DEPARTMENT OF THE ARMY
INSTALLATION MANAGEMENT AGENCY
HEADQUARTERS, UNITED STATES ARMY GARRISON-ROCK ISLAND ARSENAL
1 ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61299-5000

REPLY TO
ATTENTION OF:

13 JUN 2006

Office of the Garrison Manager

Dr. Tom McLaughlin
Materials Decommissioning Branch
Division of Waste Management and Environmental Protection
Office of Nuclear Materials Safety and Safeguard
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2738

Dear Dr. McLaughlin:

Reference Nuclear Regulatory Commission License No. SUB-1435. Provided as enclosure are three (3) copies of the Fracture Trace Analysis report for Jefferson Proving Ground, June 2006.

If you have any questions, please contact Mr. Paul Cloud, Jefferson Proving Ground License Radiation Safety Officer, at (410) 436-2381, E-mail address paul.d.cloud@us.army.mil or Mr. John J. Welling, Chief Counsel, U.S. Army Garrison-Rock Island Arsenal, at (309) 782-8433, e-mail address wellingj@ria.army.mil.

Sincerely,

Alan G. Wilson
Garrison Manager

Enclosure

CF:
Mr. Paul Cloud

U.S. Army Corps of Engineers

FRACTURE TRACE ANALYSIS JEFFERSON PROVING GROUND

Submitted to:

U.S. Department of Army
Installation Support Management Agency
Aberdeen Proving Ground, Maryland

Prepared by:

Science Applications International Corporation
Reston, Virginia

June 2006

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CERTIFICATION 4
CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Science Applications International Corporation has completed the Fracture Trace Analysis Report for Jefferson Proving Ground. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project as defined in the SAIC Quality Assurance Plan. During the independent technical review, compliance with established policy principles and procedures, using justified and valid assumptions, was verified. This included review of assumptions, methods, procedures, and materials used in analyses; the appropriateness of data used and the level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with the law and existing Corps policy.

Joseph N. Skibinski
Project Manager
SAIC

Date: 9 JUNE 2006

for Joseph E. Peters
QA Manager
SAIC

Date: 6/9/06

Corinne Shia
Independent Technical Review Team Leader
Alion Science and Technology Corporation

Date

Significant concerns and explanation of the resolutions are documented within the project file.

As noted above, all concerns resulting from independent technical review of the project have been considered.

Lisa D. Jones-Bateman
Vice President, SAIC

Date: 6/9/06

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LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

CSM	Conceptual Site Model
DU	Depleted Uranium
EI	Electrical Imaging
JPG	Jefferson Proving Ground
NARA	U.S. National Archives and Records Administration
SAIC	Science Applications International Corporation

1. INTRODUCTION

In support of the phased site characterization of Jefferson Proving Ground (JPG) detailed in the Field Sampling Plan (SAIC 2005), Science Applications International Corporation (SAIC) has completed a fracture trace analysis of the Depleted Uranium (DU) Impact Area. The fracture trace analysis was completed in support of identifying preferential groundwater pathways within the carbonate aquifer at the site. The fracture trace analysis results were used to further define the follow-on electrical imaging (EI) investigation. The results of the EI investigation will be used in conjunction with the fracture trace analysis results for selecting potential locations for drilling and installation of future well pairs. Existing and new well data will be used to confirm and further define the conceptual site model (CSM) and support ongoing and future groundwater monitoring efforts. This report provides a general description of fracture traces (Section 2) and the analysis of fracture traces in and around the JPG DU Impact Area (Section 3). References cited are listed in Section 4.

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2. GENERAL DESCRIPTION

Groundwater is the result of precipitation infiltrating the ground surface and migrating vertically through the regolith (soil and decomposed rock layer) to the water table and the bedrock aquifer. Discontinuities in the bedrock (e.g., faults, fractures, joints, and bedding planes) are avenues for movement of groundwater through the bedrock. Bedrock along these discontinuities dissolves slowly, enlarging the openings. Some of these features become enlarged preferentially with respect to smaller features. In carbonate rocks, such as those that underlie the project area, solution mechanisms favor the development of a few larger openings rather than smaller ones (Fetter 1988). The permeability (capacity for fluid flow) due to the presence of groundwater conduits is often several orders of magnitude greater than the permeability of the unaltered bedrock. Therefore, the majority of the flow through the aquifer occurs within the groundwater conduits. To accurately characterize groundwater flow characteristics in a fractured and solution enhanced (karst) aquifer, these groundwater conduits need to be identified and targeted for the installation of monitoring wells.

