Groundwater Model Refinement Plan
Riverbend Steam Station Ash Basin
Attachment 1 and 2

EAS RU # 2079

Submitted to
Duke Energy LLC

By the
Environmental Assistance Office

Infrastructure, Design, Environment, and Sustainability (IDEAS) Center

UNC Charlotte
ATTACHMENT 1

Groundwater Model Refinement Plan
Riverbend Steam Station Ash Basin

Regional Environmental Assistance & Pollution Prevention Office for Small Business

The mission of the Environmental Assistance Office (EAO) is to research, design and promote sustainable engineering and management practices to serve government entities, regional small businesses, and to offer students the opportunity to gain real-world experience in solving pollution problems. A more detailed description of the history, mission and staff of the Office is provided at the end of this document.

This document describes the Environmental Assistance Services Recharge Unit’s scope of services to be performed for Duke Energy LLC during March 1 – June 30, 2013. These services focus on: groundwater modeling.

Background

Duke Energy Carolinas, LLC (Duke Energy), owns and operates the Riverbend Steam Station (Riverbend), located near Mt. Holly, in Gaston County, North Carolina. The steam station generates electricity by burning coal. The coal ash residue from the coal combustion process is disposed of in the station’s ash basin. The discharge from the ash basin is permitted by the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) under the National Pollution Discharge Elimination System (NPDES) Permit NC0004961.

The NPDES permit requires groundwater monitoring to be performed around the ash basin. Monitoring wells are sampled three times per year with the analytical results submitted to the DWQ. The compliance boundary for groundwater quality for the Riverbend ash basin is defined in accordance with NCAC Title 15A Chapter 02L .0107(a) (T15 A NCAC 02L .0107(a)) as being established at either 500 feet from the waste or at the property boundary, whichever is closest to the waste. Compliance with groundwater standards for monitoring wells located at or near the compliance boundary is determined by comparing analytical results to the 2L Standards. Compliance with groundwater standards for monitoring wells located inside of the compliance boundary are determined by predictive calculations or groundwater modeling.
Nine monitoring wells surrounding the Riverbend ash basin are located at or near the compliance boundary. Analytical results from sampling these wells are submitted to DWQ within 60 days after each sampling event. As a result of site access conditions, monitoring wells MW-9, MW-10, and MW-13 were installed inside of the compliance boundary. These three monitoring wells are also sampled three times per year, but compliance with 2L Standards for these locations is determined by groundwater modeling. A report is submitted annually with the results of the groundwater modeling along with the analytical results from the sampling.

For the January 2012 submittal to DWQ, compliance with groundwater standards for monitoring wells located inside of the compliance boundary were determined by groundwater modeling. Duke Energy used a groundwater model to predict the concentrations at the compliance boundary. The predicted results from the groundwater model and the analytical results for samples collected at MW-9, MW-10, and MW-13 were submitted to the DWQ in January 2012. The groundwater model prepared for the January 2012 submittal utilized MODFLOW to perform the hydraulic flow modeling and MT3D6 to perform the fate and transport modeling. The MT3D model uses the flow field developed by MODFLOW to simulate the transport of contaminants. The model(s) consisted of a single layer of cells with a domain that extended along a cross section from the subject monitoring well to the compliance boundary.

On November 1, 2012, a proposed work plan was submitted to DWQ on behalf of Duke Energy that includes a groundwater assessment work plan and a groundwater model refinement plan. The groundwater assessment work plan will assess the 2L exceedances at the monitoring wells. Exceedances of iron, manganese, and pH will be evaluated to determine if the exceedances are naturally occurring, or if they are caused by particulate matter which is preserved in the sample as a result of well construction and/or sampling procedures. Available reports and data on site geotechnical, geologic, and hydrologic conditions will be reviewed and used to develop a site hydrogeologic conceptual model.

**Objectives and Scope of Services**

The groundwater model refinement plan comprises the objectives and scope of services of the Environmental Assistance Services Recharge Unit. The model that utilizes MODFLOW and MT3D to predict the concentrations of iron and manganese at the compliance boundary will be refined as follows:

- The model development will incorporate information from the site hydrogeologic conceptual model described as part of the groundwater assessment work plan.
- Where appropriate, the model boundary of the cross sections will be extended to include the ash basin dike, located hydraulically upgradient of the subject monitoring well to the compliance boundary. Piezometric and water level data from the dikes will be utilized.
- Additional layers of cells will be added to the cross section.
- A review of the existing slug test data will be performed to determine if additional testing is necessary.
- Recharge from infiltration of precipitation will be incorporated into the model.

A site specific, two-dimensional model domain will be prepared for a vertical cross section at each of the three wells (MW-9, MW-10, and MW-13) where compliance monitoring is required.

EAS RU # 2079
February 19, 2013
3 of 6
Deliverables

Deliverables are the model report and appendices including the MODFLOW input and output files. The major sections of the model report are:

Conceptual site model
Computer model
Groundwater flow and contaminant transport model construction
Sensitivity analyses
Predictive simulations
Conclusions and limitations

As with the January 2012 submittal, the sensitivity analyses will address uncertainties associated with the heterogeneities of lithology, structure, aquifer parameters, groundwater elevations, water quality, interactions with surface water bodies, and other parameters.

Schedule

The proposed work schedule calls for the following tasks to be completed in June 2013, with preliminary tasks completed earlier and in consistence with separate communication by Bill Miller, P.E.

Task 1. Initial Meetings
Task 2. Interim Meetings
Task 3. Review of existing reports
Task 4. Data gathering
Task 5. Conceptual Model development
Task 6. Model Development and Refinement
Task 7. Sensitivity Analysis
Task 8. Report Preparation - Initial
Task 9. Report Preparation - Final
Task 10. Final Review and Seal

Investigators

Principal Investigator:
Dr. John L. Daniels, P.E.
Interim Chair, Department of Civil and Environmental Engineering
UNC Charlotte

Co-Investigator:
Dr. Bill Langley, P.E.
Adjunct Professor, Department of Civil and Environmental Engineering
UNC Charlotte
Office History & Highlights

Since 1994, the Environmental Assistance Office (EAO) has functioned as an industrial outreach and experiential learning center that connects the expertise of the university with entities throughout the region and Southeast on environmental topics and research. The mission of the EAO is to apply a multidisciplinary approach in promoting and facilitating sustainable pollution prevention activities in the region, deliver customized client assistance, and provide opportunities for students to participate in projects that address real-world problems. Our goal at the EAO is to bring together talented students and faculty to build collaborations with state and regional agencies, small businesses and engineering practitioners. The EAO provides non-regulatory, client-confidential assistance in the greater Charlotte region.

The EAO is a major division of the Infrastructure, Design, Environment, and Sustainability (IDEAS) Center, a research institute organized to provide opportunities for faculty, staff and students to collaborate across disciplines to implement research on critical energy and environmental issues. It serves as an important communication, dissemination, and educational link between the Center and the community at large.

The EAO is directed by Regina Guyer, P.E., who holds a B.S. in Chemical Engineering and an M.S.C.E. in Environmental Engineering. Dr. David Young, IDEAS Center Director and Professor in the Department of Civil Engineering, provides leadership. They are assisted by Sara Watson and Karyn Williamson-Coria as the Administrative Support Associates. Principal investigators and students from the College of Engineering, the College of Business, and the College of Arts and Sciences participate on projects. Together, their expertise and experience is applied to provide the broad services and student learning opportunities available through EAO.

The EAO is funded through participating municipal agencies, research partnerships, grants, and recharge unit services. Its client portfolio includes Air National Guard, Catawba County Engineering and Utilities Services; Charlotte Mecklenburg Utility Department; City of Charlotte, City of Winston-Salem, Mecklenburg County’s Air Quality Division; Mecklenburg County’s Solid Waste Division; the NC Urban Water Consortium through the Water Resources Research Institute of the University of North Carolina System, and the Water and Sewer Authority of Cabarrus County. Collaborative grants have been received through the Centralina Council of Governments with the Biofuels Center of NC and the Green Business Fund; and a NC Department of Commerce – Energy Division grant with the City of Charlotte. The EAO has grown from an individualized program to a regional wide entity as collaborative partners throughout the Carolinas have been developed.
ATTACHMENT 2

Groundwater Model Refinement Plan
Riverbend Steam Station Ash Basin

Total Project Costs: $9,750

This cost is inclusive of students, staff and faculty salary and benefits for the research project along with supplies and other expenses in meeting project scope needs.

<table>
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<th>Task</th>
<th>Budget</th>
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<tr>
<td>Task 1. Initial Meetings</td>
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<td>Task 2. Interim Meetings</td>
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<td>Task 3. Review of existing reports</td>
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<td>Task 7. Sensitivity Analysis</td>
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<td>Task 8. Report Preparation - Initial</td>
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<td>Task 9. Report Preparation - Final</td>
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</tr>
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The University of North Carolina at Charlotte  
Service Agreement Number 2975.2017-0048

This Fixed Price Agreement, made and entered into this 17th day of August 2016, between The University of North Carolina at Charlotte (hereinafter called CONTRACTOR) and HDR, Inc. Engineering of the Carolinas (hereinafter called SPONSOR) (collectively the “Parties”), witnesses that:

Whereas, each Party desires to enter into this Agreement for the benefits reasonably expected to be gained there from;

The Parties hereto mutually agree as follows:

1. Scope of Work

CONTRACTOR will use reasonable efforts to perform services as described in its proposal entitled, “Groundwater Modeling for Corrective Action Plans,” which is attached hereto as Attachment A and incorporated herein by reference.

2. Term of Service

It is understood and agreed that CONTRACTOR will use reasonable efforts to provide these services during the period July 1, 2016 through June 30, 2017. This Agreement is subject to renewal only upon the written mutual agreement of the Parties.

3. Cost of Services

SPONSOR agrees to pay to CONTRACTOR the sum of one hundred twenty-nine thousand five hundred forty-one and no/100 dollars ($129,541.00) for these services as detailed in Attachment A upon a fully executed Agreement and the receipt of an invoice. The invoice shall reference the PO Numbers for each steam station identified below.

   Allen – PO# 1000100007099  
   Belews – PO# 1000100007102  
   Buck – PO# 1000100007104  
   Cliffside – PO# 1000100007106  
   Marshall – PO# 1000100007108

SPONSOR agrees to pay said invoice within 60 days of the invoice date. CONTRACTOR reserves the right to discontinue work if SPONSOR fails to pay invoices rendered by CONTRACTOR within the time herein specified.
4. Communications

CONTRACTOR Contract Administrator:  
Nikki C. Simmons, Sr. Contracting Manager  
The University of North Carolina at Charlotte  
Grants & Contracts Administration  
Cameron Hall 311  
9201 University City Boulevard  
Charlotte, NC 28223-0001  
Email: nsimmo17@uncc.edu  
Telephone: 704-687-1885 | Fax: 704-687-0980

SPONSOR Contract Administrator:  
Steven F. Wade, PMP, PMI-RMP  
Program Manager  
HDR  
440 S. Church Street, Suite 900  
Charlotte, NC 28202-2075  
Telephone: 704-248-3683  
Fax: 980-322-8991  
Email: steven.wade@hdrinc.com

CONTRACTOR Financial Representative:  
The University of North Carolina at Charlotte  
Grants & Contracts Administration  
Cameron Hall, 3rd Floor  
9201 University City Boulevard  
Charlotte, NC 28223-0001  
Email: grants-contracts@uncc.edu  
Telephone: 704-687-1889 | Fax: 704-687-0980

SPONSOR Financial Representative:  
Same as above

CONTRACTOR Principal Investigator:  
Dr. William Langley, P.E.  
9201 University City Boulevard  
Charlotte, NC 28223-0001  
Email: wlangle@uncc.edu  
Telephone:

SPONSOR Principal Investigator:  
Same as above

5. Use of Names in Publicity

SPONSOR agrees that no advertising or publicity matter having or containing reference to CONTRACTOR will be disseminated without the prior written consent of CONTRACTOR. CONTRACTOR agrees that no advertising or publicity matter having or containing reference to SPONSOR will be disseminated without prior written consent of SPONSOR. SPONSOR recognizes and acknowledges that under NC Public Records Act, N.C.G.S. 132-1et al. the existence of this Agreement and of the results obtained hereunder may be subject to public disclosure.

