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THE USE OF REMOTE SENSING TECHNIQUES COMPARED TO TRADITIONAL ARCHAEOLOGICAL PHASE II TESTING METHODS : A COST-BENEFIT ANALYSIS

DES MOINES CBD LOOP ARTERIAL
PHASE II CULTURAL RESOURCES INVESTIGATION

PROJECT NO. M-2787(1)--81-77

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By:

BRICE, PETRIDES-DONOHUE & ASSOCIATES, INC.

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INTRODUCTION

Remote sensing was utilized in the Phase II Cultural Resources Investigation for this project in lieu of extensive excavations. The purpose of the present report is to compare the costs and benefits of the use of remote sensing to the hypothetical use of traditional excavation methods for this project. Estimates for this hypothetical situation are based on the project archaeologist's considerable past experience in conducting similar investigations. Only that part of the Phase II investigation involving field investigations is addressed in this report. Costs for literature review, laboratory analysis, report preparation, etc., are not included. The project manager proposed the use of this technique for the following logistic, safety and budgetary reasons.

°One of the primary reasons for its use was that the urban environment precluded the use of extensive excavation methods. Located in the downtown Des Moines area, most of the open space in the project area was covered by paved or bricked streets, paved or graveled parking lots, or railroad tracks. The only major unsurfaced area was a city park where the city wished to limit disturbance to a minimum. Other unsurfaced areas were located adjacent to the railroad tracks, but railroad regulations prohibited any excavation within 20 feet of trackage for safety reasons. In addition to the disruption to the traffic and parking services provided by these paved and graveled areas, the cost to excavate and restore these surfaces after excavation would have been prohibitive. Remote sensing was used to assess the potential for archaeological deposits to occur under these surfaces and the need for a Phase III excavation.

°Safety considerations were another factor favoring the use of remote sensing. Extensive excavations could pose safety hazards to passing pedestrians and project workers. An extensive dump area also posed the potential for slumping sides, gases and exposure to disease organisms.

By limiting the extent of excavation as much as possible, it was hoped to reduce the chances for accidents to occur.

°Another factor favoring the use of remote sensing over excavation was that the entire area was covered by considerable fill -- up to 6.5 feet in many locations. To remove this fill layer would have added considerable time and cost to the project.

The techniques used and the results of this remote sensing survey are presented in detail in another report, "Cultural Resources of the CBD Loop Arterial Project Area, Phase II Investigations." This report also cites several other archaeological projects which have successfully used remote sensing. Appendix A of the present report contains several pertinent figures from the aforementioned report.

ASSESSMENT OF REMOTE SENSING TECHNIQUES

Assessment of Cost Factors

Two remote sensing techniques were used for this project: an electromagnetic (EM) survey and a ground-penetrating radar (GPR) survey. The areas in which remote sensing was used are shown in Figure 1. This figure includes areas surveyed by electromagnetism, ground-penetrating radar or both.

The EM survey was conducted between June 26 and July 2, 1985. The data obtained in this survey served as reconnaissance information for the GPR survey. As a result of the EM survey, several areas were designated for further investigation with GPR. The cost of using electromagnetism is shown in Table 1. These cost figures were taken from the Management Information System reports on labor activity kept by the Brice, Petrides-Donohue office for this project.

The GPR survey was conducted between July 8 and July 11, 1985. GPR was useful both in refining data obtained in the EM survey and obtaining data where the EM survey encountered too much interference to be effective. Table 1 shows the cost of using GPR. The figures were obtained from the Management Information System reports for this project.

Some excavations were made in conjunction with remote sensing. Backhoe Trench No. 1 was excavated in Riverside Park to determine subsurface stratigraphy and geomorphology at the trench location. This information was then correlated with remote sensing data to ensure that reliable data was being obtained. Some anomalies in vegetated areas were excavated to determine the cause of the anomalies. The cost of these excavations is shown in Table 1. This cost was obtained from invoices received for these services.

