Comprehensive Long-Term Environmental Action Navy (CLEAN) II
Contract No. N62742-94-D-0048
Contract Task Order No. 0072

Technical Memorandum

Verification of Perchlorate at IRP Site 1, Explosive Ordnance Disposal Range

Marine Corps Air Station, El Toro, California

Prepared for:

Department of the Navy
Commander, Southwest Division
Naval Facilities Engineering Command
San Diego, California 92132-5190

Prepared by:

Earth Tech, Inc.
700 Bishop Street, Suite 900
Honolulu, Hawaii 96813

July 2001

DEPARTMENT OF THE NAVY
SOUTHWEST DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
1220 PACIFIC HIGHWAY
SAN DIEGO, CA 92132-5190

5090
Ser 06CC.DG/0773
20 July 2001

United States Environmental Protection Agency, Region IX
Hazardous Waste Management Division (SFD 8-2)
ATTN: Ms. Nicole Moutoux
75 Hawthorne Street
San Francisco, CA 94105-3901

Dear Ms. Moutoux:

Subject: TRANSMITTAL OF "TECHNICAL MEMORANDUM, VERIFICATION OF PERCHLORATE AT IRP SITE 1, EXPLOSIVE ORDNANCE DISPOSAL RANGE, MARINE CORPS AIR STATION, EL TORO, CALIFORNIA"

Please find enclosed the Final version of the subject document. This Technical Memorandum has been revised and finalized in accordance with comments received from the Department of Toxic Substances Control dated 23 August 2000. Please contact either Mr. Don Whittaker at (619) 532-0791 or myself at (619) 532-0765 should you have any questions, or need additional information.

Sincerely,

DEAN GOULD
Base Realignment and Closure
Environmental Coordinator
By direction of the Commander

Enclosures: Technical Memorandum, Verification of Perchlorate at IRP Site 1,
Explosive Ordnance Disposal Range,
Marine Corps Air Station, El Toro, California

Copy to: (w/encl)
Ms. Triss Chesney, DTSC
Ms. Patricia Hannon, Cal RWQCB, Santa Ana Region
Mr. Greg Hurley, RAB Community Co-Chair
Ms. Marcia Rudolph, RAB Subcommittee Chair
Ms. Polin Modanlou, El Toro Master Development Program

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NAVAL FACILITIES ENGINEERING COMMAND
1220 PACIFIC HIGHWAY
SAN DIEGO, CA 92132-5190

5090
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Ms. Triss Chesney
California Environmental Protection Agency
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630-4700

Dear Ms. Chesney:

Subject: TRANSMITTAL OF "TECHNICAL MEMORANDUM, VERIFICATION OF PERCHLORATE AT IRP SITE 1, EXPLOSIVE ORDNANCE DISPOSAL RANGE, MARINE CORPS AIR STATION, EL TORO, CALIFORNIA"

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NAVAL FACILITIES ENGINEERING COMMAND
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SAN DIEGO, CA 92132-5190

5090
Ser 06CC.DG/0773
20 July 2001

Ms. Patricia Hannon
California Regional Water Quality Control Board
Santa Ana Region
3737 Main Street, Suite 500
Riverside, CA 92501-3339

Dear Ms. Hannon:

Subject: TRANSMITTAL OF "TECHNICAL MEMORANDUM, VERIFICATION OF PERCHLORATE AT IRP SITE 1, EXPLOSIVE ORDNANCE DISPOSAL RANGE, MARINE CORPS AIR STATION, EL TORO, CALIFORNIA"

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DOCUMENT TRANSMITTAL

Contract No. N62742-94-D-0048

To: Remedial Project Manager
Naval Facilities Engineering Command
Southwest Division
Mr. Donald Whittaker 06CC.DW
1230 Columbia Street, Suite 870
San Diego, CA 92101-8517

DATE: July 26, 2001
CTO #: 072
LOCATION: MCAS El Toro

FROM: Crispin G. Wanyoike

DESCRIPTION: Final Technical Memorandum, Verification of Perchlorate in Groundwater, IRP Site 1, Explosive Ordnance Disposal Range, MCAS El Toro

TYPE: Contract Deliverable (Cost) ✔ CTO Deliverable (Technical) Other

VERSION: REVISION #s:

ADMIN RECORD: Yes No Category Confidential
(PM to Identify)

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Document Title:

(1) Draft Technical Memorandum, Verification of Perchlorate in Groundwater, IRP Site 1, Explosive Ordnance Disposal Range, Marine Corps Air Station, El Toro, California

Reviewer: Triss M. Chesney, P.E., DTSC, August 23, 2000

Comment No.	Section/ Page No.	Comment	Response
GENERAL COMMENTS			
1.		The document should be signed and stamped by a professional engineer registered in the State of California who is responsible for the quality of the work conducted. Additionally, since geological interpretation is included in the document (i.e., boring logs, potentiometric map, cross-sections, etc.), the document should also be signed and stamped by a geologist registered in the State of California.	The final version of this document has been signed and stamped by the appropriate registered professionals.
2.		A spell check should be conducted to revise "ordinance" to "ordnance" throughout the document.	This correction was made throughout the document.
SPECIFIC COMMENTS			
1.	Section 1 Page 1-1	The third sentence states, "The evaluation was conducted in response to regulatory comments provided in Appendix A." Appendix A includes DTSC comments on the *Draft Report Evaluation of Perchlorate in Groundwater* (Bechtel National, Inc., April 1999) forwarded on May 18, 1999. Please note that the evaluation does not address all of the comments included in the DTSC letter dated May 18, 1999. Additionally, use of this verification study to address these comments was not discussed with DTSC prior to performing the work. Please revise this sentence accordingly.	The sentence was changed as follows: "This evaluation addresses some of the regulatory comments (Appendix A) on the *Draft Report, Evaluation of Perchlorate in Groundwater* (BNI 1999)."
2.	Section 2.1 Page 2-1	Last paragraph states, "Various anomalies detected throughout Site 1 appear linear in alignment suggesting locations of former trenches. It is not clear whether the soil samples collected at the site were deep enough to sample the bottom of the trenches or potential leaching of contaminants from the trenches. Please clarify.	The anomaly depths are unknown. Additional characterization of the anomalies will be conducted during the forthcoming Phase II Remedial Investigation.
3.	Section 2.2 Page 2-2	Table 2-1 shows the top of casing measurements of the new wells. The text does not mention whether the new wells were surveyed by a civil engineer. Please clarify.	The following sentence has been added to Section 2.2: "The monitoring wells were surveyed for northing, easting, and elevation by a California-licensed land surveyor."

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(1) Draft Technical Memorandum, Verification of Perchlorate in Groundwater, IRP Site 1, Explosive Ordnance Disposal Range, Marine Corps Air Station, El Toro, California

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Comment No.	Section/ Page No.	Comment	Response
4.	Section 2.3 Page 2-5	Earth Tech references a different contractors' (Bechtel National Inc.) Standard Operating Procedures	The "Bechtel" SOPs were specifically developed for work at NAVY CLEAN II sites. These SOPs have been reviewed and approved by the BCT for use at MCAS El Toro. Bechtel did develop and submit the SOP document, but the procedures detailed therein are NAVY CLEAN II procedures, not Bechtel procedures.
5.	Section 2-3 Page 2-5	This section mentions that samples were collected. Please include a narrative of the sampling procedures followed.	A narrative of the groundwater sampling procedure, including identification of the monitoring equipment, has been added to section 2.3.
6.	Section 2.3 Page 2-5	According to this section, turbidity, pH, temperature, electrical conductivity, oxidation-reduction potential, flowrate, extracted volume, and water level were monitored during well purging. Please include copies of the well development logs. These logs are important because the groundwater sampling logs indicate that the groundwater was extremely turbid, which suggests that the wells were not properly developed. In addition, the sampling logs indicate that the wells were purged dry. This should have been discovered during well development and the sampling procedures modified to sample low recharging wells	A summary of the available well development data provided by the RAC contractor have been included in Appendix E. The low recharge rates were discovered during development and the purging and sampling strategy was modified accordingly. As stated in Section 2.3, "Well development was initially attempted using a bladder pump; however, the wells were evacuated too quickly for adequate development. Due to the extremely low rates of groundwater yield at Site 1, the monitoring wells were purged using bailing techniques in accordance with CLEAN SOP 8, Groundwater Sampling."
7.	Section 2-4 Page 2-5	This section provides a summary of soil sample collection. Please elaborate on the sample collection and laboratory analytical methods used. Also, please include a narrative of the field sampling activities rather than just a statement that Bechtel National Inc. SOPs were followed. Additionally, include copies of the chain-of-custody forms, name of the analytical laboratory, analytical reports, quality assurance (QA)/quality control (QC) information, and the analytical reporting limits.	A narrative of the soil sampling procedures has been added. The text has been revised to include mention of the analytical laboratory. The QA/QC information is provided in Section 3.3 of the report. Third party data validation reports and chain-of-custody forms have been included in Appendix G of the technical memorandum.

Document Title:

(1) Draft Technical Memorandum, Verification of Perchlorate in Groundwater, IRP Site 1, Explosive Ordnance Disposal Range, Marine Corps Air Station, El Toro, California

Reviewer: Triss M. Chesney, P.E., DTSC, August 23, 2000

Comment No.	Section/ Page No.	Comment	Response
8.	Section 2.4 Page 2-5	The third paragraph states, "Twenty-eight soil samples were collected from depths of approximately 1.5 to 4.0 feet below ground surface (bgs) at anomalous locations identified by the geophysical survey." These samples were analyzed for volatile organic compounds (VOCs) and other unspecified constituents. Please list the laboratory analyses that were conducted. Additionally, please provide rationale for the sampling depths. For example, were samples collected at the bottom (where waste could have been deposited) or below (where waste would have leached/migrated) the anomalous areas?	The laboratory analyses have been added to Section 2.4. The samples were collected at shallow depths in an attempt to identify potential perchlorate sources in the soil. The depths of the anomalies are currently unknown and will be addressed in the forthcoming RI. Additional soil sampling will be conducted based upon the size and nature of the anomalies.
9.	Section 3.3 Page 3-2	Please include copies of the following data to support the sample validation process. • Chain-of-custody reports • Laboratory report explaining the reason for diluting the samples and the associated elevated reporting limits. The explanation should be included with the laboratory QA/QC results and evaluation. • Summary report of the third party data validator (who, what, where, when).	Data validation reports and chain-of-custody forms have been included in the final technical memorandum. When the laboratory submitted the initial report, it was recognized that the reported detection limits did not meet the project data quality objectives. The laboratory methods were evaluated by the Project Chemist and improvements recommended. The subsequent reanalysis, while outside of the method specified holding time, did meet the objectives of the project. The analytical data presented in the report has been qualified as such.
10.	Section 4.4 Page 4-2	Please include the chain-of-custody forms and analytical reports for the groundwater sampling and analyses. Additionally, include the QA/QC report from the analytical laboratory explaining the reason for sample dilution.	Data validation reports and chain-of-custody forms have been included in Appendix G of the technical memorandum.
11.	Section 4.4 Page 4-2	Please include a narrative of the procedure used to collect groundwater samples. The equipment used to monitor groundwater parameters (including the methods and schedule to calibrate the equipment), measure depth to groundwater, measure quantity of groundwater purged should be listed and discussed.	A narrative of the groundwater sampling procedure, including identification of the monitoring equipment available from the RAC, has been added to section 2.3.

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(1) Draft Technical Memorandum, Verification of Perchlorate in Groundwater, IRP Site 1, Explosive Ordnance Disposal Range, Marine Corps Air Station, El Toro, California

Reviewer: Triss M. Chesney, P.E., DTSC, August 23, 2000

Comment No.	Section/ Page No.	Comment	Response
12.	Section 4.4 Page 4-2	Section 2.4 states that 55 soil samples were collected during well bore drilling. Please clarify if perchlorate was analyzed and detected in soil samples corresponding to locations where perchlorate was detected in the groundwater.	Perchlorate was detected in three groundwater monitoring wells: 01_MW201, 01_MW207, and 01_DGMW58. When monitoring wells 01_MW201 and 01_DGMW58 were installed, perchlorate was not a chemical of potential concern (COPC), and collected soil samples would not have been analyzed for it. Soil samples collected at depths of 5 and 15 feet below ground surface during the drilling of 01_MW207 were analyzed for perchlorate; perchlorate was not detected.
13.	Section 5 Page 5-1	The second bullet states, "Perchlorate in groundwater at concentrations exceeding the state and federal PALs [provisional action levels] is localized near MW201." This statement is premature. Further characterization is required to define the lateral extent of perchlorate in soil and groundwater.	Perchlorate was detected at a concentration of 324 µg/l in 01_MW201. Perchlorate was also detected at 7 µg/l (the reporting limit is 4 µg/l) in 01_MW207 and 01_DGMW58, well below the state and federal PAL of 18 and 32 µg/l, respectively. Perchlorate was not detected in the nine remaining wells, including the closest wells located upgradient and downgradient of 01_MW201. Further characterization of the lateral extent will be performed as part of the Phase II RI.
14.	Section 5 Page 5-1	The fourth bullet states, "Perchlorate was detected in soil at shallow depths (less than 5 feet), however the concentrations were less than the residential or industrial PRGs [preliminary remediation goals]." This conclusion does not consider that the concentration of perchlorate may increase with depth. Also, if the soil samples were not collected at the bottom of the anomalies (holes or trenches), the soil samples may have missed the constituents that were disposed in the holes or trenches.	Comprehensive sampling and assessment of the anomalies will be conducted in the forthcoming RI.

Document Title:

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Reviewer: Triss M. Chesney, P.E., DTSC, August 23, 2000

Comment No.	Section/ Page No.	Comment	Response
15.	Appendix E	The sampling logs show that the groundwater was very turbid during purging which may indicate that the wells were not adequately developed. Please provide an explanation for why the purge water was so turbid yet the turbidity decreased significantly after the sample was collected. For example, the sampling log for well 01-MW-204 shows that the turbidity after three well volumes was over 1,000 nephelometric turbidity units (NTUs), yet decreases to 8.09 NTUs after sampling. Also, please identify the equipment that was used to measure groundwater parameters.	The wells were bailed and swabbed during development in an attempt to adequately stress the filter pack. However, due to very low recharge rates, the wells would bail dry and were allowed to recharge prior to collection of samples. The wells required a few days to a week to recharge. The turbidity of the recharged water after purging was much lower than that during development, thus indicating that the wells were adequately developed; however, conclusions regarding the completeness of development will probably require data collected over multiple sampling events. Information available from the RAC contractor pertaining to the equipment used to monitor groundwater parameters has been included in the final technical memorandum.

Technical Memorandum
Verification of Perchlorate at
IRP Site 1 Explosive Ordnance Disposal Range
MCAS El Toro, California

Contract No. N62742-94-D-0048
Contract Task Order No. 0072

Reviews and Approvals:

Jeffrey Stanek, R.G., C.HG.
Senior Hydrogeologist
Earth Tech, Inc.

Date: 7/24/01

Crispin Wanyoike, P.E.
CTO Manager
Earth Tech, Inc.

Date: 7/24/01

Ken Vinson, P.E.
Program Quality Manager
Earth Tech, Inc.

Date: July 23, 2001

PAGE NO. ii

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EXECUTIVE SUMMARY

Previous investigations have identified perchlorate in groundwater at concentrations exceeding regulatory thresholds at Installation Restoration Program Site 1, the former explosive ordnance disposal range, Marine Corps Air Station, El Toro, California. This evaluation was performed to verify the presence of perchlorate in soil and groundwater. The evaluation was conducted in response to regulatory comments. The verification was designed to provide information pertaining to the nature and extent of perchlorate in groundwater, supplemental data regarding local hydrogeologic conditions, and potential perchlorate presence in soil. Six groundwater monitoring wells were installed and sampled in addition to the six previously existing wells. As part of health and safety clearance activities, a geophysical survey was performed to identify geophysical anomaly locations. The following were analyzed for perchlorate: 11 soil samples collected during monitoring well installation (all collected between 5 feet bgs and 35 feet bgs); 28 shallow soil samples collected at anomalous locations identified by the geophysical survey and depths ranging from 1.5 feet bgs to 4.5 feet bgs); and 3 surface soil samples collected from topographic depressions.

