Environmental Laboratory

ERDC/EL TR-01-18

US Army Corps of Engineers®
Engineer Research and Development Center

Strategic Environmental Research and Development Program

S-Tracker Survey of Sites for Long-Term Erosion/Deposition Monitoring

Charles D. Hahn, Mark R. Graves, and David L. Price

August 2001

Approved for public release; distribution is unlimited.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

PRINTED ON RECYCLED PAPER

Strategic Environmental Research and Development Program

ERDC/EL TR-01-18
August 2001

S-Tracker Survey of Sites for Long-Term Erosion/Deposition Monitoring

by Charles D. Hahn, Mark R. Graves, David L. Price

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Contents

Preface

This report was prepared for the Ecosystem Characterization and Monitoring Initiative (ECMI) sponsored by the Strategic Environmental Research and Development Program (SERDP) Ecosystem Management Project (SEMP). The technical monitor was Dr. Robert Holst, SERDP Program Manager.

The work was performed under the direction of the Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. The EL Principal Investigator was Mr. Charles D. Hahn and co-investigators were Mr. Mark R. Graves and Dr. David L. Price, EL. Project Manager for the ECMI is Mr. Harold W. West, EL, and Program Manager for the SEMP is Dr. Harold E. Balbach of the Construction Engineering Research Laboratory (CERL), ERDC, Champaign, IL.

Many individuals contributed to the support of this project, including Mr. John Brent, Mr. Pete Swiderek, and Ms. Theresa Davo of Fort Benning, GA, the host site for the SEMP; Mr. Hugh Westbury, the host site coordinator of CERL; and Messrs. Thomas Berry, David Leese, and John Newton, EL.

At the time of publication of this report, Acting Director of EL was Dr. Edwin A. Theriot. Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

This report should be cited as follows:

> Hahn, C. D., Graves, M. R., and Price, D. L. (2001). "S-Tracker survey of sites for long-term erosion/deposition monitoring," ERDC/EL TR-01-18, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

1 Introduction

Purpose

The purpose of this technical report is to describe the soil erosion and deposition component of the long-term baseline ecosystem monitoring plan developed for Fort Benning, GA, under the Department of Defense's (DOD) Strategic Environmental Research and Development Program, Ecosystem Management Project, Ecosystem Characterization and Monitoring Initiative. This report documents the characterization phase of the erosion and deposition component and provides the foundation needed for monitoring erosion/deposition and interpretation and use of the data.

The soil is the common ground between the biotic and abiotic aspects of terrestrial ecosystems.[1] Soil stability is one criterion for a sustainable, healthy soil system and is a prerequisite for meeting the criteria of nutrient cycling and functioning recovery mechanisms. Approaches to ecosystem characterization and monitoring must include the interrelationships of ecological processes that link soils, plants, animals, minerals, climate, water, and topography as a living system.[2] Soil erosion dynamics relate closely to variations in water quality, changes to wildlife habitat quality, and the ability to train to mission standards. The problem of soil erosion on DOD lands is well documented and is a critical land management problem.[3] As an ecosystem process, soil erosion exhibits large temporal and spatial variation and is usually studied in a numerical modeling framework. Some measured data are essential to the proper calibration and validation of these models. The purpose of the following design and method is to characterize and monitor erosion and deposition on the landscape and to provide the data necessary to develop projections into the future, by application of modeling techniques, regarding the ability of the soil resource to sustain training.

---

1 Barbour, M. G., Burk, J. H., and Pitts, W. D. (1980). *Terrestrial plant ecology*. Benjamin/ Cummings Publishing Co., Menola Park, CA.
2 U.S. Army Construction Engineering Research Laboratory. (1997). "Evaluation of technologies for addressing factors related to soil erosion on DOD Lands," Technical Report 97/134, Champaign, IL.
3 Doe, W. W., III, Jones, D. S., and Warren, S. D. (1999). "The soil erosion model for military land managers: Analysis of erosion models for natural and cultural resources applications," Technical Report, Center for Ecological Managers of Military Lands, Colorado State University, Fort Collins, CO.

Background

Fort Benning, GA, is a highly active military training post; much of that training includes tracked vehicles. Fort Benning also has a very fine-grained, highly erodible sand/clay soil. In an effort to better understand the erosion problem and its effect on the installation watersheds in the area, a long-term study was undertaken to monitor the microtopography of selected areas (or sites) on the fort. To accurately measure the microtopography, a technique was developed based on the S-Tracker system[1] (Figure 1) to track a prism mounted on a rolling wheel (Figure 2), pulled or pushed by personnel traversing the site. This report describes the initial site selection, site construction, and baseline survey process.