6. Confidentiality

It is agreed that CONTRACTOR or SPONSOR may, from time to time, make available to the other Party's employees or students confidential information. The term “Confidential Information” includes and is limited to information disclosed by one Party’s personnel to the other Party's personnel in writing conspicuously marked as confidential or, if disclosed other than in writing, is designated as being confidential at the time of initial disclosure and is subsequently reduced to writing marked confidential and delivered to the receiving Party within thirty (30) days of initial disclosure. It is further agreed that
Confidential Information will be treated as confidential and that the receiving Party's personnel will not at any time directly or indirectly, without the prior written consent of the disclosing Party, develop, disclose, offer to divulge, furnish, or make known or accessible to anyone whatsoever for the use or benefit of anyone other than the disclosing Party any such information. The Parties shall make reasonable efforts to maintain confidentiality of the Confidential Information. All records, in whatsoever form disclosed, containing Confidential Information or copies thereof shall be and remain the property of the disclosing Party and shall be returned to that Party upon request or at the termination of the Agreement for any reason however to the extent such Confidential Information is utilized by a party to meet its Standard of Care that party may keep one copy of such information for its business records. Such copies will be kept Confidential pursuant to this Section 6. This confidentiality obligation shall survive termination of the Agreement for a period of five (5) years. The obligations of confidentiality and nondisclosure shall not apply to:

a. Information which is or becomes public knowledge through no fault of the party to whom it was disclosed as confidential.

b. Information disclosed to the recipient Party by a third party entitled to disclose.

c. Information already known to the recipient Party or information independently developed by the second party without the assistance of the disclosing Party's confidential information as evidenced by written records of the second party's personnel.

d. Information which is required by law to be disclosed; provided that the recipient Party shall give the disclosing Party as much advance notice as possible of any such request as permitted by law.

7. Patents and Copyrights

Title to all inventions, discoveries, computer software or other copyrightable material or data, conceived or resulting from the performance of work hereunder, shall reside in CONTRACTOR. CONTRACTOR shall and does grant to Duke Energy a nonexclusive, nontransferable, noncommercial, royalty-free license to utilize for its own purposes and those of its majority-owned subsidiaries any such inventions, discoveries, computer software or other copyrightable material or data.

8. Publications

CONTRACTOR retains the rights to publish the results of any work carried out by CONTRACTOR'S faculty, staff or students. However, CONTRACTOR will not publish SPONSOR'S confidential information, as defined in N.C.G.S. 132-1.2, without SPONSOR's written permission.

9. Warranties, Liability, Indemnification

CONTRACTOR SHALL PROVIDE ITS SERVICES PURSUANT TO ITS STANDARD OF CARE. CONTRACTOR WILL TO THE FULLEST EXTENT PERMITTED BY LAW, INDEMNIFY, DEFEND AND HOLD HDR, OWNER, THEIR EMPLOYEES, OFFICERS, DIRECTORS, AND AGENTS HARMLESS, FROM AND AGAINST ALL LIABILITY, CLAIMS, LOSSES, COSTS,
EXPENSES AND FEES ARISING OUT OF THIS PROJECT OR THIS AGREEMENT TO THE EXTENT CAUSED OR ALLEGED TO HAVE BEEN CAUSED BY ANY WILLFUL MISCONDUCT OR NEGLECTFUL ACTS, ERRORS OR OMISSIONS OF SUBCONSULTANT, ITS AGENTS, EMPLOYEES, SUBCONSULTANTS OR SUPPLIERS.

10. Termination

This Agreement may be terminated by either party upon thirty (30) days' written notice. Upon termination by either Party, the CONTRACTOR will be paid in an amount which bears the same ratio to the total compensation as does the service actually performed to the total service originally set forth in this Agreement.

11. Entire Agreement

This Agreement constitutes the entire understanding between the Parties. No other terms and conditions, be they consistent, inconsistent, or additional to those contained herein, shall be binding upon the CONTRACTOR, unless and until such terms and conditions have been specifically accepted in writing by both Parties.

Any purchase order issued in connection with this Agreement shall be a fiscal control document only. The terms and conditions appearing in this Agreement shall supersede and replace any and all terms and conditions contained in such purchase order.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by these duly authorized officers this day and year first above written.

HDR ENGINEERING, INC.  
OF THE CAROLINAS

Edwin C. Luttrell  
Senior Vice President

Date: August 18, 2016

THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Nikki C. Simmons  
Sr. Contracting Manager  
Grants & Contracts Administration

Date: 8/22/2016
ATTACHMENT A
PROPOSAL
Subject: Proposal for Expanded-Domain Groundwater Models

Dear Mr. Wade:

The University of North Carolina at Charlotte (UNC-Charlotte) is pleased to submit this proposal to provide research as part of the groundwater receptor assessments at selected coal ash facilities owned and operated by Duke Energy Carolinas. In particular, this project will consist of modeling to predict groundwater flow and fate and transport of constituents of potential concern (COPCs) associated with coal ash stored at each facility to identify potential COPC receptors including potable water supply wells and surface water in an expanded area adjacent to each facility.

Background

Comprehensive site assessment (CSA) reports for each facility that include the site history and source characterization, receptor information, regional geology and hydrogeology, site geology and hydrogeology, soil sampling results, groundwater sampling results, and hydrogeological investigations were prepared in 2015. Corrective Action Plans (CAPs) were prepared in late 2015/early 2016 based on the CSAs. In general, three corrective action scenarios for coal ash were considered using groundwater modeling: no action, cap-in-place, and excavation. The CAP models also considered the COPC exposure of water supply wells in close proximity to the facilities (i.e., within the CAP model domain).

In order to explore further the COPC exposure of water supply wells and surface water in a larger area surrounding each facility, the CAP model domains will be expanded in this research. The expanded models will also allow further consideration and verification of the original site hydrogeologic conceptual model and boundary conditions applied in the original CAP models.

Work elements requested by HDR:

- Review geologic model layers via output from Leapfrog for Allen, Belews, Buck, Cliffside and Marshall
- Perform groundwater flow and fate/transport modeling for Marshall using the model framework developed by HDR and reviewed by UNCC
  - Steady-state flow model calibration to monitor well water levels, seep flows, and stream flows (where measured).
- Transient calibration to identified COIs
- Predictive simulations
- Sensitivity analysis
- Review MODFLOW and MT3D models for Allen, Belews, Buck, and Cliffside
- Prepare groundwater model write-up portion of modeling report for Marshall
- Review modeling reports for Allen, Belews, Buck, and Cliffside
- Jointly issue modeling reports under UNCC/HDR cover for Allen, Belews, Buck, Cliffside and Marshall.

**Items to be provided by HDR for Marshall:**

- Model domain with geologic framework and flow-boundary conditions in Vistas format
- Flow and transport calibration targets
- CAP scenarios in Vistas format

**Items to be provided by HDR for Allen, Belews, Buck, and Cliffside:**

- Calibrated flow and transport model
- Predictive simulations
- Sensitivity analysis - flow and transport parameters
- Model report

**Support to be provided by HDR:**

- Formatting and printing figures, tables, and model report for Marshall

**UNCC deliverables for Marshall:**

- Calibrated flow and transport model
- Predictive simulations
- Sensitivity analysis - flow and transport parameters
- Model report
- Target completion date: August 22, 2016

**UNCC deliverables for Allen, Belews, Buck, and Cliffside:**

- Initial and final reviews
- Jointly issued report cover pages
- Target completion date: August 22, 2016

**Comprehensive Review of All Models and Summary Report**

- Target completion date: December 31, 2016
Our proposed budget for this work is $129,541. Below is a breakdown by station. We appreciate the opportunity to provide HDR with this proposal.

Station Breakdown:

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<td>Belews</td>
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<td><strong>Total:</strong></td>
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</tr>
</tbody>
</table>

Sincerely,

William G. Langley, Ph.D., P.E.

wlangley@uncc.edu
office: 704-687-1225
mobile: ☎️


The University of North Carolina at Charlotte
Service Agreement Number 2975-2015-0786

This Fixed Price Agreement, made and entered into this 1st day of May 2015, between The University of North Carolina at Charlotte (hereinafter called CONTRACTOR) and HDR, Inc. Engineering of the Carolinas (hereinafter called SPONSOR) (collectively the "Parties"), witnesses that:

Whereas, each Party desires to enter into this Agreement for the benefits reasonably expected to be gained there from;

The Parties hereto mutually agree as follows:

1. Scope of Work

CONTRACTOR will use reasonable efforts to perform services as described in its proposal entitled, "Groundwater Modeling for Corrective Action Plans," which is attached hereto as Attachment A and incorporated herein by reference.

2. Term of Service

It is understood and agreed that CONTRACTOR will use reasonable efforts to provide these services during the period May 1, 2015, through June 30, 2016. This Agreement is subject to renewal only upon the written mutual agreement of the Parties.

3. Cost of Services

SPONSOR agrees to pay to CONTRACTOR the sum of four hundred fifty-five thousand eighty-two and no/100 dollars ($455,082.00) for these services. SPONSOR agrees to pay the sum of one hundred thirteen thousand seven hundred seventy-one and no/100 dollars ($113,771.00) upon a fully executed Agreement and the remainder according to the following schedule:

- Eighty-five thousand three hundred twenty-eight and no/100 dollars ($85,328.00) to be invoiced by September 1, 2015
- Eighty-five thousand three hundred twenty-eight and no/100 dollars ($85,328.00) to be invoiced by December 1, 2015
- Eighty-five thousand three hundred twenty-eight and no/100 dollars ($85,328.00) to be invoiced by March 1, 2016
- Eighty-five thousand three hundred twenty-seven and no/100 dollars ($85,327.00) to be invoiced by June 30, 2016

SPONSOR agrees to pay said invoices within 30 days of the invoice date. CONTRACTOR reserves the right to discontinue work if SPONSOR fails to pay invoices rendered by CONTRACTOR within the time herein specified.

FPRES v.06.2013 HDR
4. Communications

**CONTRACTOR Contract Administrator:**
Deborah L. Bolick, Contracts Manager
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall 312
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: dlbolick@uncc.edu
Telephone: 704-687-1883 | Fax: 704-687-0980

**SPONSOR Contract Administrator:**
Mark P. Filardi, PG
Assessment & Remediation Team Leader
HDR
440 S. Church Street, Suite 900
Charlotte, NC 28202-2075
Telephone: 704-338-6787
Fax: 980-322-8991
Email: mark.filardi@hdrine.com

**CONTRACTOR Financial Representative:**
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall, 3rd Floor
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: grante-contracts@uncc.edu
Telephone: 704-687-1889 | Fax: 704-687-0980

**SPONSOR Financial Representative:**
Same as above

**CONTRACTOR Principal Investigator:**
Dr. William Langley, P.E.
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: wlangley@uncc.edu
Telephone:

**SPONSOR Principal Investigator:**
Same as above

5. Use of Names in Publicity

SPONSOR agrees that no advertising or publicity matter having or containing reference to CONTRACTOR will be disseminated without the prior written consent of CONTRACTOR. CONTRACTOR agrees that no advertising or publicity matter having or containing reference to SPONSOR will be disseminated without prior written consent of SPONSOR. SPONSOR recognizes and acknowledges that under NC Public Records Act, N.C.G.S. 132-1 et al. the existence of this Agreement and of the results obtained hereunder may be subject to public disclosure.

6. Confidentiality

It is agreed that CONTRACTOR or SPONSOR may, from time to time, make available to the other Party's employees or students confidential information. The term “Confidential Information” includes and is limited to information disclosed by one Party's personnel to the other Party's personnel in writing conspicuously marked as confidential or, if disclosed other than in writing, is designated as being confidential at the time of initial disclosure and is subsequently reduced to writing marked confidential and delivered to the receiving Party within thirty (30) days of initial disclosure. It is further agreed that
Confidential Information will be treated as confidential and that the receiving Party's personnel will not at any time directly or indirectly, without the prior written consent of the disclosing Party, develop, disclose, offer to divulge, furnish, or make known or accessible to anyone whatsoever for the use or benefit of anyone other than the disclosing Party any such information. The Parties shall make reasonable efforts to maintain confidentiality of the Confidential Information. All records, in whatsoever form disclosed, containing Confidential Information or copies thereof shall be and remain the property of the disclosing Party and shall be returned to that Party upon request or at the termination of the Agreement for any reason however to the extent such Confidential Information is utilized by a party to meet its Standard of Care that party may keep one copy of such information for its business records. Such copies will be kept Confidential pursuant to this Section 6. This confidentiality obligation shall survive termination of the Agreement for a period of five (5) years. The obligations of confidentiality and nondisclosure shall not apply to:

a. Information which is or becomes public knowledge through no fault of the party to whom it was disclosed as confidential.

b. Information disclosed to the recipient Party by a third party entitled to disclose.

c. Information already known to the recipient Party or information independently developed by the second party without the assistance of the disclosing Party's confidential information as evidenced by written records of the second party's personnel.

d. Information which is required by law to be disclosed; provided that the recipient Party shall give the disclosing Party as much advance notice as possible of any such request as permitted by law.

