APPENDIX D

SUPPORTING STUDY – GEOTECHNICAL RED FLAG SUMMARY REPORT
.

BARR AND PREVOST

RED FLAG SUMMARY REPORT

HAM-32F-0.00
PID 86461

RELOCATED SR-32 SEGMENT 1

RED BANK CORRIDOR IMPROVEMENTS

EASTERN CORRIDOR MULTIMODAL PROJECTS

HAMILTON COUNTY, OHIO

URS

URS Corporation
564 White Pond Dr.
Akron, OH 44320

SUPPORTING STUDY
GEOTECHNICAL RED FLAG REPORT
EASTERN CORRIDOR MULTI-MODAL
TRANSPORTATION PROJECTS
HAM-32F-0.00
RED BANK CORRIDOR IMPROVEMENTS: I-71 TO US-50
SR-32 SEGMENT 1

HAMILTON COUNTY, OHIO
PID# 86461

For:

URS
564 White Pond Drive
Akron, Ohio 44320

Submitted by:

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

9420 Towne Square Avenue, Suite 22
Cincinnati, OH 45242
Voice: 513.936.9400
Fax: 513.936.8400

February 8, 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS (follows text)

LIST OF APPENDICES

SUPPORTING STUDY
GEOTECHNICAL RED FLAG REPORT
EASTERN CORRIDOR MULTI-MODAL
TRANSPORTATION PROJECTS
HAM-32F-0.00
RED BANK CORRIDOR IMPROVEMENTS: I-71 TO US-50
SR-32 SEGMENT 1
HAMILTON COUNTY, OHIO
PID# 86461

EXECUTIVE SUMMARY

This report supports Barr & Prevost's geotechnical contribution to the Red Flag Summary Report for the HAM-32F-0.00 Project (PID #86461) SR-32 Segment 1, one of the Eastern Corridor multi-modal transportation projects planned for Hamilton County. This phase of the project will upgrade Red Bank Expressway from the existing I-71/Red Bank Road interchange to Red Bank /US 50 interchange, a total length of about 2.5 miles. The purpose of the report is to provide an overview of geotechnical conditions along the proposed alignments and identify issues that might require special study or engineering during design.

This segment will expand or closely follow the existing Red Bank Expressway alignment (Red Bank Expressway extends from I-71 to Brotherton Road beyond which it reverts to Red Bank Road) alignment together with a series of local area network access streets. The study was based on existing data and literature that were collected from public agencies, combined with a field reconnaissance.

Geologically, much of the proposed alignment is underlain by variable but significant thicknesses of valley fill that were deposited in the buried valleys of the ancestral Ohio and Licking Rivers. These tend to be dominantly fine-grained deposits, some of which are glacially compacted material (till). Recent fine-grained floodplain deposits mantle the southern part of Segment 1. Bedrock is more than 100 feet (ft) deep along much of this segment.

Improvements may include various bridge structures, retaining walls, drainage structures and cut/fill operations either for new facilities or for modifications to existing infrastructure, depending on the final suite of improvements selected.

In general the geotechnical issues facing designers are typical of this part of Ohio; challenging subgrade conditions for road construction and the need for deep foundations for bridge structures - probably requiring friction piles. Improvements to the local area network of streets may call for the creation of links between existing roads that are, in two cases, separated by abrupt elevation changes. Several retaining walls will be required, the design of which may, in some cases, be complicated by the presence of existing new walls within the same slopes at those locations.

1. INTRODUCTION

1.1. General

This report presents the results of a geotechnical Red Flag Study for the proposed new highway capacity for Red Bank Expressway (relocated SR-32), a component of the Eastern Corridor multi-modal transportation improvement program in Hamilton and Clermont Counties, Ohio. Highway alternatives for the Eastern Corridor were developed for four geographic segments of the project study area, of which part of Red Bank Road/Red Bank Expressway is Segment 1. Total new highway length for all segments combined is about 12.6 miles. Segment 1 is described in the Tier 1 Final Environmental Impact Statement as:

> "........... roadway improvements involve consolidation and management of access points along existing Red Bank Road and Red Bank Expressway in order to establish a controlled access arterial roadway of improved capacity and safety from I-71 to US 50. This segment has a total length of about 2.5 miles, and would expand or closely follow the existing roadway alignment" (US DOT, 2005).

The purpose of this study is to present an overview of the geotechnical conditions along the alignment and identify potential areas of concern to be considered either in design or construction planning. The findings are also summarized in tabular form for inclusion in the overall project Red Flag Summary Report. The study area is shown in Exhibit 1.

Data that can be used to evaluate subsurface conditions in this area are abundant and sources such as the Ohio Department of Transportation (ODOT) Geotechnical Branch, Ohio Department of Natural Resources (ODNR) and the State of Ohio Geographic Information Systems metadata explorer system all contributed to the accumulated data set, together with some private sector sources. The data used in the study has been described in the references section.

1.2. Geographic Information System (GIS)

Spatial geographic data regarding geology, hydrology and hydrogeology and soil type is readily available from government agencies in electronic format. Relevant data were collected and used to develop a baseline picture of conditions along the proposed alignments using geographic information system (GIS) software (GRASS 6.4, 2010). All materials used are described in the References section of this report. Each of the GIS-based exhibits for the report is based on a portable network graphic (png) exported from the GIS to a Scalable Vector Graphics (SVG) Editor (Inkscape, 2010).

2. ROUTE

The feasible alternatives framework previously developed for Segment I has evolved to consist of two main components: highway mainline along Red Bank Expressway and a local access roadway network, as summarized below:

- Highway mainline alternatives incorporating either Grade Separated Tight Diamond Intersections (TDI) or Continuous Flow Intersections (CFI) at Madison Road and Erie Avenue intersections.

- Two side road/intersection improvement options for consolidating traffic access points to Red Bank Road/Red Bank Expressway and improving local access (Alternatives LAN1 and LAN2).

Interchange options at US 50 are not included in this segment.

The study area shown in Exhibit 1 is based on a 500-foot buffer around the currently defined road alignments. This forms the approximate boundary within which data were collected, although in some cases data from well outside this zone have been considered where it was thought to be relevant to, say, the description of soil types in a particular geomorphological zone.

The alignment of the improved mainline follows generally that of the existing Red Bank Road and Red Bank Expressway. (Red Bank Expressway extends from I-71 to Brotherton Road beyond which it reverts to Red Bank Road.) The differences between alternatives lie in the type of interchange that will be constructed at the two major intersections (Madison Road and Erie Avenue). The two local area network alternatives (LANs) differ in limited respects; in particular the routing of LAN traffic in the vicinity of US 50. The project will involve four main elements from a geotechnical standpoint: grade separation structures, drainage structures, retaining walls and paving. Table 1 presents a summary of the proposed structure types and locations that may be of interest from a geotechnical stand point (Balke-American, 2006). This is intended to focus the rest of the study by highlighting areas within the overall project boundary where there are multiple possible geotechnical inputs that will be required for design.

Table 1: Red Bank Road/Red Bank Expressway by Component

Component	Alternatives	Action/Structure [1]	Site Location (Exhibit 1)
Proposed Mainline	Grade Separated Tight Diamond Intersection (TDI) at Erie Avenue.	Erie Avenue bridge spanning the SORTA Oasis RR needs to be widened.	1
		Erie Avenue bridge spanning Duck Creek needs to be widened.	2
		Retaining walls need to be constructed to keep fill away from the Duke Energy substation close to the Mainline north of Erie Avenue.	3
		A retaining wall needs to be constructed to keep fill slope close to the Mainline at the culvert crossing at Corsica Hollow.	4
		The tight diamond ramps, being close to the Mainline, will require retaining walls near Erie Avenue on the east side of the Mainline.	5
	Continuous Flow Intersection (CFI) at Erie Avenue.	Relocated Erie Avenue spans the railroad with a new bridge, located such that part-width construction is possible.	1
		A new bridge is needed over the SORTA Oasis RR due to change of grade as required by the CFI.	1
		The Erie Avenue bridge over Duck Creek needs to be widened to accommodate tapers from the Erie Avenue widening and Hike/Bike facilities.	2
		Retaining walls are needed on the north side of Erie Avenue at the Erie Woods Apts.	6

[1] Balke-American, 2006.

