increases respiratory tract tumor yields in laboratory animals following intratracheal instillation. The effects of particles on the potential human carcinogenicity of PAHs are likely to be similar. When benzo(a)pyrene is particle-bound, clearance from hamster lungs are exposed and increasing the dose to the gastrointestinal tract as a result of mucociliary clearance. Respirable benzo(a)pyrene-containing particulates such as diesel exhaust, when coated with the phospholipid component of a pulmonary surfactant, are genotoxic. Dusts can increase the rates of pulmonary cell proliferation, which in turn increases the cells' susceptibility to an initiation event in the presence of a carcinogen.

Environmental exposure to PAHs can also occur along with exposure to other environmental pollutants. The effects of exposure to SO_2 (either by inhalation or systemically with endogenous sulfit/bisulfite anions that accumulated as a result of induced sulfite oxidase deficiency) on benzo(a)pyrene-induced lung tumors were studies in male Sprague-Dawley rats. The animals were administered benzo(a)pyrene (1 mg) by weekly intratracheal instillation for 15 weeks during which time they were exposed daily by inhalation to 30 or 60 ppm SO_2 or were maintained on a high tungsten to molybdenum diet. There were no statistically significant differences between the benzo(a)pyrene only and the benzo(a)pyrene + SO_2 or benzo(a)pyrene + sulfite/bisulfite groups with respect to the incidence of squamous cell carcinomas of the lung, latency for tumor development, or rate of appearance. Even though benzo(a)pyrene alone induced almost 100% tumor incidence leaving little room for an SO_2-induced enhanced response, a shortened latency or increased rate of appearance would have suggested that SO_2 potentiates the carcinogenicity of benzo(a)pyrene, and this did not occur. Therefore, the authors concluded that SO_2 does not potentiate the carcinogenicity of benzo(a)pyrene in the lung.

Concomitant exposure to solvents may also occur, particularly in an occupational setting. It has been demonstrated that pretreatment of rats with toluene (1 g/kg intraperitoneally) inhibits the total cytochrome P-450 content in microsomes isolated from the lungs. In addition, formation of 3-hydroxybenzo(a)pyrene (a nontoxic metabolite) was inhibited by 36% by the microsomes *in vitro* whereas the formation of several diols (reactive intermediates) was unaffected by toluene pretreatment. These results indicate that toluene alters the balance between toxification and detoxification of benzo(a)pyrene by cytochrome P-450 in the lung, favoring the formation of reactive genotoxic/carcinogenic intermediates. Therefore, the authors suggested that concomitant exposure to solvents, such as toluene, and PAHs may result in an increased risk for lung cancer.

Asbestos exerts a synergistic influence on cigarette smoke (which contains several PAHs) in the development of bronchopulmonary cancers. This has important implications for workers occupationally exposed to asbestos, who also smoke. The interaction between cigarette smoke and asbestos may be explained partly by differences in the kinetics of PAH cell uptake when PAHs are preadsorbed on asbestos. Plutonium oxide (PuO_2) has also been shown to enhance benzo(a)pyrene-induced lung carcinogenesis following simultaneous inhalation of both compounds.

Another component of cigarette smoke, nicotine, may also affect the toxicokinetics of PAHs. When introduced in the perfusion medium with benzo(a)pyrene, nicotine inhibited the elimination of benzo(a)pyrene from the lung.

Naturally occurring compounds have been found to induce the enzymes that metabolize PAHs, leading to either increased or decreased toxicity. Compounds that exert a protective effect against the carcinogenicity of PAHs and are enzyme inducers include plant flavonoids, plant phenols, antioxidants, retinoids (vitamin A), garlic oil, selenium, molybdenum, turmeric extracts, nitrates, soy sauce, and Chinese herbs. Plant flavonoids can induce microsomal monooxygenases and reduce the carcinogenicity of benzo(a)pyrene. Flavones administered orally or dermally increased benzo(a)pyrene hydroxylase activity in the small intestine and skin, respectively, and prevented the formation of pulmonary adenomas and forestomach and skin tumors initiated by benzo(a)pyrene. A series of flavonoids and isoflavonoids, compounds that are found in fruits and vegetables, were tested for their ability to inhibit metabolism of benzo(a)pyrene in cultured hamster embryo cells. The results indicated that the flavonoids are generally more active than the isoflavonoids, and that two hydroxyl, two methoxyl, or methyl and hydroxyl substituents at the 5- and 7-positions and a 2,3-double bond are the structural characteristics required for inhibition of benzo(a)pyrene metabolism to reactive intermediates. Two of these compounds, acacetin and kaempferide also inhibited benzo(a)pyrene-induced mutation in Chinese hamster V79 cells. Therefore, the authors proposed that the protective effect of these compounds may be due to their ability to inhibit metabolism of benzo(a)pyrene to reactive intermediates. These results suggest that these compounds may be useful as potential chemopreventive agents in individuals exposed to genotoxic/carcinogenic PAHs.