7. Patents and Copyrights

Title to all inventions, discoveries, computer software or other copyrightable material or data, conceived or resulting from the performance of work hereunder, shall reside in CONTRACTOR. CONTRACTOR shall and does grant to Duke Energy a nonexclusive, nontransferable, noncommercial, royalty-free license to utilize for its own purposes and those of its majority-owned subsidiaries any such inventions, discoveries, computer software or other copyrightable material or data.

8. Publications

CONTRACTOR retains the rights to publish the results of any work carried out by CONTRACTOR'S faculty, staff or students. However, CONTRACTOR will not publish SPONSOR'S confidential information, as defined in N.C.G.S. 132-1.2, without SPONSOR’s written permission.

9. Warranties, Liability, Indemnification

CONTRACTOR SHALL PROVIDE ITS SERVICES PURSUANT TO ITS STANDARD OF CARE. CONTRACTOR WILL TO THE FULLEST EXTENT PERMITTED BY LAW, INDEMNIFY, DEFEND AND HOLD HDR, OWNER, THEIR EMPLOYEES, OFFICERS, DIRECTORS, AND AGENTS HARMLESS, FROM AND AGAINST ALL LIABILITY, CLAIMS, LOSSES, COSTS, EXPENSES

FPRES v.06.2013 HDR
AND FEES ARISING OUT OF THIS PROJECT OR THIS AGREEMENT TO THE EXTENT CAUSED OR ALLEGED TO HAVE BEEN CAUSED BY ANY WILLFUL MISCONDUCT OR NEGLIGENT ACTS, ERRORS OR OMISSIONS OF SUBCONSULTANT, ITS AGENTS, EMPLOYEES, SUBCONSULTANTS OR SUPPLIERS.

10. Termination

This Agreement may be terminated by either party upon thirty (30) days' written notice. Upon termination by either Party, the CONTRACTOR will be paid in an amount which bears the same ratio to the total compensation as does the service actually performed to the total service originally set forth in this Agreement.

11. Entire Agreement

This Agreement constitutes the entire understanding between the Parties. No other terms and conditions, be they consistent, inconsistent, or additional to those contained herein, shall be binding upon the CONTRACTOR, unless and until such terms and conditions have been specifically accepted in writing by both Parties.

Any purchase order issued in connection with this Agreement shall be a fiscal control document only. The terms and conditions appearing in this Agreement shall supersede and replace any and all terms and conditions contained in such purchase order.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by these duly authorized officers this day and year first above written.

HDR ENGINEERING, INC.
OF THE CAROLINAS

Mark Filardi
Assessment & Remediation Leader

Date: 7-10-2015

THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Deborah L. Bolick
Contracts Manager
Grants & Contracts Administration

Date: 7/11/15
ATTACHMENT A
PROPOSAL
Subject: Groundwater Modeling for Corrective Action Plans

Dear Mr. Filardi:

The University of North Carolina at Charlotte (UNC-Charlotte) is pleased to submit this proposal to provide research as part of the corrective action plans (CAP) to be developed at seven coal ash facilities owned and operated by Duke Energy. In particular, this project will consist of modeling to predict groundwater flow and the fate and transport of constituents of potential concern (COPC) in groundwater associated with the facilities.

Background

On August 13, 2014, NCDENR issued a Notice of Regulatory Requirements (NORR) letter to Duke Energy, pursuant to Title 15A North Carolina Administrative Code Chapter (15A NCAC) 02L.0106. The NORR stipulates that for each coal-fueled plant owned, Duke Energy will conduct a comprehensive site assessment (CSA) that includes a Groundwater Assessment Work Plan (Work Plan) and a receptor survey. Components of the resultant CSA report will include: site history and source characterization, receptor information, regional geology and hydrogeology, site geology and hydrogeology, soil sampling results, groundwater sampling results, and hydrogeological investigation.

Data obtained during the CSA will be supplemented by available reports and data on site geotechnical, geologic, and hydrologic conditions to develop a site hydrogeologic conceptual model (SCM). The SCM is a conceptual interpretation of the processes and characteristics of a site with respect to the groundwater flow and other hydrologic processes at the site.

Components of the SCM will consist of developing and describing the following aspects of the site: geologic/soil framework, hydrologic framework, and the hydraulic properties of site materials. More specifically, the SCM will describe how these aspects of the site affect the groundwater flow at the site. In addition to these site aspects, the SCM will:

- Describe the site and regional geology,
- Present longitudinal and transverse cross-sections showing the hydrostratigraphic layers,
- Develop the hydrostratigraphic layer properties required for the groundwater model,
- Present a groundwater contour map showing the potentiometric surface of the shallow aquifer, and
- Present information on horizontal and vertical groundwater gradients.
The CSA report for each site, including the CSM, will provide data and information to support the proposed modeling effort.

**Objectives, Scope of Work, and Protocols**

*Groundwater Fate and Transport Model*

A three-dimensional groundwater fate and transport model will be developed for the ash basin site. The objective of the model process will be to:

- Predict concentrations of the constituents of potential concern at the facility’s compliance boundary or other locations of interest over time,
- Estimate the groundwater flow and loading to surface water discharge areas, and
- Support the development of the CAP, as required.

*MODFLOW/MT3DMS Model*

The model and model report will be developed in general accordance with the guidelines found in the memorandum Groundwater Modeling Policy, NCDENR DWQ, May 31, 2007 (DENR modeling guidelines).

The groundwater model will be developed from the SCM, from existing wells and boring information provided by Duke Energy, and from information developed from the site investigation. The model will also be supplemented with additional information developed by HDR from other Piedmont sites, as applicable.

Groundwater flow and constituent fate and transport will be modeled using MODFLOW and MT3DMS via the GMS v. 10 MODFLOW III Software Package. If geochemical conditions across the site are not widely variable, an approach that considers each modeled COPC as a single species in the dissolved and complexed, or sorbed, phases is justified. The ratio of these two phases is prescribed by the sorption coefficient Kd which has dimensions of volume per unit mass. The variation in geochemical conditions will be considered, if needed, by examining pH, oxidation/reduction potential, alkalinity, and dissolved oxygen, perhaps combined with geochemical modeling, to justify the Kd approach utilized by MT3DMS. Geochemical modeling using PHREEQC (Parkhurst et al. 2013) running in the batch mode can be used to indicate the extent to which a COPC is subject to solubility constraints, a variable Kd, or other processes.

The groundwater model will be developed in general accordance with the guidelines found in the Groundwater Modeling Policy, NCDENR DWQ, May 31, 2007 and based on discussions previously conducted concerning groundwater modeling between Duke Energy, HDR, UNCC, and NCDENR.

*Development of Kd Terms*

As part of the Work Plans, sorption coefficients (Kd) and hydrous ferric oxide (HFO) of site-specific soils, and leaching characteristics of coal fly ash samples (EPA Methods 1313 and 1316) are being determined at UNCC to support the modeling effort.
MODFLOW/MT3DMS Modeling Process

The MODFLOW groundwater model will be developed using the hydrostratigraphic layer geometry and properties of the site as described in this section. After the geometry and properties of the model layers are input, the model will be calibrated to existing water levels observed in the monitoring wells and ash basin. Infiltration into the areas outside of the ash basin will be estimated based on available information. Infiltration within the basin will be estimated based on available water balance information and pond elevation data provided by Duke Energy. The MT3DMS portion of the model will utilize the Kd terms and the input concentrations of constituents found in the ash. The leaching characteristics of ash are complex and expected to vary with time and as changes occur in the geochemical environment of the ash basin. Due to factors such as quantity of a particular constituent found in ash, mineral complex, solubility, and geochemical conditions, the rate of leaching and leached concentrations of constituents will vary with time and respect to each other. The experience that UNCC brings to this process through their years of working with leaching and characterization of ash, particularly with Duke Energy ash, will be of particular value.

Since the ash within the basin has been placed over a number of years, the analytical results from an ash sample collected during the groundwater assessment is unlikely to represent the current concentrations that are present in the hydrologic pathway between the ash basin and a particular groundwater monitoring well or other downgradient location. As a result of these factors and due to the time period involved in groundwater flow,

- concentrations may vary spatially over time, and
- peak concentrations may not yet have arrived at compliance wells.

The selection of the initial concentrations and the predictions of the concentrations for constituents with respect to time will be developed with consideration of the following:

- Site specific analytical results from leach tests (SPLP) and from total digestion of ash samples taken at varying locations and depths within the ash basin and ash storage area. Note that the total digestion concentrations, if used, would be considered an upper bound to concentrations and that the actual concentrations would be lower that the results from the total digestion.
- Leaching characteristics of fresh coal fly ash samples measured at UNCC by EPA Methods 1313 and 1316
- Analytical results from appropriate groundwater monitoring wells or surface water sample locations outside of the ash basin.
- Analytical results from monitoring wells installed in the ash basin pore water (screened-in ash).
- Published or other data on sequential leaching tests performed on similar ash.

The information above will be used with constituent concentrations measured at the compliance boundary to calibrate the fate and transport model and to develop a representation of the concentration with respect to time for a particular constituent. The starting time of the model will correspond to the date that the ash basin was placed in service. The resulting model, which will
be consistent with the calibration targets mentioned above, can then be used to predict concentrations over space and time.

The model calibration process will consist of varying hydraulic conductivity and retardation within and between hydrostratigraphic units in a manner that is consistent with measured values of hydraulic conductivity, sorption terms, groundwater levels, and COPC concentrations.

A sensitivity analysis will be performed for the fate and transport analyses.

The model report will contain the information required by Section II of the NCDENR modeling guidelines, as applicable. Specific requirements for reporting Groundwater Modeling Results are described in a following section of this proposal.

Hydrostratigraphic Layer Development
The three-dimensional configuration of the groundwater model hydrostratigraphic layers for a site will be developed using the initial SCM and from pre-existing data and data obtained during the site investigation process. The thickness and extent for the various layers will be represented by a three-dimensional surface model for each hydrostratigraphic layer. For most sites the hydrostratigraphic layers will include ash, fills (both for dikes/dam and/or ash landfills/structural fills), soil/saprolite, transition zone (where present), and bedrock.

The boring data from the site investigation and from existing boring data, as available and provided by Duke Energy, will be entered into the RockWorks16 program. This program, along with site-specific and regional knowledge of Piedmont hydrogeology, will be used to interpret and develop the layer thickness and extent across areas of the site where boring data is not available. The material layers will be categorized based on physical and material properties such as standard penetration blow count for soil/saprolite, and percent recovery and RQD for the transition zone and bedrock. The material properties required for the model such as total porosity, effective porosity, and specific storage for ash, fill, alluvium, and soil/saprolite will be developed from laboratory testing and published data. Hydraulic conductivity (horizontal and vertical) of all layers will be developed utilizing existing site data, in-situ permeability testing (falling head, constant head, and packer testing where appropriate), slug tests in completed monitoring wells, laboratory testing of undisturbed samples (ash, fill, soil/saprolite), and from an extensive database of Piedmont soil and rock properties developed by HDR. The effective porosity (primarily fracture porosity) and specific storage of the transition zone and bedrock will be estimated from published data.

Domain and Boundary Conditions of Conceptual Groundwater Flow Model
The site specific domain and boundary conditions for the groundwater flow model at each location have been determined on a preliminary basis in the Work Plans. The final configuration of these components of the model will be developed during the model calibration process.

Groundwater Impacts to Surface Water
If the groundwater modeling predicts exceedances of the 2L Standards at or beyond the compliance boundary where the plume containing the exceedances would intercept surface
waters, the groundwater model results will be coupled with modeling of surface waters to predict contaminant concentrations in the surface waters. This work would be performed by HDR in conjunction with UNCC as described in the Work Plans.

**GAP Review Issues**
Subsequent to conditional approval of the Work Plans, NCDENR provided technical direction that will serve as the basis of expectations for completion of the site assessment referred to as Duke Energy GAP Review Issues. The items in this review summary that are relevant to groundwater modeling include a reference to the management approach based on tiered site analysis and specific requirements for the groundwater models as follows.

**Tiered Site Analysis**
Sites impacted by inorganics are typically managed using a tiered site analysis which includes four elements as referenced in EPA/600/R-07/139:

- Demonstration of active contaminant removal from groundwater & dissolved plume stability;
- Determination of the mechanism and rate of attenuation;
- Determination of the long-term capacity for attenuation and stability of immobilized contaminants, before, during, and after any proposed remedial activities; and
- Design of performance monitoring program, including defining triggers for assessing the remedial action strategy failure, and establishing a contingency plan.