Perchlorate was detected in 3 of the 12 groundwater samples, although only one sample exceeded the state and Federal provisional action levels (PALs). Perchlorate was detected in 4 of the 42 soil samples; however, none of the detected concentrations exceeded residential or industrial preliminary remediation goals. The results suggest that perchlorate in groundwater at concentrations exceeding the state and Federal PALs is localized near monitoring well 01MW201.

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CONTENTS

APPENDIXES

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
bgs	below ground surface
APCL	Applied Physics and Chemistry Laboratory
BNI	Bechtel National, Inc.
BRAC	Base Realignment and Closure
CDMG	California Division of Mines and Geology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	chain of custody
COPC	chemical of potential concern
CTO	Contract Task Order
DHS	California Department of Health Services
Earth Tech	Earth Tech, Inc.
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
FS smoke	sulfur trioxide chlorosulfonic acid
ID	identification
IRP	Installation Restoration Program
JEG	Jacobs Engineering Group
MCAS	Marine Corps Air Station
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFESC	Navy Facilities Engineering Service Center
NTU	nephelometric turbidity unit
OCWD	Orange County Water District
PACNAVFACENGCOM	Pacific Division, Naval Facilities Engineering Center
PAL	provisional action level
PE	performance evaluation
PRG	preliminary remediation goal
PVC	polyvinyl chloride
RAC	Remedial Action Contractor
RI	remedial investigation
SARA	Superfund Amendments and Reauthorization Act
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWDIV	Naval Facilities Engineering Command, Southwest Division
TEPH	total extractable petroleum hydrocarbons
TNT	trinitrotoluene
U.S.	United States
VOC	volatile organic compound

1. INTRODUCTION

Previous investigations have identified perchlorate in groundwater at concentrations exceeding regulated thresholds at Installation Restoration Program (IRP) Site 1, Marine Corps Air Station (MCAS) El Toro. This technical memorandum presents the results of an evaluation of perchlorate in soil and groundwater at IRP Site 1 and addresses some of the regulatory comments (Appendix A) on the *Draft Report, Evaluation of Perchlorate in Groundwater* (BNI 1999a). This verification provides information regarding the nature and extent of perchlorate in groundwater, supplemental data regarding local hydrogeologic conditions, and indications of potential perchlorate presence in soil.

This project complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) in Title 40 of the Code of Federal Regulations (CFR), Part 300.

This report was prepared by Earth Tech, Inc. (Earth Tech) on behalf of the United States Department of the Navy (DoN), Southwest Division, Naval Facilities Engineering Command, as authorized by the U.S. Navy, Pacific Division, Naval Facilities Engineering Command (PACNAVFACENGCOM) under Contract Task Order (CTO) no. 0072 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) II program, contract no. N62742-94-D-0048.

1.1 SITE BACKGROUND AND DESCRIPTION

MCAS El Toro is located in a semi-urban, agricultural area of southern California, approximately 8 miles south of Santa Ana and 12 miles northeast of Laguna Beach (Figure 1-1). MCAS El Toro covers 4,738 acres. Land use around the MCAS includes commercial, light industrial, and residential. MCAS El Toro closed on 2 July 1999, as part of the Base Realignment and Closure (BRAC) Act.

IRP Site 1 is the former explosive ordnance disposal (EOD) range and is located in the northeast corner of MCAS El Toro in the foothills of the Santa Ana Mountains. Site 1 is situated within a tributary canyon of Borrego Canyon Wash at elevations ranging from approximately 610 to 760 feet above mean sea level (MSL). A site plan is provided on Figure 1-2. Training in detonation of munitions began at Site 1 in 1952 (BNI 1995). The range was divided into northern and southern operational areas. The northern operational area was used for military training, while the southern area was periodically used for non-military ordnance destruction training. Military ordnance used in training at the site included hand grenades, land mines, cluster bombs, smoke bombs, and rocket warheads. Civilian and commercial explosives, confiscated by Orange County Sheriff's Department, such as trinitrotoluene (TNT), dynamite, and plastic and gelatinous explosives were also used in training at the EOD Range. Munitions were detonated in trenches and pits that were continually filled with soil and reexcavated. In 1982, approximately 2,000 gallons of sulfur trioxide chlorosulfonic acid (FS smoke) were reportedly burned in trenches located in the northern portion of the site. An estimated 300,000 gallons of petroleum fuels were used during training exercises from 1952 through 1993 (JEG 1993). In addition, there are unsubstantiated reports that low-level radioactive material may have been used in training exercises at the site. Perchlorate was identified as a potential contaminant of concern at Site 1 due to its use in explosives and propellants.

1.2 PREVIOUS INVESTIGATIONS

Previous investigations at Site 1 included a geophysical survey (JEG 1991) and a *Phase I Remedial Investigation* (RI) (JEG 1993). Three groundwater monitoring wells were installed during the Phase I

RI, and three additional wells were installed during a supplemental investigation in 1996 (BNI 1995).

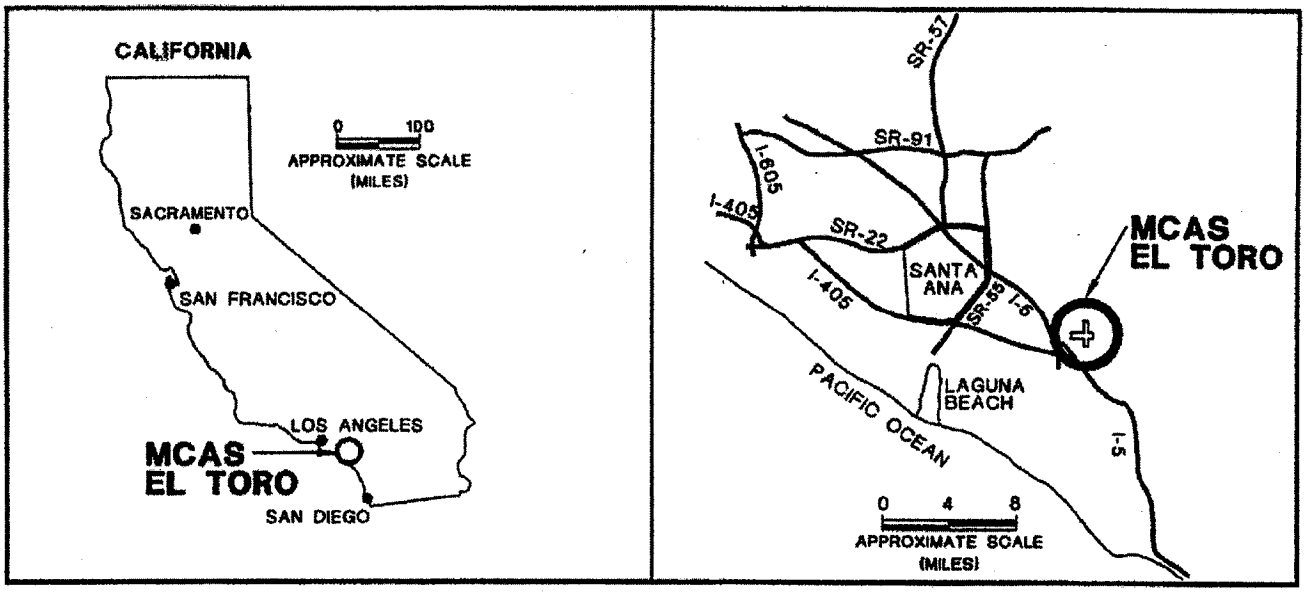
In December 1997, perchlorate was identified at low concentrations (<8 micrograms per liter [µg/L]) in groundwater downgradient from MCAS El Toro during sampling conducted by the Orange County Water District (OCWD 1998). The reported concentrations were below the California provisional action level (PAL) of 18 µg/L (California Department of Health Services [DHS] 1999) and the Environmental Protection Agency (EPA) action level of 32 µg/L (EPA 1999). Hydropunch samples were collected between 26 January and 9 March 1998 to further evaluate the presence of perchlorate at MCAS El Toro. Although perchlorate was reported at concentrations ranging from 4 to 23 µg/L, the concentrations of all but one sample were 12 µg/L or less (BNI 1998). In October 1998, January-February 1999, and July-August 1999, stationwide perchlorate sampling was performed concurrent with groundwater monitoring to assess the presence and concentration of perchlorate in groundwater throughout MCAS El Toro. The results of the 1998 investigation were presented in the *Draft Evaluation of Perchlorate in Groundwater Technical Memorandum*, (BNI 1999a). The results of the 1999 investigation were presented in the *Groundwater Monitoring Data Summary Report, 1999 Monitoring Round 9, 10, & 11* (CDM 2000). With the exception of a single well location at Site 1 (01MW201), only low concentrations (≤13 µg/L) of perchlorate were reported at 15 of the 50 on- and off-station locations sampled during the 1998 investigation (BNI 1999a). Perchlorate was not identified in the remaining 35 samples. The two subsequent sampling results show similar results. Sampling results for the 1998 investigation and the January-February 1999 and July-August 1999 investigations are summarized in Appendix B.

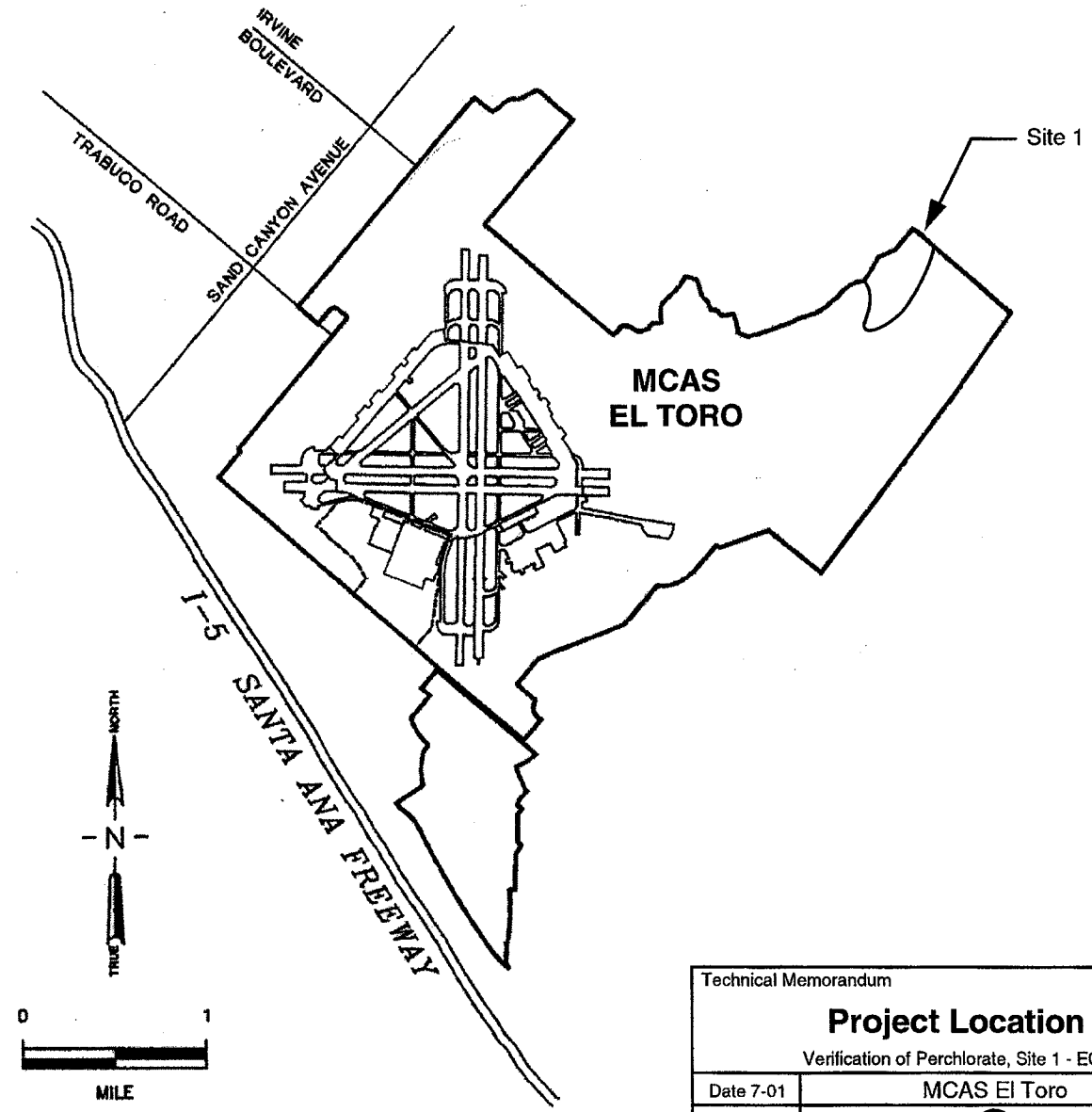
Following their review of the stationwide *Draft Evaluation of Perchlorate in Groundwater Technical Memorandum* (BNI 1999a), the regulatory agencies requested that additional wells be installed to confirm the groundwater flow magnitude and direction, and to collect groundwater samples from wells screened across the water table for perchlorate analysis.

1.3 EVALUATION OBJECTIVES

The evaluation was conducted in accordance with the final *Work Plan, Verification of Perchlorate at IRP Site 1* (Earth Tech, Inc. [Earth Tech] 1999a) and the *Addendum to Final Work Plan, Environmental Survey and Verification of Perchlorate* (Earth Tech 1999b). Previous investigations have identified perchlorate in groundwater at Site 1 at concentrations above the state and Federal PALs. The historical use and activities at Site 1 suggest a potential source for perchlorate. The objectives of the verification evaluation are as follows:

1. Confirm the presence and assess the extent of perchlorate in groundwater.
2. Identify potential perchlorate source location(s) in soil.
3. Estimate the magnitude and direction of the hydraulic gradient.
4. Evaluate potential perchlorate migration in groundwater.
5. Assess the general groundwater chemistry for comparison with adjacent IRP sites.





