Jon Guerry Taylor & Associates, Inc.
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www.jgtinc.com

May 15, 2015

Ms. Laurie Schueler
Property Management Services
1340-G Ben Sawyer Blvd.
Mt. Pleasant, SC 29464

RE: Executive Summary
Morgan Creek Harbor Association Bulkhead Study

Ms. Schueler,

Jon Guerry Taylor & Associates, Inc. (JGT) was commissioned to perform an evaluation/study of the existing steel sheet pile bulkhead along Morgan Creek on the Isle of Palms. The impetus for the study was to determine the cause of the corrosion issues and to determine a solution to the corrosion problems. JGT worked with S&ME to take measurements, test the soil adjacent to the bulkhead, test the coating and develop solutions to the corrosion problems. The issues that were identified include are as follows:

- The landside of the existing steel sheet pile bulkhead is not coated and is experiencing corrosion.
- The coating is acceptable for the application but the coating is experiencing cracking, causing subsurface corrosion of the steel.
- There is not a weep hole drainage system along the bottom (low tide line) of the bulkhead to relieve the hydrostatic pressure and groundwater from behind the bulkhead.

There are several recommendations and solutions proposed to extend the life of the steel sheet pile bulkhead. The recommendations are summarized as follows:

- Install weep holes at or just above the low tide line.
- Insure proper surface preparation is completed prior to re-coating of the bulkhead sheets.
- Repair the holes and re-coating
- Installation of a Cathodic Protection System along the bulkhead.

Should you have any questions or comments once you have reviewed the study, please feel free to contact us at 843.884.6415.

Sincerely,
JON GUERRY TAYLOR & ASSOCIATES, INC.

Christopher W. Moore, PE
President/Principle Engineer

Morgan Creek Bulkhead Study

Location:
Wild Dunes Resort
Isle of Palms, South Carolina

Dated:
May 15, 2015

Prepared for:
Morgan Creek Harbor Association

Prepared by:

Jon Guerry Taylor & Associates, Inc.

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Civil, Waterfront and Marine Planners & Engineers

Morgan Creek Bulkhead Study

Isle of Palms, South Carolina
May 15, 2015

The purpose of the following engineering study on the Morgan Creek Harbor Association steel bulkhead was to evaluate the structure and determine the cause of the corrosion issues and to determine a solution to the corrosion problems. This study is divided into five sections: **I. Purpose & Background, II. Report Investigation & Methodology, III. General Findings, IV. Recommendations.**

I. PURPOSE & BACKGROUND

Jon Guerry Taylor & Associates, Inc. (JGT) was commissioned to investigate and evaluate the existing steel bulkhead owned by The Morgan Creek Harbor Association within the Morgan Creek marina basin. The existing steel sheet piling bulkhead was constructed in approximately 1997 and modified 1999 to address issues with movement and kick-out of the bulkhead. A tie-back system was installed at that time to straighten the bulkhead and provide additional support. The bulkhead has a concrete filled I-Beam cap with tie-backs along the bulkhead at different intervals and elevations. There appears to be a French Drain system along the back side of the bulkhead with most of the drains located approximately 4'-5' below the top of the bulkhead. There are no weep holes or drainage systems located near the low water mark to relieve the hydrostatic pressure of the bulkhead. The total length of the bulkhead is approximately 6,000 linear feet (LF) with an exposed height between 8-10 feet.

The bulkhead was coated on the waterside prior to installation; however, the land-side of the bulkhead was not coated prior to installation. Starting in 2010, the bulkhead was re-coated by Phillips Industrial Services. The water-side bulkhead surface was to be pressure washed using a chloride rinse to remove chlorides, areas of corrosion were to be cleaned, spot prime connect areas of the bulkhead, around the tie-rods and edges with International Intershield 300V at 3.0 to 5.0 mils. The top coat was to be 19-23 mils thick of International Interzone 954. At least two or three coats by brush or roller application would be required to reach the desired thickness. The connection joints of the sheets and the areas around the tie-back were caulked with SikaFlex A1 moisture cured sealant. Holes in the bulkhead were also patched by welding a plate to the front surface of the sheet piling, primed and top coated. This operation was stopped in 2012. Another proposal was submitted by Phillips Industrial Services to repair additional holes along the entire length of bulkhead in 2013.