Figure 1. S-Tracker system with two instruments

[1] S-Tracker is an integrated hardware/software laser survey system that uses two or more robotic electronic theodolites and an optionally real-time kinematic global positioning system (GPS) to track sensor platforms with a prism moving over a course.

Figure 2. Prism on wheel

2 Site Selection/Site Construction

Several sites were selected based on a restricted random grid procedure as potential sites for microtopography measurements. Ten sites were located in each of the Bonham Creek and Sally Branch watersheds, and, using a restricted random selection, the remaining 10 sites were selected from the existing land condition trend analysis (LCTA) transects. A 20- by 20-m data collection area was located at each site, and the corners marked with 91.5-cm (36-in.) steel pipes and wooden stakes (Figure 3). Because of very dense woody vegetation, a few sites were reduced to a 15- by 15-m area. Three instrument locations were then selected to optimize laser tracker visibility over the data collection area. An alternate (or backsite) location was also selected so that it would be visible from the three instrument positions. These locations were then permanently marked by driving a 91.5-cm (36-in.) or 122-cm (48-in.) steel pipe into the ground surrounded by a 15-cm- (6-in.-) diameter by 51-cm- (20-in.-) long polyvinyl chloride (PVC) pipe filled with concrete, topped with an aluminum hub. Each hub was stamped with the site name and the location ID.

Figure 3. Corner pin and stake

3 Surveying and Processing

Baseline Survey

The baseline survey consisted of the actual topographic survey of each data collection area, the survey work that must precede the topographic survey, and the characterization/documentation survey of each area. These tasks are discussed in the order they were performed.

Pretopographic survey work

Prior to the topographic surveys, accurate control was established at each data collection area. To achieve this, a two-phase GPS was conducted. The first phase consisted of static surveys to establish a local network that could be used as base stations for real-time kinematic (RTK) GPS surveys.[1] Three control points were selected at each site. One point (L90-4) was actually one of the instrument locations for an LCTA site. The other two were located near the Natural Resources compound and at the Carmouche training compound. These control points were then used during RTK surveys of the actual control points at each data collection site. Survey teams would visit each site and record GPS data for as many instrument locations as could be occupied with GPS. In each case, four separate GPS occupations were recorded and then averaged to obtain the final coordinate position (Appendix A).

Characterization/documentation survey

At each data collection site, it was also necessary to survey/document the trees, shrubs, and other features (fallen trees, holes, and vehicle debris) in the site. These features have the potential to affect the erosion/deposition at the site. These features also impact the topographic surveys both by restricting the areas which can be surveyed as well as by interfering with the ability of the tracking instruments to follow the prism.

[1] Hahn, C. D. (2001). "Control survey at Fort Benning, Ga," Draft Technical Note, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Baseline microtopography surveys

A systematic procedure was followed to perform the actual microtopography survey. First, any instrument positions not surveyed during the RTK survey were surveyed using the positions already surveyed. Data from these surveys were reduced (in the instrument), and the locations were available immediately. Then, three instrument locations were selected to be occupied by Leica TCA 1102 Robotic Total Stations, and instruments were set up at these locations. Figure 4 shows an example site (L204). For the survey, instruments were deployed at L204-2, -3, and -4. L204-1 was used to orient (backsite) the three instruments. The green lines show the survey transects. Instrument heights and communications parameters were recorded at this time. These locations were selected to provide maximum visibility over the data collection area. The fourth location was used for the backsite, and a prism was erected at this mark. The procedure used is discussed below.