Technical Memorandum		Final
Project Location Map Verification of Perchlorate, Site 1 - EOD Range		
Date 7-01	MCAS El Toro	Figure **1-1**
Project No. 36097	EARTH TECH A tyco INTERNATIONAL LTD. COMPANY	

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PAGE NO. 1-4

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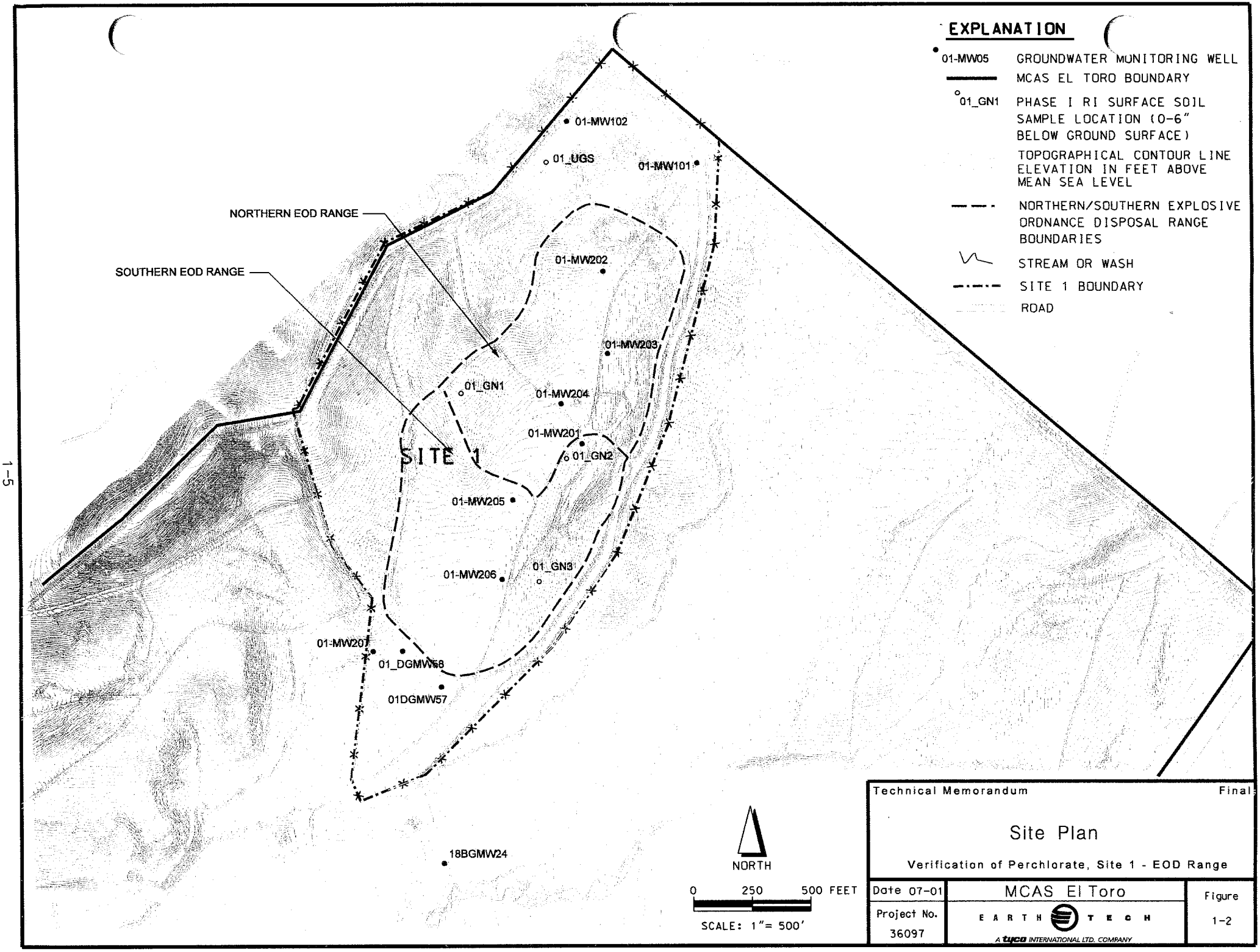

Technical Memorandum — Final

Site Plan

Verification of Perchlorate, Site 1 - EOD Range

Date 07-01	MCAS El Toro	Figure 1-2
Project No. 36097	EARTH TECH, A tyco INTERNATIONAL LTD. COMPANY	

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2. FIELD ACTIVITIES

2.1 GEOPHYSICAL SURVEY

As part of health and safety clearance activities, a geophysical survey was performed at Site 1 during October and November 1999 to identify anomalies that would be indicative of buried waste or buried detonated munitions. Although a similar geophysical survey was conducted in 1991, subsequent discing and EOD training rendered the previous survey obsolete. The 1999 geophysical survey was conducted using an EM-61 electromagnetic instrument. The EM-61 device generates a magnetic field to induce an electrical current in conductive objects. The device senses induced electrical currents to a depth of approximately 10 feet. Prior to conducting the geophysical survey, a site reconnaissance was conducted to remove metallic debris that may have interfered with electromagnetic survey equipment and to identify locations of buried ordnance. The survey was conducted in two phases: the initial phase focused on the central portion of the site, and the second phase consisted of the majority of the remaining site acreage. Data were collected along an approximately 500 foot by 1,600 foot grid at traverses spaced three feet apart. Data were collected and recorded every 0.6 foot along each traverse. The boundaries of the survey grid are provided on Figure 2-1. A limited amount of detonation training took place in the southern portion of the site, as evidenced by the results of the previous geophysical survey and the lack of visual ground disturbance.

Induced electrical current detected by the EM-61 is plotted as geophysical anomalies on Figure 2-1. The largest anomaly is located at the northeast portion of the site. At this location, surface accumulation of large metallic debris was relocated using a bulldozer in order to perform the subsurface survey. Various anomalies detected throughout Site 1 appear linear in alignment, suggesting locations of former trenches. The anomaly depths are unknown. Additional characterization of the anomalies will be conducted during the forthcoming Phase II Remedial Investigation. Appendix C presents the geophysical survey reports.

2.2 MONITORING WELL INSTALLATION

Six groundwater monitoring wells were installed to assess perchlorate concentrations in groundwater and to provide groundwater elevation data for gradient computation. Monitoring wells 01MW202, 01MW203, 01MW204, and 01MW205 were drilled using air percussion, and monitoring wells 01MW206 and 01MW207 were drilled using hollow-stem auger. An Earth Tech geologist was present during drilling and logging of all well borings. Soil classification and lithology were described during well installation as specified in CLEAN standard operating procedure (SOP) 3, Borehole Logging (BNI 1999b). Borehole logs are provided in Appendix D.

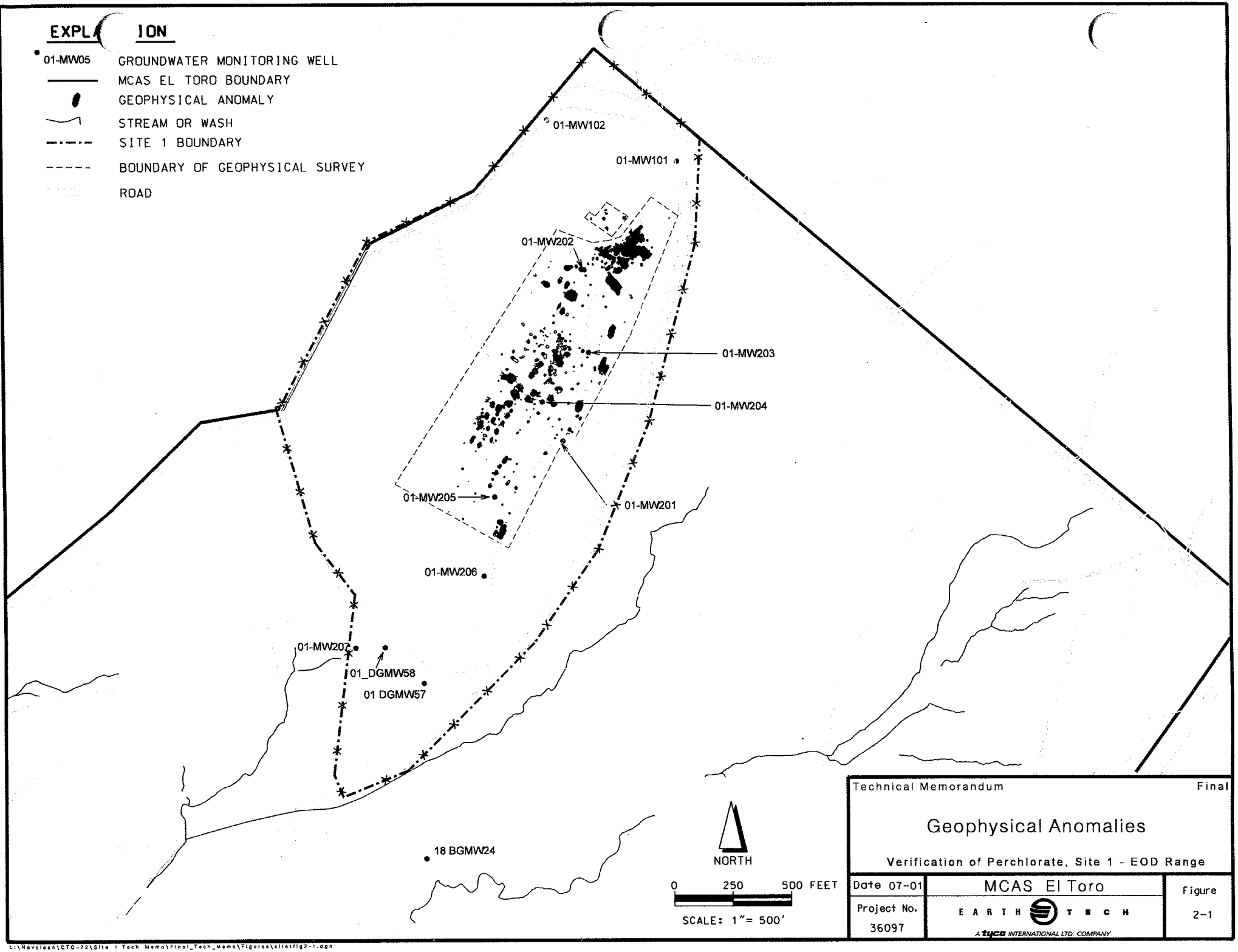
Each borehole was drilled to a depth of approximately 20 feet below first-encountered groundwater. The drill casing was then lifted above the depth of first-encountered groundwater, and the water level in the borehole was allowed to stabilize overnight. The well screen was then placed across the stabilized groundwater surface to a depth of approximately 15 feet below the groundwater surface. Delayed groundwater recharge into 01MW203 occurred 2 days after well installation, resulting in a stabilized water level approximately 5 feet above the well screen. Completion intervals are listed in Table 2-1, and well construction logs are provided in Appendix D. The wells were constructed using 4-inch-diameter, flush-threaded , Schedule 40 polyvinyl chloride (PVC) slotted screen and blank casing. The screened interval consists of machine-milled 0.020-inch slotted casing. The filter packs consist of #3 Monterey sand and the seals are composed of 0.25-inch bentonite pellets. The bentonite pellets were hydrated and allowed to dilate prior to the placement of grout. Well installation was conducted in accordance with CLEAN SOP 5, Monitoring Well Installation and Development (BNI 1999b). The monitoring wells were surveyed for northing, easting, and elevation by a California-

licensed land surveyor. Ground surface elevations and the elevations of the top of each well casing were surveyed in relation to MSL to an accuracy of 0.01-foot.

Table 2-1 Monitoring Well Details

Well	Screened Interval (ft bgs)	Depth To Water (ft bgs)	Northing	Easting	Top of Casing (ft. MSL)
01MW101	118-148	61.15	2197829	6124759	750.82
01MW102	95-135	104.70	2198007	6124202	758.13
01MW201	27-57	39.75	2196633	6124260	665.99
01MW202	10-35	20.06	2197363	6124357	688.37
01MW203	33-58	27.75	2197012	6124374	681.46
01MW204	24-54	37.39	2196799	6124173	662.49
01MW205	18-53	34.71	2196396	6123963	644.57
01MW206	17-47	33.88	2196059	6123914	635.81
01MW207	20-55	42.17	2195753	6123365	620.23
01_DGMW57	63-83	50.04	2195602	6123656	631.17
01_DGMW58	57-77	41.30	2195755	6123488	622.74
18_BGMW24	51-71	36.60	2194852	6123662	618.13

Notes:
Wells shown in italics were installed during the current investigation.
ft bgs = feet below ground surface
MSL = mean sea level



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2.3 MONITORING WELL DEVELOPMENT AND SAMPLING

Monitoring wells 01MW202, 01MW203, 01MW204, 01MW205, 01MW206, and 01MW207 were developed and purged by the Remedial Action Contractor (RAC), IT/OHM, upon instllation. Development was accomplished using surging and bailing techniques in accordance with CLEAN SOP 5, Monitoring Well Installation and Development (BNI 1999b). Well development was initially attempted using a bladder pump; however, the wells were evacuated too quickly for adequate development. Due to the extremely low rates of groundwater yield at Site 1, the monitoring wells were purged using bailing procedures in accordance with CLEAN SOP 8, Groundwater Sampling (BNI 1999b). In some cases, wells were purged until dry, then allowed to recharge prior to sampling. When possible, a total of three well volumes were purged at each well.

Turbidity was measured with a Hanna meter; pH, temperature, electrical conductivity were all measured with a Hydac meter. Flowrate, extracted volume, and water level were monitored during well purging in accordance with CLEAN SOP 8, Groundwater Sampling (BNI 1999b). Samples were collected using disposable bailers upon monitoring well recharge. Table 2-2 presents the list of groundwater samples collected during the evaluation. Appendix E presents a monitoring well development summary. Appendix F includes groundwater sampling logs.

2.4 SOIL SAMPLING

Three types of soil samples were collected in order to assess potential contaminant sources:

1. Subsurface samples (5 feet bgs to 35 feet bgs) during well borehole drilling.

2. Shallow samples (1.5 feet bgs to 4.5 feet bgs) at anomalous locations identified by the geophysical survey.

3. Surface samples from topographic depressions.

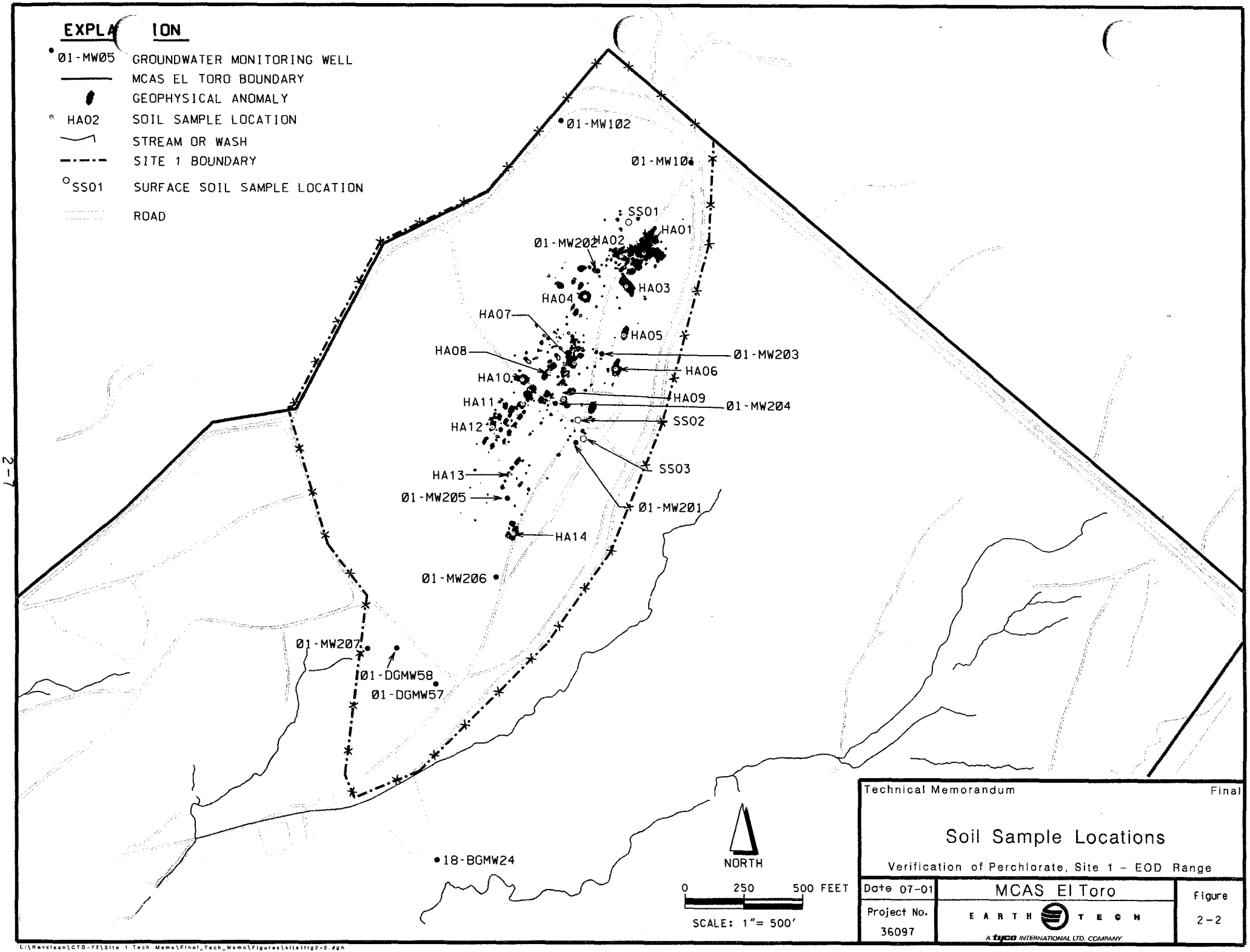
Fifty-five soil samples were collected during well borehole drilling in accordance with CLEAN SOP 4, Soil Sampling (BNI 1999b). The soil samples were collected in stainless steel sleeves, using a split-spoon sampler at depth intervals of five feet. At the prescribed sampling interval, the sampler was attached to a drive rod and driven 18 inches into undisturbed soil below the lead auger, with a 140-pound slidehammer. Sampling equipment was thoroughly decontaminated before each use by washing with a detergent solution and a double rinse with potable and deionized water.