II. REPORT INVESTIGATION & METHODOLOGY

JGT teamed with S&ME, Inc. to study the bulkhead and determine the cause of the corrosion issues and solutions. The scope of work included:

- Take five (5) shallow (approximately 18") soil samples to evaluate the make-up of the soils to determine is they are contributing to the corrosion of the bulkhead. pH, resistivity, chloride content and sulfate content were tested.
- Conduct non-destructive bulkhead thickness measurements along the bulkhead to determine the amount of corrosion and the existing thickness of the steel sheet piling along portions of the bulkhead.

- Conduct Dry Film Thickness (DFT) testing of the existing coating on the bulkhead. 180 readings were taken in nine (9) locations.
- Adhesion Testing of the existing coating was performed at nine (9) different locations along the bulkhead.

Site visits were conducted and notes and photographs were taken during these site visits. The results and information was summarized in this report and the report by S&ME.

III. GENERAL FINDINGS

Based on the testing and findings by S&ME and the evaluation by JGT, it has been determined that there are issues with the bulkhead that should be addressed.

- ***Soil Borings:***
  There were five (5) shallow hand auger borings sampled along the west end of the southern portion of the bulkhead. The laboratory testing indicates that all of the parameters tested are generally within the normal limits. None of the results gave any indication that the contents of the soil are increasing the rate of corrosion of the steel sheet piling.
- ***Bulkhead Thickness Measurements:***
  It is estimated that the design thickness of the steel sheet piling is approximately ½" (0.50"). The measurements indicate the average thicknesses along the bulkhead are now 70% to 80% of the original design thickness. Therefore 20% to 30% of the thickness of the sheets has been corroded or deteriorated away. This reduction represents between a 0.35"-0.40" thickness reading and there are several locations around repaired areas where the thickness was significantly lower. Some of the lowest readings were 0.175" and 0.185". These readings were near an existing corroded hole in the bulkhead. There were several areas where the readings were in the 0.20" to 0.30" range.

  Much of the loss of material is from the back-side (land-side) of the steel sheet piling. The areas that were exposed and inspected had large amount of corrosion and scaling from corrosion. The back-side of the steel sheets were not coated with a protective paint or epoxy and therefore have experienced significant corrosion. Many of the holes that are in the bulkhead are coming from the land-side to the water-side. This would indicate the unprotected land-side faces of the steel sheets are experiencing significant corrosion.

- ***Dry Film Thickness (DFT) Testing:***
  The DFT determines the thickness of the coating. The top coating was to be applied at between 19-23 mils per the proposal from Phillips Industrial Services. The manufacturer specifies a typical application thickness of 10 to 20 mils. The average coating thickness was measured between 24.1 to 31.8 mils. The lowest measured reading was a 12.6 mils and the highest was a 47.0 mils. These average values represent the upper end of typical coating application thicknesses.

- ***Adhesion Testing:***
  The adhesion tests give the adhesion properties between the substrate and primer, primer and coating and between other layers of the coating system. The results indicate that the adhesion between the primer to substrate is average to very good, the adhesion between the intermediate and primer is average to good and the topcoat to intermediate is average. S&ME indicates that the results show that the coating could be considered for over coating with a new coating.

- ***Groundwater:***
  Removing the groundwater on the land-side of the bulkhead would reduce the rate of corrosion on the land-side of the unprotected steel sheets. This groundwater is comprised of both stormwater runoff and saltwater from the tidal movement. There is a French Drain system along the back of the bulkhead. Based on the location of the outlets, it appears the system removes groundwater from only the top 3-4 feet of the bulkhead. The groundwater below this French Drain applies additional hydrostatic pressure on the bulkhead during low tide cycles. This groundwater is not released from behind the bulkhead, which applied added force on the bulkhead and also allows the groundwater to remain against the un-coated steel sheet piling. There are areas where there are holes in the bulkhead and where small amounts of the groundwater is released, but not at a rate significant enough to have a positive effect. (***Photo 1*** shows groundwater leaking out from a tie-back.)

  It was noted during the inspection that several of the French Drain discharge pipes appear to be clogged and not releasing the groundwater as needed.

