RESEARCH & DEVELOPMENT

Retaining Wall Inventory and Assessment System

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NCDOT Project 2014-10

FHWA/NC/2014-10

September 2015

Technical Report Documentation Page

1. Report No. **FHWA/NC/2014-10**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Retaining Wall Inventory and Assessment System**		5. Report Date **August 15, 2015** 6. Performing Organization Code
7. Author(s) **William Rasdorf, Ph.D., P.E., Mohammed A. Gabr, Ph.D., P.E., Cedrick J. Butler, E.I., Daniel J. Findley, Ph.D., P.E., Steven A. Bert, MPP**		8. Performing Organization Report No.
9. Performing Organization Name and Address **Department of Civil, Construction, and Environmental Engineering** **North Carolina State University** **Campus Box 7908** **Raleigh, NC** **Institute for Transportation Research and Education** **North Carolina State University** **Centennial Campus Box 8601** **Raleigh, NC**		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address **North Carolina Department of Transportation** **Research and Analysis Group** **104 Fayetteville Street** **Raleigh, North Carolina 27601**		13. Type of Report and Period Covered **Final Report** **August 2013 to August 2015** 14. Sponsoring Agency Code **2014-10**
Supplementary Notes:		

16. Abstract

Under Section 1106 of the "Moving Ahead for Progress in the 21st Century Act," also commonly referred to as "MAP-21," State agencies are required to "develop a risk-based asset management plan for the National Highway System to improve or preserve the condition of the assets and the performance of the system" [23 USC 119(e)(1)]. Thus, it is mandated that measures are put into place for highway assets that may potentially fail with aging. In the past, retaining walls were such assets that were often excluded from inventory programs and were regarded as non-critical or "lost" assets. With the recognition that wall failures may be detrimental to the roadway and the surroundings, and may pose a potential hazard to the safety of the public, several highway agencies have begun to incorporate retaining walls into their inventory and inspection programs. The primary goal of the research described herein was to develop a systematic means for cataloging and assessing the condition of permanent highway retaining structures for the NCDOT. The research products developed as a result of this study include a literature review of highway agencies with the most notable contributions in wall asset management, the development of data collection forms for inventory and condition assessment, a pilot study of (15) geographically distributed wall locations, short concise summaries of each field inspection, a field application study of (32) walls, and the design and development of a prototype database. Each of these products will be useful in providing the NCDOT the ability to establish effective and sustainable retaining wall maintenance and replacement priorities is support of MAP-21.

17. Key Words **retaining walls, asset management, wall inventory, data collection, field procedures, condition assessment, rating system, database**	18. Distribution Statement		
19. Security Classif. (of this report) **Unclassified**	20. Security Classif. (of this page) **Unclassified**	21. No. of Pages **273**	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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ACKNOWLEDGEMENTS

The research team acknowledges the North Carolina Department of Transportation (NCDOT) for supporting and funding of this project. We extend our thanks to the project Steering and Implementation Committee members:

Daniel Muller, P.E. (Co-Chair)
John L. Pilipchuk, P.E., L.G. (Co-Chair)
David M. Alford, P.E.
Cary Clemmons
Earl Dubin, P.E.
Paul Garrett, P.E.
Scott Hidden, P.E.
Eddie Smith
Lonnie R. Watkins, P.E.
Eric Williams, P.E.
Neil Mastin, P.E.
F. Rasay Abadilla Jr., P.E.

The NCSU research team especially thanks those who were instrumental in assisting with the project. These individuals include NCDOT personnel who participated in our interviews and are listed in the order in which we met: Mr. Walt Tallman (Bridge Maintenance System Specialist), Mr. Lewis Gettier (Bridge Maintenance System Analyst), Mr. Chris Kreider (Eastern Regional Operations Engineer), Ms. Marie Novello (HiCAMS Specialist), Mr. Dean Hardister (Western Regional Operations Engineer), Mr. Brian Hamby (Highway Maintenance Engineer: County Maintenance Yard, Wilkes), Mr. John Hughes (County Maintenance Engineer: County Maintenance Yard, Yadkin), Mr. Michael Valiquette (Geotechnical Operations Engineer), and Mr. Timothy Anderson (District Engineer: Counties-Burke, McDowell, Mitchell, Rutherfor).

Jeffrey C. Chang, E.I. contributed heavily as a research assistant to the project in the first six months. Britton E. Hammit assisted with the literature review during the early stages of the project. Amr Helal assisted with the evaluation 32 ERSs, a second time, to determine whether or not two inspectors could obtain the same or similar average criteria ratings for the same ERSs.

Without the help of all the above individuals, the project could not have been completed in such a successful manner. The active participation and the resulting contributions of NCDOT personnel and the steering committee were especially noteworthy and helpful.

EXECUTIVE SUMMARY

Asset management is a relatively new concept in geotechnical engineering. Spatial and performance data (obtained by the measurement of a wall's geometry and performance over time during operating conditions, or through a survey of a wall's condition) and their use in asset management systems is emerging as an effective approach for prioritizing maintenance and upgrades to optimize the use of ever increasingly limited rehabilitation funds. In general, the nature of permanent highway earth retaining structures (ERSs), including retaining walls, within the realm of highway engineering also renders the concept of asset management a valuable tool for operation efficiency and cost control. Asset management includes a database of assets, tools to manage the database, asset condition assessment models, and strategies for condition assessment, damage mitigation, and asset rehabilitation and replacement. Therefore, the development of a systematic means for cataloging and condition assessment of ERSs will represent a major contribution in establishing effective and sustainable maintenance and replacement priorities.

This research study included a literature review, an identification of ERS data attributes and critical elements of data collection, the development of data collection forms for inventory and condition assessment, the identification of five predominant retaining wall types of greatest interest to the North Carolina Department of Transportation (NCDOT), a study of existing rating systems, a pilot study of (15) geographically distributed ERS locations, the development of a condition assessment system for various retaining wall types, a field application study, and the development of a prototype database.

The NCSU research team recommends a data collection procedure that includes both ERS spatial as well as ERS attribute (characteristics) data. Spatial data are organized in a prototype database in such a way as to be able to link to existing NCDOT systems. The proposed database design (of key parameters defining the various types of ERSs within the state) is intended to assist NCDOT engineers and contractors in evaluating the need for maintenance and replacement as well as to inventory and preserve records for often-lost assets.

The prototype database developed in this study supports ERS data archiving and retrieval for electronic documentation, management, qualitative analysis, and ERS data display. The retaining wall types include mechanically stabilized earth (MSE), soil nail, anchored, gravity, cantilever, and other miscellaneous type of ERSs. Included in this prototype database (in the form of tables) are ERS location, ERS geometry (such as retaining wall length, height, and batter), retaining wall type and function, structural features (such as foundation type and type of internal reinforcement), history and ownership, external signs of stress (such as tilt and cracking), damage indicators, and past repair or replacement measures. Also presented in this report are definitions of all data tables and the attributes contained in the prototype database as well as a brief discussion on the (32) geographically distributed ERSs populating all the database tables.

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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) owns and operates approximately 80,000 miles of roadway that consists of 1,299 miles of interstate highways, 13,754 miles of primary U.S. and NC numbered routes, 60,068 miles of secondary paved roads, and 4,357 miles of secondary unpaved roads [Conti, et. at. 2012]. While the State's roads perform relatively efficiently, safely, and functionally, the aging pavements and assets that make up the network require investments for improvement and upkeep.

Among the infrastructure that forms the State Highway System; permanent ERSs must also be preserved, rehabilitated, and replaced for the mobility and safety of roadway users. ERSs both retain soil and rock mass as well as support and protect many other transportation assets including roads, rivers, and railways. At the NCDOT, "retaining walls are used for many reasons including repairing landslides, minimizing right-of-way requirements, shortening bridges (abutment walls), widening roads, and providing property access" [NCDOT Roadway Design Manual, 2014]. Given the critical nature of their function, ERSs typically have low failure rates as they are designed with adequate safety margins [AASHTO LRFD, 2014]. When they fail, however, the consequences can be severe [Kleiner, 2001]. Thus, the implementation of a retaining wall inventory and condition assessment system (WICAS) is essential for establishing effective master planning, engineering, design, maintenance, and management of geotechnical structures as assets.

Under Section 1106 of the "Moving Ahead for Progress in the 21st Century Act," also commonly referred to as "MAP-21," State agencies are required to "develop a risk-based asset management plan for the National Highway System to improve or preserve the condition of the assets and the performance of the system" [23 U.S.C. § 119(e)(1) (2012)]. In order to receive federal funding for transportation improvement projects, the receiving agency must provide, at minimum, the following six items in their State asset management plan [23 U.S.C. § 119(e)(4) (2012)]:

1. A summary listing of the pavement and bridge assets on the National Highway System (NHS) in the State, including a description of the condition of those assets.
2. Asset management objectives and measures.
3. Performance gap identification.
4. Lifecycle cost and risk management analysis.
5. A financial plan.
6. Investment strategies.

Thus, MAP-21 is heavily focused on transportation assets, their condition and health, and their cost. In fact, while ERSs are not explicitly addressed in the federal authorization, MAP-21 specifies that funding may be used for eligible projects with the purpose of "inspecting and evaluating other highway infrastructure assets on the National Highway System, including signs and sign structures, *earth retaining walls*, and drainage structures" [23 U.S.C. § 119(d)(2)(D) (2012)]. Recognizing that ERS failures may be costly and detrimental to the safety of the public, it is critical that measures, standards, and condition assessments be applied to ERSs as a part of managing the resources for the maintenance of these highway assets. The maintenance condition report and the infrastructure health dashboard are prime examples of how the NCDOT is already addressing this legislation. However, it is also of utmost importance that measures are put into

place for the other potentially risky assets, such as ERSs, identified by MAP-21 so the State's highway system continues to operate safely, efficiently, and cost effectively.

This report addresses one such effort by the Structures Management Unit and the Geotechnical Engineering Unit of the NCDOT. It describes a study focusing on ERSs whose purpose is to assess data collection needs and methods as well as design a data collection and rating system to inventory and assess the condition of various earth retaining wall types.

1.1 Research Objectives

This project addresses the NCDOT's need for a systematic tool to provide electronic documentation and qualitative analysis of ERSs maintained by the NCDOT. The key research product is a complete specification of the database design and structure, with the fields populated using data from 32 ERSs that were inventoried and field surveyed. The prototype database proposed herein (with key parameters defining the various types of retaining walls within the state) is intended to assist NCDOT engineers and contractors in evaluating their needs for maintenance, repair, or replacement of permanent ERSs. Most importantly, the database philosophy presented in this report emphasizes simplicity with the potential of reducing complexity and maximizing utility.

1.2 Outcomes and Benefits

The results from this research project will provide the NCDOT with a design for an information resource that documents ERSs owned and maintained by the State. The database underlying the information resource will support a number of applications that will enable the NCDOT to properly assess the condition of its ERSs and develop remediation strategies when necessary. Each application supported by the proposed database will be discussed in greater detail in this report.

One of the primary benefits of this work is that it will provide the NCDOT with a way to quantify and understand the condition of one of their critical assets. The materials provided herein will enable the NCDOT to build and populate the desired ERS database. That is, the materials provided would serve as a guideline for the purpose of implementing the design of a retaining wall inventory and condition assessment system. The development of such a system is the ease with which data can be periodically collected. Some of the data, such as the retaining wall type, location, and configuration details are static in nature while others, such as geometry are dynamic as the ERS is subjected to tilt, lateral deformation, and differential movement. Given the large network and the different type of ERSs, automated data collection with a speed that can be tolerated by road traffic is the most preferred approach.

Additionally, information presented in this report would serve as a tutorial for users. With these materials the NCDOT will be poised to implement the development of inventory, inspection, and condition assessment program and procedures. Finally, the NCDOT will obtain a full understanding and articulation of the practical applications of the ERS database.

1.3 Report Organization

The remainder of the report is organized into chapters that present each of the major analyses performed during this project. Chapter 2 provides a literature review of highway agencies with the most notable contributions in retaining wall asset management. Chapter 3 provides a summary

of NCDOT's current practices for collecting, storing, and assessing data related to ERSs. Also included in this chapter is the proposed method for collecting, storing, and assessing ERS data. Chapter 4 examines the different rating systems used by the NCDOT. Chapter 5 presents a new condition assessment system developed exclusively for ERSs serving various functions within the highway infrastructure. Chapters 6 presents a recommended framework for developing an initial inventory, defining wall condition and criticality, evaluating risk, prescribing a routine inspection cycle, and prescribing recommended actions. Chapters 7 and 8 provide the conclusions and recommendations from this research study. Chapter 9-12 present the implementation and technology transfer plans of the research project, references, bibliographies, and the appendices for the report.

2.0 LITERATURE REVIEW

A thorough review of literature was undertaken as a basis for developing a retaining wall asset management program for the State of North Carolina. This chapter of the report aims to provide a better understanding of (1) asset management and inventory systems, (2) NCDOT's existing asset management program, (3) the current state of practice, (4) classification of common retaining walls and their components, (5) data collection categories, (6) inspection, condition assessment, and ratings, and (7) action assessment.

For many highway agencies, infrastructure asset management programs for ERSs are still under development. Nevertheless, several highway agencies have made notable progress with the development and implementation of comprehensive earth retaining wall management programs. Especially noteworthy is the work by the Central Federal Land Division of the Federal Highway Administration (FHWA-CFLHD) who developed the "Retaining Wall Inventory and Condition Assessment Program (WIP): National Parks Service (NPS) Procedure Manual" [DeMarco, et. al. 2010b]. To develop an inventory and inspection program that produces useful information for the NCDOT, it was crucial to investigate the current state of practice for multiple highway agencies. The following sections in this chapter discuss in detail the agencies with the most notable contributions in retaining wall asset management and summarize all the literature related to earth retaining structures (ERS), which includes retaining walls.

2.1 Asset Management

Asset management programs have been implemented in public and private agencies all across the world. The goal of asset management is "to identify and gather the most useful, reliable and, cost-effective information and use it to make informed decisions" [Kim, et. al. 2009]. In the United States, asset management priorities have come to include the development of new data collection technologies, assessment methods, inspection procedures, and valuation techniques for infrastructure preservation and monitoring [Schofer, et. al 2010]. These priorities are being increasingly adopted by highway agencies. For many highway agencies, raw data are collected during in-field inspections and inserted into an asset management program that tracks and manages all their individual assets. This type of management tool provides useful information that enables agencies to make sound decisions regarding, budgeting, maintenance, and transportation planning. Documenting and maintaining reliable information on these highway assets, including a history of rehabilitation and maintenance, is a crucial part of the nation's goal to achieve an efficient, safe, and cost effective highway network.

2.1.1 Managing Earth Retaining Structures

For the agencies that regularly inspect ERS assets as a part of their bridge inspection program, the raw data collected in the field are generally managed by their bridge management systems (BMS). VicRoads Technical Consulting of Victoria, Australia, records its inspection data in a road asset system (RAS), which is an information system for all structures' inventory and condition data managed by the Network and Asset Planning Division [VicRoads, 2011]. Conversely, other agencies use a standalone wall management system (WMS) to track and manage their ERS assets. In most cases, these WMS are linked with other management systems. For instance, the Minnesota DOT has its WMS linked to the Permitting Department, the British Columbia Ministry of Transportation has its WMS linked with the Road Inventory Management System, and the Pennsylvania DOT has its WMS linked to the Roadway Management System, Planning and Programming System, and Maintenance Management System [Brutus and Tauber, 2009].

2.1.2 NCDOT Asset Management Program

The concept of asset management generally revolves around data collection and analytical assessment to determine how to best maintain critical assets. In collaboration with AgileAssets, the NCDOT has implemented an integrated asset management system (AMS), which is comprised of Pavement, Maintenance, and Bridge Management Systems and includes Asset Trade-Off Analyst [Bhargava, et. al. 2012]. AMS is web-based and accessible throughout the state. Along with the storage of current and historical data; condition ratings and performance analyses; and planned and actual work orders, the business processes, and associated rules for each asset are contained in a single central Oracle database. The Performance Dashboard, an online feature derived from AMS, provides the overall health of NCDOT's highway infrastructure.

2.2 Wall Inventory and Inspection Programs

Over the years, many agencies have recognized the need to include ERSs such as earth retaining, noise, and visual walls in their inventory and inspection programs. In the past, ERSs were often excluded from inventory and inspection programs. The New York City Department of Transportation first realized the importance of implementing an inventory and inspection system for their ERSs after a few major earth retaining walls failed without warning. One of those failures occurred in 2005 when a 75 foot high earth retaining wall crashed onto Riverside Drive in Manhattan, NY [Brutus, et. al. 2011]. As a result, the northbound lane of the Henry Hudson Parkway was closed for a week. With the recognition that ERS failures may be detrimental to the roadway and the surroundings, many highway agencies have begun to incorporate ERSs into their inventory and inspection programs.

The Federal Highway Administration (FHWA-CFLHD) developed the "Retaining Wall Inventory and Condition Assessment Program (WIP): National Parks Service Procedure Manual" for ERSs located in national parks throughout the United States. Brutus and Tauber with Gandhi Engineering Inc. created the "Guide to Asset Management of Earth Retaining Structures" to help highways agencies with the development of an asset management system for ERSs. Still, only a few agencies have substantial ERS inventory and inspection programs in place, which could benefit from improvement. At the time of this project, the development of ERS inventory and inspection programs for most highway agencies have not fully implemented and completed the inventory. A complete summary, based on a review of literature and online sources, of the

highway agencies with some form of an inventory and/or inspection program is outlined in Table 1.

Table 1: Agencies with an Inventory and Inspection Program

Agencies	With Inventory or an Inspection Program	With Inventory and Inspection Program	With Inventory and Inspection in an Advanced Asset Management System	With *Accessible* Guidance Manuals and/or Inspection Forms	Rating Scale
1. Alaska DOT	X	-	-		
2. British Columbia Ministry of Transportation	X	X	X		
3. California DOT	X	-	-		
4. City of Cincinnati (7,000)	X	X	X		
5. Colorado DOT	X	-	-		
6. FHWA & NPS (3,500)	X	X	X	X	1-10
7. Kansas DOT	X	X	-		
8. Maryland DOT	X	-	-		
9. Minnesota DOT	X	-	-		
10. Missouri DOT	X	-	-		
11. New York City DOT (2,000)	X	X	-	X	1-7
12. New York State DOT (2,100)	X	X	-	X	1-7
13. Oregon DOT (500)	X	X	-		Good/Fair/Poor
14. Pennsylvania DOT	X	X	X		
15. VicRoads Technical Consulting for Victoria Australia	X	X	X	X	1-4
16. Nebraska Department of Roads				X	0-9
17. Ohio DOT				X	Yes or No
18. Utah DOT				X	Yes or No

Note: The number in parenthesis represents the number of earth retaining structures surveyed by each agency, if available.

To date, the most extensive ERS inventory and inspection program in the United States is the FHWA-CFLHD's inventory of 3,500 earth retaining walls for the National Parks Service (NPS) [CTC, 2013]. The WIP was designed to inventory ERS data, assess the condition of ERSs, provide recommendations, and give cost estimates for overall improvements. It was also designed to mimic the NPS existing Road Inventory Program (RIP) and Bridge Inventory Program (BIP). Implementation of the WIP provided many benefits and challenges for the NPS as outlined below [DeMarco, et. at. 2009]:

i. Benefits

- Preventing failures resulting in injuries.

- Providing credible documentation of the total value of roadway ERSs, as well as the cost needed to repair and maintain them.
    - This documentation will assist budget request approvals.
- Identifying serious problems before failures occur.
- Improving design by identifying design problems before multiple ERSs are designed the same way.

ii. Difficulties

- Consistently defining, measuring, and categorizing all of the different types of ERSs that exist.
- Classifying a particular ERS's function (ex: wing wall supporting a bridge vs. a retaining wall connected to the wing walls).
- Resolving rating inconsistencies because of the inevitable human factor of different inspectors.

In summary, the ultimate benefit of the WIP is its ability to provide information that can be used to mitigate potential failures that may result in injuries to the public and damage to surrounding infrastructure. While the FHWA-CFLHD created the most extensive ERS inventory and inspection program in the United States, there are two agencies with substantial programs that predate the FHWA-CFLHD's WIP. Since 1990, the City of Cincinnati has used its retaining wall inventory and inspection program to prioritize repairs and replacements [FHWA, 2008]. As a result, the city has surveyed nearly 7,000 retaining walls within its right-of-way. Similarly, the Oregon DOT has a fully developed inventory program that predates FHWA-CFLHD's WIP, and which is currently being used to assess its retaining walls statewide.

Following the early efforts and contributions made by FHWA-CFLHD, Oregon DOT, and the City of Cincinnati, other highway agencies have made strides towards the development of an inventory and inspection program of their own. The Pennsylvania DOT has established a well-defined retaining wall inspection program (conducted in conjunction with its bridge inspection programs) for all ERSs including ERSs associated with bridges [Gerber, 2012]. Brutus and Tauber (2009) developed a comprehensive guide for inventorying and inspecting ERSs. Using the procedures outlined in their guide, they surveyed nearly 2,000 retaining walls for the New York City DOT. Similarly, the Alaska DOT and Public Facilities (AKDOT & PF) has relied heavily on the guidance of FHWA-CFLHD to develop a preliminary draft of their 2013 Retaining Wall Inventory Procedure Manual.

As an example of international efforts to address management of ERSs as assets, VicRoads Technical Consulting (2011) produced the "Road Structures Inspection Manual" for Victoria, Australia which applies to retaining walls, visual walls, and noise walls, along with many other roadway structures including bridges and culverts. The British Columbia Ministry of Transportation has both expanded its Bridge Management and Information System (BMIS) and revised its maintenance specification to include ERSs [BC MOT, 2003]. Still, only a few agencies have substantial ERS inventory and inspection programs in place.

2.2.1 Wall Inventory Program Development Methodology

After the FHWA-CFLHD's initial review of the state of the practice, they determined the next step was to identify all the various retaining wall types and elements. Then, they developed an estimate for the cost of rehabilitation, repair, and replacement of each retaining wall type and element. Once this basic information was established, FHWA-CFLHD devised a method for collecting wall data in a manner consistent with their existing bridge and roadway collection methods. This method also included a condition assessment of individual wall elements and the overall wall, essentially a rating system. After establishing a wall assessment criteria and condition rating system, the FHWA-CFLHD developed an inventory database using Microsoft Access to store all the pertinent data collected. Once they had all the major elements of the WIP in place, the final step was to pilot their methods at several different wall locations. A summary of FHWA-CFLHD's process for developing the final WIP is outlined below [DeMarco, et. at. 2009]:

i. Initial Research

- Identify the range of retaining wall types and elements.
- Estimate costs for wall rehabilitation, repair, and replacement.
- Determine inventor size.
- Research current inventory programs.

ii. Determine Data Collection Method

- Develop a plan to collect wall data consistent with existing bridge and road inventory programs.
- Develop a method for assessing the condition of wall elements and the entire wall as a whole.

iii. Create and Design Database

- Develop a customized wall inventory database and assessment system suited to asset management requirements.

iv. Trial and Error

- Pilot the determined data collection methods at select locations and input findings into the database.

Similarly, Brutus and Tauber's process for developing a retaining wall inventory and inspection system closely resembles that of the FHWA-CFLHD. After reviewing the current state-of-practice, the team determined their next step was to develop a map showing the physical locations of all the ERSs being inventoried and investigated. Once the locations of all ERSs were known, they created a database to store the pertinent data obtained in the field. Following the design of the database, Brutus and Tauber used the guidance of FHWA-CFLHD to develop a condition assessment checklist and rating system. The final step was to pilot the methodology at several ERS locations. A summary of Brutus and Tauber's inventory and inspection program development is outlined below [Brutus, et. al. 2011].

i. Create a Map showing the location where all retaining walls are located.

- Utilize GIS Mapping which enables one to link descriptive data and images with any location (Retaining Wall) on the map.
- Determine Location of Retaining walls.
    - Review As-built drawings in agency archives.
    - Review Arial Photographs and utilize other remote sensing data.
    - Plan field visits and do on-site searching.

ii. Create a <u>Database</u> that assigns characteristics to each structure.

- Data to be included:
    - ERS (Retaining Wall) ID #
    - Location Data (GPS coordinates)
    - Dimensional Data (height, face area, etc.)
    - Structural Type (MSE, tie-back, etc.)
    - Functional Type (Supporting roadway)
    - Ownership and/or Maintenance Responsibility
    - Previous data on wall condition
    - Records of inspections and actions taken

iii. Create a <u>Check List</u> to be used to determine the <u>Condition</u> of the retaining wall.

- Conditions to be included (among others):
    - Wall or parts of it, out of plumb, tilting or deflecting
    - Bulges or distortion in wall facing
    - Some elements not fully bearing against load
    - Misaligned joints
    - Cracks or spalls in concrete, brick or stone masonry
    - Missing blocks, bricks, or other facing elements,
    - Settlement behind wall
    - Rust stains or other evidence of corrosion of rebar
    - Damage from vehicle impact
- The inspection team records the conditions observed and takes photographic documentation.
- The surrounding area is also assessed to establish the consequences of wall failure.

iv. Assess the <u>Performance</u> of the retaining wall (Essentially the Rating System)

- Inspection data are brought back to office personnel for review and a decision for future action is made.
- Office personnel use the consequences of failure to establish the time frame for repair and future inspection.

In contrast to FHWA-CFLHD and Brutus and Tauber, the AKDOT & PFDOT&PF divided its process for developing an inventory and inspection system into two phases. At present, the AKDOT & PF is still in the first phase of this process which involves a survey of internal records to catalog ERS locations and gather basic information [CTC, 2013]. In the second phase, AKDOT & PF plans to validate and augment their in-house data with data collected in the field. As a part of the second phase, the AKDOT & PF will also rely on the guidance of FHWA-CFLHD to

develop an ERS condition assessment process and establish a rating system to measure ERS performance.

2.2.2 Locating Earth Retaining Structures

As part of a state-of-practice review, Brutus and Tauber discovered that most agencies initially locate ERSs by aerial surveying or reviewing design drawings and records, and then confirm the located ERSs on the ground [Brutus and Tauber, 2009]. Both Brutus and Tauber and the AKDOT & PF used as-built drawings to help determine the location of many ERSs. For Brutus and Tauber, once all the documented ERSs were mapped, a detailed analysis of aerial photographs and extensive site visits were undertaken to locate additional ERSs not documented in the drawing archives. At the time of this review, AKDOT & PF have not reached the point where site visits could be conducted to verify or obtain additional ERS information, but plan to use light detection and ranging (LiDAR) technologies to aid in the process of measuring ERS geometry. In addition to using as-built drawings, the AKDOT & PF also utilize Google Maps and Digital Roadway View Alaska to help locate ERSs. Similarly, the Oregon DOT currently uses Google Maps and Bing Maps for visual ERS locations and conducts field visits to locate others.

2.2.3 ERS Acceptance Criteria

For the development of an inventory program, it is essential to generate a detailed list of guidelines to clearly define the types of assets to be included in the database. The FHWA-CFLHD, Brutus and Tauber, and the AKDOT & PF each use slightly different guidelines to determine which earth retaining wall types should be included in their final inventory. Using guidelines to help reduce the size of the inventory is crucial for creating a database that is both manageable and suitable.

Included in FHWA-CFLHD's WIP are earth retaining walls and qualified culvert headwalls located on all classes of paved roadways and parking areas. The four main guidelines used to select these ERSs are: the ERS must be located along a qualifying roadway, the ERS must be related to a roadway asset, the ERS's height must be greater than or equal to 4ft with the exception of culvert headwalls and wing wall (greater than or equal to 6ft), and the ERS must have an internal wall face angle greater than or equal to 45°[DeMarco, et. al. 2010b]. Table 2 summarizes the complete wall acceptance criteria used by FHWA-CFLHD. Likewise, both the Oregon DOT and the AKDOT & PF also used a wall height greater than or equal to 4ft. However, the most common wall height criterion used by the New York State DOT, New York City DOT, and British Columbia Ministry of Transportation (British Columbia) is 6 feet. Irrespective of height preference, a minimum height criterion is used by virtually every highway agency with an ERS inventory program. In the end, the intent of this criterion is to exclude low ERSs that do not pose a major threat if failure were to occur. As a result, the extra time, cost, and effort required to inventory non-critical ERSs can be reduced significantly.

In general, the ERS acceptance criteria used by the AKDOT & PF mimic that of the FHWA-CFLHD. Similar to that of the FHWA-CFLHD, the AKDOT & PFDOT&PF system also includes ERSs that are a part of a roadway asset (such as a bridge) or ERSs that have a face angle greater than or equal to 45°. Similarly, the British Columbia also included ERSs that have a face angle greater than or equal to 45°in their inventory. According to the National Highway Institute, a retaining wall is defined as an earth retaining structure having an internal face angle greater than or equal 70^0 [Brutus and Tauber, 2009]. However, the AKDOT & PF, FHWA-CFLHD, and

British Columbia each opted to deviate from this standard definition to allow the capture of ERSs with shallower slopes (e.g., rockeries, tiered wall) in the final inventory.

Table 2: ERS Acceptance Crieria for the WIP [DeMarco, et. al. 2010a]

Criteria Subject	Criteria Definition
Qualifying Roads	The inventory includes retaining walls, together with qualifying culvert headwalls, located on all classes of paved park roadways and parking areas as described in the RIP Route Inventory Report or identified by park facilities, maintenance, or resource staff.
Relation to Roadway Asset	Retaining walls and culvert headwalls, that meet the minimum height requirements, must reside within the known or assumed construction limits of the existing roadway or parking area and must support or protect the roadway or parking area.
Wall Height	The maximum wall height, measuring only that portion of the wall structure intended to actively retain soil and/or rock, must be greater than or equal to 4 ft. For culvert headwalls or wing walls, maximum wall heights must be greater than or equal to 6 ft.
Wall Embedment	Include fully- or partially-buried retaining wall structures in the inventory that are known to meet the minimum wall height requirements, and when wall locations are known or verifiable.
Wall Face Angle	Individual walls are further defined by an internal wall face angle, measured at the wall face, greater than or equal to 45^0 ($\geq$1H:1V face slope ratio). This criterion also applies to the internal angle of tiered wall systems (when considered as a single wall system), measured along the top edges of each wall tier.
General Acceptance	When wall acceptance based on the above criteria is marginal or difficult to discern, include the wall in the inventory, particularly where the intent is to support and/or protect the roadway or parking area and where failure would significantly impact the roadway or parking area and/or require replacement with a similar structure.

For most agencies, only walls that serve as an earth retaining structure are included in the final inventory. As a result, sound and noise walls are often excluded from inventory because they do not retain earth. In the same way, agencies like the NY City DOT generally exclude ERSs that are associated with bridges. Unlike the National Park Service and the Alaska Department of Transportation and Public Facilities, Brutus and Tauber excluded all ERS associated with bridges in the NY City DOT wall inventory. This would include retaining walls along a bridge abutment (wing wall) and culvert headwalls. According to Brutus and Tauber, there is no need to include wing walls and culvert headwall in the final wall inventory because they are already inventoried by bridge inspection programs [Brutus and Tauber, 2009].

2.2.4 ERS Classification

The FHWA-CFLHD identified seventeen different retaining wall types and six different functions served by their retaining wall assets. Consequently, all ERSs captured by the NPS database are classified by their wall function. The FHWA-CFLHD defined only three distinct retaining wall types that govern the entire WIP Database. These retaining wall types include: mortared stone masonry gravity structures, dry-laid stone masonry walls, and concrete gravity and concrete cantilever walls. Additionally, when the FHWA-CFLHD queried the WIP database against wall functions, nearly 90% of the NPS Retaining Wall inventory consisted of fill walls designed and built to retain soil. This also included the culvert headwalls [DeMarco, et. al. 2010a].

Similarly, the typical retaining wall types included in Brutus and Tauber's inventory were gravity walls, soldier piles with lagging, mechanically stabilized earth walls, and soil nail walls. AKDOT & PF plans to have its final data base structure correspond directly with those used by FHWA-CFLHD. A summary of the retaining wall types and wall functions used by FHWA-CFLHD, AKDOT & PF, and Brutus and Tauber is listed in Table 3. Depicted in Table 4 is FHWA-CFLHD's suggested approach of classifying different wall structure types.

Table 3: Classification of Wall Function and Type

Wall Function		**Wall Type**	
FHWA-CFLHD	**AKDOT & PF**	**FHWA-CFLHD & AKDOT & PF**	**Brutus and Tauber (NYC DOT)**
Fill Wall	Bridge associated	Anchor, Tieback H-Pile	Gravity Walls
Cut Wall	Grade separation	Anchor, Micropile	Soldier Piles with Lagging,
Head Wall	Slope stabilization	Anchor, Tieback SheetPile	Mechanically Stabilized
Bridge Wall	Earth retaining, cut	Bin, Concrete	Soil Nail Walls
Switchback wall	Earth retaining, fill	Bin, Metal	
Slope Protection	Pedestrian Undercrossing	Cantilever, Concrete	
	Flood control	Cantilever, Soldier Pile	
	Seawall	Cantilever, Sheet Pile	
		Crib, Concrete	
		Crib, Metal	
		Crib, Timber	
		Gravity, Block, or Brick	
		Gravity, Mass Concrete	
		Gravity, Dry Stone	
		Gravity, Gabion	
		Gravity, Mortared Stone	
		MSE, Geosynthetic Face	
		MSE, Precast Panel	
		MSE, Segmental Block	
		MSE, Welded Wire Face	
		Soil Nail	
		Tangent or Secant Pile	

Table 4: FHWA-CFLHD Classification of Wall Structural Types [Brutus and Tauber, 2009]
(Adapted from FHWA Geotechnical Engineering Circular No. 2, 1997)

Fill-Constructed Walls (Built from the Bottom Up)	
Externally Stabilized	Internally Stabilized
Rigid Gravity Walls -Masonry gravity walls (stone, concrete, brick) -Cast-in-place (CIP) concrete gravity walls	Mechanically Stabilized Earth (MSE)Walls -Segmental, pre-Cast facing MSE wall -Prefabricated modular block facing -Flexible facing (geotextile, geogrid or welded- wire facing)
Rigid Semi-Gravity Walls -CIP concrete cantilever T-wall or L-wall (including counterforted walls and buttressed walls)	Reinforced Soil Slopes (RSS)
Prefabricated Modular Gravity Walls -Crib wall -Bin wall -Gabion wall	
-Rockeries	
Cut-Constructed Walls (Built from the Top Down)	
Externally Stabilized	Internally Stabilized
Non-Gravity Cantilevered (Embedded) Walls -Sheet-pile wall (steel, concrete, timber) -Soldier pile and lagging wall -Slurry (diaphragm) wall -Tangent or secant pile walls -Soil-mixed wall (SMW)	In-situ Reinforced Walls -Soil-nailed wall -Micropile walls Root-pile wall Insert pile wall
Anchored Walls* -Ground anchor (tieback) -Deadman anchor	

*Anchors are often used in combination with embedded walls of various types and may also be used in combination with semi-gravity cantilever walls.

2.2.5 Data Collection Categories

All the highway agencies identified in this study that collects and records ERS information in a database include the following: wall location, retaining wall type, wall function, geometrics, conditions of structure and elements, and the consequence associated with structural failure. For the FHWA-CFLHD's WIP, 65 different attributes were collected to define, quantify, and assess the different variety of ERSs included in its database [DeMarco, et. al. 2009]. As a result, their database application uses three forms for entering data collected during field inspections. The first form contains general descriptions including the ERS's location, function, type, age, facings, and surface treatments. The second form is used to enter condition assessment data for each individual wall element. The third form is used to enter action assessment data such as an overall wall

condition rating, a wall action status, the consequence of failure, the repair and/or replacement cost, work order descriptions, and repair recommendations [DeMarco, et. al. 2010b].

Even though the FHWA-CFLHD collects a wide range of data for the NPS, it is recommended to keep data collection relatively simple. Brutus and Tauber recognized the advantage of having a relatively simple database since the entry of data fields increase cost in terms of time, financial resources, and personnel. Before Brutus and Tauber standardized the NY City DOT wall database to reflect a concise and uniform set of data fields; the team identified all the possible data attributes that could be collected for a single ERS. With the assistance of a several notable highway agencies, Brutus and Tauber developed a complete list of 96 possible ERS attributes. The complete list of data fields used in existing inventory and inspection programs is outlined in Table 5.

2.2.6 Inspection, Condition Assessment, and Rating

For the FHWA-CFLHD's WIP, ERS conditions are assessed by qualified inspection teams. An inspection team consists of at least two persons, where the lead inspector is a licensed geotechnical engineer. Consequently, ERS conditions are assessed using a very detailed assessment criterion. First, the ERS components are divided into primary and secondary wall elements as depicted in Table 6. Generally, each ERS is considered to have between five and ten different elements which vary somewhat based on the retaining wall type. For each element the inspectors examine the ERS and record signs of distress including: corrosion or weathering, cracking or breaking, distortion or deflection, and lost or missing elements. Then, each element is described relative to the extent, severity, and urgency of the observable distress [DeMarco, et. al. 2010b]. Finally, the elements are rated with a numerical value according to a predetermined rating system. After each individual element is rated, the overall wall rating is determined by a weighted average of all the elemental ratings.

Unlike the FHWA-CFLHD, many agencies don't have to ability to use qualified inspectors or persons with the required expertise. Unfortunately, due to the cost and time required for these ERS inspections, many agencies resort to using junior engineers and technicians to perform them. As a result, many agencies do not look at individual ratings of wall elements and overall wall performance to establish a final wall rating. Instead, a simple check list is used to assess and determine the overall condition of ERSs.

A sample condition inspection checklist used by Brutus and Tauber is outlined in Table 7. The inspector at the site looks specifically for the items enumerated in the checklist. If any of the conditions exist, the inspector records the condition and takes photographs for the database. The inspector then assesses the area surrounding the ERS and evaluates the consequence if failure were to occur. A decision regarding any required ERS maintenance is later made by personnel in the office. The observed consequence of failure is used to establishing maintenance and future inspection priorities.