Table 1: Red Bank Road/Red Bank Expressway by Component (continued)

Component	Alternatives	Action/Structure (1)	Site Location (Exhibit 1)
Proposed Mainline		The Erie Avenue Bridge over Duck Creek needs to be widened.	2
	TDI at Madison Road.	A larger bridge opening under Indiana and Ohio RR and Upper Access is proposed similar to the Madison Road/CFI alternative.	7
		The ramp from Madison Road to Duck Creek will require the existing channel to be relocated. A retaining wall in the vicinity will lessen the distance of the relocation and lessen the amount of RW required.	8
		A grade-separated intersection at Duck Creek Road will require a new bridge over Red Bank Expressway.	22
		A retaining wall is needed between the ramp and the Mainline.	9
		Retaining walls are needed to maintain the channel on both sides of Deerfield Creek at the north end of the Madison Road/NW ramp to I-71.	10
	CFI at Madison Road.	New RR structure-shorten the length of the structure.	7
		Widening of Madison Road requires a new culvert.	11
		The culvert under Madison Road/Mainline intersection needs to be extended to accommodate the widening for the CFI.	12
		A new culvert is needed to convey Duck Creek Road to the channel on the east side of the Mainline.	13
		An extension of the existing culvert is needed to accommodate the widening in the same vicinity for the Mainline.	14

Table 1: Red Bank Road/Red Bank Expressway by Component (continued)

Component	Alternatives	Action/Structure [1]	Site Location (Exhibit 1)
Local Access Network	LAN1 & 2	A bridge is required for Indiana and Ohio RR crossing.	15
		A bridge is required for Jonlen Drive crossing.	16
		A retaining wall needs to be constructed to keep fill slope out of the existing oxbow on the west side of South Access.	17
		A retaining wall needs to be constructed to keep fill slope out of East Tributary near Jonlen Drive.	18
		A retaining wall needs to be constructed near Shannon Way very near existing buildings to the south.	19
		A retaining wall needs to be constructed on the east side of Red Bank Road to keep the slopes away from the buildings in Erie Avenue Woods and Fountain Apts and the west side for the existing development in Corsica Hollow.	20
		A culvert crossing is needed to maintain positive drainage along South Access to oxbow of Duck Creek.	21

3. TOPOGRAPHY

The topography of the Cincinnati area has been strongly influenced by its glacial history and while seemingly complex, its evolution has been simply but succinctly described (Fenneman, 1916):

> 'A structure of nearly horizontal thin-bedded limestone and shale, reduced to an almost perfect peneplane, uplifted to about 900 feet above the sea and trenched at least 400 feet by large through-flowing streams (Ohio, Miami, and Little Miami), dissected by tributaries

> in dendritic fashion almost to maturity near the major valleys but elsewhere young in the cycle following uplift; glaciated (except the southerly border), without glacial erosion and with deposition sufficient to obliterate only the smallest valleys; the master streams displaced in parts by the ice, taking new courses which they have since retained. The larger valleys partly filled by till and glacial outwash, which have since been in part removed.'

Almost every facet of this description is relevant when describing the geography of this project area. The landforms through which it will pass are shown in Exhibit 2, a vertically exaggerated (x15) shaded elevation map based on the statewide 10 meter (m) Digital Elevation Model (DEM) coverage, resampled.

The alignment generally follows the valley of Duck Creek as it flows south towards the Little Miami River (LMR) over glacially deposited soils that occupy the ancestral channel of the Ohio/Licking River. The project neatly spans the ancestral valley from north to south and the depth to bedrock varies accordingly. The high ground shown north and south of the project area is typical of the ~900 ft elevation peneplane and the 400 ft of entrenchment is exemplified by the >200 ft depth of the former river channel that occurs in the vicinity of Madison Road, as shown in Exhibit 3.

The actual topography of the project area is quite subdued with an overall elevation change of only about 50 ft from US-50 up to the I-71 ramp (elevation 527-579 ft). Greater lateral variation exists, and some LAN streets climb that much in less than half a mile as they rise out of the relatively shallow, but steep sided valley of Duck Creek.

4. GEOLOGY

The geomorphologic processes leading to the current landscape are discussed briefly above. This section provides a more detailed description of local geology. The area is underlain by rocks representing the Cincinnatian Series of the Upper Ordovician. These are predominantly shale deposits of the Kope and Fairview formations that are exposed in the Ohio River and LMR valley walls (Fleming, 1975). These formations include lesser amounts of limestone, generally in layers less than 6-12 inches thick. The contact between the Kope and Fairview generally occurs at about elevation 700 feet. Below the Kope the Middle Ordovician begins with a succession of limestone formations. No karst has been mapped in the Red Bank Road/Red Bank Expressway area (ODNR, 2002).

Topography and soil coverage tend to reflect the effects of glaciation even though the City of Cincinnati itself was south of the glacial margin during the two most recent advances (Illinoian and Wisconsinan). Illinoian till is found to the north of the city and partly within the general study area. The erosion of deep, steeply sided valleys by glacial melt water has repeatedly altered the drainage pattern in the area and subsequent infilling of these valleys with glacial outwash and, more recently, with floodplain alluvium creates a landscape that masks the historical features, but which strongly influences soil conditions in the area. Bedrock on the higher ground tends to be mantled with a relatively thin soil cover consisting of glacial till or, on slopes, colluvium.

The overburden thickness along Red Bank Road/Red Bank Expressway is shown on Exhibit 3, derived from the 10 m ground surface DEM combined with the statewide bedrock surface analysis (ODNR, DGS, 2004). Where zero is indicated on higher ground, some minor soil cover can be expected. The striking feature in Exhibit 3 is the extent of the buried valley system associated with ancestral valley of the Ohio/Licking Rivers as it swings to the northwest into what is known as the Norwood Trough. The thickness of infill deposits varies from almost zero to more than 200 feet, changing rapidly depending on proximity to the bedrock valley walls.

Exhibit 4 is a surficial geology map covering the proposed project area. The nearby shale and limestone highlands mantled with till are evident to the southwest and northeast, generally beyond the study area boundaries, but the buried valley containing deposits of clay, sand, and silt, is readily apparent and dominates the study area. Within the valley, four stratigraphic profiles are mapped. The first (over which Segment 1 of the main line begins - just south of the I-71/ Red Bank Expressway interchange) consists of a thick, up to 40 ft-layer, of Illinoian-age loam till overlying 160 ft of inter-layered fine sand, silt and clay of lacustrine and deltaic origin. The second profile consists of up to 250 ft of the same fine sand, silt and clay, but absent the till mantle. The third profile is the dominant one beneath the Red Bank Road/Red Bank Expressway alignment and again consists of about 180 ft fine sand, silt and clay but mantled with up to 10 ft of Wisconsinan age silt. The fourth profile at the south end of the segment is underlain by Holocene (recent) alluvium that can vary from silt to boulders and is generally up to 20 ft thick. Given its proximity to the valley wall, it is likely that the alluvium overlies bedrock.

The US Department of Agriculture, Natural Resources Conservation Service (2010) mapping of the shallow soil coverage in the area was reviewed to assess potential subgrade conditions along the main line and side streets. The most common map unit names in the area of interest include Bonnell silt loam, Genesee-Urban and Rossmoyne-Urban land complexes. These are all considered 'Very limited' from the standpoint of local road and street development because of their low strength, shrink swell and frost action potential. The AASHTO group classifications are estimated to be A-4, and the entire project area falls within these unit and group classifications.

Earthquake hazard analysis in this part of the country is dominated by proximity to the New Madrid Fault Zone (NMFZ) approximately 330 miles to the southwest. Possible future movements along this fault could generate earthquakes of magnitude 7.0-8.0 with a recurrence period of 500-1,500 years (USGS, 2008). The resulting ground motion would be experienced over a wide area, with Cincinnati located within the likely zone of influence. A cluster of earthquake epicenters of lesser magnitude (< ~ magnitude 5) about 150 miles north of Cincinnati indicates another potential earthquake source area that is contributory to seismic risk (ODNR, 2005).