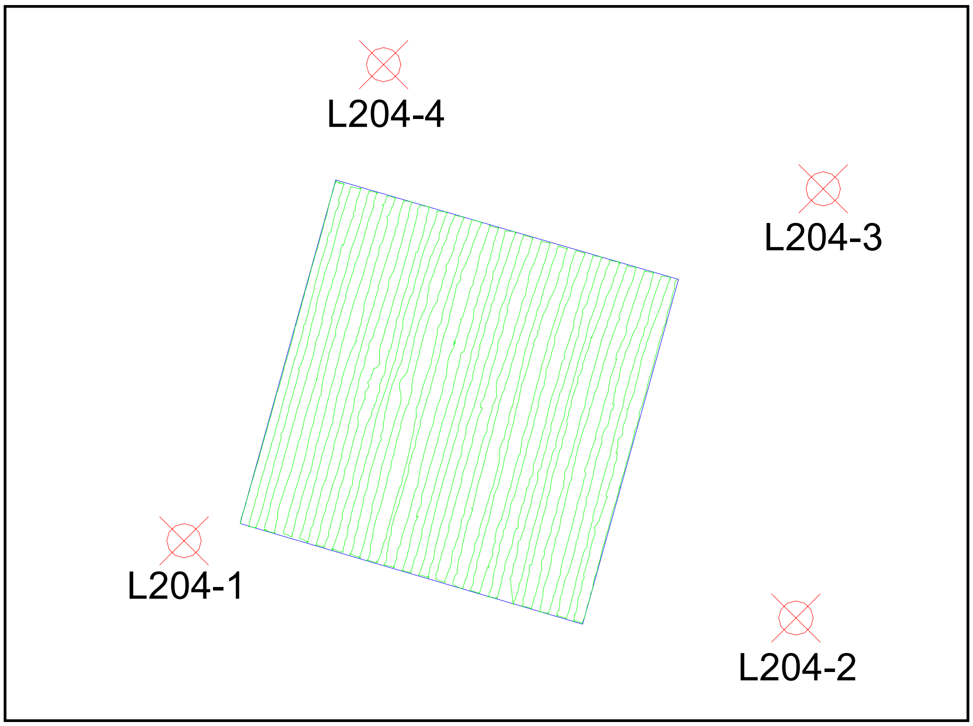


Figure 4. Map of Site L204, showing near-parallel transects

First all instruments were set up, leveled, and plumbed over the control point. Two instruments were connected with the field computer via radio modems, with the third directly connected with a serial cable. Each instrument was then aimed at the backsite prism. Then, each individual instrument was oriented using the back-site and the instrument position fine-tuned to return the correct backsite position within ±1 mm. These adjustments were generally very small (< 2 cm typically). The instruments were then sighted on the prism on the wheel for the topography measurements. Alternate colored flags were placed on the sides parallel to the slope of the site at 0.5-m intervals to guide survey transects. Guide strings were placed across the site at 5-m intervals to provide a visual reference for the wheel operator. The wheeled prism was then pulled across the site perpendicular to the apparent direction of slope. The survey process continued as long as at least two instruments maintained lock on the prism. If two instruments lost lock on the prism, the wheel operator was instructed to stop until all instruments were tracking the prism. The surveyed positions were recorded using the Geolink® Data collection software developed for the U. S. Army Engineer Research and Development Center, Environmental Laboratory. After all the transects had been measured, the setup information was saved together with the site topographic data on the field computer. After the field data had been collected, it was processed using the same Geolink software and output in an Excel spreadsheet file format, with four columns (time, X-coordinate, Y-coordinate, Z-value).

GIS Processing

Arc/Info version 8.1 was used to process the data collected by the field team. To get the data into Arc/Info, the Excel spreadsheets were imported into an empty Microsoft Access database as a table.

In ArcMap (a component of Arc/Info), the Access table was added as a layer, and the data were displayed as points using the "Display X Y" function (selecting the appropriate fields in the database which represented the X- and Y-coordinates, respectively). The data were then converted into an ArcView shapefile format. A map of the survey points collected for site B8 is presented in Appendix B.

Profiles were generated from points collected at the 0-, 5-, 10-, 15-, and 20-m transects. These are presented in Appendix B.

A triangulated irregular network (TIN) was constructed from the point shapefile in ArcMap using the 3D Analyst software extension. TIN's consist of nodes that store Z-values, connected by edges to form contiguous, nonoverlapping triangular facets. A map of the TIN surface for site B8 is presented in Appendix C.

When each site is resurveyed, the two dates of surfaces will be compared, and maps showing areas of soil accretion and erosion will be produced using the GIS.

Resurvey Procedure

Annual resurveys are planned for each of these sites to document the erosion/deposition change. The same process used for the baseline survey will be used for the resurveys. The same instrument/backsite configuration will be used in each resurvey so that the survey data will be directly comparable. Should the backsite location be destroyed, it will be necessary to use data from the other three positions to reconstruct the control monument, and it should be resurveyed from two of the remaining instrument positions (one position would be required to orient the two instruments). Instrument locations should be taken from the positions recorded at the time of the latest resurvey.

4 Summary

Erosion is a serious problem in many areas at Fort Benning. In many cases, erosion problems are not addressed until these problems become very severe. Also, uncontrolled erosion has a severe impact on the watershed in the region by seriously degrading water quality and threatening the health of the river or creek. This study is an attempt to quantify the erosion problem at Fort Benning in terms of how much, and under what conditions, erosion occurs. The key to quantifying this problem is developing accurate, high-resolution surface models and being able to compare those models of the same area over time.

