February 22, 2021 Project No. 18113500

Mr. Timothy J. Unseld
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Materials Management Division
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UNIT 3 CLOSURE CERTIFICATION DENIAL, J.B. SIMS GENERATING STATION – COMMENT RESPONSE

Dear Mr. Unseld,

Golder Associates Inc. (Golder) has prepared this letter to address the comments that were received via e-mail by the Grand Haven Board of Light and Power (GHBLP) on January 21, 2021 from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) regarding the December 11, 2020 J.B. Sims Generating Station (JB Sims) – Unit 3 Impoundments – CCR Removal Documentation Report (Unit 3 Closure Report). The comments received from EGLE are included below in bold with Golder's responses directly below the comment.

1.0 COLORIMETRIC AND MICROSCOPIC TESTING

EGLE: GHBLP proposed utilizing a colorimetric test to document that coal ash was removed from the clay liner. For the following reasons EGLE does not agree that a single colorimetric sample (sample u3E-CS-03) is sufficient to document removal and decontamination of coal ash from the unit. GHBLP previously collected six samples of the liner but only utilized one sample to represent the entire liner. Although GHBLP demonstrated a relationship between colorimetric values and mixtures of coal ash in one of the six samples (sample u3E-CS-03), GHBLP has not provided information that demonstrates that the one sample's colorimetric properties would accurately represent all liner areas. In addition, the history of the site has been to augment the existing clay liner after some pond cleanout operations. No documentation on the properties or source of these additional clays has been provided.

The microscopy methodology provided did not include any preprocessing of the material to ensure that characteristic properties of bottom ash could be properly identified. In the photographs provided, fine grained materials covered all coarser grained materials making it difficult to determine if the grains were coal ash or other material. The samples need to be prepared in a way so that coal ash can be identified through microscopic investigation.

Response: As stated in a meeting between EGLE and GHBLP on December 21, 2020, the assertion that only one sample of the clay samples collected was used for baseline analysis is incorrect. Thirteen samples were collected in total for the baseline analysis; 6 clay liner samples, 6 bottom ash samples and 1 island fill sample. The colorimetric analysis did not use just one clay liner sample to construct the curve for the baseline analysis, all six clay liner samples collected were used. Golder contacted the accredited laboratory CTL Group's expert Principal Petrographer and Materials Scientist, Laura Powers, for additional documentation on the process used to create the baseline curve. This information is included in Attachment 1. As stated in Attachment 1 "Visual examination suggested that the clay soil represented by Sample U3E-CS-03 and the bottom ash represented by Sample U3W-BA-03 were the most homogeneous in terms of color. **Color was measured for all samples. Clay soil samples with similar color values were combined to obtain sufficient material for the preparation of mixtures.**" Additionally, "Mixtures of 0%, 3%, 5%, 10%, 15%, and 20% were prepared for colorimetric analysis to construct the calibration curve. The mixtures used combined clay soil samples U3E-CS-01, U3E-CS-03, and U3E-CS-05, and CCR Sample U3W-BA-03." Given that this method of baseline preparation includes a range of samples and this method has been used by Golder and approved by EGLE at other closure by removal sites in Michigan, this baseline method is acceptable for the Unit 3 Closure Report.

The colorimetric testing reports included three distinct items:

- Colorimetric Testing
- Microscopic Testing for CCR percentage verification
- Photographs for illustrations in the report

The intention of the testing was to provide, on a colorimetric basis, a determination of the amount of CCR remaining in a clay sample after CCR removal based on color.

Regarding the clay sources; for the colorimetric analysis we are looking for the presence of CCR particles in a clay matrix to determine the extent to which portions of clay liner need to be removed. Since clay particles are generally different in shape and vastly different in color from CCR particles, as shown in the photographs in Attachments 1 and 2, the source of the clay is not required for this line of evidence.

With respect to the alternate line of evidence using microscopy, the assertion that there was no preprocessing to assure that bottom ash could not be properly identified is incorrect. Preprocessing was done prior to microscopic analysis. Microscopes were used to visually determine the percentage of CCR in a clay sample to verify the results of the colorimetric testing. CTL Group used standard and appropriate petrographic methods for determining the percentage of different components in a sample. Clarification on the microscopic method was provided by Laura Powers with CTL Group and is included in Attachment 2 and summarized below:

- Microscopy had different processing from the colorimetry because it would not be possible to distinguish CCR in the fully pulverized samples.
- The microscopy samples were dried and crushed more gently by hand to pass a No. 30 sieve. Ash particles and sand particles, if present, are harder than clay so they remain larger than the clay particles. Those larger particles are then added back into the entire sample after the clay is processed.
- The visual estimation charts used are the same ones used in petrology for percentages of larger objects mixed with smaller objects. When in doubt about any identification using the stereomicroscope, CTL mixes

the sample with immersion liquid and examines it further with the petrographic microscope (which takes advantage of light interacting with crystal faces to determine identification) for verification.

- The microscopy analysis preparation should not be confused with the photography, which was intended to illustrate the visual character of the sample. In some cases, a photograph shows a sample that was only very coarsely broken. This was because it was the easiest way to illustrate the ash particles in the photographs (the processed clay particles are electrostatically drawn to the ash and mineral grains which makes photography difficult).

Again, given that these methods are standard and this method has been used by Golder and approved by EGLE at other closure by removal sites in Michigan, these methods are acceptable for the Unit 3 Closure Report. Moreover, the results for each method (color, microscope, photographs) support each other and provide a predictable and reliable means to objectively measure concentrations of CCR based on physical sample properties.

2.0 ANALYTICAL VALUES

EGLE: Next, under MCL 324.11519b(9), closure by removal of a coal ash impoundment requires either certification of closure under 40 CFR 257.102(c) or certification "that testing confirms that constituent concentrations remaining in the coal ash impoundment or landfill unit and any concentrations of soil or groundwater affected by releases therefrom do not exceed the lesser of the applicable standards adopted by the department pursuant to section 20120a or the groundwater protection standards established pursuant to 40 CFR 257.95(h) and the department accepts the certification or if the constituent concentrations do exceed those standards, the department has approved a remedy consistent with R 299.4444 and R 299.4445 of the Part 115 rules.". Thus, in order to leave the clay liner in place, GHBLP must demonstrate that the clay liner left in place is not impacted by coal ash or coal ash releases. All samples collected from the clay liner exceed relevant Part 201 soil criteria indicating coal ash or coal ash leachate has impacted the liner. EGLE has previously provided the relevant criteria established pursuant to MCL 324.20120a(3). GHBLP provided information that indicated Selenium concentrations exceed Part 201 Groundwater Surfacewater Interface Protection (GSIP) criteria and Statewide Default Background values at all sample locations. Additionally, Lithium concentrations exceed Part 201 Non-Residential Water Protection Criteria and Statewide Default Background Levels at all sample locations. Several other constituents were also above respective criteria at individual points. As stated above, GHBLP's provided data indicates the liner is impacted by releases from the CCR unit, and in order to meet closure requirements under Part 115, the impacted liner areas must be decontaminated.