Twenty-eight shallow soil samples (plus one duplicate) were collected from depths of approximately 1.5 feet to 4.0 feet below ground surface (bgs) at anomalous locations identified by the geophysical survey. The samples were collected at shallow depths in order to identify potential perchlorate sources in the soil. The depths of the anomalies are currently unknown and will be addressed in the forthcoming RI. Additional soil sampling will be conducted based upon the size and nature of the anomalies. Samples were collected using a hand auger, in accordance with CLEAN SOP 4, Soil Sampling (BNI 1999b). Samples analyzed for perchlorate, metals, total extractable petroleum hydrocarbons (TEPH), semivolatile organic compounds (SVOCs), explosives, and dioxins were collected in glass jars. Samples for volatile organic compound (VOC) analysis were collected using an En Core sampling device.

Three surface samples were collected at topographic depressions to evaluate the presence of contaminants deposited by surface runoff. The samples were collected with a stainless steel trowel and placed into glass jars in accordance with CLEAN SOP 4, Soil Sampling (BNI 1999b).

In addition to analysis of perchlorate, selected samples were also analyzed for additional compounds. Because the focus of this technical memorandum is perchlorate, only perchlorate results are presented. The results from the additional analytical work are presented in the *Phase II Remedial Investigation Work Plan* (Earth Tech 2001)

Figure 2-2 shows soil sample locations, and Table 2-2 lists soil and groundwater samples collected during the evaluation.


EXPLANATION
Ø1-MWØ5 GROUNDWATER MONITORING WELL
MCAS EL TORO BOUNDARY
GEOPHYSICAL ANOMALY
HA02 SOIL SAMPLE LOCATION
STREAM OR WASH
SITE 1 BOUNDARY
SSØ1 SURFACE SOIL SAMPLE LOCATION
ROAD
Ø1-MW102
Ø1-MW101
SS01
HA01
Ø1-MW202
HA02
HA03
HA04
HA07
HA05
HA08
Ø1-MW203
HA10
HA06
HA11
HA09
Ø1-MW204
HA12
SS02
SS03
HA13
Ø1-MW205
Ø1-MW201
HA14
Ø1-MW206
Ø1-MW207
Ø1-DGMW58
Ø1-DGMW57
18-BGMW24
NORTH
0 250 500 FEET
SCALE: 1"= 500'
Technical Memorandum
Final
Soil Sample Locations
Verification of Perchlorate, Site 1 - EOD Range
Date 07-01
MCAS El Toro
Figure
Project No.
36097
EARTH TECH
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PAGE NO. 2-8

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Table 2-2: Soil and Groundwater Sample Identification (Page 1 of 3)

EPA ID	Earth Tech Sample ID	Matrix	Description	Date
LD-021	01MW202-SS01-D010	Soil	Well bore sample	10/26/99
LD-022	01MW202-SS02-D020	Soil	Well bore sample	10/26/99
LD-023	01MW202-SS03-D025	Soil	Well bore sample	10/26/99
LD-024	01MW202-SS04-D030	Soil	Well bore sample	10/26/99
LD-025	01MW202-SS05-D035	Soil	Well bore sample	10/26/99
LD-026	01MW202-SS06-D040	Soil	Well bore sample	10/26/99
LD-027	01MW202-SS07-D045	Soil	Well bore sample	10/26/99
LD-028	01MW202-GW01E	Water	Equipment Blank	10/26/99
LD-029	01MW203-SS01-D010	Soil	Well bore sample	10/28/99
LD-030	01MW203-SS02-D015	Soil	Well bore sample	10/28/99
LD-031	01MW203-SS03-D020	Soil	Well bore sample	10/28/99
LD-032	01MW203-SS04-D025	Soil	Well bore sample	10/28/99
LD-033	01MW203-SS05-D030	Soil	Well bore sample	10/28/99
LD-034	01MW203-SS06-D035	Soil	Well bore sample	10/28/99
LD-035	01MW203-SS07-D040	Soil	Well bore sample	10/28/99
LD-036	01MW203-SS08-D045	Soil	Well bore sample	10/28/99
LD-037	01MW203-SS09-D050	Soil	Well bore sample	10/28/99
LD-038	01MW203-SS010-D055	Soil	Well bore sample	10/28/99
LD-039	01MW203-SS011-D060	Soil	Well bore sample	10/28/99
LD-040	01MW203-QW01E	Water	Equipment blank	10/28/99
LD-041	01MW203-QW01F	Water	Field blank	10/28/99
LD-042	01MW204-SS01-D010	Soil	Well bore sample	10/29/99
LD-043	01MW204-SS02-D015	Soil	Well bore sample	10/29/99
LD-044	01MW204-SS03-D020	Soil	Well bore sample	10/29/99
LD-045	01MW204-SS04-D025	Soil	Well bore sample	10/29/99
LD-046	01MW204-SS05-D030	Soil	Well bore sample	10/29/99
LD-047	01MW204-SS06-D035	Soil	Well bore sample	10/29/99
LD-048	01MW204-SS07-D040	Soil	Well bore sample	10/29/99
LD-049	01MW204-QW01E	Water	Equipment Blank	10/29/99
LD-050	01MW205-SS01-D010	Soil	Well bore sample	11/1/99
LD-051	01MW205-SS02-D015	Soil	Well bore sample	11/1/99
LD-052	01MW205-SS03-D020	Soil	Well bore sample	11/1/99
LD-053	01MW205-SS04-D025	Soil	Well bore sample	11/1/99
LD-054	01MW205-SS05-D030	Soil	Well bore sample	11/1/99
LD-055	01MW205-SS06-D035	Soil	Well bore sample	11/1/99
LD-056	01MW205-SS07-D040	Soil	Well bore sample	11/1/99
LD-057	01MW205-SS08-D045	Soil	Well bore sample	11/1/99
LD-058	01MW205-SS09-D050	Soil	Well bore sample	11/1/99
LD-059	01MW205-QW01E	Water	Equipment blank	11/1/99
LD-060	01MW206-SS01-D005	Soil	Well bore sample	11/2/99
LD-061	01MW206-SS02-D010	Soil	Well bore sample	11/2/99
LD-062	01MW206-SS03-D015	Soil	Well bore sample	11/2/99
LD-063	01MW206-SS04-D020	Soil	Well bore sample	11/2/99
LD-064	01MW206-SS05-D025	Soil	Well bore sample	11/2/99
LD-065	01MW206-SS06-D030	Soil	Well bore sample	11/2/99
LD-066	01MW206-SS07-D035	Soil	Well bore sample	11/2/99

Table 2-2: Soil and Groundwater Sample Identification (Page 2 of 3)

EPA ID	Earth Tech Sample ID	Matrix	Description	Date
LD-067	01MW206-SS08-D040	Soil	Well bore sample	11/2/99
LD-068	01MW206-SS09-D045	Soil	Well bore sample	11/2/99
LD-069	01MW206-SS10-D050	Soil	Well bore sample	11/2/99
LD-070	01MW206-SS11-D055	Soil	Well bore sample	11/2/99
LD-071	01MW206-SS12-D060	Soil	Well bore sample	11/2/99
LD-072	01MW206-QW01E	Water	Equipment Blank	11/2/99
LD-073	01MW207-SS01-D005	Soil	Well bore sample	11/3/99
LD-074	01MW207-SS02-D010	Soil	Well bore sample	11/3/99
LD-075	01MW207-SS03-D015	Soil	Well bore sample	11/3/99
LD-076	01MW207-SS04-D020	Soil	Well bore sample	11/3/99
LD-077	01MW207-SS05-D025	Soil	Well bore sample	11/3/99
LD-078	01MW207-SS06-D030	Soil	Well bore sample	11/3/99
LD-079	01MW207-SS07-D035	Soil	Well bore sample	11/3/99
LD-080	01MW207-SS08-D040	Soil	Well bore sample	11/3/99
LD-081	01MW207-SS09-D045	Soil	Well bore sample	11/3/99
LD-082	01MW207-QW01E	Water	Equipment blank	11/3/99
LD-086	01MW102-QW01E	Water	Equipment blank	11/16/99
LD-087	01MW206-QW01E	Water	Equipment blank	11/17/99
LD-088	01MW207-QW01E	Water	Equipment blank	11/18/99
LD-089	01MW207-GW01S	Groundwater	Monitoring well	11/18/99
LD-090	01MW207-GW01D	Groundwater	Duplicate	11/18/99
LD-091	18BGMW24-GW01S	Groundwater	Monitoring well	11/18/99
LD-092	01DGMW58-GW01S	Groundwater	Monitoring well	11/19/99
LD-093	01MW202-GW01S	Groundwater	Monitoring well	11/19/99
LD-094	01MW203-GW01S	Groundwater	Monitoring well	11/19/99
LD-095	01MW204-GW01S	Groundwater	Monitoring well	11/19/99
LD-096	01MW204-GW01D	Groundwater	Duplicate	11/19/99
LD-097	01MW201-GW02S	Groundwater	Monitoring well	11/19/99
LD-098	01MW205-GW01S	Groundwater	Monitoring well	11/23/99
LD-099	01MW206-GW01S	Groundwater	Monitoring well	11/23/99
LD-100	01DGMW57-GW01S	Groundwater	Monitoring well	11/23/99
LD-101	01MW102-GW01S	Groundwater	Monitoring well	11/23/99
LD-102	01MW101-GW01S	Groundwater	Monitoring well	11/23/99
LD-110	01HA01-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-111	01HA01-SS02-D4.0	Soil	Shallow soil sample	12/22/99
LD-112	01HA02-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-113	01HA02-SS02-D4.0	Soil	Shallow soil sample	12/22/99
LD-114	01HA03-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-115	01HA03-SS02-D4.0	Soil	Shallow soil sample	12/22/99
LD-116	01HA04-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-117	01HA04-SS02-D3.5	Soil	Shallow soil sample	12/22/99
LD-120	01HA05-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-121	01HA05-SS02-D4.5	Soil	Shallow soil sample	12/22/99
LD-122	01HA06-SS01-D1.5	Soil	Shallow soil sample	12/22/99
LD-123	01HA06-SS02-D4.5	Soil	Shallow soil sample	12/22/99
LD-124	01HA06-QW01E	Water	Equipment blank	12/22/99
LD-125	01HA07-SS01-D1.5	Soil	Shallow soil sample	12/23/99

Table 2-2: Soil and Groundwater Sample Identification (Page 3 of 3)

EPA ID	Earth Tech Sample ID	Matrix	Description	Date
LD-126	01HA07-SS02-D4.0	Soil	Shallow soil sample	12/23/99
LD-127	01HA08-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-128	01HA08-SS02-D3.5	Soil	Shallow soil sample	12/23/99
LD-129	01HA09-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-130	01HA09-SS01-D1.5D	Soil	Duplicate	12/23/99
LD-131	01HA09-SS02-D4.0	Soil	Shallow soil sample	12/23/99
LD-132	01HA10-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-133	01HA10-SS02-D4.5	Soil	Shallow soil sample	12/23/99
LD-134	01HA11-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-135	01HA11-SS02-D3.0	Soil	Shallow soil sample	12/23/99
LD-136	01HA12-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-137	01HA12-SS02-D3.5	Soil	Shallow soil sample	12/23/99
LD-138	01HA13-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-139	01HA13-SS02-D4.0	Soil	Shallow soil sample	12/23/99
LD-140	01HA13-QW02E	Water	Equipment blank	12/23/99
LD-141	01HA14-SS01-D1.5	Soil	Shallow soil sample	12/23/99
LD-142	01HA14-SS02-D4.0	Soil	Shallow soil sample	12/23/99
LD-143	01SS01-SS01-D0.0	Soil	Surface soil sample	12/23/99
LD-144	01SS02-SS01-D0.0	Soil	Surface soil sample	12/23/99
LD-145	01SS03-SS01-D0.0	Soil	Surface soil sample	12/23/99

Notes:
EPA = Environmental Protection Agency
ID = identification

3. SAMPLE ANALYSIS AND VALIDATION

3.1 SAMPLE ANALYSIS

Samples were submitted under chain of custody (COC) to Applied Physics and Chemistry Laboratory (APCL) in Chino, California. The samples were analyzed in accordance with California DHS procedure CLO4METH. The number and type of samples analyzed for perchlorate are listed below.

- 12 groundwater samples
- 11 well borehole soil samples (at 5 feet bgs to 35 feet bgs)
- 28 shallow soil samples (at 1.5 feet bgs to 4.5 feet bgs)
- 3 surface soil samples

3.2 SAMPLING RATIONALE

3.2.1 Perchlorate Extent in Groundwater

Groundwater samples were collected from the six previously existing and the six newly installed wells and analyzed for perchlorate. The locations of the six new wells were selected to assess the extent of the perchlorate and document the groundwater flow direction and magnitude. The rationale for the placement of the six groundwater monitoring wells is provided in Table 3-1 below.

Table 3-1: Monitoring Well Placement Rationale

Well ID	Rationale
01MW202	Evaluate perchlorate extent upgradient of 01MW201.
01MW203	Evaluate perchlorate extent upgradient of 01MW201.
01MW204	Evaluate perchlorate extent directly downgradient from geophysical anomaly areas.
01MW205	Evaluate perchlorate extent downgradient from 01MW201.
01MW206	Evaluate perchlorate extent downgradient from 01MW201.
01MW207	Evaluate perchlorate extent downgradient from 01_DGMW58.

3.2.2 Potential Source Areas

Shallow soil sample locations were chosen coincident with geophysical anomaly areas identified by the geophysical survey to provide a preliminary estimate of the extent of perchlorate, if present. Soil samples were also collected during monitoring well installation. Soil samples from the well boreholes were selected for analysis based upon the lithology observed during drilling. Samples selected for analysis included a shallow sample and the deepest alluvial sample from each borehole. Future investigations will use this data to support the conceptual model for the design for further assessment.

3.2.3 General Groundwater Chemistry

Previously reported general groundwater chemistry data from IRP Site 1 was compared with general chemistry data from IRP Site 2, located hydraulically downgradient from Site 1.

3.2.4 Hydraulic Gradient

Groundwater elevations were measured at the monitoring wells and used to calculate the direction and magnitude of the local hydraulic gradient.

3.3 SAMPLE VALIDATION

Samples were submitted under COC to APCL in Chino, California. The samples were analyzed in accordance with the California DHS method for perchlorate in drinking water. The analytical results were validated in accordance with the United States (U.S.) Navy Facilities Engineering Service Center (NFESC) guidance (NFESC 1999) (90% validated Level III and 10% validated Level IV).

The presence of interfering ions (sulfate and chloride) required the laboratory to dilute samples and elevate the reporting limit for select samples. Subsequent method improvements were made, and the affected samples had analyses rerun in order to achieve reporting limits below the California PAL.

Data validation was performed by an independent third party in accordance with the EPA Contract Laboratory Program Functional Guidelines for Inorganic Data Validation, as applicable to the method. The validation was performed in accordance with the Level III and IV guidelines specified by Naval Facilities Engineering Command, Southwest Division (SWDIV) Environmental Work Instructions.

The results of the validation are presented as qualifiers associated with the measurements. The following qualifiers may be used:

U The analyte was not detected at the specified threshold.

J Quality control measurements or procedural discrepancies require the result to flagged as an estimated value, to be used with caution. However, the data is usable for the purpose intended.

R Quality control measurements or procedural discrepancies require the result to be flagged as rejected; not usable for any purpose.