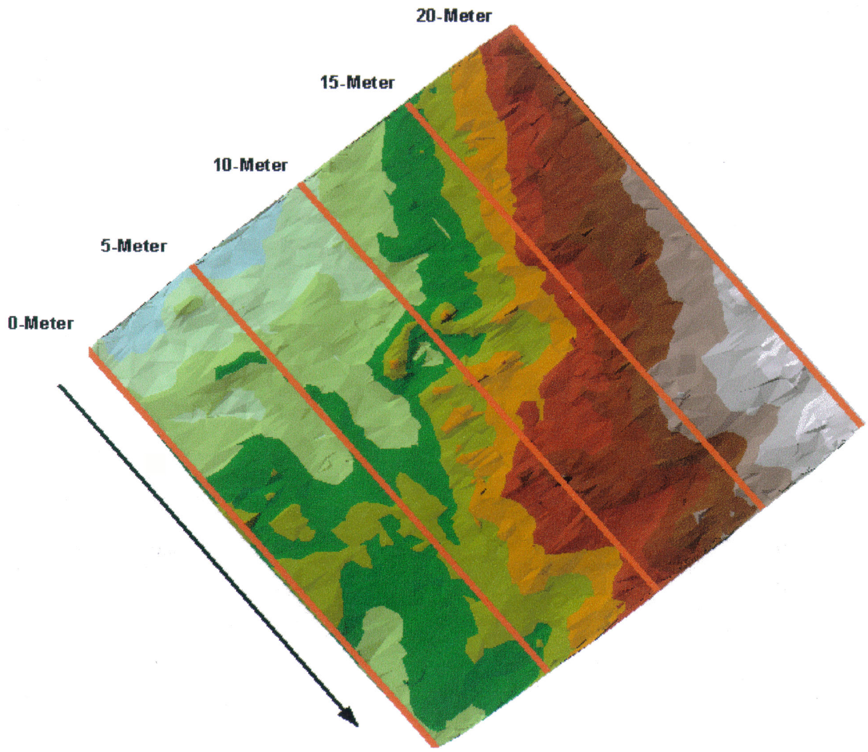
Appendix A
Data Collection Site Control

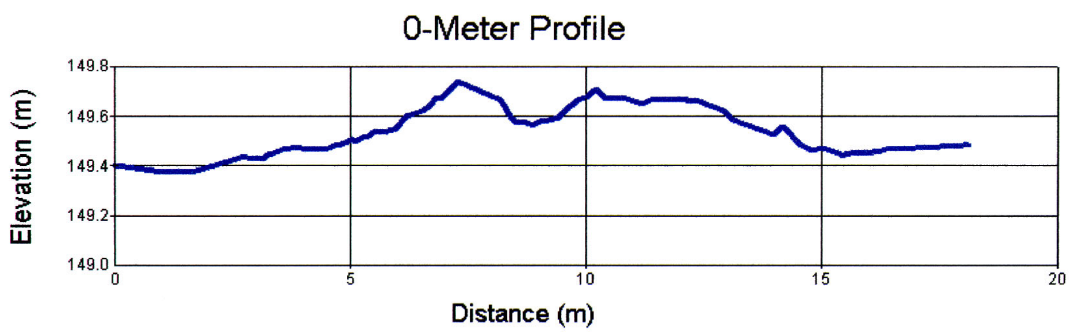
Name	Northing (m)	Easting (m)	Elevation (m)	Hz Acc (m)	Vt Acc (m)
B1-1	3589746.344	710182.194	92.032	0.005	0.018
B1-2	3589727.672	710180.969	93.211	0.005	0.019
B1-3	3589724.472	710191.025	93.258	0.005	0.017
B1-4	3589745.372	710188.743	92.159	0.005	0.018
B2-1	3589810.315	711480.894	131.148	0.006	0.015
B2-3	3589840.511	711497.378	134.294	0.007	0.016
B2-4	3589808.382	711507.717	132.776	0.006	0.017
B4-2	3588838.130	711817.068	124.514	0.007	0.010
B4-3	3588816.489	711809.248	123.093	0.009	0.012
B4-4	3588815.355	711798.850	122.053	0.009	0.012
B6-1	3587334.675	711463.698	124.975	0.011	0.019
B6-2	3587318.506	711477.828	124.097	0.010	0.013
B6-3	3587331.204	711498.129	123.120	0.010	0.018
B6-4	3587309.896	711448.034	125.271	0.008	0.012
B7-1	3587301.077	712751.340	127.996	0.009	0.018
B7-2	3587267.066	712740.277	124.762	0.007	0.014
B7-3	3587284.806	712724.230	125.549	0.007	0.016
B7-4	3587293.481	712728.369	127.358	0.009	0.015
B8-1	3586177.404	710260.568	151.327	0.010	0.019
B8-2	3586202.819	710247.650	149.078	0.009	0.016
B8-3	3586205.058	710284.119	150.748	0.010	0.018
B8-4	3586216.004	710251.297	148.873	0.008	0.015
B9-1	3586184.214	711554.648	125.734	0.012	0.018
B9-3	3586154.969	711573.951	125.835	0.014	0.019
B10-1	3586154.358	712766.668	151.052	0.013	0.016
B10-2	3586139.304	712758.188	153.584	0.011	0.015
B10-3	3586160.089	712731.517	147.68	0.01	0.014
B10-4	3586160.078	712731.521	147.671	0.011	0.016
L90-1	3588430.062	712628.411	149.784	0.009	0.016
L90-2	3588411.658	712656.989	147.204	0.010	0.018
L90-3	3588398.716	712652.163	146.835	0.007	0.013