<u>Response</u>:

In emails dated December 11, and 22, 2020, EGLE took the position that without documentation as to the source of the clay used in the Unit 3 Impoundment, Golder must base its comparison on the Part 201 Statewide residential standards (MCL 324.20120a(3)). As such, Golder evaluated each constituent and compared it to available Statewide background values and the criteria from the 2015 Michigan Soil Survey for the relevant soil lobe. While EGLE has taken a position that the 2015 soil survey should not be used here, that is not consistent with MCL 324.20101(1)(e) which provides that a person may demonstrate that a hazardous substance does not exceed background concentration including by using two standard deviations of that mean for the soil type and glacial lobe area in which the hazardous substance is located. MCL 324.20101(1)(e) calls into question lobe data where fewer than 9 samples are used to calculate for lobe specific data. Per the 2005 Soil Survey, fewer than 9 samples were used with respect to the Michigan lob regarding lithium and iron, therefore it is more appropriate to use the combined Statewide data. Pursuant to 324.20101(1)(e)(ii)(C), the combined Statewide data in the 2015 Soil Survey may also be utilized. Using the combined Statewide data for clay there are no exceedances for arsenic, lithium and iron (with the exception of two samples).

Golder agrees that arsenic, iron, lithium and selenium are above the Statewide Default background screening levels. However, leaving the clay liner materials in place is supported for at least two reasons: (1) the constituents still appear to be naturally occurring and (2) removing these materials would exacerbate the existing conditions beneath the former Impoundments.

The constituents are naturally occurring.

The constituent levels can be attributed to naturally occurring concentrations. It is clear from the 2005 Michigan Soil Survey that the levels reported in the remaining clay are below levels found naturally elsewhere throughout Michigan (see link: EGLE Remediation and Redevelopment Division's Soil Background and Use of the 2005 Michigan Soil Survey (MBSS), Resource Materials, dated September 2019). Further, Golder's evaluations of the remaining clay materials consistently reflect no evidence of material impact by the CCR previously stored in the impoundments on the clay liner which remain after the surficial clay was removed. The areas of clay tested were what was left behind after residuals were removed from the impoundments and the clay visibly impacted by the storage had been removed.

The reported concentrations are statistically equivalent across the remaining liner sample locations suggesting natural occurrence in the clay. Specifically, the results for each sample location are within 20 relative percent difference from the average result for both selenium and lithium. Statistically similar results is an indication that the concentrations are naturally occurring metals in clay soils. Further, if the constituent exceedances were not naturally occurring, it would be reasonable to expect a specific location to have significantly elevated concentrations – that was not the case. Further, residual contamination would not result in uniform concentrations across the clay liner (since the clay liner is not one singular elevation (i.e., floor, sidewalls, and berm). Golder would expect to see concentrations differ at the varying elevations. Specifically, if there was CCR impact remaining in the clay liner, Golder would expect the concentrations to be higher at the floor samples than the sidewalls and even the berm (outside the wetted boundary), which was not observed. In fact, the analytical results detected above background screening levels primarily came from sample locations outside the wetted boundary of the impoundment. Since the CCR material is primarily placed inside the wetted boundary, residual in the clay liner would be anticipated inside the wetted boundary not outside. For example, lithium and selenium were detected at grid sampling node locations 3, 6, 10, 18, 28, 36, 46, 75, 77, and 81, outside the wetted boundary. These are consistent with those levels detected within the wetted boundary. In addition, since each of the randomly selected sample locations for arsenic, iron, lithium and selenium are similar and statistically similar to other locations, it is reasonable to conclude that the observed concentrations are representative of background levels from the clay liner and not indicative of residual CCR in the clay liner. EGLE's "Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria" (S3TM) (EGLE, 2002) allows for a statistical approach to site cleanup. Therefore, the analytical results for arsenic, iron, selenium and lithium are indicative of naturally occurring metals and not residual CCR in the clay liner.

In addition, there were no other CCR related constituents such as boron, cobalt, fluoride, mercury, molybdenum, etc. with reported concentrations above the screening levels which further supports the reported concentrations of selenium are representative of background for the clay liner. If there were CCR impacts to the remaining clay liner, detection of these constituents would be expected. Since the results for the four metals are statistically similar across the randomly selected grid samples and can be associated with organic materials and silicates in clay, the concentrations of the four metals in question in the grid samples is indicative of naturally occurring metals and not residual in the clay liner.

Further, EGLE requested on November 20, 2020 that GHBLP confirm any remaining clay left in place is protective of the GSI, as permitted by Michigan Administrative Code 299.22. In response, we evaluated the clay samples using SPLP analyses to document the remaining clay left in place is protective of the GSI. Review of SPLP results show that remaining clay is below the GSI criteria demonstrating that the conditions are protective of the GSI and protective of human health and the environment. This supports that the clay liner remaining is not impacted and is protective of the Grand River. GHBLP requests that EGLE view the constituent concentrations and define “uncontaminated” as being a condition such that the clay poses no human or ecological risk to human health and the environment. The SPLP results show that constituents do not leach above Rule 57 (GSI) criteria. Therefore, the analytical testing conducted on the remaining clay liner from the former Unit 3 Impoundments does not show evidence of residual in the clay liner.

Avoidance of exacerbation

The only criteria exceeded by the naturally occurring metals are those relating to the protection of drinking water and the GSI pathway. Golder recommends that a site use restriction be placed on the property barring the installation of any wells other than monitoring wells. By taking into account a risk-based approach and considering the underlying ash and MSW that is under the clay liner left in place, this would avoid exacerbation as required by Part 201, MCL 324.20107a. This would take into account the probable risks to human health and the environment when exposing the substrate materials beneath the clay layer by removing that unimpacted clay in place. Given past use and what is underlying the clay, Golder recommends to the GHBLP that the site have appropriate restrictions (per the use of a restrictive covenant) on the property to ensure no direct contact.