Photo 1

- ***Coating Failures:***

  The corrosion spots that are coming through the coating could possibly be from a couple of sources. The first is corrosion coming through from the land-side of the steel sheets. This is evident in some areas where holes have formed. The second issue is the failure of the coating. This failure could be caused by improper surface prep and/or chlorides still being on the sub-surface prior to coating. Over time, the chlorides (salts) would cause the coating to fail and then expose the steel to corrosion. (***Photo 2*** and ***Photo 3*** are of areas where the coating has failed.) At this time, it is unknown if this corrosion is from the land-side or from the coat failure. (***Photos 4-7*** are of repaired areas and where holes have formed. In ***Photo 6*** and ***Photo 7*** the primer can be seen over repaired areas.)

  Areas where the bulkhead sheets have been repaired by welding a steel plate to cover holes, or where the existing coating has been stripped to be re-coated should be properly primed and recoated. This included stripe coating the edges of the repaired area to ensure proper coverage of the edge. In the harsh saltwater environment, proper surface and repair preparation is very important to long term performance. (In ***Photo 6*** and ***Photo 7***, the primer coat over the repaired area is beginning to fail as corrosion is beginning to appear.)

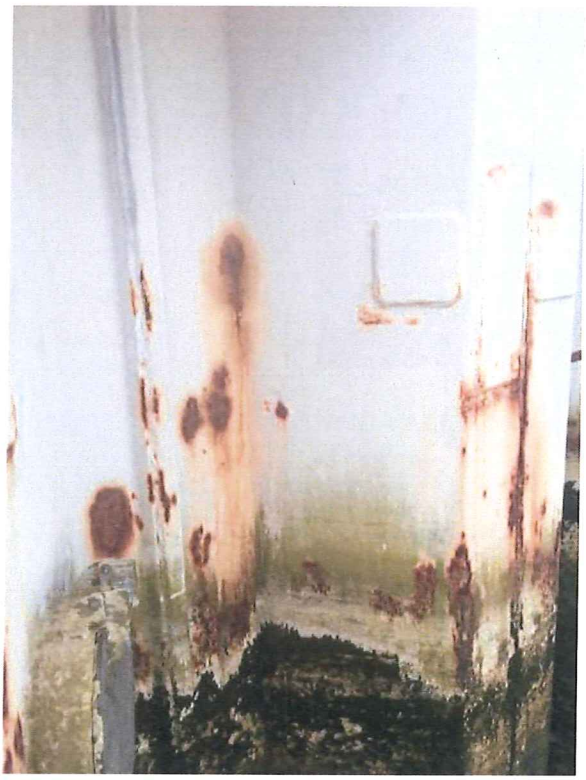


Photo 2

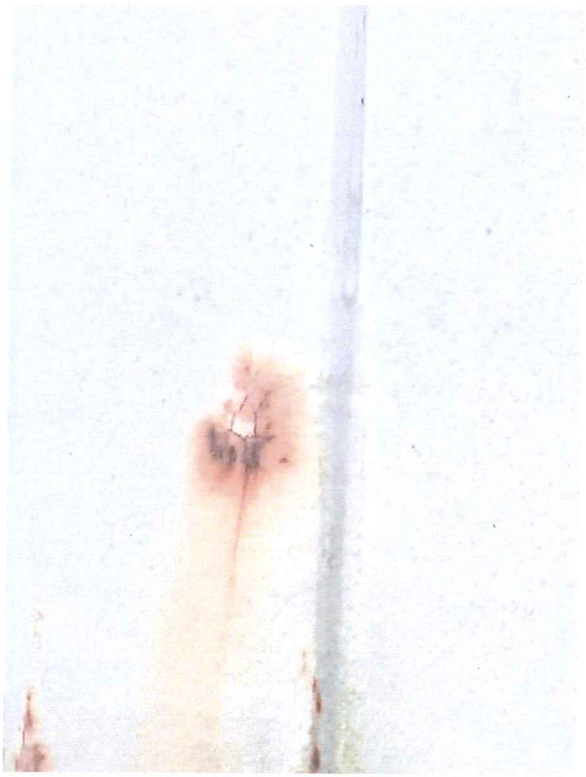


Photo 3

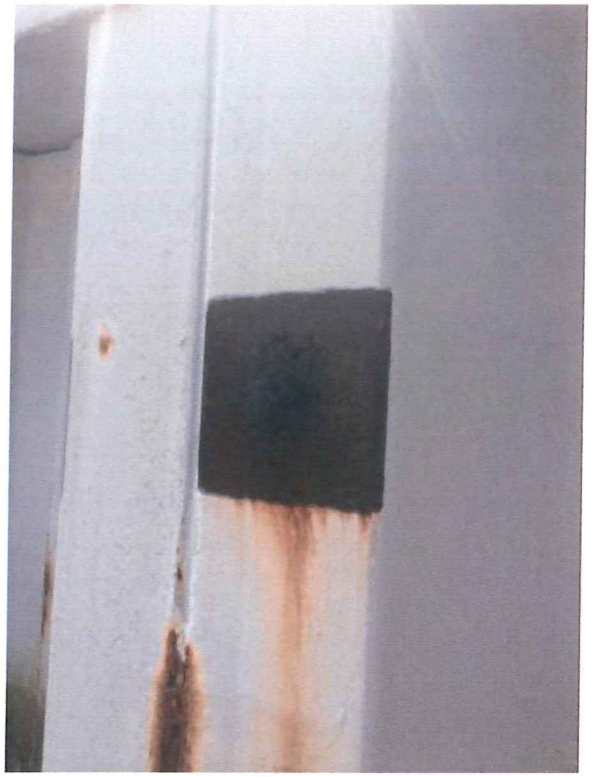


Photo 4

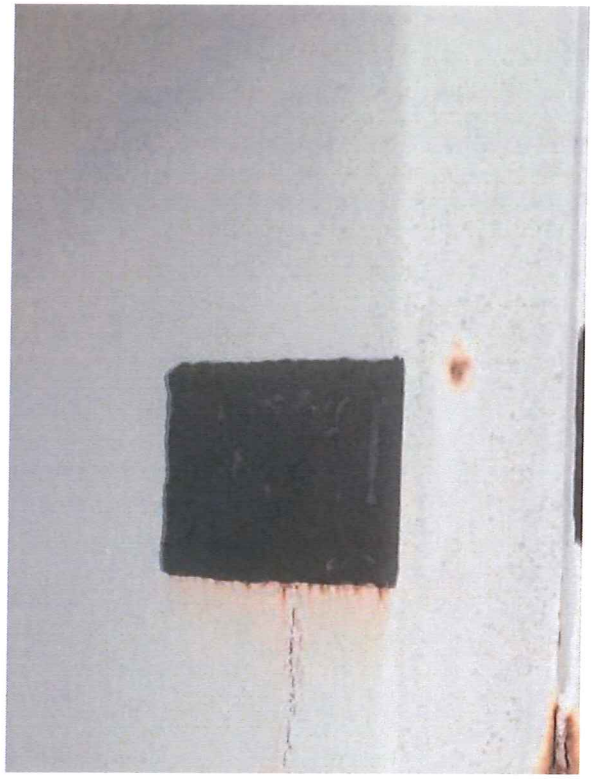


Photo 5

Photo 6

Photo 7