Table 5: ERS Data Attributes [Brutus and Tauber, 2009]

SURVEY LOG DATA	LOCATION DATA	DIMENSION DATA (GENERAL)	STRUCTURAL DATA (PRELIMINARY)	STRUCTURAL DATA (VERIFIED)
-ID number*	-GPS location coordinates*	-Exposed height*	-Wall face material*	-Structral type*
-Date of survey*	-Location*	-Total length*	-Apparent wall type	-Total wall face area*
-Times of arrival and departure*	-Offset*	-Wall face slope*	-Wall surface treatment	-Estimated replacement* cost per square foot
-Surveyed by*	-Location photos*	-Total height*	-Wall top feature	-Cost estimate reference*
-Weather*	-District or pollital subdivision	-Estimated area of exposed face*	-Top of wall attachments	-Estimated total replacement cost*
-Soil Moisture	-End coordinates	-Exposed height at beginning point	-Wall face attachments	-Wall face angle as built*
-Work-zone saftey or measures	-Bridge or culvert assocation	-Exposed height at end point	**HISTORY AND OWNERSHIP**	-Foundation type
-Special access equiptment	-Other realted feature	-Height above retained soil	-Year built*	-Proprietary type
FUNCTION DATA	-Access constraints	-Upslope angle	-New or retrofit*	-Fill material
-Functional type*	-Did constraints affect accuracy?	-Downslope angle	-Design Service Life*	**CONSEQUENCES-OF FAILURE FACTORS**
-Supported feature	-Block and lot number	-Criterion length	-Current owner*	-Critical wall height*
-Protected feature	-Photo(s) of access constraints	-Offset of criterion portion	-Owner contact information*	-Critical distance*
-Photo(s) of supported and/or protected features	**CONDITION DATA FROM INSPECTION**	-Photo(s) of top profile	-Original owner	-Roadway type and lanes*
CONDITION DATA (PRELIMINARY)	-Inspection report*	-Roadside features above	-Original contract number	-Sensitive facility supported*
-Checklist conditions*	-Inspection date*	-Roadside features below	-Original cost	-Sensitive facility protected*
-Inspection priority*	-Name of inspector*	-Photos of roadside feature	-Original designer	-COF rating*
-Condition photos & sketches	-Prior documentation reviewed*	**ACTION PRIORITY**	-Original contractor	-Traffic volumes
	-Potential failure type*	-Action approved*	-Maintenance/repair/ modification record	-Interchange distances
	-Condition rating*	-Action priority*		-Utilities near top of wall
	-Performance rating*	-Action date scheduled*		-Utilities near base of wall
	-Projected replacement date*	-Action completed*		-Utilities on wall face
	-Recommended action type*			-Detour length
	-Recommended action summary			-Affected locations

*****Minimum data that should be collected and stored in the ERS database

Table 6: FHWA-CFLHD Primary and Secondary Wall Elements [DeMarco, et. al. 2010b]

Primary Element Condition Ratings		Secondary Element Condition Rating	
Piles and Shafts	Soldier piles, sheet piles, micropiles or drilled shafts, as well as supplemental structures such as walers, comprising part or all of the visible wall.	Wall Drains	Function and capacity of visible drain holes, pipes, slot drains, etc., that provide wall subsurface drainage.
Lagging	Structural lagging between piles and walers.	Architectural Facing	Facing that is not relied on for structural capacity, including concrete, shotcrete, stone, timber, vegetation, etc.
Anchor Heads	All visible parts of tieback anchor, including pad (generally observed without removing cap).	Traffic Barrier or Fence	Traffic barrier or fence above or below wall, and within the influence of the wall.
Wire or Geosyn. Facing Elements	Visible facing or basket wire, soil reinforced elements, hardware cloth, geotextile or geogrids and facing stone.	Road, Sidewalk or Shoulder	Road and/or sidewalk surface above or below a wall, and within the influence of the wall.
Bin or Crib	Visible portion of cellular gravity wall.	Upslope	Groundslope area above a wall affecting wall condition and/or performance.
Concrete	Visible precast or cast-in-place concrete wall and footing elements (does not include piles, lagging, crib blocks, manufactured block or brick, and architectural facing).	Downslope	Groundslope area below the wall, distinct from the Wall Foundation Material element, affecting wall condition and/or performance.
Shotcrete	Visible shotcrete (does not include piles lagging, architectural facing or other specific elements).	Lateral Slope	Groundslope laterally adjacent to a wall affecting wall condition and/or performance.
Mortar	Visible mortar used between uncut or masoned rock, manufactured blocks or brick, or used for wall repairs.	Vegetation	Vegetation near wall or on wall face affecting wall condition and/or performance.
Manufactured Block/Brick	Manufactured blocks and bricks, including CMU's segmental blocks, large gravity blocks, etc. (does not include concrete lagging or crib wall elements).	Culvert	Culvert and inlets or outlets through, below, or adjacent to wall.
Placed Stone	Dry-laid or mortar-set *uncut* rock	Curb/Berm/Ditch	Lined or unlined surface drainage feature above or below wall.
Stone Masonary	Dry-laid or mortar cut rock	Other Secondary Wall Element	Any secondary wall element not listed (provide detailed narrative definition)
Wall Foundation Material	Soil or rock immediately adjacent to and supporting the wall.		
Other Primary Wall Element	Any primary wall element not listed (provide detailed narrative definition).		

In the case of VicRoads Technical Consulting, the basic Inspection Process involves three levels that occur at different times and by personnel with different backgrounds and degrees of experience. The first level of inspection is referred to as a routine maintenance inspection. This inspection is conducted twice a year to check the structural integrity and general serviceability of an ERS. For level one inspections, the inspectors looks for obvious signs of defects and distress such as lateral tilting or budging, extended cracks, corrosion, spalling, heat damage, and erosion to determine if and where maintenance is required. If any elements or signs of distress are noted, the inspector then takes a photograph and determines whether further investigation is needed.

The level two inspections are conducted every two to five years to assess and rate the condition of ERSs. The data from these inspections then goes into an asset database to determine final maintenance needs, assess the effectiveness of past maintenance treatments, model and forecast future changes in condition, and estimate future budget requirements. For the level two inspections, the inspector visually inspects the condition of each element using a standard condition rating system and compares the defects observed with past inspection photographs. After the visual inspection, the inspector documents the ERS by taking a new photograph and identifies the structural elements that may need a detailed engineering inspection (level three inspections), closer condition monitoring, or additional testing. If the inspector identifies a potentially hazardous defect during level one or level two inspections and believes further condition assessment is needed, the inspector can request a level three inspection.

Level three condition inspections are conducted by qualified engineers and specialists. These inspections generally involve an additional assessment of the specific wall elements noted as potential threats to the overall health of the ERS. A summary of the Vic Roads Inspection Process for Retaining Walls is outlined in Table 8.

Table 7: Earth Retaining Structures Condition Checklist [Brutus, et. al. 2011]

1. Wall or parts of it, out of plumb, tilting or deflecting
2. Bulges or distortion in the wall facing
3. Some elements not fully bearing against load
4. Joints between facing units (panels, bricks, etc.) are misaligned
5. Joints between panels are too wide or too narrow
6. Cracks or spalls in concrete, brick, or stone masonry
7. Missing blocks, bricks, or other facing units
8. Settlement of wall or visible wall elements
9. Settlement behind wall
10. Settlement or heaving in front of wall
11. Displacement of coping or parapet
12. Rust stains of other evidence of corrosion of rebars
13. Damage from vehicle impact
14. Material from upslope rockfall or landslide adding to load on wall
15. Presence of graffiti (slight, moderate, heavy)
16. Drainage channels along top of wall not operating properly
17. Drainage outlets (pipes or weepholes) not operating properly
18. Any excessive ponding of water over backfill
19. Any irrigation or watering of landscape plantings above wall
20. Root penetration of wall facing
21. Trees growing near top of wall
22. Any other observations not listed above

This literature review identified agencies that had an ERS inventory and inspection programs. However, no sufficient information was found to conclusively determine an exact inspection cycle for ERS. Based on the literature, inspection interval can range from 2-7 years. For the Oregon DOT, ERSs that were rated “good” are to be inspected every 5 years while those rated “fair” or

"poor" are inspected more frequently. The VicRoads Technical Consulting suggests an inspection cycle of 2 years and the FHWA-CFLHD is considering a 5-7 year inspection cycle.

Table 8: Vic Roads Inspection Process for Retaining Walls [VicRoads, 2011]

	Level One (Routine Maintenance Inspection)	**Level Two (Road Structure Condition Inspection)**	**Level Three (Detailed Engineering Inspection)**
Purpose	To check general serviceability of a structure, particularly for the safety of road users and to identify any emerging problems	To assess and rate the condition of a structure and adjacent roadway and report any significant damage or defects that may require urgent repair or replacement	To undertake specific, detailed structural investigation of a specific component or element of a structure.
Entails	Brief inspection of structural elements – reporting any significant visual signs of damage, distress or unusual behavior	Inspection of road structure elements and an assessment of the condition rating for the structure as a whole using the standard condition rating system. • Inspection shall start at bottom of structure and continue to the top of the structure • Inspect and rate each specified element individually • Compare photos and observations from previous inspections	A variety of tests and inspections may occur depending on the severity and element experiencing the defect.
Recommendation	Determine if structure is in need of a more in-depth and qualified inspection.	Determine if structure is in need of a more in-depth and qualified inspection and nominate elements for closer monitoring if necessary.	
Frequency	Every 6 Months	Every new structure should be given a Level 2, Road Structure Condition Inspection within 12 months of opening and thereafter, once every 2-5 years.	As-Needed Basis
Data Sheets		Structure inventory and photographic record sheet, Condition rating sheet, Structure defect sheet (if element assessed as condition 3 or 4), Structure information sheet, Structure sketch sheet	

2.2.7 Rating Scales

The element conditional rating system developed by FHWA-CFLHD consists of a numerical scale from 1-10, where 10 is the best and 1 is the worst. This rating scale uses a detailed condition assessment criterion to ensure each ERS inspection is completed in the most objective manner. The final wall performance rating used to represent the overall wall condition ranges from 5-100. The meaning attributed to each condition rating in the FHWA-CFLHD's rating system for the NPS is outlined in Table 9.

Table 9: Wall Element Condition Rating Criteria [DeMarco, et. at. 2009]

Element Condition Rating	Rating Definition
9-10 Excellent	No-to-very-low extent of very low distress. Any defects are minor and are within the normal range for *newly constructed or fabricated* elements. Defects may include those typically caused from fabrication or construction. Ratings of 9-10 are only given to conditions typically seen shortly after wall construction or substantial wall repairs.
7-8 Good	Low-to-moderate extent of low severity distress. Distress present does not significantly compromise the element function, nor is there significant severe distress to major structural elements of an element. Ratings of 7-8 indicate highly functioning wall elements that are only beginning to show the first signs of distress or weathering.
5-6 Fair	High extent of low severity distress and/or low-to-medium extent of medium to high severity distress. Distress present does not compromise element function, but lack of treatment may lead to impaired function and/or elevated risk of element failure in the near term. Ratings of 5-6 indicate functioning wall elements with specific distresses that need to be mitigated in the near-term to avoid significant repairs or element replacement in the longer term.
3-4 Poor	Medium-to-high extent of medium-to-high severity distress. Distress present threatens element function, and strength is obviously compromised and/or structural analysis is warranted. The element condition does not pose an immediate threat to wall stability and closure is not necessary. Ratings of 3-4 indicate marginally functioning, severely distressed wall elements in jeopardy of failing without element repair or replacement in the near-term.
1-2 Critical	Medium-to-high extent of high severity distress. Element is no longer serving intended function. Element performance is threatening overall stability of the wall at the time of inspection. Ratings of 1-2 indicate a wall that is no longer functioning as intended, and is in danger of failing catastrophically at any time.

Similarly, most of the agencies that have an on-going inventory and inspection programs for ERSs use a numerical rating system that relies on a single number to reflect the overall condition of their ERS assets. However, since there are not any formal rating metrics, inspection standards, or condition assessment measures for ERSs, the types of rating systems used to evaluate ERSs can vary between qualitative assessments and quantitative assessments. A summary of the variation in ratings systems utilized was also previously presented in Table 1.

For example, the City of Cincinnati uses a numerical rating system with ratings that range from 0-4 [Brutus and Tauber, 2009]. Brutus and Tauber (2009) used a numerical rating system that ranged from 1-7 to survey ERSs for the New York City Department of Transportation. Likewise, the Pennsylvania Department of Transportation and the Nebraska Department of Roads have developed inspection and conditions assessment procedures for MSE walls, which rely on a numerical rating of 2-8 and 0-9 respectively [Jensen, 2009]. Conversely, the Oregon Department of Transportation relies on a three level rating system based on good, fair, or poor condition ratings [Brutus and Tauber, 2009]. The Ohio and Utah Departments of Transportation also use a qualitative assessment method to evaluate the condition of MSE walls. In both of these rating systems, condition assessments are based on a "Yes" or "No" observational evaluation [Gerber, 2012].

As an example of international efforts, VicRoads Technical Consulting (2011) developed a percentage based condition rating system. In the VicRoads rating system, ERS condition assessments are divided into four individual elements: the wall facings or panels (measured by

area), the column and horizontal supports (measured by unit), the foundations or supports (measured by length), and the hold down bolts, base plates, and fittings (measured by unit). The ERS rating is then established by evaluating each individual element and assigning a conditional percentage to the portion of the element that meets the criteria in one of the four conditional states listed in Table 10. For example, if the facing of a concrete retaining wall is 100 meters long and has a 10 meter crack, 90% of the facing would be considered condition 1 and 10% would be condition 3. The sum of the individual condition percentages assigned to each element has to equal 100%. The approach used in this rating system closely resembles the 1-4 rating system outlined in AASHTO's "Manual for Bridge Element Inspection" for its bridge element ratings [AASHTO, 2013b].

Table 10: Conditional Rating States and Calculations [VicRoads, 2011]

Conditional Rating States	Percentage Calculations
Condition 1: Element is in good condition with little or no deterioration	The number of *unit*s making up the element (ex: if 2 out of 10 units are at condition 2, then the rating at condition 2 is 20%)
Condition 2: Element shows minor deterioration: minor cracking & no spalls of real concern	The *length* of the element (ex: if 2 ft. out of 10 ft. of an element are at condition 2, then the rating at condition 2 is 20%)
Condition 3: Element shows advanced deterioration and loss of protection to the supporting material: large spalls, medium cracking	The *area* of the element (ex: if 2 ft^2 out of 10ft^2 of an element are at condition 2, then the rating at condition 2 is 20%)
Condition 4: Element shows advanced deterioration and loss of effective section to the primary supporting material or showing signs of distress: very large spalls, heavy cracking	

2.2.8 Action Assessment

For the FHWA-CFLHD's WIP, highly trained and qualified inspectors are used to obtain wall condition assessments. Thus, the FHWA-CFLHD inspectors generally provide recommendations for further action immediately after assessing the ERS. If further action is required, the FHWA-CFLHD inspector submits a work order that lists the required improvements and gives a cost estimate for repair or replacement. When determining these recommended actions, the numerical condition ratings of the wall elements, the overall wall rating, the apparent design criteria, and the consequences of wall failure are all taken into consideration. The inspector can then recommend one of the following.

- No action is needed
- Need to continue monitoring the wall
- Maintenance work needs to be performed on the wall
- Repair on specific wall elements is needed
- Wall elements should be replaced

A summary of the FHWA-CFLHD retaining Wall Assessment Procedure is depicted in Figure 1. In contrast to the FHWA-CFLHD inspectors, the field inventory and inspection teams for most agencies reviewed in this report do not determine any corrective actions in the field. For many agencies, they don't have the means to use qualified persons for their routine ERS inspections.

Therefore, the inspectors are given a condition assessment checklist to help with identifying structurally deficient ERSs and to identify ERSs and ERS elements in distress. For Brutus and Tauber, instead of determining corrective actions in the field, the inspection team brings the collected data to a reviewing committee that examines the records and photographs and establishes the appropriate course of action.

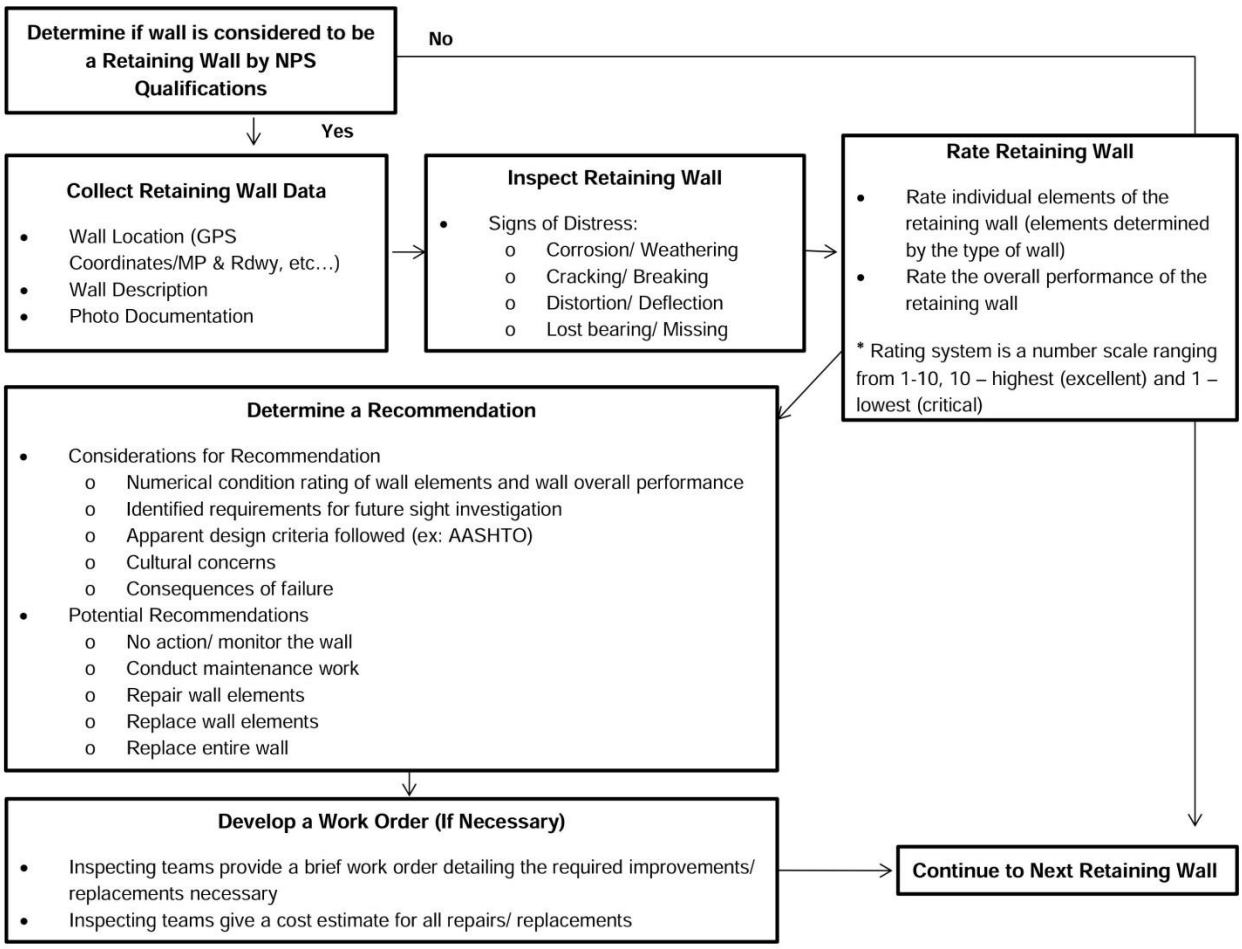

Figure 1: FHWA-CFLHD's Retaining Wall Assessment Procedure [DeMarco, et. at. 2009]

3.0 METHODOLOGY

The work scope for this research study includes the development of a relational database with the appropriate data and query fields, the development of an interactive user interface (using Microsoft Access), identification of retaining wall types of greatest interest to the NCDOT, and the collection of data (using the two data collection forms developed) for 32 ERSs geographically distributed throughout the state of North Carolina. Various data fields were specified and organized according to key identifiers specific to retaining wall type (such as common description given to the apparent retaining wall type). The data collected was utilized to develop a rating system for a quantitative condition assessment of various retaining wall types. Presented in Figure 2 are the ten individual tasks pursued in this research study and the process for which each task was executed.

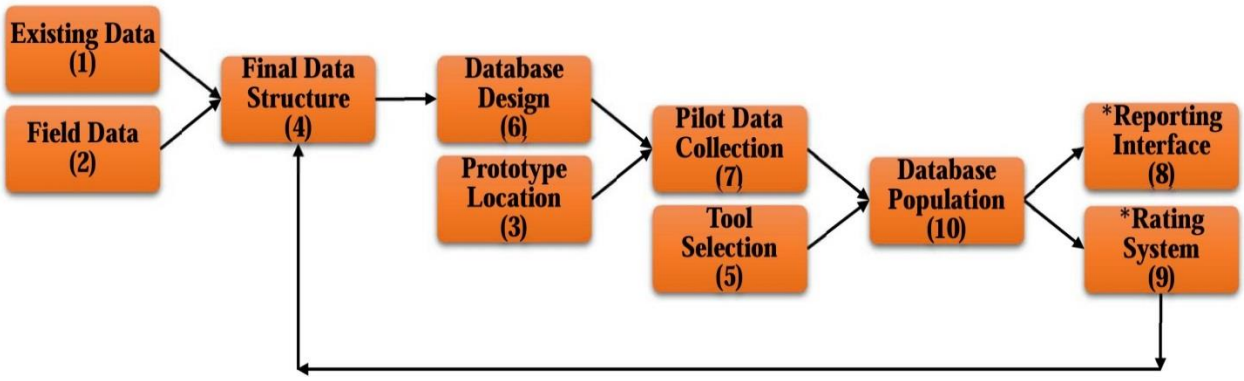

Figure 2: Flow Chart of Project Tasks Undertaken

The WICAS database was designed to provide the NCDOT with a consistent process in managing transportation assets. The purpose of the WICAS serves to improve the overall life-cycle sustainability of new and existing ERSs as to meet performance goals related to safety, mobility, preservation, economics, and environmental stewardship.

3.1 Review of NCDOT Walls and Identification of Data Fields

A review was conducted to collect and assess ERS characteristics that are deemed to be the most important to NCDOT. Existing NCDOT files and databases were reviewed and compiled. The NCSU research team met and worked with personnel from the Structures Management and Geotechnical Engineering Units to identify the ERS wall data aspects and features that each unit might like to maintain and manipulate using a relational database.

3.1.1 BMS

The NCSU research team investigated NCDOT's Bridge Management System (BMS) to determine what data NCDOT collects for its bridges and how BMS uses these data to manage them. BMS is an asset management system that enables NCDOT to manage current and historical bridge inventory and condition data, and then use those data to recommend an optimal set of projects and treatments. BMS manages bridge inventory and condition data by evaluating the performance and deterioration potential of NCDOT bridges, determining maintenance treatments and their costs, and creating a model for prioritizing maintenance actions.

Bridge data are maintained by NCDOT's State Bridge Management Unit (SBMU) and are made available to the State Road Maintenance Unit (SRMU) so that any maintenance work performed by SMRU can be tracked, recorded, and updated in the BMS inventory. In this way, bridge maintenance history and bridge condition data can be stored and evaluated in a single integrated database. NCDOT utilizes AgileAssets (an integrated infrastructure asset management software) as a database platform to maintain BMS inventory.

When evaluating BMS inventory, three bridge elements: deck, superstructure, and substructure, and their corresponding sub-elements, are rated based on their conditions. Bridge inspectors then recommend maintenance treatments based on the condition of bridge elements and sub-elements. The impact of these treatments are then assessed at the project level – by analyzing the impact of

maintenance on each specific bridge – and the network level – by analyzing the impact of maintenance across several bridges.

In conjunction with the assessment of maintenance treatments, BMS also determines the lifecycle costs of bridge maintenance. A maintenance activity's labor hours, equipment, materials, and overall cost is tracked and recorded. This information enables NCDOT to estimate the allocation of resources and budget while preparing maintenance work plans.

BMS offers some maintenance advantages that are transferable to ERSs. A summary of the BMS functions that can also be applied to ERSs are as follows:

- Storing inventory and condition data in an integrated database.
- Using a rating of various criteria to assess condition.
- Developing a maintenance action plan based on criteria condition ratings.
- Evaluating the impact of maintenance at both the project and network level.
- Determining the lifecycle cost based on a maintenance activity's labor and resources.
- Allocating limited budget resources based on maintenance priorities.

3.1.2 HiCAMS

The NCSU research team also investigated NCDOT's Highway Construction and Material System (HiCAMS) to determine what its data items are, how the data are collected, and how the data are stored. HiCAMS is a database system used by two primary user groups (the Central Construction Unit and the Materials & Test Unit) to help manage major construction projects in North Carolina. The Central Construction Unit is primarily responsible for reviewing contract details and authorizing the contracts for work in HiCAMS. The Materials & Test Unit (M&T) is primarily responsible for setting, maintaining, and enforcing compliance standards for the materials used on construction projects for the State. Collectively, both utilize different functions (data entry, records processing and tracking, reference data retrieval, and reporting) within HiCAMS to effectively monitor and manage ongoing construction work, the control and testing of materials, and the producers and suppliers used in that work. A summary of the systems functionality and capabilities are as follows:

- Authorizing and maintaining contract line items for Highway Projects.
- Recording construction work via entry of Material Receipts, Pay Records, and Tickets.
- Calculating contractor payments based on Work Accomplished (Estimates).
- Processing contract changes and adjustments, such as Supplemental Agreements.
- Processing and tracking Contractor Claims.
- Recording information on Subcontracts.
- Entering and maintaining reference data on Materials, Producers and Suppliers.
- Entering and maintaining information about Technicians, Technician Certifications, and Certification Courses and Classes.
- Entering Material Samples and Field Inspection Data.
- Auditing materials, tests, and contractor payments for adherence to standards in support of Project Certification efforts.

With regards to data related to ERSs, the HiCAMS currently stores basic construction data (project number, project location, multimodal investment network (road tier), wall types constructed, wall size, construction cost of walls, and year constructed) for ERSs constructed since the year 2000.

3.2 Field Site Visit (3) Identification of Data Fields

Preliminary site visits were made to three local ERSs in the Raleigh-Durham area, one each of soil nail, anchored, and MSE walls. The purpose of these preliminary site visits was to conduct an initial visual survey of the different retaining wall types and their characteristics to obtain a view and understanding not attainable by office documents and data resources alone. These visits were also used to identify particular data types of interest and to document these via notes and pictures.

As a result of the three initial site visits and internal discussions among the members of the NCSU research team, it was determined that two separate data collection forms would ultimately be needed for cataloging and assessing the condition of permanent highway ERSs (a discussion of each form is provided in Section 3.4 (Data Collection) of this report). As a result of these site visits, the NCSU research team also recommends that the inspector takes pictures and provide comments whenever the ERS or is elements are in a poor or severe state of distress.

3.3 Prototype Locations

For the pilot study in this project, the NCSU research team worked with NCDOT personnel to identify several ERS sites to include in the prototype database design. Originally, the NCSU research team planned to conduct a pilot study on ERSs at 12 different field site locations. However, to provide the NCDOT with the most effective asset management and inspection tool for ERSs, additional field sites with ERSs in either poor condition or performing poorly were investigated. Thus, a total of 15 ERS sites containing a variation in the distribution of ERSs, with respect to geography, retaining wall type, and condition were investigated. About half of these ERS sites were located in the Western Region of North Carolina and the others were located in the Eastern Region of North Carolina. Presented in Figure 3 is a map with the geographical locations of each of the ERSs surveyed throughout the state of North Carolina.

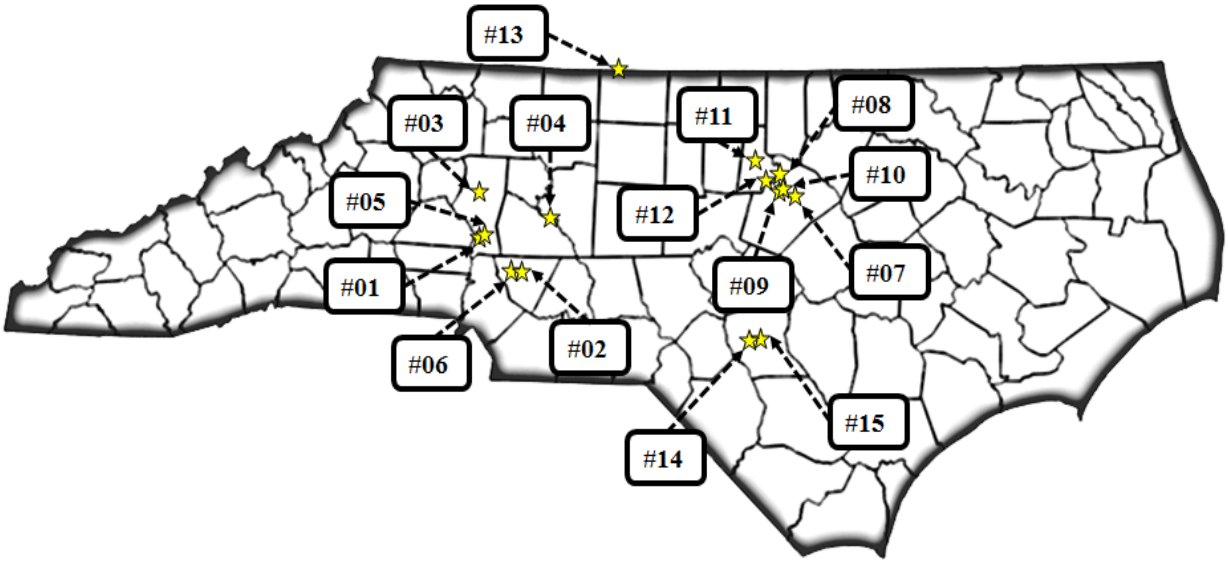

Figure 3: Geographical Location of Field Surveyed ERSs

3.3.1 Western Region

In this study, 6 different wall locations and a total of 12 ERSs were evaluated throughout the Western Region of North Carolina. Table 11 presents a geographical summary of the 12 ERSs evaluated in this region. A summary of the retaining wall types for these 12 ERSs and their function and/or purpose are as follows:

i. Pilot Location #01: SR 1100 (Brawley School Road) over I-77

- 2 MSE wall abutments.
  - Wall ID: 480019 and 480020
- 4 MSE wing walls.
  - Wall ID: 480021, 480022, 480023, and 480024
- Constructed with precast concrete panels.
- Both abutments support the Brawley School Road bridge (Bridge ID: 70) over I-77 in Iredell County.
- Wing walls (parallel to I-77) were constructed to minimize right-of-way and serve as right-of-way support for I-77.

ii. Pilot Location #02: 380 Corban Ave SW, Concord, NC

- 1 MSE wall.
  - Wall ID: 120025
- Constructed with segmental retaining wall units.
- Constructed to minimize right-of-way, encroachment, and permitting.

iii. Pilot Location #03: East Bound on I-40 - East of Radio Road and West of US 21

- 1 Soil Nail wall.
  - Wall ID: 480026
- Constructed with shotcrete (with an architectural finish).

- Constructed to minimize right-of-way and serve as right-of-way support.

iv. Pilot Location #04: SR 2120 (Long Ferry Road) over I-85

- 2 Anchored walls
  - Wall ID: 790027 and 790028
- Constructed with a cast-in-place concrete facing.
- Both abutments support the Long Ferry Road bridge (Bridge ID: 134) over I-85 in Rowan County.

v. Pilot Location #05: 798 Brawley School Road, Mooresville, NC

- 1 Gravity wall.
  - Wall ID: 480029
- Construction with segmental retaining wall units.
- Constructed to minimize right-of-way and maximize or protect the parking areas below the wall.

vi. Pilot Location #06: 5790 Poplar Tent Rd, Concord, NC

- 1 Gravity wall.
  - Wall ID: 120030
- Construction with cast-in-place concrete.
- Constructed to minimize right-of-way and maximize or protect the parking areas below the wall.

Table 11: ERSs Field Surveyed In Western North Carolina

Wall ID	County	Division	Latitude	Longitude	Location Description
480019	Iredell	12	35° 34' 47.94"	80° 51' 23.84"	West Wall Abutment - SR 1100 (Brawley School Rd) over I-77
480020	Iredell	12	35° 34' 45.16"	80° 51' 23.05"	Left Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77
480021	Iredell	12	35° 34' 51.22"	80° 51' 24.63"	Right Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77
480022	Iredell	12	35° 34' 46.48"	80° 51' 21.80"	East Wall Abutment - SR 1100 (Brawley School Rd) over I-77
480023	Iredell	12	35° 34' 49.26"	80° 51' 22.23"	Left Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77
480024	Iredell	12	35° 34' 44.25"	80° 51' 20.97"	Right Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77
120025	Cabarrus	10	35° 24' 04.30"	80° 35' 32.09"	380 Corban Ave SW, Concord, NC 28025
480026	Iredell	12	35° 48' 22.77"	80° 52' 52.52"	East Bound on I-40 - East of Radio Rd and West of US 21
790027	Rowan	9	35° 41' 43.33"	80° 24' 03.38"	East Wall Abutment - SR 2120 (Long Ferry Rd) over I-85
790028	Rowan	9	35° 41' 44.35"	80° 24' 04.35"	West Wall Abutment - SR 2120 (Long Ferry Rd) over I-85
480029	Iredell	12	35° 34' 41.66"	80° 53' 09.35"	The Brawley Market - 798 Brawley School Road, Mooresville, NC 28117
120030	Cabarrus	10	35° 24' 30.56"	80° 40' 25.05"	5790 Poplar Tent Rd, Concord, NC 28027

3.3.2 Eastern Region

Additionally, 9 more wall locations and a total of 20 individual ERSs were evaluated in the Eastern Region of North Carolina. Table 12 presents a geographical summary of each ERS field surveyed in the Eastern Region. A summary of the retaining wall types for these 20 ERSs and their function and/or purpose are as follows:

vii. Pilot Location #07: US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

- 1 Anchored wall abutment.
  - Wall ID: 910001
- 2 Cantilever (Soldier Pile) wing walls.
  - Wall ID: 910002 and 910003
- 1 MSE wall abutment (constructed in 2002 with corrosion monitoring).
  - Wall ID: 910004
- All constructed with cast-in-place concrete and a simulated rock facing.
- All were post-bid designs.
- Both abutments support the Glenwood Avenue bridge (Bridge ID: 540) over Wade Avenue in Wake County.
- Both wing walls (parallel to Wade Avenue) were constructed to minimize right-of-way and serve as right-of-way support for Wade Avenue.

viii. Pilot Location #08: US 70 (Glenwood Avenue) over SR 1837 (Westgate Road)

- 2 MSE walls.
  - Wall ID: 910005 and 910006
- Constructed with precast concrete panels.
- NCDOT does not know the design type but, it could have been back when they were putting 3 vender designs in plans.
- Both MSE walls serve as bridge abutments that support the Glenwood Avenue bridge (Bridge ID: 665) over Westgate Road in Wake County.

ix. Pilot Location #09: I-40 (North Bound) near MM189.1

- 1 Anchored wall.
  - Wall ID: 910007
- Constructed with H-piles, strand anchors, and timber lagging (a chain-link fence is all you can see from the road).
- Constructed about 20 years ago to mitigate a slope failure adjacent to the I-40/Wade Ave Interchange.

x. Pilot Location #10: I-40 (South Bound) near MM189.1

- 1 Anchored wall.
  - Wall ID: 910008
- Constructed with H-piles, strand anchors, and timber lagging (a chain-link fence is all you can see from the road).
- Constructed about 20 years ago to mitigate a slope failure adjacent to the I-40/Wade Ave Interchange.

xi. Pilot Location #11: SR 1322 (Broad Street) over I-85

- 2 Soil Nail wall abutments.
  - Wall ID: 310009 and 310010
- 2 Soil Nail wing walls.
  - Wall ID: 310011 and 310012
- All constructed with brick veneers.
- All in-house design.
- Both wing walls have brick noise walls above them and higher corrosion protection than normal for soil nails (encapsulated nails).
- Walls connected to abutment wall were redesigned during construction (constructed in approximately 2003) due to diabase dike and newly built apartment complex not showing on survey data from 80s.
- Both abutments support the Broad Street bridge (Bridge ID: 136) over I-85.
- Both wing walls (parallel to I-85) were constructed to minimize right-of-way and serve as right-of-way support for I-85 in Durham County.

xii. Pilot Location #12: NC-147 (Triangle Expressway) over SR-1999 (Davis Drive)

- 2 MSE walls.
  - Wall ID: 310013 and 310014
- Constructed with a brick veneer facing.
- Both abutments support two Triangle Expressway bridges (Bridge ID: 588/589) over Davis Drive in Durham County.

xiii. Pilot Location #13: SR 1378 (Martinsville Loop) over Norfolk Southern Railway

- 1 Cantilever wall.
  - Wall ID: 780015
- Constructed with H-piles and timber lagging.
- Wall serves as right-of-way support for the church property above the wall.
- Constructed to minimize right-of-way and maximize the church's property.

xiv. Pilot Location #14: Morganton Road in Fayetteville, NC (Part of U-4756 project)

- 3 Cantilever walls.
  - Wall ID: 250016, 250017, and 250018
- Constructed with H-Piles and precast concrete panels.
- All serve as right-of-way support for SR 1404 (Morganton Road)
- All were constructed to minimize right-of-way and maximize or protect the parking areas below the wall.

xv. Pilot Location #15: Ramsey Street, Fayetteville, NC

- 2 Cantilever walls.
  - Wall ID: 250031 and 250032
- Constructed with steel sheet piles.

- Both sheet pile walls serve as right-of-way support for SR 3950 (Ramsey Street) in Fayetteville, NC.
- Both were constructed to minimize right-of-way and protect the roadway below the wall.