Golder believes that Unit 3 was properly closed and such closure was protective of the environment, particularly considering the materials that exist beneath the original clay liner. The former Unit 3 impoundment clay liner materials left in place are more protective of the environment by providing a cap over those substrate materials, particularly given the high water tables in the Grand River which could infiltrate those areas without that clay layer. EGLE’s position appears to be that the clay in this location must be stripped off the former Unit 3 leaving the existing historical fill materials underneath exposed to leach out to the environment. This would certainly exacerbate the existing materials – something prohibited by Part 201. EGLE’s position appears to be based on the presence of some naturally occurring metals in the clay without any other indication that the clay has been impacted. While four of the metals exceed the State’s conservative residential standards for protection of drinking water and surface water receiving groundwater, such levels would be well below naturally occurring levels throughout the State. Further, there are no drinking water wells on the property and testing of the clay materials confirms that the metals do not leach – meaning that surface water is protected and that these metals are naturally occurring.

3.0 DECONTAMINATION EXTENTS

EGLE: GHBLP provided a strategy for documenting the depth of coal ash contamination to the liner but did not provide a strategy for documenting the horizontal extents of contamination above background or respective Part 201 soil criteria. GHBLP must provide documentation demonstrating that contaminated areas of the liner have been decontaminated both horizontally and vertically. There is no documentation that the extent of impacted soils has been delineated. In order to achieve closure, GHBLP must provide this documentation and perform any additional work needed to document that both the horizontal and vertical extent of contamination has been removed.

Response: Golder has already performed a horizontal extent testing program as recommended by EGLE's "Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria" (S3TM) (EGLE, 2002). Golder performed horizontal testing by means of using a grid spaced at 25 feet on center, a grid spacing which is less than is required for a medium site per calculations provided in the S3TM. Golder also performed sampling using vertical extents at 6-inch intervals (S3TM calls for at least one sample per 5 feet of depth, which can be at the surface) at the failed nodes until a passing test was obtained and then removed surrounding material to a minimum 5-ft diameter and replaced with clean clay under Golder's supervision and observation. Each of the nodes that failed for percentage of CCR (18, 43, 46, and 81) and per analytical results (33, 48, 50, and 77) were surrounded by passing grid nodes, which were sampled per the S3TM and which passed as described above, therefore delineating the maximum extent of the horizontal failures. Golder has already documented cleanup by using EGLE's guidance that both the horizontal and vertical extents of contamination have been removed.

EGLE: GHBLP additionally has not demonstrated that it addressed all areas impacted by the impoundments. Specifically, the grid area investigated did not contain all areas that are adjacent to the Unit 3 impoundments utilized for ash storage and placement from the Unit 3 impoundment area. GHBLP staff should have conducted an appropriate inquiry and documented all areas where ash was stored/spilled prior to disposal when the units were in operation and routinely mechanically cleaned. In December 2020, EGLE provided to GHBLP photographic documentation from a 2014 EPA report of coal ash stored/spilled outside the gridded boundaries, which provides GHBLP with a limited snapshot of waste outside the grid area GHBLP has investigated. These areas identified in the 2014 EPA report and any additional impacted areas will need to be included for documentation of removal and decontamination.

Response: Overtopping of the impoundments did not occur, therefore we assumed that the ash being described in this comment is related to the methods used to clean the CCR from the impoundments and any spillage that resulted during cleaning operations. The ash in the areas outside the clay lined impoundments crest was removed at the same time as the rest of the ash. Golder will prepare a separate work plan with lines of evidence to demonstrate that CCR materials present outside the limits of the Unit 3 Impoundments have been properly removed. In this case, we will not have a clay liner. We will instead have multiple and distinct types of native and fill sources to compare using visual methods. The multiple lines of evidence approach provides a predictable and reliable means to objectively measure concentrations of CCR based on physical sample properties. The approach takes advantage of the clear visible distinction between the color of the bottom ash type CCR that was present in the Unit 3 Impoundments and the color of the underlying sandy soils or underlying island fill (fly ash or municipal solid waste (MSW)).

The following information will be obtained to document that possible bottom ash CCR removal is met for areas outside of the clay liner for Unit 3 CCR at JB Sims using a sampling grid as provided in the S3TM.

- First line of evidence – comparison of the excavation surface to known elevations of the original perimeter road surface, based on historical information as available.
- Second line of evidence – photographic documentation including periodic photographs of bottom ash CCR removal progression and photographs of excavated areas at random grid nodes.
- Third line of evidence - quantitative colorimetric analysis, using multiple newly established baselines, at random grid nodes to confirm Unit 3 bottom ash CCR removal from either multiple underlying materials (native sands/other types of ash/fly ash/MSW).
- Alternative third line of evidence – microscopic quantification of bottom ash CCR content where excavated areas are greater than 5-percent bottom ash CCR in the colorimetric samples for confirmation.

An analytical line of evidence is not required for this work plan. Bottom ash Unit 3 CCR removal that was originally from Unit 3 is the goal.

If EGLE agrees with this strategy, we can move forward with preparing the work plan for EGLE to approve and then performing the work.

4.0 CLAY LINER LEFT IN PLACE

EGLE: While not noted as part of coal ash removal and impacted clay liner removal, several of the close-up photographs of grid points show large amounts of cracking and lack of a monolithic clay liner in the Unit 3 impoundments. This lack of a monolithic clay liner and the lack of construction documentation standards to ensure appropriate construction to install a monolithic clay liner indicates that the liner may have not prevented releases to the underlying soils/waste and to the groundwater below the unit.

Response: EGLE did not list photographs that specifically show a lack of monolithic clay. The Unit 3 clay liner material certainly appeared to be monolithic when viewed in the field and therefore EGLE's comment is incorrect.

As you are aware, the construction of Unit 3's 3-foot-thick clay liner in 1983 included construction quality assurance (CQA) documentation including compaction using approved nuclear moisture/density testing methods which was documented in the August 19, 1983 J.B. Sims Station Unit 3 Ash Pond Construction report, prepared by Black & Veatch. Black & Veatch is a reputable engineering firm that is still in operation today. Appropriate compactive effort being used on clay liners will decrease the permeability and will promote alignment of the clay particles perpendicular to flow through the liner. Golder notes that the Unit 3 Impoundments were designed specifically with seepage control structures and a geotechnical analysis of the design of the compacted clay liner specifically to provide assurance against cracking due to settlement (B&V, 1983). During construction of the clay liner, compaction testing was performed under the direction of an experienced engineer (B&V, 1983). The integrity of the Unit 3 clay liner constructed in 1983 is evidenced by the fact that the Impoundments held water throughout operations.

In addition to the construction certification report, the direct observation from CQA monitors in the field, and the consistent performance throughout their operation, the integrity of the Unit 3 Impoundments' clay liner is also evidenced through the Alternate Source Demonstration (ASD) that was prepared by Golder, dated December 28,

2020. The investigation and evaluation indicate that the source of groundwater contamination is from the historical ash and MSW that is directly beneath the clay liner.