A number of samples were initially reported as not detected with elevated detection limits, due to high chloride and sulfate concentrations. Review of the preliminary laboratory data by project staff recognized that the elevated detection limits did not meet the project data objectives. The method and procedures were reviewed and improvements were implemented to reduce the interferences. The samples were subsequently reanalyzed and the reports were amended. The reanalysis confirmed the undetected result, but at a lower reporting limit. Due to the reanalysis, the samples were analyzed outside of the method-specified holding time, although they did not exceed two times the holding time. The reanalysis data was flagged as estimated with a J.

All reported sample data were assessed as usable and no data were rejected, except for one equipment blank that was assigned an R qualifier due to the missed holding times. Appendix G presents copies of the validation reports for data presented in this report. Appendix G also presents further explanation of qualifiers.

A blind certified performance evaluation (PE) sample was submitted to APCL in accordance with the project quality assurance plan. A sample with a known perchlorate concentration of 25 µg/L was submitted. The result reported by the laboratory (20 µg/L) was below the lower acceptance criteria of 20.5 µg/L. A review of the laboratory's method and technique identified improvements, and a subsequent blind PE sample was submitted and analyzed. The laboratory reported a Perchlorate

concentration of 15 µg/L, which was equal to the known concentration of 15 µg/L. The associated sample results were not judged to have been significantly impacted.

4. DATA EVALUATION

4.1 GEOLOGY

Subsurface stratigraphy at Site 1 consists of unconsolidated sand, silt, and clay overlying sandstone and siltstone bedrock. The conceptual site geology is provided on Figure 4-1. The locations of cross sections A-A′ and B-B′ are shown on Figure 4-2. A fault is present in the southwestern portion of the site between the locations of 01_DGMW57 and 01_DGMW58 (California Division of Mines and Geology [CDMG 1974]). The fault depth and angle are unknown. Apparent relative movement was upward east of the fault and downward west of the fault. The thickness of the unconsolidated sand, silt, and clay generally increases towards the southwest, most notably on the western side of the fault. Depth to bedrock ranges from approximately 5 feet at 01_MW101 to approximately 70 feet at 01_DGMW57. Site 1 is surrounded by ridges of sandstone bedrock, except for the southern boundary where the drainage converges with a tributary of Borrego Canyon Wash (Earth Tech 2001).

4.2 HYDROGEOLOGY

Site 1 is within a tributary canyon to Borrego Canyon Wash and lies within the Irvine Subbasin, which is located southeast and adjacent to the Main Orange County Groundwater Basin. The Irvine Subbasin has been divided into a forebay area and a pressure area. The forebay area lies along the margin of the basin, where relatively shallow and coarse-grained sediments overlie semi-consolidated rock. The forebay area encompasses most of the station (Brown and Caldwell 1986). Recharge to the regional system takes place in the forebay area, primarily along washes (such as the Borrego Canyon Wash) that exit the Santa Ana Mountains. The pressure area lies in the central portion of the basin where productive aquifers are present mainly in deeper zones (BNI 1995). Groundwater in this area is primarily used for irrigation of agricultural and greenbelt areas (i.e., parkways and parks). According to the Santa Ana River Basin Water Quality Control Plan (CRWQCB, Santa Ana Region 1995), the groundwater beneath MCAS El Toro has potential beneficial uses for municipal, agricultural, industrial, and industrial process supplies.

Groundwater in the shallow aquifer beneath Site 1 generally flows toward the south-southwest consistent with the site topography. Based on groundwater elevations measured on 14 February 2001, depth to groundwater ranges from approximately 20.91 feet at 01_MW202 to 106.08 feet below ground surface (bgs) at 01_MW102, as shown in Table 4-1. The measurements were used to generate the groundwater elevation contours shown on Figure 4-3. As observed from these contours, the groundwater gradient direction is generally towards the southwest. The hydraulic gradient ranges from approximately 0.03 feet per foot at the Southern EOD Range to 0.07 feet per foot at the Northern EOD Range for an average gradient of 0.05 feet per foot. At the northernmost boundary of Site 1, groundwater appears to have a flow component towards the west.

The current monitoring well network (Figure 4-2) was designed to allow coverage of groundwater conditions beneath Site 1. This design is consistent with the inferred groundwater flow direction along the longitudinal axis of Site 1 and includes two upgradient wells (01_MW102 and 01_MW101), three downgradient wells (01_MW207, 01_DGMW57, and 01_DGMW58) and a total of six wells (01_MW201 through 01_MW206) along the primary groundwater flow path. Additionally, monitoring well 18_BGMW24 was installed approximately 700 feet from the site boundary, as part of the RI for Site 18 (regional VOCs groundwater investigation for on and off MCAS El Toro).

Monitoring wells 01_MW102, 01_MW201, 01_MW202, 01_MW204, 01_MW205, 01_MW206, and 01_MW207 are screened across the potentiometric surface; 01_MW101, 01_MW203,

01_DGMW57, 01_DGMW58, and 18BGMW24 are screened below the potentiometric surface. Based on data gathered from these wells, groundwater flows through the bedrock, and the fault does not appear to serve as a flow barrier.

Table 4-1: Groundwater Elevations and Perchlorate Results

Well	Depth to Groundwater	Elevation (2/01)	Perchlorate Concentrations (µg/L)			
			10/98	5/99	7-8/99	11/99
01MW101	62.30	688.52	<4[a]	2J	<4	4UJ
01MW102	106.08	652.05	NA	2J	2J	4UJ
01MW201	42.00	623.99	280	380	350J	324
01MW202	20.91	667.46	NA	NA	NA	8UJ
01MW203	29.78	651.68	NA	NA	NA	10U
01MW204	38.35	624.14	NA	NA	NA	8U
01MW205	36.20	608.37	NA	NA	NA	4UJ
01MW206	35.02	600.79	NA	NA	NA	4UJ
01MW207	45.94	574.29	NA	NA	NA	7J
01DGMW57	54.65	576.52	<4[b]	2J	3J	4UJ
01DGMW58	46.82	575.92	NA	17	5	7J
18BGMW24	40.48	577.65	NA	NA	NA	4UJ

Notes:
µg/L = micrograms per liter
< = less than
U = not detected above the indicated laboratory reporting limit
J = indicates the result or reporting limit is an estimated value
NA = not analyzed
[a] = Replicate samples were collected for the EPA (two replicates) and DTSC (two replicates) and submitted to laboratories designated by these agencies. The EPA samples were reported to contain 2.77 µg/L and 2.89 µg/L perchlorate (validated data). Only one of the DTSC replicates was analyzed and perchlorate was not reported (<4 µg/L) (data not validated).
[b] = Replicate samples were collected for the EPA (two replicates) and DTSC (two replicates) and analyzed at laboratories designated by these agencies. The EPA samples were reported to contain 4.53 µg/L and 4.31 µg/L perchlorate (validated data). The DTSC samples were reported to contain 6.01 µg/L and 5.06 µg/L perchlorate (data not validated) (BNI 1999a).

Using an average hydraulic gradient of 0.050 feet per foot, a hydraulic conductivity value of 1.2 feet per day (JEG 1993a), and an assumed effective porosity value of 0.20, the calculated average groundwater linear velocity in the shallow aquifer at Site 1 is 0.30 feet per day. Groundwater elevations measured in December 1999 and February 2001 are listed in Table 4-1, and a contour plot for the February 2001 round is provided on Figure 4-3 (Earth Tech 2001).

From December 1999 to February 2001, groundwater elevations rose between 0.85 feet (01_MW202) and 5.52 feet (01_DGMW58) in the 12 wells associated with Site 1.

4.3 HYDROLOGY

The tributary to Borrego Canyon Wash is the closest surface water feature to Site 1. Observations by Earth Tech personnel following storm events indicate that runoff in this wash is minimal to nonexistent, depending on storm intensity. Additionally, a hydrologic evaluation based on a 100-year storm, for the topographical depression area (bermed retention pond) located at the northern boundary of the Northern EOD Range indicated that the total predicted storm volume is well below the capacity of the depression. Ponding at this location was evaluated following significant storm events and was confirmed to be seasonal, consistent with historical aerial photographs, some of which show this topographic depression to be ponded. However, even when ponding occurs, there has been no evidence of ponding that overflows and causes surface water flow, which is consistent with the hydrologic evaluation.

4.4 GENERAL GROUNDWATER CHEMISTRY

A Piper trilinear diagram representing previously reported inorganic compounds in groundwater from Site 1 and IRP Site 2, located hydraulically downgradient from Site 1, is provided on Figure 4-4. The Piper trilinear diagram provides a graphical representation of groundwater chemistry based upon normalized percentages of eight major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, carbonate, and bicarbonate). Concentrations of the eight major ions are provided in Appendix H. The general groundwater chemistry at Site 1 is consistent with the general chemistry of the groundwater at IRP Site 2, located downgradient from Site 1.

4.5 PERCHLORATE IN GROUNDWATER

Results of the perchlorate analyses performed on the November 1999 groundwater samples are summarized in Table 4-1 and graphically depicted on Figure 4-5. Results of the previous Site 1 perchlorate sampling are also included in Table 4-1 for comparative purposes.

Perchlorate was detected in 3 of the 12 groundwater samples, one of which exceeded the state and Federal PALs of 18 µg/L (DHS 1999) and 32 µg/L (EPA 1999), respectively. Perchlorate was detected at 7 µg/L in both 01_DGMW58 and 01MW207 (qualified J in both), and 324 µg/L in 01MW201 in the November 1999 sampling round. The presence of interfering ions (sulfate and chloride) required the laboratory to dilute samples and elevate the reporting limit for samples collected from 01MW202, 01MW203, and 01MW204.

The perchlorate concentration has been in excess of the PALs for each of the four samples collected from 01MW201 (October 1998, May 1999, July-August 1999, November 1999). However, perchlorate was not detected in 01MW205 and 01MW206, located immediately downgradient from 01MW201. Perchlorate was detected further down gradient in 01_DGMW58 and 01MW207; however, the concentrations were below the PALs. Perchlorate was has been reported in six groundwater monitoring wells: 01_MW101, 01_MW102, 01_MW201, 01_MW207, 01_DGMW57, and 01_DGMW58, although only 01_MW201 contained concentrations exceeding the PALs.

4.6 PERCHLORATE IN SOIL

Results of the perchlorate analyses performed on the soil samples collected as part of this evaluation are summarized in Table 4-2 and depicted graphically on Figure 4-6. Perchlorate was detected in 4 of the 42 samples: 29 micrograms per kilogram (µg/kg) in HA07 at a depth of 4 feet bgs; 110 µg/kg in HA08 at a depth of 1.5 feet bgs; 210 µg/kg in HA08 at a depth of 3.5 feet bgs; and 320 µg/kg in surface sample SS02. None of the detected perchlorate concentrations exceeded the residential and industrial soil preliminary remediation goals (PRGs) of 39 milligrams per kilogram (mg/kg) and 1,000 mg/kg, respectively (EPA 1999).

PAGE NO. 4-4

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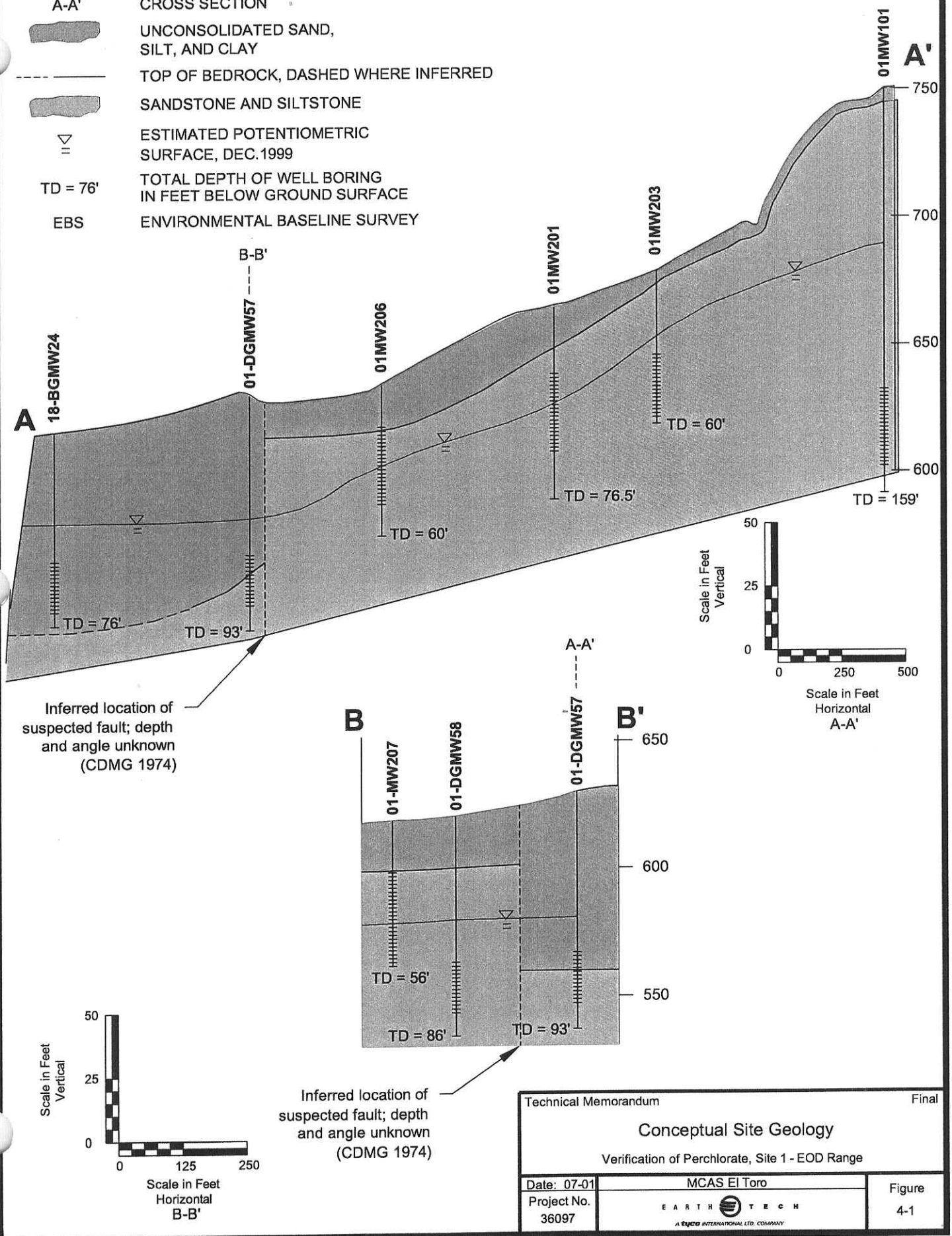

Technical Memorandum — Final

Conceptual Site Geology

Verification of Perchlorate, Site 1 - EOD Range

Date: 07-01	MCAS El Toro	Figure
Project No. 36097	EARTH TECH, A tyco INTERNATIONAL LTD. COMPANY	4-1