Table 12: ERSs Field Surveyed In Eastern North Carolina

Wall ID	County	Division	Latitude	Longitude	Location Description
910001	Wake	5	35° 47' 52.70"	78° 38' 46.52"	South Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)
910002	Wake	5	35° 47' 51.85"	78° 38' 44.92"	Left Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue
910003	Wake	5	35° 47' 51.94"	78° 38' 47.37"	Right Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue
910004	Wake	5	35° 47' 52.69"	78° 38' 46.67"	North Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)
910005	Wake	5	35° 54' 05.61"	78° 45' 56.63"	West Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)
910006	Wake	5	35° 54' 05.93"	78° 45' 57.50"	East Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)
910007	Wake	5	35° 48' 44.04"	78° 44' 15.95"	I-40/Wade Ave Interchange (North Bound)
910008	Wake	5	35° 48' 46.59"	78° 44' 24.93"	I-40/Wade Ave Interchange (South Bound)
310009	Durham	5	36° 01' 31.20"	78° 54' 59.51"	East Wall Abutment - SR 1322 (Broad Street) over I-85
310010	Durham	5	36° 01' 30.49"	78° 55' 00.83"	West Wall Abutment - SR 1322 (Broad Street) over I-85
310011	Durham	5	36° 01' 33.70"	78° 55' 04.50"	West Wing Wall - SR 1322 (Broad Street) over I-85
310012	Durham	5	36° 01' 26.28"	78° 54' 53.40"	East Wing Wall - SR 1322 (Broad Street) over I-85
310013	Durham	5	35° 52' 13.60"	78° 51' 56.46"	South Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)
310014	Durham	5	35° 52' 14.70"	78° 51' 56.05"	North Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)
780015	Rockingham	7	36° 32' 22.47"	79° 54' 50.70"	SR 1378 (Martinsville Loop) over Norfolk Southern Railway beside Price United Methodist Church
250016	Cumberland	6	35° 04' 09.76"	78° 57' 31.77"	Bank of America - 503 Cross Creek Mall, Fayetteville, NC 28303
250017	Cumberland	6	35° 04' 05.25"	78° 57' 12.48"	Vantage South Bank - 4200 Morganton Road, Fayetteville, NC 28314
250018	Cumberland	6	35° 04' 03.30"	78° 57' 13.10"	Bubba's 33 - 500 Westwood Shopping Center, Fayetteville, NC 28304
250031	Cumberland	6	35° 04' 01.80"	78° 52' 44.42"	North of Railroad - 905 Ramsey Street, Fayetteville, NC 28301
250032	Cumberland	6	35° 03' 57.68"	78° 52' 43.47"	South of Railroad - 881 Ramsey Street, Fayetteville, NC 28301

3.4 Data Collection

The WICAS proposed herein supports ERS data archiving and retrieval for electronic documentation, management, qualitative analysis, and display in the form of photographs. The retaining wall types include mechanically stabilized earth (MSE), soil nail, anchored, gravity, cantilever, and other miscellaneous retaining wall types.

Determining which data to be included in the WICAS database is not driven only by all the possible data that can be collected. In other words, collecting to much data can be expensive, can consume valuable time and labor, can result in a reduction in data quality, and sometimes does not provide a true information return. After a careful study of the data items and consultation with NCDOT personnel, the research team determined the necessary data items to be collected for a focused and targeted ERS management system. The majority of this ERS data can be obtained from inspections, photographs, and other reports available to NCDOT.

To obtain this data, two data collection forms were developed and are presented in Appendix A, and Appendix C. The first form (Appendix A) is the **Wall Identification and Data Attributes Form**. It was determined that this form should only to be used one time to collect basic ERS data of interest to NCDOT. The data collected on this form will be obtained primarily from existing in-house records and resources. The second form (Appendix C) is the **ERS Field Condition Inspection Data Collection Form.** This form collects data related to the condition of the ERS and should be used periodically over an extensive period of time. All the data collected and stored in the WICAS database is solely based on information gather with these two forms.

3.4.1 Inventory Data Collection Form

The inventory data for the WICAS database was largely based on the available data stored within existing NCDOT records. These data include, but are not limited to, information from design or construction drawings, bridge inventory, the Highway Construction and Materials System (HiCAMS), and other types of documentation. Once the information is obtained from these external resources, the data are then entered into the **Wall Identification and Data Attributes Form** provided in Appendix A. The entry fields on this form are (1) an ERS identification number and project reference number that relates a specific ERS to other associated transportation assets and their respective databases, and (2) attributes related to location data, dimension data, retaining wall type and function data, as well as history and ownership. A description of all the data fields listed on the **Wall Identification and Data Attributes Form** is provided in Appendix B. A complete discussion on the development of the ERS identification number is also provided in Section 3.5.4 (ERS identification number) of this report.

Following the office collection of data from available records and respective business areas, the information collected must be verified by field observation and ground-truth and any missing data must then be collected. That is, each ERS entered into the inventory database should be physically visited by trained or qualified staff to verify and collect data in the field.

3.4.2 Field Condition Assessment Data Collection Form

In addition to the verification or acquisition of ERS attribute data, an initial condition assessment should be carried out to establish a baseline for each ERSs structural health and integrity. To

collect data related to the condition of an ERS, an **ERS Field Condition Assessment Data Collection Form** was developed. The NCDOT requested a condition assessment form that includes a broad list of condition assessment criteria characterized by the four ERS categories listed below.

- Facing
- Movement
- Drainage
- Exterior

The NCSU research team was also asked to provide a way to show or describe how much of the ERS is effected by different elements in distress. To address this concern, the NCSU research team recommends the same rating approach outlined in AASHTO's "Manual for Bridge Element Inspection." Since the Structures Management Unit is required to collect element level data for its bridges, this is already the rating method that they are implementing for other work. This rating method is also very similar to the one previously discussed in section 2.2.7 (Rating Scale) for VicRoads Technical Consulting in Victoria Australia. A demonstration of how this rating system and **ERS Field Condition Assessment Data Collection Form** are used for ERSs in North Carolina is presented in section 5.1 (Rating Demonstration) of this report.

3.4.2.1 *Category Observations*

The **ERS Field Condition Assessment Data Collection Form** presented in Appendix C is divided into five sections. The first section provides basic ERS data necessary for identifying and physically locating an ERS in the field and for identifying the inspectors and the date the inspection occurred. The next four form sections are comprised of the four category observations (drainage, facing, movement, and exterior). Each section contains a number of condition evaluation criteria, an average rating (discussed in section 5.0) for each criteria, and a comment box for each criteria. Combined, there are a total of 17 condition evaluation criteria among the four category observations.

The second form section (Facing) identifies visual signs of distress detected on the facing of the ERS including facial deterioration, staining, damage, cracking, joint alignment, joint spacing, and material loss. The third form section (Movement) identifies visual signs of distress that may indicate the ERS is moving including deflection or rotation, bulges or distortion, settlement, and heaving. The fourth form section (Drainage) pertains to visual signs of distress that are related to the presences of excessive water or the improper passage of water including erosion, scour, and the absence of stormwater ditches or blocked weep holes. Therefore, to evaluate the condition of an ERS, the drainage, facing, movement, and exterior categories each have 7, 4, 3, and 3 criteria respectively. A description of the each criterion and the elements that should be observed and evaluated are listed below.

1. **Facial Deterioration:** Missing facing units, spalling, delamination, weathering (splitting or rotting), other deterioration of the wall facing, or graffiti.
2. **Staining:** Discoloration of the facing of the wall from water, efflorescence, rust, or other evidence of corrosion.

3. **Damage:** Damage to the wall from vehicle impact or root penetration.
4. **Cracking:** Structural cracking that penetrates the facing of the wall.
5. **Joint Alignment:** Joints between facing units (panels, bricks, etc.) and/or adjacent wall sections that are inconsistent, misaligned, or uneven across the facing of the wall.
6. **Joint Spacing:** Joints between facing units (panels, bricks, etc.) that are too wide (exposing organic material) or too narrow (removing proper spacing).
7. **Material Loss:** The loss of backfill material through the facing of the wall.
8. **Defection/Rotation:** Wall or parts are visually out of plumb, tilting, or deflecting resulting in a negative or positive inclination beyond the wall's original batter.
9. **Bulges/Distortion:** Local bulges (outward bend or curve) or distortion in the wall facing.
10. **Settlement:** Settlement of wall, visible wall elements, or tension cracks behind wall.
11. **Heaving:** Upward movement or swelling of soil in front of wall.
12. **Erosion**: Disruption or loss of soil or backfill material over a wide area within the sphere of influence of the wall.
13. **Scour**: Evidence of localized material loss specifically at the wall or around the foundation.
14. **Internal/External Drains:** Evidence of improper passage of water through or over the facing of the wall (i.e., clogged drainage outlets (pipes or weepholes) or drainage channels along top of wall that are not operating properly).
15. **Wall Top Attachment:** Displacement, misalignment, or deterioration (staining, cracking, damage, etc.) of the wall top attachment (Fence or Handrail, Coping, Concrete Barrier Rail, Guardrail, etc.).
16. **Road/Sidewalk/Shoulder:** Cracks, depressions, heaves, and any other evidence of active earth movement within the sphere of influence of the wall.
17. **Vegetation:** Evidence of excessive vegetation on or around the wall.

Where there are signs of degradation, structural instability, damaged ERS components, or functional issues that call for significant concern, additional engineering investigations may be warranted for individual ERSs. That is, if the findings from the field condition assessments indicate that an ERS is showing signs of failure, then the additional field evaluations should be undertaken immediately. For critical safety problems, a more detailed means of measurement may include LiDAR measurements taken at some point in time or at other regular intervals as determined by the NCDOT. For noncritical ERSs, LiDAR measurements could be taken only if and when an ERS element is distorted, deflecting, or settling. The use of LiDAR for inventory assessment and infrastructure health monitoring has been demonstrated in a wide variety of applications and is well-suited for ERSs [Chang, et. al. 2014].

3.5 Database Structure and Manipulation

A relational database model was used to design and develop the retaining wall information collection and assessment system (WICAS). The WICAS was designed such that data can be

readily collected in the office and the field. In a relational database, data are collected, organized, and stored in the form of tables. The tables are formatted with columns as named fields and rows for input records. The various data fields identified on the two data collection forms (Appendix A and C**)** are specified and organized in various tables according to key identifiers.

The term relational comes from the fact that, each table is designed such that data are consistent in terms of units, signs, etc., and incorporate an appropriately identified and specified set of rules, or inter-relationships among the data items (rows). The ability to retrieve specific data from different tables (using a key data field) and present it in an organized fashion (i.e., in the form of queries, forms, or reports) is based on the relationship (according to key identifiers) between tables. Thus, the WICAS database is comprised of a set of tables (that stores the data), a set of queries, forms, and reports (that retrieves and presents the data), and a set of programs written in Visual Basic for Applications (VBA) code that are used to update, modify, and delete data. An appropriate set of capabilities to enter and modify data have also been provided. These rules are outlined in the Data Field Description Table attached as Appendix B**.**

3.5.1 Enumerated Data Fields

In consultation with NCDOT, the NCSU research team established a list of enumerated data types for specific data fields listed on the **Wall Identification and Data Attributes Form**. Due to the inherent nature of human beings (prone to making mistakes or clerical errors), there is a restriction on the type of data that can be stored in the WICAS database. As mention previously, significant difficulties arise when incorrect data are collected, stored, and managed including an increase in the cost of doing so, a misuse of manpower, and a reduction in data quality. Therefore, the data entry process was designed such that field personnel are given a specific set of named values (enumerators) to choose from when completing certain entries on the **Wall Identification and Data Attributes Form**.

In the WICAS databased, there are several data fields programmed with drop down menus that contain an enumerated set of values. Presented in Table 13 through Table 24 are the hard coded choices for the enumerated data fields identified on the Data Field Description Table attached as Appendix B.

Table 13: Retaining Wall Type & Facing Table

Wall Type	Full Wall Name	Wall Face	Facing Description
MSE	Mechanically Stabilized Earth	CIP Concrete	Cast-In-Place Concrete
MSE	Mechanically Stabilized Earth	Precast Panels	Precast Concrete Panels
MSE	Mechanically Stabilized Earth	Wire Baskets	
MSE	Mechanically Stabilized Earth	SRW	Segmental Retaining Wall Units
MSE	Mechanically Stabilized Earth	PRW	Precast Retaining Wall Units
Gravity	Gravity Retaining Wall	CIP Concrete	Cast-In-Place Concrete
Gravity [SGW]	Gravity Retaining Wall	SRW	Segmental Retaining Wall Units
Gravity [PGW]	Gravity Retaining Wall	PRW	Precast Retaining Wall Units
Gravity [GGW]	Gravity Retaining Wall	Gabion Baskets	
Anchored [AW]	Anchored Retaining Wall	CIP Concrete	Cast-In-Place Concrete
Anchored [AW]	Anchored Retaining Wall	Precast Panels	Precast Concrete Panels
Anchored [AW]	Anchored Retaining Wall	Timber Lagging	
Anchored [AW]	Anchored Retaining Wall	Steel H-Piles	
Anchored [AW]	Anchored Retaining Wall	Steel Sheet Piles	
Anchored [AW]	Anchored Retaining Wall	Shotcrete	
Soil Nail [SN]	Soil Nail Retaining Wall	CIP Concrete	Cast-In-Place Concrete
Soil Nail [SN]	Soil Nail Retaining Wall	Precast Panels	Precast Concrete Panels
Soil Nail [SN]	Soil Nail Retaining Wall	Timber Lagging	
Soil Nail [SN]	Soil Nail Retaining Wall	Steel H-Piles	
Soil Nail [SN]	Soil Nail Retaining Wall	Steel Sheet Piles	
Soil Nail [SN]	Soil Nail Retaining Wall	Shotcrete	
Cantilever	Cantilever Retaining Wall	CIP Concrete	Cast-In-Place Concrete
Cantilever	Cantilever Retaining Wall	Precast Panels	Precast Concrete Panels
Cantilever	Cantilever Retaining Wall	Timber Lagging	
Cantilever	Cantilever Retaining Wall	Steel H-Piles	
Cantilever	Cantilever Retaining Wall	Steel Sheet Piles	
Cantilever	Cantilever Retaining Wall	Shotcrete	
Miscellaneous		SRW	Segmental Retaining Wall Units
Miscellaneous		PRW	Precast Retaining Wall Units
Miscellaneous		CIP Concrete	Cast-In-Place Concrete
Miscellaneous		Precast Panels	Precast Concrete Panels
Miscellaneous		Timber Lagging	
Miscellaneous		Steel H-Piles	
Miscellaneous		Steel Sheet Piles	
Miscellaneous		Shotcrete	
Miscellaneous		Gabion Baskets	
Miscellaneous		Wire Baskets	

Table 14: Wall Top Features Table

Wall Top Feature	Full Name
Concrete Barrier Rail	Concrete Barrier Rail with Moment Slab
Coping	Concrete Coping
End Bent Cap	Bridge End Bent Cap
Fence or Hand Rail	
Guardrail	
N/A	
Other	
Precast Parapet	
PRW Cap Unit	Precast Retaining Wall Cap Unit
Single Faced Barrier	Single Faced Precast Concrete Barrier
SRW Cap Unit	Segmental Retaining Wall Cap Unit

Table 15: Wall Support Table

Wall Foundation Type
Concrete Footing
Aggregate Footing
Concrete Leveling Pad
Aggregate Leveling Pad
H-Piles
Pipe Piles
Concrete Piles
Drilled Piers
N/A

Table 16: Veneers Table

Wall Veneer
Brick
Stone
Painted
Vegetation
Formed
Stained
Exposed Aggregate
Dyed
Sculpted
Ashlar
Straight-Faced
Tri-Planar
N/A

Table 17: Wall Function Table

Wall Function
Bridge Abutment
Roadway Support
Right-of-Way Support

Table 18: Internal Drainage Table

Wall Face	Full Name
Weep Holes	
Aggregate Drain	
Drain Strip/Board	Geocomposite drain strip or board
None	

Table 19: Wall Features Table

Protected Features:
Roadway
Deceleration Lane
Ramp
Parking Area
Service Road
Sidewalk
Bike Path
Stream or River
Historic Structure
Commercial or Residential Structure(s)
N/A

Table 20: Soil Reinforcement Table

Soil Reinforcement	Full Name
Steel Strips	
Steel Grid	
Geostrips	Geosynthetic Strips
Geogrid	Geosynthetic Grid
Driven Soil Nails	Non-Grouted
Drilled Soil Nails	Grouted
Bar Anchors	
Strand Anchors	
Reinforcing Mesh	
N/A	

Table 21: Wall Obstructions Table

Wall Obstructions
Fence Posts
Handrail Posts
Guardrail Posts
Noise Wall Foundation
Bridge Foundation
Lighting Foundation
Sign Foundation
Signal Pole Foundation
Drainage Box
Utilities
Barbed Wire
Culvert
Pipe
Dense Vegetation
Other
None

Table 22: External Drainage Table

External Drainage
Paved Ditch
Grass Ditch or Swell
Drain Pipes
Inlet Box
Rip Rap
Sloped to Drain
None

Table 23: Fill Material Table

Fill Material	Full Name
ABC	Aggregate Base Course
#57 Stone	
#67 Stone	
#67 Stone	
Coarse Aggregate	
Fine Aggregate	
Select Material	
In Situ	

Table 24: Wall Purpose Table

Wall Purpose	Description
Shorten Bridge Length	Bridge Abutment
Slope Repair or Stabilize	
Minimize ROW/Encroachment/Permitting	Minimize Right-of-Way, Property Encroachment, and Permitting Issues

3.5.2 Tool Selection

A data management system is used to automate the collection, storage, retrieval, and presentation of data. To design and develop the WICAS, the NCSU research team used the Microsoft Access (MS Access) database management software tool. The decision to use MS Access was based on a number of factors. (1) the software is significantly less expensive than other database management tools, (2) it is the most widely used desktop database software for small business application, (3) it is included as part of the Microsoft Office program application (providing a common application interface), (4) it is user friendly, and (5) it is equipped with all the tools necessary to design a fully functional relational database. While there are advantages to using this software for proof of concept, the NCODT can choose to use any software as is appropriate. A platform such as Sharepoint (web application) can be used in conjunction with MS Access services to create a database that is accessible via the internet.

3.5.3 User Interface

The interface of the WICAS provides a user friendly and comprehensive set of menus to provide data that can be used to meet and achieve different management decisions regarding the construction, maintenance, or replacement of ERSs. As depicted by the main menu (Home Screen) in Figure 4, the WICAS has six different menu options. The first option (Wall Search) allows the NCDOT to quickly search for ERSs and review basic information related to an ERS's locations, retaining wall type, and condition. A screenshot of this menu option is presented as Figure 5.

Figure 4: WICAS Home Screen

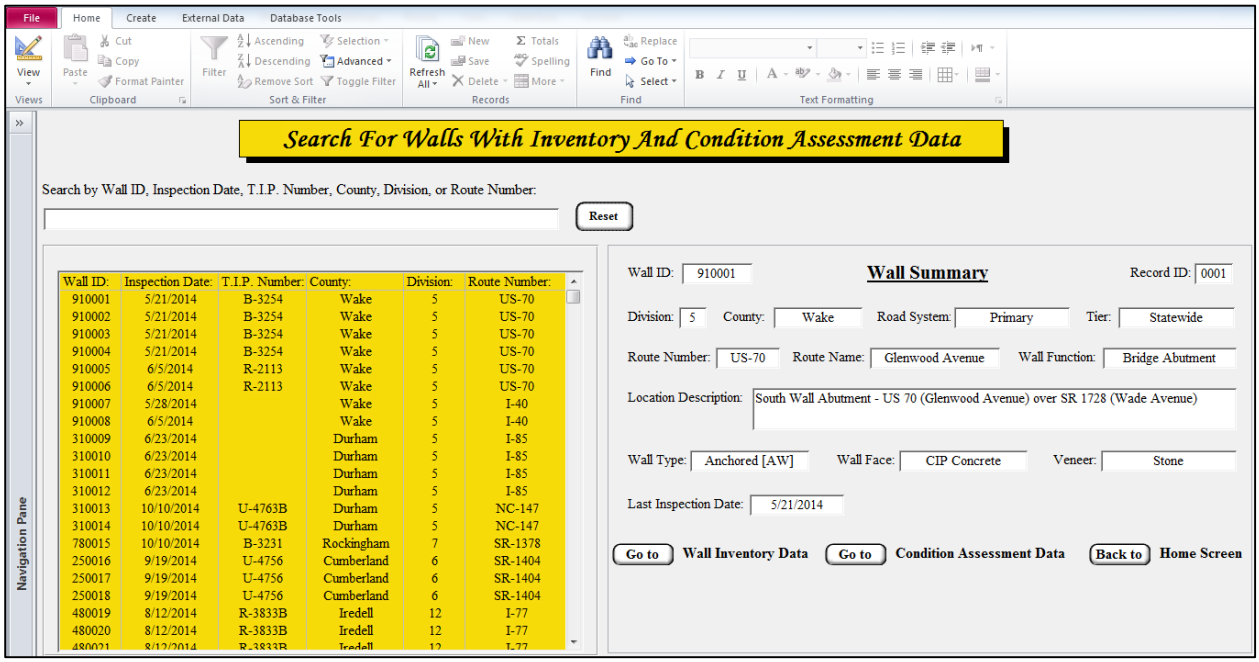

Figure 5: Wall Search Menu

The second option (Enter New Retaining Wall Data) allows the NCDOT to enter new ERS data into the WICAS based on the data collected with the **Wall Identification and Data Attributes Form** and the **ERS Field Condition Inspection Data Collection Form** developed by the NCSU

research team in Section 3.4 (Data Collection). A screenshot of this menu option is presented as Figure 6. The third option (Edit Existing Retaining Wall Data) allows the NCDOT to update, modify, or delete data for existing ERSs stored in the WICAS. A screenshot of this menu option is presented as Figure 7. The fourth option (Open Reports Menu) allows the NCDOT to generate different summary reports about the ERSs stored in the WICAS. A discussion on these summary reports is provided in section 3.5.6 (Reporting Interface) of this report. The fifth option (Exit WICAS Database) allows the NCDOT to exit the WICAS database and the sixth option (Contact Information) provides the contact information for the developer of the WICAS database.

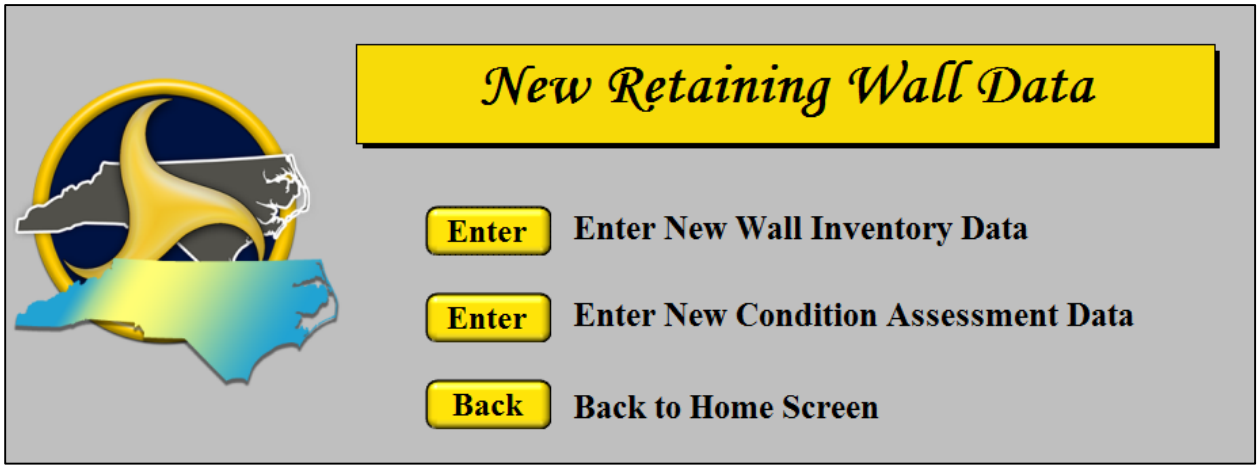

Figure 6: Enter New Retaining Wall Data Menu

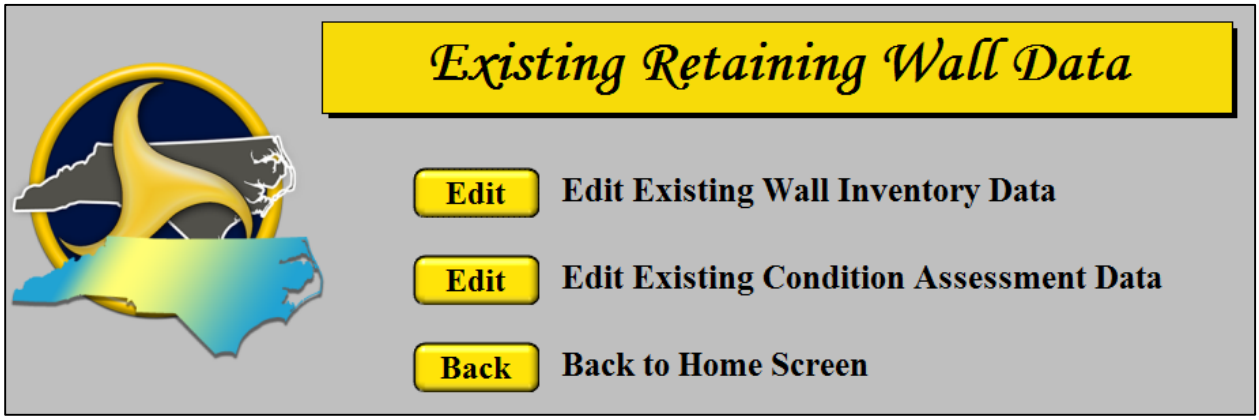

Figure 7: Edit Existing Retaining Wall Data Menu

3.5.4 ERS Identification Number

To enter a new ERS in the WICAS, a new record has to be created and stored in the database. Each record in the WICAS database is associated with a unique four digit number. This four digit number is referred to as the "Record Identification Number" or "Record ID." When a new record is created, the four digit number is automatically generated by the WICAS and assigned to the new record. Essentially, the record identification number serves as an automatically incremented numeric counter. Thus, when a new record is added to the database, the record identification number is determined by incrementing the last record identification number stored in the database by 1.

In the WICAS database, every ERS is assigned a unique six digit identification number. The first two digits indicate the county where the ERS is located and the last four digits (Record ID) uniquely identify the individual records created and stored in the database for that ERS. Presented in Figure 8 is a visual illustration and breakdown of the ERS identification numbering convention. For example, if the ERS is located in Moore County, the two digit county number is 62. If this ERS was the fourth record created and stored in the WICAS database, the record identification number would be 0004. Thus, the ERS identification number for this example would be 620004. Table 25 presents the two digit numbering convention used by NCDOT's Bridge Maintenance personnel to identify the 100 counties located in North Carolina.

Table 25: Bridge Maintenance County Numbers

BRIDGE MAINTENANCE COUNTY NUMBERS							
ALAMANCE	00	CUMBERLAND	25	JOHNSTON	50	RANDOLPH	75
ALEXANDER	01	CURRITUCK	26	JONES	51	PICHMOND	76
ALLEGHANY	02	DARE	27	LEE	52	ROBESON	77
ANSON	03	DAVIDSON	28	LENOIR	53	ROCKINGHAM	78
ASHE	04	DAVIE	29	LINCOLN	54	ROWAN	79
AVERY	05	DUPLIN	30	MACON	55	RUTHERFORD	80
BEAUFORT	06	DURHAM	31	MADISON	56	SAMPSON	81
BERTIE	07	EDGECOMBE	32	MARTIN	57	SCOTLAND	82
BLADEN	08	FORSYTH	33	MCDOWELL	58	STANLY	83
BRUNSWICK	09	FRANKLIN	34	MECKLENBURG	59	STOKES	84
BUNCOMBE	10	GASTON	35	MITCHELL	60	SURRY	85
BURKE	11	GATES	36	MONTGOMERY	61	SWAIN	86
CABARRUS	12	GRAHAM	37	MOORE	62	TRANSYLVANIA	87
CALDWELL	13	GRANVILLE	38	NASH	63	TYRELL	88
CAMDEN	14	GREENE	39	NEW HANOVER	64	UNION	89
CARTERET	15	GUILFORD	40	NORTHAMPTON	65	VANCE	90
CASWELL	16	HALIFAX	41	ONSLOW	66	WAKE	91
CATAWBA	17	HARNETT	42	ORANGE	67	WARREN	92
CHATHAM	18	HAYWOOD	43	PAMLICO	68	WASHINGTON	93
CHEROKEE	19	HENDERSON	44	PASQUOTANK	69	WATAUGA	94
CHOWAN	20	HERTFORD	45	PENDER	70	WAYNE	95
CLAY	21	HOKE	46	PERQUIMANS	71	WILKES	96
CLEVELAND	22	HYDE	47	PERSON	72	WILSON	97
COLUMBUS	23	IREDELL	48	PITT	73	YADKIN	98
CRAVEN	24	JACKSON	49	POLK	74	YANCEY	99

1. County Number (00-99)
2. Record Identification Number (0001-9999)

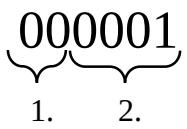

Figure 8: ERS Identification Number

3.5.5 Database Population and Quality Control

The NCSU research team has populated the prototyped database with the data collected from the 15 wall sites previously visited and described in Section 3.3 (Prototype Locations). To provide a sufficient amount of data for testing and demonstration, the NCSU research team evaluated ERSs that varied in type, geographic location, and condition. As a result, a total of 32 ERSs were initially inspected and documented at the 15 wall sites. To better assess the validity of the ERS data that was documented and stored in the WICAS database, the NCSU research team re-evaluated the 32 ERSs a second time, adding a new inspector to collect additional data. In this way, the NCSU research team could determine whether or not different inspectors can obtain the same or similar scores. The results of this assessment are present in section 5.2 (Field Application Study) of this report. Accuracy of the data stored in the WICAS was ensured through the use of quality control procedures and enumerated data fields. An emphasis was placed on developing a functional database that meets NCDOT needs and that can be tested and assessed by NCDOT personnel.

3.5.6 Reporting Interface

The prototype database developed for this project incorporates the ability to query and filter data and to present it in the form of a useful and desired set of tables, queries, forms, and reports. The reporting interface also provides a user friendly and comprehensive set of menus to generate reports to meet different management objectives, benefits, and practices in support of making engineering decisions regarding constructing, maintaining, or replacing ERSs. Of course, the NCDOT could create other reports to meet the needs of other data queries. What we have presented in our system are some basic useful queries but others could easily be programmed.

One of the menus provided by the WICAS is the "Reports Menu." As depicted in Figure 9, the WICAS reports menu is presently comprised of seven different options.

The first option (Review Inventory Data for All Walls) enables the NCDOT to generate a report with the **Wall Identification and Data Attributes Form** populated for all the ERSs stored in the WICAS database (the completed **Wall Identification and Data Attributes Forms** for all of the walls surveyed by the research team have been provided in Appendix H). The second option (Wall Type Summary) enables the NCDOT to generate a report that summarizes the quantity of ERSs by NCDOT Division and by structural type (MSE, Anchored, Soil Nail, Cantilever, Gravity, and Miscellaneous). An example of this summary report is attached as Appendix F.

The third option (Wall Function Summary) enables the NCDOT to generate a report that summarizes the quantity of ERSs by NCDOT Division and by function type (Bridge Abutment, Roadway Support, and Right-of-Way Support). An example of this summary report is attached as Appendix G. The fourth option (Wall Inspection Summary) enables the NCDOT to generate a report with the **ERS Field Condition Assessment Data Collection Form** populated, with the latest condition inspections data, for each ERS stored in the WICAS database. The completed **ERS Field Condition Inspection Data Collection Forms** have been provided in Appendix I.

Options five (Wall Identification and Data Attributes Form) and six (ERS Field Condition Inspection Data Collection Form) enables the NCDOT to either print blank copies of the two data collection forms or print a completed copy of each form for a specific record within the WICAS

database. Finally, option seven (Back to Home Screen) allows the NCDOT to navigate back to the main menu.

Additionally, since there are 17 condition evaluation criteria that are evaluated at each field inspection, the NCSU research teams has programed 17 basic queries (one for each evaluation criteria) in the WICAS database. These queries serve as an example of the type of questions that the NCDOT could ask and answer with the WICAS regarding the condition of their ERS assets. With the basic queries that have been provided, the following questions can be answered:

1. Where are the walls with an average criterion rating ≥ 3 (or any number between 1 and 4)?
2. How many walls have an average criterion rating ≥ 3 (or any number between 1 and 4)?

The average criteria rating and the numerical meaning of these ratings are discussed in the next in Section 5.0 (Proposed Rating System) of this report.

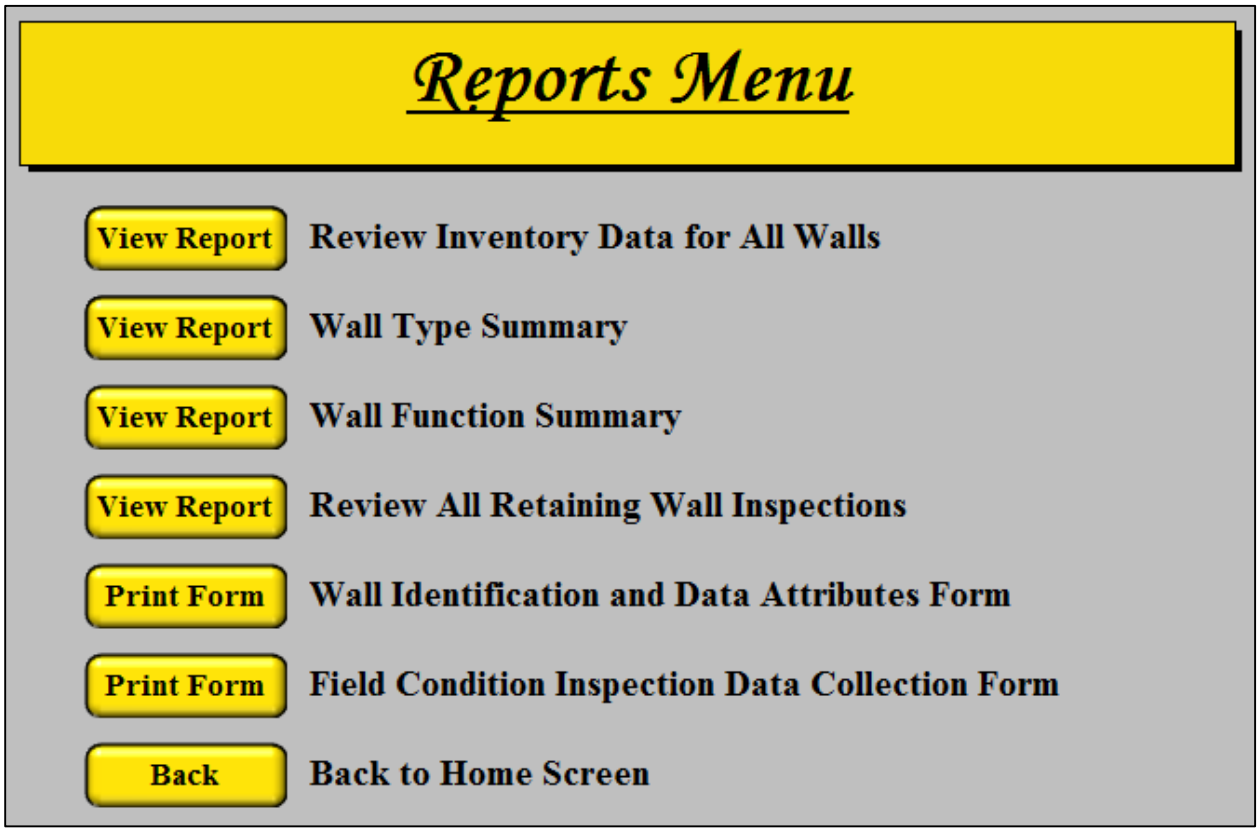

Figure 9: WICAS Reports Menu

4.0 RATING SYSTEMS

A rating system was developed as a part of the database interface such that ERS condition can be quantitative assessed with a set of summary indicators. In consultation with NCDOT personnel and a review of several existing rating systems, the NCSU research team was able to determine the extent to which the database and rating system will be connected.

4.1 MCAP

In an effort to incorporate best practices for assessing the condition of ERSs in North Carolina, the NCSU research team examined the NCDOT Maintenance Condition Assessment Program's (MCAP) condition assessment survey. This survey is used to evaluate the condition of the State's roadways in order to estimate needs for routine maintenance and resurfacing. The elements evaluated in this survey include unpaved shoulders and ditches, drainage, roadside, and traffic control devices.

After a review of MCAP's assessment survey, it was determined that the assets (or asset components) evaluated in this survey are given a performance rating based on meeting a criteria or not meeting a criteria (pass or fail). The research team considered this approach, but ultimately determined that a multi-tiered performance rating approach - using four levels of rating (similar to American Association of State Highway and Transportation Officials' (AASHTO) CoRe Elements rating system or the NCDOT Pavement Management Unit's condition rating system) - would help provide more precision and clarity regarding the overall condition of ERSs and their components. Thus, the research team decided it was more appropriated to use a similar approach to that offered by AASHTO and NCDOT's Pavement Management Unit.

4.2 PMS

Additionally, the NCSU research team examined the NCDOT Pavement Management System's (PMS) pavement condition survey. This survey is used to evaluate the condition of the State's paved surfaces in order to estimate needs for routine maintenance and resurfacing.

The pavement condition survey's rating system uses a four-tiered approach, which provides more precision and clarity regarding the overall rating of specific sections of pavement. For example, a section of pavement may receive a rating of none, light, moderate, or severe for a certain element of distress, depending on its severity. The four-tiered approach is very much in line with the type of rating system the research team is looking to implement with ERSs.

The PMS condition survey uses the ratings for each element to build an overall rating for a specific section of pavement. Maintenance is then prioritized, so that it is provided based on whatever sections of pavement have the most critical score.

Though the logic works well for the Pavement Management System, the NCSU research team has identified that such logic would cause issues if used for ERSs. This is because retaining wall types are varied. Comparing one retaining wall type with another is difficult, thus using elements from disparate ERSs in one equation would be too coarse of a method. In addition, many of the ERSs have elements that are unable to be rated (some ERSs have elements covered by landscapes or the wall facades themselves). These characteristics make it difficult for ERS elements to be input into a single equation and then scored. As a result, the research team is interested in pulling pieces from the PMS rating system, but adjusting the logic to better fit the variation extant in ERSs.

4.3 BMS

Since it is possible to regularly inspect ERS assets, either separately or as a part of existing bridge inspection programs, the condition ratings used to quantitatively assess the condition and

sufficiency of bridges were carefully evaluated. Under Section 1111 of Map-21, commencing on October 1, 2014, State and Federal agencies that have not already done so are to begin collecting element level data as each NHS highway bridge is field inspected (23 U.S.C. 144(d)(2), MAP-21 § 1111). As a result, the Structures Management Unit at NCDOT has implemented the 1-4 rating system outlined in AASHTO's "Manual for Bridge Element Inspection" for its bridge element ratings [AASHTO, 2013b].

At present, WIGINS Inspector is the tool used by the Structures Management Unit for their bridge inspection program (BIP). The WIGINS Inspector rates bridge components based on FHWA bridge condition rating categories (0-9) that are derived from the National Bridge Inventory (NBI). However, the application is currently under reconstruction. The revised WIGINS application will now be referred to as WIGINS Element. The new revised application was scheduled for release in the spring of 2014 and uses AASHTO's four condition states (1 - "good," 2 - "fair," 3 - "poor," and 4 - "critical") to conduct element level bridge inspections. The condition states rating system will also quantify the portion of the rating in distress. At the time of this research study, the Structures Management Unit is using both the 0-9 condition rating system and the 1-4 condition states rating system concurrently.