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3. FRACTURE TRACE ANALYSIS AND RESULTS

An aerial photograph fracture trace analysis was completed for the JPG site to identify possible fracture locations and fracture orientation in the carbonate limestone aquifer in the DU Impact Area. A photogeologic fracture trace is defined by Lattman (1958) as a "natural linear feature consisting of topographic (including straight stream segments), vegetal, or soil tonal alignments, visible primarily on aerial photographs, and expressed continuously for less than one mile. Only natural linear features not obviously related to outcrop pattern or tilted beds, lineation and foliation, and stratigraphic contacts are classified as fracture traces."

SAIC obtained stereo-paired aerial photographs from the U.S. National Archives and Records Administration (NARA) showing the site prior to construction of JPG and the DU testing range. Black and white 10- by 10-inch contact prints of photographs taken in November 1937 were obtained at a scale of 1:20,000. The historical aerial photographs were used to map fracture traces and lineaments to identify enhanced groundwater flow pathways in the aquifer. An area of approximately 22 square miles including the DU projectile testing range and immediate surrounding area was analyzed.

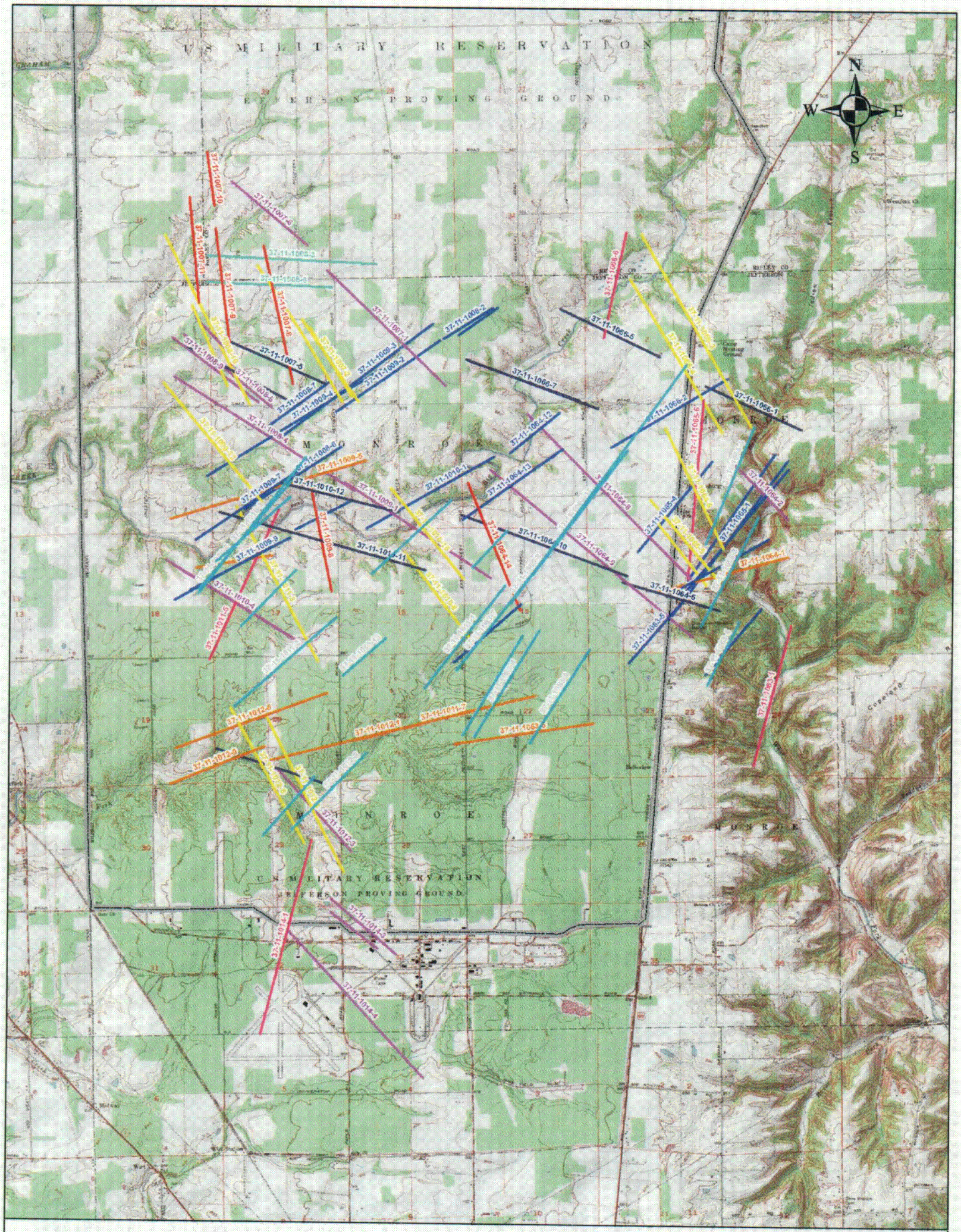
The photographs were viewed obliquely and in stereo at various magnifications. Fracture traces were mapped and marked directly on the photographs. The photographs were digitally scanned, imported into the Arcview®, and superimposed on the site map, rotated, and scaled for best-fit. Straight line segments were aligned with the mapped fractures on the photographs and saved as an Arcview® shape file. Each fracture trace line was given an identification number that represents the year of the aerial photograph, the month the photograph was taken, the photograph frame number, and a unique numeral for the fracture trace on that frame, starting with 1, generally in the southwest corner of the frame. A total number of 110 numbered fracture trace lines were identified from the aerial photographs.