Dietary plant phenols, such as tannic acid, quercetin, myricetin, and anthraflavic acid exhibit a protective effect against the tumorigenicity of benzo(a)pyrene and other PAHs by altering the metabolic pathways that detoxify and activate PAHs to their ultimate carcinogenic metabolites, thus suppressing PAH metabolish and subsequent PAH-DNA adduct formation. It has been suggested that the possible mechanism for the anticarcinogenic effect of these plant phenols ma be an inhibitory effect on the binding of the ultimate carcinogen to the target tissue CNA. Antioxidants also affect benzo(a)pyrene hydroxylation by rat liver microsomal MFOs, and reduce the bacterial mutagenicity of benzo(a)pyrene in the presence of rat liver microsomes and cofactors. Antioxidants such as BHA, BHT, phenothiazine, phenothiazine methosulfate, and ethoxyquin all can reduce

the quantitative yield of benzo(a)pyrene metabolites in incubations with rat liver microsomes.

Retinoids, of which vitamin A is a member, have demonstrated an antagonistic effect on benzo(a)pyrene-induced carcinogenicity. (Vitamin A has been shown to prevent and/or reverse the genetic damage caused by benzo[a]pyrene.) Similarly, the ability of benzo(a) pyrene (75 mg/kg, oral administration) to induce micronuclei in vitro was completely inhibited in Swiss mice orally administered doses of vitamin. A ranging from 750 to 1,500 mg/kg 1 hour prior to benzo(a)pyrene treatment. Although the protective mechanism has not been fully elucidated, it has been suggested that vitamin A interferes with the activation of benzo(a)pyrene to its reactive metabolites, thus reducing the amount of enzo(a)pyrene-DNA binding in rat liver and target tissues (i.e., stomach) to prevent the mutagenic action of benzo(a)pyrene. It has also been suggested that vitamin A can enhance CNA repair. Conversely, vitamin A deficiency enhances the mutagenicity and carcinogenic effect of cigarette smoke and benzo(a)pyrene. This activity is related to a decreased level of free radical scavengers like ascorbic acid and glutathione in the liver. Another study observed that vitamin A deficient animals exposed to cigarette smoke via inhalation exhibited enhanced benzo(a)pyrene-DNA adduct formation. This has important implications for humans who smoke and consume diets deficient in vitamin A. Mammary tumor incidence was reduced by 27% (from 67% to 40%) in female rats receiving retinyl acetate before, during, and after the administration of either a single dose or eight weekly doses of benzo(a)pyrene. These results demonstrate that retinyl acetate is capable of inhibiting benzo(a)pyrene-induced mammary tumor formation in rats when given before, during, and after carcinogen treatment.

The oral gavage administration of 25 mg/kg *n*-acetylcysteine (NAC) prevented the formation of benzo(a)pyrene-diol-epoxide-DNA adducts in rats receiving benzo(a)pyrene by intratracheal instillation for 3 consecutive days (25 mg/kg in 2% Tween 80). Inhibition of DNA adduct formation was more efficient in the liver than in the lungs. Similarly, micronuclei induction in the benzo(a)pyrene-treated rats was completely reversed by NAC. These results suggest that NAC, which is a glutathione precursor, may be effective in preventing or reversing the binding of the reactive intermediates of PAHs to cellular macromolecules and, therefore, may prevent the subsequent toxic effects of PAHs.

Coumarin, also known to be anticarcinogenic, inhibited benzo(a)pyrene-induced micronuclei in male ICR mice pretreated with 65 or 130 mg/kg/day coumarin for 6 days

prior to the intraperitoneal administration of 150 mg/kg benzo(a)pyrene. However, pretreatment with either dose of coumarin did not alter the genotoxicity of benzo(a)pyrene when females were included in the study.