5.0 PROPOSED RATING SYSTEM

After reviewing several condition rating systems used in existing NCDOT asset management programs as well as in other existing wall management programs, the NCSU research team believes the impending 1-4 rating (best-worst) scale [AASHTO, 2013b] that has been adopted by the Structures Management Unit is the most applicable for this research project. To establish the most suitable condition assessment procedure for ERSs specific to North Carolina, the NCSU research team has applied a 1-4 rating method similar to the method initialized for bridges and abutment walls (outlined in AASHTO's "Manual for Bridge Element Inspection") to all ERSs. In this way, the rating system developed specifically for ERSs also complements the existing framework for bridge inventory and inspection procedures.

In the proposed rating system, the condition of an ERS is determined by performing field inspections and recording quantities for criteria with defects that correlate to a prescribed condition state (GOOD = 1, FAIR = 2, POOR = 3, and SEVERE = 4). The condition assessment is complete when the appropriate portion of the total quantity is stratified over the defined condition states (e.g., with respect to cracks in the wall facing 25% of the wall may be in FAIR condition and the remaining 75% in POOR condition). Examples of how this calculation can be performed were previously provided in Table 10. As with VicRoads and AASHTO, the sum of the individual condition percentages assigned to each criterion has to equal 100%. Once the appropriated percentages are assigned to the 17 criteria listed on the **Field Condition Assessment Data Collection Form**, they are then used in a weighted averaging process to determine a single value rating for each criterion. A demonstration of this rating process is discussed and demonstrated in the next section.

To establish a common understanding of the meaning of the average single value ratings, the NCSU research team chose to modify and adopt the wall condition rating definitions used by FHWA-CFLHD in the "Retaining Wall Inventory and Condition Assessment Program (WIP): National Parks Service Procedure Manual." The NCSU research team has modified and tailored

FHWA-CFLHD's 1-10 element condition rating definitions to fit the recommend 1-4 rating scale. Table 26 shows the final rating definitions and examples for each of the four condition states.

5.1 Rating Demonstration

In the condition assessment example presented in Figure 10 there are 17 criteria that are individually evaluated and rated during field investigations. For each criterion, the inspector has to determine how much of the ERS is affected by each criterion and the relative extent of their severity distress. Based on the inspectors best judgment, percentages are assigned to four different condition states (GOOD = 1, FAIR = 2, POOR = 3, and SEVERE = 4) to quantify the affected areas in distress while simultaneously describing the extent of those distresses. To align with the "Condition Rating Definitions Table" presented as Table 26, the percentages assigned to each criterion are then used as weight factors in an averaging process to generate a single numerical rating (or overall criteria rating). In the WICAS database, overall criteria ratings are referred to as the "Average Rating."

In the "Staining" criteria presented in Figure 10, for example, the inspector determined that roughly 10% of the entire ERS showed signs of staining corresponding to a "Fair" condition state, 40% in a "Poor" condition state, and 50% in a "Severe" condition state. In this example, the majority of staining (roughly 90%) was deemed to be in a "Poor" or "Severe" condition because the steel sheet piles were severely rusted allowing groundwater to seep through the wall facing. As a result, when all the percentages (by rating) were aggregated together (using a weighted average), the overall criteria rating (average rating) was determined to be 3. The calculation for the "Average Rating" was determined in the following manner:

Example Average Rating Calculation: (**1** x 0%) + (**2** x 10%) + (**3** x 40%) + (**4** x 50%) = 3.4

In the calculation illustrated above, the values highlighted in red font correspond to the numerical designations associated with each of the four different condition states. When the product of the numerical designations and the percentages (assigned each condition state) are summed together, then rounded to the nearest whole number, an "Average Rating" is generated. Thus, as depicted in Figure 10, the final "Average Rating" was determined to be 3. In accordance with the element condition rating definitions outlined in Table 26, this means the distressed "staining" criterion may result in a wall failure without near-term repair or replacement.

Table 26. Proposed Condition Rating Definitions

Condition State	Description	Example
1 "GOOD"	**Low Severity Distress** The distress does not significantly compromise the wall's function, nor is there significant or severe distress to major structural elements. An average criteria rating of 1 indicates a criterion that is showing no distress whatsoever or is only beginning to show the first signs of distress or weathering.	A soldier pile wall may have moderately extensive minor surface corrosion on piles where protective paint has weathered and peeled, and may have wood lagging beginning to split. Distresses are very low overall, present over a modest amount of the wall, and do not require immediate or near-term attention.
2 "FAIR"	**Low-to-Medium Extent of Medium Severity Distress** The distress does not compromise wall function, but lack of treatment may lead to impaired function and/or elevated risk of wall failure in the long term. An average criteria rating of 2 indicates a criterion with specific distresses that need to be mitigated in the near-term to avoid significant repairs or replacement in the longer term.	Numerous anchor struts holding MSE wire facing elements in place are beginning to break due to corrosion and suspected over-stressing of the connections at the time of construction. Although the overall function of the reinforced earth wall is not in jeopardy, failing wall facing baskets are allowing facing fill to spill out. If several overlying baskets experience this isolated element failure, significant wall face sag, and deformation may result at the top of wall, eventually impacting the overlying guardrail installation. The element should be inspected carefully along the entire wall and repaired as needed to forestall further facing basket deterioration.
3 "POOR"	**Medium-to-High Extent of Medium Severity Distress** The distress threatens wall function, and strength is obviously compromised and/or structural analysis is warranted. The criteria condition does not pose an immediate threat to wall stability and roadway closure is not immediately necessary. An average criteria rating of 3 indicates a distressed criterion that may result in a wall failure without near-term repair or replacement.	Mortar throughout a stone masonry wall is cracked, spalling, highly weathered, and often missing. Individual stone blocks are missing from the wall face, and adjacent blocks show signs of outward displacement. Although not an immediate threat to overall wall stability, stone block replacement and repointing throughout the wall in the near term are necessary to forestall rapid wall deterioration.
4 "SEVERE"	**High Severity Distress** The criteria condition is compromising the wall's performance and is threatening the overall stability of the wall at the time of inspection. The wall is in danger of failing, requiring the roadway be closed to all traffic until the wall can be replaced or stabilized. An average criteria rating of 4 indicates a severely distressed criterion that may result in a wall failure.	A 15-ft-tall cast-in-place concrete cantilever wall has a large open horizontal crack running the full length of the wall at the base of the stem. Vertical cracks are also beginning to open up in the wall face. Water is seeping from most wall cracks, and is running from the basal horizontal crack at several locations. The wall face has rotated outward, resulting in a negative batter of several degrees. The overlying guardrail is highly distorted above the wall and the adjacent roadway is showing significant settlement above the retained fill.

Note: This table was adopted and modified from FHWA-CFLHD's, "Retaining Wall Inventory and Condition Assessment Program (WIP): National Parks Service Procedure Manual."

ERS Field Condition Inspection Data Collection Form

Wall ID: 250031 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-3950 Route Name: Ramsey Street

Location Description: North of Railroad - 905 Ramsey Street, Fayetteville, NC 28301

Latitude: 35° 04' 01.80" Longitude: 78° 52' 44.42" Wall Type: Cantilever

CATEGORY	OBSERVATIONS	PERCENT BY RATING 1	2	3	4	AVERAGE RATING	COMMENTS
Facing	Facial Deterioration	0	0	50	50	4	Severely weathered sheet piles.
	Staining	0	10	40	50	3	The steel sheet piles are severely rusted allowing groundwater to seep through the wall.
	Damage	100	0	0	0	1	
	Cracking						Not Applicable.
	Joint Alignment						Not Applicable.
	Joint Spacing						Not Applicable.
	Material Loss	100	0	0	0	1	
Movement	Deflection/ Rotation	0	0	10	90	4	The wall face has rotated outward, resulting in a negative batter of several degrees.
	Bulges/ Distortion	0	0	20	80	4	There is a very pronounced bulge near the center of the wall.
	Settlement	100	0	0	0	1	
	Heaving	100	0	0	0	1	
Drainage	Erosion	100	0	0	0	1	
	Scour	100	0	0	0	1	
	Internal/ External Drains						None present.
Exterior	Wall Top Attachment	0	10	10	80	4	The wall top feature has displaced as a result of the wall's negative batter of several degrees.
	Road/Sidewalk /Shoulder	90	10	0	0	1	Some standing water on the sidewalk at the left end of the wall.
	Vegetation	100	0	0	0	1	

Note: If the average rating for any of the criteria listed above is ≥ 2, please include a corresponding picture and comment for each observation respectively.

Figure 10: Field Condition Assessment Data Collection Form Rating Example

Since condition assessments are based on visual inspections (i.e., what the inspector can physically see) it is common to have some blank or missing ratings on the **Field Condition Assessment Data Collection Form**. In Figure 10, one criteria related to drainage did not receive a condition rating because it could not be seen or visually inspected. In such a case, the criterion was not rated and a description about the criteria not being visible or present was added to the comment box. Moreover, since some wall criteria vary with wall type, it is not always necessary or reasonable to rate every criteria listed on the condition assessment form. For example, there were a few criteria (cracking, joint alignment, and joint spacing) related to the wall facing that also did not receive a condition rating because they do not exist for this particular wall type. Thus, it was not sensible to provide a rating for these criteria. Instead, a description stating the criteria were not applicable was added to each comment box respectively.

5.2 Field Application Study

To better assess the validity of the ERS data collected during field investigations, the NCSU research team conduced a field application study. This study involved two different inspectors that field surveyed 32 ERS using the same **ERS Field Condition Assessment Data Collection Form** provided in Appendix C. The objective of this study was to determine whether or not two inspectors could obtain the same or similar average criteria ratings for the same ERSs. As a result of this field application study, some honest differences were noted between the two inspectors. The graph presented in Figure 11 shows the rating differences between 544 (17 Criteria x 32 ERSs) criteria evaluated by each inspector. As depicted in Figure 11, 87.7% (477/544) of the criteria evaluated by each inspector showed no difference between the average criteria ratings. Conversely, only 12.3% (67/544) of the average criteria ratings had a rating difference of 1 or more.

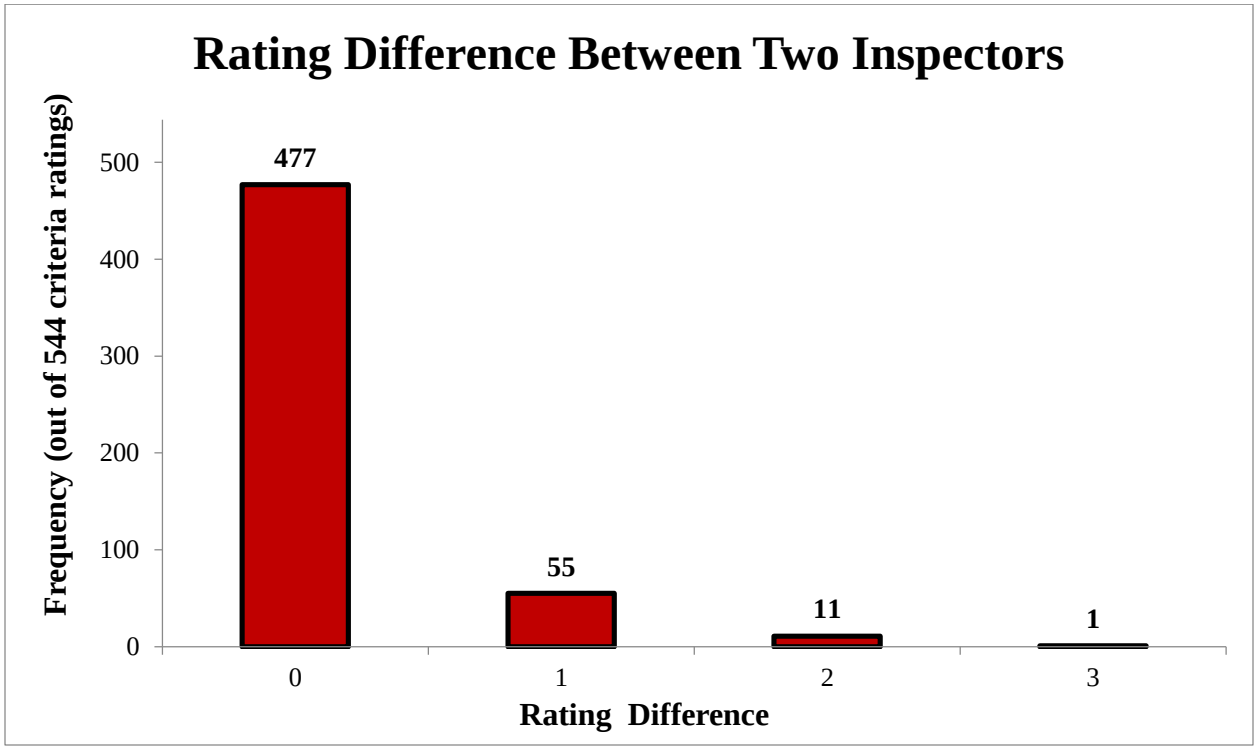

Figure 11: Field Application Study Results

Despite all human differences (i.e., the inspectors experience level, rating style, and ability to identify and/or evaluate distresses that are not clear and apparent), the results from this study would suggest that the ratings between the two inspectors were relatively close. Only 2.0% (11/544) and 0.2% (1/544) of the average criteria ratings had a difference of 2 and 3 respectively. It is worth mentioning that these ratings only represent the condition of individual criterion and not the condition of an entire ERS. In general, it should be expected to have some of the average criteria ratings vary between two closely related condition states (i.e., from GOOD = 1 to FAIR = 2, FAIR = 2 to POOR = 3, or POOR = 3 to SEVERE = 4). For the few instances where the average criteria ratings were not that close (greater than 1), the differences could be attributed to the following:

1. Although each inspection was given a set of definitions for the 17 evaluation criteria, the four condition states, and the average criteria rating, a standard method of quantifying the percentage of the wall that an inspector can rate as either "good," "fair," "poor," and "severe" was not utilized. Thus, both inspectors had to rely on their best judgment and not always use actual measurements to evaluate the condition of every criterion. For example, the "cracking" criteria rating definition does not specify how deep, how long, or how many cracks the ERS has to have along its facing to properly quantify it (or portions of the wall) as either "good," "fair," "poor," or "severe."

2. While the AASHTO "Manual for Bridge Element Inspection" does provide some guidance and addition definitions that could be used to evaluate and assign quantities to various condition assessment criteria, many of their definitions are limited to specific retaining wall types (reinforced concrete, timber, masonry, steel, and other) used as bridge abutments. Thus, there is a need to expand or enhance some of the criteria definitions and tolerances to accommodate other retaining wall types that don't serve as bridge abutments. For example, the "joint spacing" criteria does not exist in AASHTO's "Manual for Bridge Element Inspection" so there is no tolerance defined or specified for the width of joints (i.e., how wide or narrow the joints need to be) in the manual. However, this is a very important criterion that should be rated when evaluating ERSs such as mechanically stabilized earth walls, anchored or cantilever retaining walls with timber lagging, or gravity segmental retaining walls.

3. Lastly, one inspection may consider each ERS evaluation criteria to be mutually exclusive while another may view them as interdependent. Thus, ratings can vary depending on the views of the inspector. For example, the relationship between the "Deflection/Rotation" and "Bulging/Distortion" criteria can be, at times, interdependent. Likewise, the "Staining" criteria can provide some indication about other criteria related to the ERS's drainage system. However, a criterion like the "Wall Top Attachment" may not always be directly affected by the condition of other criteria. Thus, it is possible to have a "Wall Top Attachment" that is in a "Good" condition state even though the rest of the wall is in a Poor" condition state. However, as noted above, these differences may not be that great. Furthermore, experience gained by NCDOT inspectors, coupled with a consistent training program, will reduce the differences even further.

6.0 WICAS FRAMEWORK PHILOSOPHY

Whether formally documented or not, most agency goals are centered on optimizing operational efficiencies and maintaining infrastructure assets at or above the minimum levels of performance for their useful life [Akofio-Sowah et. al., 2014]. To properly maintain these assets, agencies must include asset inventories and condition assessments in their infrastructure asset management programs. Additionally, the evaluation of risk can also be used to assess how well their assets may perform in the future. The WICAS framework is designed to support the inventory, condition assessment, and implementation of systematic data collection procedures for ERSs. Figure 12 illustrates the recommended framework of developing an initial inventory, defining wall condition and criticality, evaluating risk, prescribing a routine inspection cycle for individual ERSs or specific retaining wall types, prescribing recommended actions, and utilizing information for NCDOT planning and programming.

6.1 Risk Assessment

The American Association of Highway and Transportation Officials (AASHTO) defines the term "risk management" as "a process of identifying sources of risk, evaluating them, and integrating mitigation actions and strategies into routine business functions of the agency" [AASHTO, 2013a]. According to AASHTO, a typical method for calculating risk assessment ratings is usually based on likelihood, consequence, and impact [AASHTO, 2013a]. According to Boadi et. al. (2015), "when decision makers develop and implement risk decisions that are solely based on probabilities and magnitudes, they may fail to address broader societal risks." Unfortunately, there are currently no standard metrics available to assist decisions makers with defining risk metrics that also account for societal risks (such as a roadway closure due to an ERS failure) [Boadi et. al., 2015].

To assist the NCDOT with defining the relationship between qualitative ratings and time sensitive actions, the NCSU research team has developed a risk assessment matrix. In Table 27 risk is evaluated qualitatively as a function of both criticality ratings (i.e., whether the consequence of failure (COF) is "High" or "Low") and condition ratings (i.e., whether the likelihood of failure (LOF) is "Very High," "High," "Moderate," or "Low"). Definitions for the COF criteria and the LOF criteria are presented in Table 28 and Table 29 respectively. Once the appropriate level of risk is determined, the frequency of wall inspections and the actions taken as a response to the risk can be determined accordingly. Table 30 and Table 31 present the recommended actions and inspection frequencies as a function of risk.

Table 27: Risk Assessment Matrix

Condition Rating (Likelihood) / Criticality Rating (Consequence)	Low	Moderate	High	Very Likely
High	Moderate	Moderate	High	High
Low	Low	Low	Moderate	Moderate

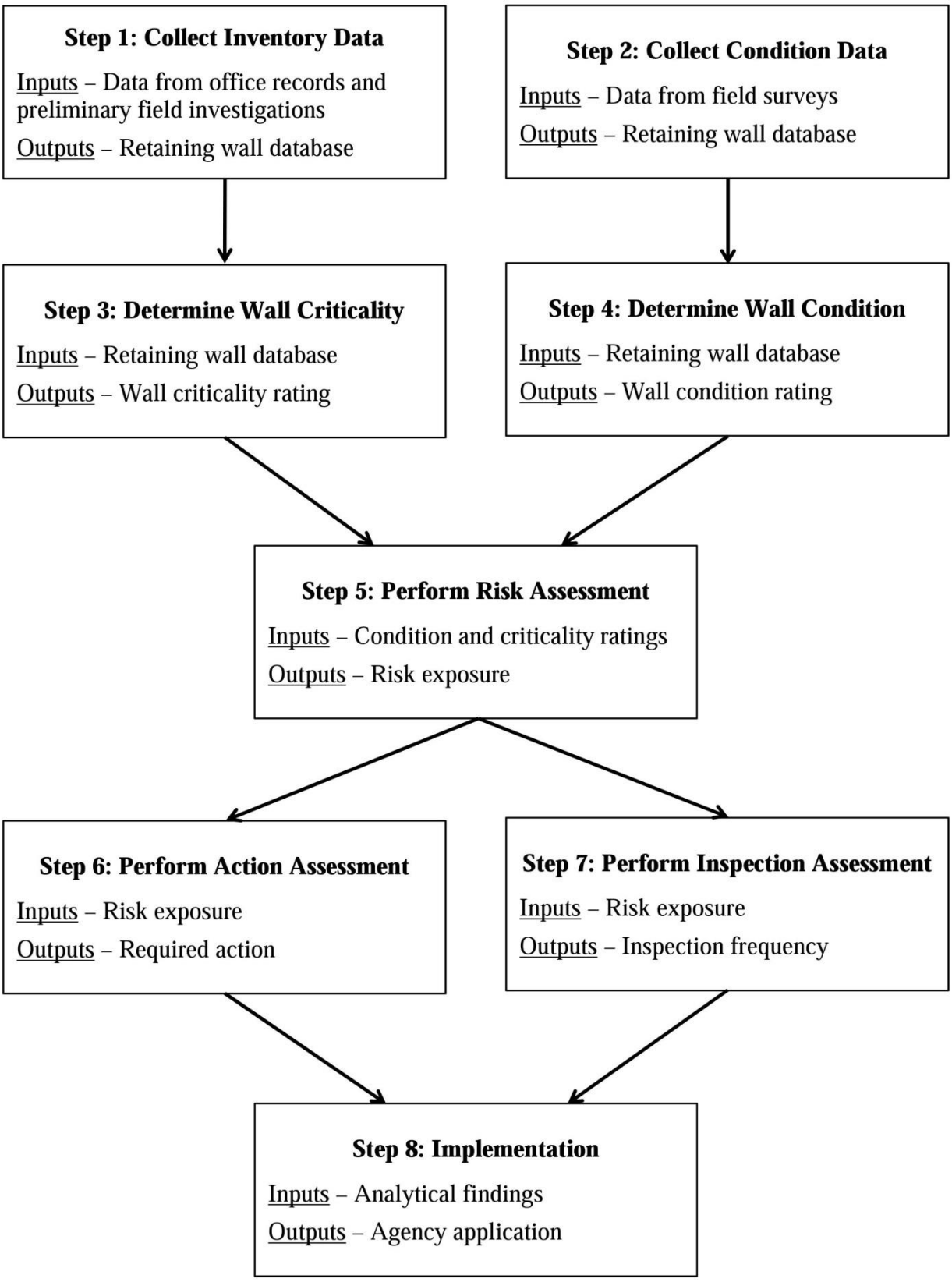

Figure 12: WICAS Framework Philosophy

6.2 Discussion of System Framework Philosophy

The following steps should be considered for the development and implementation of a comprehensive ERS asset management program that incorporates risk assessments.

6.2.1 Step 1: Collect Inventory Data

For a comprehensive asset management program, the initial inventory should be based on the available data stored within NCDOT records (design or construction drawings, bridge inventory, the Highway Construction and Materials System (HiCAMS), and other types of documentation and data sources). The information should then be used to populate the **Wall Identification and Data Attributes Form** provided in Appendix A. The data entry fields listed on the ERS inventory data collection form should include, but should not be limited to, (1) an ERS identification and project reference number that relates a specific ERS to other associated transportation assets and their respective databases and (2) attributes related to location, geometry, retaining wall type, retaining wall function, history (maintenance, year built, etc.), and ownership. A set of definitions, like the **Wall Attribute Data Definitions Table** provided in Appendix B, should be prescribed for each data field identified on the ERS inventory data collection form.

Following the collection of basic inventory data from available records and respective NCDOT business units, the inventory data must be verified by field observation and any missing data must then be collected. That is, each ERS should be physically visited by trained or qualified staff to verify and collect data in the field.

The output of Step 1 will provide the NCDOT with a preliminary inventory of pertinent ERS information that will be used in Step 3 (Determine Wall Criticality).

6.2.2 Step 2: Collect Condition Data

To collect data related to the condition of ERSs, inspection teams should consist of a geotechnical field engineer as well as either support staff designated at the central office or field crews from the appropriate divisions within the NCDOT. The geotechnical field engineer should act as the team leader and be familiar with the expected types and variations of ERSs as well as with the rock and soil formations at the different ERS locations. For this reason, the regional offices within the NCDOT should typically designate a staff member who meets inspector qualifications. Prior to actual field inspections, the team leader should complete the following preparation work in advance.

6.2.2.1 *Assemble Inspection Preparation*

- Develop a schedule for the ERSs to be inspected; schedule sets of ERS inspections by geographic location, accessibility, and special needs.
- Obtain or be able to refer to existing records.
- Verify preliminary data.
- Contact the local engineer in the division where ERSs are located.
- Assemble support field crew.
- Prepare data collection and safety equipment.
- Request special needs or work zone plans.

6.2.2.2 *Inspection Tools and Equipment*

- Measuring tape or wheel.
- Flashlight.
- Long screwdriver.
- Level.
- Hand held GPS.
- Personal protective equipment (protective clothing, safety vest, hard hat, safety glasses, or other protective gear as needed).

6.2.2.3 *Conduct Field Inspections*

The **ERS Field Condition Assessment Data Collection Form**, provided in Appendix C should be used to collected and record field condition data. Ideally, the field crew should be able to complete 4 to 6 wall inspections in a day, and should plan to visit 15 to 20 ERSs within a week. All safety and data collection equipment should be checked for functionality and reliability prior to field departure.

6.2.2.4 *Perform Additional Engineering Investigation*

In the case of degradation, structural instability, damaged wall components, and functional issues that generate significant concern, additional engineering investigations may be warranted for individual ERSs. That is, if the findings from the field condition assessments reveal that a wall is at risk of failure, then additional field evaluations may be necessary, required, or time critical.

The output of Step 2 will provide the NCDOT with an inventory of condition assessment evaluations for the investigated ERSs and their elements that will be used in Step 4 (Determine Wall Condition). Additionally, it will provide the NCDOT with an ERS condition benchmark.

6.2.3 Step 3: Determine Wall Criticality

Wall criticality is the quantification of the consequences of failure of individual ERSs computed as a function of factors including roadway type, traffic volume, detour length, wall type, wall length and height (size), wall function, wall purpose, or wall location. Each of these parameters should undergo a careful evaluation (conducted internally for each ERS) to determine how critical it is for both the NCDOT and the traveling public to sustain functionality of the wall and the roadway. That is, the aforementioned parameters should be carefully evaluated to establish a criticality rating for each ERS. As presented in Table 28, a criticality rating should be assigned to individual ERSs based on their evaluated consequences of failure (i.e., whether the consequence of failure is “High” or “Low”).

Table 28: Consequence of Failure Criteria Definitions

Criticality Criteria Rating	Definition of Failure Consequence
Low	No threat to people or property. No loss of roadway or impact to traffic during wall repair or replacement.
High	Severe injuries to people or fatalities. Total-loss damage to structures or long-term damage to the environment, cultural resources, or other property. Complete closure (long-term) of heavily traveled roadways.

The output of Step 3 provides the NCDOT with a baseline criticality rating that will be used in the qualitative assessment of risk in Step 5 (Perform Risk Assessment).

6.2.4 Step 4: Determine Wall Condition

The age of ERSs is a key factor within most transportation agencies as many walls were built over 50 years ago. Standards, practices, and construction materials have changed regularly over time. Thus, the careful evaluation of criteria related to the condition of ERSs is essential for determining the overall condition and structural integrity of these aging assets.

The quantification of the likelihood of failure of individual ERSs (wall condition) is determined by rating various condition evaluation criteria using the **ERS Field Condition Assessment Data Collection Form** presented in Appendix C. These condition evaluation criteria should be evaluated and rated in the field periodically over an extensive period of time. The ratings obtained from the **ERS Field Condition Assessment Data Collection Form** should then be evaluated further to establish an overall condition rating for an ERS (and its elements). The failure likelihood criteria definitions presented in Table 29 should be used to determine the overall ERS condition rating.

Table 29: Failure Likelihood Criteria Definitions

Condition Criteria Rating	Failure Likelihood Criteria Definitions [FHWA, 2013]
Low	A failure could occur but would require a remote circumstance to trigger failure.
Moderate	A failure could occur but evidence suggests the event could be either unlikely than likely.
High	There is evidence a failure will occur with only a minor triggering event.
Very High	There is significant evidence that failure has occurred or will occur without any further triggering events.

The output of Step 4 provides the NCDOT with a baseline condition rating that will also be used in the qualitative assessment of risk in Step 5 (Perform Risk Assessment).

6.2.5 Step 5: Perform Risk Assessment

Risk relates to safety and traffic operations, or to the amount of traffic that could be affected in the case of an ERS failure. If an ERS failure results in an extended road closure the routes adjacent to the ERS may be affected and the routes within the vicinity may be used as alternative routes. ERS function and the features protected and supported by a particular ERS, should be taken into consideration and analyzed in the evaluation of risk. Features include, but are not limited to, roadway, deceleration lanes, ramps, parking areas, service roads, sidewalks, bike paths, streams and rivers, historical structures, and commercial and residential structures.

ERS risk should be carefully assessed to develop wall inspection plans, remedial or time sensitive actions, and the frequency of future inspections (routine or special need). For example, if the LOF is "Low" and the COF is "High," the risk (from Table 27) for this ERS would be "Moderate."

The output of Step 5 provides the NCDOT with an actual level of risk for various ERSs that will be used in the determination of remedial actions in Step 6 (Perform Action Assessment) and inspection frequencies in Step 7 (Perform Inspection Assessment).

6.2.6 Step 6: Perform Action Assessment

Agencies should develop a procedure for initiating ERS remedial actions based on the acceptable level of risk associated with an ERS. When the appropriate level of risk is determined, the extent to which action is warranted in either the short term or long term can be determined. For example, if the risk is "Moderate," then remedial action (from Table 30) would be required in the long term.

Table 30: Action Assessment Table

Risk	Actions
High	Remedial action is required in the short term.
Moderate	Remedial action is required in the long term.
Low	No action is required.

The output of Step 6 provides the NCDOT with both an action and a subsequent documented history of ERS maintenance, repairs, and replacements. This information is used for the implementation of future planning and programming in Step 8 (Implementation).

6.2.7 Step 7: Perform Inspection Assessment

Agencies should also schedule and develop both an individual and overall inspection plan for all ERSs based on their level of risk. With a quantified risk the NCDOT can determine whether inspections for individual ERSs or retaining wall types should be frequent or infrequent. For example, if risk is "Moderate," then the inspection frequency (from Table 31) is ultimately based on the LOF. Thus, if the risk is "Moderate" and the likelihood of failure is "Moderate," then the inspection frequency for this particular ERS can occur on an infrequent basis.

Table 31: Inspection Assessment Table

Risk	Inspection Frequency
High	Frequent Inspections.
Moderate	The inspection frequency should be based on the likelihood of failure (LOF). If the LOF is "Low-Moderate," the inspection frequency can be infrequent. Conversely, if the LOF is "High-Very High," inspections should occur more frequently.
Low	Infrequent Inspections.

The output of Step 7 provides the NCDOT with both an inspection plan and a subsequent documented history of prior inspections. This information is used for the implementation of future planning and programming in Step 8 (Implementation).

6.2.8 Step 8: Implementation

Many transportation agencies lack the necessary data, service-life measurement methods, or service-life evaluation methods to effectively manage ERSs and other assets [Akofio-Sowah, et. al. 2014]. But if this information is available (properly gathered and assessed), the NCDOT and other agencies can better execute and implement an ERS asset management program to achieve the following:

- Improve accuracy of asset with better quality data.
- Project future asset condition and risk to determine when ERSs should be replaced.
- Assess the effectiveness of past maintenance treatments.
- Model and forecast future changes in asset condition.
- Use geographic and condition data to assist with the replacement of multiple ERSs in close proximity with a similar COF and LOF at the same time.
- Make informed decisions regarding the selection of rehabilitation candidates in lieu of the traditional worst-first or need-based method.
- Prioritize investments to reduce risk and optimally expend funds.

7.0 CONCLUSIONS

Infrastructure asset management is a relatively new concept that is receiving greater attention in geotechnical engineering as new tools and methods emerge and as the need to improve operations and reduce costs become ever more urgent. In general, the nature of earth structures within the realm of highway engineering is well suited to the concept of asset management as a valuable tool for operational efficiency and cost control. Asset management includes a database of assets, tools to manage the database, asset condition and strategies for assessment, mitigation, rehabilitation, and replacement. The development of a systematic means for cataloging and condition assessment of permanent highway retaining structures will represent a major contribution to the ability to establish effective and sustainable maintenance and replacement priorities in support of MAP-21.

Two critical components of an infrastructure asset management program for retaining walls (or other geotechnical assets) are asset inventories and condition assessments. The literature review conducted in this research study identified agencies that had an ERS asset management system and inventory program, how agencies located their ERS, what wall acceptance criteria were used,

what retaining wall types and elements were considered, which inventory data elements were considered, what condition assessments and rating system were utilized, and what action assessments were implemented. However, most highway agencies have not yet implemented each of these components in a fully functional wall management program and none have conducted extensive risk analysis for their ERS assets to properly measure how well their ERS assets are performing.

To date, the Federal Highway Administrators wall inventory and inspection program for the National Parks Service is the most extensive ERS program in the United States. Their efforts have been well documented and involve a very rigorous inspection procedure. Consequently, their inspection teams encompass qualified inspectors and licensed geotechnical engineers. After the FHWA-CFLHD implemented their wall inventory program, they discovered a relatively small proportion of their walls requiring immediate attention. In fact, approximately 1/3 of their ERSs were in need of maintenance or repair and less than 3% of the ERSs needed to be replaced completely [DeMarco, et. al. 2009]. Although many of their ERSs were in an acceptable condition, the use of the WIP has enabled the NPS to build their body of knowledge about their ERSs. As a result, they now have the necessary tools to further reduce the number of deficient ERSs and ultimately reduce the likelihood of ERS failure.

The role of ERSs must be understood in the context of the agency's programming and planning process. The realization and implementation of a WICAS involves an effective allocation of resources that will add value to the overall asset management process of North Carolina's publically owned transportation infrastructure assets. When dealing with ERSs, variations in design, undocumented construction materials, unknown subsurface conditions, lack of historical records, and other potential data omission situations are certain to arise. The NCSU research team concludes that the problems listed below can introduce uncertainty in data management. These problems may result in ineffective asset management and must be carefully considered and addressed so that the methodology presented herein may be implemented in a manner that is consistent and applicable.

7.1 Data Management

- Some ERS inventory and condition assessment data may already exist within NCDOT but are collected, stored, and maintained amongst internal and external parties as opposed to being centrally managed.
    - Information about abutment walls may be retained by the Structures Management Unit.
    - Information about ERSs that are internally designed may be retained by the Geotechnical Engineering Unit's Eastern and Western Regional Offices.
    - Information about ERSs designed by Private Engineering Firms (PEF) may be dispersed.
    - Information about ERS construction and materials may be managed by the Materials & Tests Unit and stored in the Highway Construction and Materials System (HiCAMS).
    - Historic construction and maintenance data may be distributed throughout the 14 divisions.

- The existing databases are not necessarily standardized and the format and organization within individual databases may have changed over time and become inconsistent.
    - Geotechnical engineering projects are designated with either pre-TIP or TIP numbering systems.
    - For spatial data, the NCDOT uses a number of different location referencing systems.
- Many archived records are hard files that have not been fully digitized.
- Other archived records are only available in paper form.

7.2 ERS Identification and Data Collection

- The design of an ERS is not standard and each ERS has been constructed with a variety of features.
- The ERS is not geometrically uniform.
- The buried depth and length of an ERS is not known.
- In some cases the construction of the ERS does not agree with the final drawing, but was accepted without any as-built documentation.

7.3 Data Integrity and Redundancy

- The data are collected by different staff with varying perspectives.
- The data are collected with varying surveying and measurement techniques.
- The data are transferred between groups and through many levels.
- The data are time sensitive.

8.0 RECOMMENDATIONS

Currently, there is no systematic means of inventorying and assessing the condition of permanent highway ERSs. The NCSU research team recommends using the two data collection forms presented in Appendix A and Appendix C to collect both inventory and condition assessment data for these aging transportation assets. It is also recommended that the NCDOT used the WICAS database developed herein to store the data collected on their ERSs. To improve the overall data collection process, the NCDOT should consider programming the data collection forms on tablet computers. This will enable the NCDOT with the ability to access the WICAS database from virtually anywhere (i.e., the office or in the field) to readily collect and store pertinent ERS data.

Every inspector is different and will inevitably rate ERSs differently without the proper training and/or guidance. To improve the condition assessment procedure presented herein, NCDOT personnel should conduct an in-house evaluation of the **ERS Field Condition Inspection Data Collection Form** (presented in Appendix C**)** to properly assess the appropriate level of training required to effectively evaluate the condition of their ERS assets. For example, an in-house evaluation can be an effective way to determine whether condition criteria ratings should be mutually exclusive or interdependent so that inspectors can be trained accordingly.

Moreover, if an inspector identifies an ERS that is at risk of failing, they should also be trained on how to clearly document and articulate those concerns so an additional field evaluation can be scheduled and undertaken in the immediate future. It is recommend that the inspector takes

pictures and provide detailed comments whenever ERS distresses are deemed to be "Poor" or "Severe." In lieu of storing photos directly in the WICAS database, the NCDOT should consider storing the photos on a remote server that can be linked or synchronized with the WICAS database. This will help reduces the overall database file size and improve the overall performance of the WICAS database. Additionally, for critical safety issues that may require additional field evaluation, a more detailed means of measurement may include LiDAR measurements taken at some point in time or at other regular intervals as determined by the NCDOT. For noncritical ERSs, LiDAR measurements could be taken only if and when an ERS element is distorted, deflecting, or settling.

Lastly, the NCSU research team recommends using the WICAS framework philosophy to develop an initial inventory, define wall condition and criticality, evaluate risk, prescribe a routine inspection cycle for individual ERSs or specific retaining wall types, prescribe recommended actions, and utilize the information for future planning and programming. The framework and methodology presented herein will enable the NCDOT better execute an ERS asset management program that can be implemented with NCDOT's integrated asset management system (AMS).

9.0 IMPEMENTATION AND TECHNOLOGY TRANSFER PLAN

Given a database design, a sample prototype database, and a tool, the research team has developed a strategy for achieving the implementation of the WICAS proposed herein. The WICAS provides a framework that can be used to develop and implement inventory and condition assessment procedures for permanent earth retaining structures. The WICAS can also be implemented using existing asset management systems, a database management system, or HiCAMS.

This report fully documents our recommended process and includes a complete discussion of the work completed and the meetings held. This report provides recommendations on tool selection, on data collection (field, office, survey, etc.), and on database use. The recommendations also identify which data can be obtained in the office and which data must be obtained from the field.

The research team worked closely with NCDOT personnel and the NCDOT steering committee to ensure that the progress of the project and the activities undertaken met the specific needs of the State Geotechnical and Structures Engineers. In addition to project kickoff and closeout meetings the research team met with appropriate NCDOT personnel regarding site and retaining wall selections. On December 4, 2014 the NCSU research team also met with the project steering and implementation committee to deliver a demonstration of the prototype database tool that was created to illustrate the range of functionality that could be obtained in an implementation.