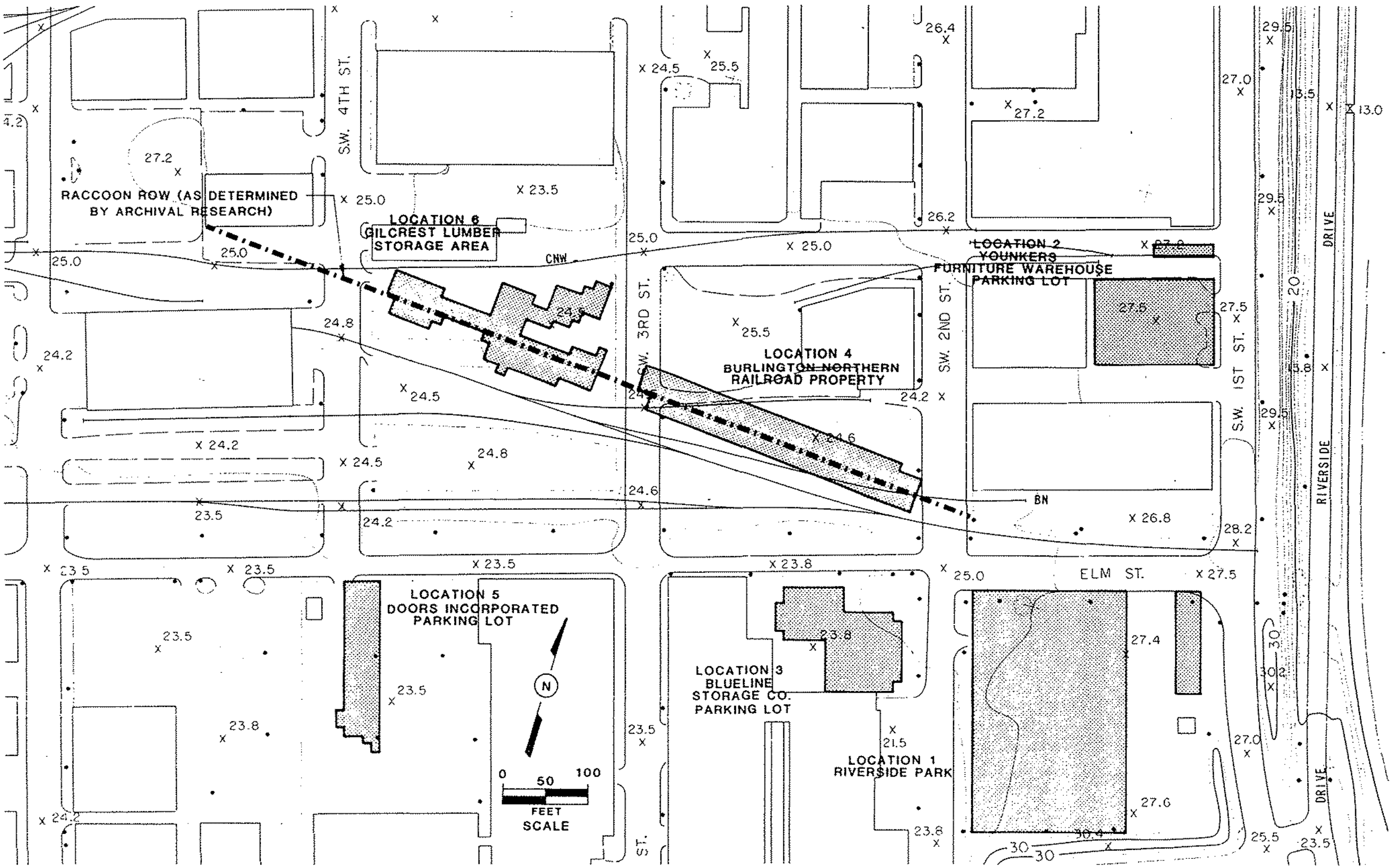

FIGURE 1 AREAS WHERE REMOTE SENSING WAS USED

TABLE 1

PROJECT COST OF REMOTE SENSING

Electromagnetism:	
Labor and Equipment	$ 5,276.00
Expenses (Travel and Per Diem)	1,013.00
Ground-Penetrating Radar:	
Labor and Equipment	9,148.00
Expenses (Travel and Per Diem)	892.00
Field Verification and Correlation:	
Backhoe Expenses	1,945.00
	$18,274.00

Correlations Between Remote Sensing and Excavations

At several locations, remote sensing results could be directly correlated with excavations or data obtained through archival research (Table 2). Unless otherwise noted, the remote sensing data was obtained at the same location where the backhoe trench was excavated.

The anomalies excavated were not the most promising anomalies resulting from the remote sensing surveys. Several anomalies which appeared to represent buried foundations, walls or other high potential features were located in areas where it was not possible to dig. Factors such as the type of surfacing in an area, the current usage of an area and property ownership often precluded excavating these areas at this stage of the project.

The purpose of using remote sensing in these areas at this stage was to assess the potential for buried features to exist and the need for Phase III excavations. The data gained from remote sensing will be useful in estimating the density of buried features, determining in which areas further excavation may be most productive and estimating the cost of Phase III work.

TABLE 2

SUMMARY OF CORRELATION BETWEEN
REMOTE SENSING DATA AND EXCAVATIONS

Feature	Location	Results: Remote Sensing	Results: Backhoe Trench or Literature Review	Comments
Top of Buried Terrace Escarpment	Riverside Park	*Grid Location 160S-170S (At BHT #1 Location)	*BHT #1 160S	
Depth of Fill Over-lying Top of Terrace	Riverside Park	5.0' (Average)	BHT #1 6.4'	The depth projected by remote sensing was an average for a more extensive portion of the terrace.
Depth of Fill Over-lying Buried City Dump	Riverside Park	6.5'	BHT #1 6.9'	
Depth to Buried "A" Horizon	Younker's Furniture Warehouse Parking Lot	5.0'	BHT #2 3.9'	The excavation was located approximately 5 feet from the remote sensing area where depth was determined.
	Burlington Northern Rail-road Property	2'-3'	BHT #4 2.2' BHT #5 2.4'	
Anomalies	Younker's Furniture Warehouse Parking Lot	Low Conduc-tivity Anomaly	BHT #2 Brick Hearth on Limestone Foot-ing Cause of Anomaly	
	Burlington Northern Rail-road Property	Spot Anomalies and Discontinu-ities	BHT #4 Prehistoric Material Found-Probably Not Cause of Anomaly	Anomaly probably caused by gravel fill, brick fragments, pebbles and cobbles overlying the buried "A" Horizon.

TABLE 2

SUMMARY OF CORRELATION BETWEEN
REMOTE SENSING DATA AND EXCAVATIONS
(Continued)

Feature	Location	Results: Remote Sensing	Results: Backhoe Trench or Literature Review	Comments
			BHT #5 Limestone Rubble Probable Cause of Anomaly	
	Gilcrest Lumber Storage Area	Spot Anomalies and Discontinuities	BHT #6 Historic Artifacts Found-Probably Not Cause of Anomalies	Anomaly probably caused by limestone cobbles and brick and limestone fragments overlying buried "A" Horizon.
	Blue Line Transfer Company	Low Conductivity Anomaly	Archival Research and Personal Interviews Indicate That This is the Remains of an Old Brewery Which Occupied This Location	

*Refer to Figure 4.3, Appendix A
BHT = Backhoe Trench

In this phase, emphasis was placed on excavating anomalies along the location of Raccoon and Des Moines Rows as determined by archival research (Figure 1). It was anticipated that these areas would provide cultural information most likely associated with Fort Des Moines No. 2.

As indicated in Table 2, remote sensing was successfully used to locate the buried terrace escarpment north of the filled abandoned channel of the Raccoon River (Figures 4.3 and 4.4, Appendix A). The probable extent of the buried city dump along this escarpment and the approximate amount of fill overlying the terrace and city dump were also determined. This remote sensing data correlated well with the stratigraphy and geomorphology exposed by Backhoe Trench No. 1 in Riverside Park.

GPR was also very useful in determining the depth of fill overlying the buried cultural surface (buried "A" Horizon) in most of the areas surveyed. This information is useful both in reconstructing the "lay of the land" during the time Fort Des Moines No. 2 and early Des Moines were occupied and in estimating costs associated with future Phase III work.

Several anomalies consisting of areas of high or low conductivity or changes in dielectric characteristics were located with remote sensing. GPR was used to determine the approximate depth of burial and extent of features causing these anomalies.

A summary of anomalies which were excavated in conjunction with remote sensing is presented in Table 2 and discussed in the following paragraphs.