5. HYDROLOGY/HYDROGEOLOGY

The buried valley infill deposits form a regionally extensive and important sole source aquifer system known as the Great Miami Aquifer that extends along the valley of the Great Miami River, west of Cincinnati, through the Norwood Trough (along the ancestral valley of the Ohio/Licking Rivers) and into the valley of the LMR. The study area lies completely within the boundary of this sole source aquifer. Based on well logs (see below), the yield in this part of the aquifer is relatively low; probably because of the dominance of finer grained infill deposits than are found, say, in the LMR valley.

A stabilized groundwater table can be expected at the approximate elevation of Duck Creek, the dominant surface water body in the vicinity. In areas of localized ground water withdrawal the water table may be depressed below this level. On the higher ground and along the valley walls, groundwater may occur discontinuously as perched systems.

6. PREVIOUS STUDIES AND EXISTING GEOTECHNICAL DATA

Three primary sources of existing geotechnical data were used to support this study: ODOT's archive of geotechnical exploration reports, the ODNR water well log inventory, and the results of third party geotechnical/geo-environmental studies at two sites along the expressway. While there are undoubtedly other sources, these yielded sufficient data and created an adequate basis for the level of study.

6.1. ODOT Geotechnical Exploration Reports

The ODOT Falcon Geotechnical Docket Management System (GDMS, 2010) web-based archive of geotechnical information produced data from eight geotechnical explorations either within or close to the study area. These range from structure foundation explorations for various bridges to geotechnical exploration of an area afflicted by slope instability. The projects are listed below in Table 2.

The US-50/Red Bank Road listing refers to the 1958 foundation investigations for four bridge structures along a 2,200-ft segment of Columbia Parkway that roughly corresponds to the south edge of the study area. At the west end of that series of projects even the shallow 20 and 30 ft deep borings encountered shale bedrock; further to the east, the valley fill becomes deeper and less fine grained with dominant soil types shifting from A-7-6 (alluvium) to A-1 and A-2 (sands and gravels) consistent with the geological mapping.

Just north of the Duck Creek Road intersection with Red Bank Expressway, the embankment experienced a slope failure in ~1971. The problem was attributed to poor construction practices (excessively wet fill placed on a sloping surface without benching) rather than instability of a natural formation such as the common local culprit, the Kope Formation. The investigation into the cause showed the embankment fill to be silty clay and the foundation soils to be stiff silty clay - probably glacial till, and consistent with the geological mapping.

Further north two projects relating to the original construction of I-71 (I-71 over Red Bank Road and the current Red Bank Expressway ramp system) were investigated in 1965. These are located slightly outside the study area, but serve to characterize soils at the north end of the project which are predominantly hard or stiff glacial till to the depths explored (~50 ft), again consistent with the geological mapping.

The locations of the geotechnical exploration sites are shown on Exhibit 4.

Table 2: ODOT Geotechnical Explorations

Location Number (Exhibit 1)	ODOT Project Identification	Project Type	Soil Type Investigated	Number of Borings	Maximum Depth Explored (feet)
1	HAM-50 Sites 7-10 (Red Bank Road/ US 50 interchange)	Bridge foundations	alluvium /till/ outwash/bedrock	25	30
2	HAM-Red Bank Expressway failure	Embankment failure	fill/glacial till	5	60
3	HAM-71/Red Bank Road	Bridge foundation	lake deposit/till	2 (relevant)	65
4	HAM-71/Red Bank Road ramps	Elevated highway foundations	lake deposit/till	2 (relevant)	50

6.2. ODNR Well Logs

ODNR maintains a computerized database of well logs that can be searched by geographic area. A search of the Segment 1 study area revealed the presence of 15 wells in the archive. The locations of these wells are shown on Exhibit 4.

The information contained is valuable for determining a few critical parameters such as the depth to bedrock, the depth to the water table at the time of drilling and a very generalized lithology based on a description by the driller, as indicated in Table 3. Much of this information has already been synthesized and incorporated into such publications as the bedrock topography map (ODNR, 2004) and the surficial geology map (Brockman, 2004).

Table 3: Selected ODNR Well Logs

ODNR Well Number	Location	Depth (feet)	Lithology (feet)
2028869 - 2028874 (5 wells)	3980 Erie Avenue	21	0-21 clay and silt
2027552 - 2027556 (4 wells)	3601 - 3643 Red Bank Road	42	0-7 clay and sand 7-35 clay 35-42 clay/sand/gravel
9931091	4000 Red Bank Road	136 (120 to rock)	clay sand and gravel sand and clay
2001127 - 2001131 (3 wells)	4205 Red Bank Road	30	0-25 clay 25-30 clay and silt
58802	Red Bank Road (Old Ford Plant)	120 (115 to rock)	0-24 sandy clay 24-64 sand and gravel 64-75 sandy clay 75-115 sand and gravel
100547	Red Bank Road 1/4 mile north of US 50	55	0-51 clay 51-55 lime

Overall, these descriptions are consistent with the expected soils based on the surficial geological mapping. The rock depths are a little smaller than expected, but in the same general range.

6.3. Other Geotechnical Sources

Three additional sources of information were reviewed: geotechnical/geo-environmental conditions were investigated for two new developments along Red Bank Road/Expressway and for a US Army Corps of Engineers drainage project along Red Bank Road. Locations of the areas explored are shown on Figure 4.

Indian Springs Health Care and Barrington of Oakley

The logs of five soil borings drilled in support of geotechnical investigations for these developments located south west of the Madison Road/Red Bank Expressway intersection show soil conditions to depths of between 50 and 100 ft (Thelan, 2007). The soils are logged dominantly as silty clay with considerable varving (fine interbedding) indicating a fluvial or lacustrine depositional mode. Significant (10-20 ft thick) sand layers were encountered. These are usually fine grained and dense to very dense. The findings at this site are consistent with the geological model, which predicts up to 10 ft of silt underlain by up to 180 ft of interbedded sand and clay for this area.

Former Ford Property

The former Ford property has been redeveloped following extensive investigation to determine the nature and extent of any adverse environmental conditions. Much of the documentation relating to the process of investigation and remediation has been reviewed including the logs of 15 deep borings drilled for monitoring well installation during groundwater contamination investigations (SECOR, 2004). These describe the materials encountered in geological terms but there is only limited, qualitative information on strength or consistency.

Three borings serve to characterize the overall site conditions: one at the northwest corner not far from the Erie Avenue intersection, one at the southwest corner, and one east of the site at about the mid point. Of the three borings (MW-1D, MW-13D, MW-15D), only MW-13D in the southwest corner, indicated bedrock - at 95 ft. The other two were drilled to depths of 77 ft (MW-1D) and 118 ft (MW-15D) and were both terminated in dense sand. The overall stratigraphy consists of thick layers of silty clay (some logged as 'tightly compacted') and dense sand. These findings are, again, consistent with the geological model.

The groundwater investigation showed that the groundwater table in this area is at an elevation of 470 - 485 ft (about 60-80 ft below ground surface) with about 15 ft of drop across the site from west to east. This suggests that there is an active pumping center that is controlling the flow direction and depressing the groundwater table.

US Army Corps of Engineers Drainage Project

The US Army Corps of Engineers has conducted geotechnical explorations in connection with Duck Creek flood control projects in the general area of interest. Specifically, a group of 10 borings were drilled in 1995 to investigate conditions at the south end of the project near the former Swallens site. Conditions were reported as 10 - 15 ft of fill consisting of silty clay with gravel.

7. RECONNAISSANCE

A field reconnaissance of the proposed Red Bank Expressway Improvements (I-71 to US 50–Relocated SR-32, Segment 1) area was conducted on October 7, 2010 to review the general layout of the project, to observe geotechnical conditions that might be apparent and to provide a preliminary assessment of site conditions at primary structure locations. The structure locations listed in Table 1 were each visited and, to the extent possible, photographed and described.

Observations of general geotechnical interest include:

The upper reaches (within the project boundary) of Duck Creek and its north and northwest tributaries flow through fairly shallow, but steep-sided valleys formed in silty soils that appear to offer poor erosion resistance (Photographs 1 and 2). In the vicinity of the proposed Duck Creek Road relocation, large pieces of broken concrete slabs have been placed in the creek bed to retard scour and erosion (Photograph 3).