This reference and the framework described above should be used as applicable to meet the corrective action requirements found in 15A NCAC 02I. .0106.

**Groundwater Models**
The technical direction for developing the fate and transport modeling will follow guidelines found in Groundwater Modeling Policy, NCDENR DWQ, May 31, 2007, and discussions conducted between Duke Energy and their consultants with the Division. Ultimate direction for completion of fate and transport models will be provided by the Division.

1. The CAP Report should include a subsection within Groundwater Modeling Results titled ‘Site Conceptual Model’ that succinctly summarizes, for purposes of model construction, the understanding of the physical and chemical setting of the site and shall include, at a minimum: a) the site setting (hydrogeology, dominant flow zones, heterogeneities, areas of pronounced vertical head gradients, areas of recharge and discharge, spatial distribution of geochemical conditions across the site, and other factors as appropriate), b) source areas and estimated mass loading history, c) receptors, d) chemical behavior of COPCs, and f) likely retention mechanisms for COPCs and how the mechanisms are expected to respond to changes in geochemical conditions.

2. Modeling will be included in the Corrective Action Plan (CAP). The four-tiered analysis previously referenced and appropriate modeling should be conducted, and the mass flux calculations described in the EPA/600/R-07/139 should be performed.

3. The CAP Report shall provide separate subsections for reporting groundwater flow models and fate and transport models.
4. The CAP Report should include subsections within Groundwater Modeling Results titled ‘Groundwater Model Development’ that describes, for each chosen model: a) purpose of model, built-in assumptions, model extent, grid, layers, boundary conditions, initial conditions, and others as listed in Division guidance. Include in this section a discussion of heterogeneities and how the model(s) account for this (e.g. dual porosity modeling, equivalent porous media approach, etc.). Separate subsections should be developed for the groundwater flow model, fate and transport model, and batch geochemical models, respectively.

5. CAP Reports should include a subsection within Groundwater Modeling Results titled ‘Groundwater Model Calibration’ that describes, for each model used, the process used to calibrate the model, the zones of input and calibration variables (for example, hydraulic conductivities) that were used, the actual (measured) versus modeled results for all key variables, and others. Separate subsections should be developed for the groundwater flow model, fate and transport model, and batch geochemical model(s), respectively.

6. CAP Reports should include a subsection within Groundwater Modeling Results titled ‘Groundwater Model Sensitivity Analysis’ that describes, for each model used, the process used to evaluate model uncertainty, variable ranges tested, and the key sensitivities. Separate subsections should be developed for the groundwater flow model, fate and transport model, and batch geochemical model(s), respectively.

Deliverables, Schedule, and Proposed Budget

The deliverables will consist of the Groundwater Modeling Results in the format described above for inclusion in the CAP for each of the seven facilities. Up to three corrective action plan options, to be specified by HDR and Duke Energy, may be simulated using the groundwater model of each facility. The estimated completion dates for Groundwater Modeling Results will depend on availability of the completed CSAs and are provided in the attached table. HDR will complete the remaining elements of each CAP, exclusive of the Groundwater Modeling Results described in this proposal, in accordance with 15A NCAC 02L .0106. As such, HDR will also provide the final engineering review of all elements of the CAP, including the Groundwater Modeling Results. The final CAP will be sealed by HDR’s review engineer and submitted under HDR’s letterhead.

Our proposed budget for this work is $455, 082. We appreciate the opportunity to provide HDR with this proposal.

Sincerely,

William G. Langley, Ph.D., P.E.

Attachment: Table - Estimated Completion Dates for Groundwater Modeling Results
Table: Estimated Completion Dates for Groundwater Modeling Results

<table>
<thead>
<tr>
<th>Site</th>
<th>CSA Due Date</th>
<th>Estimated Date for Completion for Groundwater Modeling Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dan River</td>
<td>8/15/2015</td>
<td>10/14/2015</td>
</tr>
<tr>
<td>Cliffside</td>
<td>8/18/2015</td>
<td>10/21/2015</td>
</tr>
<tr>
<td>Riverbend</td>
<td>8/18/2015</td>
<td>10/21/2015</td>
</tr>
<tr>
<td>Allen</td>
<td>8/23/2015</td>
<td>10/28/2015</td>
</tr>
<tr>
<td>Buck</td>
<td>8/23/2015</td>
<td>10/28/2015</td>
</tr>
<tr>
<td>Belclws Creek</td>
<td>9/9/2015</td>
<td>11/18/2015</td>
</tr>
</tbody>
</table>

Note: The estimated completion dates for Groundwater Modeling Results will depend on availability of the completed CSAs.
The University of North Carolina at Charlotte
Research Project Agreement Number 2975-2015-0259

This Fixed Price Agreement, made and entered into this 19th day of November, 2014, between The University of North Carolina at Charlotte (hereinafter called CONTRACTOR) and HDR Engineering, Inc. of the Carolinas (hereinafter called SPONSOR), witnesses that:

Whereas, each party desires to enter into this Agreement for the benefits reasonably expected to be gained there from;

The parties hereto mutually agree as follows:

1. **Scope of Work**

CONTRACTOR will use reasonable efforts to perform research as described in its proposal entitled "Sorption Evaluation for Ash Basin Closure at the H.B. Robinson Steam Station" which is attached hereto as Attachment A and incorporated herein by reference.

2. **Term of Service**

The term of the Agreement will begin on November 19, 2014, and end on June 10, 2015, unless extended by the mutual agreement of the parties.

3. **Cost of Services**

SPONSOR agrees to pay to CONTRACTOR the sum of thirty-one thousand eight hundred forty-nine and no/100 dollars ($31,849.00) for these services. SPONSOR agrees to pay the sum of ten thousand six hundred seventeen and no/100 dollars ($10,617.00) upon a fully executed Agreement and the remainder according to the following schedule:

Ten thousand six hundred sixteen and no/100 dollars ($10,616.00) by February 28, 2015
Ten thousand six hundred sixteen and no/100 dollars ($10,616.00) by June 10, 2015

SPONSOR agrees to pay said invoices within 30 days of the invoice date. CONTRACTOR reserves the right to discontinue work if SPONSOR fails to pay invoices rendered by CONTRACTOR within the time herein specified. SPONSOR agrees to pay a late payment charge of 1 1/2 percent per month on all overdue amounts that are due to the sole fault of the SPONSOR.
4. Communications

CONTRACTOR Contract Administrator:
Deborah L. Bolick, Contracts Manager
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall 312
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: dlbolick@uncc.edu
Telephone: 704-687-1883 | Fax: 704-687-0980

SPONSOR Contract Administrator:
Mac McGarity, PE
HDR Engineering, Inc.
440 S. Church St., Suite 1000
Charlotte, NC 28202
Email: Mac.McGarity@hdrinc.com
Telephone: 704-248-3683

CONTRACTOR Financial Representative:
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall, 3rd Floor
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: grants-contracts@uncc.edu
Telephone: 704-687-1887
Fax: 704-687-0980

SPONSOR Financial Representative:
Same as above

CONTRACTOR Principal Investigator:
Dr. William Langley
University of North Carolina at Charlotte
Civil and Environmental Engineering
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: wlanglely@uncc.edu

SPONSOR Principal Investigator:
Same as above

5. Use of Names in Publicity

SPONSOR agrees that no advertising or publicity matter having or containing reference to CONTRACTOR will be disseminated without the prior written consent of CONTRACTOR. CONTRACTOR agrees that no advertising or publicity matter having or containing reference to SPONSOR will be disseminated without prior written consent of SPONSOR. SPONSOR recognizes and acknowledges that under NC Public Records Act, §132-1 et al. the existence of this Agreement and of the results obtained hereunder may be subject to public disclosure.

6. Confidentiality

It is agreed that CONTRACTOR or SPONSOR may, from time to time, make available to the other party’s employees or students confidential information. The term “Confidential Information” includes and is limited to information disclosed by one party’s personnel to the other party’s personnel in writing conspicuously marked as confidential or, if disclosed other
than in writing, is designated as being confidential at the time of initial disclosure and is
subsequently reduced to writing marked confidential and delivered to the receiving party within
thirty (30) days of initial disclosure. It is further agreed that Confidential Information will be
treated as confidential and that the receiving party's personnel will not at any time directly or
indirectly, without the prior written consent of the disclosing party, develop, disclose, offer to
divulge, furnish, or make known or accessible to anyone whatsoever for the use or benefit of
anyone other than the disclosing party any such information. The parties shall make reasonable
efforts to maintain confidentiality of the Confidential Information. All records, in whatsoever
form disclosed, containing Confidential Information or copies thereof shall be and remain the
property of the disclosing party and shall be returned to that party upon request or at the
termination of the Agreement for any reason however to the extent such Confidential
Information is utilized by a party to meet its Standard of Care that party may keep one copy of
such information for its business records. Such copies will be kept Confidential pursuant to this
Section 6. This confidentiality obligation shall survive termination of the Agreement for a period
of five (5) years. The obligations of confidentiality and nondisclosure shall not apply to:

a. Information which is or becomes public knowledge through no fault of the party
to whom it was disclosed as confidential.

b. Information disclosed to the recipient party by a third party entitled to disclose.

c. Information already known to the recipient party or information independently
developed by the second party without the assistance of the disclosing party's confidential
information as evidenced by written records of the second party's personnel.

d. Information which is required by law to be disclosed; provided that the recipient party
shall give the disclosing party as much advance notice as possible of any such request as
permitted by law.

7. Patents and Copyrights

Title to all inventions, discoveries, computer software or other copyrightable material or data,
conceived or resulting from the performance of work hereunder, shall reside in CONTRACTOR.
CONTRACTOR shall and does grant to Duke Energy a nonexclusive, nontransferable,
commercial, royalty-free license to utilize for its own purposes and those of its majority-owned
subsidiaries any such inventions, discoveries, computer software or other copyrightable material
or data.

8. Publications

CONTRACTOR retains the rights to publish the results of any work carried out
CONTRACTOR'S faculty, staff or students, except that CONTRACTOR will not publish
SPONSOR'S confidential information, as defined by N.C.G.S. 132-1.2, without SPONSOR'S
written permission.
9. **Termination**

Performance under this Agreement may be terminated by either party upon thirty (30) days' written notice. Upon termination by either party, CONTRACTOR will be paid in an amount which bears the same ratio to the total compensation as does the service actually performed to the total service originally set forth in this Agreement.

10. **Warranties; Liability, Indemnification**

CONTRACTOR SHALL PROVIDE ITS SERVICES PURSUANT TO ITS STANDARD OF CARE AND WILL TO THE FULLEST EXTENT PERMITTED BY LAW, CONTRACTOR WILL INDEMNIFY, DEFEND AND HOLD HDR, OWNER, THEIR EMPLOYEES, OFFICERS, DIRECTORS, AND AGENTS HARMLESS, FROM AND AGAINST ALL LIABILITY, CLAIMS, LOSSES, COSTS, EXPENSES AND FEES ARISING OUT OF THIS PROJECT OR THIS AGREEMENT TO THE EXTENT CAUSED OR ALLEGED TO HAVE BEEN CAUSED BY ANY WILLFUL MISCONDUCT OR NEGLIGENT ACTS, ERRORS OR OMISSIONS OF SUBCONSULTANT, ITS AGENTS, EMPLOYEES, SUBCONSULTANTS OR SUPPLIERS.

11. ** Entire Agreement**

This Agreement constitutes the entire understanding between the parties. No other terms and conditions, be they consistent, inconsistent, or additional to those contained herein, shall be binding upon the CONTRACTOR, unless and until such terms and conditions have been specifically accepted in writing by both parties. Any purchase order issued in connection with this Agreement shall be a fiscal control document only. The terms and conditions appearing in this Agreement shall supersede and replace any and all terms and conditions contained in such purchase order.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed by these duly authorized officers this day and year first written above.

**HDR ENGINEERING, INC. OF THE CAROLINAS**

Alex Grenoble
Vice President

Date: 11/20/2017

**THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE**

Deborah L. Bolick
Contracts Manager
Grants and Contracts Administration

Date: 11/19/14

FPRES v.06.2013
AGREEMENT NO. 2975-2015-0259
ATTACHMENT A
PROPOSAL
Mack McGarity, P.E.
HDR Engineering, Inc.
Director of Project Management | Hydropower Services
440 S. Church St, Suite 1000 | Charlotte, NC 28202
704.248.3683 | c: 704.338.6760 | f: 704.338.6760
Mac.McGarity@hdrinc.com

October 7th, 2014

Subject: Sorption Evaluation for Ash Basin Closure at the H. B. Robinson Steam Station

Dear Mr. McGarity:

The University of North Carolina at Charlotte (UNC Charlotte) is pleased to submit this proposal to provide the research required for the ash basin closure at Duke Energy’s H. B. Robinson Steam Station. In particular, this project will evaluate the sorption characteristics of site-specific soils for incorporation into a groundwater model, which will be considered in a separate proposal.