The NCSU research team will make a final presentation of the entire research process. The team is also available as a resource for future consultation or training sessions, if desired, to convey the results and use of the products to the NCDOT.

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11.0 BIBLIOGRAPHY

Included in this section are the abstracts of all the resources consulted but not cited in the report (in the References section). The abstracts are provided so the reader can better understand the content of the document.

Reports

6.1 "Asset Management for Retaining Walls"
[CTC, 2013]

Asset Management for Retaining Walls is a synthesis report produced by CTC & Associates for the Minnesota Department of Transportation. The report was intended to aid the Minnesota Department of Transportation in the development of and asset management system for metro retaining wall. In this report, CTC & Associates state that retaining wall asset management programs for most agencies are still in the infancy phase. However, they did identify a select few that had substantial programs already in place. These agencies included the FHWA, the Alaska DOT, and the Oregon DOT. In addition to the guidance obtained from these three agencies, this report also references a number of reports regarding the development of retaining was asset management programs and geotechnical asset management programs.

6.2 "Inspection Guidelines for Construction and Post-Construction of Mechanically Stabilized Earth Walls"
[Vankavelarr, et. al. 2002]

The Delaware Center of Transportation Inspection Guidelines for MSE walls is extremely informative about the nature of MSE retaining walls and the possible interior and exterior materials that may be used to create MSE walls. A list of important parameters to watch for during construction and to monitor after construction is also included. The guidelines give a basic construction sequence description for the MSE walls and provide many helpful photographs to aid in understanding the process. Most importantly this guideline gives a Post Construction Inspection checklist and photo essay that describes possible problems with retaining walls (typically but not exclusively MSE walls). Photocopies of these documents are outlined in this source.

6.3 "Investigation of Corrosion of MSE Walls In Nevada"
[Siddharelarr, et. al. 2010]

The "Investigation of Corrosion of MSE Walls in Nevada" is a report funded by the Nevada DOT. Included in this report is the development process for an MSE wall database in the form of both an excel spreadsheet and a Microsoft Access database. The report discusses MSE wall failures and the causes of these failures, specifically taking Nevada MSE walls into consideration. It was reported that MSE walls suffer from corrosion of their metal reinforcements. This corrosion is primarily caused by the aggressiveness of the backfill soil. Differing levels of aeration, primarily cause by the level of compaction in the backfill and variations in moisture content, is the primary causes of aggressive soils. In order to slow the rate of corrosion, it is important to have a balance between soil resistivity and the amount of Sacrificial Thickness, which is the amount of galvanized covering.

According to the NCHRP 24-28 2007survey referenced in this report, North Carolina has 24 MSE retaining wall sites and reported not having direct physical measurements of corrosion. Without direct physical measurements, it is near impossible to obtain a correct evaluation of the MSE wall. As seen in the Nevada case studies, the MSE walls near failure, due to heavily corroded reinforcements, did not show any outward signs of distress. If direct measurements are not taken and the corrosion rate is higher than expected, despite the cause, wall failure is likely to occur prematurely. Direct invasive measurements such as taking reinforcement samples are considered one of the best testing methods for providing the most accurate results.

6.4 "NCDOT Maintenance Condition Report"
[Conti, et. al. 2012]

The NCDOT is unlike most Departments of Transportation because it maintains all road types with the exception of municipal or private roads (~80,000 miles of road). The NCDOT goal is to protect the investments made on these roadways by properly maintaining and thereby preserving roadway assets. In 2007, the NC General Assembly began requiring NCDOT to establish performance standards for the maintenance and operation of the state highway system (qualitative and quantitative descriptions) and report the findings along with the funding needs. In October 2011, the NCDOT completed "The Roadway Review" which was a survey including over 300 participants from 61 different communities in North Carolina. The purpose of this survey was to revise the performance measures used for the Maintenance, Bridge, and Pavement Condition Surveys so that they reflected public opinion.

6.5 "NCDOT Performance Dashboard Documentation: Rationale and Supporting Information for the Performance Dashboard"
[NCDOT, 2010]

The NCDOT Dashboard is a collective document explaining how NCDOT carries out departmental goals. The goal most closely relevant to the retaining wall project is: "Make our infrastructure last longer: Infrastructure Heath." NCDOT's current infrastructure health index

utilizes three statewide surveys: Maintenance Condition Survey, Bridge Condition Survey (1-9 ranking scale) and Pavement Condition Survey (0-100 ranking scale).

In addition, the Roadside Feature Condition represents the physical condition of all highway features and elements excluding pavements and bridges. These elements include shoulders and ditches, drainage, roadside elements (mowing, brush, tree control, slope, guardrail, etc.), traffic control devices, and environmental (vegetation) management. The roadside feature Level of Service (LOS) is primarily determined by evaluating samples of 0.2 mile segments and giving them a score on a 0 to 100 scale. The data collected for the roadside feature report comes from the Maintenance Condition Survey.

The overall health index is a weighted average of the pavement condition, bridge condition and roadside feature condition: Pavement Condition (40%) + Bridge Condition (35%) + Roadside Feature Condition (25 %).

6.6 "Manual for Design & Monitoring of Soil Nail Walls"
[FHWA, 1998]

The FHWA Manual for the design and monitoring of Soil Nail walls provides an in depth description and explanation of soil nailing. It also provides a comparison between soil nail, tie back, and MSE retaining walls with respect to the wall construction, wall behavior, and design considerations. Soil Nail walls are built from the top down. Excavations are performed in small segments and after the excavation occurs, a nail is driven into the slope and another excavation is performed. Similar to MSE walls, if Soil Nail walls are to be used as a permanent structure, a facing (such as CIP concrete) is required. Soil Nail walls are also commonly used during construction as temporary reinforcement. This manual also suggests parameters to monitor when inspecting retaining walls. A qualitative comparison between MSE, Soil Nail, and Tie Back walls as well as the monitoring parameters can be found in the manual.

6.7 "Review of Mechanically Stabilized Earth Wall Performance Issues"
[Alzamora, et. al. 2009]

This review of MSEW performance provided many examples of why MSE walls are experiencing failure. The review goes into detail about possible design and construction issues that can occur fie MSE walls. A list of benefits for having a retaining wall asset management system is presented in this report. These benefits include making more informed cost-effective decisions, optimizing the use of existing highway funds and resources, maximizing transportation system performance, minimize life cycle costs, and improve asset preservation through focused preventive maintenance efforts.

6.8 "Asset Management Systems for Retaining Walls"
[Anderson, et. al. 2013]

This report gives an overview of the asset management system for retaining walls of the NPS. In this report, it brings forth evidence in the development of inventorying wall assets by various DOTs

since 2004, where only seven DOTs had experience in this field. It uses this information to compare to the NPS system and its effectiveness.

6.9 "Corridor Management: A Means to Elevate Understanding of Geotechnical Impacts on System Performance"
[Anderson, et. al. 2013]

This paper discusses the application the principles of asset management to geotechnical assets, including inventorying, condition assessment and condition prediction. This paper presents an overview of the importance of the correlation between asset and geotechnical assets while examining states that have either cut this program from their budget or have not included it at all.

6.10 "Capturing the Impacts of Geotechnical Features on Transportation System Performance"
[Anderson, et. al. 2013]

This paper discusses the components of corridors individually to assess the overall performance as they are primary assets of transportation agencies. The components of corridors discussed include embankments, slopes, walls, bridges, and pavements. If these individual components were to fail or weaken, processes like settlement, slope instability, rockfall, erosion, and corrosion could occur. This paper also discussed the need and opportunity for geo-professionals to develop tools and practices for inventorying, assessing performance, and predicting life-cycle costs and degradation or risk associated with geotechnical features.

6.11 "Geotechnical Asset Management: Implementation Concepts and Strategies"
[FHWA, 2013]

This document discusses agency goals, data management, data collection, performance measures and performance analysis as well as general concepts for managing geotechnical features. This document discusses the development of the practice of the items discussed previously by providing examples of states that exemplify successful and unsuccessful attempts of a management program. This document recommends that a geotechnical management program should include the following components: Data management, Inventory and condition surveys, Levels of service, Service life, Performance measures and condition indices, Risk management, Life-cycle and benefit and costs analyses, and Decision support.

6.12 "Condition Assessment of Earth Reinforcements for Asset Management"
[Fishman, et. al. 2009]

This document discusses the history and importance of MSE structures and its components in a transportation management program. This document also discusses various techniques and data tools used to collect and analyze data to best measure the performance of MSE structures.

6.13 "Network-Level Data Collection for Asset Management of Retaining Walls and Approach Slabs"
[Gabr, 2012]

This paper discusses the new concept within geotechnical engineering, asset management, and its possibility to be highly successful through increased operation efficiency and cost control. This paper presents an overview of geotechnical asset management and its relation to settlement of bridge approach slabs, retaining walls inventory and profile measurements. These relations represent a collection of challenges frequently addressed by departments of transportation. Results in the paper demonstrates aspects of data collection on a network level for the bridge approach slabs and four retaining walls, and summarize important features of data collection approaches, and challenges associated with data management and manipulation.

6.14 "Assessing the Long-term Performance of Mechanically Stabilized Earth Walls"
[Gerber, 2012]

This report addresses the practice of asset management of MSE walls by agencies and the importance of implementing these practices as they are often overlooked. This report discusses the state of inventory practice, data collection, data assessment, and rating systems by various states and agencies.

6.15 "Feasibility of a Management System for Retaining Walls and Sound Barriers"
[Hearn, 2003]

This report provides an overview of inventory records, elements, components, condition states, and appraisals of walls and barriers. This report also discusses a wall and barrier management program that can be implemented using existing bridge management software. This correlation between wall, barrier, and bridge management programs is also discussed in this report.

6.16 "Inventory System for Retaining Walls and Sound Barriers"
[Hearn, et. al. 2004]

This document discusses the information needed to create an inventory system for retaining walls and sound barriers. Such information includes: location, age, service, type, dimensions, and appraisals of a structure together with element-level models and element-level condition reports. These inventory items have been developed from corresponding bridge inventory information and notes the correlation between walls, barriers, and bridge elements.

6.17 "DIGGS: Setting the Standard for Geotechnical and Geoenvironmental Data Management"
[Lefchik, et. al. 2007]

This document discusses the conjunction of the FHWA with the Ohio DOT to oversee the development of data formats and dictionaries used for geotechnical management systems. The development of these items produced a geotechnical and geoenvironmental data exchange called DIGGS, which was released in 2008. The advantages of DIGGS includes the ability to exchange data between databases within an organization and with external organizations, ability to efficiently incorporate data from consultants into any database, ability to perform software-automated data checks, ability to exchange data between compatible software packages, and the ability to merge databases and incorporate software into an integrated geotechnical management system. The tools available with DIGGS includes a database with GIS interface for state

transportation agencies, software for subsurface data reporting, a virtual data center that enables data exchange across organizational boundaries, and the United Kingdom Highway Agency geotechnical management system. Several geotechnical and geoenvironmental software vendors have already included DIGGS translators in their software.

6.18 "Struggling to Keep an Eye on 2,000 Retaining Walls"
[Luo, et. al. 2005]

This article notes that New York City start a retaining wall inventory system after a retaining wall collapse in 1998.

6.19 "Estimating Life Expectancies of Highway Assets"
[NCHRP, 2012]

This report, consisting of two volumes, provides methods for estimating the life expectancies of major types of highway system assets, in a form for the usage of state DOTs and other agencies to conduct lifecycle cost analyses that support management decision making. The two volumes discuss applying this method and the technical issues and data needs associated with these performances.

6.20 "LRFD Metal Loss and Service-Life Strength Reduction Factors for Metal-Reinforced Systems"
[NCHRP, 2011]

This report presents the conclusions of prior research in the development of metal loss models used for metal-reinforced systems. The research conducted is of interest to state agencies and various industries that focus in the construction and maintenance of bridges, structures, and primarily MSE walls.

6.21 "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes"
[NHI, 2009]

This manual primarily provides a criteria used in evaluation of corrosion loss through the use of coated and uncoated steel reinforcements. This criterion is also used to determine the age and installation damage losses found when using geosynthetic reinforcements. This manual also recommends proper monitoring methods of these reinforcements.

6.22 "Evaluation of Corrosion of Metallic Reinforcements and Connections in MSE Retaining Walls"
[ODOT, 2008]

This document discusses the importance of MSE retaining walls in various Oregon DOT projects that have prevented serious financial and safety impacts for the DOT by using metallic reinforcements and facing connections. This document discusses the development of the MSE walls and the DOTs monitoring of corrosion in a developed MSE wall.

6.23 "Oregon DOT Retaining Walls Asset Assessment"
[ODOT, 2007]

This document gives an overview of Oregon DOT's very limited retaining wall asset management as of 2007.

6.24 "Trial of Geotechnical Asset Management for Highway Embankments Constructed on Soft Clay Foundations"
[Ohta, et. al. 2009]

This paper discusses a project in Ebetsu, Hokkaido in Japan that developed a trail of implementing a geotechnical asset management program for highway embankments that were place on soft clay foundations. This project developed predictions and estimates of the settlement of embankments and maintenance costs of these embankments.

6.25 "Geotechnical Asset Management: A Case Study of Practice in the Highways Agency"
[Patterson, et. al. 2007]

This document discusses the geotechnical assets of the England Highways Agency. The geotechnical asset supports landscaping (soft estate), communications, drainage, and highway structures, as well as road pavement. This document further discusses the current and predicted approaches to geotechnical asset management. The elements of asset discussed in this document included the elements of all asset management process levels, from risk assessment, information management systems, performance targets, continual improvement, and policy. Asset management policy and strategy, data management systems, asset management procedures, asset data analysis, performance management, and geotechnical performance indicators are all examined.

6.26 "Geotechnical Asset Management for the UK Highways Agency"
[Power, et. al. 2012]

This paper discusses England's Highways Agency strategy for geotechnical asset management. This strategy includes components such as setting standards and advice, through data collection and analysis through to the ultimate aim of providing and maintaining an asset that meets the service level that it is required to attain.

6.27 "Asset Management in a World of Dirt: Emergence of an Underdeveloped Sector of Transportation Asset Management"
[Stanley, 2011]

This article discusses the development of the application of asset management principles to geotechnical assets by transportation agencies. This article provides examples from various departments of transportations to exemplify programs that have taken initiative to include geotechnical asset principles.

6.28 "Investigation and Implications of MSE Wall Corrosion in Nevada"
[Thornley, et. al. 2010]

This document provides an overview of the MSE walls and locations with Nevada and the process of reducing corrosion levels through Nevada's department of transportation. Investigation of corrosion levels led to the discovering of metal losses and electrochemical properties within the MSE reinforced fill. The conclusion of this research within Nevada led to predictions of improving service life of MSE walls.

6.29 "Assessing Corrosion of MSE Wall Reinforcement"
[UDOT, 2010]

This document discusses research on MSE walls in the detection of corrosion by extracting reinforcement coupons. This project also developed proper techniques for the removal of these reinforcement coupons found on MSE walls.

6.30 "Risk Based Methods for Management of Geotechnical Features in Transportation Infrastructure"
[Vessely, 2013]

This document presents the purpose of asset management in transportation to meet performance goals in the most cost-effective manner. These goals include safety, mobility, preservation, economics, and environmental aspects. This document develops the proper incorporation of these goals into a transportation asset management program while also discussing past and predictions of improvement of asset management. This document also discusses risk-based methods for asset management and its uses.

6.31 "LiDAR for Data Efficiency"
[WDOT, 2011]

This report provides an overview of a research project designed to evaluate LiDAR technology that is used to enhance safety, determine efficiency gains, accuracy benefits, technical issues, and cost benefits of using this technology with a focus on collection, processing, and storage of the data into current DOT business processes. This report discusses the current LiDAR systems and the future improvements and implementations of LiDAR, primarily mobile LiDAR, in business processes.

Presentations

6.32 "Incorporating Performance Measures into NCDOT's Bridge Management System"
[Nelson, et. al. 2012]

This presentation describes the many uses of the Bridge Management System (BMS) created by Agile Assets for the NCDOT. These uses include, long and short term analysis framework, overall budgeting, safety plans, real-time tracking of bridge maintenance work and cost, and activity analysis stemming from planning and decision making modules. Based on the actual cost of bridge

maintenance and the number of times a preservation activity was performed, Agile Assets developed an activity performance guideline and quantity standard for each preservation activity.

6.33 "NCDOT's Bridge Management System and Executive Trade-off Analysis"
[Edgerton, 2009]

Jim Edgerton from Agile Assets presented this PowerPoint describing the NCDOT Bridge Management System and what the system entails. This presentation also discussed the implementation of an Executive Trade off Analysis that would combine NCDOT asset management systems: BMS, PMS and MMS into one program that would effectively weigh the needs on an annual basis and ideally increase budget and maintenance efficiency.

When a bridge is uploaded into the system, it is first inventoried and presented in a structured manner which names the structure number, name, location, etc. The bridge can then be "built" into the program by selecting elements of the bridge from the element dictionary and quantifying them by number, importance level and measurement unit. After this initial information is in place the inspectors can attach pictures, files, and drawings to each bridge.

The bridges are primarily rated using the Bridge Condition Inspection for which each element and bub-element that undergo inspections are ranked on the type of defect, severity of the defect and the extent of severity. After collecting all this information, reports are generated to map the location of the bridge and graph the data.

6.34 "NCDOT Condition Assessment and Funding Needs"
[Gibson, 2012]

This presentation describes the purpose of NCDOTs Bridge and Maintenance Condition Surveys. These surveys are used to create big picture tables and graphs that make it possible to create big picture goals and budget changes.

6.35 "Nevada DOT's Experience with MSE Wall Corrosion"
[Salazar, et. al. 2010]

"Nevada DOT's Experience with MSE Wall Corrosion" is a PowerPoint presentation that describes the process that NDOT took when unexpected and premature corrosion was found in the backfill of MSE (Mechanically Stabilized Earth) walls. NDOT first hired McMahon & Mann Consulting Engineers (MMCE) to repair and evaluate the corrosion on three specific walls. MMCE determined that the reinforcements seemed to have lost approximately 60% of their capacity and the quality of a 20 year old bridge seemed to be that of a 50 year old bridge. When NDOT conducted their own study of the corrosive nature of the MSEWs their conclusion matched the MMCE results: the biggest factor causing the corrosion was over-aggressive and very corrosive backfill. NDOT noted that the *soil resistivity* and *sulfate* levels of the backfill had significantly changed since the walls were built.

In response to their recent discoveries, NDOT developed an MSEW inventory. Data on MSEW performance, corrosion history, and specs from other states were collected. This enables NDOT

to develop a corrosion monitoring system, developed guidelines, and procedures to evaluate consequences of corrosion problems in MSE walls, and developed a procedure for estimating the remaining service life of walls.

6.36 "Using Integrated Asset Management System to perform Corridor-Level Analysis for Planning & Scheduling Bridge and Pavement Projects"
[Bhargava, et. al. 2012]

This presentation was an overview of Agile Assets and NCDOTs effort to integrate Asset Management programs currently in place for Pavement and Bridges. In order to integrate NCDOTs asset management programs it is important to create a centralized inventory and condition database, decision trees and performance or deterioration models. These inputs were needed to receive project level life-cycle reports, network level investment, and funding strategies, condition forecasts at the network and project levels, and comparative analysis of investment strategies as outcomes.

12.0 APPENDICES

Included in this section are the following ten items:

1. The Wall Identification and Data Attributes Form **(Appendix A)**.
2. The Wall Attributes Data Definitions Table **(Appendix B)**.
3. The ERS Field Condition Inspection Data Collection Form **(Appendix C)**.
4. The meeting summaries from each NCDOT Project Steering and Implementation Committee meeting **(Appendix D)**.
5. The trip reports from each ERS field investigation **(Appendix E)**.
6. An example Wall Type Summary Report for the 32 documented ERSs **(Appendix F)**.
7. An example Wall Function Summary Report for the 32 documented ERSs **(Appendix G)**.
8. The completed Wall Identification and Data Attributes Forms **(Appendix H)**.
9. The completed ERS Field Condition Inspection Data Collection Forms **(Appendix I)**.

APPENDIX A: WALL IDENTIFICATION AND DATA ATTRIBUTES FORM

Wall Identification and Data Attributes Form

Page 1

Wall ID: Date: NCDOT Reviewer(s):

Revision Date: Picture(s):

LOCATION DATA

County: Division: Travel Direction:

Route Number: Route Name: Latitude: Longitude:

Location Description:

Bridge Association: Bridge Number: Culvert Association: Culvert Number:

Road System: Tier:

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): Extension (ft): Total Length (ft):

Wall Batter: Back Slope: Front Slope: Berm Dimension: Distance to Stream (ft):

Roadside Features:

Plan View:

Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Wall Facing Veneer:

Construction Type: Function Type: Traffic Volume:

Protected Features: Purpose:

Wall Identification and Data Attributes Form

HISTORY AND OWNERSHIP

Current Owner: | Year Built: | Design Life: | Engineer of Record:

T.I.P. Number: | Design Type: | Design Category: | Inspection Frequency:

Special Access Needs: | Work Zone Requirments:

STRUCTURAL DATA

Wall Support: | Foundation Dimension: | Fill Material:

Bridge Foundation Type: | Soil Reinforcement Type: | Surcharge:

Reinforcement off ROW: | External Drainage: | Internal Drainage:

Wall Top Feature: | Scour Depth: | Wall Obstruction(s):

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s):

Comments On Design:

Comments On Construction Details:

Maintenance/Repair Details:

APPENDIX B: WALL ATTRIBUTE DATA DEFINITIONS TABLE

Wall Attribute Data Definitions					
Item	**Type**		**Constraints**	**Values**	**Description**
SURVEY LOG DATA					
Wall ID	Number	Integer	********	-	Provide the unique identification number assigned to each ERS, which is used in managing all data and documents related to that ERS. The first two digits indicate the county where the ERS is located and the last four digits uniquely identify the individual records created and stored in the database.
Date	Number	Short Date	**/ **/ 20**	-	Provide the month, day, and year when the data was entered.
Revision Date	Number	Short Date	**/ **/ 20**	-	Provide the month, day, and year when data entries were updated, modified or deleted
NCDOT Reviewer(s)	Text	-	-	-	Provide the full name of the individual(s) entering the data.
LOCATION DATA					
County	Enumerated	-	-	From Counties Table	Provide the County where the ERS is located.
Division	Enumerated	-	-	From Counties Table	Provide the Division (1-14) where the ERS is located.
Travel Direction	Enumerated	-	-	"South - North", "West - East"	Provide the direction for which traffic is traveling along the primary or secondary road
Route Number	Text	-	-	-	Provide the primary or secondary road number of the highest ranking/rated route along the ERS
Route Name	Test	-	-	-	Provide the primary or secondary road name of the highest ranking/rated route along the ERS
Latitude	Number	Integer	**° ** ' **.** "	-	Provide the global positioning system (GPS) reading near the center of the length of the ERS that specifies the east-west position of the ERS on the earth's surface.
Longitude	Number	Integer	**° ** ' **.** "	-	Provide the global positioning system (GPS) reading near the center of the length of the ERS that specifies the north-south position of the ERS on the earth's surface.
Location Description	Text	-	-	-	Provide a general description of the ERS location by which the ERS can easily be found in the field (i.e., the intersection of the primary and/or secondary road(s) near the ERS location or the distance beyond a permanent point of reference).
Location Photo(s)	Attachment	Picture	-	-	Provide one or more general location photographs
Bridge Association	Enumerated	-	-	"Yes", "No"	Does the ERS shorten the length of a bridge ("Yes" or "No")?
Bridge Number	Number	Integer	-	-	If associated with a bridge, provide the bridge identification number.
Culvert Association	Enumerated	-	-	"Yes", "No"	Does the ERS shorten the length a culvert ("Yes" or "No")?
Culvert Number	Number	Integer	-	-	If associated with a culvert, provide the identification number
Road System	Enumerated	-	-	"Interstate", "Primary", "Secondary"	Provide the road system corresponding to the appropriate route
Road Tier	Enumerated	-	-	"Statewide", "Regional", "Subregional"	Provide the North Carolina multimodal investment network (road tier) corresponding to the appropriate road system.
DIMENSION DATA					
Embedment	Number	Integer	-	-	Provide the required difference between the bottom of ERS and the bottom of footing, cast-in-place face, or precast panels (i.e., the buried or embedded portion of the wall).
Maximum Wall Height	Number	Integer	-	-	Provide the measured difference between the top and bottom of ERS (i.e., the exposed height of the wall at the maximum point, excluding top-of wall attachments not designed to retain soil, such as a parapet or noise wall).
Extension	Number	Integer	-	-	Provide the measured difference between the top of ERS and grade elevation. If the height of the retained soil is 6 inches or more below the back of the ERS provide the actual height
Total Length	Number	Integer	-	-	Provide the actual length of the ERS.
Wall Batter	Number	Integer	**°	-	Provide the wall batter or face slope in degrees of deviation from horizontal to the face of the ERS
Back Slope	Number	Integer	*:*	-	Provide the upslope ratio of any slope above the top of the ERS (i.e., Back Slope Configuration)
Front Slope	Number	Integer	*:*	-	Provide the downslope ratio of any slope below the foot of the ERS (i.e., Front Slope Configuration).
Berm Dimension	Number	Integer	-	-	Provide the height of the berm.
Distance to Stream	Number	Integer	-	-	Provide the distance from the ERS to the stream.
Roadside Features	Text	-	-	-	Provide a list of any roadside features behind the top of the ERS and at the base of the ERS.

This table was adopted and modified from Gandhi Engineering's, "Guide to Asset Management of Earth Retaining Structures."

Wall Attribute Data Definitions					
Item	**Type**		**Constraints**	**Values**	**Description**
WALL TYPE AND FUNCTION DATA					
Wall Type	Enumerated	-	-	From Wall Type & Facing Table	Provide the apparent wall type of the ERS (e.g., MSE, Anchored, Soil Nail, Gravity, Cantilever, or Miscellaneous).
Wall Facing	Enumerated	-	-	From Wall Type & Facing Table	Provide the face material and/or attachment utilized (e.g., Segmental Retaining Wall Units (SRW), Precast Retaining Wall Units (PRW), Cast-In-Place Concrete, Precast Concrete Panels, Timber Lagging, Sheet H-Piles, Steel Sheet Piles, Shotcrete, Gabion Baskets, or Wire Baskets).
Veneer	Enumerated	-	-	From Veneers Table	When applicable, provide the type of veneer or wall surface treatment utilized (e.g., Brick, Stone, Painted, Vegetation, Formed, Stained, Exposed Aggregate, Dyed, Sculpted, Ashlar, Straight-Faced, Tri-Planar, or N/A).
Construction Type	Enumerated	-	-	"Cut", "Fill", "Partial Cut/Fill"	Provide the construction type for the ERS.
Function Type	Enumerated	-	-	From Wall Function Table	Provide the general function of the ERS (e.g., Bridge Abutment, Roadway Support, or Right-of-Way Support).
Traffic Volumes	Number	Integer	-	-	Provide the average daily traffic (ADT) volume.
Protection Features	Enumerated	-	-	From Wall Features Table	Provide the specific feature(s) protected by the ERS (e.g., Roadway, Deceleration Lane, Ramp, Parking Area, Service Road, Sidewalk, Bike Path, Stream/River, Historical Structure, Commercial/Residential Structure(s), or N/A).
Purpose	Enumerated	-	-	From Wall Purpose Table	Provide the general purpose of the ERS (e.g., Shorten Bridge Length, Slope Repair/Stabilize, or Minimize ROW/Encroachment/Permitting).
HISTORY AND OWNERSHIP					
Current Owner	Text	-	-	-	Who currently has ownership or maintenance responsibility of the ERS.
Year Built	Number	Integer	*****	-	Provide the year the ERS was originally construction.
Design Life	Enumerated	-	-	"75", "100"	Provide the designed service life as per the original design documents.
Engineer of Record	Text	-	-	-	Provide the name of the licensed engineer that stamp and approved the plans.
T.I.P. Number	Text	-	-	-	Provide the project T.I.P. number.
Design Type	Enumerated	-	-	"ASD", "LRFD"	Provide the method used to design the ERS.
Design Category	Enumerated	-	-	"In-House", "Post-Bid", "Standard Design"	Provide the design category.
Inspection Frequency	Number	Integer	-	-	Provide the frequency of routine inspection.
Special Access Needs	Text	Memo	-	-	Provide the special access equipment used (e.g. lift truck, cherry picker, long ladder, rock-climbing gear) and other equipment recommended for future visits to this site.
Work Zone Requirements	Text	Memo	-	-	Provide all safety devices or measures used (e.g. arrow board, flagger, and shadow vehicle) and any additional measures recommended for future visits to this site.

This table was adopted and modified from Gandhi Engineering's, "Guide to Asset Management of Earth Retaining Structures."

Wall Attribute Data Definitions					
Item	**Type**		**Constraints**	**Values**	**Description**
STRUCTURAL DATA					
Wall Support	Enumerated	-	-	From Wall Support Table	Provide the foundation type for the ERS (e.g., Concrete Footing, Aggregate Footing, Concrete Leveling Pad, Aggregate Leveling Pad, H-Piles, Pipe Piles, Concrete Piles, Drilled Piers, or N/A).
Foundation Dimension	Number	Integer	"-" x "	-	Provide the dimension of the foundation.
Fill Material	Enumerated	-	-	From Fill Material Table	Provide the backfill material or cellular fill material used (e.g., Aggregate Base Course (ABC), #57 Stone, #67 Stone, #67 Stone, Coarse Aggregate, Fine Aggregate, Select Material, or In Situ).
Bridge Foundation Type	Text	-	HP *** x ***	-	Provide the foundation type for the bridge.
Soil Reinforcement Type	Enumerated	-	-	From Soil Reinforcement Table	Provide the type of soil reinforcement utilized (e.g., Steel Strips, Steel Grid, Geosynthetic Strips, Geosynthetic Grid, Driven Soil Nails (Non-Grouted), Drilled Soil Nail (Grouted), Bar Anchors, Strand Anchors, Reinforcing Mesh, or N/A).
Surcharge	Enumerated	-	-	"Yes", "No"	Provide the presence or absence surcharge ("Yes" or "No")?
Reinforcement Off ROW	Enumerated	-	-	"Yes", "No"	Does the reinforcement length extend beyond the Right-of-Way or easement ("Yes" or "No")?
External Drainage	Enumerated	-	-	From External Drainage Table	Provide the external wall drainage system utilized (e.g., Paved Ditch, Grass Ditch/Swell, Drain Pipes, Inlet Box, Rip Rap, Sloped to Drain, or None).
Internal Drainage	Enumerated	-	-	From Internal Drainage Table	Provide the internal wall drainage system utilized (e.g., Drain Strip/Board, Weep Holes, Aggregate Drain, None).
Wall Top Feature	Enumerated	-	-	From Wall Top Features Table	Provide the feature on top of the ERS (e.g., Concrete Barrier Rail, Coping, End Bent Cap, Fence/Hand Rail, Guardrail, Precast Parapet, Precast Retaining Wall Cap Unit, Segmental Retaining Wall Cap Unit, Single Faced Barrier, Other, or N/A).
Scour Depth	Number	Integer	-	-	Provide the design depth for scour.
Wall Obstructions	Enumerated	-	-	From Wall Obstructions Table	Provide the different elements obstructing the ERS (i.e., Fences Posts, Handrail Posts, Guardrail Posts, Noise Wall Foundation, Bridge Foundation, Lighting Foundation, Sign Foundation, Signal Pole Foundation, Drainage Box, Utilities, Barbed Wire, Dense Vegetation, Other, or None).
As-Builts	Hyperlink	-	-	-	Link to the As-Built Drawings
Design Calculations	Hyperlink	-	-	-	Link to the Design Calculations
Inventory	Hyperlink	-	-	-	Link to the subsurface plans
Conflicts	Text	Memo	-	-	Comment on other potential conflicts (e.g., right-of-way or easements types and limits, narrow or absent highway shoulders, a body of water, or steep upslope or downslope).
Comments (Design Parameters)	Text	Memo	-	-	Comments on design parameters (e.g., traffic impact designs, soil parameters, friction angles, countermeasures, back slope configuration).
Comments (Construction Details)	Text	Memo	-	-	Comments on Construction Details.
Maintenance/Repair Details	Text	Memo	-	-	List any significant repairs, non-routine maintenance or modification to the original structure (e.g., crack repairs or addition of a noise wall).

This table was adopted and modified from Gandhi Engineering's, "Guide to Asset Management of Earth Retaining Structures."

APPENDIX C: ERS FIELD CONDITION INSPECTION DATA COLLECTION FORM

ERS Field Condition Inspection Data Collection Form

Wall ID: _____ Date: _____ NCDOT Inspector(s): _____

Division: _____ County: _____ Route Number: _____ Route Name: _____

Location Description: _____

Latitude: _____ Longitude: _____ Wall Type: _____

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	AVERAGE RATING	COMMENTS
Facing	Facial Deterioration						
	Staining						
	Damage						
	Cracking						
	Joint Alignment						
	Joint Spacing						
	Material Loss						
Movement	Deflection/ Rotation						
	Bulges/ Distortion						
	Settlement						
	Heaving						
Drainage	Erosion						
	Scour						
	Internal/ External Drains						
Exterior	Wall Top Attachment						
	Road/Sidewalk /Shoulder						
	Vegetation						

Note: If the average rating for any of the criteria listed above is ≥ 2.5, please include a corresponding picture and comment for each observation respectively.

Kickoff Meeting Notes [QPR#1 - September 2013]

APPENDIX D: NCDOT MEETING SUMMARIES

MEETING: Kickoff Meeting
DATE: August 20, 2013
TIME: 1:00 PM

1. **NCDOT Inventory and Asset Management System**
    - **What do they do (Lonnie Watkins DEMO)?**
        a. Data Collection, Inventory, Maintenance Condition Assessments, Performance Measures (against different assessment criteria).
        b. Division 10 - Contractor in Charlotte conducts the assessment and maintains all of their interstates through a Performance Based Maintenance Contract. Retaining walls are only part of the PBMC contract in Charlotte and are not included in the statewide MCAP.
            - (1) Contract for assessing the condition of **Interstates "ONLY."**
            - Field Assessment conducted every **6 Months**.
            - Standard maintenance levels set for the individual assets are based on specified criteria outlined in the contract.
            - Criteria are used for **Routine Maintenance Purposes "ONLY"** not long term capital improvements**.**
            - Final report is developed based on the assessment.
        c. System uses: GIS through a program called ArcPad.
    - **What do they currently do with Retaining Walls Specifically?**
        a. Assessment Criteria (Very Basic)
        b. Pass or Fail rating is assigned based on the criteria assessment.
    - **System Requirement?**
        a. AgileAssets uses Oracle Backend.
        b. Any database format can be converted to be compatible with the AgileAssets system.
        c. Needs to be compatible with GIS requirements.

2. **Inventory/Assessment System Discussion**
    - **How do we define critical retaining walls?**
        a. No head walls of pipes (Greg Perfetti)
        b. Typical roadway cut and fill walls are the ones that failed most often in the past. (John Pilipchuk)
        c. Need to consider the consequences of failure in conjunction with physical attributed. (Dr. Gabr)
        d. Don't include only critical walls in this research project
    - **What inventory data are currently available?**
        a. Very basic data from the Charlotte Performance Based Maintenance Contract.

b. Unreliable (0-9) ratings based on the inspector's subjective opinion. Information is stored in BMS but not used.
c. Corrosion database for mechanically stabilized walls.

- **What tools are needed to develop this retaining wall system?**
  a. Lonnie: In order to assess the tools needed, the following questions need to be answered:
     - What criteria are we going to use to rate and assess the condition?
       i. Once the criteria is established use that to drive what data needs to be collected.
     - What condition triggers maintenance?
     - What are other states doing?

3. **Bridge Management System vs. Maintenance Management System (of AgileAssets)**
   a. Based on the maintenance funding source
      - Bridge funds for "bridge elements" = BMS
      - Inventory Items/Condition Data = MMS
   b. Cary Clemmons would prefer to use the BMS with the current asset management system.
      - Would have to be linked to a bridge number
      - If we opted to use an independent system, we would have to establish a common identifier (Primary Key) within the database.
      - Also suggests that we develop an independent database with enough attributes to pull relevant data into "All Three" management system maintained by AgileAssets.