The current alignment of mainline Red Bank Road does not depend on any significant cuts or fills (Photographs 4 and 5). Those shallow fills that do exist within the project area such as at Duck Creek Road at Red Bank Expressway, and Madison Road at Red Bank Expressway appear to be performing satisfactorily and the limited embankment slopes look stable (Photographs 6 and 4). Cut slopes, such as Duck Creek Road at Red Bank Road, also appear to be stable (Photograph 7).

Recent commercial developments that back up to Red Bank Road (Upper Access) have already encroached significantly into the foot of this hillside and required retaining walls up to about 13 ft in height. Widening of the Upper Access towards these developments may be complicated by the need to increase the height of segmental block walls that were not originally designed to be raised (Photograph 8).

Existing in-service bridges (Indiana and Ohio Railroad over Red Bank Expressway (Photograph 9), SORTA Oasis Railroad under Erie Avenue (Photograph 10) and Erie Avenue over Red Bank Expressway (Photograph 11) appear to be functioning well from a geotechnical standpoint. No evidence of settlement of the piers was observed or distortion of the abutments or spill through slopes where present. The spill through slopes at Erie Avenue over Red Bank Road are paved to minimize erosion. Foundations of the closed road bridge at Red Bank Road crossing of the Indiana and Ohio Railroad are experiencing severe erosion that might lead to eventual loss of stability (Photograph 12).

The extension of Track Street (aka Shannon Way) to link with Virginia Avenue will involve a significant elevation increase (~ 22 ft) over what is currently a distance of 140 ft (Photograph 13). With construction of a longer embankment this could be accomplished over a distance of about 500 ft, at approximately 6% grade. The embankment could be free standing with 2:1 side slopes, or retained on one or both sides by MSE walls.

A similar situation exists at the connector from Virginia Avenue down across the Duck Creek ox-bow to the South Access road (Photograph 14). Here the elevation difference is 44 ft over a horizontal distance of 210 ft. The distance from Virginia Avenue to the proposed location of the South Access is on the order of 525 ft and a cut/fill design incorporating the Duck Creek ox-bow would have to be graded at more than 8% to fit in the space as currently planned. Slope stability for both the cut and fill segments of such a design, and the foundation conditions in the ox-bow should be evaluated carefully.

In summary, while there are several items described above that will require careful evaluation, no geotechnical issues were observed that would rise to the status of a 'red flag' and require more than the normal level of geotechnical exploration and analysis as set out in the Specification for Geotechnical Exploration (ODOT, 2010).

A photographic record of the reconnaissance was maintained and representative photographs are provided in Appendix A.

8. GEOTECHNICAL CONDITIONS AND CONSIDERATIONS

Geotechnical conditions within the study area, as indicated by the results of geotechnical explorations and well logs reviewed, are consistent with the general geological model described in the literature. The shallow soils as described by the soil survey mapping are also consistent with this.

The entire project area is underlain by dominantly fine grain materials that infill the ancestral valley of the Ohio/Licking Rivers to depths of more than 200 ft. This will mean that elements of design that are influenced by geotechnical conditions may be sized near the upper end of their overall spectrum, but in a range that is not unusual for development projects in this part of Ohio.

8.1. General Grading

The amount of mass grading associated with the project is likely to be relatively small. Two areas of potential concern were identified at the south end of the LAN system where two links from the low Red Bank Road area to the higher Virginia Avenue are planned. These will traverse a steep bluff and require a significant cut and fill combination to achieve the increase in grade. Soil conditions in the vicinity are expected to be generally sandy to a depth on the order of 20 ft.

8.2. Subgrade

Subgrade conditions are classified as 'Very limited' and the soils as A-4. This is likely to indicate a CBR value of ~ 6 (at the low end of the range). The need for subgrade treatment will depend largely on the density, moisture content and sub classifications as determined during the geotechnical exploration. If soils are found to be A-4(b) (ODOT classification), measures will be required to address frost action potential through stabilization or undercut. Similarly, excessively weak or wet soils will require stabilization or undercut.

8.3. Bridge Structure Foundations

Bridge work (modification, replacement or new structure) may be required at several locations depending on the combination of alternatives selected. These possibilities are highlighted in Table 1 and may be characterized from south to north:

Erie Avenue over Red Bank Expressway

The depth to bedrock is likely to be on the order of 125 ft. The valley fill below a surface layer of silt is mapped as inter-layered sand and clay. This is likely to have moderate load bearing characteristics; sufficient for the design of friction supported deep foundations.

Erie Avenue over SORTA Oasis Railroad

Depth to bedrock is estimated to be about 100 ft and the soil conditions similar to those at the adjacent road crossing.

Red Bank Road over Indiana and Ohio Railroad

Depth to bedrock is estimated to be about 250 ft. The soil conditions will likely be similar to those at the Erie Avenue crossings, but absent the surface silt layer. Friction piles will again be required to support the replacement bridge structure.

Indiana and Ohio Railroad over Red Bank Expressway

Depth to bedrock is estimated to be almost 200 ft. The soil conditions will likely be similar to those at the Erie Avenue crossings; the surface silt layer may or may not be present as this is close to the edge of the mapped unit. Friction piles will again be required to support any modification to the bridge structure.

Madison Road and Red Bank Expressway

A grade-separated intersection may require one or more bridge structures that will be underlain by conditions similar to those at Erie Avenue. The depth to bedrock is estimated to be about 150 feet and the overlying soils are interbedded sands and clay with a silt stratum at the surface. Friction piles will be required to support any bridge structure that is planned.

Duck Creek Road and Red Bank Expressway

A grade-separated intersection will require a bridge structure to carry the northbound ramp over Red Bank Expressway. The depth to bedrock is estimated to be about 100 ft. The soil conditions are mapped without the silt mantle, but observations of the creek banks in this area during the field reconnaissance suggest that it is present and that the soil profile will be generally similar to that at the Madison Road intersection.

8.4. Drainage Structures

Several major culvert modifications are expected to be required and these are typically located in low areas where shallow soil conditions are the worst. However, major drainage improvements have recently been carried out throughout the area and design requirements are not likely to be unusual, but as indicated above, at the upper end of the size or support spectrum.

8.5. Retaining Walls

Retaining walls will be required to support slopes that will be modified to accommodate widened roadways in the eastern part of the LAN network. These may be co-located at sites where recent commercial development has already encroached into the toe of these slopes with ~12 ft high cuts. Existing segmental block walls may not have been designed considering the potential need that they be raised or that the live loading pattern on them be changed.

Retaining walls will also be required around the main line interchanges where space for slopes is limited. These could be founded on relatively weak soils that may require some improvement or undercut.

9. SUMMARY

In general the geotechnical issues facing designers are typical of this part of Ohio; challenging subgrade conditions for road construction and the need for deep foundations for bridge structures - probably requiring friction piles. Development of the local area network of streets may call for the creation of links between existing roads that are, in two cases, separated by abrupt elevation changes. Several retaining walls will be required, the design of which may, in some cases, be complicated by the presence of new walls within the same slopes at those locations.

A Red Flag Summary is presented in Appendix B.

It has been a pleasure to be of service to URS in performing this Red Flag Study for the Red Bank Road Segment 1 Improvements.

Respectfully Submitted,

Barr & Prevost

Caroline Duffy, P.E.
Project Manager

Stuart Edwards, P.E.
Geotechnical Engineer

REFERENCES

Brockman S.C., 1998. *Physiographic Regions of Ohio*. Ohio Department of Natural Resources Division of Geological Survey

Brockman, C.S., Pavey, R.P., Schumacher, G.A., Shrake, D.L., Swinford, E.M., and Vorbau, K.E., 2004. *Surficial Geology of the Ohio Portions of the Cincinnati and Falmouth 30 X 60-minute quadrangles.* Ohio Division of Geological Survey Map SG-2 Cincinnati-Falmouth, scale 1:100,000.

Balke-American, 2006. *Preliminary Input for the Assessment of Feasible Alternatives, Red Bank Road Improvements US50 to I-71, Segment 1.* Hamilton County Engineer, Hamilton County Transportation Improvement District, Ohio Department of Transportation.