Background

The Robinson Plant is located in Darlington County, South Carolina, approximately 4.5 miles West Northwest of Hartsville, South Carolina. It is situated on the southwestern shore of Lake Robinson and uses water from the lake as process cooling water. The Robinson Plant is comprised of one-coal fired steam unit, one combustion turbine unit, and one pressurized water nuclear unit.

Development of the Robinson facility began in the late 1950's when Black Creek was impounded to create Lake Robinson. Shortly thereafter, the 177-megawatt (MW) coal-fired unit (referred to as Unit 1) began commercial operation in 1960 and was retired in October 2012. The 11 MW combustion turbine unit began operation in 1968 and the 724 MW nuclear unit (referred to as Unit 2) was brought online in 1971. Duke Energy also owns the Darlington I.C. Plant, which is located just north of the Robinson Plant, and is also along the western shore of Lake Robinson. The 790 MW Darlington I.C. Plant includes 13 combustion turbine units fueled by natural gas and oil, began operation in 1974.

The Robinson Plant coal ash management facilities include the coal-fired unit (Unit 1), one ash basin unit located north of the fossil and nuclear units, and a “lay-of-the-land” (LOL) ash storage area located west of Units 1 and 2. (Figure 1)

The LOL storage area was created in 1960 and received ash from Unit 1 until the ash basin was constructed in the mid-1970s. In May 2013, Duke Energy conducted a preliminary evaluation of the horizontal and vertical extent of ash stored in this area. Based on this data, ash covers a surficial area measuring approximately 25.4 acres at a thickness ranging from 6 to 13 feet.

A 55-acre pond and a 22-acre dry ash storage area are located within the extents of the approximate 77-acre ash basin. The basin was formed via construction of a dam across an unnamed tributary
to Black Creek. The ash basin began receiving sluiced ash from Unit 1 in the mid-1970s, and continued to receive sluiced ash until the coal fired unit was retired in October 2012. Based on a cursory review of construction drawings provided by Duke Energy, ash thickness within the basin ranges from approximately 20 feet in the western reaches of the basin to more than 50 feet near the downstream dam. Ash thickness is expected to be greater than 50 feet within the dry ash storage area.

Free liquids sluiced to the ash basin have historically discharged through the bottom of the basin. There are no permitted National Pollution Discharge Elimination System (NPDES) outfalls from the basin to Lake Robinson. The basin also receives discharge from the Darlington I.C. Plant oil/water separator. Duke Energy is currently evaluating options to re-route this waste stream. HDR also understands low-level radioactive waste (LLRW) from Unit 2 was historically disposed within the ash basin. The LLRW was contained in boiler sludge and sediment from two settling basins located south of Unit 2 during periodic clean-out events.

Subsequent to re-routing of the oil/water separator waste stream, the ash basin will cease to operate as a wastewater treatment system (WWTS). Per SCDHEC Regulation R.61-67.300.F.17, an operator has 180 days from cessation of operations to properly close a WWTS lagoon. However, Duke Energy was granted a three-year extension of the 180-day closeout window. In a proposal to Duke Energy dated May 15, 2014, HDR presented a scope of work (SOW) to assist Duke Energy in meeting the requirements SCDHEC for WWTS closure. The following general objectives of the SOW were identified as follows:

- Develop a cost-effective conceptual closure plan for Duke Energy’s submittal to SCDHEC – Bureau of Water.
- Develop a cost-effective ash-basin decommissioning plan for Duke Energy’s submittal to SCDHEC – Dams and Reservoirs Safety Program to satisfy requirements for removing the ash basin structures from regulation as dam structures, and
- Develop a conceptual closure plan that will minimize impacts to ongoing operations at the nuclear site.

Groundwater fate and transport modeling of dissolved constituents exceeding their Maximum Contaminant Levels (MCLs) will be performed to support the development of the conceptual ash basin closure report. Data requirements for the modeling effort include site-specific distribution coefficient ($K_d$) terms for native soils surrounding the ash basin unit. HDR has requested that UNC Charlotte prepare this proposal to evaluate $K_d$ terms for selected soils samples from the site. A work plan and estimated costs for the modeling effort will be provided in a separate proposal.
Figure 1: Site map of Robinson Plant
Objectives, Scope of Work, Deliverable, Schedule, and Proposed Budget

Batch and column methods for estimating sorption have been considered. We recommend an adaption of the column method described by Daniels and Das (2014)[1] to develop $K_d$ estimates that are more conservative and representative of in-situ conditions, especially with regards to soil-to-liquid ratios. Soil samples with measured dry density and maximum particle size will be placed in lab-scale columns configured to operate in the upflow mode. A solution with measured concentrations of the constituents of concern (COC) will be pumped through each column, effluent samples will be collected at regular intervals over time. When constituent breakthroughs are verified, a “clean” solution (no COCs) will be pumped through the columns and effluent samples will be collected as well. Samples will be analyzed by inductively coupled plasma-mass spectroscopy (ICP-MS) and ion chromatography (IC) in the Civil & Environmental Engineering laboratories at EPIC building, UNC Charlotte. Plots of effluent COC concentration versus cumulative pore volume exchanges will be analyzed to estimate $K_d$ values and to confirm reversibility of COC sorption. Five soil samples will be tested, with the column tests performed in triplicate. COCs to be considered will include: antimony, arsenic, boron, cadmium, chromium, lead, iron, manganese, and sulfate.

It is noted that some COCs may have indeterminate $K_d$ values by the column method due to solubility constraints and background conditions. In this case, batch sorption tests will be conducted in accordance with U.S. Environmental Protection Agency Technical Resource Document EPA/530/SW-87/006-P. COC-specific solutions will be used to prepare a range of soil-to-solution ratios. After mixing, supernatant samples will be drawn and analyzed as described above. Plots of sorbed versus dissolved COC mass will be used to estimate $K_d$ values. Batch tests will be performed in triplicate.

At the end of the study, a report will be prepared that includes descriptions of procedures, analytical data in tabular and graphic forms, and a summary of $K_d$ terms for each constituent. The estimated time to complete the laboratory work and data report is approximately 6 months after the receipt of the soil samples and notice to proceed. The fixed fee budget for the study is $31,849.

We appreciate the opportunity to work with HDR on this project.

Sincerely,

William G. Langley, Ph.D., P.E.
Reference

The University of North Carolina at Charlotte
Service Agreement Number 2975-2015-0562

This Fixed Price Agreement, made and entered into this 1st day of February, 2015, between The University of North Carolina at Charlotte (hereinafter called CONTRACTOR) and HDR, Inc. Engineering of the Carolinas (hereinafter called SPONSOR) (collectively the “Parties”), witnesses that:

Whereas, each Party desires to enter into this Agreement for the benefits reasonably expected to be gained therefrom;

The Parties hereto mutually agree as follows:

1. Scope of Work

CONTRACTOR will use reasonable efforts to perform services as described in its proposal entitled, “Sorption, Leaching and Hydrous Ferric Oxide Determination for Groundwater Assessment Work Plans,” which is attached hereto as Attachment A and incorporated herein by reference. The facilities from which the SPONSOR will provide samples are attached hereto as Attachment B and incorporated herein by reference.

2. Term of Service

It is understood and agreed that CONTRACTOR will use reasonable efforts to provide these services during the period 02/01/2015 and 01/31/2016. This Agreement is subject to renewal only upon the written mutual agreement of the Parties.

3. Cost of Services

SPONSOR agrees to pay to CONTRACTOR the sum of Three-Hundred-Ninety-Eight-Thousand-Eight-Hundred-Eleven and no/100 dollars ($398,811.00) for these services. SPONSOR agrees to pay the sum of Ninety-Nine-Thousand-Seven-Hundred-Five and no/100 dollars ($99,705.00) upon a fully executed Agreement and the remainder according to the following schedule:

- Eighty-Nine-Thousand-Seven-Hundred-Two and no/100 dollars ($89,702.00) to be invoiced by May 1, 2015
- Eighty-Nine-Thousand-Seven-Hundred-Two and no/100 dollars ($89,702.00) to be invoiced by July 1, 2015
- Eighty-Nine-Thousand-Seven-Hundred-Two and no/100 dollars ($89,702.00) to be invoiced by September 30, 2016
- Thirty-Thousand and no/100 dollars ($30,000.00) to be invoice by January 31, 2016

SPONSOR agrees to pay said invoices within 30 days of the invoice date. CONTRACTOR reserves the right to discontinue work if SPONSOR fails to pay invoices rendered by CONTRACTOR within the time herein specified. SPONSOR agrees to pay a late payment charge of 1 1/2 percent per month on all overdue amounts that are due to the sole fault of the SPONSOR.

EPRES v.06.2013 HDR
4. Communications

**CONTRACTOR Contract Administrator:**
Deborah L. Bolick, Contracts Manager
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall 312
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: dlbolick@uncc.edu
Telephone: 704-687-1883 | Fax: 704-687-0980

**SPONSOR Contract Administrator:**
Mae McGarity, PE, Director of Project Management
440 South Church Street, Suite 1000
Charlotte, NC 28202-2075
Email: mac.mcgarity@hdrinc.com
Telephone: 704-248-3683

**CONTRACTOR Financial Representative:**
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall, 3rd Floor
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: grants-contracts@uncc.edu
Telephone: 704-687-1889 | Fax: 704-687-0980

**SPONSOR Financial Representative:**

**CONTRACTOR Principal Investigator:**
Dr. William Langley, P.E.
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: wlangley@uncc.edu
Telephone:

**SPONSOR Principal Investigator:**

5. Use of Names in Publicity

SPONSOR agrees that no advertising or publicity matter having or containing reference to CONTRACTOR will be disseminated without the prior written consent of CONTRACTOR. CONTRACTOR agrees that no advertising or publicity matter having or containing reference to SPONSOR will be disseminated without prior written consent of SPONSOR. SPONSOR recognizes and acknowledges that under NC Public Records Act, N.C.G.S. 132-1 et al, the existence of this Agreement and of the results obtained hereunder may be subject to public disclosure.

6. Confidentiality

It is agreed that CONTRACTOR or SPONSOR may, from time to time, make available to the other Party's employees or students confidential information. The term “Confidential Information” includes and is limited to information disclosed by one Party's personnel to the other Party's personnel in writing conspicuously marked as confidential or, if disclosed other than in writing, is designated as being...
confidential at the time of initial disclosure and is subsequently reduced to writing marked confidential and delivered to the receiving Party within thirty (30) days of initial disclosure. It is further agreed that Confidential Information will be treated as confidential and that the receiving Party's personnel will not at any time directly or indirectly, without the prior written consent of the disclosing Party, develop, disclose, offer to divulge, furnish, or make known or accessible to anyone whatsoever for the use or benefit of anyone other than the disclosing Party any such information. The Parties shall make reasonable efforts to maintain confidentiality of the Confidential Information. All records, in whatsoever form disclosed, containing Confidential Information or copies thereof shall be and remain the property of the disclosing Party and shall be returned to that Party upon request or at the termination of the Agreement for any reason however to the extent such Confidential Information is utilized by a party to meet its Standard of Care that party may keep one copy of such information for its business records. Such copies will be kept Confidential pursuant to this Section 6. This confidentiality obligation shall survive termination of the Agreement for a period of five (5) years. The obligations of confidentiality and nondisclosure shall not apply to:

a. Information which is or becomes public knowledge through no fault of the party to whom it was disclosed as confidential.

b. Information disclosed to the recipient Party by a third party entitled to disclose.

c. Information already known to the recipient Party or information independently developed by the second party without the assistance of the disclosing Party's confidential information as evidenced by written records of the second party's personnel.

d. Information which is required by law to be disclosed; provided that the recipient Party shall give the disclosing Party as much advance notice as possible of any such request as permitted by law.

7. Patents and Copyrights

Title to all inventions, discoveries, computer software or other copyrightable material or data, conceived or resulting from the performance of work hereunder, shall reside in CONTRACTOR. CONTRACTOR shall and does grant to Duke Energy a nonexclusive, nontransferable, noncommercial, royalty-free license to utilize for its own purposes and those of its majority-owned subsidiaries any such inventions, discoveries, computer software or other copyrightable material or data.