IV. RECOMMENDATIONS

Based on the findings outlined in this report, JGT and S&ME have developed several recommendations that should extend the life of the steel sheet piling bulkhead. They are as follows:

- **Groundwater:**
  The French Drain system outlets should be cleaned to allow free drainage from behind the bulkhead. The installation of weep holes along or just above the low water line would relieve the hydrostatic or groundwater pressure from the bulkhead. The weep holes would allow the groundwater to drain freely at all tide levels and also at the lowest point possible behind the bulkhead. The releasing of this hydrostatic pressure on

the bulkhead would lessen the load the bulkhead experiences and allow the soils to not be fully saturated in between tide cycles.

The weep holes could be retro-fitted on the existing bulkhead. The cost for doing the retro-fit is unknown at this time.

- **Coating:**
  The International Interzone 954 coating may continue to be used for future coating, however, application and surface preparation is critical in the salt water environment. Phillips Industrial Services specified pressure washing and chloride rinsing in their proposal. It is unknown as to if the proper procedure was followed, nor the time between the pressure washing/rinse and when the surface was recoated. JGT and S&ME would recommend having a 3rd party NACE Certified Coating Inspector inspect future coating and repairs to ensure proper specification and procedures for repairs and surface preparation are followed. Other coatings are available and should be considered following a review by a NACE Cathodic Protection Specialist.