Fenneman, N.M., 1916. *Geology of Cincinnati and Vicinity, Fourth Series.* Bulletin 19, Geological Survey of Ohio.

Fleming, R.W., 1975. *Geologic Perspectives - The Cincinnati Example*. Ohio Valley Soils Seminar Proceedings, 6th, Ft. Mitchell, Ky., October 17, 1975.

GRASS Development Team, 2010. Geographic Resources Analysis Support System (GRASS) Software, Version 6.4.0. Open Source Geospatial Foundation. http://grass.osgeo.org

Inkscape Development Team, 2010. Inkscape Version 0.47. http://www.inkscape.org

Ohio EPA/US Geological Survey, 2004. *Ohio 10 Meter Digital Elevation Model.* Ohio EPA, Division of Emergency and Remedial Response. ftp://ftp-gis.epa.state.oh.us/gisdepot/gisdata/derr/ohio_10meter_dem.zip

Ohio Department of Natural Resources, 2002. *Ohio Karst Areas.* Division of Geological Survey.

2004. *Shaded Bedrock Topography Map of Ohio.* Division of Geological Survey, (Publication BG-3, V1.1).

2005. *Earthquake Epicenters in Ohio and Adjacent Areas.* Division of Geological Survey.

SECOR, 2004. *Phase II Environmental Site Assessment, Volume 1 - Text, Figures and Tables for The Red Bank Road Property Clean Ohio Revitalization Fund Project*. SECOR, June 23, 2004.

State of Ohio, 2010. *FALCON Geotechnical Document Management System (GDMS).* Department of Transportation, Office of Geotechnical Engineering. http://www.dot.state.oh.us/Divisions/ProdMgt/Geotechnical/Pages/GDocMS.aspx#GRSR

2010. *Specifications for Geotechnical Explorations.* Department of Transportation, Office of Geotechnical Engineering.

Thelan Associates, 2007. *Log of Borings and Soil Profile, Geotechnical Exploration, Indian Springs Health Care Facility*. Thelan Associates, Inc. January 9, 2007.

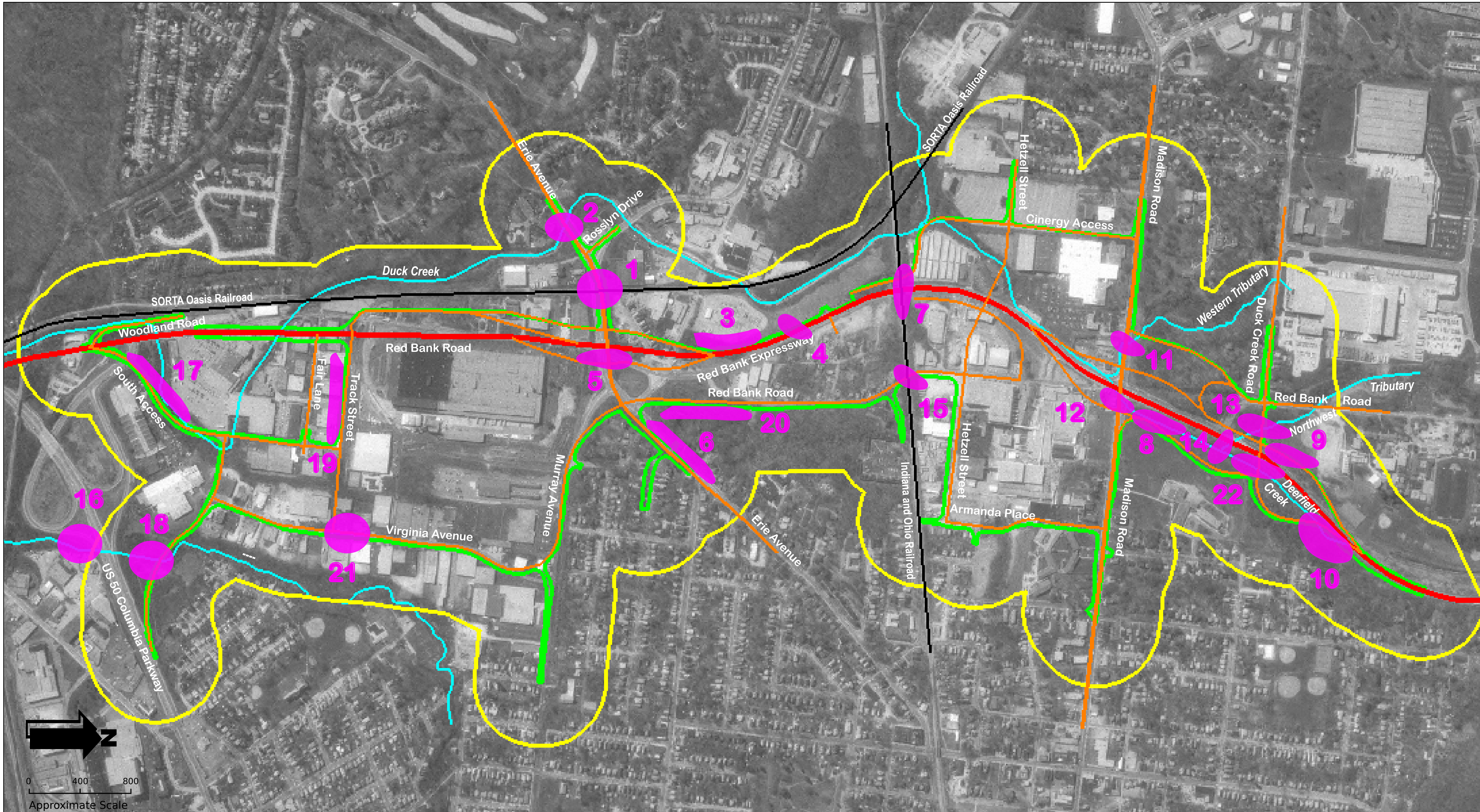
U.S. Department of Agriculture, 2010. Web Soil Survey, National Cooperative Soil Survey. Natural Resource Conservation Service. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

US Department of Transportation, 2005. *Tier 1 Final Environmental Impact Statement - Eastern Corridor Multi-Modal Projects, Hamilton and Clermont Counties, Ohio PID 22970.* Federal Highway Administration, Ohio Department of Transportation and Hamilton County Transportation Improvement District.

U.S. Geological Survey, 2008. *Seismic Design Parameters.* V2.10 USGS SEIS-1-CD.