8. Publications

CONTRACTOR retains the rights to publish the results of any work carried out by CONTRACTOR’S faculty, staff or students. However, CONTRACTOR will not publish SPONSOR’S confidential information, as defined in N.C.G.S. 132-1.2, without SPONSOR’s written permission.

9. Warranties, Liability, Indemnification

CONTRACTOR SHALL PROVIDE ITS SERVICES PURSUANT TO ITS STANDARD OF CARE. CONTRACTOR WILL TO THE FULLEST EXTENT PERMITTED BY LAW, INDEMNIFY, DEFEND
AND HOLD HDR, OWNER, THEIR EMPLOYEES, OFFICERS, DIRECTORS, AND AGENTS HARMLESS, FROM AND AGAINST ALL LIABILITY, CLAIMS, LOSSES, COSTS, EXPENSES AND FEES ARISING OUT OF THIS PROJECT OR THIS AGREEMENT TO THE EXTENT CAUSED OR ALLEGED TO HAVE BEEN CAUSED BY ANY WILLFUL MISCONDUCT OR NEGLIGENT ACTS, ERRORS OR OMISSIONS OF SUBCONSULTANT, ITS AGENTS, EMPLOYEES, SUBCONSULTANTS OR SUPPLIERS.

10. Termination

This Agreement may be terminated by either party upon thirty (30) days' written notice. Upon termination by either Party, the CONTRACTOR will be paid in an amount which bears the same ratio to the total compensation as does the service actually performed to the total service originally set forth in this Agreement.

11. Entire Agreement

This Agreement constitutes the entire understanding between the Parties. No other terms and conditions, be they consistent, inconsistent, or additional to those contained herein, shall be binding upon the CONTRACTOR, unless and until such terms and conditions have been specifically accepted in writing by both Parties.

Any purchase order issued in connection with this Agreement shall be a fiscal control document only. The terms and conditions appearing in this Agreement shall supersede and replace any and all terms and conditions contained in such purchase order.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by these duly authorized officers this day and year first above written.

HDR ENGINEERING, INC.
OF THE CAROLINAS

SPONSOR

Authorized Signing Official
By: B. Alex Grenoble
Title: Vice President
Date: 3/26/2015

THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

CONTRACTOR

Authorized Signing Official
By: Deborah L. Bolick
Title: Contracts Manager
Date: 3/24/15

FPRES v. 06.2013 HDR
ATTACHMENT A
Sorption, Leaching, and Hydrous Ferric Oxide Determination for Groundwater Assessment Work Plans
 Agreement No. 2975-2015-0562
Page 6 of 14

March 20, 2015

Mack McGarity, P.E.
HDR Engineering, Inc.
Director of Project Management | Hydropower Services
440 S. Church St, Suite 1000 | Charlotte, NC 28202
704.248.3683 | c: [REDACTED] | f: 704.338.6760
Mac.McGarity@hdinc.com

Subject: Sorption, Leaching, and Hydrous Ferric Oxide Determination for Groundwater Assessment Work Plans

Dear Bill:

The University of North Carolina at Charlotte (UNC Charlotte) is pleased to submit this proposal to provide research as part of Groundwater Assessment Work Plans at specific coal ash facilities owned and operated by Duke Energy. In particular, this project will estimate sorption characteristics of site-specific soils to support a groundwater model for predicting the long term fate and transport of constituents of concern in groundwater associated with ash management units. Leaching characteristics of coal fly ash and hydrous ferric oxide of soil samples will also be determined to support the modeling effort. The cost proposal is presented on a per site basis.

Background

In a Notice of Regulatory Requirements (NORR) dated August 13, 2014, the North Carolina Department of Water Resources requested that Duke Energy prepare Groundwater Assessment Plans at these facilities to identify the source and cause of contamination, any imminent hazards to public health and safety and actions taken to mitigate them, and all receptors and significant exposure pathways. In addition, the Plans should determine the horizontal and vertical extent of soil and groundwater contamination and factors affecting contaminant transport and the geological and hydrogeological features influencing the movement, chemical, and physical character of the contaminants. The plans include:

- Implementation of a receptor survey to identify public and private water supply wells (including irrigation wells and unused or abandoned wells), surface water features, and wellhead protection areas (if present) within a 0.5 mile radius of the compliance boundary at the facility;
- Installation of borings within the ash basins for chemical and geotechnical analysis of residuals and in-place soils;
- Installation of background soil borings;
- Installation of monitoring wells and piezometers;
- Collection and analysis of groundwater samples from existing site wells and newly installed monitoring wells;
- Collection and analysis of surface water, seep, and sediment samples;
- Statistical evaluation of groundwater analytical data; and
- Development of a groundwater model to evaluate the long term fate and transport of constituents of concern in groundwater associated with the ash management units;

FPRES v.06.2013 HDR
• Conduct a screening level human health and ecological risk assessment. This assessment will include the preparation of a conceptual exposure model illustrating potential pathways from the source to possible receptors.

The information obtained through these Work Plans will be utilized to prepare Comprehensive Site Assessment (CSA) reports in accordance with the NORR. In addition to the components listed above, a human health and ecological risk assessment will be conducted. This assessment will include the preparation of a conceptual site model illustrating potential pathways from the source to possible receptors.

The results of the proposed research will be used in the aforementioned groundwater model development.

**Objectives, Scope of Work, Protocols, Deliverables, Schedule, and Proposed Budget**

Both column and batch methods for estimating sorption have been considered. We recommend an adaptation of the column method described by Daniels and Das [1] to develop $K_d$ estimates that are more conservative and representative of in-situ conditions, especially with regards to soil-to-liquid ratios. Soil samples with measured dry density and maximum particle size of 2 mm will be placed in lab-scale columns configured to operate in the up-flow mode. A solution with measured concentrations of the constituents of concern (COCs) will be pumped through each column, effluent samples will be collected at regular intervals over time. When constituent breakthroughs are verified, a “clean” solution (no COCs) will be pumped through the columns and effluent samples will be collected as well. Samples will be analyzed by inductively coupled plasma-mass spectroscopy (ICP-MS) and ion chromatography (IC) in the Civil & Environmental Engineering laboratories at EPIC building, UNC Charlotte. Plots of effluent COC concentration versus cumulative pore volumes exchanged will be analyzed to estimate $K_d$ values and to confirm reversibility of COC sorption. A maximum of fifteen soil samples per site will be tested by the column method, with one sample performed in triplicate.

It is noted that some COCs may have indeterminate $K_d$ values by the column method due to solubility constraints and background conditions. Also, in order to complete the tests in the allotted time, $K_d$ values estimated by the column method will have an upper limit of 100 mL/gram. In order to address these limitations and otherwise supplement the column method results, batch sorption tests will be conducted in accordance with U.S. Environmental Protection Agency Technical Resource Document EPA/530/SW-87/006-F [2]. COC-specific solutions will be used to prepare a range of soil-to-solution ratios. After mixing, supernatant samples will be drawn and analyzed as described above. Plots of sorbed versus dissolved COC mass will be used to estimate $K_d$ values. A maximum of fifteen soil samples per site will be tested by the batch method, with one sample performed in triplicate. This proposal includes testing for up to six COCs per site for both batch and column.

The measured $K_d$ terms will apply to the selected soil samples and background geochemistry of the test solution, including pH and oxidation-reduction potential. In order to make these results transferable to other soils and geochemical conditions at the site where $K_d$ terms have not been derived, core samples for which derived $K_d$ values have been measured and 15 additional core samples will be analyzed for hydrous ferrous oxides (HFO) content, which is considered to be the primary determinant of COC sorption capacity of soils at the site. HFO will be determined by the method described by Chao et al. [3]
In order to provide a basis for estimating COC source terms, EPA Method 1313 [4] Liquid-Solid Partitioning as a Function of Extract pH Using a Parallel Batch Extraction Procedure and EPA Method and EPA Method 1316 [5] Liquid-Solid Partitioning as a Function of Liquid-Solid Ratio using a Parallel Batch Extraction Procedure will be performed on three samples of fresh coal fly ash (CFA) from the site. Method 1313 provides COC concentration as a function of pH. Method 1316 provides COC concentration as a function of liquid to solid ratio.

**Testing Protocols for Sorption, Leaching, and Hydrous Ferric Oxide (HFO) Determination**

**Soil, Core, and CFA Samples**

Soil, core, and CFA samples will be shipped to the lab in plastic buckets or in sleeves from recovered cores. The minimum soil sample volume is two gallons. Soil and core samples should be clearly marked with boring designation cross-referenced to the site map, the date of sample, and the depth interval. Boring designations should be cross-referenced to data tables containing in-situ water quality parameters including pH, oxidation-reduction potential, and dissolved oxygen. CFA samples should be “fresh,” with minimal post-combustion, environmental exposure. If fresh CFA samples are not available, the field engineer or geologist of record should select three CFA samples deemed to be most recently generated by combustion.

Samples should be shipped to the following address:

UNC Charlotte / Lee College of Engineering  
Civil and Environmental Engineering  
EPIC Building 3252  
9201 University City Blvd. / Charlotte, NC 28223  
704-687-1739

Attention: Bill Langley  
Shubha Oza

**Soil and Core Sample Preparation**

Once the samples are received at UNC Charlotte, receipt of the sample and sample details will be recorded appropriately for future reference. Soil and core samples will be dried at room temperature. During the drying processes, samples will be mixed periodically to break up agglomerations. After drying, samples will be sieved using a No. 10 U.S. standard sieve (10 mm) with 0.0787 inch openings.

**Column Tests for \( K_d \) Determination** (adapted from Daniel and Das [1])

The columns are 8 inch long (20.3cm) polyethylene tubes with dimensions 0.675 in. (16 mm) I.D. by 0.75 in. (19 mm) O.D. Each column is supplied with two polypropylene end caps with barbed fittings which accept 0.25 to 0.375 in. (6.4 to 9.5 mm) I.D. tubing. The end caps are sized to hold a porous disc of polyethylene and a polymer mesh screen to restrain the soil sample in the column.

With one end cap attached to the column, acid-washed Ottawa sand is added through the open end of the
column to a depth of about 2 cm. The coarse sand layer ensures the effective dispersal of flow across the column cross section. After weighing the column, lower end cap (with polyethylene disc and screen), and sand, the column is filled with soil sample in 5 cm lifts. Between each lift, the sample is lightly compacted to achieve a uniform density based on visual inspection. After weighing the column, lower end cap, sand, and sample, a 2 cm thick sand layer is added at the top of the compacted sample and the upper end cap will be attached. Based on the measured weights and sample dimensions, the dry bulk densities of the samples and column pore volumes will be determined.

Using representative analytical results for pore water and well water samples from the site, the results for major cations and anions will be used as the basis to prepare a background feed solution using reagent grade solid chemicals and deionized water. Target COC concentrations will be attained by diluting concentrated reference standards with the background feed solution. After adding the reference standards, the COC amended feed solutions will be back-titrated as needed to an approximate pH range of 6.5 to 7.5 using either sodium or potassium hydroxide solution.

Feed solution will be pumped from 5 L low density polyethylene carboys to the columns using a Masterflex 7520-50 peristaltic pump drive with a 12-channel, 8-roller cartridge pump head connected to the columns using Tygon tubing, valves, and fittings. The columns will be operated in the up-flow mode with a pore volume exchange rate of approximately 0.5 days.

Real-time, grab sample volumes of approximately 100 mL per day will be available for analyses. The sample time and total volume pumped since the previous sampling event will be recorded for calculating flow rates and pore volume exchanges. Concurrent samples of the feed solutions will also be taken for each sampling event. Table 1 list the analysis and analytical equipment’s that will be used in the study.

For all feed and column effluent, analytical results versus cumulative pore volumes displaced will be plotted. For the steady-state flow regime considered in these tests, van Genuchten and Alves (1982)[8] presented the following form of Ogata-Banks (O-B) equation for one-dimensional, advection-dispersion equation with linear instantaneous sorption as a close approximation to that for a finite length, lab-scale column:

\[
c(x,t) = \frac{c_0}{2} \left[ \text{erfc} \left( \frac{Rx - vt}{2\sqrt{D} t} \right) + \exp(vx/D) \text{erfc} \left( \frac{Rx + vt}{2\sqrt{D} t} \right) \right]
\]

Where the variable are defined as follows:

- \(c(x,t)\) solute concentration (M/L³),
- \(x\) length in the direction flow from the inlet (L),
- \(t\) elapsed time (T),
- \(c_0\) feed concentration (M/L³),
- \(R\) dimensionless retardation coefficient,
- \(v\) seepage velocity (L/T),
- \(D\) soil dispersion coefficient (L²/T).