Garlic oil also exhibits an antagonistic effect on benzo(a)pyrene by inhibiting benzo(a)pyrene-induced skin carcinogenesis in Swiss mice during the initiation phase. A primary constituent of garlic oil, allyl methyl trisulfide (ATM), has also demonstrated an inhibitory effect on benzo(a)pyrene induced neoplasia of the forestomach in mice.

Selenium has been shown to reduce the mutagenicity of benzo(a)pyrene as well as AHH activity.. Selenium also inhibits the metabolism of benzo(a)pyrene *in vitro*. Several different salts of molybdenum inhibited the formation of certain metabolites of benzo(a)pyrene by lung and liver microsomes *in vitro* obtained from rats pretreated with 3-methylcholanthrene. In a later study, it was demonstrated that benzo(a)pyrene metabolism in vitro by lung and liver microsomes isolated from rats that were exposed to 40 or 80 mg/kg of ammonium heptamolybdate for 8 weeks was inhibited. These results suggest that molybdenum interferes with the cytochrome P-450 enzymes responsible for the activation of benzo(a)pyrene, and thus may have a protective effect against benzo(a)pyrene-induced toxicity/carcinogenicity.

Chinese herbs commonly used in anti-cancer drugs have also been demonstrated to inhibit the mutagencity of benzo(a)pyrene.

Aqueous extracts of turmeric, curcumin-free aqueous turmeric extract, and curcumin were tested for their ability to inhibit benzo(a)pyrene-induced mutagenicity in the *S. typhimurium* assay and the bone marrow micronucleus test in Swiss mice. A dose-dependent inhibition of benzo(a)pyrene-induced mutagenicity was observed in two strains of *Salmonella* in the presence of Aroclor-1254-induced rat liver homogenate, and 3 mg/kg of these three extracts also significantly inhibited benzo(a)pyrene-induced bone marrow micronuclei formation by 43%, 76%, and 65%. Female Swiss mice were treated with either aqueous turmeric extract (3 mg/day), curcumin-free aqueous tumeric extract (1 mg/day), or curcumin (1 mg/day) 5 days/week for 2 weeks prior to receiving twice weekly gavage administrations of 20 mg/kg benzo(a)pyrene for 4 weeks. The treatment with the turmeric extracts continued for another 2 weeks after the cessation of benzo(a)pyrene treatment, and the animals were observed until they were 180 days old. A group receiving just benzo(a)pyrene served as a control. The benzo(a)pyrene only animals exhibited 100%

tumor incidence with 9.1±0.6 papillomas/mouse. All three extracts significantly ($p<0.001$) inhibited the formation of forestomach papillomas by benzo(a)pyrene by 53%, and the average numbers of papillomas/mouse was also significantly decreased. The authors suggested that turmeric extracts may be useful as chemopreventive agents, but that there are probably several mechanisms of action for these inhibitory effects.

Other environmentally ubiquitous substances, such as nitrites and nitrates, have been shown to interact with PAHs. Pyrene is not mutagenic in the *Salmonella typhimurium* assay. However, when injected intraperitoneally into mice at does of 10-200 mk/kg in combination with inhalation exposure to 50 or 100 ppm nitrous oxide (NO_2), mutagenic metabolites of pyrene were recovered from the urine. In addition, 1-hydroxypyrene (the major urinary metabolite of pyrene) administration in combination with NO_2 exposure also produced mutagenic metabolites. These results suggest that combined exposure to pyrene, a prevalent environmental PAH, and nitrogen compounds could result in the formation of nitrogenated mutagenic metabolites of pyrene. The effects of nitrite (in drinking water) and/or soy sauce (in food) on the forestomach tumors induced by twice weekly gavage administration of eight total does of benzo(a)pyrene were studies in mice. The combination of nitrite and soy sauce resulted primarily in a significant reduction in the number of tumors per animal induced by benzo(a)pyrene, and also a resuction in tumor incidence. Neither substance alone had much effect on the carcinogenicity of benzo(a)pyrene alone. The mechanism for this protective effect of the combination of nitrite and soy sauce is not known.

The fungicide (prochloraz), the topical antifungal agent (miconazole) and 7,8-benzoflavone (a strong inhibitor of cytochrome P-450) limited the conversion of benzo(a)pyrene to a mutagen in *S. typhimurium*. The order of inhibitory action was 7,8-benzoflavone __ prochloraz __ miconazole.