°Low conductivity anomalies are often indicative of buried foundations, walls or other high density, nonmetallic areas. The brick hearth with limestone footings exposed in Backhoe Trench No. 2 was the cause of the low conductivity anomaly located at 20-40 South, 20 West (Figure 4.5, Appendix A). This excavation yielded substantial artifactual material postdating 1850.

°A GPR spot anomaly immediately above the "A" Horizon and discontinuities in the "A" Horizon appear to be expressions of the buried limestone rubble uncovered in Backhoe Trench No. 5 (Figure 4.8, Appendix A). Some prehistoric material consisting of small flakes and ceramic shards was found in this trench.

°The area, which was later excavated as Backhoe Trench No. 4, also exhibited discontinuities and spot anomalies (Figure 4.8, Appendix A). Prehistoric material similar to that found in Backhoe Trench No. 5 was found. However, it appears that the anomalies were caused by gravel fill, brick fragments, pebbles and cobbles overlying the buried "A" horizon.

°Backhoe Trench No. 6 was excavated in an area where GPR picked up some anomalies. A number of historic artifacts were recovered. It appears that limestone cobbles, as well as brick and limestone fragments, lying within the 27 cm above the buried "A" Horizon could be the cause of the anomalies.

°A large area of low conductivity located in the Blue Line Transfer and Storage parking lot is consistent with a buried foundation and related debris (Figure 4.7, Appendix A). This is most likely the remains of an old brewery which is recorded as once occupying this location.

ASSESSMENT OF TRADITIONAL ARCHAEOLOGICAL PHASE II TECHNIQUES

To obtain cost estimates for a traditional excavation approach, it was assumed that traditional methods would have been used in the same areas to obtain the same level of information acquired with remote sensing. The result is a conservative estimate which represents the anticipated minimal cost of using traditional archaeological methods. These cost estimates are based on the archaeologist's experience in conducting such projects.

It was judged that most of the area surveyed with remote sensing would have to have been excavated to obtain information similar to that obtained by remote sensing. This would involve several activities including:

°Removing pavement or paving bricks at some locations.
°Removing fill material.
°Skim shoveling and troweling by hand to expose features.
°Mapping the extent of the exposed features.
°Replacing and compacting the fill material.

Figure 2 shows the areas where excavation would have been required. It should be noted that the area of two locations (Riverside Park and Doors, Inc.) has been reduced somewhat from that covered by remote sensing. The remote sensing results indicate that the excavation of these reduced areas would provide a sufficient data base for these locations. The earlier cultural surface is buried by up to 6.5 feet of fill (Figure 2). This fill would have to be removed to expose the buried cultural surface. The cost of the removal, replacement and compaction of this fill with heavy equipment would be a substantial portion of the cost of using traditional methods (Table 3).

Once the cultural surface is exposed, skim shoveling and troweling by hand would expose archaeological features. It is not possible to provide precise cost estimates in this category. The cost of handwork is only

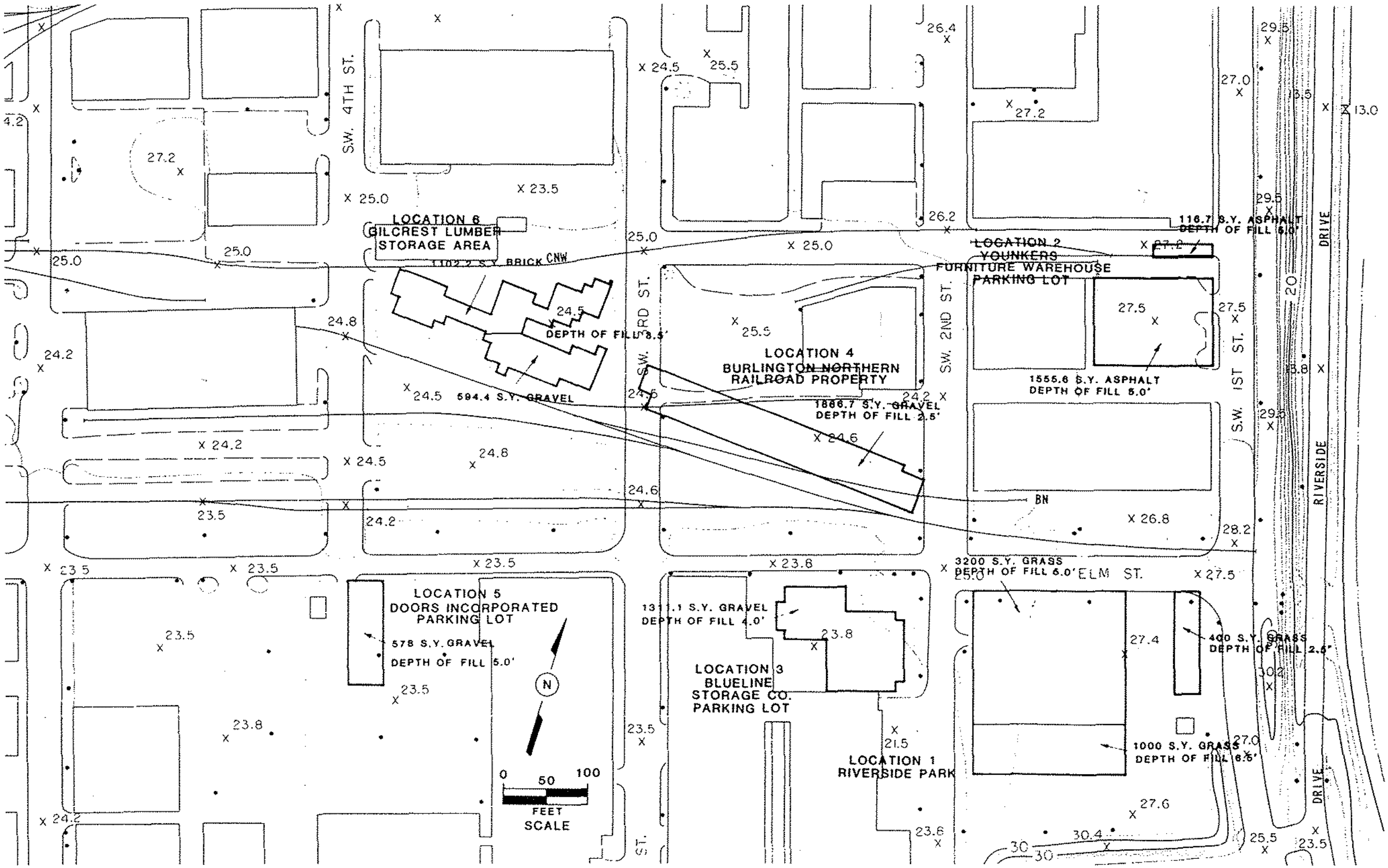

FIGURE 2 AREAS USED IN CALCULATING COST ESTIMATES FOR TRADITIONAL PHASE II SURVEY METHODS

approximate and depends on the density and type of features uncovered as well as the type of matrix involved.