During the CCR and CCR contaminated clay removal project in 2020 for Unit 3 Impoundments, Golder's experienced engineers were on site during detailed CCR and CCR contaminated clay removal. Using Golder's extensive experience with cohesive soils, it is common that when clays are unloaded, water is removed and the clay surface is exposed to dry air, suction effect pulls the clay particles apart in a "scales" type pattern. This is commonly referred to as desiccation. The photographs that EGLE is referring to in this deficiency can be found in Appendix C of the Unit 3 Closure Report (Golder, 12-11-2020), specifically photographs 20, 21, 37, 39, and 42. These appear to be desiccation cracks as described above. This agrees with the fact that there was no longer water on top of the clay to keep the clay moist and in a confined condition which would hold the surficial clay particles together. During operation of the ponds, desiccation would not have been possible since the clay was under water and not exposed to dry air.

EGLE is not considering the multiple lines of evidence that have been documented in the Unit 3 Closure Report and is assuming, incorrectly, that the clay liner has leaked. We have presented multiple lines of evidence that prove the liner did not leak, including an excavation profile, visual, photographic, colorimetric analysis, microscopy, and analytical testing program. The testing program followed EGLE's guidance for soil cleanup (EGLE, 2002). Based on the characteristics of the coal ash and resulting porewater that was stored in the ash pond, if a release were to have occurred, soil staining would have been observed as the ash and clay liner was removed. Soil staining was not observed after the CCR and top several inches of the clay liner was removed.

5.0 REFERENCES

Black & Veatch. August 19, 1983. City of Grand Haven, Michigan Board of Light and Power J.B. Sims Station, Unit 3 Ash Pond Construction Report.

Golder Associates Inc. December 11, 2020. J.B. Sims Generating Station, Unit 3 Impoundments – CCR Removal Documentation Report.

Golder Associates Inc. December 28, 2020. Alternate Source Demonstration, J.B. Sims Generating Station – Unit 3 Impoundments.

Michigan Department of Environment, Great Lakes and Energy (EGLE). 2002. Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria.

6.0 CLOSING

The closure of Unit 3 was performed in a manner that is protective of the environment. Golder has considered the other environmental concerns on the site and has the necessary documentation that the clay liner left in place is protecting the underlying historical ash and municipal solid waste, coupled with future site use restrictions. Golder and GHBLP understand and appreciate the nature of these comments provided by EGLE; however it is important to move forward with closure of Unit 3 so that GHBLP can move to the next step of Unit 1 and 2 Impoundment closure and site remediation for the underlying historical ash and municipal solid waste at JB Sims.

Golder trusts that the additional information provided in this letter addresses the deficiencies provided by EGLE on January 21, 2021.

Sincerely,

Golder Associates Inc.

Carolyn Powrozek, C.P.G.
Senior Geologist

Tiffany D. Johnson, P.E.
Principal and Senior Consultant

CC:

David Walters – GHBLP
Erik Booth, P.E. – GHBLP
Paul Cederquist – GHBLP
Arthur Siegal – Jaffe, Raitt Heuer & Weiss, P.C.

Attachments:

Attachment 1 – Revised CTL Group Baseline Report for JB Sims Unit 3
Attachment 2 – Revised CTL Group Results Report for JB Sims Unit 3

https://golderassociates.sharepoint.com/sites/106416/18113350_ghblp jb sims/5 technical work/unit 3 cqa/closure report/egle deficiency letter 1-21-21/unit 3 cqa- egle denial response memo 2-22-21.docx

ATTACHMENT 1

Revised CTL Group Baseline Report

MEMO

Project No.: 150419
To: Tiffany Johnson
Golder Associates, Inc.

Date: August 12, 2020
From: L. Powers and J. Ferraro

Subject: **Calibration Curve for J B Sims Unit 3 Pond CCR Removal Colorimetry Samples**

Thirteen samples, listed in Table 1, were received on July 22, 2020. A portion of each sample was dried and pulverized for analysis. Visual examination suggested that the clay soil represented by Sample U3E-CS-03 and the bottom ash represented by Sample U3W-BA-03 were the most homogeneous in terms of color. **Color was measured for all samples. Clay soil[1] samples with similar color values were combined to obtain sufficient material for the preparation of mixtures.**

The appearance of the processed clay composite soil is shown in Fig. 1. Sample U3E-CS-03, shown in Fig. 2, contains granular sand particles that may be a site contaminant. The presence of quartz does not noticeably affect the color measurement of this sample and the presence of the sand particles was diluted by combining this sample with other clay soil samples. The appearance of the as-received CCR is shown in Fig. 3; the as-received appearance best illustrates the characteristics of the material.

Mixtures of 0%, 3%, 5%, 10%, 15%, and 20% were prepared for colorimetric analysis to construct the calibration curve. The mixtures used combined clay soil samples U3E-CS-01, U3E-CS-03, and U3E-CS-05, and CCR Sample U3W-BA-03. The calibration curve is presented in Fig. 4. Mixtures of 4.8% CCR and 9.0% CCR were analyzed as checks (arrows in Table 2).

Methods: Color was measured using an X-Rite® Sphere Spectrophotometer, Model Ci62, Serial Number 013714. Analyzed sub-samples were flattened with and measured through a glass slide; glass correction was applied and specular component was included. Colorimetric values were determined for the CIE D65 Illuminant (daylight 6500k) and 2° standard observer. Optical microscopy was performed using a Leica S9D stereomicroscope.