Diet (i.e., dietary fat levels) can also have an effect on the disposition and toxicity of PAHs. The metabolism of benzo(a)pyrene in hepatocytes *in vitro* from rats fed high-fat (as corn oil) diets was decreased. This effect was not due to a decrease in the activity of AHH. The authors postulated that the high-fat diets allowed benzo(a)pyrene, which is highly lipophilic, to become sequestered in lipid droplets and, therefore, become inaccessible to the P-450 enzymes.

The ubiquitous nature of PAHs in the environment, particularly as constituents of complex mixtures such as automobile emissions, coal tar, coke oven emissions, and combustion products of tobacco, increases the likelihood that the type of interactions discussed will occur. Thus, interactions may play a decisive role in the expression of toxicity and the development of cancer in exposed populations.

11.4 References

ATSDR Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). Update, Draft for Public Comment. October 1993.

Integrated Reference Information System (IRIS). 1995.

12.0 BERYLLIUM

Beryllium is a hard, grayish element that does not occur naturally. The element does occur as a chemical component of certain rocks, coal and oil, soil, and volcanic dust. Two kinds of mineral rocks, bertrandite and beryl, are mined commercially for the recovery of beryllium. Very pure gem-quality beryl is better known as either aquamarine (blue or blue-green) or emerald (green). Beryllium is also present in a variety of compounds. They do not have any particular smell. There are two types of beryllium compounds, those that dissolve in water and those that do not.

Most of the beryllium ore that is mined is converted into alloys (mixture of metals). Most of these alloys are used in making electrical and electronic parts or as construction materials for machinery and molds for plastics. Pure beryllium metal has applications in nuclear weapons and reactors, aircraft and space vehicle structures and instruments, X-ray machines, and mirrors. Beryllium oxide is also made from beryllium ores and is used to make specialty ceramics for electrical and high-technology applications.

Beryllium enters the air, water, and soil as a result of natural and human activities. Emissions from burning coal and oil increase beryllium levels in air. Beryllium enters waterways from the wearing away of rocks and soil. Most of the man-made beryllium that enters waterways comes when industry dumps waste water and when beryllium dust in the air from industrial activities settles over water. Beryllium as a chemical component, occurs naturally in soil; however, disposal of coal ash, incinerator ash, and industrial wastes may increase the concentration of beryllium in soil. In air, beryllium compounds are present mostly as fine dust particles. The dust eventually settles over land and water. Rain and snow aid in the removal of beryllium from air. Sufficiently small beryllium particles may remain airborne for about 10 days. Most of the beryllium in water settles in the material on the bottom. Beryllium compounds remain in ocean water for a few hundred years before settling to the bottom of the ocean. Fish do not accumulate beryllium from water into their bodies to any great extent. A major portion of beryllium in soil does not dissolve in water but remains bound in soil, so it is not very likely to move deeper into the ground and enter groundwater. In the environment, chemical reactions can change the water-soluble beryllium compounds into insoluble forms. Exposure to water-soluble beryllium compounds in the environment, in general, will pose a greater threat to human health than water-insoluble forms.

12.1 Toxicokinetics

Exposure to low levels of beryllium can occur by breathing air, eating food, or drinking water that contains beryllium. In the United States, the average concentration of beryllium in air is 0.03 nanograms (ng) (1 ng = 1 billionth of a gram) in a cubic meter (ng/m^3) of air. In U.S. cities, the average air concentration is higher, and its value is 0.2 ng/m^3 of air. Cities have higher levels of beryllium in the air because beryllium is released from burning coal and fuel oil. Beryllium was not in 5% of 1,577 drinking water samples obtained throughout the United States. Of these samples, the average beryllium concentration was only 190 ng in a liter (L) of water. Beryllium, as a chemical component, is naturally found in some food. The concentration of beryllium in both raw carrots and field corn grown in the United States is less than 25 micrograms (μg) (1μ = 1 millionth of a gram) in a kilogram (kg) of the fresh vegetables. The intake of beryllium for most people will be very small.

In certain workplaces you can be exposed to higher than normal levels of beryllium, mostly in the form of beryllium oxide and beryllium metal. Occupational exposure to beryllium occurs at places where the chemical is mined, processed, and converted into metal, alloys, and other chemicals. Workers engaged in machining metals containing beryllium, in recycling beryllium from scrap alloys, or in using beryllium products may also be exposed to higher levels of beryllium. An estimated 18,000 workers may be exposed to beryllium and beryllium oxide in the workplace.

People who live near industry or hazardous landfill sites that contain high concentrations of beryllium may also be exposed to higher than normal levels of beryllium. Beryllium, as a chemical component, occurs naturally in tobaccos and can be inhaled from cigarette smoke. People who smoke may breathe considerably more beryllium than people who do not smoke.