Mapped fracture traces location and orientations overlying the site topographic base map are illustrated in Figure 1. Each illustrated fracture trace is labeled with the identification number for reference. Because of the registration and distortion associated with the aerial photographs, compounded by the paucity of useful features that survived since 1937, the accuracy of the fracture trace locations is approximately ±100 feet. The error was estimated by comparing fracture trace positions with the positions of topographic features, such as breaks in the ridges, which were caused by fracture traces, and the difference in the position of a single fracture trace mapped on two different photographs.

Fracture traces were grouped based on similar orientation and color coded into nine groups, as illustrated in Figure 1. Seventy percent of the mapped traces were oriented either North 27 to 59° West (33 fracture traces) or North 31 to 56° East (43 fracture traces). This figure also indicates the locations of existing monitoring wells with respect to the fracture traces.

During the mapping process, fracture traces can be given quality rankings, which are relative values indicating how distinct the fracture traces appeared when viewed obliquely and in stereo on the aerial photographs. In the case of the JPG fracture trace analysis, most of the fracture traces were faint to moderately distinct, and compared to other karst areas mapped by the analyst, fracture traces were generally less distinct. Air photograph quality, ground cover, and the season in which the photographs were taken can impact this assessment considerably. Based on these factors, the mapped traces are not considered any less indicative of fracture features.

The distribution of fracture traces was used to select the locations and extent of EI geophysical survey traverse lines proposed to be completed in the summer and fall of 2006. The fracture traces will be used in conjunction with the results of the EI survey to select locations to drill and install paired groundwater monitoring wells in groundwater conduits. Figure 2 shows the identified fracture traces and the proposed EI geophysical survey traverse lines.



Legend

Direction

- N 13 to 23 W
- N 27 to 39 W
- N 44 to 59 W
- N 67 to 78 W
- N 87 to 89 W
- N 4 to 23 E
- N 31 to 36 E
- N 48 to 56 E
- N 69 to 81 E

0 2,000 4,000 8,000

Scale in Feet

Figure 1

Jefferson Proving Ground
Madison, Indiana

Fracture Trace Prevalant Directions

Drawn	Checked
PAE 05/04/06	SMS 05/17/06

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Revisions:

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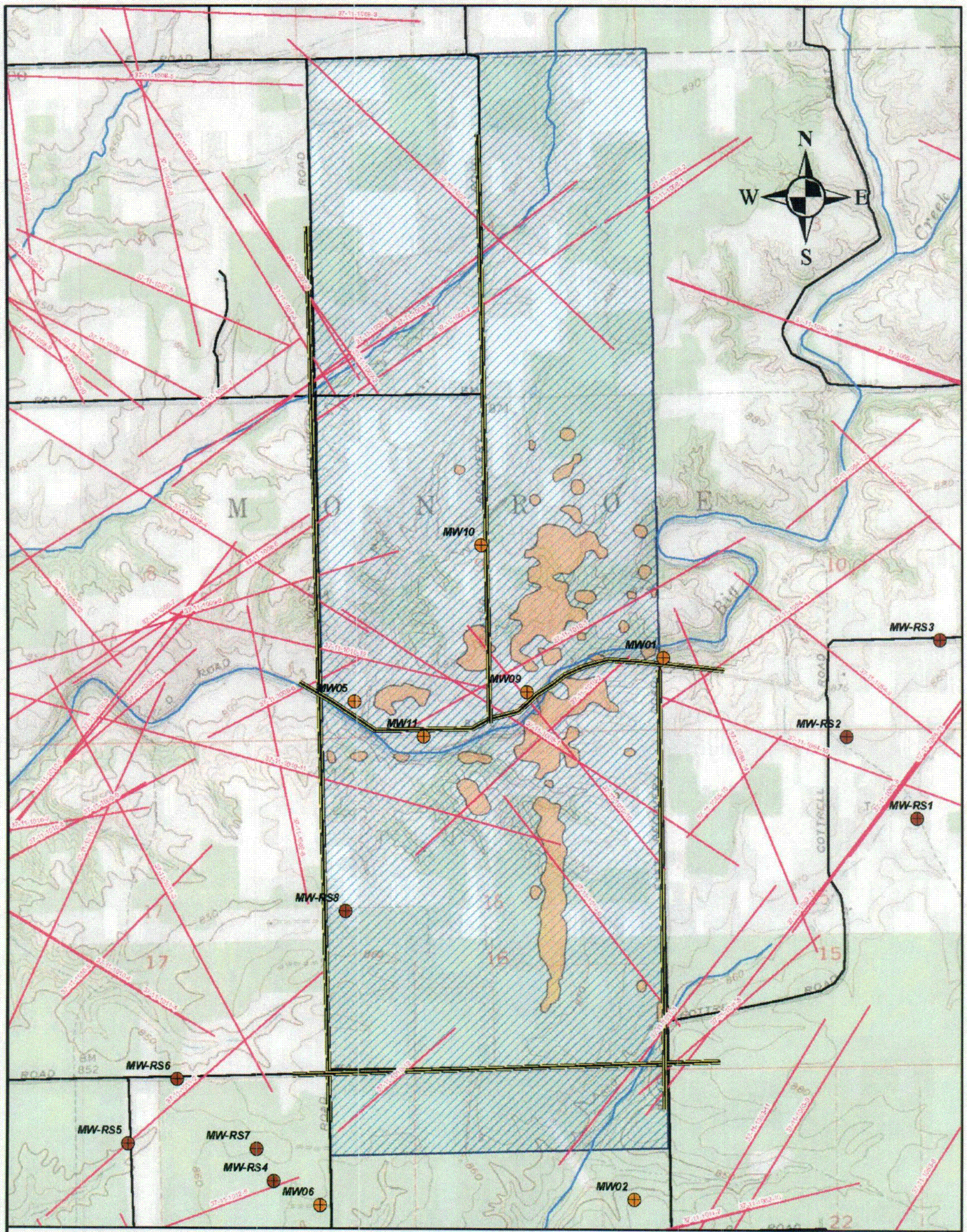

Legend

- Monitoring Well Locations
- Range Monitoring Well Locations
- Proposed Electrical Imaging Traverses
- Fracture Traces
- Streams
- Roads
- DU Impact Area
- 14 μR/hr Exposure Rate (1995 SEG Scoping Survey Report)

0 1,000 2,000 4,000

Scale in Feet

Jefferson Proving Ground
Madison, Indiana

Fracture Trace Locations and
Proposed Electrical Imaging Traverses

Drawn	Checked
PAE 04/20/06	SMS 4/21/06

Revisions:

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FIGURE 2

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4. REFERENCES

SAIC (Science Applications International Corporation). 2005. Field Sampling Plan, Depleted Uranium Impact Area Site Characterization Jefferson Proving Ground, Madison, Indiana. Final. May.

Fetter, C.W. 1988. *Applied Hydrogeology*. Second Edition. Merrill Publishing Company. Columbus, Ohio.

Lattman, L.H. 1958. *Technique of Mapping Geologic Fracture Traces and Lineaments on Aerial Photographs*, Photogrammetric Engineering, Vol. 84, pp. 568-576.

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