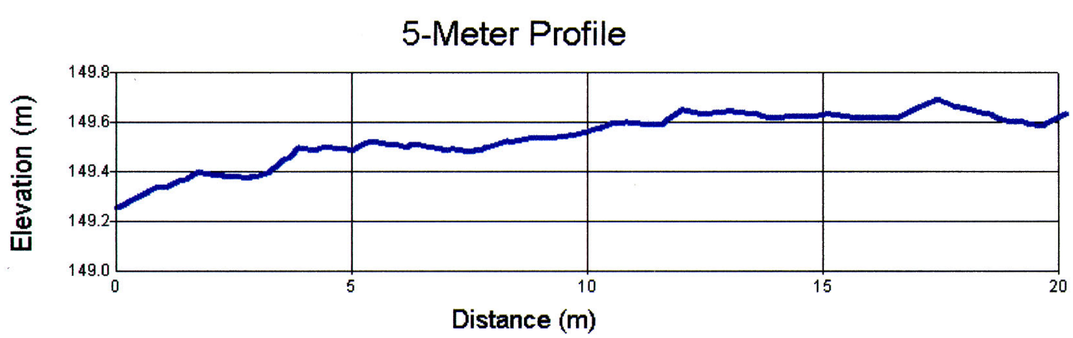
Name	Northing (m)	Easting (m)	Elevation (m)	Hz Acc (m)	Vt Acc (m)
L90-4	3588357.580	712853.787	146.385		
L144-1	3589311.812	709895.846	129.219	0.009	0.016
L144-4	3586415.268	710874.487	138.222	0.010	0.019
L147-1	3596526.932	707425.521	107.072	0.011	0.015
L147-2	3596539.913	707433.141	105.041	0.011	0.011
L147-3	3596521.091	707439.734	105.067	0.013	0.017
L147-4	3596543.676	707442.268	104.431	0.013	0.019
L204-1	3590402.190	710513.454	116.022	0.011	0.015
L204-3	3590421.952	710548.992	118.089	0.014	0.018
L204-4	3590428.920	710524.552	117.046	0.012	0.016
L211-1	3586578.272	701721.553	104.948	0.009	0.014
L211-2	3586572.910	701701.552	103.244	0.010	0.017
L211-3	3586592.511	701702.900	103.098	0.009	0.016
L211-4	3586584.966	701740.989	107.711	0.009	0.016
L315-1	3589301.847	714832.630	152.509	0.010	0.019
L315-2	3589272.250	714853.908	149.788	0.011	0.019
L315-3	3589270.394	714844.952	150.213	0.009	0.016
S1-1	3590458.157	712565.015	121.878	0.009	0.013
S1-3	3590437.684	712590.918	118.174	0.010	0.016
S1-4	3590466.305	712556.047	122.784	0.012	0.018
S2-3	3588984.072	712675.654	126.144	0.013	0.015
S2-4	3588978.598	712667.832	126.405	0.011	0.013
S3-2	3589033.699	714136.276	129.994	0.007	0.014
S3-4	3589007.632	714135.738	127.074	0.007	0.015
S4-1	3587379.931	714044.238	119.843	0.008	0.016
S4-2	3587385.820	714009.724	116.165	0.008	0.014
S4-4	3587403.952	714002.031	114.669	0.006	0.013
S5-1	3587468.022	715686.339	140.696	0.006	0.011
S5-4	3587485.458	715695.245	136.949	0.008	0.017
S6-1	3586028.106	714177.522	156.609	0.010	0.014