The partition coefficient \(K_d\) (L³/M) is incorporated in \(R\) as follows:
\[ R = 1 + \frac{\rho_d K_d}{n} \]

Where the variable are defined as follows:

- \( \rho_d \) : dry bulk density of the soil
- \( n \) : porosity

For the given test conditions where dispersion was dominant over diffusion, the soil dispersion coefficient \( D \) is equal to the product of the longitudinal dispersivity \( a_L \) (L) and the seepage velocity.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method</th>
<th>Equipment</th>
<th>Sample Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace metals (Sb, As, B, Cd, Cr, Fe, Mn, Pb, Tl)</td>
<td>EPA 200.8</td>
<td>Thermo Scientific iCAP Q</td>
<td>acidify to pH &lt; 2, 0.45 ( \mu )m filtration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ICP-MS</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>EPA 300.0</td>
<td>Dionex ICS3000 Ion Chromatograph</td>
<td>0.45 ( \mu )m filtration</td>
</tr>
<tr>
<td>pH,</td>
<td>Standard Method 4500 B</td>
<td>Mettler Toledo Seven Excellence S470 pH/Conductivity Meters</td>
<td>N/A</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Standard Method 2510</td>
<td>Mettler Toledo Seven Excellence S470 pH/Conductivity Meters</td>
<td>N/A</td>
</tr>
<tr>
<td>Oxidation-reduction potential (ORP)</td>
<td>Standard Method 2508</td>
<td>Mettler Toledo Seven Excellence S470 pH/Conductivity Meters (with In lab Redox Pro Electrode)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Supporting data used to estimate \( K_d \) based on O-B equation are: average flow rate, column cross-sectional area, estimated porosity, seepage velocity, estimated dispersivity, and dispersion coefficient. The O-B solution will be calibrated to the analytical results for COCs by varying \( K_d \) in a spreadsheet equation for the O-B curve. Alternately, the data will be analyzed using CXTFIT [6] to select the appropriate model and associated parameters of the sorption coefficient \( K_d \), either linear, Freundlich, or Langmuir. Given the pore volume of each column and the practical maximum flow rate and duration of the test, the maximum \( K_d \) that can be estimated by the column method is approximately 100 mL/gram. When COCs in the column effluent reaches levels where \( K_d \) can be estimated, a “clean” solution (no COCs) will be pumped through the columns and effluent samples will be collected for analysis to determine the extent to which sorption is reversible for each COC.

**Batch Tests for \( K_d \) Determination**

**FFRES v.06.2013 HDR**
Batch sorption tests will be conducted in accordance with U.S. Environmental Protection Agency Technical Resource Document EPA/530/SW-87/006-F [2]. The COC-amended solution described previously for the column tests will be equilibrated with soil samples across a range of soil-to-solution ratios. After equilibration, supernatant samples will be drawn and analyzed as described above in Table 1. Plots of sorbed versus dissolved COC concentration will be used to estimate $K_d$ values.

Soil-solution mixtures at ratios of 0.1, 0.2, 0.3, 0.4, and 0.5 grams per mL will be prepared in 250 mL Nalgene bottles with screw-type polypropylene lids. Equilibration will be attained after 24 hours of rotary mixing at a rate of 60 rpm. At the given soil-solution ratios and initial COC concentrations, the maximum $K_d$ that can be estimated by the batch method is approximately 300 mL/gram. Sorbed COC concentrations on soil samples will be determined based on a mass balance of initial COC and final COC concentrations in the test solution. Plots of sorbed versus dissolved COC concentration, analyzed using IsoFit [7], will indicate the appropriate model and associated parameters of the sorption coefficient $K_d$, either linear, Freundlich, or Langmuir.

**Methods for Coal Fly Ash Leaching and Hydrous Ferric Oxide (HFO) Determination**

The following methods will be applied to CFA samples for characterizing leaching potential:

**Method 1313: Liquid-Solid Partitioning as a Function of Extract pH Using a Parallel Batch Extraction Procedure** [4]. The procedure calls for reaching nine specific pH targets after mixing. If the natural pH of the material, without acid or based addition, is not one of the target pH positions, the natural pH is a tenth position in the procedure. But for the purpose of this study, this test will be conducted at the natural pH of the material only. The CFA samples will be extracted for 24 hours with de-ionized water (DI). The leachate from the extraction step will be filtered using 0.45μ filter paper and analyzed for pH, ORP, conductivity and concentration of anions, cations, and target COCs.

**Method 1316: Liquid-Solid Partitioning as a Function of Liquid-Solid Ratio using a Parallel Batch Extraction Procedure** [5]. This method consists of five parallel extractions over a range of liquid to solid (L/S) ratios from 0.5 to 10 mL eluent per gram dry material. In addition to the five test extractions, a method blank without solid sample will be carried out to verify that analyte interferences are not introduced as a consequence of reagent impurities or equipment contamination. The 250 mL test bottles are equilibrated in a rotary mixer for a specified contact time based on the particle size of the solid (and as per method specification). At the end of the contact interval, the leachate from the extraction step was filtered (0.45μ filter paper) and analyzed for pH, ORP, conductivity and concentration of anions, cations, and target COCs.

The method for HFO determination in core and soil samples will be adapted from Chao and Zhou (1983). The method calls for extracting a soil sample using 0.25M NH$_2$OH-HCl-0.25M HCl combined solution as the extractant at 50°C for 30 min [3].

Water samples for the above methods will be analyzed as described in Table 1.

**Deliverables**

At the end of the study, a report will be prepared that includes the following:

**FPRES v.06 2013 HDR**
• descriptions of procedures
• analytical data in tabular and graphic forms
• summaries of $K_d$ terms, Method 1313 and 1316 concentrations by sample and constituent,
• summaries of HFO by sample
• correlations of $K_d$ terms to HFO by constituent
• sensitivity of $K_d$ terms to pH and redox potential based on PHREEQC geochemical modeling

The estimated completion date for the data reports are 07/01/2015. Ancillary activities including response to comments, laboratory equipment repair and replacement, and laboratory supplies’ replacement will be concluded by 01/31/2016. The fixed fee budget for this study is $56,973 per site. Revised cost proposals for additional samples and constituents, and specific sample preparation requirements will be provided as needed.

We appreciate the opportunity to provide Synterra with this proposal.

Sincerely,

William G. Langley, Ph.D., P.E.
References


ATTACHMENT B
Duke Energy Facilities Included for This Project

1. Allen Steam Station
2. Belews Creek Steam Station
3. Buck Stream Station
4. Cliffside Steam Station
5. Dan River Steam Station
6. Marshall Steam Station
7. Riverbend Steam Station
This Fixed Price Agreement, made and entered into this 1st day of October, 2013, between The University of North Carolina at Charlotte (hereinafter called CONTRACTOR) and HDR Engineering, Inc. of the Carolinas (hereinafter called SPONSOR), witnesses that:

Whereas, each party desires to enter into this Agreement for the benefits reasonably expected to be gained there from;

The parties hereto mutually agree as follows:

1. **Scope of Work**

CONTRACTOR will use reasonable efforts to perform research as described in its proposal entitled "Sorption Evaluation and Groundwater Modeling for Ash Basin Closure at the Buck Stream Station" which is attached hereto as Attachment A and incorporated herein by reference.

2. **Term of Service**

The term of the Agreement will begin on October 1st, 2013, and end on June 15th, 2014, unless extended by the mutual agreement of the parties.

3. **Cost of Services**

SPONSOR agrees to pay to CONTRACTOR the sum of forty-six thousand two hundred and twenty-four and no/100 dollars ($46,224.00) for these services. SPONSOR agrees to pay the sum of eleven thousand five hundred fifty six and no/100 dollars ($11,556.00) upon a fully executed Agreement and the remainder according to the following schedule:

Eleven thousand five hundred fifty six and no/100 dollars ($11,556.00) by December 31st, 2013
Eleven thousand five hundred fifty six and no/100 dollars ($11,556.00) by February 28th, 2014
Eleven thousand five hundred fifty six and no/100 dollars ($11,556.00) by June 15th, 2014

SPONSOR agrees to pay said invoices within 30 days of the invoice date. CONTRACTOR reserves the right to discontinue work if SPONSOR fails to pay invoices rendered by CONTRACTOR within the time herein specified. SPONSOR agrees to pay a late payment charge of 1 1/2 percent per month on all overdue amounts that are due to the sole fault of the SPONSOR.

FPRES v.06.2013
4. Communications

CONTRACTOR Contract Administrator:
Deborah L. Bolick, Contracts Manager
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall 312
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: dbolick@uncc.edu
Telephone: 704-687-1883 | Fax: 704-687-0980

SPONSOR Contract Administrator:
Mac McGarity, PE
HDR Engineering, Inc.
440 S. Church St., Suite 1000
Charlotte, NC 28202
Email: Mac.McGarity@hdrinc.com
Telephone: 704-248-3683

CONTRACTOR Financial Representative:
Tamara Hill
Manager, Award Management
The University of North Carolina at Charlotte
Grants & Contracts Administration
Cameron Hall 308
9201 University City Boulevard
Email: thill55@uncc.edu
Telephone: 704-687-1887 | Fax: 704-687-0980

SPONSOR Financial Representative:

CONTRACTOR Principal Investigator:
Dr. John Daniels
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001
Email: jodaniel@uncc.edu
Telephone: (704) 687-1739

SPONSOR Principal Investigator:

5. Use of Names in Publicity

SPONSOR agrees that no advertising or publicity matter having or containing reference to CONTRACTOR will be disseminated without the prior written consent of CONTRACTOR. CONTRACTOR agrees that no advertising or publicity matter having or containing reference to SPONSOR will be disseminated without prior written consent of SPONSOR. SPONSOR recognizes and acknowledges that under NC Public Records Act, §132-1 et al. the existence of this Agreement and of the results obtained hereunder may be subject to public disclosure.

6. Confidentiality

It is agreed that CONTRACTOR or SPONSOR may, from time to time, make available to the other party's employees or students confidential information. The term “Confidential Information” includes and is limited to information disclosed by one party’s personnel to the
other party’s personnel in writing conspicuously marked as confidential or, if disclosed other than in writing, is designated as being confidential at the time of initial disclosure and is subsequently reduced to writing marked confidential and delivered to the receiving party within thirty (30) days of initial disclosure. It is further agreed that Confidential Information will be treated as confidential and that the receiving party’s personnel will not at any time directly or indirectly, without the prior written consent of the disclosing party, develop, disclose, offer to divulge, furnish, or make known or accessible to anyone whatsoever for the use or benefit of anyone other than the disclosing party any such information. The parties shall make reasonable efforts to maintain confidentiality of the Confidential Information. All records, in whatsoever form disclosed, containing Confidential Information or copies thereof shall be and remain the property of the disclosing party and shall be returned to that party upon request or at the termination of the Agreement for any reason however to the extent such Confidential Information is utilized by a party to meet its Standard of Care that party may keep one copy of such information for its business records. Such copies will be kept Confidential pursuant to this Section 6. This confidentiality obligation shall survive termination of the Agreement for a period of five (5) years. The obligations of confidentiality and nondisclosure shall not apply to:

a. Information which is or becomes public knowledge through no fault of the party to whom it was disclosed as confidential.

b. Information disclosed to the recipient party by a third party entitled to disclose.

c. Information already known to the recipient party or information independently developed by the second party without the assistance of the disclosing party’s confidential information as evidenced by written records of the second party’s personnel.

d. Information which is required by law to be disclosed; provided that the recipient party shall give the disclosing party as much advance notice as possible of any such request as permitted by law.

7. Patents and Copyrights

Title to all inventions, discoveries, computer software or other copyrightable material or data, conceived or resulting from the performance of work hereunder, shall reside in CONTRACTOR. CONTRACTOR shall and does grant to Duke Energy a nonexclusive, nontransferable, commercial, royalty-free license to utilize for its own purposes and those of its majority-owned subsidiaries any such inventions, discoveries, computer software or other copyrightable material or data.

8. Publications

CONTRACTOR retains the rights to publish the results of any work carried out CONTRACTOR’S faculty, staff or students, except that CONTRACTOR will not publish SPONSOR’S confidential information, as defined by N.C.G.S. 132-1.2, without SPONSOR’S written permission.
9. **Termination**

Performance under this Agreement may be terminated by either party upon thirty (30) days' written notice. Upon termination by either party, CONTRACTOR will pay in an amount which bears the same ratio to the total compensation as does the service actually performed to the total service originally set forth in this Agreement.