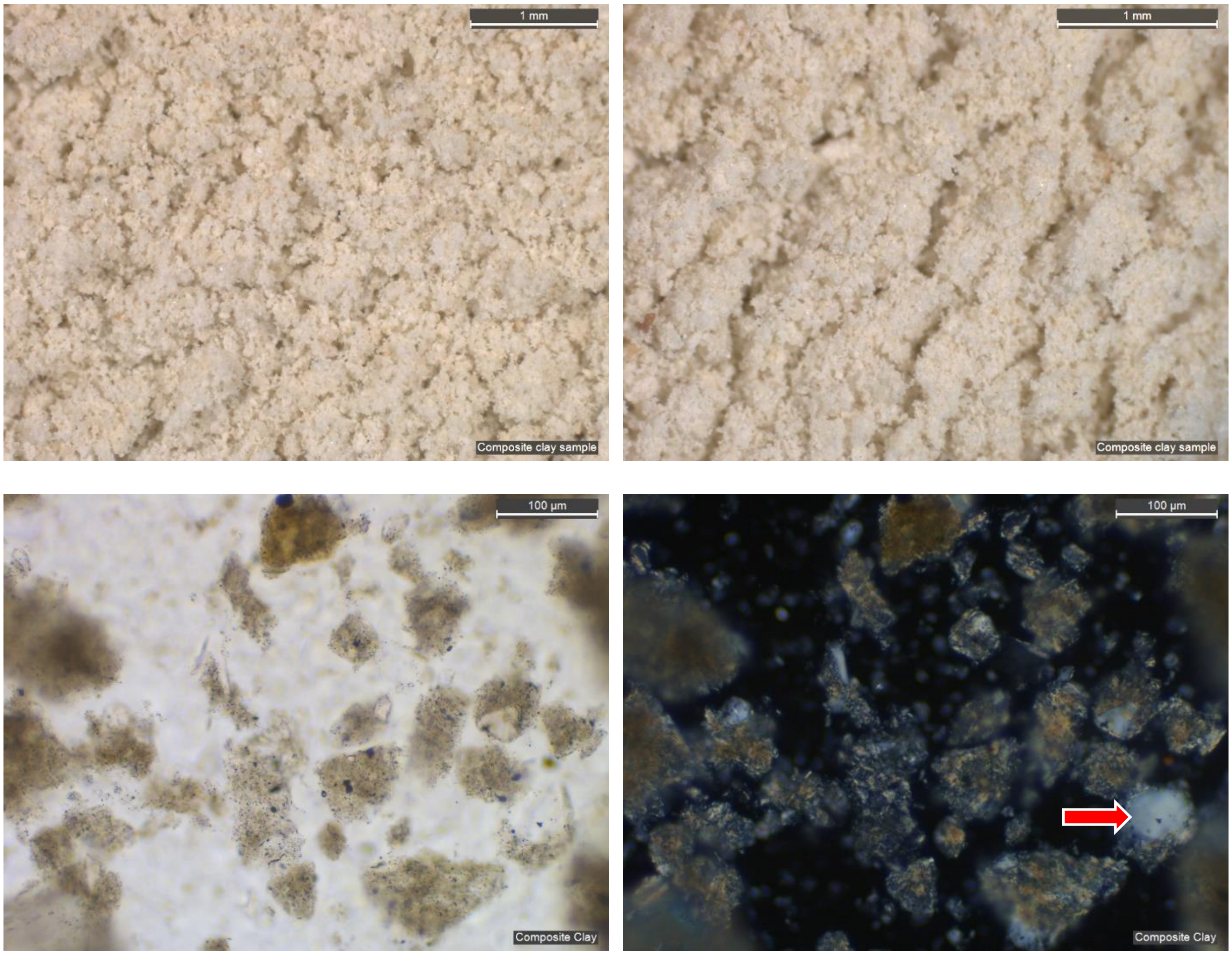
[1] Clay is defined as sediment consisting of particles less than 0.005 mm. Constituents may include a variety of minerals other than clay minerals. Common minerals include quartz, feldspar, and iron compounds.

TABLE 1 J B SIMS UNIT 3 POND SAMPLES

U3E-BA-01	U3W-BA-01	U3E-CS-01	U3E-CS-04
U3E-BA-02	U3W-BA-02	U3E-CS-02	U3E-CS-05
U3E-BA-03	U3W-BA-03	U3E-CS-03	U3E-CS-06
U3-F-01 FILL			

TABLE 2 CCR CONCENTRATIONS AND COLOR VALUES

% bott ash	CIE LAB			RGB Integer value	
	L*	a*	b*		
0.0	68.66	4.13	15.67	4500775	
3.0	68.1	3.91	15.31	4464018	
4.8	67.18	3.69	14.88	4403668	
5.0	66.22	3.88	15.12	4340802	
9.0	65.39	3.57	14.59	4286328	
10.0	64.79	3.53	14.48	4246996	
15.0	63.99	3.29	13.97	4194505	
20.0	61.64	2.98	13.1	4040415	
100.0	32.22	0.2	3.46	2111625	



Plane-polarized light | Cross-polarized light

Fig. 1 Composite Clay Soil. Stereomicroscope photographs in the top row show the appearance of the dried and pulverized composite soil sample. Polarized-light micrographs in the bottom row show the constituents of the sample. Chunks of fine-grained clay are the major constituent. Quartz fragments (example shown with red arrow) make up approximately 1% of the composite sample.

Fig. 2 Granular Material in Clay Soil Sample U3E-CS-03. The soil sample consists of powder and granules of quartz, feldspar, and granite. The area photographed was intentionally selected to illustrate the granular particles and does not represent the overall abundance of these particles in clay soil sample.