PAGE NO. 4-6

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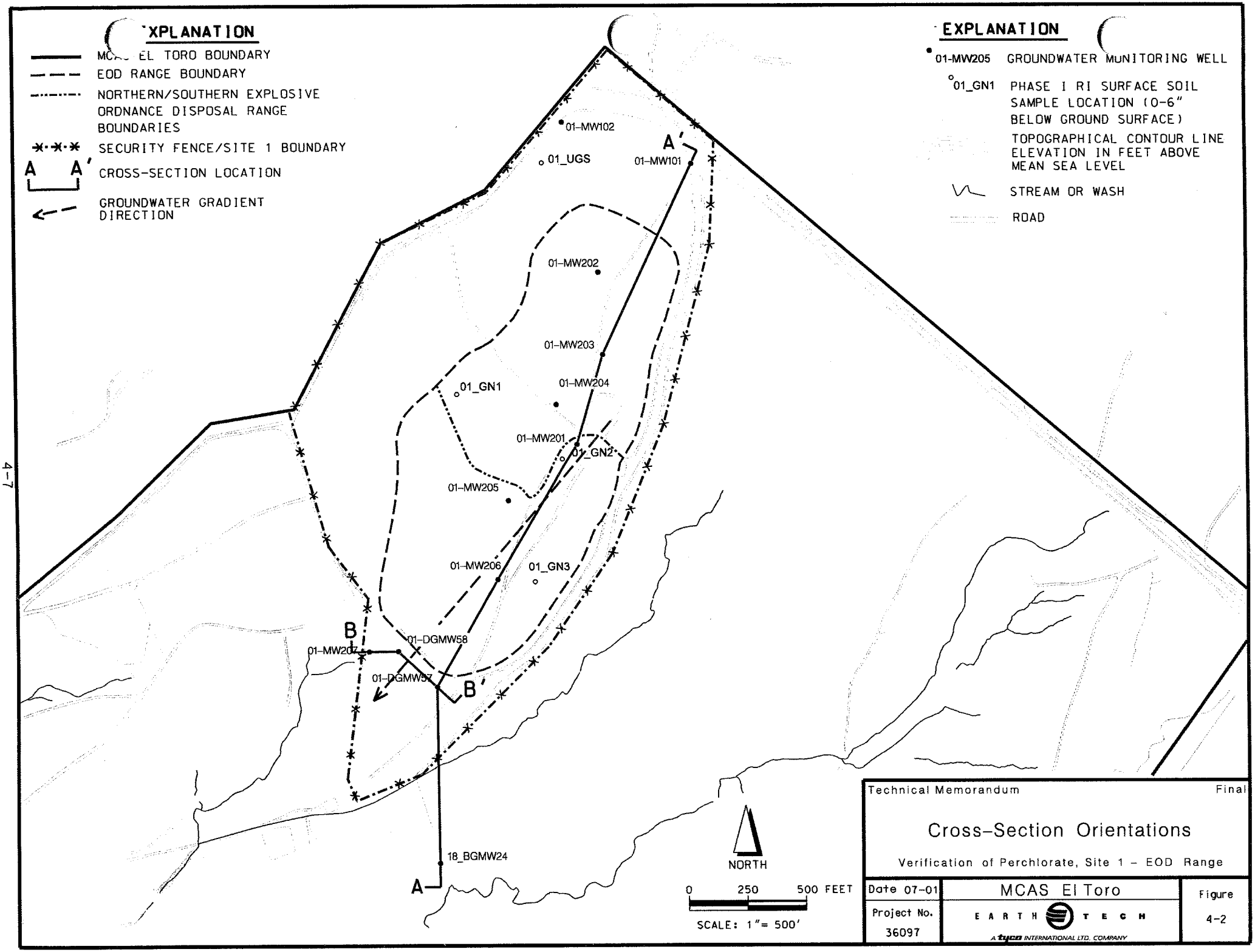

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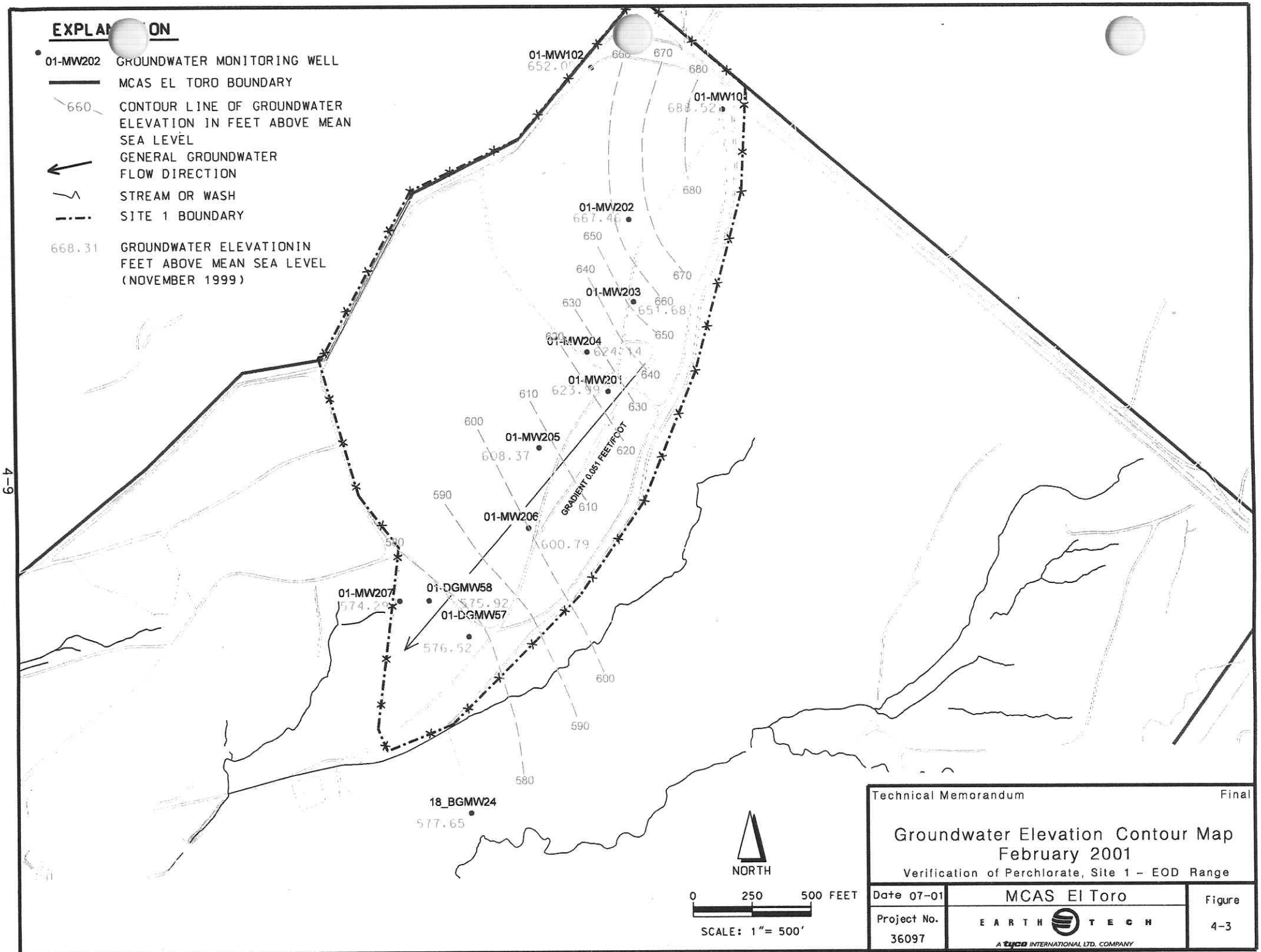

Technical Memorandum — Final

Groundwater Elevation Contour Map February 2001

Verification of Perchlorate, Site 1 – EOD Range

Date 07-01	MCAS El Toro	Figure
Project No. 36097	EARTH TECH, A tyco INTERNATIONAL LTD. COMPANY	4-3

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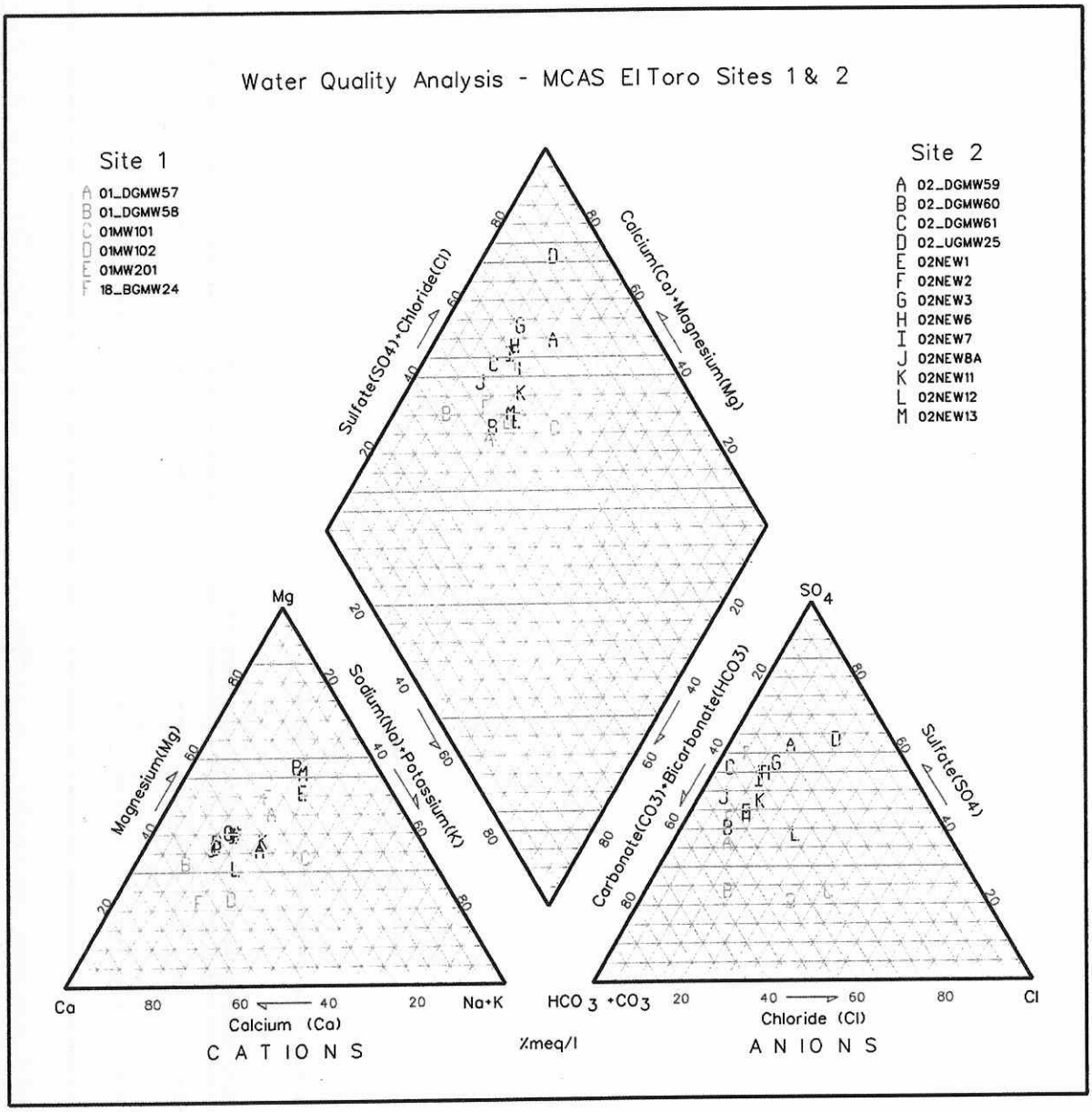

Technical Memorandum — Final

Piper Trilinear Diagram

Verification of Perchlorate, Site 1 – EOD Range

Date 07-01	MCAS El Toro	Figure
Project No. 36097	EARTH TECH, A tyco INTERNATIONAL LTD. COMPANY	4-4

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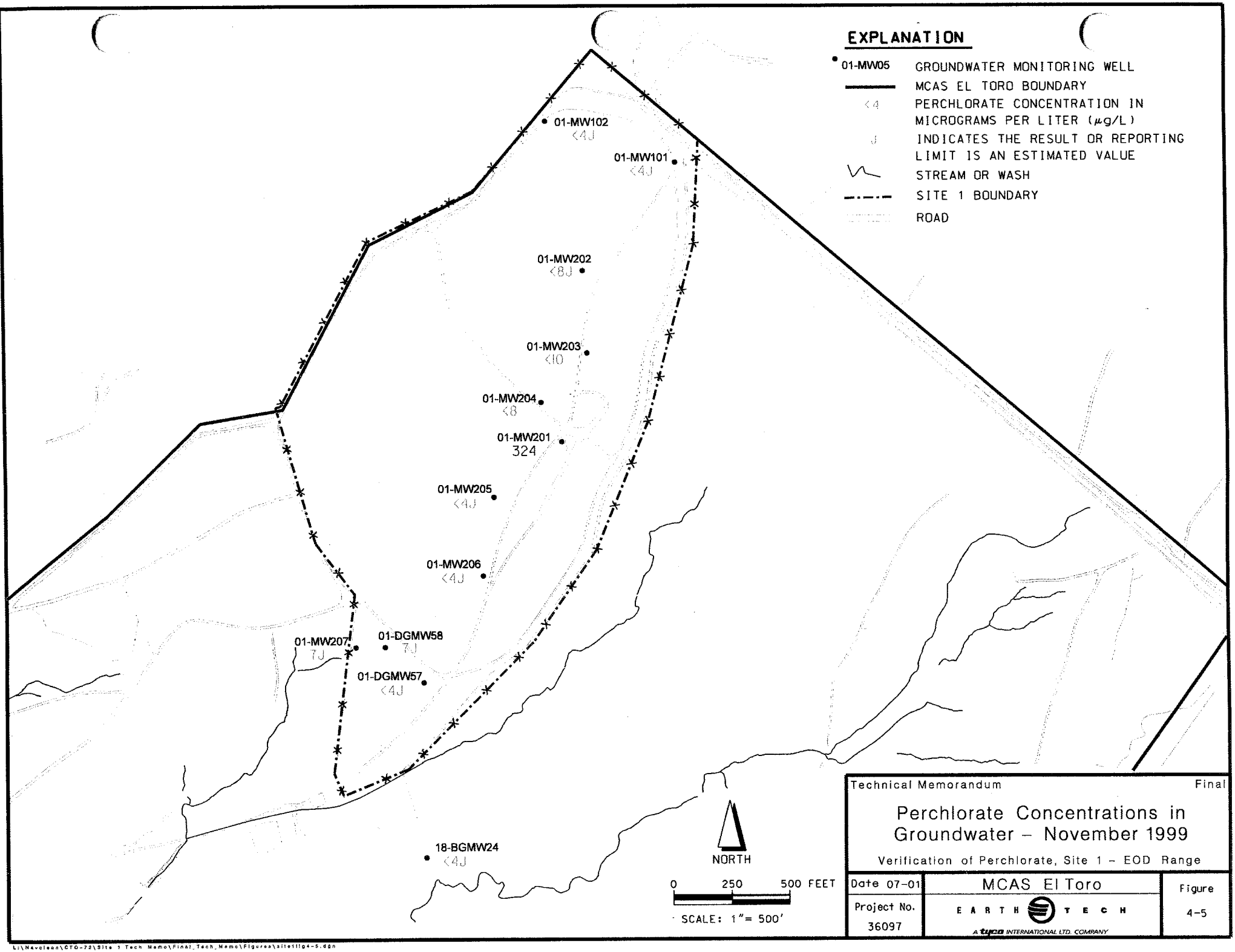

Technical Memorandum — Final

Perchlorate Concentrations in Groundwater – November 1999

Verification of Perchlorate, Site 1 – EOD Range

Date 07-01	MCAS El Toro	Figure
Project No. 36097	EARTH TECH, A tyco INTERNATIONAL LTD. COMPANY	4-5

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Table 4-2: Perchlorate Concentrations in Soil

Sample ID	Lab Tracking ID	Perchlorate Concentration (µg/kg)
01MW202-SS01-D010	LD021	<23
01MW202-SS02-D020	LD022	<22
01MW203-SS01-D010	LD029	<22
01MW204-SS01-D010	LD042	<22
01MW204-SS06-D035	LD047	<24
01MW205-SS01-D010	LD050	<21
01MW205-SS05-D030	LD054	<23
01MW206-SS01-D005	LD060	<23
01MW206-SS03-D015	LD062	<25
01MW207-SS01-D005	LD073	<23
01MW207-SS03-D015	LD075	<24
HA01-SS01-D1.5	LD110	<21
HA01-SS02-D4.0	LD111	<22
HA02-SS01-D1.5	LD112	<21
HA02-SS02-D4.0	LD113	<22
HA03-SS01-D1.5	LD114	<21
HA03-SS02-D4.0	LD115	<22
HA04-SS01-D1.5	LD116	<21
HA04-SS02-D3.5	LD117	<21
HA05-SS01-D1.5	LD120	<22
HA05-SS02-D4.5	LD121	<22
HA06-SS01-D1.5	LD122	<22
HA06-SS02-D4.5	LD123	<22
HA07-SS01-D1.5	LD125	<21
HA07-SS02-D4.0	LD126	29
HA08-SS01-D1.5	LD127	110
HA08-SS02-D3.5	LD128	210
HA09-SS01-D1.5	LD129, LD130	<21
HA09-SS02-D4.0	LD131	<22
HA10-SS01-D1.5	LD132	<21
HA10-SS02-D4.5	LD133	<21
HA11-SS01-D1.5	LD134	<21
HA11-SS02-D3.0	LD135	<22
HA12-SS01-D1.5	LD136	<21
HA12-SS02-D3.5	LD137	<22
HA13-SS01-D1.5	LD138	<21
HA13-SS02-D4.0	LD139	<21
HA14-SS01-D1.5	LD141	<21
HA14-SS02-D4.0	LD142	<22
SS01-SS01-D0.0	LD143	<20
SS02-SS01-D0.0	LD144	320
SS03-SS01-D0.0	LD145	<20