Another variable to consider is the type of cultural material encountered. For instance, a high density of fragile organic material, such as human remains or birch bark wrapped cremations, would involve a great deal more handwork and more man hours to expose than a less fragile find.

It was estimated from past experience and the remote sensing results that approximately one-third of the total area included in the survey would require skim shoveling and troweling by hand. An estimated minimum expenditure in this category is shown in Table 3. It is anticipated that this would provide a level of information similar to that obtained with remote sensing. This minimal cost could double if any one of several situations previously discussed was encountered, including certain changes in the matrix, a high density of features, certain types of features, fragile cultural remains or some unforeseen conditions.

The archaeological features, thus exposed, would then be mapped. Time for only cursory mapping is included in the estimate. This would allow mapping comparable to that accomplished with remote sensing. It is estimated that mapping of features would be required for approximately one-fourth of the total survey area. The minimal cost of mapping is given in Table 3 as $14,371.00. This could easily double under any of the situations previously discussed.

TABLE 3

ESTIMATED COST USING TRADITIONAL ARCHAEOLOGICAL PHASE II INVESTIGATION METHODS (REFER TO APPENDIX B FOR INFORMATION USED IN COST ESTIMATE)

		Heavy Equipment		Field Crew Handwork		
Location	Surficial Material	Volume/Area	Cost	Area	Anticipated Minimum Cost	Total
Riverside Park	Grass	7,835 C.Y.	$78,350.00	S 13,800 S.F. M 380 S.Y.	$46,230.00 $ 2,527.00	$127,107.00
Younkers (Including Market Street)	Paving Brick & Asphalt	2,790 C.Y. P 1,672 S.Y.	$27,900.00 $ 6,688.00	S 4,965 S.F. M 418 S.Y.	$16,633.00 $ 2,780.00	$54,001.00
Blue Line Transfer	Gravel	1,748 C.Y.	$17,480.00	S 3,933 S.F. M 328 S.Y.	$13,175.00 $ 2,181.00	$32,836.00
Burlington Northern Railroad	Gravel	1,556 C.Y.	$15,560.00	S 5,600 S.F. M 467 S.Y.	$18,760.00 $ 3,105.00	$37,425.00
Doors, Inc.	Gravel	963 C.Y.	$9,630.00	S 1,733 S.F. M 144 S.Y.	$5,805.00 $ 958.00	$16,393.00
Gilcrest Lumber Company	Gravel	693 C.Y.	$6,930.00	S 1,784 S.F. M 149 S.Y.	$5,976.00 $ 991.00	$13,897.00
Gilcrest Lumber Company	Paving Brick	1,286 C.Y. P 1,102 S.Y.	$12,860.00 $ 4,408.00	S 3,307 S.F. M 275 S.Y.	$11,078.00 $ 1,829.00	$30,175.00
TOTAL COST			$179,806.00		$132,028.00 (S $117,657.00) (M $ 14,371.00)	$311,834.00

P = Removal of Pavement or Paving Brick
S = Skim Shoveling and Troweling
M = Mapping Extent of Features Exposed

Note: This table gives minimum anticipated cost to obtain the same level of information as that gained with remote sensing.

RESTORATION COSTS

The costs of surface restoration are compared in Table 4. The only surface restoration required with remote sensing was cleanup and reseeding of the backhoe trench in Riverside Park. This work is only partially completed, but it is estimated to cost approximately $900.00. Figure 2 shows the areas which would require surface restoration if traditional archaeological methods had been used. The square yardage and type of existing surface material are also shown in this figure.

Areas with any surficial treatment such as paving brick, asphalt, gravel or grass would require some form of surface restoration. These cost estimates are presented in Table 4. For the purpose of estimating, it was assumed that all areas currently in paving brick would be patched with asphalt.

TABLE 4

ESTIMATED COST OF SURFACE RESTORATION

Location	Surficial Material	Surface Restoration Area	Surface Restoration Cost
REMOTE SENSING			
Riverside Park*	Grass	0.28 Acre	$ 900.00
Total			$ 900.00
TRADITIONAL METHODS			
Riverside Park*	Grass	0.95 Acre	$ 2,450.00
Younkers (Including Market Street)	Paving Brick and Asphalt	1,672 S.Y.	234,080.00
Blue Line Transfer	Gravel	1,311 S.Y.	47,450.00
Burlington Northern Railroad	Gravel	1,867 S.Y.	68,133.00
Doors, Inc.	Gravel	578 S.Y.	21,097.00
Gilcrest Lumber Company	Gravel	594 S.Y.	21,697.00
Gilcrest Lumber Company	Paving Brick	1,102 S.Y.	154,280.00
Total			$549,187.00

*Includes labor to clean up dump and fill debris.

CONCLUSIONS

The use of remote sensing was more cost-effective than traditional archaeological techniques for this project. The cost of remote sensing was approximately six percent of the estimated costs of the hypothetical excavation method (Table 3).

The surface restoration cost estimate associated with remote sensing would be approximately 0.2 percent of that estimated for using traditional methods (Table 4).

Table 5 summarizes other advantages of using remote sensing on this project. It also points out the disadvantages of this technique.

TABLE 5

OTHER ADVANTAGES AND DISADVANTAGES OF REMOTE SENSING COMPARED WITH TRADITIONAL ARCHAEOLOGICAL TECHNIQUES

ADVANTAGES

°Is faster.
°Does not disturb the landscape.
°Provides continuous record.
°Targets areas for Phase III excavation.
°Can be used in areas not accessible with heavy equipment.
°Can penetrate to deeply buried layers.
°Provides basis for developing cost estimates for Phase III budget.
°Does not pose safety hazards that an excavation would.