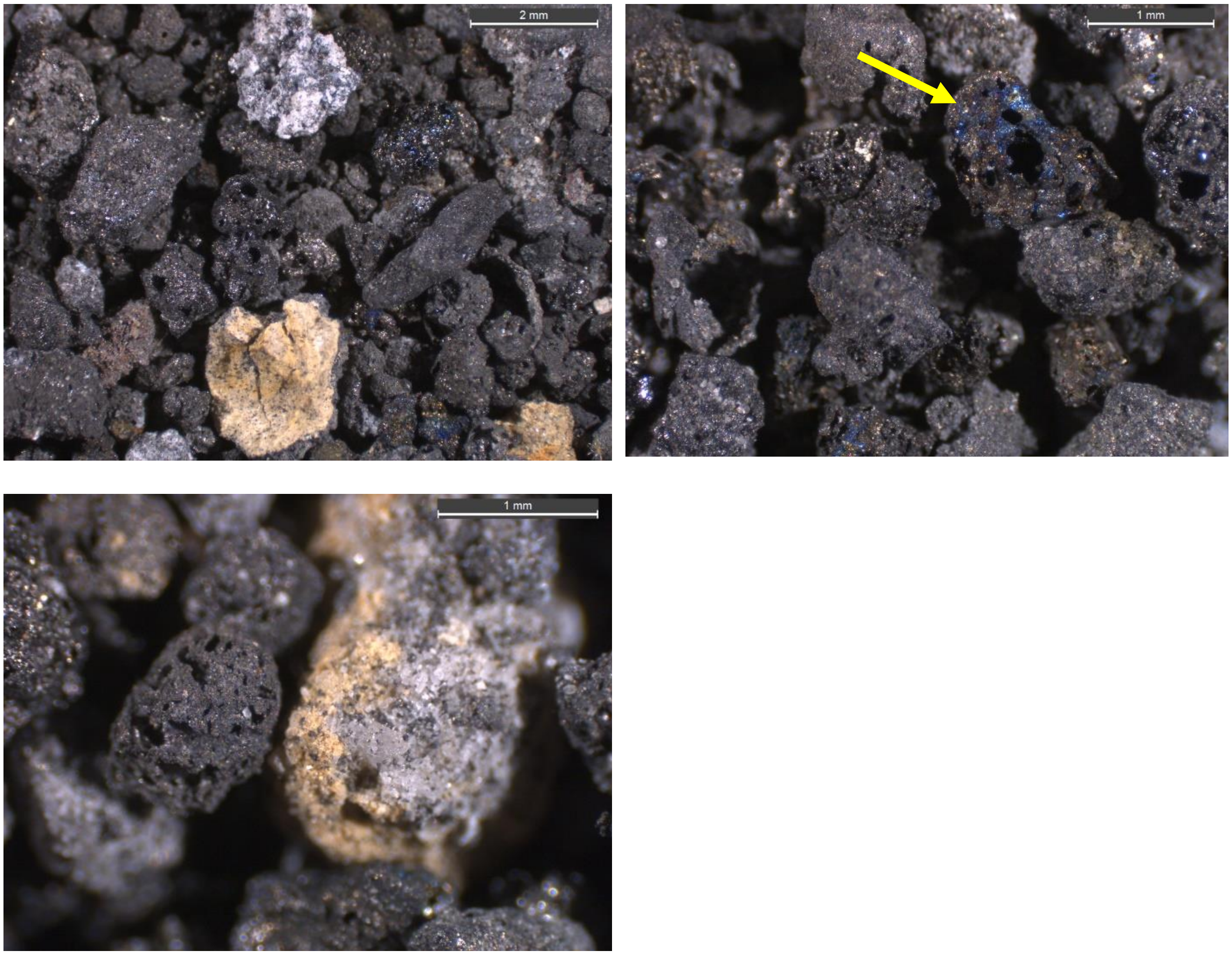


Fig. 3 CCR Sample U3W-BA-03. CCR particles are predominantly porous and black. Smaller amounts of white-gray and yellow-beige particles. Many particles exhibit peacock iridescence (arrow).

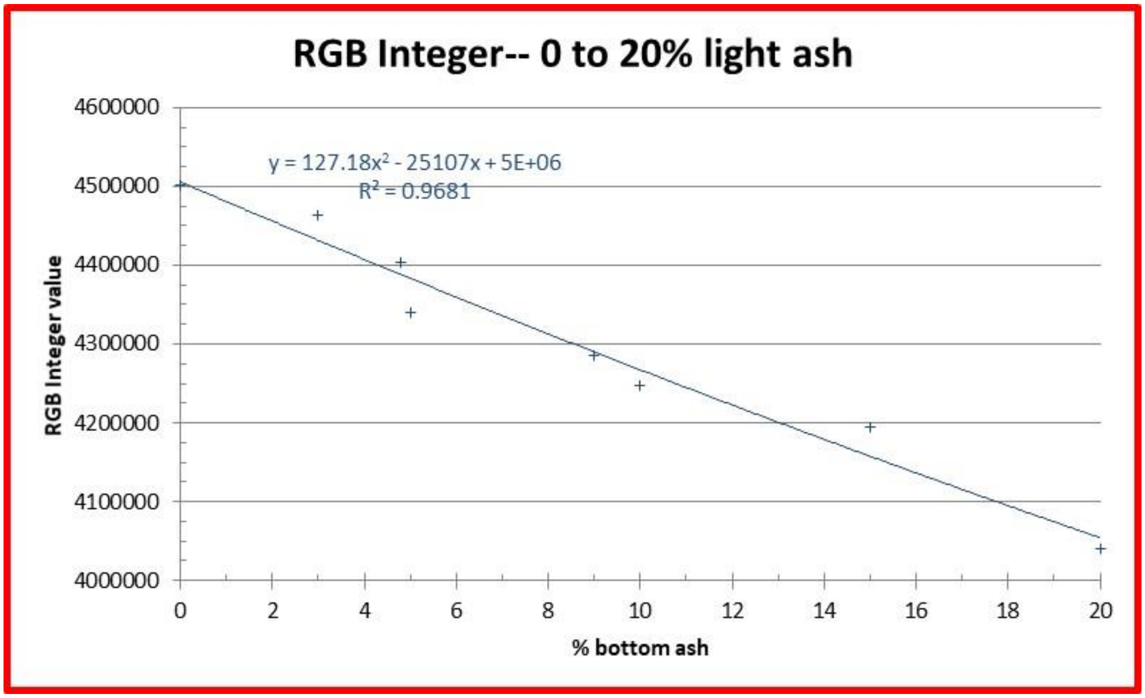


FIG. 4 CALIBRATION CURVE

ATTACHMENT 2

Revised CTL Group Results Report

Report of Colorimetry and Microscopical Analysis of CCR Content
JB Sims Generating Plant, Grand Haven, Michigan

Project No.: 150419
To: Bryan Brown, Golder Assoc., Inc.
Tiffany Johnson, Golder Assoc., Inc.

Date: February 4, 2021
From: Laura Powers

Results of colorimetry and optical microscopy analyses of samples obtained during CCR removal operations are presented in Table 1. CCR contents determined by colorimetry are based on a calibration curve developed for JB Sims Generating Plant, Grand Haven, Michigan using CCR and clay samples received by CTLGroup on July 22, 2020. The curve was generated using 100% clay, and mixtures of each clay with 3%, 5%, 10%, 15%, and 20% CCR.

Color Measurement: Color was measured using an X-Rite® Sphere Spectrophotometer, Model Ci62, Serial Number 013714. Analyzed specimens were flattened with and measured through a glass slide; glass correction was applied and specular component was included. Colorimetric values were determined for the CIE D65 Illuminant (daylight 6500K) and 2° standard observer.

Optical Microscopy: Microscopical examination was performed using a Leica S9D stereomicroscope to assess the quantity of CCR in each node sample. The amount of CCR was visually determined in at least ten fields of view at magnifications of 25X to 55X using comparison charts[1].

SAMPLES

Twenty-one node samples received on November 19, 2020, and nine re-test samples received on November 25, 2020, from Aaron Bickel, Golder Associates, Inc. are listed in Table 1. Samples from each node location had been processed by Golder Associates, Inc. in Lansing, Michigan. Half of each sample had been dried and pulverized to pass No. 30 U.S. Standard sieve and half had been dried but not pulverized. CTLGroup performed color analysis on each pulverized sample. Quantities of CCR determined by colorimetry are given in column 2 of Table 1. Amounts exceeding 5% are in bold. Re-test and additional node samples are shaded in Table

[1] Terry, R. D. and Chilingar, G. V., 1955, *Summary of "Concerning Some Additional Aids in Studying Sedimentary Formations" by M. S. Shvetsov*, Journal of Sedimentary Petrology, Vol. 25, No. 3, pp. 229-234.

1 and are designated by node number and -1 or -2 and depth (when this information was included).