Notes:
Perchlorate concentrations are in µg/kg.
ID = identification
µg/kg = micrograms per kilogram (parts per billion)

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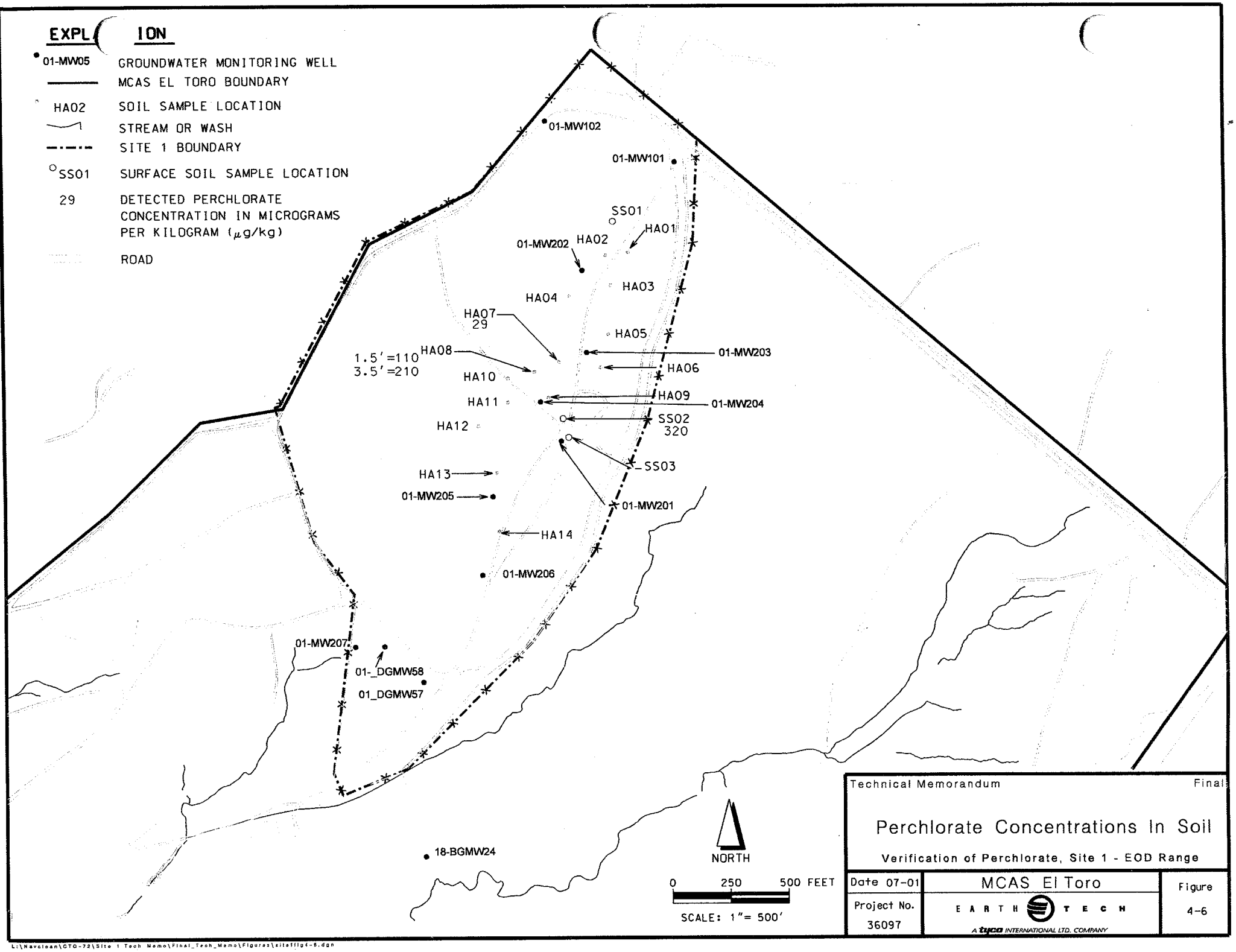

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5. CONCLUSIONS

Based upon the results of the current evaluation

- The presence of perchlorate was confirmed, with perchlorate being detected in one groundwater sample in excess of the state and Federal PALs of 18 µg/L and 32 µg/L, respectively.

- Perchlorate in groundwater at concentrations exceeding the state and Federal PALs is localized near MW201. Perchlorate was detected at a concentration of 324 µg/L in monitoring well 01_MW201. Perchlorate was also detected at 7 µg/L (the reporting limit is 4 µg/L) in monitoring wells 01_MW207 and 01_DGMW58, below the state and Federal PAL of 18 µg/L and 32 µg/L, respectively. Perchlorate was not detected in the nine remaining wells, including the closest wells located upgradient and downgradient of 01_MW201. Additional sampling of existing wells and further characterization of the lateral extent of perchlorate in groundwater will be performed as part of the Phase II RI.

- Groundwater flow is toward the south-southwest with a calculated groundwater velocity at the downgradient boundary of IRP Site 1, of 0.05 feet per day (less than 1.4 feet per year).

- Perchlorate was detected in soil at shallow depths (less than 5 feet); however, the concentrations were less than the residential or industrial PRGs. Comprehensive sampling and assessment of the geophysical anomalies will be conducted in the forthcoming RI.

- The general groundwater chemistry at IRP Site 1 was consistent with the general chemistry of groundwater at IRP Site 2, located hydraulically downgradient of IRP Site 1.

6. REFERENCES

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Appendix A
Regulatory Comments

Department of Toxic Substances Control

Edwin F. Lowry, Director
5796 Corporate Avenue
Cypress, California 90630

W[illegible]on H. Hickox
Secretary for
Environmental
Protection

Gray Davis
Governor

May 18, 1999

Mr. Joseph Joyce
BRAC Environmental Coordinator
U.S. Marine Corps Air Station - El Toro
AC/S, Environmental (1AU), BRAC Building #899
P. O. Box 95001
Santa Ana, California 92709-5001

Dear Mr. Joyce:

COMMENTS ON DRAFT REPORT EVALUATION OF PERCHLORATE IN GROUNDWATER, MARINE CORPS AIR STATION (MCAS) El TORO

The Department of Toxic Substances Control (DTSC) has completed the review of the above subject documents dated April 1999, prepared by Bechtel National, Inc. The Report summarizes the investigation conducted to assess the presence and concentration of perchlorate in groundwater at Marine Corps Air Station El Toro. DTSC comments are as follows:

1. Section 1 INTRODUCTION, Page 1-1

Please describe in the introductory statement the scope of work that was conducted. At a minimum, the introduction should discuss the number of monitoring wells sampled and total number of groundwater samples collected for perchlorate analysis.

2. Section 3.1 PERCHLORATE CONCENTRATIONS IN GROUNDWATER, Page 3-1

a. The second paragraph within this section discusses the elevated perchlorate value (280 μg/l) detected at monitoring well 01MW201 located at Site 1. The Report states that perchlorate was not detected at the downgradient well (01_DGMW57) from Site 1. The Report should clarify whether well 01_DGMW57 is screened at the same depths as well 01MW201. Additional wells/monitoring points are needed downgradient of 01MW201 to determine the extent of contamination and groundwater flow direction.

b. The detection of perchlorate adjacent to Site 3 may indicate disposal of perchlorate-containing materials at the Site 3 landfill. The prechlorate detected at Site 3 could also originate from Site 1. The groundwater flow direction southwest

of Site 1 has not been determined. Prior investigations assumed that groundwater flow follows the general path of the Borrego Canyon Wash. A portion of the groundwater may be flowing to the south-southwest, in the direction of Site 3. The groundwater potentiometric elevation map in the CERCLA Groundwater Monitoring Plan for MCAS El Toro (Figure F4-1) shows the groundwater elevation contours southwest of Site 1 as estimated contours (dashed lines). No groundwater monitoring wells are located between well 01MW201 at Site 1 and the wells adjacent to Site 3 to determine groundwater flow direction. A groundwater investigation between Sites 1 and 3 is needed to resolve this data gap.

3. Section 4 CONCLUSION, Page 4-1

a. DTSC agrees with the recommendation to conduct further monitoring at Sites 1, 2, 3, 5, 17 and at all other wells where perchlorate was reported in October 1998. As mentioned in comment 2.b., groundwater investigation is needed southwest of Site 1 and northeast of Site 3. In addition, groundwater monitoring wells along the north-south runway should be sampled to determine whether perchlorate extends farther east of monitoring wells 19_DGMW86 and 07_DBMW100.

b. MCAS El Toro has several ordnance storage bunkers that trend in a north-northeast direction from near the Golf Course area to Site 1. These bunkers may have been used for storage of perchlorate-containing ordnance. The Marines have not disclosed the type of ordnance stored in the bunkers nor conducted an inspection for spills or releases. An investigation of these ordnance storage bunkers should be conducted to determine whether a release or disposal of rocket propellant had occurred.

If you have any questions, please call me at (714) 485-5418.

Sincerely,

Tayseer Mahmoud
Remedial Project Manager
Office of Military Facilities
Southern California Operations

cc: See next page

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

August 23, 1999

Mr. Dean Gould
BRAC Environmental Coordinator
U. S. Marine Corps Air Station El Toro
P. O. Box 51718
Irvine, CA 92619-1718

Re: U. S. EPA Comments on Draft Final Evaluation of Perchlorate in Groundwater - July 1999

Dear Mr. Gould:

The United States Environmental Protection Agency (EPA) has reviewed the above referenced document and the accompanying Department of Navy's (DON) response to agency comments on the Draft Evaluation of Perchlorate in Groundwater.

While DON is proposing to continue monitoring for perchlorate on a regular basis (for some wells), DON has not responded to my memorandum dated February 26, 1999, (attachment) which outlines the regulatory agency's recommendations for additional monitoring wells and sampling frequency. The memorandum was also attached to EPA's comment letter dated June 3, 1999 and needs to be addressed in order for EPA to approve any final monitoring plan.

Please feel free to contact me at (415) 744-2210 if you have any questions.

Sincerely,

Glenn Kistner
Remedial Project Manager
Federal Facilities Cleanup Branch

cc: Patricia Hannon, RWQCB
Gregory Hurley, RAB Co-Chair
Tayseer Mahmoud, DTSC
Polin Modanlou, LRA
Andy Piszkin, SWDIV

Glenn Kistner

02/26/99 11:56 AM

To: fapiszkin@efdswest.navfac.navy.mil, jjjoyce@efdswest.navfac.navy.mil
cc: phannon@gwgate.swrcb.ca.gov, t.mahmoud@dtsc.ca.gov
Subject: perchlorate sampling in the longterm monitoring plan

Andy and Joseph:

Patricia, Tayseer and I confered via phone today on the need for continuing perchlorate sampling as part of the longterm monitoring program fo El Toro. The water purveyors and the RAB have expressed concern over continued perchlorate monitoring and the regulatory agencies agree that it should be included in the longterm monitoring plan. After independent evaluation and then joint discussion we are recommending the following wells and sampling frequency for perchlorate:

Site 1 - MW 201 quarterly sampling for one year to establish a baseline, followed by semi-annual sampling.
Place two new monitoring wells downgradient of MW210 (the other nearby wells are not screened in zones similar to MW 201 thereby limiting their usefullness) screened in zones matching MW 201. Sampling to be carried out quarterly for one year, then semi-annually.

Site 3 - Well DGMW 64 - yearly sampling

Site 16 - Well 16 DBMW52 - yearly sampling

Site 18 - Well 18 DW135 - yearly sampling

Other areas - two wells screened in the shallow aquifer and one well screened in the deep aquifer located upgradient of the pumping station for the desalter. The navy can propose wells for this once pumping well locations have been established.

The above information needs to be included in the final longterm monitoring plan. Please feel free to contact us if you have any questions.

Appendix B
Previous Stationwide Perchlorate Sampling Results

Previous Perchlorate Sampling Results

Well	October 1998 Result (µg/L)	April-May 1999 Result (µg/L)	July-August 1999 Result (µg/L)
01_DGMW57	<4[a]	2	3
01MW101	<4	2	<4
01MW201	280	380	350
02_DGMW59	<4	<4	<4
02_DGMW60	<4	<4	<4
02_UGMW25	<4	<4	2
03_DGMW64	12	4	5
03_DGMW65X	4	7	5
03_UGMW26	4	5	4
05_DBMW41	<4	<4	<4
05_UGMW27	<4	<4	2
05NEW1	5	2	3
07_DBMW100	6	6	5
09_DBMW45	<4	NA	NA
09_DGMW75	<4	10	9
16_DBMW52	<4	3	3.8
17_DGMW82	<4	<4	<4
17NEW1	<4	2	3
17NEW2	<4	<4	<4
18_BGMP06D	4	4	7
18_BGMP06E	<4	NA	NA
18_BGMP08D	<4	NA	NA
18_BGMP10F	<4	NA	NA
18_BGMW05D	<4	NA	NA
18_BGMW101	7	5	6
18_BGMW16	<4	NA	NA
18_BGMW17	<4	NA	NA
18_BGMW18	<4	NA	NA
18_BGMW19D	<4	NA	NA
18_BGMW24	<4	NA	NA
18_DW135	13	11	12
18_MCAS01-1	<4	NA	NA
18_MCAS01-3	<4	NA	NA
18_MCAS01-5	<4	4	<4
18_MCAS01-6	<4	NA	NA
18_MCAS02-1	<4	NA	NA
18_MCAS02-3	<4	NA	NA
18_MCAS02-4	<4	2	3.3
18_MCAS03-1	<4	NA	NA
18_MCAS03-2	10	NA	7.7
18_MCAS03-3	<4	NA	NA
18_MCAS03-4	<4	NA	NA
18_MCAS07-2	<4	NA	NA
18_MCAS07-3	<4	NA	NA
18_MCAS07-4	<4	NA	NA
18_MCAS10	<4	NA	NA
19_DGMW86	13	NA	NA
21_DGMW90	6	5	6
24NEW4	<4	7	5
24NEW8	<4	NA	NA

Note: <4[a] The concentration was below the method detection limit of 4 µg/L.

Appendix C
Geophysical Survey Reports

Sub Surface Surveys

215 So. Highway 101, Suite 203 P.O. Box 1152 Solana Beach, CA 92075
Telephone: (858) 481-8949 Facsimile: (858) 481-8998 E mail: geop@subsurfacesurveys.com

January 17, 2000

Earth Tech Inc.
100 West Broadway, Suite 5000
Long Beach, California 90802

Project No. 99285

Attn: Jeff Stanek

Re: Geophysical Investigation Report, EOD Range, Marine Corps Air Station, El Toro, California

This report is to present the results of our geophysical surveys carried out over portions of the Explosive Ordnance Disposal Range (EOD), located at the Marine Corps Air Station, El Toro California (Figure 1) on October 27, November 1, 2, 3, 4, 5, and 19, 1999. Extensive use of the range in the past has resulted in buried concentrations of explosive fragments and other metallic debris. The purpose of the geophysical surveys was to scan selected portions of the range using time-domain, pulse electromagnetic (EM) instrumentation in an effort to delineate the affected areas. Additionally, five planned monitoring well locations were investigated with the geophysical instrumentation in order to identify anomalies which might indicate unexploded ordnance and to guide the final selection of these drill sites. A combination of magnetic and electromagnetic induction devices was applied to the well clearance survey (Figure 2).