DISADVANTAGES

°Is subject to some forms of interference.
°Interpretation of data does not provide same level of detail as if the feature was physically unearthed.
°After a feature is located using traditional archaeological methods, it is exposed and ready for further study. This is not the case with remote sensing.

APPENDIX A

SELECTED FIGURES FROM
CHAPTER 4 OF THE
CULTURAL RESOURCES OF THE CBD LOOP
ARTERIAL PROJECT AREA, PHASE II INVESTIGATION REPORT

REMOTE SENSING MAPS

ELECTROMAGNETIC LEGEND

40 —— 40	ELECTROMAGNETIC CONTOUR LINE
A	LOCATION OF FILLED BACKHOE TRENCH
	AREAS OF LOW CONDUCTIVITY DISCUSSED IN TEXT
B—— ——B	ESTIMATED LOCATION OF THE TOP OF THE BURIED TERRACE ESCARPMENT
B′—— ——B′	ESTIMATED LOCATION OF THE BASE OF THE BURIED TERRACE ESCARPMENT

GROUND PENETRATING RADAR LEGEND

|——|	LOCATION OF IMPORTANT ANOMALIES
	LOCATION OF SPOT ANOMALIES
	AREA OF HIGH CONDUCTIVITY
B—·—·B	LOCATION OF THE TOP OF THE BURIED TERRACE ESCARPMENT