The National Institute for Occupational Safety and Health (NIOSH) recommends a standard for occupational exposure of 0.5 μg $beryllium/m^3$ of workroom air for an 8-hour work shift. The Environmental Protection Agency restricts the amount of beryllium emitted into the environment by industries that process beryllium ores, metal, oxide, alloys, or waste to 10 grams (g) in a 24-hour period, or to an amount that would result in atmospheric levels of 0.01 μg $beryllium/m^3$ of air, averaged over a 30-day period.

Beryllium will not enter the body from skin contact with the metal unless the skin is scraped or cut and beryllium particles become imbedded in the wound. Only a small amount of beryllium may enter your body if your skin comes into contact with a beryllium salt dissolved in water. Beryllium particles inhaled into the lungs slowly dissolve and move slowly into the bloodstream. Most of the beryllium ingested leaves the body through feces without entering into the bloodstream. The small amount of beryllium that moves from the lungs, stomach, and intestines into the bloodstream is carried by the blood to the kidneys. Beryllium leaves the kidneys by the urine.

Beryllium is a metal that can be harmful when inhaled. The effects depend on how much and how long exposure occurs. When inhaled, beryllium can damage the lungs, resembling pneumonia with reddening and swelling of the lungs. This condition is called acute beryllium disease.

Although the soluble and insoluble forms of beryllium can cause beryllium disease, workers breathing air containing beryllium at less than 0.002 milligrams (mg) in a cubic meter (mg/m^3) will probably not develop lung damage as a result of exposure. Both The short-term, pneumonia-like disease and the chronic beryllium disease can be fatal. Long periods of exposure to beryllium have been reported to cause cancer in laboratory animals, but some of these studies are not reliable. Some studies of workers reported an increased risk of lung cancer, but these studies are not conclusive, and new studies are being performed. The Department of Health and Human Services has determined that beryllium and certain beryllium compounds may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer has determined that beryllium and beryllium compounds are probably carcinogenic to humans. The EPA has determined that beryllium is a probable human carcinogen.

Beryllium compounds are absorbed primarily through the lungs, but sufficient information to determine the rate and extent of absorption were not located. Due to an accidental leakage of beryllium dust in a laboratory, 25 people were exposed to an undetermined concentration for 10-20 hours. The day after exposure, serum beryllium levels were 3.5 ppb beryllium, compared to 1.0 ppb in unexposed controls. Six days later, the serum level decreased to 2.3 ppb beryllium, and 2-8 weeks after exposure the serum levels returned to normal. The biological half-time of beryllium was calculated to be from 2 to 8 weeks. In eight men accidentally exposed to 8 ng beryllium/m^3 as beryllium chloride for 4-6

hours/day for 10 days, the beryllium levels in urine and blood increased four-fold above the levels of 1 ng beryllium/g of either blood or urine in unexposed individuals.

Rats exposed to 0.034 mg beryllium/m3 as an aerosol of beryllium sulfate 7 hours/day, 5 days/week for 72 weeks achieved steady state concentrations in the lungs in 36 weeks of exposure. The beryllium concentration in tracheobronchial lymph nodes peaked between 36 and 52 weeks, and decreased thereafter. In guinea pigs and rats exposed to 2-40 mg beryllium/m3 as beryllium nitrate for 16 hours, steady state concentrations in the blood were reached after 8-12 hours of exposure.

Beryllium and its compounds are poorly absorbed from the gastrointestinal tract. Urinary excretion data from rats treated by gavage with radioactive beryllium chloride indicate that the cumulative excretion of beryllium in the urine and feces was 0.11 and 104.7% of the total dose, respectively.

It is unlikely that beryllium is absorbed through intact skin. Skin ulceration in workers exposed to beryllium occurred only after the skin was abraded.

The EPA-derived subchronic and chronic oral RfDs for beryllium are both 5E-03 mg/kg-day. These values are based on studies conducted by Schader and others in which 52 weenling rats of each sex received beryllium in drinking water for a lifetime exposure. Microscopic changes were noted in the heart, kidney, liver, and spleen. These effects were not considered adverse, therefore, 9.5E-01 mg/kg-day is considered a NOAEL. The uncertainty factor of 100 reflects a factor of 10 each for interspecies conversion and for the protection of sensitive human subpopulations. On the basis of available information, EPA concluded that the confidence in the study is low because only one dose level was administered. The studies are considered as low to medium quality; thus the data base is given a low confidence rating. The overall confidence in the RfD is low, reflecting the need for more toxicity data by the oral route (IRIS 1995).