Multiple instruments were utilized for the well clearances because each instrument senses different material properties of the ground and buried objects. At any given site the situation, geologic and cultural, may be such that one or two of the instruments may record excessive "noise", the ground may not provide sufficient contrasts, or there may be overlapping anomalies, for a given instrument to be effective. Generally, however, the interpretation is based on the best reconciliation of the several instrument responses.

Survey Design – Portions of the EOD range were surveyed by Sanford Cohen and Associates (SC&A) between October 13 and 15, 1999 utilizing Geonics EM-61 instrumentation equipped with an integrated GPS system. Areas selected for our survey were designed to expand on the site coverage provided by SC&A's efforts as well as to fill gaps left in their data. A formal rectilinear grid measuring 500 X 1600 feet was established to guide data acquisition over the range. For our survey, EM-61 Data were collected at stations every 0.6 feet along southwest-northeast oriented survey lines spaced three feet apart.

Sub Surface Surveys

SITE LOCATION MAP

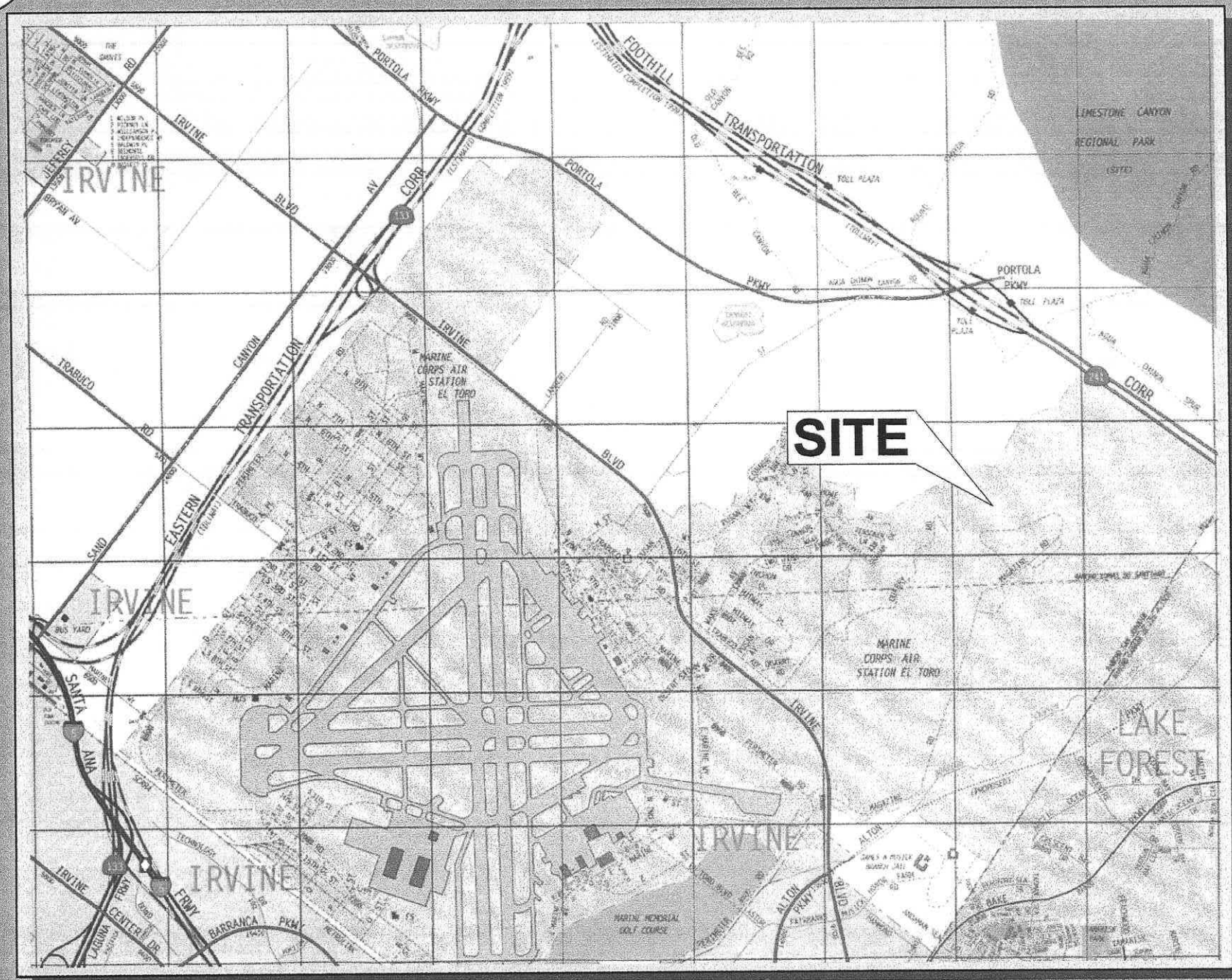

FIGURE 1

Sub Surface Surveys

SITE PHOTOGRAPHS

FIGURE 2

Brief Description of the Geophysical Methods Applied - The EM61 instrument is a high resolution, time-domain device for detecting buried conductive objects. It consists of a powerful transmitter that generates a pulsed primary magnetic field when its coils are energized, which induces eddy currents in nearby conductive objects. The decay of the eddy currents, following the input pulse, is measured by the coils, which in turn serve as receiver coils. The decay rate is measured for two coils, mounted concentrically, one above the other. By making the measurements at a relatively long time interval (measured in milliseconds) after termination of the primary pulse, the response is nearly independent of the electrical conductivity of the ground. Thus, the instrument is a super-sensitive metal detector. Due to its unique coil arrangement, the response curve is a single well-defined positive peak directly over a buried conductive object. This facilitates quick and accurate location of targets.

The EM-31 device energizes the ground by producing an alternating primary magnetic field with AC current in a transmitting coil. If conducting materials are within the area of influence of the primary field, AC eddy currents are induced to flow in the conductors. A receiving coil senses the secondary magnetic field produced by these eddy currents, and outputs the response to a meter in the form of ground conductivity values. The strength of the secondary field is a function of the conductivity of the object, say a pipe, tank or cluster of drums, its size, and its depth and position relative to the instrument's two coils. Conductive objects, to a depth of approximately 20 feet, are sensed. The device is also somewhat focused, that is, it is more sensitive to conductors below (and above) the instrument than it is to conductors off to the side.

Metal pipes, drums, etc. are generally very much more conductive than the surrounding ground; therefore, they produce high amplitude signals. The readings are different, depending on whether the approach to the conductive object is "head-on" or "broadside". When an elongate conductor, say a pipe, is approached with the line of separation of the coils, CS, perpendicular to the length of the pipe, a "head-on" approach, the readings directly over the pipe will normally be absolutely negative with positives on each side. When the same pipe is approached with the line of separation parallel to the elongate pipe, a "broadside" approach, only positive readings (above background) will be taken.

The magnetic gradiometer has two flux gate magnetic fixed sensors that are passed closely to and over the ground. When not in close proximity to a magnetic object, that is, only in the earth's field, the instrument emits a sound signal at a low frequency. When the instrument passes over a buried iron or steel object, so that locally there is a high magnetic gradient, the frequency of the emitted sound increases. The frequency is a function of the gradient between the two sensors.

Findings and Conclusions – The well clearance work was conducted prior to the EM-61 survey. Five planned monitoring well sites were pre-selected by the client's representative and staked in the field (Figure 3). The EM and magnetic instruments were systematically traversed over the area surrounding the staked locations and isolated anomalies detected were marked with paint on the ground surface. In general, the source of the anomalies

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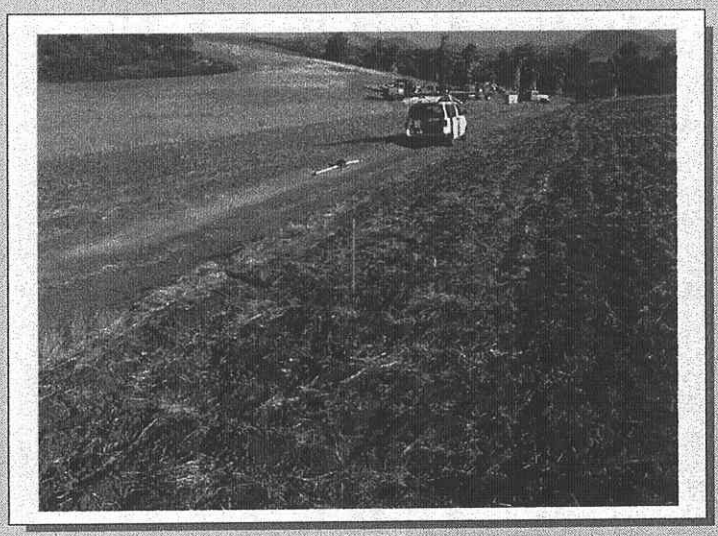

MW-203

MW-204

MW-205

MW-206

MW-207

FIGURE 3

detected is likely due to metal fragments and debris resulting from ordnance demolition activities. With this in mind, the well stake was moved a short distance away from any buried metal, as it could possibly represent unexploded ordnance.

Site conditions over the EOD range are illustrated on Figure 4 (upper photo). Subsurface Surveys established a formal rectilinear grid with survey lines extending along the long axis of the site (y-axis). The grid was tied to an existing concrete block building shown on Figure 5 (lower photo). Production over the site varied mostly due to terrain and ground surface condition (low grass, hard soil, and disked soil) (Figure 5). In addition to the main survey area, brush clearing was undertaken for a retention basin at the north end of the site in preparation for geophysical surveying (Figure 6).

The EM-61 data collected over the site were transferred to a computer in the field at the end of each day and monitored for positioning and data quality. In this way, the client was also able to review the resulting data in contour format as the survey progressed. Upon completion of our survey, the EM-61 data was transformed from the X-Y coordinate system established in the field to the northing-easting coordinate system (NAD 83) utilized by SC&A using survey coordinates of selected points on our grid. The resulting transformed data set was gridded and is presented in contour map format superimposed on a site plan (Figure 7).

Based on inspection of the EM-61 data, concentrations of metal fragments and debris are clearly evident. A contour interval of 50 mVolts was utilized in the preparation of the data display illustrated in Figure 7. This view clearly shows both large and small accumulations of buried metal. It should be noted, however, that even smaller metal fragments are seen when the data is contoured at a finer interval.

All data acquired in these surveys are in confidential file in this office, and are available for review by your staff, or by us at your request, at any time. We appreciate the opportunity to participate in this project. Please call, if there are questions.

Lawrence J. Favilla, GP 969
Senior Geophysicist

Sub Surface Surveys

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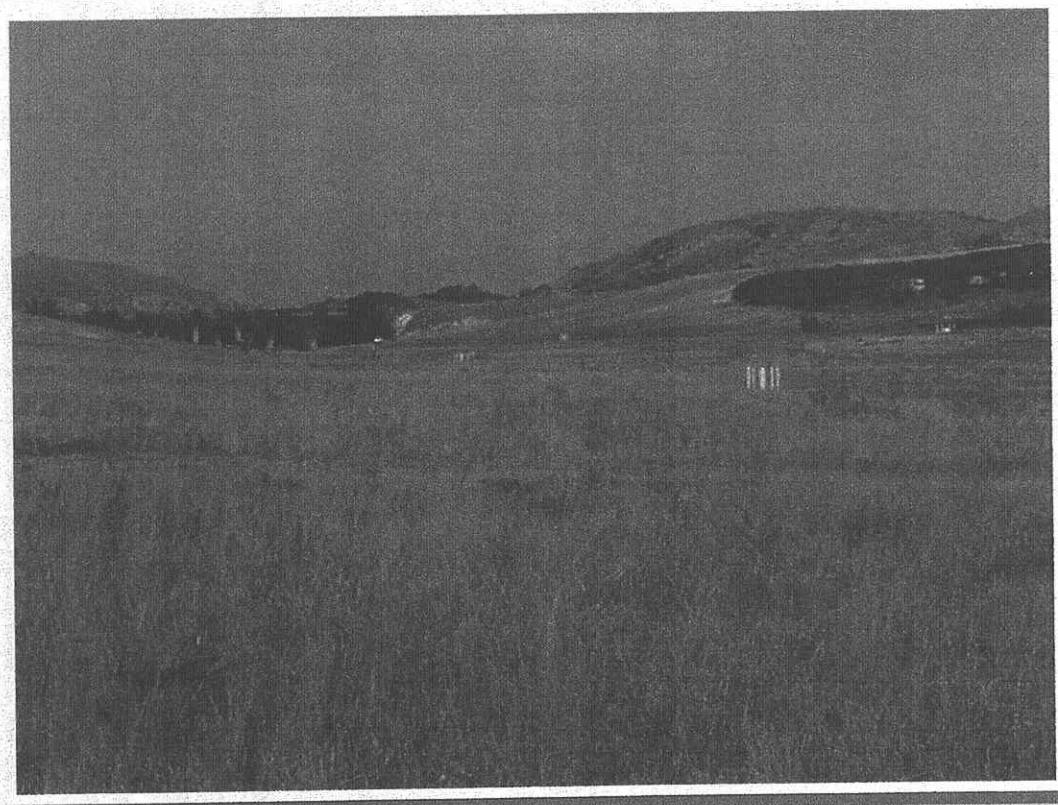

FIGURE 4

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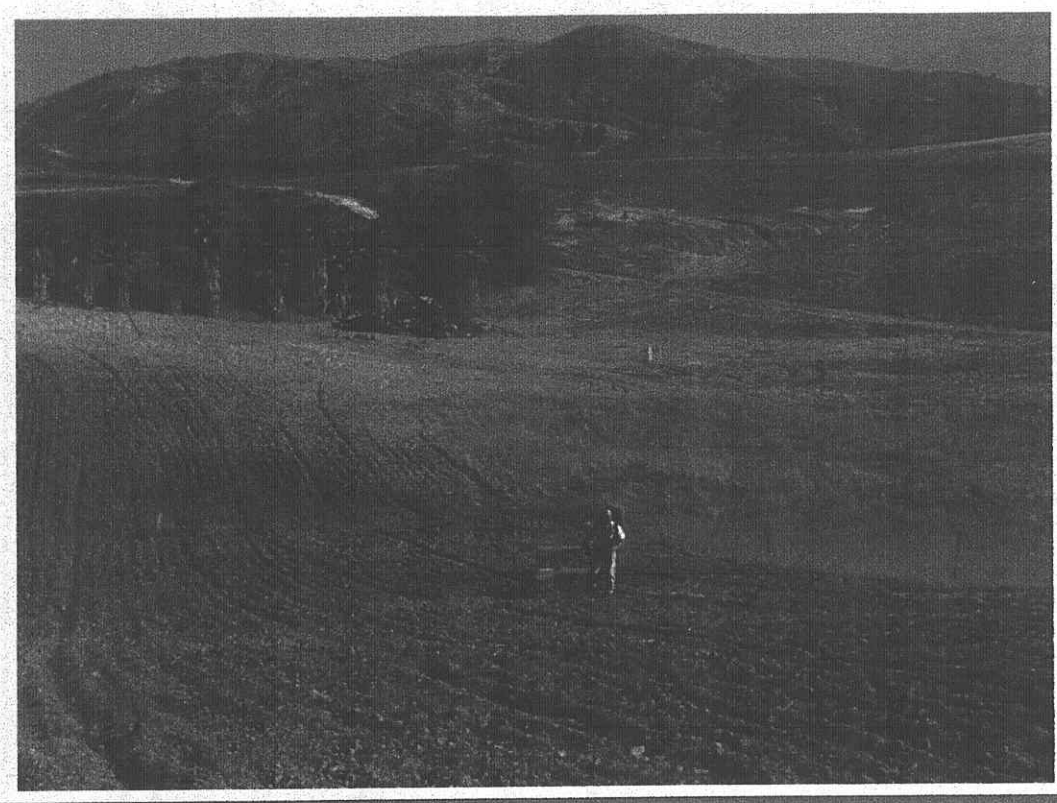

FIGURE 5

Sub Surface Surveys

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FIGURE 6