1998. *Cincinnati ESE DOQQ.* File ci421nw3402.zip

1998. *Maderia SW DOQQ.* File ci422nw3402.zip



Legend

18 Possible Structure Locations (Table 1)

Study Area

Limit of Improvements

Streams

Area Roads

Mainline Red Bank Expressway

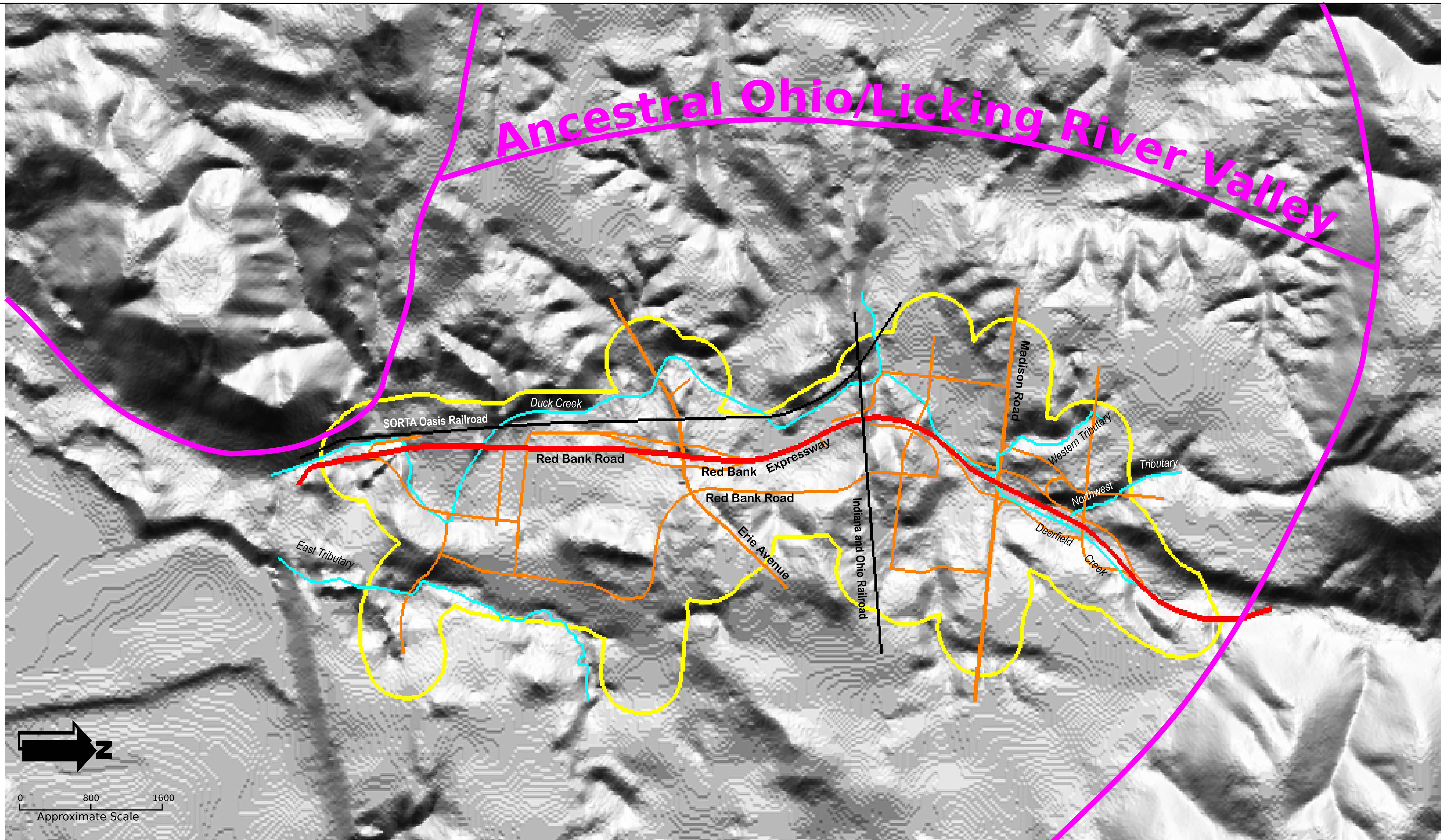
Railroads

Geotechnical Red Flag Study

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

Exhibit 1: Study Area

Eastern Corridor Multi-modal Transportation Projects
Red Bank Expressway Improvements: I-71 to US-50
SR-32 Segment 1



Vertical Exaggeration = 15

Legend

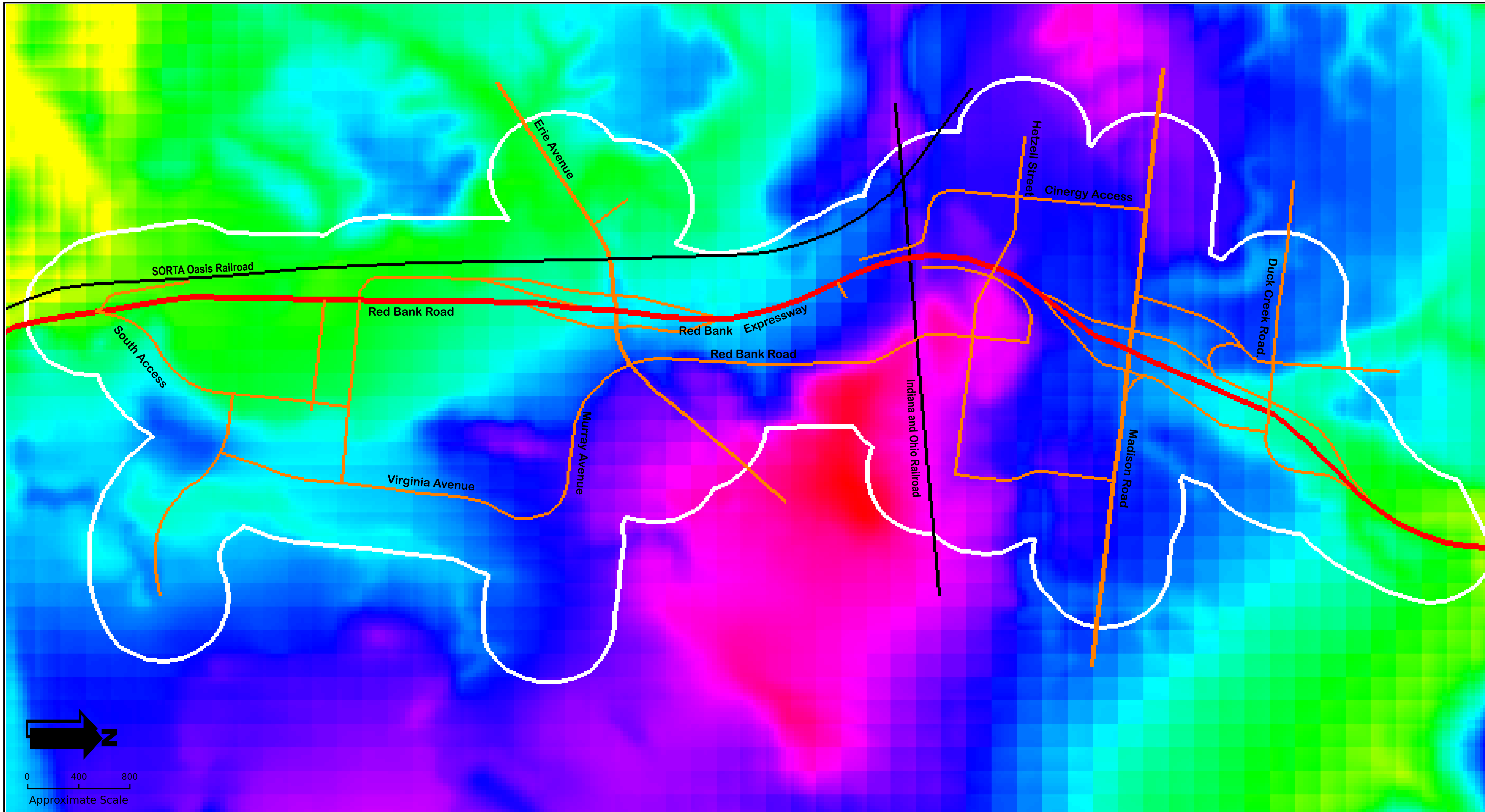
- Edge of Ancestral Ohio River Valley
- Study Area
- Streams
- Area Roads
- Mainline Red Bank Expressway
- Railroads

Geotechnical Red Flag Study

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

Exhibit 2: Shaded Terrain Model

Eastern Corridor Multi-modal Transportation Projects
Red Bank Expressway Improvements: I-71 to US-50
SR-32 Segment 1