10. **Warranties; Liability, Indemnification**

CONTRACTOR SHALL PROVIDE ITS SERVICES PURSUANT TO ITS STANDARD OF CARE AND WILL TO THE FULLEST EXTENT PERMITTED BY NORTH CAROLINA LAW, CONTRACTOR WILL INDEMNIFY, DEFEND AND HOLD HDR, OWNER, THEIR EMPLOYEES, OFFICERS, DIRECTORS, AND AGENTS HARMLESS, FROM AND AGAINST ALL LIABILITY, CLAIMS, LOSSES, COSTS, EXPENSES AND FEES ARISING OUT OF THIS PROJECT OR THIS AGREEMENT TO THE EXTENT CAUSED OR ALLEGED TO HAVE BEEN CAUSED BY ANY WILLFUL MISCONDUCT OR NEGLIGENCE ACTS, ERRORS OR OMISSIONS OF SUBCONSULTANT, ITS AGENTS, EMPLOYEES, SUBCONSULTANTS OR SUPPLIERS.

11. **Entire Agreement**

This Agreement constitutes the entire understanding between the parties. No other terms and conditions, be they consistent, inconsistent, or additional to those contained herein, shall be binding upon the CONTRACTOR, unless and until such terms and conditions have been specifically accepted in writing by both parties. Any purchase order issued in connection with this Agreement shall be a fiscal control document only. The terms and conditions appearing in this Agreement shall supersede and replace any and all terms and conditions contained in such purchase order.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed by these duly authorized officers this day and year first written above.

HDR ENGINEERING, INC.  
OF THE CAROLINAS  

By: B. Alex Grenoble  
Title: Vice President  
Date: 11/13/13

THE UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE  

By: Deborah L. Bolick  
Contracts Manager  
Grants and Contracts Administration  
Date: 11/13/13

FPRES v.06.2013
Mack McGarity, P.E.
HDR Engineering, Inc.
Director of Project Management | Hydropower Services
440 S. Church St, Suite 1000 | Charlotte, NC 28202
704.248.3683 | c: [redacted] | f: 704.338.6760
Mac.McGarity@hdrinc.com

November 1, 2013

Subject: Sorption Evaluation and Groundwater Modeling for Ash Basin Closure at the Buck Steam Station

Dear Mr. McGarity:

As we discussed, The University of North Carolina at Charlotte (UNC Charlotte) is pleased to submit this proposal to provide the research required for the ash basin closure at Duke Energy’s Buck Steam Station. In particular, this project will evaluate the sorption of site-specific soils and incorporate this information into a groundwater model of approximately six cross-sections.

Background

Duke Energy Carolinas, LLC (Duke Energy), owns and operated the Buck Steam Station (Buck), located on the Yadkin River in Rowan County, North Carolina. Buck is a six unit coal-fired electricity generating facility with a capacity of 256 megawatts located on the Yadkin River in Rowan County, North Carolina. Buck began commercial operations in 1926. As of April 1, 2013, all of the coal fired units have been retired. Three simple cycle combustion turbine units were in operation at the Buck site until their retirement in October 2012. The site also contains the new Buck Combustion Turbine Combined Cycle Plant, a 620-megawatt natural gas powered electricity generating station. The site is approximately 640 acres in area.

The ash basin system at the plant was used to retain and settle ash generated from coal combustion at the Buck plant. The discharge from the ash basin is permitted by the NCDENR DWQ under the National Pollution Discharge Elimination System (NPDES) Permit NC0004774. The ash basin system consists of three cells, the associated earthen dikes, discharge structures, and two canals. The ash generated from the combustion process was sluiced to the Primary Cell through ash discharge lines. Flow from the Primary Cell entered the Old Primary Cell via the Primary Cell Discharge Tower. Flow from the Old Primary Cell entered the Secondary Cell via the Old Primary Cell Discharge Structure. Flow from the Secondary Cell was then discharged to the Yadkin River through the Secondary Cell Discharge Tower.

In addition to surface water monitoring, the NPDES permit requires groundwater monitoring to be conducted three times per year. Fourteen groundwater monitoring wells are sampled for the following parameters: antimony, chromium, nickel, thallium, arsenic, copper, nitrate,
barium, iron, pH, zinc, boron, lead, selenium, cadmium, manganese, sulfate, chloride, mercury, and TDS. Exceedances of the North Carolina Administrative Code (NCAC) Title 15A Chapter 02L (g) groundwater quality standards (2L Standards) have been measured in groundwater samples collected from groundwater monitoring wells at the Buck ash basin.

On behalf of Duke Energy, HDR Engineering, Inc. of the Carolinas (HDR) is developing a closure plan for the ash basin system at Buck. The closure plan will detail all aspects of the closure and post-closure activities at the facility, and should include the following elements:

- Facility and Ash Pond Description
- Site Maps
- Hydrogeologic, Geologic, and Geotechnical Investigation
- Closure Method
- Groundwater (Hydrogeologic) Modeling
- Post-closure plan
- Schedules
- Future Site Use

HDR has requested that UNC Charlotte prepare this proposal to perform the groundwater modeling as required by the Draft Ash Closure Plan Requirements (NCDENR 2013).

Supporting Information and Data

In support of fulfilling the requirements for groundwater modeling, HDR will provide the information listed in Sections 2, 3, and 5 of the Draft Ash Closure Plan Requirements (NCDENR 2013). In particular, this will include:

- Summarized results of any previous environmental investigations performed at the site.
- Topographic contours of the site (no less than 5 ft. intervals).
- A description of the hydrogeology and geology of the site.
- A description of the stratigraphy of the geologic units underlying the ash ponds, with cross-sections provided in report-ready AutoCAD-based drawings.
- The saturated hydraulic conductivity for the ash, liner (if present), and all identified stratigraphic units underlying the ash pond(s).
- The geotechnical properties for the ash, liner (if present), and the uppermost identified stratigraphic unit underlying the ash pond(s).
- Laboratory results for a chemical analysis of the ash basin pond water, ash, and ash-affected soil. Identify constituents with concentrations found to be in excess of 15A NCAC 02L.0202 Groundwater Quality Standards.
- Summary tables of historical records of groundwater and surface water sampling results.
- A map that illustrates the following: potentiometric contours and flow directions for all identified aquifers underlying the ash pond(s) (shallow, intermediate, and deep), and
the known horizontal extent of areas where 15A NCAC 02L.0202 Groundwater Quality Standards are exceeded.

- Cross-sections that illustrate the following: vertical and horizontal extent of the ash within the ash pond, stratigraphy of the geologic units underlying the ash pond, the vertical extent of areas where 15A NCAC 02L.0202 Groundwater Quality Standards are exceeded.
- A description of the closure method and timing. Assuming the selected method is Closure-in-Place, this will include the engineered cover system such as a composite geomembrane, impermeable clay, and/or a soil cover over the ash pond.

In addition HDR will provide the following items which are specifically related to the modeling effort:

- Surfaces in digital format for all vertical cross sections to be modeled, including top of ground, top of ash cover or liner, top of ash, bottom of ash, stratigraphic contacts (surficial soil, saprolite, partially weathered rock, fractured bedrock), and potentiometric surfaces (shallow, intermediate, and deep) for all identified aquifers underlying the site.
- Report-ready illustrations of all vertical cross sections to be modeled.
- Location of potential receptors within 1500 feet of the compliance boundary on all vertical cross sections to be modeled.
- Where potential receptors consist of water-supply wells, depths of stratigraphic contacts (surficial soil, saprolite, partially weathered rock, fractured bedrock), well construction including the depth interval of extraction zone, static water levels, and extraction rates.

Objectives and Scope of Work

As described in Section 4 of the Draft Ash Closure Plan Requirements (NCDENR 2013), the groundwater modeling portion of the closure plan to be prepared by UNC Charlotte will consist of the following:

a) Perform groundwater modeling based on the design of the proposed pond closure method. Generally this should:
   i) Be based on the site hydrogeologic conceptual model developed using the Hydrogeologic Investigation and Reporting Policy.
   ii) Include predictions on post-closure groundwater elevations, groundwater flow directions and velocities including the effects on/from the potential receptors.
   iii) Include predictions at the compliance boundary for constituents identified as exceeding 15A NCAC 2L.0202 Groundwater Quality Standards in ash basin pond water, ash, and ash-affected soil.

b) Predictions should include the effects on the groundwater chemistry, and should describe:
i) Migration, concentration, mobilization and fate of the constituents that exceed 15A NCAC 2L standards before and after closure activities including the effects on/from potential receptors.

c) If required, describe the groundwater trend analysis methods necessary to demonstrate compliance with 15A NCAC 02L.0202 Groundwater Quality Standards and 15A NCAC 02L .0106.

Groundwater flow and constituent fate and transport will be modeled using MODFLOW and MT3D to predict post-closure constituent concentrations over time at the compliance boundary and potential receptors. Subject to data sufficiency, up to six cross sections will be modeled, possibly corresponding to monitoring wells MW-2S/D, MW-8S/D, MW-10D, MW-11S/D, MW-12S/D, and MW-13D. The flow model component will include infiltration through surficial soils and ash in its proposed final condition. The flow model will be calibrated to average, steady-state potentiometric surfaces using measured hydraulic conductivities as initial input. For cross sections without water supply wells at potential receptors, the model domain will be a two dimensional vertical plane (one row) consisting of multiple columns of finite difference cells in the horizontal direction and multiple layers of finite difference cells in the vertical direction. For cross sections with a water supply well as a potential receptor, a third dimension may be added consisting of multiple rows of finite difference cells in the horizontal direction to reasonably simulate the capture zone of extraction well(s). This proposal is based on modeling up to six chemical constituents at each cross section.

Research will be performed to develop or estimate site-specific distribution coefficient ($K_d$) terms for native soils beneath the ash basin system. This research will involve column-based experiments where simulated leachate is percolated through site-specific soils.

**Deliverables**

Deliverables contained in the groundwater modeling report are based on the Closure Plan requirements listed above and will include:

- Conceptual site model
- Computer model
- Groundwater flow and contaminant transport model construction
- Sensitivity analyses
- Predictive simulations
- Conclusions and limitations
- Distribution coefficient measurements

The sensitivity analyses will estimate uncertainties associated with the heterogeneity of lithology, structure, aquifer parameters, groundwater elevations, water quality, interactions with surface water bodies, and other parameters.
The final report must be sealed and signed by a Professional Engineer (PE) with current registration in North Carolina. As the Principal Investigator and employee of UNC Charlotte, Dr. John L. Daniels, P.E. will provide the seal.

**Schedule**

The proposed work schedule calls for the following tasks to be completed by February 28, 2014, as shown below according to weekly activity.

<table>
<thead>
<tr>
<th>Week Ending</th>
<th>Activity</th>
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| 11/8/13     | • Meetings and Review of existing reports, data gathering  
              • Receive/Review SPLP data from HDR |
| 11/15/13    | • Conceptual model development  
              • Sorption experiments |
| 11/22/13    | • Receive surveying data, site topography, cross-sections & site-specific properties from HDR |
| 11/29/13    | • Send extracts to Duke’s environmental lab for analysis  
              • Model development, refinement, and predictions (flow)  
              • Sensitivity analysis (flow) |
| 12/6/13     | • Receive analytical results from Duke’s lab and compute coefficients  
              • Model development, refinement, and predictions (fate & transport)  
              • Possible sorption/leaching experiments as needed based on analytical results |
| 12/13/13    | • Sensitivity analysis (fate & transport)  
              • Send additional extracts from sorption/leaching experiments to Duke’s environmental lab for analysis |
| 12/20/13    | • Report preparation - Initial (fate & transport) |
| 12/27/13    | • Draft report to HDR  
              • Receive analytical results from Duke’s lab and refine coefficients  
              • Receive comments from HDR  
              • Receive analytical results from Duke’s lab and compute coefficients |
| 1/3/14      | • Revised report to HDR |
| 1/10/14     | • HDR incorporates modeling into draft report to Duke  
              • Meeting with HDR and Duke to review documents  
              • Duke Review  
              • Duke Feedback to HDR and UNC Charlotte  
              • Final edits  
              • Final review and PE Seal for UNC Charlotte’s work |
RECOMMENDED BUDGET AND WORK SCHEDULE

The fixed fee budget for the study to be conducted at the Civil & Environmental Engineering laboratories at EPIC building, UNC Charlotte is $46,224. The cost of analyzing the leachates (e.g., at Duke’s Environmental Laboratory) from the column sorption tests is not included in this estimate.

We appreciate the opportunity to work with HDR Inc., on this project.

Sincerely,

John L. Daniels