- **Repairs:**
  JGT would recommend continuing to repair the existing holes in the steel bulkhead. As has been done previously, this would involve welding a 5/8" steel plate over the holes and priming and re-coating. Proper technique and surface preparation are important prior to priming and re-coating.

- **Cathodic Protection:**
  Cathodic Protection (CP) is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. A simple method of protection connects the metal to be protected to a more easily corroded "sacrificial metal" (such as zinc, magnesium or aluminum) to act as the anode. The sacrificial metal then corrodes instead of the protected metal. This system is called a passive or sacrificial anode cathodic protection (SACP). These SACP systems are similar to zinc systems on motor boats to protect the engines and hulls from corrosion. For structures such as this steel sheet pile bulkhead, where passive or sacrificial cathodic protection are not adequate, an external DC electrical power source is used to provide sufficient current to protect the structure. This is called an Impressed Current Cathodic Protection System (ICCP). ICCP systems work by supplying a controlled amount of DC current to submerged surfaces using highly reliable mixed metal oxide anodes and zinc reference electrodes. This electrical current is constantly monitored and regulated by the system itself, to prevent the electrochemical action of galvanic corrosion. These systems are used on oil pipelines, oil rigs, ships and boats of all sizes to prevent corrosion. These systems (if properly installed and maintained) would nearly stop all further corrosion from occurring along the steel sheet pile bulkhead. This would not reverse the corrosion of the steel, but they could halt further corrosion. Systems would be designed and installed for both the front and back of the sheet pile bulkhead, as each surface would need to be protected.

  JGT and S&ME strongly recommend having a CP system installed along the steel sheet pile bulkhead. A properly designed and regulated CP system could extend the life of the

bulkhead by 15-20 years. Given the size of the bulkhead, an ICCP system or a combination SACP/ICCP system may be installed. A properly designed and maintained CP system halts the progression of further corrosion, and is designed for a 15-20 year life. This system would protect the steel sheet pile bulkhead over the life of the system, or 15-20 years.

Should a CP system be installed along the bulkhead, JGT recommends consulting and working with the CP specialist to determine the best coating to be used with the CP system. This may or may not be the current coating that has been used.

JGT consulted and worked with *Southern Cathodic Protection* from Atlanta, GA and *BGL Asset Services* from Mt. Pleasant, WI. Both are CP specialists. Outlined below are the design and construction estimates for a CP system to protect the steel sheet pile bulkhead along Morgan Creek.

Cathodic Protection System Design:..... $12,000-$70,000

Cathodic Protection system Install:.....$1,000,000-$1,800,000

Annual Maintenance:..... $10,000-$15,000

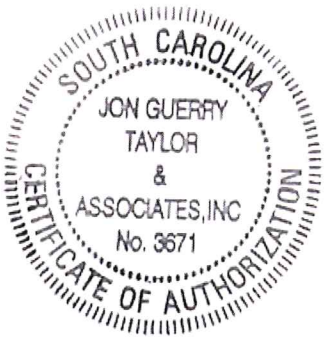
Additional Costs:.....Electricity consumption unknown at this time

The proposals from each of the CP Specialist are attached in Appendix A of this JGT report.

It should be noted that the estimated cost for permitting, design and construction of a replacement bulkhead (approximately 6,000 linear feet) would be between $18,000,000 to $24,000,000. In that event, it would be recommended that a CP system be installed on the replacement bulkhead as well.

Sincerely,
JON GUERRY TAYLOR & ASSOCIATES, INC.

Christopher W. Moore, PE
President/Principle Engineer



Appendix A

BGL ASSET SERVICES, LLC
2193 NORTHWAY
MT. PLEASANT, MI 48858
PHONE (989) 772-8888
FAX (989) 772-7778
WWW.BGLAS.COM

May 13th, 2015

John Guerry Taylor & Associates, Inc.
PO Box 1082
Mount Pleasant, SC 29465

ATTEN: Christopher Moore

RE: Wild Dunes Yacht Harbor Bulkhead

BGL Asset Services, LLC (BGL) respectfully submits the following response to previous conversations and the information shared via email on April 23rd, 2015 with subject name Wild Dunes Marina Bulkhead.