4. **Unit Specific Needs/Wants**
   - Information on the walls (Geotechnical)
   - Specific queries for rating (Asset Management)

5. **Decision Items:**
   - Don't include headwalls in our study
   - Include some "non-critical" walls, such as cut or fill walls (which have been the source of all failures in NC in the past 20 years)
   - Consider consequences of failures
   - Include bridge number in retaining wall inventory to allow cross referencing

6. **Action Items:**
   - Copy of the standardized database with fixed data field. To be provided by Lonnie Watkins.
   - Access to existing systems
   - Schedule working meeting to further discuss retaining wall types, criteria, and assessment need. (Cary and Scott)
   - Schedule Demo Meeting: First week of September (9-9:30AM on Wednesday)

- 1st QPR: Literature review on other Retaining Wall Inventory and Conditions Assessment Systems.
- Work with M&T to evaluate corrosion rates that are monitored statewide

7. Unanswered Questions:

- Retaining wall type or purpose?
- Implementation or Assessment Need?
- Inspection Rate?
- Database Type?
- Condition Criteria (which will drive data needs)?
- What triggers maintenance? (Lonnie)

8. Attendees:

- Greg Perfetti-Structures Management Unit
- John Pilipchuk-Geotechnical Unit
- Jeff Chang-ITRE/NCSU
- Dr. William Rasdorf-NCSU
- Cedrick Butler-NCSU
- Dr. Mo Gabr-NCSU
- Scott Hidden - Geotechnical Unit
- Paul Garrett - Structures Management Unit
- Lonnie Watkins - Asset Management
- Daniel Findley - ITRE/NCSU
- Earl Dubin - Federal Highways
- Cary Clemmons - Structures Management Unit
- Rasay Abadilla - Research and Development Unit
- Eric Williams - Geotechnical Unit

Asset Management System (AMS) Demonstration Notes [QPR#1 - September 2013]

MEETING: AMS Demo Meeting by Cary Clemmons and Paul Garrett
DATE: September 04, 2013
TIME: 9:30 AM

NCDOT's Asset Management System

- Web-based interface accessible through the NCDOT central server containing the Maintenance Management System (MMS), Pavement Management System (PMS), and Bridge Management System (BMS).
- Organizational Structure
    - Oversight: Lonnie Watkins
    - IT Programming and Development: David Alford
    - Product Vendor: Agile Assets
- Features – Maintenance optimization and tradeoff analysis to help manage funding and work order programming

BMS

- WIGINS
    - Workflow
        1. Inspector does field collection
        2. Area supervisor performs QC check
        3. Data are pulled into the central server
        4. Data are used for performance ratings
        5. Additional Analysis?
        6. Reporting – PDF format and NBI reports
    - NCDOT developed Inventory and Inspection Application
        - WIGINS Inspector: Digital forms on tablets used by inspectors to perform National Bridge Inspections (NBI) on a two year cycle
            - 95% of data comes from NBI
            - Other supplemental inspections: underwater foundations, drawbridge mechanics, materials
        - Field data collected feeds into the backend Oracle database
        - Agile Assets has their own data collection tools, but WIGINS was developed in house and takes its place (David Alford and developers)
        - WIGINS could possibly be programmed to limit inspection components and input fields by bridge type
    - Performance Ratings
        - Bridge Health Indices (BHI)
            - Based on bridge deck, super structure, sub structure?, and calculated posting scores
        - Structures Management Unit (SMU) unit currently goes by FHWA's NBI rating system (0-9), but plans to put in place AASHTO's core element

guide and four point rating system (1 – good; 2 – fair; 3 – poor; 4 – critical)

- AASHTO's system makes better use of WIGINS data because it assesses various elements of a bridge as opposed to an single BHI for an entire bridge

- Based on field inspections, WIGINS contains fields for potential future work

- BMS in Agile Assets
  - BHI and BHI Score are updated nightly from WIGINS
  - Provide maintenance history
  - Analysis
    - Current bridge needs by elements
    - Scenario analysis and forecasting for maintenance optimization

PMS

- Very robust for maintenance optimization

MMS

- Contact: John Arnold
- MMS and BMS share unique identifiers for bridges so that work orders and inspection data can be accessed by both maintenance operations and bridge management
- Simple data collection using ESRI and ARCPad

WIGINS Meeting Notes [QPR #2 - December 2014]

WIGINS Meeting - 31 October 2013

Attendance:

- Walt Tallman, Bridge Maintenance System Specialist, Engineering Applications Development (David Alford)
- Lewis Gettier, Bridge Maintenance System Analyst, Engineering Applications Development
- Jeff Chang, Research Assistance, ITRE

Objectives:

1. Gain a better understanding of the bridge inspection process
2. Obtain screenshots or access to WIGINS Inspector
3. Determine the applicability of integrating a retaining wall inventory into the overall asset management system

Notes:

WIGINS Inspector (current inspection tool)

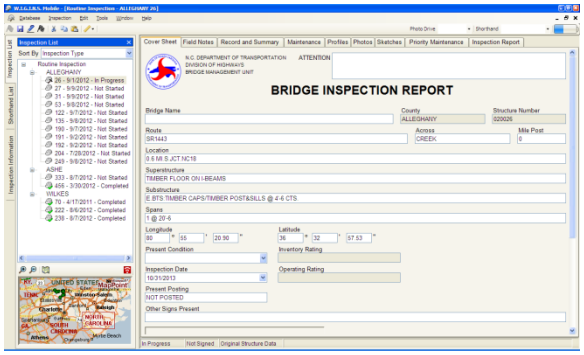
- Rates bridge components based off FHWA Bridge Condition Rating Categories, derives the NBI one-page report and bridge inspection report, generates performance ratings and indices for BMS
- FHWA established a rating scale to evaluate the severity of deterioration on bridge components. The evaluation only assesses the entire component and takes the most severe deterioration as the overall condition.

Exhibit 3-8
Bridge Condition Rating Categories

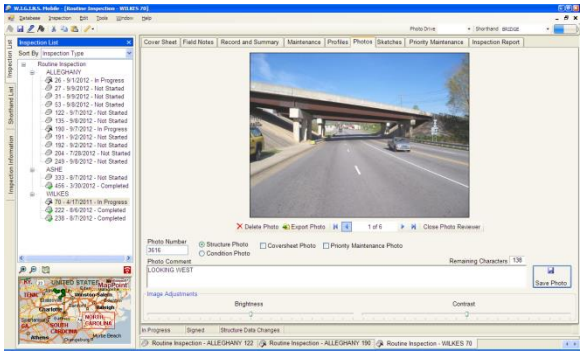
Rating	Condition Category	Description*
9	Excellent	
8	Very Good	No problems noted.
7	Good	Some minor problems.
6	Satisfactory	Structural elements show some minor deterioration.
5	Fair	All primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	Poor	Advanced section loss, deterioration, spalling, or scour.
3	Serious	Loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	Critical	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored, it may be necessary to close the bridge until corrective action is taken.
1	Imminent Failure	Major deterioration or section loss present in critical structural components, or obvious loss present in critical structural components, or obvious vertical or horizontal movement affecting structural stability. Bridge is closed to traffic, but corrective action may be sufficient to put the bridge back in light service.
0	Failed	Bridge is out of service and is beyond corrective action.

WIGINS Meeting Notes [QPR #2 - December 2014]

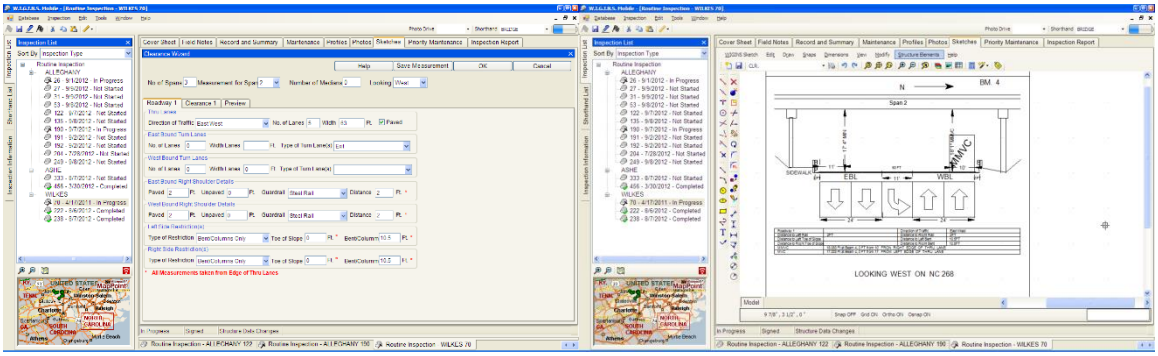
1) The inspector selects the type of inspection from a drop down menu.



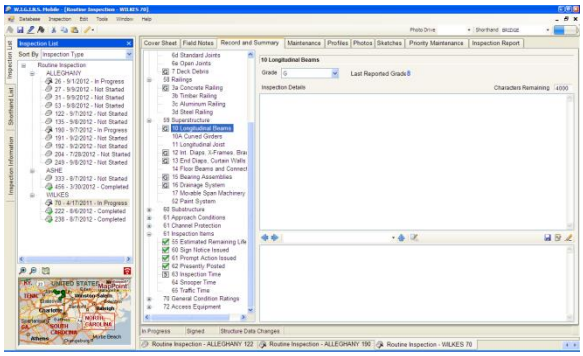
2) Historically pictures are taken first and used for direct referencing. Thus, the photos tab allows the user to upload and assign references to pictures taken. For deterioration of specific components, the inspector would take a photo and provide details in the field notes tab.



3) The inspector can use the sketch tool to further identify deterioration. The user inputs geometry and design configuration, CAD software outputs drawing.



4) Based on inspection, the inspector assigns grades for bridge components.

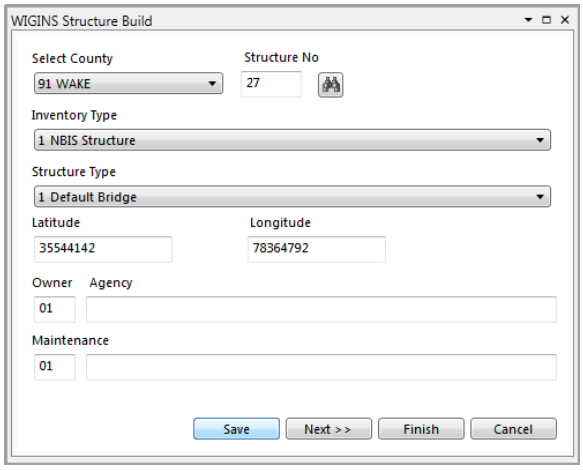


5) Maintenance activities (tasks) and priority are recommended and assessed. Historical data can be referenced.
6) The inspector can generate a report upon completion.
7) Bridge maintenance analysis is summarized and sent to BMS.

WIGINS Elements (scheduled release in Spring 2014)

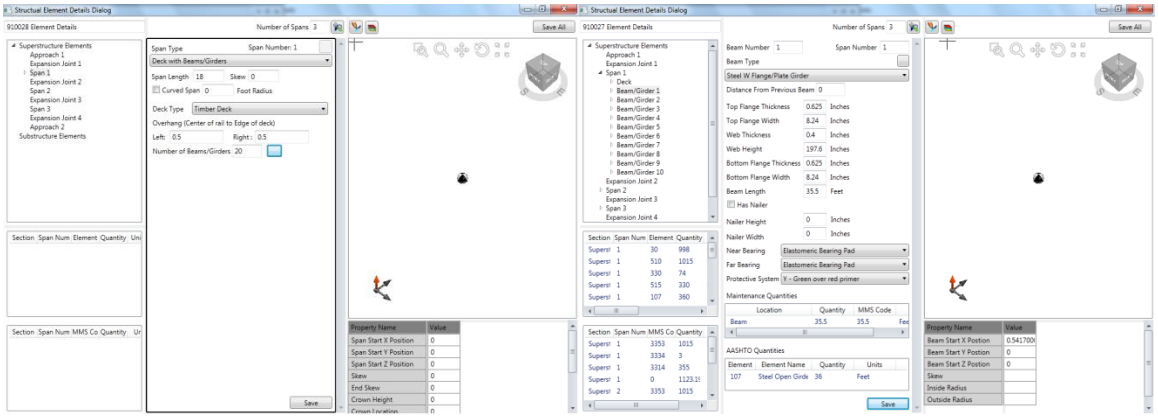
- Uses AASHTO's four condition states to assess structural elements on the element level; AASHTO utilizes multiple distress paths within defined condition states and incorporates all possible defects within the overall condition assessment of an element.
- Currently under development, WIGINS Elements will use a graphical user interface to allow inspectors to build a 3D model of a structure and locate the areas of defect. The CAD software for .NET application is Eyeshot by devDept.

1) User selects the type of inspection for a given bridge.
2) User inputs basic information and reviews previously associated data with a particular bridge.

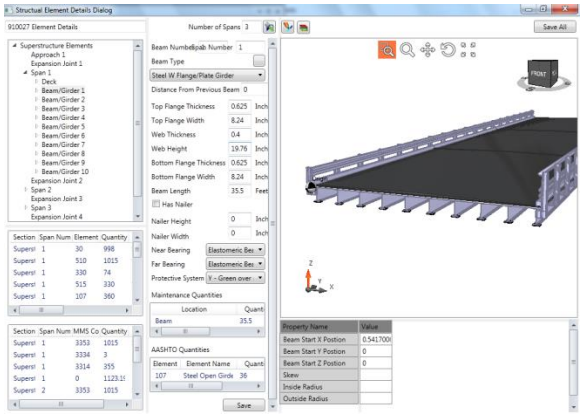


3) User provides geometry and design configuration in WIGINS Structure Build for bridge elements. Bridge elements fall under two primary categories: Superstructure and Substructure.

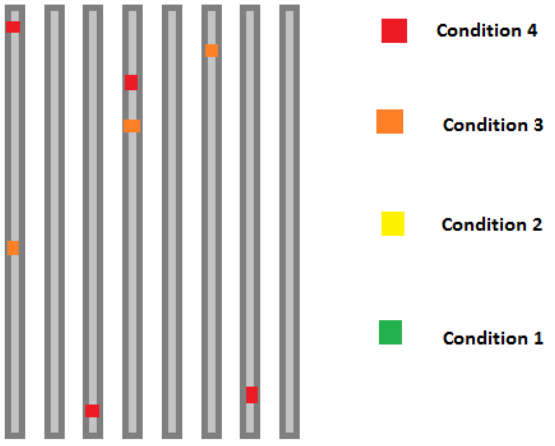
WIGINS Meeting Notes [QPR #2 - December 2014]



4) IT programs in CAD relationships/references on the back end that feed into Eyeshot.



5) Defects are located on the model. (Work-In-Progress)



Bridge 27 - Beams and Girder between EB1 and Bent 1

6) Provide action recommendations and priorities.
7) Generate Report
8) Feed BMS

WIGINS Meeting Notes [QPR #2 - December 2014]

Bridge Elements and Associated Features

Applicability to Retaining Walls

- Key fields to define for retaining wall inspection tool:
    1. What elements require condition ratings and how are they stratified?
    2. What elements will stay the same?
    3. What elements must be measured?
    4. Who will be in charge of the retaining wall data?

Preliminary Working Group Meeting Notes [QPR #2 - December 2014]

MEETING: Preliminary Working Group Meeting
DATE: November 20, 2013
TIME: 9:30 AM

- **Handouts**
  - Meeting Agenda
  - Retaining Wall Brainstorming Notes

- **Meeting Attendees**
  - Dr. William Rasdorf
  - Dr. Mo Gabr
  - Dr. Daniel Findley
  - Cedrick Butler
  - Jeff Chang
  - John Pilipchuk
  - Scott Hidden
  - Scott Webb
  - Brian Hanks

- **AASHTO LFRD Bridge Design Specifications, 6th, 2012**
  - 11.6 abutments and conventional retaining walls through 11.11
    - Naming conventions between AASHTO and NCDOT may not be consistent (e.g. modular block walls refer to gabion walls and big block walls in AASHTO, while NCDOT may consider modular blocks to be SGW units

- **NCHRP – potential development of soil nail wall specs**
  - FHWA may update ASD to LRFD

- **NCDOT has three wall design categories (controls responsibility of the internal stability design)**
  - The vast majority (approximately 90%), NCDOT walls are post bid design-build contracts
    - NCDOT specifies:
      - Alignment layout
      - Design and construction wall envelope (wall elevations)
      - Retaining wall type
      - Drainage
      - Guardrail, barriers, or fencing
      - Clearances
      - Aesthetic treatments
      - Global stability
    - Consultant/contractor designs the internal stability and builds the wall*
      - Preapproved materials and specs
  - In-house design – designed by Eastern and Western Regional Design Groups, potential constructability issues with contractors

        - Eastern Regional Office – KJ Kim (Manager) and Jamey Batts (Design Engineer)
        - Western Regional Office – Eric Williams (Manager) and Shane Clark (Design Engineer)
    - Standard design – quick and cheap method (used by divisions or resident offices) based off not-to-scale drawings
        - Cast-in-place gravity wall
        - Segmental gravity walls

- **Retaining Wall Brainstorming Notes**
    - Scott Hidden reviewed the retaining wall brainstorming notes sent by him to the NCSU research team via email on November 18, 2013. He discussed these notes and showed drawings and cross sections illustrating the walls that were discussed.
    - Purposes of wall
        - Protect features
        - Support features
        - Protect and Support
    - Two key items were considered: retaining wall types and wall characteristics.
        - Two types of wall characteristics were identified: common wall characteristics which represent data needed for all retaining wall types and characteristics that are unique to each retaining wall type.
    - Major challenge – all walls have something unique about them
        - E.g. Red pile panel wall by Angus Barn on US-70 looks like an MSE
    - MSE walls first constructed in 1986 or 1989
        - Reinforcement zone is the length of the soil reinforcement plus 6" (pertains to bridge association and abutment designation)
    - The notes provided by Scott Hidden represent the key retaining wall types and wall characteristic needed by NCDOT in the retaining wall database. The research team will incorporate these items into the final database design.
    - Scott Hidden did note that cantilever walls generally are the primary source of most NCDOT wall problems. Most issues deal with drainage, but sometimes with excessive deflection
    - Scott Hidden also noted that the number one cause of problems is drainage.
    - There are many sources of documents (material testing, post-bid contract, etc.)
        - Resident Office
        - Eastern and Western Regional Offices
        - Central server
        - Material and Testing

- **Initial Survey Locations**
    - In a separate email dated November 18, 2013, Scott Hidden identified the (3) initial survey locations to be visited by the NCSU research team.
        - US 70 (Glenwood Ave.) over Wade Ave. - 1 MSE wall abutment, 1 anchored wall abutment, both with cast-in-place face and simulated rock facing, post-bid designs, MSE has corrosion monitoring (constructed in 2002)

        - US 70 (Glenwood Ave.) over Westgate Rd. - 2 MSE wall abutments with precast panels, walls may have concrete barriers with moment slabs, I don't know design type but might have been back when we were putting 3 vender designs in plans?, at least one of the walls has corrosion monitoring (constructed in 1990) – seems like I heard this wall has had some deflection issues/losing stone around panels at one time?
        - I-85 between Guess Rd. and Duke St. (designed in-house) – 1 soil nail wall, 1 concrete cantilever (?, definitely different than soil nail walls) abutment wall (at Broad St.) connected to soil nail walls on both sides, all have brick veneers and were in-house design, soil nail walls have brick noise walls above them and higher corrosion protection than normal for soil nails (encapsulated nails), soil nail walls connected to abutment wall were redesigned during construction (constructed in approximately 2003) due to diabase dike and newly built apartment complex not showing on survey data from 80s
    - An NCDOT representative will join the research team for the (3) initial survey exercises.
        - All eastern region walls
    - NCDOT will provide in-house documents for theses (3) wall locations.
        - Contact Chris Kreider (Geotech Operations Engineer) and Paul Lambert (Structures Management Project Engineer - Working Drawings and Approvals)

- **Next steps include the following:**
    - Finalizing the retaining wall types and wall elements.
    - Designing the retaining wall database.
    - Designing the field data collection procedure.
    - Test the database and procedure on (12) field site wall locations.

NCDOT Working Group Meeting Notes [QPR#4 June 2014]

MEETING: Working Group Meeting with Structures and Geotechnical Unit
DATE: April 28, 2014
TIME: 10:00 AM

- **Handouts**
  - Meeting Agenda
  - Blank Data Collection Forms
    i. Wall Identification and Data Attributes Form
    ii. ERS Field Condition Inspection Data Collection Form
  - Complete Data Collection Form Example
  - Data Field Description Table
  - Proposed Element Condition Rating

- **Meeting Attendees**
  - William Rasdorf
  - Steven Bert
  - Daniel Findley
  - Cedrick Butler
  - Cary Clemmons
  - Brian Hanks
  - Dan Muller
  - John Pilipchuk
  - Scott Hidden
  - Rasay Abadilla
  - Scott Webb
  - Eric Williams

- **Discussion on Data Collection Forms and Elements**
  - Eric Williams reviewed the "Wall Identification and Data Attributes Form" and the "ERS Field Condition Inspection Data Collection Form" distributed by the NCSU research team via email on April 23, 2014. Questions, comments, and concerns pertaining to the forms data fields were discussed amongst the working group. As a result of this discussion, the NCDOT suggested the addition, removal, and modification of several data fields.
  - Cary Clemmons emphasized the importance of including data fields that capture the "road system" and/or "tier" associated with the retaining wall. He informed the group that funding for maintenance and preservation are based on the type of road system or tier.

- **Difference Between "Road System" and "Tier"**
  - *Road System:* Consists of a three level road classification hierarchy
    - Interstate
    - Primary
      - US Routes
      - NC Routes
      - Caveat: Interstate is also part of the primary

        - Secondary
            - SR Routes
            - Access Roads

    - *Tier:* Consists of a three level road classification hierarchy
        - Statewide
            - Routes that serve long-distance trips, connect regional centers, have the highest usage, and mostly provide a mobility function (as opposed to a land access function).
            - Mostly consist of US routes and a handful of NC routes.
        - Regional
            - Routes that connect major population centers and have a mix of functions.
            - Mostly consists of NC routes, a handful of US routes, and heavily traveled secondary routes (SR) routes.
        - Subregional
            - Routes that serve localized movements. They provide more of an access function than mobility, and are of a higher interest to cities and counties than the state.
            - All routes not included on the Statewide or Regional Tier.
    - For the purpose of classification, when a retaining wall is associated with multiple routes, the route with the highest ranking prevails.

- **Defining the Travel Direction**
    - To ensure that walls are located the same way for every inspection, Cary suggested that we denote the "travel direction" with a "South-North" orientation or "West-East" orientation. Using this designation, the inspectors will then identify abutment wall #1 as the wall located to the South or West and abutment wall #2 would be the wall located to the North or East.
    - To eliminate confusion, Scott Hidden suggested that we not use offset distances to aid in the location of retaining walls.

- **Discussed data field description table**
    - Scott Hidden reviewed the "Data Fields Description Table" distributed by the NCSU research team via email on April 23, 2014. He discussed his notes and comments pertaining to the definition of the data fields on the "Wall Identification and Data Attributes Form." As a result of this discussion, the NCDOT suggested the addition, removal, and modification of several data fields.
    - Scott suggested that we define the term "association" as a means to shorten the length of a pipe or bridge.
    - Scott also suggested that we find a way to define the purpose for building the wall in addition to defining the function of the wall. He agreed to assist the NCSU research team with developing a list of reasons for which a retaining wall is built.

NCDOT Working Group Meeting Notes [QPR#4 June 2014]

- **Action Items**
  - Send Cary Clemmons an email to obtain equations used in the BMS database for calculating the bridge health index (BHI) and for calculating the priority ranking index (PRI).
  - Send Scott Hidden an email with all the tables referenced in the "Wall Data Attributes Definition" handout distributed by the NCSU research team via email on April 23, 2014.
  - Identify the (12) wall locations for the pilot study.

- **Next Steps Include the Following:**
  - Finalizing the data collection forms.
  - Designing the retaining wall database.
  - Designing the field data collection procedure.
  - Testing the database and procedure on (12) field site wall locations.

NCDOT Project Progress Meeting Notes [QPR#6 December 2014]

Thursday: 12-04-2014 Time: 2:30pm	NCDOT Project Progress Meeting Meeting Minutes	Century Center Structures Conference Room

Agenda Item	Discussion/Outcome/Decision	Action/Follow Up
Provide project overview	• Discussed database design through flow chart	
Present Microsoft Access Software System	• Discussed the proposed software system and database structure • Demonstrated how to run a data query • Demonstrated condition ratings	
Present data collection forms and methodology used to obtain a rating	• Discussed the six safety critical wall elements • Demonstrated the advantages of a multi-part rating system versus a single-score rating system • Demonstrated rating system and procedures used when critical wall elements are deemed to be in critical distress conditions	• Consider changing form from determinations to observations • Consider how to reorganize form into more broad elements: - Drainage - Facing - Movement - Exterior • Consider how to enable inspectors to denote a wall that requires immediate action (critical find)
Present initial methodology for determining wall criticality	• Discussed combining wall condition and consequence of failure to determine criticality • Condition Rating (x) • Consequence of Failure (y) • Risk = x * y • Discussed how poor rating leads to a work plan by an engineer • Briefly discussed bridge maintenance priorities: - Priority maintenance need - Priority maintenance - Routine maintenance	• Consider meeting with bridge group to learn more about their workflow process (what determines immediate action) • Consider what may be an acceptable response action • Consider what may be an acceptable inspection frequency
Propose field testing of forms	• Discussed wall identification and condition assessment system form and how NCDOT personnel would be an invaluable resource to field test forms • This would demonstrate whether or not they are obtaining the same or similar scores	• NCDOT personnel who attended the meeting are considering field-testing the form

NCDOT Project Progress Meeting Notes [QPR#6 December 2014]

Meeting Attendees

1. Cedrick Butler, NCSU
2. William Rasdorf, NCSU
3. Mohammed Gabr, NCSU
4. Daniel Findley, NCSU
5. Steven Bert, NCSU
6. Ali Almalki, NCSU
7. Daniel Muller, NCDOT
8. John Pilipchuk, NCDOT
9. Lonnie Watkins, NCDOT
10. Scott Hidden, NCDOT
11. Paul Garrett, NCDOT
12. Tom Koch, NCDOT
13. Rasay Abadilla, NCDOT
14. Eddie Smith, NCDOT
15. David Alford, NCDOT
16. Eric Williams, NCDOT

APPENDIX E: TRIP REPORT SUMMARIES

Meeting: **Field Visit**
Location: **US 70 (Glenwood Ave.) over Wade Ave**
Date: **January 21, 2014**
Time: **10:00 AM**

- **Handouts**
  - Inventory data collection form
  - Condition assessment data collection form

- **Meeting Attendees**
  - Dr. William Rasdorf
  - Dr. Mo Gabr
  - Dr. Daniel Findley
  - Mr. Jeff Chang
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the use and applicability for the following:
    - The inventory data collection form
    - The condition assessment data collection form
  - The research team inspected the walls, assessed the site, evaluated the data collections forms, and documented the wall and visit with pictures.

- **Retaining Wall Type(s)**
  - (1) MSE Wall
  - (1) Anchored Wall
    - Both with cast-in-place face and simulated rock facing, post-bid designs

- **Wall Function**
  - Wall abutments support Glenwood bridge #540 in Wake County
  - Structure protects Wade Avenue

- **Results**
  - Three separate data collection forms will ultimately be need.
    - **Office Inventory Data Collection Form** - used once to build the initial database
    - **Field Inventory Data Collection Form** - used once to build the initial database
    - **Field Condition Assessment Data Collection Form** – used multiple time to determine the wall condition
  - For critical walls, always conduct a LiDAR survey
  - For noncritical walls do not initially conduct a LiDAR survey. Conduct a LiDAR survey only when the answer to any of the first three questions on the **Field Condition Assessment Data Collection Form** is "YES"
- **Next steps include the following:**

- Make revisions to the forms based on the field observations and research team discussion
- Further evaluate and revise the forms based on site visit to the 2 walls on February 18, 2014
- Distribute the data collection forms to NCDOT personnel for review and approval

- **Pictures**

Figure 1. Glenwood over Wade bridge and MSE abutment (SB)

Figure 2. Southern Glenwood approach with tieback abutment and H-pile with CIP facing wing walls

Figure 3. Graffiti on south side MSE abutment

Figure 5. Minor erosion on south side MSE abutment

Figure 4. Exposed footing on south side MSE abutment

Figure 6. Weep hole on south side MSE abutment

Trip Report #2: First Meeting with Chris Kreider of NCDOT

Meeting: **NCDOT East Geotechnical Engineer – Chris Kreider**
Date: **February 18, 2014**

- **Handouts**
  - Office Inventory Data Collection Form
  - Field Inventory Data Collection Form
  - Field Condition Assessment Data Collection Form

- **Meeting Attendees**
  - Chris Kreider **[Full-Day]**
  - Mr. Cedrick Butler **[Full-Day]**
  - Mr. Jeff Chang **[Full-Day]**
  - Dr. William Rasdorf **[Half-Day]**
  - Ms. Cameron Whisnant **[Half-Day]**

- **Purpose:** The purpose of this meeting was to gain additional field visual inspection experience and evaluate our three data collection forms (handouts) against various retaining wall types.

- **Office:** In the morning we met with Mr. Kreider at his office to reviewed wall documentation for various walls and retaining wall types located in North Carolina. This included the review of pictures and construction drawing.

- **Field Site Visit:** After reviewing some of the in-house documents for different retaining wall types, the research team rode with Mr. Kreider to view and inspect different retaining wall types in field near the Raleigh/Durham area. The locations and retaining wall types visited are summarized in the following table.

Site	City	Location	Wall Type	Facing	Wall Function
1.	Raleigh	US 70 (Glenwood Ave.) over Westgate Rd	MSE	Precast Panels	Bridge Abutment
2.	Raleigh	I-40/Wade Ave Interchange	Anchored	Timber-Pile	Slope Stabilization
3.	Durham	SR 1322 (Broad Street) over I-85	Soil Nail	Brick Veneer	Bridge Abutment
4.	Durham	NC 147 over SR 1321 (Hillandale Road)	MSE	Precast Panels	Bridge Abutment
5.	Durham	Below I-85/Guess Road Exit Ramp (Behind Texas Roadhouse)	Gravity	Concrete	Grade Separation

- **Pictures**

Figure 1. Chris Kreider (NCDOT) and Cedrick Butler examining an anchored wall with timber lagging on I-40 (Raleigh, NC)

Figure 2. Soil nail wall and bridge abutment on I-85 (Durham, NC)

Figure 3. MSE Wall on NC 147 (Durham, NC) with damaged panels, sign of erosion, exposed foundation, and improper drainage

- **Additional Comments:**
  - Research needs – approaches at bridges have voids from internal erosion and settlement. Over time the approach settles while the abutments which are constructed with piles do not. Differential elevation between abutments and approaches cause bumps in the road.
  - Technical needs – digital archive of wall files (typically include borings/soil investigation, design, calculations, design drawings, and reviews). Hard files contain walls under pre-TIP and TIP numbering systems.

- Notes
  - Design calculations for pile walls are mostly concerned with lateral stresses and bending moments, as opposed to axial loading of structures and bearing capacity.
  - Soil nail wall – verification test and proof test. The primary long term issue with soil nail walls is water between the walls.
  - Many LiDAR scans on walls (including US-70 and Westgate) were taken during the asset management conference hosted by NCDOT. These could be useful as a baseline model for monitoring movement and/or degradation.
  - HICAMS could be used to query, sort, and locate the majority if not all walls built in the last ten years.

Meeting: **Field Visit**
Location: **US 70 (Glenwood Ave.) over Wade Ave**
Date: **May 21, 2014**
Time: **9:00 AM**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Dr. Mo Gabr
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form.**
  - The research team inspected the walls, assessed the site, evaluated the data collection form, and documented the wall and visit.

- **Retaining Wall Type(s)**
  - (1) Anchored Wall: With a cast-in-place simulated stone facing
  - (2) Cantilever-Solider Pile Walls: With a cast-in-place simulated stone facing
  - (1) MSE Wall: With a cast-in-place simulated stone facing

- **Wall Function**
  - The Anchored and MSE walls are both bridge abutment walls. They support the Glenwood Avenue bridge (Bridge ID: 540) over Wade Avenue in Wake County.
  - The two Cantilever-Solider Pile walls are both wing walls parallel to Wade Avenue. They are used to retain earth to protect both Wade Avenue and other roadside features.

- **Condition Inspection Results**
  - Anchored Wall
    - Minor signs of local bulges were identified but these could have occurred during the installation of simulated stone facing.
    - Coping near the expansion joint is misaligned but this could have occurred during construction.
    - Drainage pipes were clogged and need to be cleaned out.
    - Vegetation along the top of the wall needs to be removed.
  - Cantilever-Solider Pile Walls
    - Wing wall to the **LEFT** of the Anchored Wall
      - Identified (14) vertical cracks about 1/16" to 1/8" wide. Each crack extended from the top of the wall to the bottom. Also noticed early signs of spalling in the stone facing.
      - The drainage channel along the top of the wall is full of debris and is no longer serving its intended function.
      - Drainage pipes are clogged and need to be cleaned out.
    - Wing wall to the **RIGHT** of the Anchored Wall

- Counted (7) vertical cracks about 1/16" wide. Each crack extended from the top of the wall to the bottom.
- The drainage channel along the top of the wall is full of debris and is no longer serving its intended function.
- Drainage pipes are clogged and need to be cleaned out.

➢ MSE Wall

❖ Wall overall is in good condition. Clogged drainage pipes were the only items noted for this wall.

- **Next Steps Include the Following:**
  - ➢ Add an additional field to the inspection form to capture information about the joint alignment between adjacent wall sections.
  - ➢ Further evaluate and revise the form based on site visits to two more wall locations.

Meeting: **Field Visit**
Location: **I-40/Wade Ave Interchange**
Date: **May 28, 2014**
Time: **9:00 AM**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Steven Bert
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form**.
  - The research team inspected the walls, assessed the site, evaluated the data collection forms, and documented the wall and visit with pictures.

- **Retaining Wall Type**
  - (1) Anchored Wall: With Timber Lagging

- **Wall Function**
  - After a slope failure in the early 90's, this wall was constructed to stabilize the slope adjacent to the I-40/Wade Ave Interchange.

- **Condition Inspection Results**
  - One of the H-Piles is crooked but this could have occurred during construction.
  - Some of the timber lagging is bulging outward and has a slight overhang. A bulge in one specific section of the wall is very pronounced.
  - Some on the timber lagging has a wider gap than others.
  - Weathered timber is more pronounced near the base of the wall.
  - H-Piles have rust stains.
  - The fencing at the end of the wall is displaced.
  - Evidence of an impending slope failure at the end of the wall.
  - Trees are in close proximity to the wall and lots of overgrown vegetation around the wall.

- **Next Steps Include the Following:**
  - Further evaluate and revise the form based on this site visit and another site visit to one more wall location.

- **Pictures:**

Figure 1: Trees and overgrown vegetation in close proximity of the wall.

Figure 2: Weathered timber lagging more pronounced at the base of the wall.

Figure 3: Wide gaps between several timber lagging units.

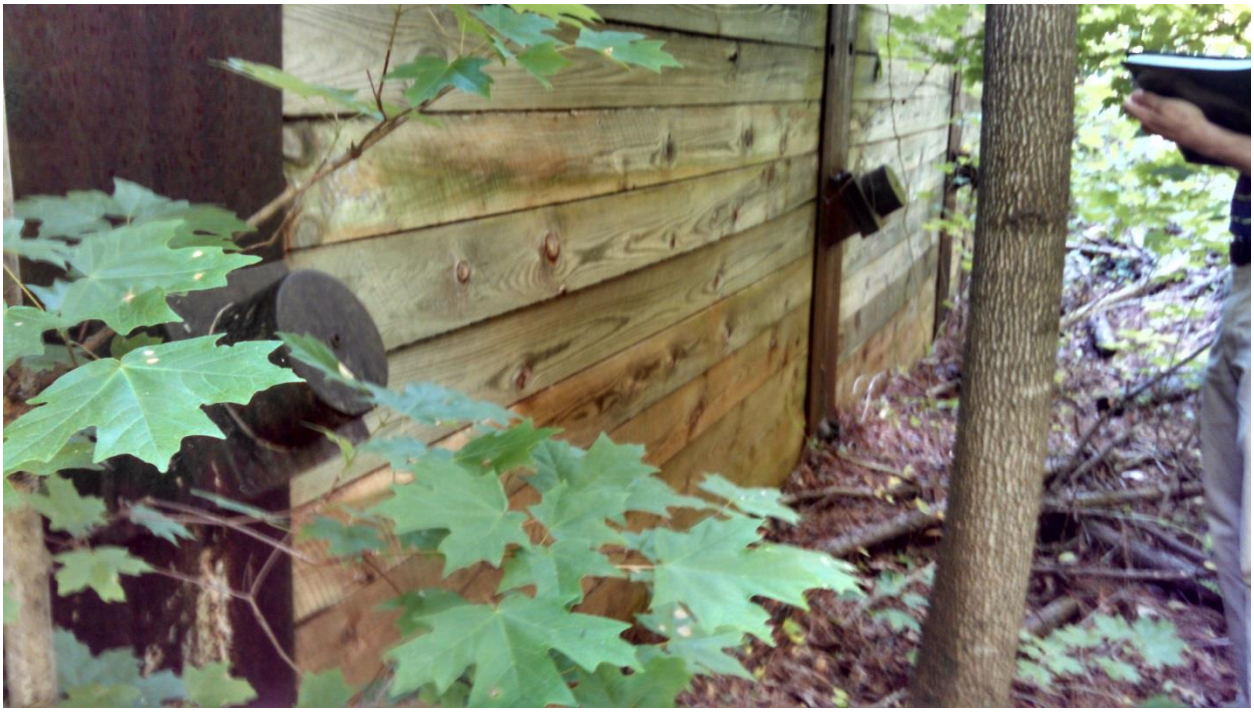


Figure 4: Pronounce bulge in one specific section of the wall and rusty H-piles.

Figure 5: Evidence of an impending slope failure at the end of the wall.

Figure 6: Displaced chain link fencing at the end of the wall.

Meeting: **Field Visit**
Location: **I-40/Wade Ave Interchange and US 70 (Glenwood Ave.) over Westgate Rd.**
Date: **June 5, 2014**
Time: **9:00 AM**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form**.
  - The research team inspected the walls, assessed the site, evaluated the data collection forms, and documented the wall and visit with pictures.

- **Retaining Wall Type**
  - (1) Anchored Wall: With Timber Lagging
  - (2) MSE Walls

- **Wall Function**
  - After a slope failure in the early 90's, the Anchored wall with timber lagging was constructed to stabilize the slope adjacent to the I-40/Wade Ave Interchange.
  - Both MSE walls serve as bridge abutments. They support Glenwood Avenue bridge (Bridge ID: 665) over Westgate Road in Wake County.

- **Condition Inspection Results**
  - Anchored Wall: With Timber Lagging
    - There appears to be some deflection in the wall.
    - Some H-Piles are crooked but this could have occurred during construction.
    - Some of the timber lagging is bulging outward and has a slight overhang.
    - Some on the timber lagging has a wider gap than others.
    - H-Piles are weather with rust stains.
    - There is evidence of an impending slope failure at the end of the wall.
    - Trees are in close proximity to the wall and there is a lot of overgrown vegetation around the wall.
  - MSE Walls
    - There appears to be some deflection in the wall on the left side of the south bridge abutment.
    - Evidence of local bulges and misaligned facing units.
    - Several roots are penetrating the facing of the wall.
    - (2) Panels are either chipped or cracked.

- **Next Steps Include the Following:**
  - Further evaluate and revise the form based on this site visit and another site visit to one more wall location.

- **Pictures:**

I-40/Wade Ave Interchange (South Bound)

Figure 1: Evidence of some deflection in the wall and timber lagging units that are bulging outwards.

Figure 2: Severely rusted H-Piles and several that are rotated (this likely occurred during construction).

US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Figure 3: Evidence of some deflection in the wall on the left side of the south bridge abutment.

Figure 4: Chipped and cracked MSE panels.

Figure 5: Several roots penetrating the facing of the wall.

Meeting: **Field Visit**
Location: **SR 1322 (Broad Street) over I-85**
Date: **June 23, 2014**
Time: **9:00 AM**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form**
  - The research team inspected the walls, assessed the site, evaluated the data collection forms, and documented the wall and visit with pictures.

- **Retaining Wall Type**
  - (2) Soil Nail Walls: With brick veneers.

- **Wall Function**
  - Both Soil Nail walls serve as bridge abutments. They support the Broad Street bridge (Bridge ID: 136) over I-85 in Durham County.
  - Their respective wing walls have brick noise walls above them.