The EPA derived oral slope factors for beryllium is 4.3 mg/kg-day. This value is based on studies in which lung cancer was induced in rats and monkeys by beryllium inhalation and osteosarcomas was induced in rabbits via intravenous or intramedullary injection. Based on available scientific information, EPA assigned a weight-of-evidence. Group B2 to humans (probable human carcinogen) (IRIS 1995).

12.2 Fate and Transport

The transport of beryllium from the atmosphere to terrestrial and aquatic surfaces occurs through wet and dry deposition. The dry deposition rate of aerosol particles is a function of particle aerodynamic size, windspeed, and surface roughness. A study of stack emissions from coal combustion reported that most beryllium is found on particles of median aerodynamic diameter <2.4 μm; particles of this size can remain airborne for approximately 10 days. By analogy to other elements, a typical dry deposition velocity for beryllium particles over a vegetative surface would be 0.25 cm/second.

The estimated residence time of beryllium in ocean water (before it is removed from the aquatic phase by sedimentation or other removal processes) is about a few hundred years.

Beryllium is extremely toxic to warm water fish in soft water. The degree of toxicity decreases with increasing water hardness. Bioconcentration of beryllium in fish to high levels is not likely due to the low uptake of beryllium from water by aquatic animals. A measured bioconcentration factor (BCF) of 19 was reported for beryllium in bluegill fish. Other investigators have reported a BCF of 100 for freshwater and marine plants, invertebrates, and fish. Chemicals with BCFs <1000 will not bioaccumulate significantly in aquatic organisms. It is possible that bottom-feeding crustaceans, such as clams and oysters, could accumulate beryllium from sediment and show higher bioconcentration than freshwater fish.

In most types of soil, beryllium is expected to be tightly absorbed because it displaces divalent cations that share common sorption sites. Due to its geochemical similarity to aluminum, beryllium may be expected to absorb onto clay surfaces at low pHs, and it may remain precipitated as insoluble complexes at higher pHs; therefore, beryllium is expected to have limited mobility in soil. At high soil pH, the mobility of beryllium in soil may increase as a result of formation of soluble polynuclear hydroxide complexes.

12.3 Interaction with Other Chemicals

Mortality rates were lower if rats exposed to 2.59 mg beryllium/m^3 as beryllium sulfate tetrahydrate were injected daily with ferric ammonium citrate beginning 4 days prior to beryllium exposure. The protective action of ferric ammonium citrate may be related to the ability of beryllium to form a complex with citrate. In addition, the protective action

of iron on beryllium toxicity may be related to the ability of iron to increase ferritin synthesis, making more ferritin available to bind with beryllium. Ferritin chelates with beryllium to protect against the inhibition of phosphoglucomutase.

The presence of beryllium oxide in the lungs of rats following acute inhalation exposure to beryllium oxide decreased the clearance rate of radioactive plutonium oxide from the lungs when the rats were exposed to an aerosol of radioactive plutonium oxide 30 or 60 days later. The decreased clearance of plutonium oxide by beryllium oxide was believed to be due to beryllium oxide-induced damage to macrophages. Thus, beryllium oxide could prolong potential toxic effects of other chemicals that are cleared through the action of macrophages.

12.4 References

ATSDR Toxicological Profile for Beryllium. Update, April 1993.

On-Line Integrated Risk Information System (IRIS) 1995.

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23 FEB 1996

Mr. John Hale
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Dear Mr. Hale:

Subj: NAVY'S INSTALLATION RESTORATION (IR) PROGRAM AT NAVAL AIR FACILITY (NAF), MIDWAY ISLAND

Enclosed is a final report of the Site Inspection at NAF Midway Island. The submission of this document is for your information and in accordance with the Superfund Amendments and Reauthorization Act (SARA) of 1986 which requires federal agencies to coordinate closely with the regulatory agencies during Installation Restoration (IR) investigations.

Should you have any questions, please contact Mr. Robert Kaito of our Environmental Restoration Branch at 474-5967.

Sincerely,

Melvin Z. Waki

MELVIN Z. WAKI
Head
Environmental Engineering Branch

Encl: (1 cy)
(1) Naval Air Facility (NAF), Midway Island, Site Inspection (SI) Report of January 1996

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