Microscopical examination was performed on companion samples that had been dried but had not been pulverized by Golder. ***These samples were prepared for microscopy using mortar and pestle to break apart the material, minimizing shattering of CCR particles to aid in their identification. The difference in hardness (clay is soft and CCR is hard) results in larger hard angular fragments of CCR embedded in clumping soft powdery clay. Homogenization of particle size, which is advantageous for colorimetry, reduces the size of the CCR particles making it necessary to use polarized-light microscopy of immersion mounts to estimate CCR content instead of using stereomicroscope examination. For illustrative purposes, some samples were photographed after minimal crushing in order to show embedded CCR particles with less interference from clay powder; clay particles are electrically charged and are readily attracted to CCR particles and to each other (causing clumping).***

Quantities of CCR determined by microscopy are given in column 3 of Table 1. Two samples, Node 3 and Node 28, determined by colorimetry to have 0% CCR, were verified by microscopy. Samples determined by colorimetry to have greater than 5% CCR (Nodes 18, 43, 46, and 81) were examined microscopically and confirmed to contain more than 5% CCR. The amount of CCR in sample Node 43 determined by microscopy is 4 to 5% by volume. Typical CCR particles in these samples are illustrated in Figs. 1 through 4.

Results of Re-Test: The re-test samples were analyzed by colorimetry and microscopy. Node 18 @ 6 in. contains more than 5% CCR by both methods. Node 18 @ 12 in. contains less than 2% CCR. Node 81 @ 6 in. contains less than 5% CCR by both methods; however, Node 81 @ 12 in. contains 5.5% CCR by colorimetry and 3 to 4% CCR by microscopy.

Table 1 CCR Content Determined by Colorimetry and Microscopy

Node	Colorimetry % CCR	Microscopy % CCR
3	0	0
6	0	n.d.*
10	0	n.d.
13	0	n.d.
18	**>20**	**16 - 18**
18-1 (6 in.)	**7.5**	**5 - 6**
18-2 (12 in.)	1.5	1 - 2
22	0	n.d.
28	0	n.d.
33	2.0	1 - 2
36	4.0	2 - 3
39	2.0	1 - 2
43	**6.5**	**4 - 5**
43-1 (6 in.)	3.8	2 - 3
45	4.5	3 - 4
46	**7.5**	**5 - 6**
46-1 (6 in.)	4.5	2 - 3
46-2 (12 in.)	3.5	1 - 2
48	4.5	3 - 4
50	4.5	3 - 4
56	4.0	3 - 4
58	4.0	3 - 4
61	4.0	2 - 3
67	2.0	1 - 2
75	2.0	1 - 2
76	2.0	1 - 2
77	2.0	1 - 2
81	**5.5**	**6 - 7**
81-1 (6 in.)	3.8	2 - 3
81-2 (12 in.)	**5.5**	3 - 4

Notes:

*not determined
Original samples determined to contain >5% CCR are in bold.
Re-test samples received Nov. 25, 2020 are shaded blue.

PHOTOGRAPHS OF CCR IN NODE SAMPLES

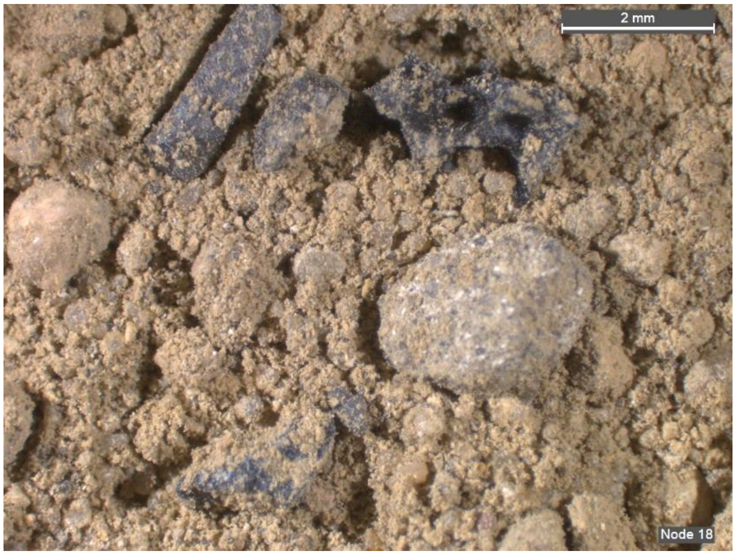


Fig. 1 Node 18 – The dark particles are CCR. The sample mainly consists of clay, iron oxides, and quartz sand particles.

Fig. 2 Node 43 – The dark particle is CCR. The sample mainly consists of yellow clay and pale gray clay.

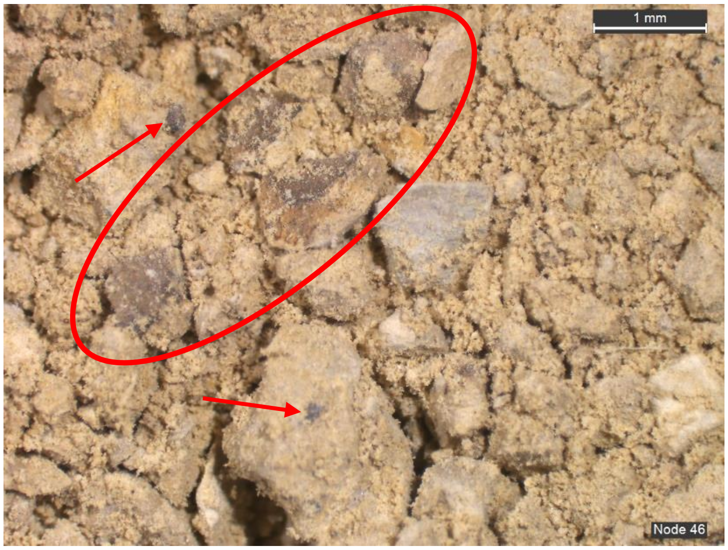


Fig. 3 Node 46 – Dark specks (arrows) and rust-colored particles (circled) are CCR. The sample mainly consists of yellow clay. Minor amounts of quartz, feldspar, and chert are observed.

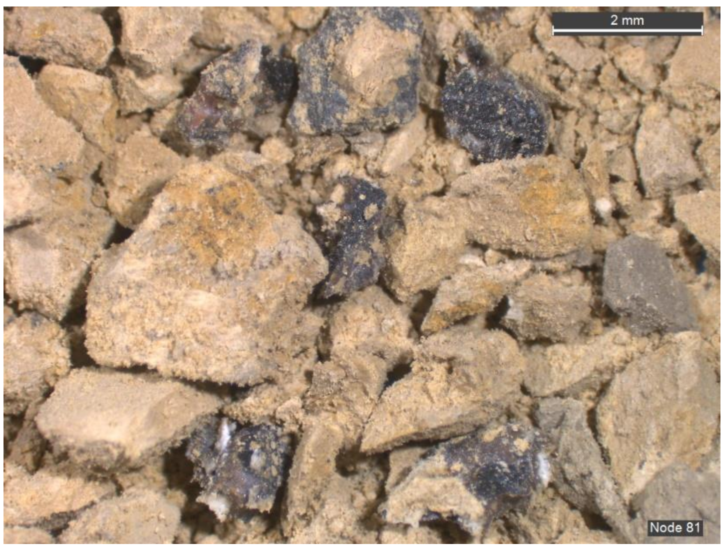


Fig. 4 Node 81 – Dark particles are CCR. The sample mainly consist of buff, yellow, and pale gray clay.