- **Condition Inspection Results**
  - West Wall Abutment and respective wing walls
    - Identified a few sections where brick is beginning to spall
    - Drainage pipes are clogged and need to be cleaned out
  - East Wall Abutment and respective wing walls
    - Identified a 1.5 inch gap between the wall top feature and top of wall
    - Drainage pipes are clogged and need to be cleaned out

- **Pictures**

Figure 1. East wing wall showing a 1.5 inch gap that has developed between the wall top feature and top of the wall.

Figure 2. West wing wall showing signs of spalling.

Trip Report #7: Second Meeting with Chris Kreider of NCDOT

Meeting: **NCDOT Eastern Regional Operations Engineer – Chris Kreider**
Date: **August 8, 2014**
Location: **Geotechnical Engineering Unit - Garner Office**

- **Handout**
  - Wall Identification and Data Attributes Form

- **Meeting Attendees**
  - Mr. Chris Kreider
  - Mr. Cedrick Butler

- **Purpose**
  - The purpose of this meeting was to review in-house documentation (construction drawings and other related resources) and evaluate the applicability of our data collection form (handout) for six NCDOT retaining wall sites in the eastern part of North Carolina.

- **Office Visit**
  - In the morning Mr. Butler met with Mr. Kreider at his office in Garner, NC to review wall documentation and complete the **Wall Identification and Data Attributes Form** for 6 of 12 wall sites selected by NCDOT. The documents reviewed included construction drawings and design files. The locations and retaining wall types identified by NCDOT are summarized in the following table.

Site	County	Approximate Location (Western NC)	Wall Type	Facing	Veneer	Wall Function
1a.	Wake	US-70 (Glenwood Avenue) over SR-1728 (Wade Avenue)	MSE	Cast-In-Place Concrete	Stone	Bridge Abutment
1b.	Wake	US-70 (Glenwood Avenue) over SR-1728 (Wade Avenue)	Anchored	Cast-In-Place Concrete	Stone	Bridge Abutment
1c.	Wake	US-70 (Glenwood Avenue) over SR-1728 (Wade Avenue)	Cantilever	Timber Lagging	Stone	Bridge Abutment
2.	Wake	US-70 (Glenwood Avenue) over SR-1837 (Westgate Rd)	MSE	Precast Panels	N/A	Bridge Abutment
3.	Wake	I-40/Wade Ave Interchange	Anchored	Timber Lagging	N/A	Right-of-Way Support
4.	Durham	NC-147 (Triangle Expressway) over SR-1999 (Davis Drive)	MSE	Precast Panels	N/A	Right-of-Way Support
5a.	Rockingham	SR-1378 (Martinsville Loop) over Norfolk Southern Railway	Soil Nail	Shotcrete	N/A	Right-of-Way Support
5b.	Rockingham	SR-1378 (Martinsville Loop) over Norfolk Southern Railway	Cantilever	Timber Lagging	N/A	Right-of-Way Support
6.	Cumberland	SR-1404 (Morganton Rd) between Sycamore Dairy Rd. and Glensford Rd.	Cantilever	Precast Panels	N/A	Right-of-Way Support

- **Additional Comments**
    - Research needs – To provide the NCDOT with the most effective asset management and inspection tool for retaining walls of various types and in varying condition, the NCSU research team wants to study and document several walls that are either in poor condition or are performing poorly.

Trip Report #8: Meeting with Dean Hardister of NCDOT

Meeting: **NCDOT Western Regional Operations Engineer – Dean Hardister**
Date: **August 12, 2014**
Location: **Geotechnical Engineering Unit - Harrisburg Office**

- **Handouts**
  - Wall Identification and Data Attributes Form
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Dean Hardister
  - Mr. Cedrick Butler

- **Purpose**
  - The purpose of this meeting was to review in-house documentation (construction drawings and other related resources) and visually assess the condition of various NCDOT retaining wall types located in the western part of North Carolina, gain additional field visual inspection experience, and evaluate the applicability of our two data collection forms (handouts).

- **Office Visit**
  - In the morning Mr. Butler met with Mr. Hardister at his office in Harrisburg, NC to review wall documentation and complete the **Wall Identification and Data Attributes Form** for various ERSs and retaining wall types located near the office. The documents reviewed included construction drawings and design files.

- **Field Site Visit**
  - After reviewing the in-house documents for different retaining wall types, Mr. Butler and Mr. Hardister visited several retaining wall sites (to view and inspect them) in the following counties: Iredell, Cabarrus, Rowan, and Gaston. The locations and retaining wall types visited are summarized in the following table.

Site	County	Approximate Location (Western NC)	Wall Type	Facing	Veneer	Wall Function
1.	Iredell	SR 1100 (Brawley School Rd, Mooresville) over I-77	MSE	Precast Panels	N/A	Bridge Abutment
2.	Cabarrus	380 Corban Ave SW, Concord	MSE	Segmental Retaining Wall Units	N/A	Right-of-Way Support
3.	Iredell	East Bound on I-40 (East of Radio Rd, Statesville and West of US-21)	Soil Nail	Shotcrete	N/A	Right-of-Way Support
4.	Rowan	SR 2120 (Long Ferry Rd, Salisbury) over I-85	Anchored	Cast-In-Place Concrete	N/A	Bridge Abutment
5.	Iredell	798 Brawley School Road, Mooresville	Gravity	Segmental Retaining Wall Units	N/A	Right-of-Way Support
6.	Cabarrus	5771 Poplar Tent Rd, Concord	Gravity	Cast-In-Place Concrete	N/A	Right-of-Way Support
7.	Gaston	404 Cox Rd, Gastonia	Cantilever	Timber Lagging	N/A	Right-of-Way Support

- **Pictures**

Figure 1. MSE Walls on I-77 (Mooresville, NC) under SR-1100 (Brawley School Road).

A few joints between panels are too wide or narrow and a few chipped panels were identified. External drainage is in good condition.

Figure 2. MSE Segmental Retaining Wall near 380 Corban Avenue SW (Concord, NC).

A collection of mud and debris is present in the top corners of the concrete ditch and a few joints between SRW units are too wide.

Figure 3. Soil Nail Wall on EB I-40 between Radio Road and US-21 (Statesville, NC).

Several cracks about 1/16” wide were identified. Efflorescence staining is present on the wall facing and a collection of mud and debris is present in the concrete ditch along the top of the wall.

Figure 4. Anchored Wall with a timber lagging facing and a cast-in-place concrete veneer on I-85 (Salisbury, NC) under SR-2120 (Long Ferry Road).

Several hair line cracks on the concrete facing were identified. One transverse crack is about 11 feet long.

Figure 5. Gravity Segmental Retaining Wall near 798 Brawley School Road (Mooresville, NC).

Joints between SWR units are too wide.

Figure 6. Gravity Wall with a cast-in-pace concrete facing near 5771 Poplar Tent Road (Concord, NC).

Several weep holes are full of grass and debris and one vertical crack is present that is about 1/16" wide and 1" inch away from the expansion joint.

Figure 7. Cantilever Wall with timber lagging near 404 Cox Road (Gastonia, NC).

Some evidence of material loss behind the wall under the concrete coping was identified.

- **Additional Comments:**
  - The oldest wall inspected during this investigation was constructed around 2005. The remaining walls were all constructed within the last five years. As a result, all the walls evaluated during this investigation were in good condition.
  - None of the wall elements evaluated showed major signs of distress.
  - To provide the NCDOT with to most effective asset management and inspection tool for retaining walls of various types, the NCSU research team will also need to identify, assess, and document retaining walls that are either in poor condition or performing poorly.

Meeting: **Field Visit**
Location: **Fayetteville, NC: Morganton Road and Ramsey Street**
Date: **September 19, 2014**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Cedrick Butler

- **Purpose**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form**.
  - The research team inspected the walls, assessed the site, evaluated the field data collection form, and documented the wall and visit with pictures.

- **Retaining Wall Types**
  - (3) Cantilever Walls: With H-Piles and Precast Panels
  - (2) Cantilever Walls: With Steel Sheet Piles

- **Wall Function**
  - All three pile-panel walls serve as right-of-way support for SR 1404 (Morganton Road) in Fayetteville, NC. They were constructed to minimize right-of-way and maximize/protect the parking areas below the wall.
  - Both sheet panel walls also serve as right-of-way support for SR 3950 (Ramsey Street) in Fayetteville, NC. They were constructed to minimize right-of-way and protect the roadway below the wall.

- **Condition Inspection Results**
  - Cantilever Wall: With Steel Piles and Precast Panels
    - All three walls had a few H-Piles that were misaligned. As a result, some panels were out of plumb and misaligned.
    - All three walls had several vertical hairline cracks along the cast-in-place concrete coping.
    - Two of the walls had some efflorescence staining around the hairline cracks present on the cast-in-place concrete coping.
    - For two of the walls, the cast-in-place concrete coping was slightly displaced in areas where the H-Piles were misaligned.
  - Cantilever Walls: With Steel Sheet Pile
    - The wall face on both walls has rotated outward, resulting in a negative wall batter.
    - One wall has a very pronounced bulge near the center of the wall, resulting in a negative batter of several degrees and displacement in the wall top feature.
    - The steel sheet piles on both walls are severely rusted allowing groundwater to seep through the wall.
    - One wall also showed signs of excessive moisture in the backfill.

- **Next Steps Include the Following:**
  - Further evaluate and revise the condition rating system based on the data from this site visit and future site visits to walls in poor condition.

- **Pictures**

Figure 1: Cantilever Wall with H-Piles and Precast Panels near 4200 Morganton Road, Fayetteville, NC (Vantage South Bank)

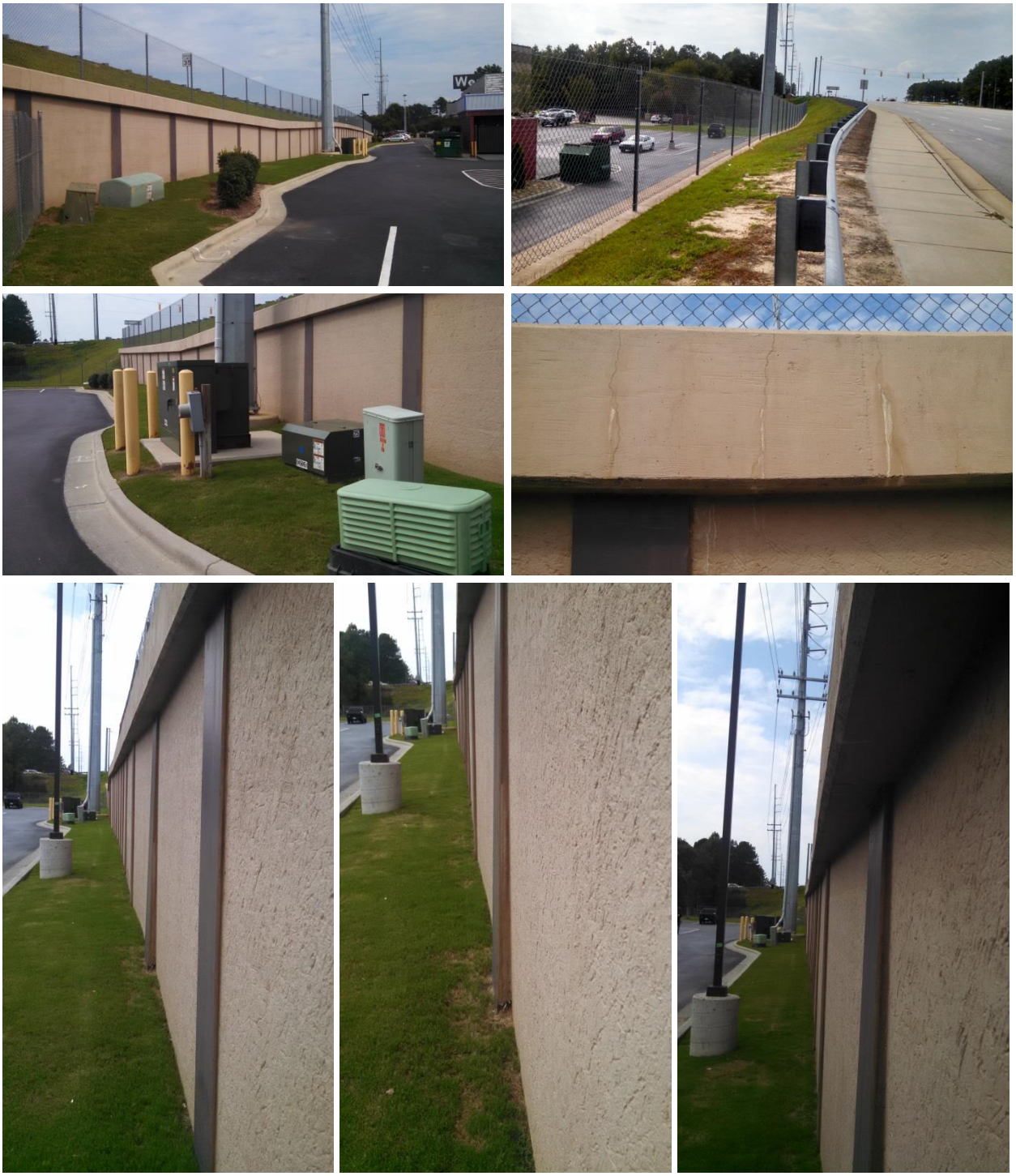


Figure 2: Cantilever Wall with H-Piles and Precast Panels near 500 Westwood Shopping Center, Fayetteville, NC (Bubba's 33)

Figure 3: Cantilever Wall with H-Piles and Precast Panels near 503 Cross Creek Mall, Fayetteville, NC (Bank of America)

Figure 4: Cantilever Wall with Steel Sheet Pile near 905 Ramsey Street, Fayetteville, NC (North of Railroad)

Figure 5: Cantilever Wall with Steel Sheet Pile near 881 Ramsey Street, Fayetteville, NC (South of Railroad)

Meeting: **Field Visit**
Location: **Martinsville Loop (Stoneville, NC) & Triangle Expressway over Davis Drive**
Date: **October 10, 2014**
Time: **8:30 AM**

- **Handouts**
  - ERS Field Condition Inspection Data Collection Form

- **Meeting Attendees**
  - Mr. Chris Kreider
  - Mr. Cedrick Butler

- **Purpose & Activities**
  - The purpose of this visit was to assess the applicability of the **ERS Field Condition Inspection Data Collection Form**.
  - The research team inspected the walls, assessed the site, evaluated the data collection forms, and documented the wall and visit with pictures.

- **Retaining Wall Type**
  - (1) Cantilever Wall: With Timber Lagging
  - (2) MSE Walls: With a Brick Veneer

- **Wall Function**
  - The Cantilever Wall serves as Right-of-Way Support for the church property above the wall. It was constructed to minimize right-of-way and maximize the church's property.
  - Both MSE walls serve as bridge abutments. They support two Triangle Expressway bridges (Bridge ID: 588/589) over Davis Drive in Durham County.

- **Condition Inspection Results**
  - <u>Cantilever Wall: With Timber Lagging</u>
    - There appears to be some deflection in the wall.
    - A few H-Piles are crooked and misaligned but this could have occurred during construction.
    - Some on the timber lagging has a wider gap than others.
    - Weathered timber is more pronounced near the center of the wall.
    - Timber lagging units were installed incorrectly on the right wing of the wall.
  - <u>South MSE Wall Abutment</u>
    - There is some evidence of deflection in the right approach wall on the south bridge abutment.
    - There is evidence of settlement near the end of the right approach wall. The concrete parapet has displaced exposing a 2" gap in one of the control joints.
    - The expansion joint has opened significantly exposing an additional ½" gap.
    - Several vertical cracks have developed in the concrete barrier rail. Vertical cracks about ¼" wide have also developed on the brick veneer facing.
    - The concrete barrier rail on top of the wall has displaced significantly.

- ❖ There is some evidence of earth movement along the right approach wall. The earth material is also significantly lower (about 2 feet) than specified.

➢ North MSE Wall Abutment

- ❖ There is some evidence of deflection in the left approach wall on the north bridge abutment.
- ❖ There is evidence of settlement near the end of the left approach wall. The concrete parapet has displaced exposing a 4.5" gap between the concrete barrier rail and the concrete section behind the parapet.
- ❖ A long vertical crack about ¼" wide have also developed on the brick veneer facing.
- ❖ The concrete barrier rail on top of the wall has displaced about 3.5".
- ❖ The earth material is also lower than specified.
- ❖ Outlet at the end of the draining channel is full of debris and no longer serving its intended function.

- **Next Steps Include the Following:**
  - ➢ Define the meaning of an overall numerical rating including time sensitive actions.

- **Pictures:**

Martinsville Loop (Stoneville, NC)

Figure 1: Several misaligned H-Piles along the *Cantilever Wall*.

Figure 2: Weathered timber concentrated near the center of the *Cantilever Wall*.

Figure 3: Improper installation of timber lagging units on the right wing of the *Cantilever Wall*.

South MSE Bridge Abutment over Davis Drive in Durham County

Figure 4: Displaced concrete barrier rail and evidence of deflection in the right approach wall.

Figure 5: Evidence of settlement near the end of the right approach wall exposing a 2" gap in one of the control joints.

Figure 6: Several vertical cracks in the concrete barrier rail right approach wall.

Figure 7: Vertical cracks about ¼" wide and separation of the expansion joint exposing an additional ½" gap on the of the right approach wall.

Figure 8: There is some evidence of earth movement along the right approach wall. The earth material is also significantly lower (about 2 feet) than specified.

North MSE Bridge Abutment over Davis Drive in Durham County

Figure 9: Evidence of deflection in the left approach wall. The concrete barrier rail has displaced about 3.5".

Figure 10: Outlet at the end of the draining channel along the left approach wall is full of debris and no longer serving its intended function.

Figure 11: Evidence of settlement near the end of the left approach wall. The concrete parapet has displaced exposing a 4.5" gap between the concrete barrier rail and the concrete section behind the parapet.

APPENDIX F: WALL TYPE SUMMARY REPORT

Wall Type Summary

WALL TYPE	NO. OF WALLS
Division 5	
Soil Nail [SN]	4
MSE	5
Cantilever	2
Anchored [AW]	3
Division 6	
Cantilever	5
Division 7	
Cantilever	1
Division 9	
Anchored [AW]	2
Division 10	
MSE	1
Gravity	1
Division 12	
Soil Nail [SN]	1
MSE	6
Gravity [SGW]	1
TOTAL:	32

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APPENDIX G: WALL FUNCTION SUMMARY REPORT

Wall Function Summary

WALL FUNCTION	NO. OF WALLS
Division 5	
Right-of-Way Support	6
Bridge Abutment	8
Division 6	
Right-of-Way Support	5
Division 7	
Right-of-Way Support	1
Division 9	
Bridge Abutment	2
Division 10	
Right-of-Way Support	2
Division 12	
Right-of-Way Support	6
Bridge Abutment	2
TOTAL:	32

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APPENDIX H: COMPLETED WALL IDENTIFICATION AND DATA ATTRIBUTES FORMS

Wall Identification and Data Attributes Form

Page 1

Wall ID: 910001 Date: 1/21/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 47' 52.70" Longitude: 78° 38' 46.52"

Location Description: South Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Bridge Association: Yes Bridge Number: 540 Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): Extension (ft): N/A Total Length (ft):

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk at the base of the wall.

Plan View:

Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Anchored [AW] Wall Facing CIP Concrete Veneer: Stone

Construction Type: Partial Cut/Fill Function Type: Bridge Abutment Traffic Volume: 4500

Protected Features: Roadway Purpose: Shorten Bridge Length

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HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2002 | Design Life: 100 | Engineer of Record:

T.I.P. Number: B-3254 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Strand Anchors | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strips, Weep Holes

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910002 Date: 1/21/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 47' 51.85" Longitude: 78° 38' 44.92"

Location Description: Left Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): Extension (ft): N/A Total Length (ft):

Wall Batter: 90° Back Slope: Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk at the base of the wall.

Plan View:

Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Timber Lagging Veneer: Stone

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 4500

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2002 | Design Life: | Engineer of Record:

T.I.P. Number: B-3254 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: N/A | External Drainage: Paved Ditch | Internal Drainage: Weep Holes

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: A soldier pile wall with a simulated rock facing.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910003 Date: 1/21/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 47' 51.94" Longitude: 78° 38' 47.37"

Location Description: Right Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): Extension (ft): N/A Total Length (ft):

Wall Batter: 90° Back Slope: Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Timber Lagging Veneer: Stone

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 4500

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2002 | Design Life: | Engineer of Record:

T.I.P. Number: B-3254 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: N/A | External Drainage: Paved Ditch | Internal Drainage: Weep Holes

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: A soldier pile wall with a simulated rock facing.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910004 Date: 1/21/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 47' 52.69" Longitude: 78° 38' 46.67"

Location Description: North Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Bridge Association: Yes Bridge Number: 540 Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): 4 Max. Wall Height (ft): 18 Extension (ft): N/A Total Length (ft): 174

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing CIP Concrete Veneer: Stone

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 4500

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2002 | Design Life: 100 | Engineer of Record: Kim Truong

T.I.P. Number: B-3254 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-6" X 6" | Fill Material: 57 Stone

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Aggregate Drain, Weep Holes

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910005 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: West-East

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 54' 05.61" Longitude: 78° 45' 56.63"

Location Description: West Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Bridge Association: Yes Bridge Number: 665 Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 25 Extension (ft): N/A Total Length (ft): 1059

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features:

Plan View:

Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 13000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1991 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-2113 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: ABC

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Reinforcing Mesh | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: Inlet Box | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: Walls may have concrete barriers with moment slabs.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910006 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: West-East

Route Number: US-70 Route Name: Glenwood Avenue Latitude: 35° 54' 05.93" Longitude: 78° 45' 57.50"

Location Description: East Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Bridge Association: Yes Bridge Number: 665 Culvert Association: No Culvert Number: N/A

Road System: Primary Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 26 Extension (ft): N/A Total Length (ft): 1515

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features:

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 13000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1991 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-2113 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: ABC

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Reinforcing Mesh | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: Inlet Box | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: Walls may have concrete barriers with moment slabs.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910007 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: I-40 Route Name: N/A Latitude: 35° 48' 44.04" Longitude: 78° 44' 15.95"

Location Description: I-40/Wade Ave Interchange (North Bound)

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 15 Extension (ft): N/A Total Length (ft): 220

Wall Batter: 90° Back Slope: N/A Front Slope: Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Guardrail and chain link fence

Plan View:

Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Anchored [AW] Wall Facing Timber Lagging Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 4500

Protected Features: N/A Purpose: Slope Repair/Stabilize

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1993 | Design Life: 75 | Engineer of Record: John Ledbetter

T.I.P. Number: | Design Type: | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: 57 Stone

Bridge Foundation Type N/A | Soil Reinforcement Type: Strand Anchors | Surcharge:

Reinforcement off ROW: No | External Drainage: Sloped to Drain | Internal Drainage: None

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 910008 Date: 3/28/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Wake Division: 5 Travel Direction: South-North

Route Number: I-40 Route Name: N/A Latitude: 35° 48' 46.59" Longitude: 78° 44' 24.93"

Location Description: I-40/Wade Ave Interchange (South Bound)

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 10 Extension (ft): N/A Total Length (ft): 210

Wall Batter: 90° Back Slope: N/A Front Slope: Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Guardrail and chain link fence

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Anchored [AW] Wall Facing Timber Lagging Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 3800

Protected Features: N/A Purpose: Slope Repair/Stabilize

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1993 | Design Life: 75 | Engineer of Record: John Ledbetter

T.I.P. Number: | Design Type: | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: 57 Stone

Bridge Foundation Type N/A | Soil Reinforcement Type: Strand Anchors | Surcharge:

Reinforcement off ROW: No | External Drainage: Sloped to Drain | Internal Drainage: None

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 310009 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 36° 01' 31.20" Longitude: 78° 54' 59.51"

Location Description: East Wall Abutment - SR 1322 (Broad Street) over I-85

Bridge Association: Yes Bridge Number: 136 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 19 Extension (ft): N/A Total Length (ft): 80

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete barrier at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Soil Nail [SN] Wall Facing Shotcrete Veneer: Brick

Construction Type: Cut Function Type: Bridge Abutment Traffic Volume: 13000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2003 | Design Life: 100 | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type | Soil Reinforcement Type: Drilled Soil Nails | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Hole

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: Soil nail walls have brick noise walls above them and higher corrosion protection than normal for soil nails (encapsulated nails). Soil nail walls connected to abutment wall were redesigned during construction (constructed in approximately 2003) due to diabase dike and newly built apartment complex not showing on survey data from 80s.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 310010 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 36° 01' 30.49" Longitude: 78° 55' 00.83"

Location Description: West Wall Abutment - SR 1322 (Broad Street) over I-85

Bridge Association: Yes Bridge Number: 136 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 17 Extension (ft): N/A Total Length (ft): 80

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete barrier at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Soil Nail [SN] Wall Facing Shotcrete Veneer: Brick

Construction Type: Cut Function Type: Bridge Abutment Traffic Volume: 13000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2003 | Design Life: 100 | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type | Soil Reinforcement Type: Drilled Soil Nails | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Hole

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s):	N/A
Comments On Design:	N/A
Comments On Construction Details:	Soil nail walls have brick noise walls above them and higher corrosion protection than normal for soil nails (encapsulated nails). Soil nail walls connected to abutment wall were redesigned during construction (constructed in approximately 2003) due to diabase dike and newly built apartment complex not showing on survey data from 80s.
Maintenance/Repair Details:	N/A

Wall Identification and Data Attributes Form

Wall ID: 310011 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 36° 01' 33.70" Longitude: 78° 55' 04.50"

Location Description: West Wing Wall - SR 1322 (Broad Street) over I-85

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 16 Extension (ft): N/A Total Length (ft): 1282

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete barrier at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Soil Nail [SN] Wall Facing Shotcrete Veneer: Brick

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 13000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2003 | Design Life: | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: Drilled Soil Nails | Surcharge:

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Holes

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: Wall was designed using metric units.
Total wall length including the bridge abutment is 1282 + 80 = 1362 feet

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 310012 Date: 2/18/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 36° 01' 26.28" Longitude: 78° 54' 53.40"

Location Description: East Wing Wall - SR 1322 (Broad Street) over I-85

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 20 Extension (ft): N/A Total Length (ft): 1823

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete barrier at the base of the wall.

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Soil Nail [SN] Wall Facing Shotcrete Veneer: Brick

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 13000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2003 | Design Life: | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: In-House Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: Drilled Soil Nails | Surcharge:

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Holes

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: Wall was designed using metric units.
Total wall length including the bridge abutment is 1823 + 80 = 1903 feet

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 310013 Date: 6/1/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: NC-147 Route Name: Triangle Expressway Latitude: 35° 52' 13.60" Longitude: 78° 51' 56.46"

Location Description: South Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Bridge Association: Yes Bridge Number: 588/589 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 27 Extension (ft): N/A Total Length (ft): 295

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: Brick

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 22000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: U-4763B | Design Type: LRFD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-6" X 6" | Fill Material: #57 Stone

Bridge Foundation Type: HP 14 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Precast Parapet | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s):	N/A
Comments On Design:	N/A
Comments On Construction Details:	N/A
Maintenance/Repair Details:	N/A

Wall Identification and Data Attributes Form

Wall ID: 310014 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Durham Division: 5 Travel Direction: South-North

Route Number: NC-147 Route Name: Triangle Expressway Latitude: 35° 52' 14.70" Longitude: 78° 51' 56.05"

Location Description: North Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Bridge Association: Yes Bridge Number: 588/589 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 33 Extension (ft): N/A Total Length (ft): 363

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk and guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: Brick

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 22000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: U-4763B | Design Type: LRFD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-6" X 6" | Fill Material: #57 Stone

Bridge Foundation Type: HP 14 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Precast Parapet | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s):	N/A
Comments On Design:	N/A
Comments On Construction Details:	N/A
Maintenance/Repair Details:	N/A

Wall Identification and Data Attributes Form

Wall ID: 780015 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Rockingham Division: 7 Travel Direction: West-East

Route Number: SR-1378 Route Name: Martinsville Loop Latitude: 36° 32' 22.47" Longitude: 79° 54' 50.70"

Location Description: SR 1378 (Martinsville Loop) over Norfolk Southern Railway beside Price United Methodist Church

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 15 Extension (ft): 0.5 Total Length (ft): 130

Wall Batter: 90° Back Slope: N/A Front Slope: 1.5:1 Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features:

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Timber Lagging Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 950

Protected Features: Parking Area Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2004 | Design Life: | Engineer of Record:

T.I.P. Number: B-3231 | Design Type: | Design Category: | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: H-Piles | Foundation Dimension: N/A | Fill Material: #57 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge:

Reinforcement off ROW: N/A | External Drainage: Sloped to Drain | Internal Drainage: Aggregate Drain

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s):

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 250016 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cumberland Division: 6 Travel Direction: West-East

Route Number: SR-1404 Route Name: Morganton Road Latitude: 35° 04' 09.76" Longitude: 78° 57' 31.77"

Location Description: Bank of America - 503 Cross Creek Mall, Fayetteville, NC 28303

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 8 Extension (ft): N/A Total Length (ft): 290

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk and guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Precast Panels Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 35000

Protected Features: Parking Area Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2008 | Design Life: 75 | Engineer of Record: Ricky Keith

T.I.P. Number: U-4756 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Aggregate Leveling Pad | Foundation Dimension: 6" | Fill Material: #57 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge:

Reinforcement off ROW: N/A | External Drainage: Grass Ditch/Swell | Internal Drainage: Weep Holes

Wall Top Feature: Coping, Fence/Hand Rail | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 250017 Date: 8/22/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cumberland Division: 6 Travel Direction: West-East

Route Number: SR-1404 Route Name: Morganton Road Latitude: 35° 04' 05.25" Longitude: 78° 57' 12.48"

Location Description: Vantage South Bank - 4200 Morganton Road, Fayetteville, NC 28314

Bridge Association: No Bridge Number: N/A Culvert Association: Yes Culvert Number:

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 11 Extension (ft): N/A Total Length (ft): 480

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk and guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Precast Panels Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 31000

Protected Features: Parking Area Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2008 | Design Life: 75 | Engineer of Record: Ricky Keith

T.I.P. Number: U-4756 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Aggregate Leveling Pad | Foundation Dimension: 6" | Fill Material: #57 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge:

Reinforcement off ROW: N/A | External Drainage: Grass Ditch/Swell | Internal Drainage: Weep Holes

Wall Top Feature: Coping, Fence/Hand Rail | Scour Depth: N/A | Wall Obstruction(s): Culvert

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 250018 Date: 8/22/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cumberland Division: 6 Travel Direction: West-East

Route Number: SR-1404 Route Name: Morganton Road Latitude: 35° 04' 03.30" Longitude: 78° 57' 13.10"

Location Description: Bubba's 33 - 500 Westwood Shopping Center, Fayetteville, NC 28304

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 12 Extension (ft): N/A Total Length (ft): 405

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk and guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Precast Panels Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 31000

Protected Features: Parking Area Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2008 | Design Life: 75 | Engineer of Record: Ricky Keith

T.I.P. Number: U-4756 | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Aggregate Leveling Pad | Foundation Dimension: 6" | Fill Material: #57 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge:

Reinforcement off ROW: N/A | External Drainage: Grass Ditch/Swell | Internal Drainage: Weep Holes

Wall Top Feature: Coping, Fence/Hand Rail | Scour Depth: N/A | Wall Obstruction(s): Utilities

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480019 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 47.94" Longitude: 80° 51' 23.84"

Location Description: West Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Bridge Association: Yes Bridge Number: 70 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 22 Extension (ft): N/A Total Length (ft): 325

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 23000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: None | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480020 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 45.16" Longitude: 80° 51' 23.05"

Location Description: Left Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 20 Extension (ft): N/A Total Length (ft): 525

Wall Batter: 90° Back Slope: 2:1 Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 23000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge:

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480021 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 51.22" Longitude: 80° 51' 24.63"

Location Description: Right Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 22 Extension (ft): N/A Total Length (ft): 265

Wall Batter: 90° Back Slope: 2:1 Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 23000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge:

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480022 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 46.48" Longitude: 80° 51' 21.80"

Location Description: East Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Bridge Association: Yes Bridge Number: 70 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 25 Extension (ft): N/A Total Length (ft): 325

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Bridge Abutment Traffic Volume: 23000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: None | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s):	N/A
Comments On Design:	N/A
Comments On Construction Details:	N/A
Maintenance/Repair Details:	N/A

Wall Identification and Data Attributes Form

Wall ID: 480023 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 49.26" Longitude: 80° 51' 22.23"

Location Description: Left Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 23 Extension (ft): N/A Total Length (ft): 465

Wall Batter: 90° Back Slope: 2:1 Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 23000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge:

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480024 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: I-77 Route Name: N/A Latitude: 35° 34' 44.25" Longitude: 80° 51' 20.97"

Location Description: Right Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 18 Extension (ft): N/A Total Length (ft): 290

Wall Batter: 90° Back Slope: 2:1 Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing Precast Panels Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 23000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 100 | Engineer of Record: Roger Bloomfield

T.I.P. Number: R-3833B | Design Type: | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 1-0" X 6" | Fill Material: Select Material

Bridge Foundation Type: HP 12 x 53 Steel Piles | Soil Reinforcement Type: Steel Strips | Surcharge:

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 120025 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cabarrus Division: 10 Travel Direction: South-North

Route Number: SR-1002 Route Name: Cabarrus Avenue Latitude: 35° 24' 04.30" Longitude: 80° 35' 32.09"

Location Description: 380 Corban Ave SW, Concord, NC 28025

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 18 Extension (ft): N/A Total Length (ft): 119

Wall Batter: 82° Back Slope: N/A Front Slope: 2:1 Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk and Guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: MSE Wall Facing SRW Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 4500

Protected Features: N/A Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2013 | Design Life: 75 | Engineer of Record: Michael Kiser

T.I.P. Number: B-3421 | Design Type: LRFD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 2-0" X 6" | Fill Material: #67 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: Geogrid | Surcharge: No

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Aggregate Drain

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480026 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: West-East

Route Number: I-40 Route Name: N/A Latitude: 35° 48' 22.77" Longitude: 80° 52' 52.52"

Location Description: East Bound on I-40 - East of Radio Rd and West of US 21

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 6 Extension (ft): N/A Total Length (ft): 525

Wall Batter: 90° Back Slope: 2:1 Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: None

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Soil Nail [SN] Wall Facing Shotcrete Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 53000

Protected Features: N/A Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2013 | Design Life: 75 | Engineer of Record: Michael Stephens

T.I.P. Number: I-3819A | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Aggregate Footing | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: Drilled Soil Nails | Surcharge: No

Reinforcement off ROW: No | External Drainage: Paved Ditch | Internal Drainage: Drain Strip/Board

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 790027 Date: 8/22/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Rowan Division: 9 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 35° 41' 43.33" Longitude: 80° 24' 03.38"

Location Description: East Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Bridge Association: Yes Bridge Number: 134 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 24 Extension (ft): N/A Total Length (ft): 153

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail and Guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Anchored [AW] Wall Facing CIP Concrete Veneer: N/A

Construction Type: Cut Function Type: Bridge Abutment Traffic Volume: 63000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2005 | Design Life: 100 | Engineer of Record: John Davis

T.I.P. Number: I-2511CB | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 6" | Fill Material: In Situ

Bridge Foundation Type: | Soil Reinforcement Type: Strand Anchors | Surcharge: Yes

Reinforcement off ROW: No | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Hole

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: This wall appears to have a CIP Concrete facing. Behind the CIP Concrete there is an Anchored wall with Timber Lagging facing units.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 790028 Date: 8/22/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Rowan Division: 9 Travel Direction: South-North

Route Number: I-85 Route Name: N/A Latitude: 35° 41' 44.35" Longitude: 80° 24' 04.35"

Location Description: West Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Bridge Association: Yes Bridge Number: 134 Culvert Association: No Culvert Number: N/A

Road System: Interstate Tier: Statewide

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 22 Extension (ft): N/A Total Length (ft): 134

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Concrete Barrier Rail and Guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Anchored [AW] Wall Facing CIP Concrete Veneer: N/A

Construction Type: Cut Function Type: Bridge Abutment Traffic Volume: 63000

Protected Features: Roadway Purpose: Shorten Bridge Length

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2005 | Design Life: 100 | Engineer of Record: John Davis

T.I.P. Number: I-2511CB | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Leveling Pad | Foundation Dimension: 6" | Fill Material: In Situ

Bridge Foundation Type: | Soil Reinforcement Type: Strand Anchors | Surcharge: Yes

Reinforcement off ROW: Yes | External Drainage: | Internal Drainage: Drain Strip/Board, Weep Hole

Wall Top Feature: N/A | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: This wall appears to have a CIP Concrete facing. Behind the CIP Concrete there is an Anchored wall with Timber Lagging facing units.