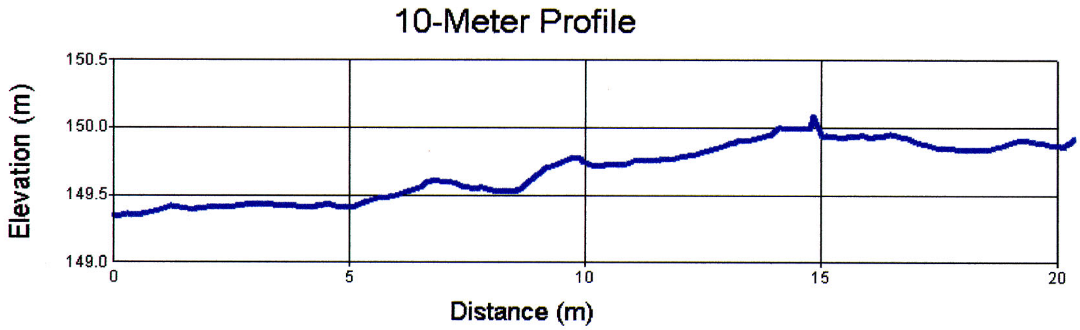
Name	Northing (m)	Easting (m)	Elevation (m)	Hz Acc (m)	Vt Acc (m)
S6-2	3586013.312	714175.307	156.655	0.010	0.017
S6-4	3586045.171	714165.838	155.651	0.011	0.015
S7-1	3585813.084	715645.053	142.023	0.013	0.019
S7-2	3585822.229	715662.405	138.091	0.012	0.016
S7-4	3585833.476	715670.466	139.344	0.008	0.012
S8-3	3585836.595	717083.306	164.906	0.010	0.017
S8-4	3585856.005	717078.133	166.088	0.010	0.016
S9-1	3584533.285	715631.838	162.769	0.009	0.014
S9-4	3584529.245	715646.148	163.669	0.011	0.019
S10-4	3584603.513	717157.092	137.914	0.005	0.017

Appendix B
Site B8 Profiles and Survey Points

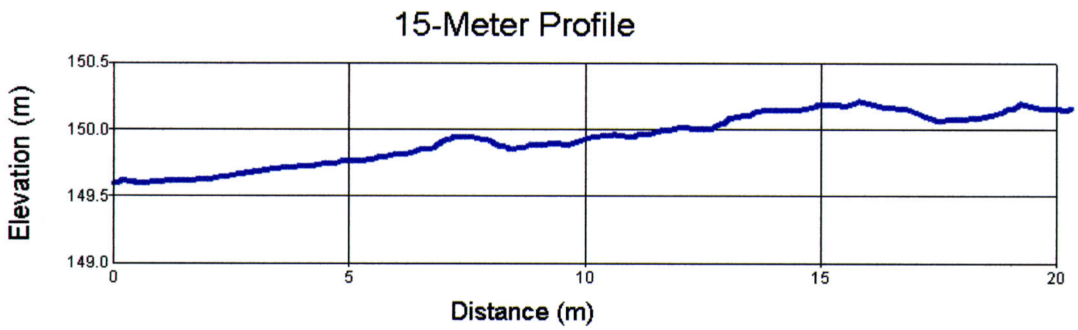

20-Meter
15-Meter
10-Meter
5-Meter
0-Meter


0-Meter Profile
Elevation (m)
149.8
149.6
149.4
149.2
149.0
0
5
10
15
20
Distance (m)

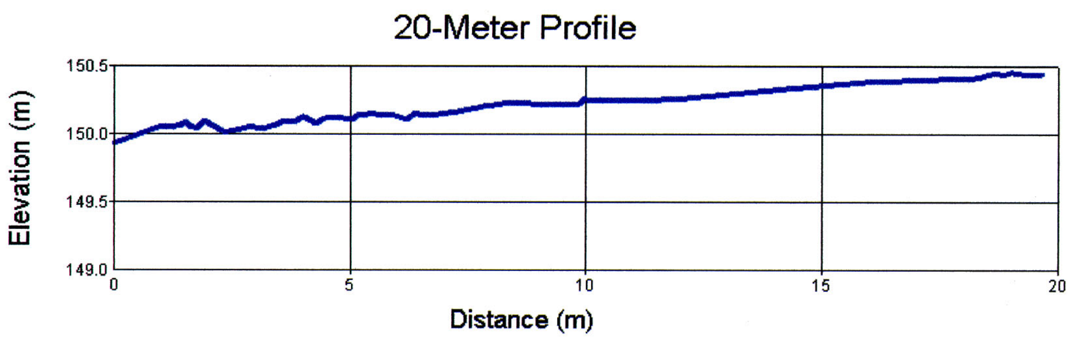

5-Meter Profile
Elevation (m)
149.8
149.6
149.4
149.2
149.0
0
5
10
15
20
Distance (m)