Legend

Overburden Thickness (feet)
0
50
100
150
200
250
300

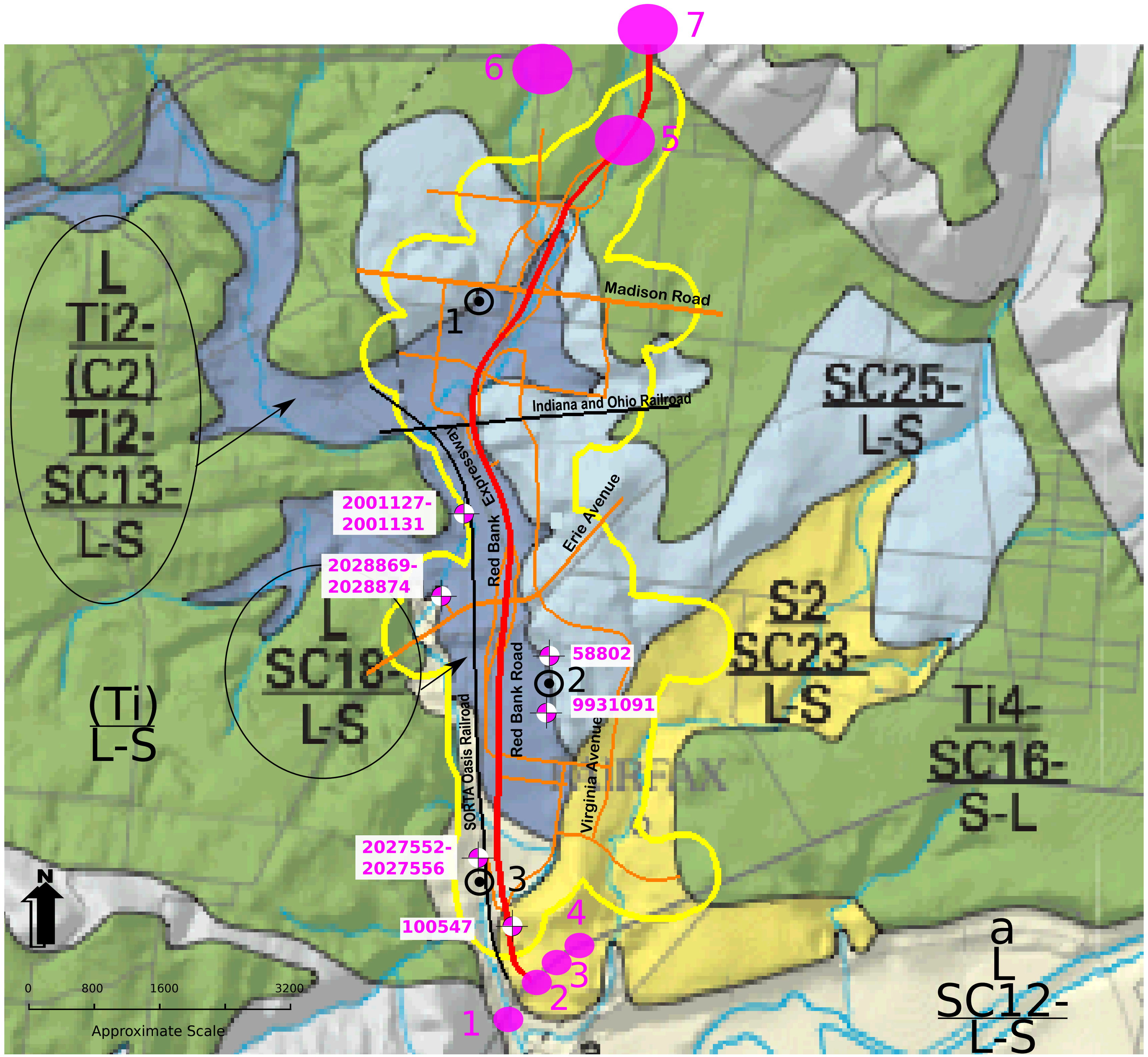
- Mainline Red Bank Expressway
- Railroads
- Study Area
- Area Roads

Geotechnical Red Flag Study

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

Exhibit 3: Overburden Thickness (Depth to Bedrock)

Eastern Corridor Multi-modal Transportation Projects
Red Bank Expressway Improvements: I-71 to US-50
SR-32 Segment 1



Source: Brockman, 2004.

Legend

Other Geotechnical Explorations

1 - Indian Springs
2 - Former Ford Plant
3 - US Corps of Engineers Drainage

1 ODOT Geotechnical Exploration Sites

1 - Site 7 Columbia Parkway Extension
2 - Site 8 Columbia Parkway Extension
3 - Site 9 Columbia Parkway Extension
4 - Site 10 Columbia Parkway Extension
5 - Red Bank Road Slope Failure
6 - 1-71 over Old Red Bank Road (bridge)
7 - 1-71/Red Bank Road Ramps (2)

Mainline Red Bank Expressway
Railroads
Study Area
Area Roads

58802 ODNR Well Locations and ID number

Geologic Units

S-L

Shale-dominant bedrock and clay-rich, bedrock-derived colluvium, prone to landsliding, Ordovician-age. Interbedded shale, gray, thin to thick bedded, and limestone, medium gray, thin to medium bedded, fossiliferous. Shale ranges from 50% to 85% of the unit, although minor limestone-rich beds are present. Unit associated with the shale-rich Kope Formation, on steep slopes near Cincinnati and north of Cincinnati, and with the Waynesville Formation on uplands in the northern part of the map area. On side-slopes and toe-slopes, unit is clay-rich colluvium with downslope-oriented limestone slabs and organic matter. Colluvium has relatively low shear strength and is the source of numerous landslides, especially on steep slopes. Landslides commonly form at the colluvium-bedrock interface.

L-S

Limestone-dominant bedrock and bedrock-derived colluvium, Ordovician-age. Interbedded limestone, medium gray, thin to medium bedded, fossiliferous, and shale, 450 gray, thin to medium bedded. Limestone ranges from 50% to 85% of the unit, although shale-rich beds are present. Includes Point Pleasant, Fairview, Grant Lake, Arnheim, Liberty and Whitewater Formations. On side-slopes and toe-slopes, unit is colluvium, predominantly clay with downslope-oriented limestone slabs and organic matter. Colluvium has relatively low shear strength and is the source of numerous landslides, especially on steep slopes.

Ti

Loam till, Illinoian-age. Generally overlain by up to 3.5 feet of loess, but loess may be 10 feet thick along bluffs bordering major rivers. Till may contain silt, sand, and gravel lenses. Sand/silt/clay percentages of till vary widely averaging 25/47/28 percent and range from 8/43/49 percent to 34/41/25 percent (Wentworth classification). Upland areas leached to 6 feet, including loess cap. J oints/fractures common. Averages 20 to30 feet thick and ranges to 90 feet thick in buried valleys. Stratigraphic names: Richmond and Centerville Tills approximately west of the Great Miami River, RainsboroTill east of the river. Landsliding may occur in oversteepened, wet areas. Deposited by glacial ice. Most common surficial unit in the southeastern part of the map area.

SC

Interlayered medium-fine to fine grained materials, unspecified age. Fine sand predominates and includes clay, silt, and thin gravel interbeds. Variable thickness and sequence of lithologies. Unit identified from well logs and is similar to unit CS but coarser; up to 150 feet thick. Deposited as lacustrine and proximal deltaic facies as well as overbank sediments within the area's largest valleys.

S

Sand, generally Wisconsinan-age. Contains minor amounts of disseminated gravel and thin lenses of silt and gravel; grains well to poorly sorted, moderately to well rounded with high quartz percentage; finely laminated to massive, may be cross bedded; locally may contain organics as disseminated particles or sticks and logs. Beds may be lithified by calcium carbonate in stable valley-side exposures; concretions may be present with varying degrees of cementation. In deep buried valleys, may be older than Wisconsinan- age; up to 50 feet thick. A fluvial unit in low terraces and buried valleys throughout the map area.

L

Silt, generally Wisconsinan-age. Contains localized clay, sand, or gravel layers. Laminated to massive; disseminated organics commonly present, may contain fossil snails, clams, and small branches or logs. Carbonate-cemented concretions in finer silt. Up to 100 feet thick, but generally thinner. Fine silts develop shallow angle slumps; coarse silts prone to piping, may be thixotropic ("quick sand"). Lacustrine deposit found in low-level slackwater terraces and buried valley-fills throughout the map area.

a

Alluvium, Holocene-age. Includes a wide variety of textural classes from silt to boulders with disseminated or concentrated organics; generally not compact; rarely greater than 20 feet thick. Found within floodplains of modern streams throughout the entire map area. Mapped only where areal extent and thickness are significant.

C

Clay, generally Wisconsinan-age. Massive to laminated; may contain thin interbedded silt, fine sand, and minor gravel; clay content may exceed 80%. Laminated clay commonly contains thin silt or sand partings. May contain joints/fractures 6 to 12 inches apart and disseminated organics, fossil snails and clams. Unit may contain areas of modern alluvium. In deep buried valleys, includes till and may be older than Wisconsinan-age. Generally less than 30 feet thick; landslide-prone. Lacustrine deposit on lowland surfaces, low-level terraces, and buried valley-fills throughout the map area.