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 480029 Date: 8/15/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Iredell Division: 12 Travel Direction: South-North

Route Number: SR-1100 Route Name: Brawley School Road Latitude: 35° 34' 41.66" Longitude: 80° 53' 09.35"

Location Description: The Brawley Market - 798 Brawley School Road, Mooresville, NC 28117

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 1 Max. Wall Height (ft): 5 Extension (ft): N/A Total Length (ft): 90

Wall Batter: 82° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk, handrail, and guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Gravity [SGW] Wall Facing SRW Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 21000

Protected Features: Commerical/Residential Structure(s) Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2009 | Design Life: 75 | Engineer of Record: Michael Kiser

T.I.P. Number: R-3833A | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Aggregate Leveling Pad | Foundation Dimension: 3-0" X 6" | Fill Material: #57 Stone

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: No | External Drainage: Drain Pipes | Internal Drainage: Aggregate Drain

Wall Top Feature: SRW Cap Unit | Scour Depth: N/A | Wall Obstruction(s): Other

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 120030 Date: 8/22/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cabarrus Division: 10 Travel Direction: West-East

Route Number: SR-1394 Route Name: Poplar Tent Road Latitude: 35° 24' 30.56" Longitude: 80° 40' 25.05"

Location Description: 5790 Poplar Tent Rd, Concord, NC 28027

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): 2 Max. Wall Height (ft): 5 Extension (ft): 0.5 Total Length (ft): 191

Wall Batter: 90° Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Guardrail

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Gravity Wall Facing CIP Concrete Veneer: N/A

Construction Type: Fill Function Type: Right-of-Way Support Traffic Volume: 15000

Protected Features: Parking Area Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 2010 | Design Life: 75 | Engineer of Record: Dean Hardister

T.I.P. Number: B-4449 | Design Type: ASD | Design Category: Standard Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: Concrete Footing | Foundation Dimension: 5-0" X 1-3" | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: N/A | External Drainage: Grass Ditch/Swell | Internal Drainage: Weep Holes

Wall Top Feature: Guardrail | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 250031 Date: 9/17/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cumberland Division: 6 Travel Direction: South-North

Route Number: SR-3950 Route Name: Ramsey Street Latitude: 35° 04' 01.80" Longitude: 78° 52' 44.42"

Location Description: North of Railroad - 905 Ramsey Street, Fayetteville, NC 28301

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 6 Extension (ft): N/A Total Length (ft): 236

Wall Batter: Back Slope: Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Steel Sheet Piles Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 19000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1963 | Design Life: | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: No | External Drainage: Grass Ditch/Swell | Internal Drainage: None

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

Wall Identification and Data Attributes Form

Wall ID: 250032 Date: 9/20/2014 NCDOT Reviewer(s): Cedrick Butler

Revision Date:

Picture(s):

LOCATION DATA

County: Cumberland Division: 6 Travel Direction: South-North

Route Number: SR-3950 Route Name: Ramsey Street Latitude: 35° 03' 57.68" Longitude: 78° 52' 43.47"

Location Description: South of Railroad - 881 Ramsey Street, Fayetteville, NC 28301

Bridge Association: No Bridge Number: N/A Culvert Association: No Culvert Number: N/A

Road System: Secondary Tier: Subregional

DIMENSION DATA

Embedment (ft): Max. Wall Height (ft): 6 Extension (ft): N/A Total Length (ft): 91

Wall Batter: Back Slope: N/A Front Slope: N/A Berm Dimension: N/A Distance to Stream (ft): N/A

Roadside Features: Sidewalk

Plan View:	Profile View:

WALL TYPE AND FUNCTION DATA

Wall Type: Cantilever Wall Facing Steel Sheet Piles Veneer: N/A

Construction Type: Cut Function Type: Right-of-Way Support Traffic Volume: 19000

Protected Features: Roadway Purpose: Minimize ROW/Encroachment/Permitting

HISTORY AND OWNERSHIP

Current Owner: NCDOT | Year Built: 1963 | Design Life: | Engineer of Record:

T.I.P. Number: | Design Type: ASD | Design Category: Post-Bid Design | Inspection Frequency:

Special Access Needs: N/A | Work Zone Requirments: N/A

STRUCTURAL DATA

Wall Support: N/A | Foundation Dimension: N/A | Fill Material: In Situ

Bridge Foundation Type: N/A | Soil Reinforcement Type: N/A | Surcharge: No

Reinforcement off ROW: No | External Drainage: Grass Ditch/Swell | Internal Drainage: None

Wall Top Feature: Coping | Scour Depth: N/A | Wall Obstruction(s): None

As-Built Drawings: | Design Calculations: | Subsurface Plans:

Conflict(s): N/A

Comments On Design: N/A

Comments On Construction Details: N/A

Maintenance/Repair Details: N/A

APPENDIX I: COMPLETED ERS FIELD CONDITION INSPECTION DATA COLLECTION FORMS (BY TWO DIFFERENT INSPECTORS)

ERS Field Condition Inspection Data Collection Form

Wall ID: 910001 Date: 5/21/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: South Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Latitude: 35° 47' 52.70" Longitude: 78° 38' 46.52" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	95	5	0	0	There is some graffiti on the left approach wall.
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Horizontal crack from the beginning of the wall to the end.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	95	5	0	0	Minor signs of local bulges but these could have occurred during the installation of simulated stone facing.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	80	20	0	Drainage pipes need to be cleaned out.
Exterior	Wall Top Attachment	95	5	0	0	Coping near the expansion joint is misaligned but this could have occurred during construction.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910001 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: South Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Latitude: 35° 47' 52.70" Longitude: 78° 38' 46.52" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	95	5	0	0	Graffiti is present at the wall.
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	95	5	0	0	Horizontal crack from the beginning of the wall to the end.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	95	5	0	0	Bulges/Distortion at the center joint of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	90	10	0	0	Clogged drainages.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910002 Date: 5/21/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: Left Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Latitude: 35° 47' 51.85" Longitude: 78° 38' 44.92" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	95	5	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Identified (14) vertical cracks about 1/16" to 1/8" wide. Each crack extended from the top wall to the bottom. Also noticed early signs of spalling in the stone facing.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	0	100	0	Drainage pipes need to be cleaned out. Drainage channel along the top of the wall is full of debris and is no longer serving its intended function.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	40	0	60	0	Vegetation growth along the top of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910002 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: Left Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Latitude: 35° 47' 51.85" Longitude: 78° 38' 44.92" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	95	5	0	0	Vertical cracks along the wall.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	90	10	0	0	Clogged drains.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	30	0	70	0	Vegetation growth along the wall top causing drainage issues.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910003 Date: 5/21/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: Right Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Latitude: 35° 47' 51.94" Longitude: 78° 38' 47.37" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	90	10	0	0	Counted (7) vertical cracks about 1/16" wide. Each crack extended from the top of the wall to the bottom.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	95	5	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	20	80	0	Drainage pipes need to be cleaned out. Drainage channel along the top of the wall is full of debris and is no longer serving its intended function.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	0	20	80	0	Vegetation growth all along the top of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910003 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: Right Wing Wall (South Wall Abutment) - US 70 (Glenwood Avenue) over Wade Avenue

Latitude: 35° 47' 51.94" Longitude: 78° 38' 47.37" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	80	20	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	95	5	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	20	0	80	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	20	0	80	0	Lots of vegetation growth around the backfill, maybe because of drainage clogging.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910004 Date: 5/21/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: North Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Latitude: 35° 47' 52.69" Longitude: 78° 38' 46.67" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	95	5	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	50	0	50	0	Drainage pipes need to be cleaned out.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910004 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: North Wall Abutment - US 70 (Glenwood Avenue) over SR 1728 (Wade Avenue)

Latitude: 35° 47' 52.69" Longitude: 78° 38' 46.67" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	95	5	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	95	5	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910005 Date: 6/5/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: West Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Latitude: 35° 54' 05.61" Longitude: 78° 45' 56.63" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Several discolored panels from water near the top of the wall.
	Damage	70	20	10	0	Several roots penetrating the wall facing causing panels to move. Some roots were rather long.
	Cracking	100	0	0	0	Counted (1) cracked panel near the base of the wall.
	Joint Alignment	50	50	0	0	Evidence of misaligned facing units.
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	90	10	0	0	There appears to be some deflection on the left side of the bridge abutment.
	Bulges/ Distortion	80	20	0	0	Evidence of local bulges.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	50	0	50	0	Drainage channel along the top of the wall is full of vegetation and debris.
Exterior	Wall Top Attachment	90	10	0	0	Evidence of some displacement on the right approach wall.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	50	30	20	0	Vegetation is present all along the wall and in the drainage channel along the top of the wall. Several roots are also penetrating through the wall facing.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910005 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: West Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Latitude: 35° 54' 05.61" Longitude: 78° 45' 56.63" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	90	10	0	0	Cracks in abutment mid-section.
	Joint Alignment	90	10	0	0	Joint spacing is wide and not consistent.
	Joint Spacing	90	10	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	Bulging is evident in some areas of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	95	5	0	0	Cracks along the top of wall because of bulging and deflection.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	80	20	0	0	Lots of vegetation along the top of the wall, roots are coming through the wall facing.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910006 Date: 6/5/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: East Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Latitude: 35° 54' 05.93" Longitude: 78° 45' 57.50" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	80	20	0	0	Several chipped panels along the wall facing.
	Staining	70	30	0	0	Several discolored panels from water near the top of the wall.
	Damage	80	20	0	0	Several roots penetrating the wall facing causing panels to move.
	Cracking	100	0	0	0	
	Joint Alignment	50	50	0	0	Evidence of several misaligned facing units.
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	80	0	20	0	There appears to be some rotation (towards the pole) on the left side of the bridge abutment.
	Bulges/ Distortion	70	0	30	0	Evidence of bulging throughout the wall facing.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	70	30	0	0	Some vegetation growth along the drainage channel.
Exterior	Wall Top Attachment	80	20	0	0	Some cracking along the concrete coping.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	40	0	60	0	Vegetation is present all along the wall with several roots penetrating through the wall facing.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910006 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: US-70 Route Name: Glenwood Avenue

Location Description: East Wall Abutment - US 70 (Glenwood Avenue) over SR 1837 (Westgate Rd)

Latitude: 35° 54' 05.93" Longitude: 78° 45' 57.50" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	90	10	0	0	Joints between panels are not consistent. Spacing's are different and gaps are large at times.
	Joint Spacing	90	10	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	90	10	0	0	Some areas (small part) suffer from deflection (leaning) towards the steel pole.
	Bulges/ Distortion	70	30	0	0	Areas of the wall have bulged. Some panels are distorted and there is a bulge in front of the abutment.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	95	5	0	0	Cracks at the top of the abutment near the middle.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	85	15	0	0	Vegetation and roots coming through the wall facing from behind the panels. Vegetation is also present along the top of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910007 Date: 5/28/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: I-40 Route Name: N/A

Location Description: I-40/Wade Ave Interchange (North Bound)

Latitude: 35° 48' 44.04" Longitude: 78° 44' 15.95" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	0	0	100	0	Weathered timber is more pronounced near the base of the wall.
	Staining	0	0	100	0	H-Piles have rust stains and the wall facing is discolored.
	Damage	100	0	0	0	
	Cracking					N/A
	Joint Alignment	0	0	100	0	
	Joint Spacing	0	0	100	0	Some of the timber lagging units have wider gap than others.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	0	0	100	0	One of the H-Piles is crooked but this could have occurred during construction.
	Bulges/ Distortion	0	0	100	0	Some of the timber lagging is bulging outward and has a slight overhang. A bulge in one specific section of the wall is very pronounced.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	80	0	20	0	Filter fabric was exposed in some areas. Evidence of an impending slope failure at the end of the wall.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	The fencing at the end of the wall is displaced.
	Vegetation	70	0	30	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910007 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: I-40 Route Name: N/A

Location Description: I-40/Wade Ave Interchange (North Bound)

Latitude: 35° 48' 44.04" Longitude: 78° 44' 15.95" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	0	0	100	0	Timber is suffering from weathering specially near the base of the wall.
	Staining	0	0	100	0	Rust and water discoloration is evident through lots of the wall sections.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	0	0	100	0	Alignment of lagging are in issue due to bulging and H-pile misalignment.
	Joint Spacing	0	0	100	0	Gaps between some lagging are wider.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	0	0	100	0	Deflection is happening due to bulging.
	Bulges/ Distortion	0	0	100	0	Bulging is an issue in sections of the wall and needs to be addressed.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	Signs of erosion of material neat the bottom of the wall. Filter fabric was exposed in some areas.
	Scour	90	10	0	0	Signs of scour.
	Internal/ External Drains					None.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	50	50	0	0	Vegetation growth near the ends of the wall and some areas in-between.

ERS Field Condition Inspection Data Collection Form

Wall ID: 910008 Date: 6/5/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Wake Route Number: I-40 Route Name: N/A

Location Description: I-40/Wade Ave Interchange (South Bound)

Latitude: 35° 48' 46.59" Longitude: 78° 44' 24.93" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	0	70	30	0	
	Staining	0	0	100	0	H-Piles are weather with rust stains the wall facing is discolored.
	Damage	100	0	0	0	
	Cracking					N/A
	Joint Alignment	0	80	20	0	
	Joint Spacing	0	50	50	0	Joints between timber lagging are much wider than others.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	80	20	0	0	Several H-Piles are rotated but this likely occurred during construction.
	Bulges/ Distortion	0	100	0	0	Some of the timber lagging is bulging outward and has a slight overhang.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	90	0	10	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	80	20	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 910008 Date: 5/14/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Wake Route Number: I-40 Route Name: N/A

Location Description: I-40/Wade Ave Interchange (South Bound)

Latitude: 35° 48' 46.59" Longitude: 78° 44' 24.93" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	80	20	0	0	Wall has some weathering on some of the timber lagging.
	Staining	70	30	0	0	Discoloring of the facing material and rust on the piles.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310009 Date: 6/23/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: East Wall Abutment - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 31.20" Longitude: 78° 54' 59.51" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Staining from water in present near the top of the wall.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	30	70	0	Drainage pipes are clogged and need to be cleaned out.
Exterior	Wall Top Attachment	95	5	0	0	Some cracking on the coping.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310009 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: East Wall Abutment - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 31.20" Longitude: 78° 54' 59.51" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Weathering and staining from water is visible.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	90	10	0	0	Drainage outlets are probably clogged.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310010 Date: 6/23/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: West Wall Abutment - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 30.49" Longitude: 78° 55' 00.83" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Staining from water in present along the top of the wall.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	0	100	0	Drainage pipes are clogged and need to be cleaned out.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310010 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: West Wall Abutment - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 30.49" Longitude: 78° 55' 00.83" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Signs of staining on the wall from water.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	90	10	0	0	Clogging of drainage pipes.
Exterior	Wall Top Attachment	95	5	0	0	Damage on some wall top coping.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310011 Date: 6/23/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: West Wing Wall - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 33.70" Longitude: 78° 55' 04.50" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Staining from water in present near the top of the wall.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	0	80	20	Drainage pipes are clogged and need to be cleaned out. Some have vegetation growing inside or completely blocking the weepholes.
Exterior	Wall Top Attachment	50	0	50	0	Identified a 1.5 inch gap between the wall top feature and top of wall.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	95	5	0	0	Some roots hanging over the wall at the right end of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 310011 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: West Wing Wall - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 33.70" Longitude: 78° 55' 04.50" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Staining along the top of the wall due to poor drainage (clogged).
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	50	30	20	0	Most of the drainage pipes are clogged.
Exterior	Wall Top Attachment	50	50	0	0	Coping separated from the top of wall by (1 -2 cm) in some areas.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Vegetation along the top of wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 310012 Date: 6/23/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: East Wing Wall - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 26.28" Longitude: 78° 54' 53.40" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	95	5	0	0	Some brick displacement near the top of the wall.
	Staining	90	10	0	0	Staining from water in present near the top of the wall.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	Identified one section where brick is beginning to spall.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	0	10	80	10	Drainage pipes are clogged and need to be cleaned out. Some have vegetation growing inside or completely blocking the weepholes.
Exterior	Wall Top Attachment	90	10	0	0	Small gap between the wall top feature and top of wall.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Vegetation draped over the wall at the left end.

ERS Field Condition Inspection Data Collection Form

Wall ID: 310012 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: I-85 Route Name: N/A

Location Description: East Wing Wall - SR 1322 (Broad Street) over I-85

Latitude: 36° 01' 26.28" Longitude: 78° 54' 53.40" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Some weathering and staining from water.
	Damage	95	5	0	0	Some bricks have damage near the top of wall.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	70	10	20	0	Most of the drainage outlets are clogged.
Exterior	Wall Top Attachment	90	10	0	0	Coping at the end of the wing walls are separated by around 1cm. There is also some damage to the coping.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	80	20	0	0	Vegetation along the top of wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 310013 Date: 10/10/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: NC-147 Route Name: Triangle Expressway

Location Description: South Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Latitude: 35° 52' 13.60" Longitude: 78° 51' 56.46" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Several vertical cracks have developed in the concrete barrier rail. Vertical cracks about ¼" wide have also developed on the brick veneer facing.
	Joint Alignment	80	0	20	0	The expansion joint has opened significantly exposing an additional ½" gap.
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	0	30	0	There appears to be some deflection in the right approach wall on the south bridge abutment.
	Bulges/ Distortion	100	0	0	0	
	Settlement	70	0	30	0	There also appears to be some settlement at the end of the right approach wall. The concrete parapet has displaced exposing a 2" gap in one of the control joints.
	Heaving	100	0	0	0	
Drainage	Erosion	70	0	30	0	There is some evidence of earth movement along the right approach wall. The earth material is also significantly lower (about 2 feet) than specified.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	70	0	30	0	The concrete barrier rail on top of the wall has displaced significantly.
	Road/Sidewalk/ Shoulder	90	10	0	0	There is some separation between the facing and concrete barrier rail in from of the wall.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310013 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: NC-147 Route Name: Triangle Expressway

Location Description: South Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Latitude: 35° 52' 13.60" Longitude: 78° 51' 56.46" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining and discoloring because of weathering.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	90	10	0	0	Joint separating due to settlement.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	80	20	0	0	Settlement is obvious on the left side of the abutment.
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	80	20	0	0	Cracks in the wall top attachment (right side).
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310014 Date: 10/10/2014 NCDOT Inspector(s): Cedrick Butler

Division: 5 County: Durham Route Number: NC-147 Route Name: Triangle Expressway

Location Description: North Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Latitude: 35° 52' 14.70" Longitude: 78° 51' 56.05" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	
	Damage	100	0	0	0	
	Cracking	90	10	0	0	A long vertical crack about ¼" wide have also developed on the brick veneer facing.
	Joint Alignment	80	0	20	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	0	30	0	There is some evidence of deflection in the left approach wall on the north bridge abutment.
	Bulges/ Distortion	100	0	0	0	
	Settlement	70	0	30	0	Evidence of settlement near the end of the left approach wall. The concrete parapet has displaced exposing a 4.5" gap between the concrete barrier rail and the concrete section behind the parapet.
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	The earth material is also lower than specified.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	70	0	30	0	The concrete barrier rail on top of the wall has displaced about 3.5". Cracking all along the concrete barrier rail.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 310014 Date: 5/19/2015 NCDOT Inspector(s): Amr Helal

Division: 5 County: Durham Route Number: NC-147 Route Name: Triangle Expressway

Location Description: North Wall Abutment - NC 147 (Triangle Expressway) over SR 1999 (Davis Drive)

Latitude: 35° 52' 14.70" Longitude: 78° 51' 56.05" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Some discoloring of the wall facing.
	Damage	100	0	0	0	
	Cracking	80	20	0	0	A vertical crack can be seen on the left side of the abutment. May be due to rotation.
	Joint Alignment	80	20	0	0	Joint is not aligned well. There are also signs of separation and settlement on the left side of the abutment.
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	90	10	0	0	Signs of rotation on the left side of the abutment causing the bridge slab to separate.
	Bulges/ Distortion	100	0	0	0	
	Settlement	70	30	0	0	Maybe settlement issues that caused cracks.
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	90	10	0	0	Cracks on the wall top attachment (right side).
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 780015 Date: 10/10/2014 NCDOT Inspector(s): Cedrick Butler

Division: 7 County: Rockingham Route Number: SR-1378 Route Name: Martinsville Loop

Location Description: SR 1378 (Martinsville Loop) over Norfolk Southern Railway beside Price United Methodist Church

Latitude: 36° 32' 22.47" Longitude: 79° 54' 50.70" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	70	30	0	0	Weathered timber is more pronounced near the center of the wall.
	Staining	60	40	0	0	H-Piles have rust stains and the wall facing is discolored.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	80	20	0	0	A few H-Piles are crooked resulting in misaligned timber lagging units. This most likely occurred during construction.
	Joint Spacing	50	50	0	0	Some of the timber lagging units have wider gap than others.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	30	0	0	Some deflection is present but, could be a result of misaligned H-piles.
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 780015 Date: 5/28/2015 NCDOT Inspector(s): Amr Helal

Division: 7 County: Rockingham Route Number: SR-1378 Route Name: Martinsville Loop

Location Description: SR 1378 (Martinsville Loop) over Norfolk Southern Railway beside Price United Methodist Church

Latitude: 36° 32' 22.47" Longitude: 79° 54' 50.70" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Discoloring of the timber due to weathering.
	Damage	95	5	0	0	H-piles are rusted.
	Cracking	100	0	0	0	
	Joint Alignment	95	5	0	0	H-piles are misaligned.
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	Wall is distorted in some sections but no major bulging.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					Not Applicable.
Exterior	Wall Top Attachment					Not Applicable.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Vegetation growth in the backfill.

ERS Field Condition Inspection Data Collection Form

Wall ID: 250016 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Bank of America - 503 Cross Creek Mall, Fayetteville, NC 28303

Latitude: 35° 04' 09.76" Longitude: 78° 57' 31.77" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	60	40	0	0	Efflorescence staining is also present on the cast-in-place concrete coping.
	Damage	100	0	0	0	
	Cracking	40	60	0	0	Several vertical hairline cracks along the cast-in-place concrete coping were identified.
	Joint Alignment	40	60	0	0	A few H-Piles are misaligned causing some panels to be misaligned.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	30	0	0	A few H-Piles are misaligned causing some panels to be out of plumb.
	Bulges/ Distortion	90	10	0	0	A few panels are bulging outward due to H-Pile misalignment.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	95	5	0	0	Evidence of some erosion in the backfill.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	40	60	0	0	Several vertical hairline cracks along the cast-in-place concrete coping and discoloration from water coming through the cracks.
	Road/Sidewalk/ Shoulder	95	5	0	0	Evidence of some earth movement in the back slope.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250016 Date: 5/21/2015 NCDOT Inspector(s): Amr Helal

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Bank of America - 503 Cross Creek Mall, Fayetteville, NC 28303

Latitude: 35° 04' 09.76" Longitude: 78° 57' 31.77" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Signs of weathering and water staining.
	Damage	100	0	0	0	
	Cracking	10	90	0	0	Vertical hairline cracks along the concrete coping.
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	80	20	0	0	Deflection due to bulging.
	Bulges/ Distortion	80	20	0	0	Bulging in one panel of the wall.
	Settlement	90	10	0	0	Maybe a sign of settlement in areas (especially coping) of the wall.
	Heaving	100	0	0	0	
Drainage	Erosion	90	10	0	0	Signs of erosion in the soil behind the wall.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	10	90	0	0	Hairline cracks and staining
	Road/Sidewalk/ Shoulder	90	10	0	0	Signs of erosion in the soil behind the wall.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250017 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Vantage South Bank - 4200 Morganton Road, Fayetteville, NC 28314

Latitude: 35° 04' 05.25" Longitude: 78° 57' 12.48" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	60	40	0	0	Efflorescence staining is also present on the cast-in-place concrete coping.
	Damage	100	0	0	0	
	Cracking	40	60	0	0	Several vertical hairline cracks along the cast-in-place concrete coping were identified.
	Joint Alignment	40	60	0	0	A few H-Piles are misaligned causing some panels to be misaligned.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	30	0	0	A few H-Piles are misaligned causing some panels to be out of plumb.
	Bulges/ Distortion	90	10	0	0	A few panels are bulging outward due to H-Pile misalignment.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	90	10	0	0	Evidence of some erosion in the backfill.
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	40	60	0	0	Cast-in-place concrete coping is displaced in some areas because of a few misaligned H-Piles.
	Road/Sidewalk/ Shoulder	90	10	0	0	Evidence of some earth movement in the back slope.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250017 Date: 5/21/2015 NCDOT Inspector(s): Amr Helal

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Vantage South Bank - 4200 Morganton Road, Fayetteville, NC 28314

Latitude: 35° 04' 05.25" Longitude: 78° 57' 12.48" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Signs of water staining along the wall.
	Damage	100	0	0	0	
	Cracking	10	90	0	0	Vertical hairline cracks in the coping of the wall.
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	60	40	0	0	Deflection due to bulging.
	Bulges/ Distortion	60	40	0	0	Major bulging in two panels of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	90	10	0	0	Signs of erosion in the soil behind the wall.
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	10	90	0	0	Vertical hairline cracks in the coping.
	Road/Sidewalk/ Shoulder	90	10	0	0	Evidence of some earth movement in the backfill.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250018 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Bubba's 33 - 500 Westwood Shopping Center, Fayetteville, NC 28304

Latitude: 35° 04' 03.30" Longitude: 78° 57' 13.10" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	60	40	0	0	Efflorescence staining is also present on the cast-in-place concrete coping.
	Damage	100	0	0	0	
	Cracking	40	60	0	0	Several vertical hairline cracks along the cast-in-place concrete coping were identified.
	Joint Alignment	40	60	0	0	A few H-Piles are misaligned causing some panels to be misaligned.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	70	30	0	0	A few H-Piles are misaligned causing some panels to be out of plumb.
	Bulges/ Distortion	90	10	0	0	A few panels are bulging outward due to H-Pile misalignment.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	40	60	0	0	Cast-in-place concrete coping is displaced in some areas because of a few misaligned H-Piles.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250018 Date: 5/21/2015 NCDOT Inspector(s): Amr Helal

Division: 6 County: Cumberland Route Number: SR-1404 Route Name: Morganton Road

Location Description: Bubba's 33 - 500 Westwood Shopping Center, Fayetteville, NC 28304

Latitude: 35° 04' 03.30" Longitude: 78° 57' 13.10" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Water staining in some areas of the wall.
	Damage	100	0	0	0	Cracks in the coping.
	Cracking	10	90	0	0	
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	80	20	0	0	Signs of rotation in the wall.
	Bulges/ Distortion	70	30	0	0	A little bit of bulging in areas of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	10	90	0	0	Multiple vertical hairline cracks and staining.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480019 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: West Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 47.94" Longitude: 80° 51' 23.84" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	95	5	0	0	Some minor damage on the concrete panels from installation. Several chipped panels have been repaired and likely occurred during construction.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	Appears to be some bulging near the left end of the wall abutment.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480019 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: West Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 47.94" Longitude: 80° 51' 23.84" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Discoloring of wall panels due to water and weathering.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	80	20	0	0	Deflection near the middle section.
	Bulges/ Distortion	80	20	0	0	Bulging of the panels near the middle section.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480020 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Left Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 45.16" Longitude: 80° 51' 23.05" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	95	5	0	0	Some minor damage on the concrete panels from installation. A few chipped panels have been repaired and likely occurred during construction.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	90	10	0	0	Appears to be some deflection near the end of the wall.
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480020 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Left Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 45.16" Longitude: 80° 51' 23.05" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480021 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Right Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 51.22" Longitude: 80° 51' 24.63" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	95	5	0	0	Some minor damage on the concrete panels from installation. A few chipped panels have been repaired and likely occurred during construction.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	95	5	0	0	Some vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480021 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Right Wing Wall (West Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 51.22" Longitude: 80° 51' 24.63" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	95	5	0	0	Vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480022 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: East Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 46.48" Longitude: 80° 51' 21.80" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	95	5	0	0	Some minor damage on the concrete panels from installation. A few chipped panels have been repaired and likely occurred during construction.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480022 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: East Wall Abutment - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 46.48" Longitude: 80° 51' 21.80" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Discoloring of some panels. Maybe due to water and weathering.
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Cracks near the middle of the wall.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	95	5	0	0	Vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480023 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Left Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 49.26" Longitude: 80° 51' 22.23" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	20	0	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480023 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Left Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 49.26" Longitude: 80° 51' 22.23" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Some vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480024 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Right Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 44.25" Longitude: 80° 51' 20.97" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	80	15	5	0	Staining (brown rust color) from water is present on the wall facing. Discoloration is also present along the concrete coping.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Joint spacing is too wide in several sections throughout the wall.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480024 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-77 Route Name: N/A

Location Description: Right Wing Wall (East Wall Abutment) - SR 1100 (Brawley School Rd) over I-77

Latitude: 35° 34' 44.25" Longitude: 80° 51' 20.97" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Discoloring of some panels due to water.
	Damage	95	5	0	0	Some damage to front coping.
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Some vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 120025 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 10 County: Cabarrus Route Number: SR-1002 Route Name: Cabarrus Avenue

Location Description: 380 Corban Ave SW, Concord, NC 28025

Latitude: 35° 24' 04.30" Longitude: 80° 35' 32.09" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Staining from water on along the wall facing.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	75	20	5	0	Some joints are too wide allowing aggregate to come through the wall facing.
	Material Loss	95	5	0	0	Some aggregate has come through the wall facing.
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	40	60	0	0	Collection of mud and debris at the corners of the concrete ditch.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 120025 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 10 County: Cabarrus Route Number: SR-1002 Route Name: Cabarrus Avenue

Location Description: 380 Corban Ave SW, Concord, NC 28025

Latitude: 35° 24' 04.30" Longitude: 80° 35' 32.09" Wall Type: MSE

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	Top wall drains needs cleaning.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480026 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: I-40 Route Name: N/A

Location Description: East Bound on I-40 - East of Radio Rd and West of US 21

Latitude: 35° 48' 22.77" Longitude: 80° 52' 52.52" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Efflorescence and water (brown/red color) staining is present on the wall facing.
	Damage	100	0	0	0	
	Cracking	50	50	0	0	Identified several vertical cracks about 1/8" to 3/16" wide extending from the top of the wall down to the bottom of the wall.
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	60	40	0	0	Collection of mud along the concrete ditch.
Exterior	Wall Top Attachment					None.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 480026 Date: 5/28/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: I-40 Route Name: N/A

Location Description: East Bound on I-40 - East of Radio Rd and West of US 21

Latitude: 35° 48' 22.77" Longitude: 80° 52' 52.52" Wall Type: Soil Nail [SN]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	70	30	0	0	Discoloring and water staining is present.
	Damage	100	0	0	0	
	Cracking	70	30	0	0	Vertical cracks along the wall (around 3 mm and varies throughout the wall).
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	90	10	0	0	Collection of debris in the drainage at the top of the wall.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 790027 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 9 County: Rowan Route Number: I-85 Route Name: N/A

Location Description: East Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Latitude: 35° 41' 43.33" Longitude: 80° 24' 03.38" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	90	10	0	0	Caulking in the expansion joints has weathered away.
	Staining	80	20	0	0	Staining from water is present along the facing of the wall.
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Counted (7) cracks about 1/16" wide. One transverse crack about 11 feet long.
	Joint Alignment	100	0	0	0	
	Joint Spacing	90	10	0	0	Expansion joints are a little wide.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	Evidence of some distortion near the left end of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	10	0	85	5	Weephole in front of the wall are clogged. Dirt is completely blocking some of weephole.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 790027 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 9 County: Rowan Route Number: I-85 Route Name: N/A

Location Description: East Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Latitude: 35° 41' 43.33" Longitude: 80° 24' 03.38" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	80	20	0	0	Cracks, staining, and bulging.
	Staining	80	20	0	0	Signs of water staining.
	Damage	100	0	0	0	
	Cracking	60	40	0	0	Horizontal cracks in several locations of the wall.
	Joint Alignment	70	30	0	0	Joint alignment is wide and rusted.
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	80	20	0	0	Clogging of drainage outlets, wash material is coming out of it.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 790028 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 9 County: Rowan Route Number: I-85 Route Name: N/A

Location Description: West Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Latitude: 35° 41' 44.35" Longitude: 80° 24' 04.35" Wall Type: Anchored [AW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	90	10	0	0	Caulking in the expansion joints has weathered away.
	Staining	70	30	0	0	Staining from water is present along the facing of the wall.
	Damage	100	0	0	0	
	Cracking	80	20	0	0	Several horizontal cracks on the facing of the wall.
	Joint Alignment	100	0	0	0	
	Joint Spacing	80	20	0	0	Expansion joints are a little wide.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	Evidence of some distortion near the center of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	10	0	80	10	Weephole in front of the wall are clogged. Several weepholes have dirt and debris completely blocking them.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 790028 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 9 County: Rowan Route Number: I-85 Route Name: N/A

Location Description: West Wall Abutment - SR 2120 (Long Ferry Rd) over I-85

Latitude: 35° 41' 44.35" Longitude: 80° 24' 04.35" Wall Type: Anchored [AW]

CATEGORY	OBSERVATIONS	PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	90	10	0	0	Cracks and staining.
	Staining	80	20	0	0	Signs of water staining near the top of the wall.
	Damage	100	0	0	0	
	Cracking	60	40	0	0	Several cracks on the wall facing.
	Joint Alignment	100	0	0	0	
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	A little bit of bulging on the wall facing.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	80	20	0	0	Some drains are clogged and has vegetation growth.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	90	10	0	0	Vegetation growth in front of the wall. Signs of good drainage function.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480029 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 12 County: Iredell Route Number: SR-1100 Route Name: Brawley School Road

Location Description: The Brawley Market - 798 Brawley School Road, Mooresville, NC 28117

Latitude: 35° 34' 41.66" Longitude: 80° 53' 09.35" Wall Type: Gravity [SGW]

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	90	10	0	0	Staining from water is present along the facing of the wall.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	50	50	0	0	Some joints are too wide exposing aggregate behind the wall facing.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	95	5	0	0	Vegetation is planted in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 480029 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 12 County: Iredell Route Number: SR-1100 Route Name: Brawley School Road

Location Description: The Brawley Market - 798 Brawley School Road, Mooresville, NC 28117

Latitude: 35° 34' 41.66" Longitude: 80° 53' 09.35" Wall Type: Gravity [SGW]

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	95	5	0	0	Discoloring of some blocks. Maybe due to water and weathering.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment	100	0	0	0	
	Joint Spacing	90	10	0	0	Spacing between blocks is big in some areas.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 120030 Date: 8/12/2014 NCDOT Inspector(s): Cedrick Butler

Division: 10 County: Cabarrus Route Number: SR-1394 Route Name: Poplar Tent Road

Location Description: 5790 Poplar Tent Rd, Concord, NC 28027

Latitude: 35° 24' 30.56" Longitude: 80° 40' 25.05" Wall Type: Gravity

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	100	0	0	0	
	Staining	95	5	0	0	Some staining from water is present on the wall facing.
	Damage	100	0	0	0	
	Cracking	80	20	0	0	One vertical crack is present that is about 1/16" wide and 1" inch away from the expansion joint.
	Joint Alignment	95	5	0	0	Once control joint is misaligned.
	Joint Spacing	100	0	0	0	
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	100	0	0	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	10	80	10	0	Several weep holes are full of grass and debris.
Exterior	Wall Top Attachment					None present.
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 120030 Date: 5/27/2015 NCDOT Inspector(s): Amr Helal

Division: 10 County: Cabarrus Route Number: SR-1394 Route Name: Poplar Tent Road

Location Description: 5790 Poplar Tent Rd, Concord, NC 28027

Latitude: 35° 24' 30.56" Longitude: 80° 40' 25.05" Wall Type: Gravity

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	100	0	0	0	
	Staining	100	0	0	0	
	Damage	100	0	0	0	
	Cracking	90	10	0	0	Vertical cracks near the drainage pipes and beside the expansion joint.
	Joint Alignment	90	10	0	0	Joint alignment are misaligned.
	Joint Spacing	90	10	0	0	Some joints are too wide.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	100	0	0	0	
	Bulges/ Distortion	90	10	0	0	A little bulging in the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains	100	0	0	0	
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250031 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-3950 Route Name: Ramsey Street

Location Description: North of Railroad - 905 Ramsey Street, Fayetteville, NC 28301

Latitude: 35° 04' 01.80" Longitude: 78° 52' 44.42" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	0	0	50	50	Severely weathered sheet piles.
	Staining	0	10	40	50	The steel sheet piles are severely rusted allowing groundwater to seep through the wall.
	Damage	100	0	0	0	
	Cracking					Not Applicable.
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	0	0	10	90	The wall face has rotated outward, resulting in a negative batter of several degrees. The wall has been leaning over like this for at least 15 years.
	Bulges/ Distortion	0	0	20	80	There is a very pronounced bulge near the center of the wall.
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present.
Exterior	Wall Top Attachment	0	10	10	80	The wall top feature has displaced as a result of the wall's negative batter of several degrees.
	Road/Sidewalk/ Shoulder	90	10	0	0	Some standing water on the sidewalk at the left end of the wall.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250031 Date: 5/21/2015 NCDOT Inspector(s): Amr Helal

Division: 6 County: Cumberland Route Number: SR-3950 Route Name: Ramsey Street

Location Description: North of Railroad - 905 Ramsey Street, Fayetteville, NC 28301

Latitude: 35° 04' 01.80" Longitude: 78° 52' 44.42" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING				COMMENTS
		1	2	3	4	
Facing	Facial Deterioration	30	20	50	0	Weathering has severely affected the wall.
	Staining	10	30	60	0	Sheet piles are badly rusted from water.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	0	20	80	0	Deflection is very excessive in the wall.
	Bulges/ Distortion	0	20	80	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present and the backfill is retaining moisture.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	20	80	0	0	Vegetation growth in front of the wall.

ERS Field Condition Inspection Data Collection Form

Wall ID: 250032 Date: 9/19/2014 NCDOT Inspector(s): Cedrick Butler

Division: 6 County: Cumberland Route Number: SR-3950 Route Name: Ramsey Street

Location Description: South of Railroad - 881 Ramsey Street, Fayetteville, NC 28301

Latitude: 35° 03' 57.68" Longitude: 78° 52' 43.47" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	0	50	50	0	Weathered sheet piles. Trace amounts of graffiti.
	Staining	0	30	20	50	The steel sheet piles are rusted allowing groundwater to seep through the wall.
	Damage	100	0	0	0	
	Cracking					Not Applicable.
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	90	10	0	0	Some loss of material at the right end of the wall.
Movement	Defection/ Rotation	0	20	80	0	The wall face has rotated outward, resulting in a negative batter.
	Bulges/ Distortion	0	70	30	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					No drainage is present and backfill material was completely saturated.
Exterior	Wall Top Attachment	50	50	0	0	Coping is displaced due to deflection and bulging.
	Road/Sidewalk/ Shoulder	90	10	0	0	A lot of standing water on the sidewalk.
	Vegetation	100	0	0	0	

ERS Field Condition Inspection Data Collection Form

Wall ID: 250032 Date: 5/21/2015 NCDOT Inspector(s): Amr Helal

Division: 6 County: Cumberland Route Number: SR-3950 Route Name: Ramsey Street

Location Description: South of Railroad - 881 Ramsey Street, Fayetteville, NC 28301

Latitude: 35° 03' 57.68" Longitude: 78° 52' 43.47" Wall Type: Cantilever

CATEGORY OBSERVATIONS		PERCENT BY RATING 1	2	3	4	COMMENTS
Facing	Facial Deterioration	20	80	0	0	Graffiti drawings are present.
	Staining	20	80	0	0	Rusty sheet piles form weathering and water.
	Damage	100	0	0	0	
	Cracking	100	0	0	0	
	Joint Alignment					Not Applicable.
	Joint Spacing					Not Applicable.
	Material Loss	100	0	0	0	
Movement	Defection/ Rotation	0	20	80	0	Deflection is evident in the wall and should be evaluated.
	Bulges/ Distortion	0	20	80	0	
	Settlement	100	0	0	0	
	Heaving	100	0	0	0	
Drainage	Erosion	100	0	0	0	
	Scour	100	0	0	0	
	Internal/ External Drains					None present. The backfill is moist and the drainage of water through the wall is bad.
Exterior	Wall Top Attachment	100	0	0	0	
	Road/Sidewalk/ Shoulder	100	0	0	0	
	Vegetation	20	80	0	0	Vegetation growth in front of the wall.