10-Meter Profile
Elevation (m)
150.5
150.0
149.5
149.0
0
5
10
15
20
Distance (m)

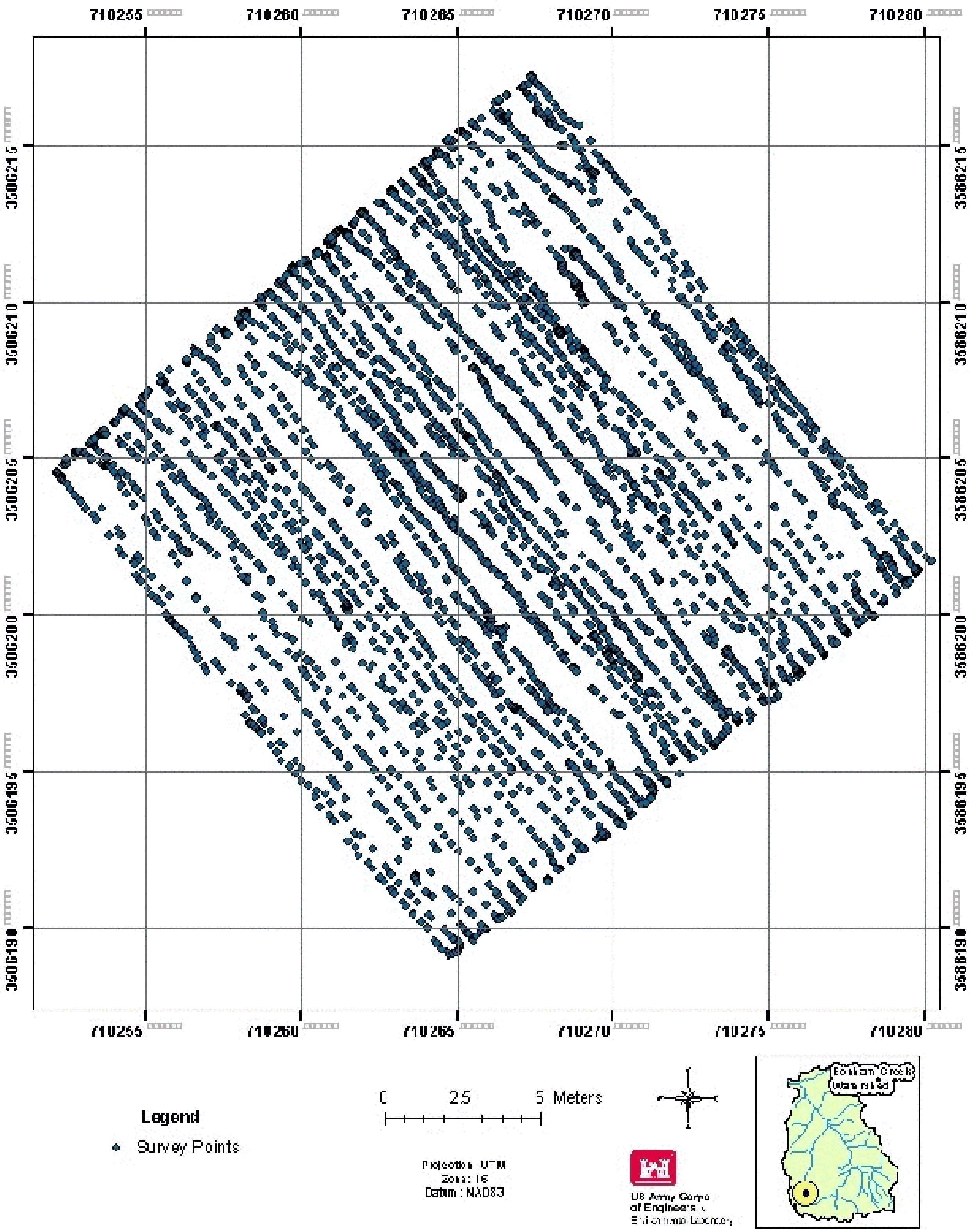


15-Meter Profile
Elevation (m)
150.5
150.0
149.5
149.0
0
5
10
15
20
Distance (m)