Thickness Estimates (Soils)

X	10 ft
(X)	up to 10 ft - where present
X2	20 ft
X20	200 ft
X20-	up to 200 ft

Geotechnical Red Flag Study

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

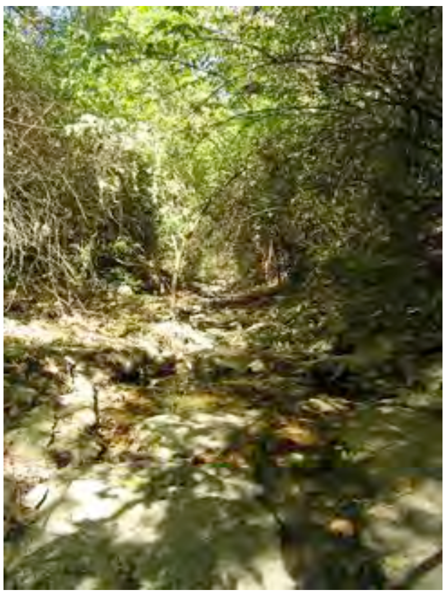
Exhibit 4: Surficial Geology

Eastern Corridor Multi-modal Transportation Projects
Red Bank Expressway Improvements: I-71 to US-50
SR-32 Segment 1

APPENDIX A
RECONNAISSANCE PHOTOGRAPHS

1. Erosion of silty creek bank soils - Duck Creek

2. Erosion of silty creek bank soils - Northwest Tributary

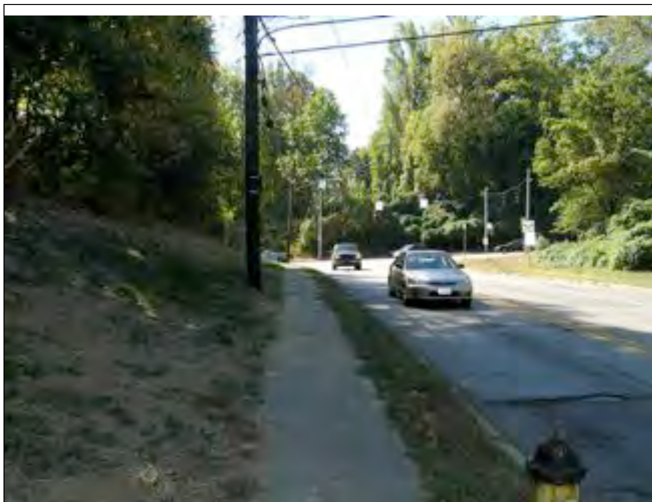


3. Concrete slabs in creek bed as scour protection - Northwest Tributary

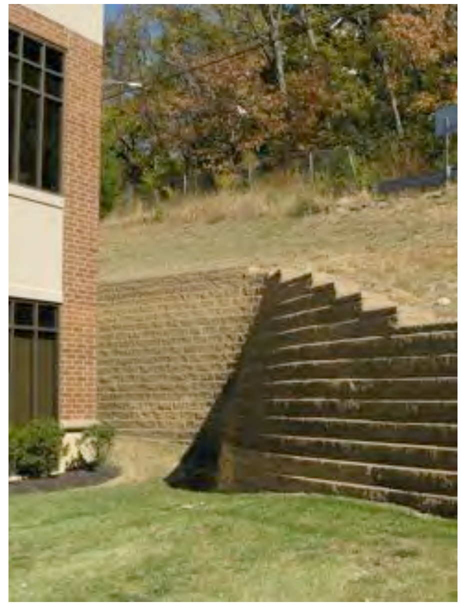
4. Typical low embankment - Red Bank Expressway at Madison Road looking North

5. Relatively flat terrain - Red Bank Expressway south from Indiana and Ohio Railroad to Erie Avenue

6. Typical low embankment - Madison Road looking east to Red Bank Expressway



7. Cut slope - Red Bank Road looking south to Duck Creek Road



8. Existing 12 ft high retaining wall below Red Bank Road

9. Indiana and Ohio Railroad crossing Red Bank Expressway

10. Erie Avenue crossing of SORTA Oasis Railroad

 11. Erie Avenue crossing over Red Bank Expressway	 12. Erosion damage to bridge piers – Red Bank Road over Indiana and Ohio Railroad
 13. Current end of Track Street (Shannon Way) looking east - abrupt elevation change occurs in distance to Virginia Avenue.	 14. General view towards proposed Jonlen Drive/ South Access. Duck Creek ox-bow approximately at tree line and abrupt elevation change to Virginia Avenue beyond.

APPENDIX B
RED FLAG SUMMARY

RED FLAG SUMMARY

Red Flag Summary Completed: July 2010

Purpose

The purpose of this Red Flag Summary is to identify concerns that could cause revisions to the following:

- Anticipated design and construction scope of work
- Proposed project development schedule
- Estimated project budget
- Potential impacts of the project on the surrounding area

Instructions

- A written Red Flag Summary is required for both major and minor projects. A written Red Flag Summary is optional for minimal projects; though red flag issues must still be identified.
- A field review is required for all projects. Each specialty area of the Red Flag Summary should be completed by individuals who possess sufficient experience to enable them to correctly identify and evaluate issues arising from the field review.
- In the Location/Comments field provide information concerning potential impacts that is brief, but gives enough detail to allow an understanding of the issue(s).
- The scope of services document should account for any issues identified in the Red Flag Summary that have the potential to affect scope, schedule, and budget.
- A list of resources that may need to be consulted in order to complete this form can be found in the introduction to Appendix H of the Project Development Process Manual.

Red Flag Summary Deliverables

Provide an expanded Study Area Map identifying project design constraints identified through the Red Flag Summary. Tables, photographs or other support material may also be submitted with the Red Flag Summary to illustrate specific problem areas. (**This information is mandatory for Major Projects.**)

General

Project Name (County, Route, Section):	Red Bank Road Improvements: I-71 to US-50	**PID:**	86461
Date Red Flag Summary Completed:	10/13/10	**Prepared By:**	se
City, Township or Village Name(s):		**Project Manager:**	

GEOTECHNICAL ISSUES:

Based on the information compiled during this study indicate whether or not the following geotechnical issues are present or should be further considered during project development. Provide additional comments as needed.

	Design Issue	Comments
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there evidence of soil drainage problems (e.g., wet or pumping subgrade, standing water, the presence of seeps, wetlands, swamps, bogs)?	
[ ] Yes [X] No [ ] Possible [ ] N/A	Is the groundwater table anticipated to be affected by construction?	
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there evidence of any embankment or foundation problems (e.g., differential settlement, sag, foundation failures, slope failures, scours, evidence of channel migrations)?	In-service structures generally appear to be functioning satisfactorily from a geotechnical standpoint. The foundations of the closed Upper Access / Penn Central bridge are experiencing sever erosion at several piers.
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there evidence of any slope instability (soil or rock)?	
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there evidence of unsuitable materials (e.g., presence of debris or man-made fills or waste pits containing these materials, indications from old soil borings)?	
[X] Yes [ ] No [ ] Possible [ ] N/A	Is there evidence of rock strata (e.g., presence of exposed bedrock, rock on the old borings)?	Shallow bedrock is present in the extreme southwest and northeast corners of the study area. However, over a substantial majority of the area it is >50 ft in depth.
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there evidence of active, reclaimed or abandoned surface mines?	
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there information pertaining to the existence of underground mines?	
[ ] Yes [X] No [ ] Possible [ ] N/A	Is there Acid Mine Drainage present within the study area?	
[ ] Yes [ ] No [X] Possible [ ] N/A	Does an undercut or subgrade stabilization appear to be needed?	Typical subgrade conditions are likely to reflect the presence of fine grained shallow soils throughout the study area
[ ] Yes [X] No [ ] Possible [ ] N/A	Should the Office of Geotechnical Engineering be contacted to evaluate the project site?	
[ ] Yes [ ] No [ ] Possible [X] N/A	Were there any significant items found during plan and specification review? Specify.	
[ ] Yes [ ] No [X] Possible [ ] N/A	Are There any other geotechnical issues? Specify.	1. Space constraints caused by existing retaining structures along the Upper Access present design challenges. 2. Steep natural slopes between Virginia and South Access create slope design challenges.