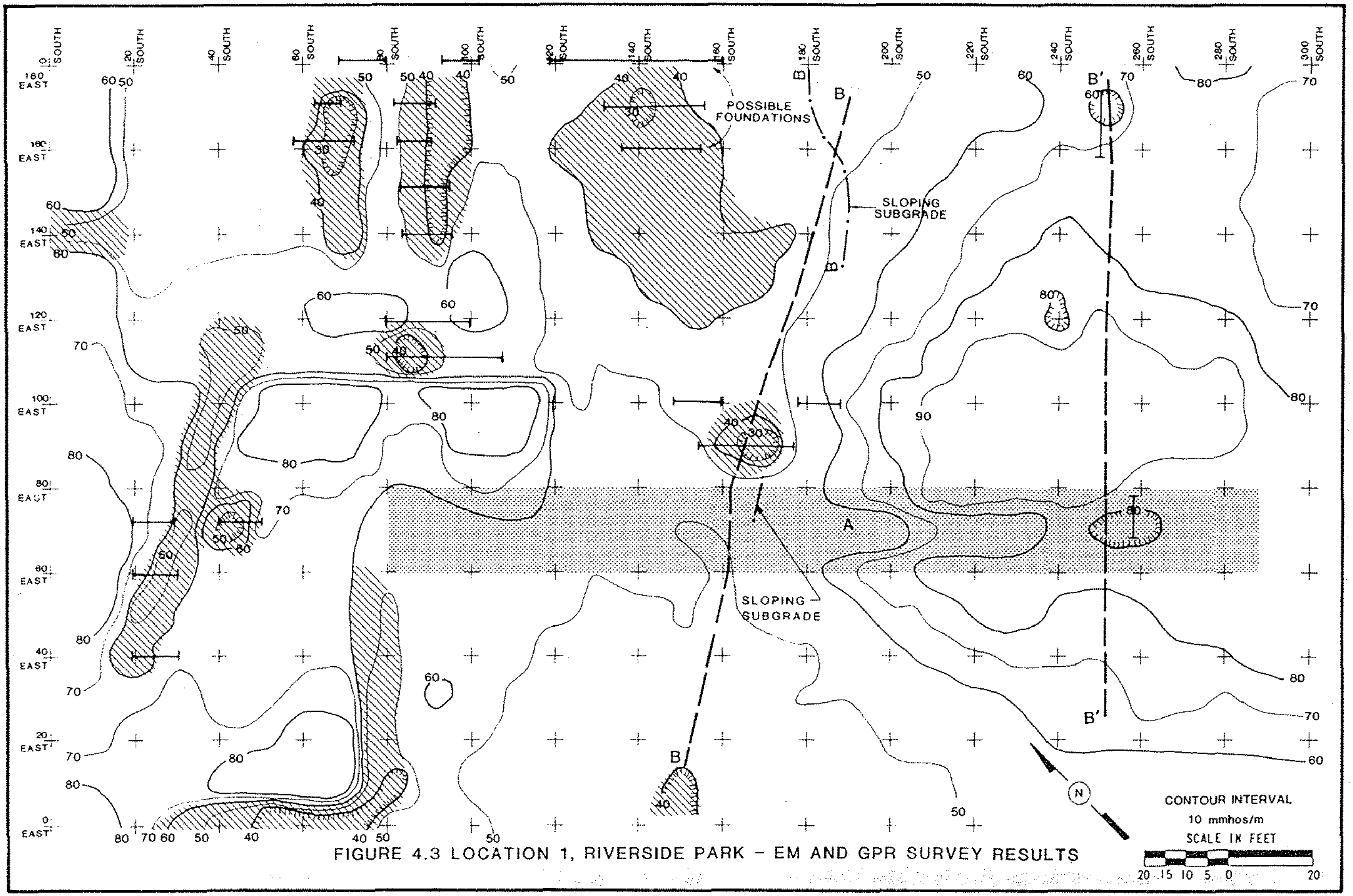

FIGURE 4.3 LOCATION 1, RIVERSIDE PARK – EM AND GPR SURVEY RESULTS

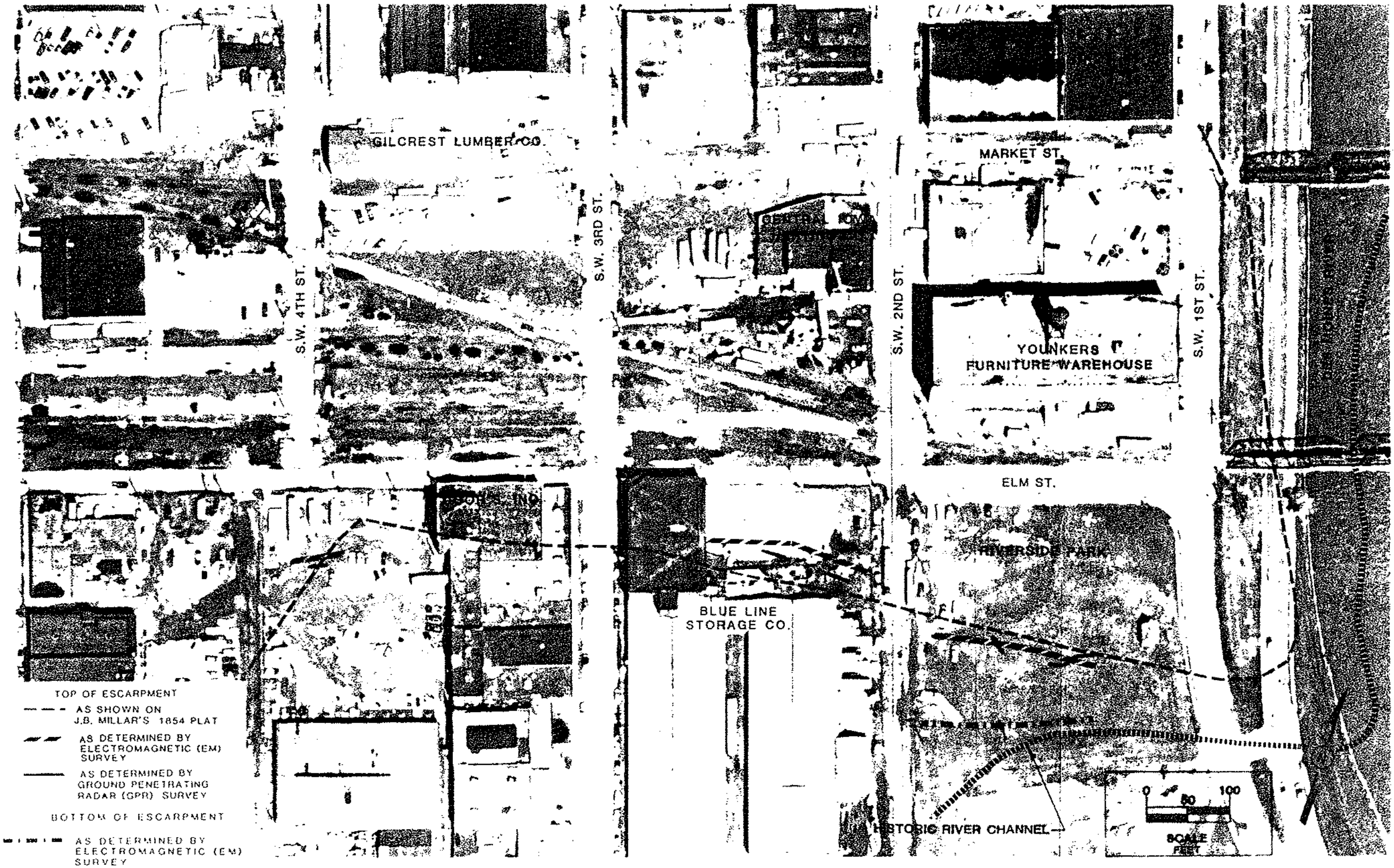

FIGURE 4.4 LOCATION OF TERRACE ESCARPMENT

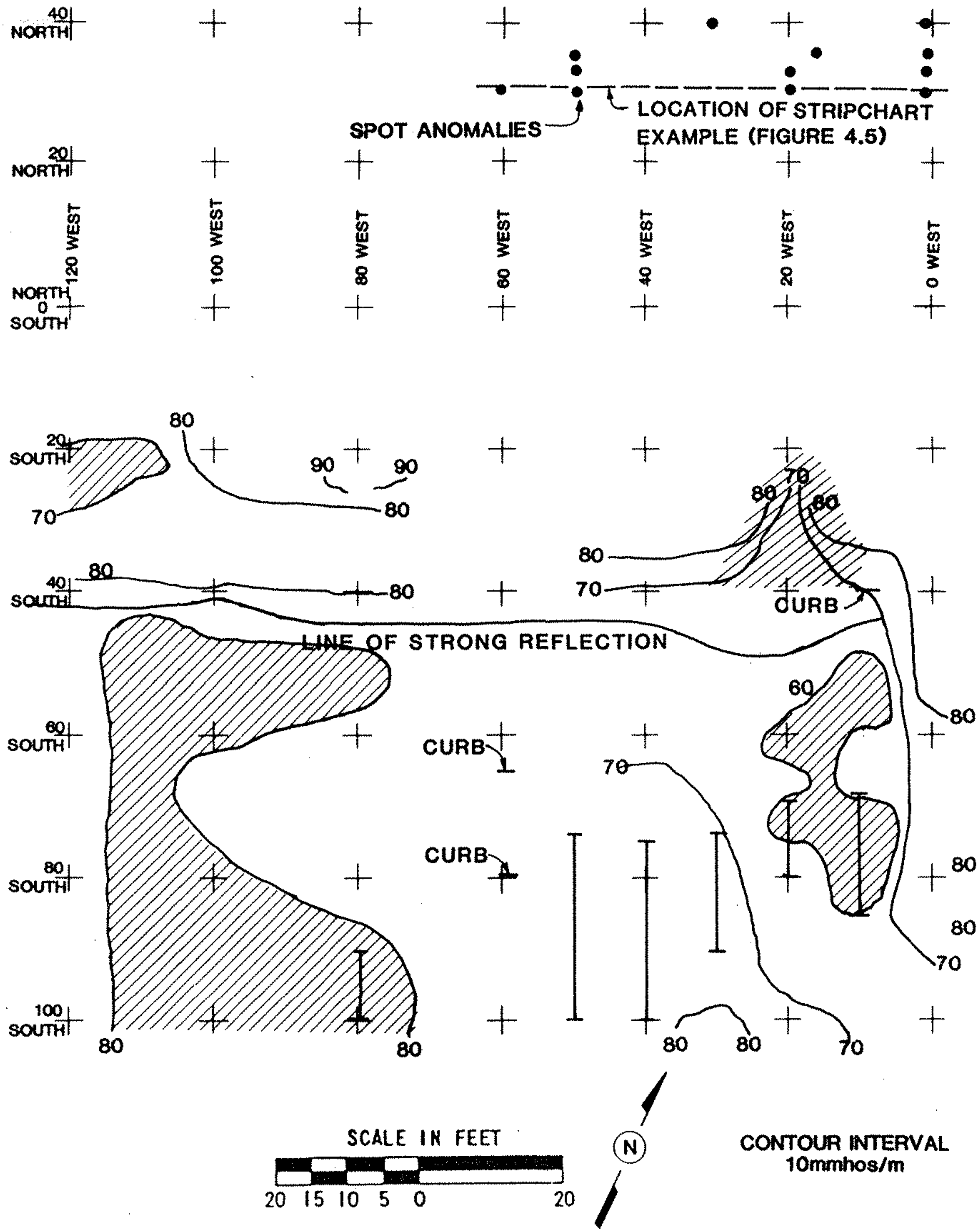

FIGURE 4.5 LOCATION 2, YOUNKERS FURNITURE WAREHOUSE PARKING LOT - EM AND GPR SURVEY RESULTS

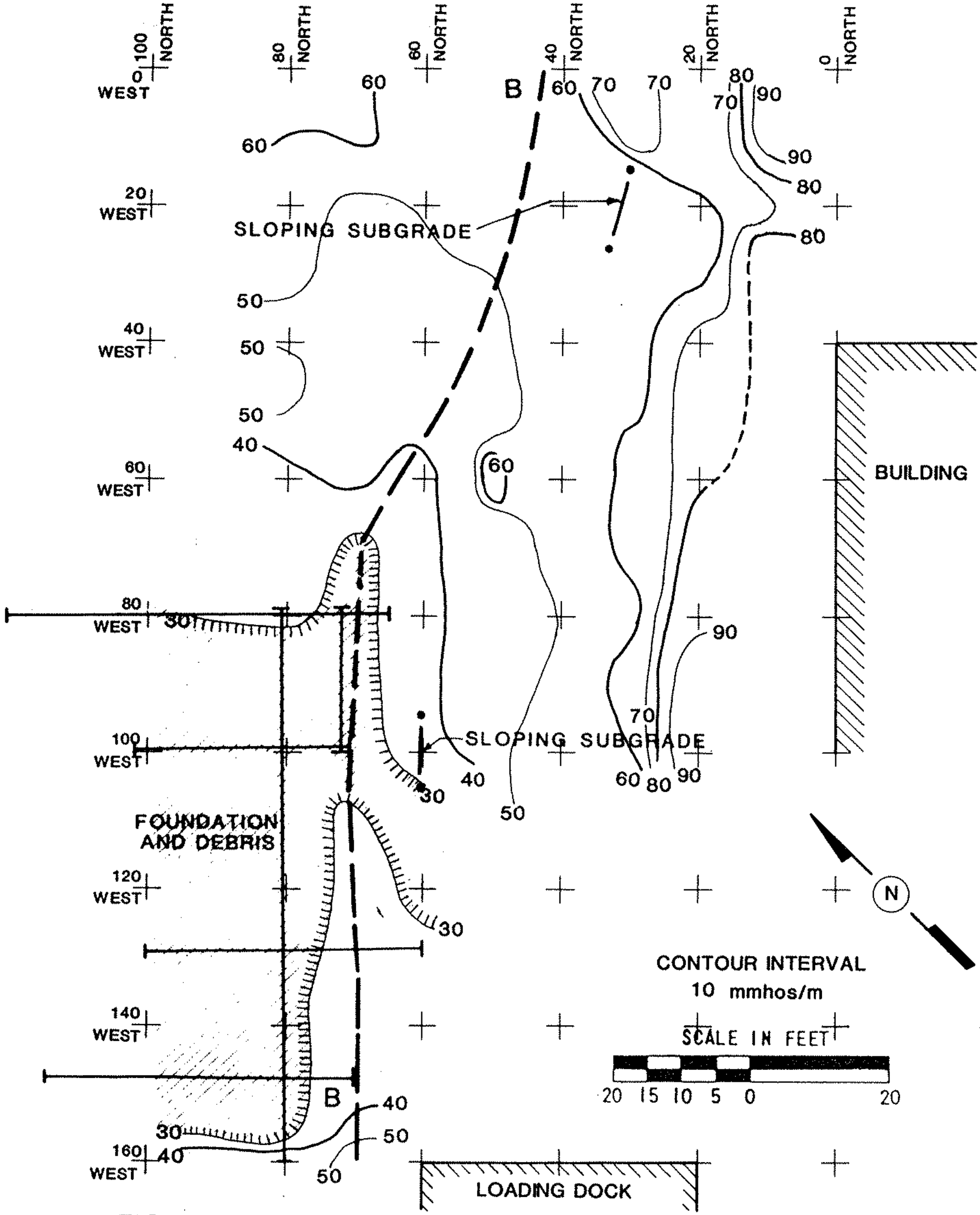

FIGURE 4.7 LOCATION 3, BLUE LINE TRANSFER & STORAGE PARKING LOT – EM AND GPR SURVEY RESULTS

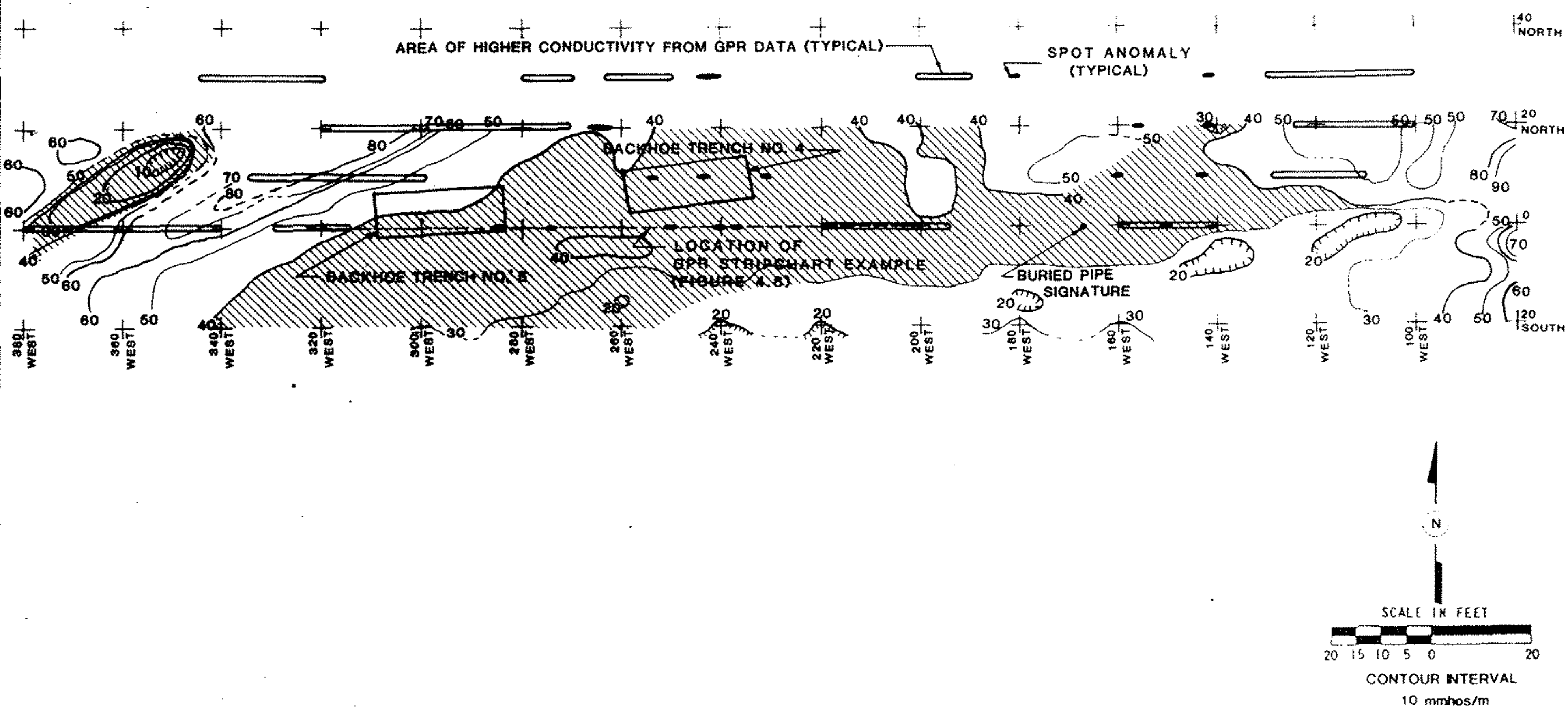

FIGURE 4.8 LOCATION 4, BURLINGTON NORTHERN RAILROAD PROPERTY - EM AND GPR SURVEY RESULTS

APPENDIX B

CALCULATIONS AND COSTS USED IN ESTIMATES

TABLE B.1

AREA AND VOLUME CALCULATIONS

Grassy — Riverside Park

(28,800 S.F.)(5') = 144,000 C.F.
(9,000 S.F.)(6.5') = 58,500 C.F.
(3,600 S.F.)(2.5') = 9,000 C.F.

41,400 S.F. 27/211,500 C.F. = 7,833.3 C.Y.

Asphalt & Brick — Younkers Parking Lot

140' x 100' = 14,000 Ft.^{2}
15' x 70' = 1,050 Ft.^{2}

15,050 Ft.^{2} (5') = 75,250 C.F. = 2,787.0 C.Y.