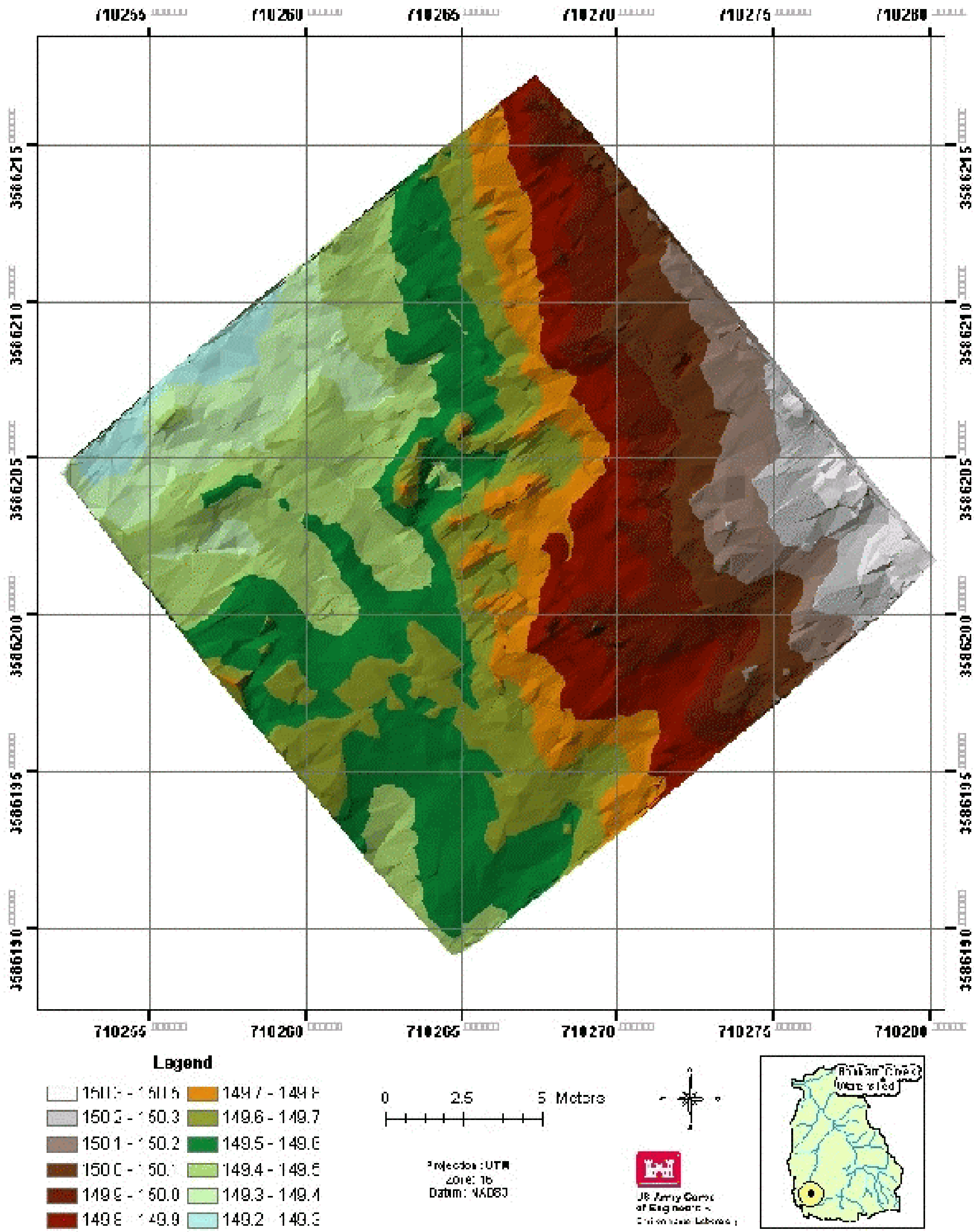
20-Meter Profile
Elevation (m)
150.5
150.0
149.5
149.0
0
5
10
15
20
Distance (m)

Site B8
Survey Points



Appendix C
Site B8 TIN Surface Model

Site B8
TIN Surface Model



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
August 2001	Final report	

4. TITLE AND SUBTITLE

S-Tracker Survey of Sites for Long-Term Erosion/Deposition Monitoring

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Charles D. Hahn, Mark R. Graves, and David L. Price

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/EL TR-01-18

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Erosion significantly impacts water quality in the environment. Training on Army bases disturbs the terrain and can be a significant cause of erosion. Many methods exist to quantify the amount of sediment in the water; however, very few methods have been developed to quantify the source of the sediment and actually measure the quantity of soil deposited in the water over long periods of time. The Environmental Laboratory, U.S. Army Engineer Research and Development Center, developed an approach that measures the micro-topography of the terrain and is repeatable so that successive measurements can be made and the erosion or deposition occurring can be quantified. This report describes the initial efforts and data collection for a long-term study of the soil erosion/deposition processes active at Fort Benning, GA.

15. SUBJECT TERMS

Erosion	Fort Benning, Georgia	S-Tracker Survey
Deposition	SERDP	

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		22	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18