The intention of this proposal letter is to provide a preliminary impressed current cathodic protection design, installation cost, and maintenance costs for budgetary consideration. When doing a preliminary design there are certain parameters where assumptions need to be made (such as soil resistivity and coating effectiveness) so there would need to be data collected from the location before moving forward with the actual design.

Preliminary Design Summary

Coating Quality

BGL made the assumption that the coating is effectively bare, therefore the current requirements utilized for this preliminary design are worst case scenario.

Direct Current Positive Groundbed Arrangement

Results from BGL's rough calculations indicate that this system would encompass approximately 1100 anodes and 36 rectifiers. The placement for the anodes would be distributed along the linear footage with a percentage of the anodes installed in the water on skids, and the remainder would be distributed for the soil side surface area.

Direct Current Negative

As bulkhead sheeting begins to deteriorate the corrosion causes an increase in resistance between bulkhead sheets. To remediate this scenario, BGL has included in the preliminary design a negative cable that spans the entire linear footage of the bulkhead that would be attached to each bulkhead sheet.

Remote Monitoring Units (RMU)

Included in this proposal is to arm each of the rectifiers with a RMU. An RMU wirelessly relays the critical rectifier data to an internet based source where you can login and view the current status of the CP power sources. This equipment mitigates the need to repetitively visit the system to verify that everything is in proper working order.

Coating/Painting
This proposal does not include any re-coating/re-painting.

Budgetary Numbers
BGL feels that the following numbers have +-10% accuracy from preliminary design and proposal to final design and actual execution.

Final Design..... $70,000.00
- Includes the site visit to conduct necessary testing, Design CAD Drawings, & sign off from BGL's certified NACE CP Level 4 Specialist.

Installation.....$1,850,000.00
- This includes all materials and labor for the installation, land surveying, RMU registration and startup, post testing and system adjustments, and an additional trip to the location after 1 month of operation to make adjustments as needed.

Maintenance Costs
Electricity Consumption
BGL cannot anticipate this cost; it could potentially be 1500 amps of direct current for the necessary protection.

Monthly/Annual RMU services
RMU monthly service fees are $8-$15 per unit, per month, depending on the type of unit.

Annual Survey
Expense to conduct an annual survey will be approximately $10,000.00 for a technician to do a site visit at least once per calendar year and collect pipe to soil potentials at each designated test locations.

As always, BGL appreciates the invitation to evaluate this project. Should you have any questions or concerns please contact us at (989) 772-9111, or email me directly at andyg@bglas.com.

Regards,

BGL Asset Services, LLC

VOSB
cVE

Andrew Gillespie
Operations Manager

Subject: Re: Wild Dunes Marina Bulkhead - Report
From: shawn@cathodicprotection.com
Date: 4/30/2015 8:44 AM
To: cmoore@jgtinc.com

Chris,

Following a review of the information which you provided in the referenced email, SCPC has developed a plan for you to present to your client.

I am available to discuss in depth at your convenience. I can prepare a formal proposal next week if necessary.

SCPC will provide a design and material list to provide CP for the Wild Dunes Yacht Harbor bulkhead at a cost of Eleven Thousand Nine Hundred Dollars ($11,900.00).
This cost includes site visit to gather additional data necessary for an accurate design.

Once the design is performed and material list developed a cost to install and commission the cathodic protection system can be given.

Thanks,

Shawn

Shawn Aiken
Business Development Manager
Southern Cathodic Protection
780 Johnson Ferry Road
Suite 225
Atlanta, GA 30342

404-252-4649 office
404-252-1824 fax
859-559-3682 cell

shawn@cathodicprotection.com
www.cathodicprotection.com

From: "Christopher Moore, PE" <cmoore@jgtinc.com>
To: shawn@cathodicprotection.com
Date: 04/23/2015 04:44 PM
Subject: Wild Dunes Marina Bulkhead - Report

Shawn,
Please find the attached report for the Wild Dunes Yacht Harbor bulkhead. Once you have reviewed it please let me know if you have any questions.

Thank you,
Chris Moore

Christopher W. Moore, PE

Jon Guerry Taylor & Associates, Inc.

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[attachment "3513-15-009 Report (Revised).pdf" deleted by Shawn Aiken/Southern]