Gravel — Blue Line Storage

10' x 70' = 700 Ft.^{2}
80' x 90' = 7,200 Ft.^{2}
20' x 30' = 600 Ft.^{2}
50' x 60' = 3,000 Ft.^{2}
10' x 30' = 300 Ft.^{2}

Total 11,800 Ft.^{2} (4') = 47,200 C.F. = 1,748.0 C.Y.

Gravel — Burlington Northern Railroad Property

320' x 40' = 12,800 Ft.^{2}
10' x 20' = 200 Ft.^{2}
30' x 30' = 900 Ft.^{2}
10' x 290' = 2,900 Ft.^{2}

Total 16,800 Ft.^{2} (2.5') = 42,000 C.F. = 1,556.0 C.Y.

Gravel — Doors, Inc.

(40)(130) = 5,200 S.F. (5') = 26,000 C.F. = 963 C.Y.

Gravel — Gilcrest Lumber Storage Area

40' x 40' = 1,600 Ft.^{2}
10' x 10' = 100 Ft.^{2}
60' x 40' = 2,400 Ft.^{2}
10' x 10' = 100 Ft.^{2}
35' x 30' = 1,050 Ft.^{2}
10' x 10' = 100 Ft.^{2}

Total 5,350 Ft.^{2} (3.5') = 18,725 C.F. = 693.0 C.Y.

TABLE B.1

AREA AND VOLUME CALCULATIONS
(Continued)

Asphalt	40' x 20' =	800 $Ft.^2$
	10' x 40' =	400 $Ft.^2$
	40' x 30' =	1,200 $Ft.^2$
	10' x 10' =	100 $Ft.^2$
	20' x 20' =	400 $Ft.^2$
	58' x 40' =	2,320 $Ft.^2$
	30' x 50' =	1,500 $Ft.^2$
	10' x 40' =	400 $Ft.^2$
	50' x 50' =	2,500 $Ft.^2$
	10' x 30' =	300 $Ft.^2$
	Total	9,920 $Ft.^2$ (3.5') = 34,720 C.F. = 1,286 C.Y.

TABLE B.2

PRICES USED IN COST ESTIMATES

Remove Paving Brick or Asphalt	$4.00/S.Y.
Remove, Replace and Compact Fill Material Lying Above Buried A Horizon Using Heavy Equipment	$10.00/C.Y.
Skim Shoveling and Troweling - Three-Person Crew Consisting of One Archaeologist and Two Crew Members - Rate: 30 S.F./Hour	Minimum Cost
Map Extent of Archaeological Features Located - Three-Person Crew Consisting of One Archaeologist and Two Crew Members - Rate: 15 S.Y./Hour	Minimum Cost
Surface Restoration of Grassed Areas, Including Seedbed Preparation, Fertilizing, Seeding and Mulching	$1,000/Acre
Surface Restoration of Graveled Parking Areas, Including Surface Preparation and Installation of Six Inches of Gravel	$36.50/S.Y.
Surface Restoration of Paved Areas, Including Surface Preparation and Installation of a Four-Inch Gravel Base and Four Inches of Asphalt (Areas Currently Paved With Brick Would be Replaced with Asphalt)	$140/S.Y.