PHOTOGRAPHS OF RE-TEST SAMPLES

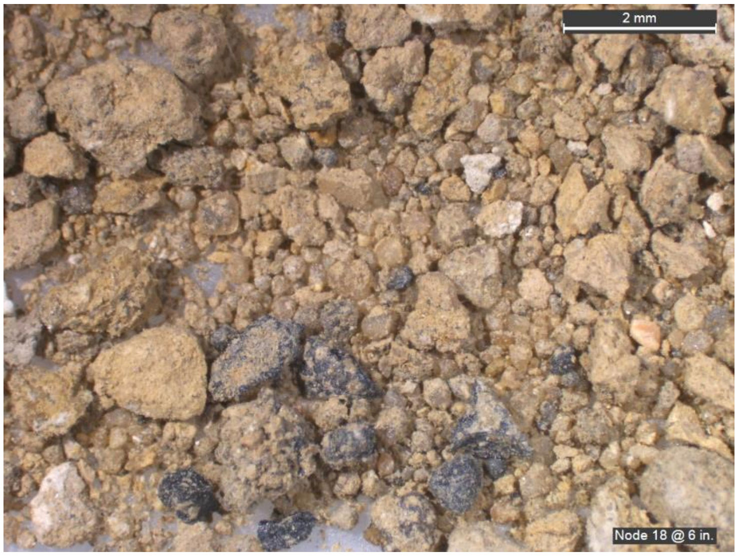


Fig. 5 Node 18 6 in. – Dark particles are CCR. The sample mainly consists of yellow clay and pale gray clay.

Fig. 6 Node 18 12 in. – Dark patches are CCR embedded in clay.

Fig. 7 Node 43 6 in. – Dark particles are CCR. The sample mainly consists of yellow clay.

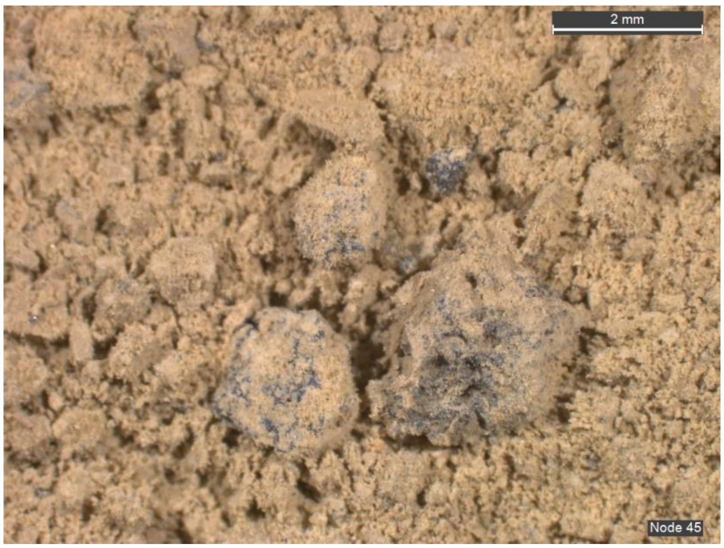


Fig. 8 Node 45 – Dark particles in center are CCR. The sample mainly consists of yellow clay.

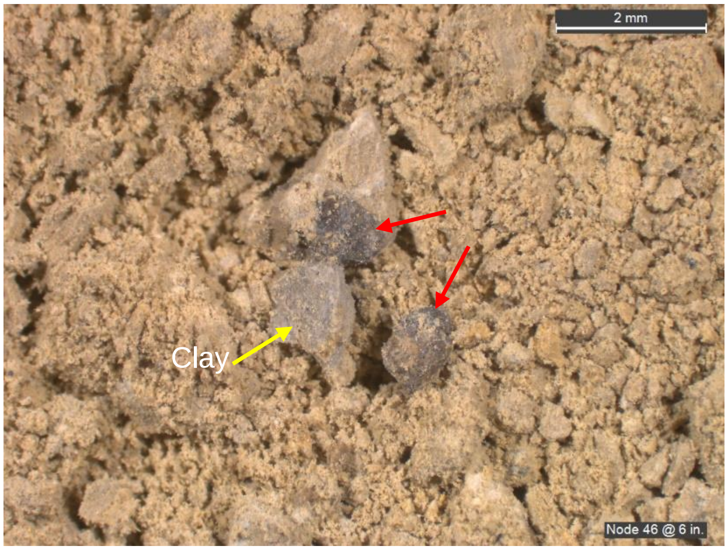


Fig. 9 Node 46 6 in. – Dark patch and dark particle are CCR. Gray particle is clay. The sample mainly consists of yellow clay.

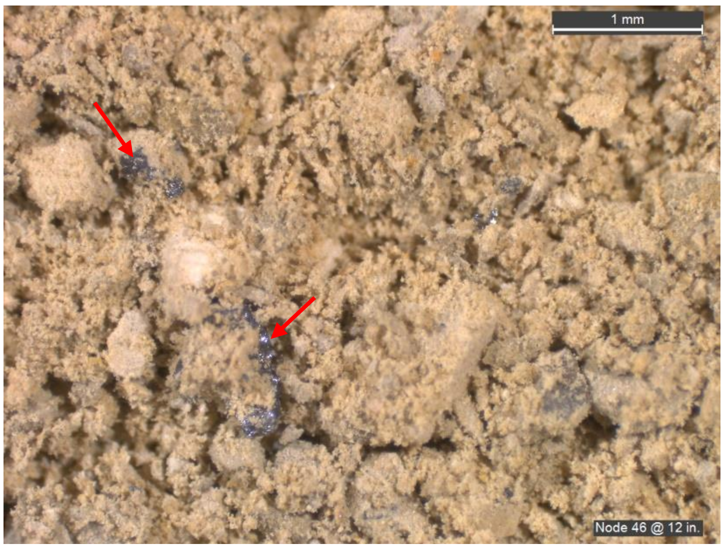


Fig. 10 Node 46 12 in. – Dark particles (arrows) are CCR. The sample mainly consists of yellow clay. Small amounts of quartz sand particles are also present.

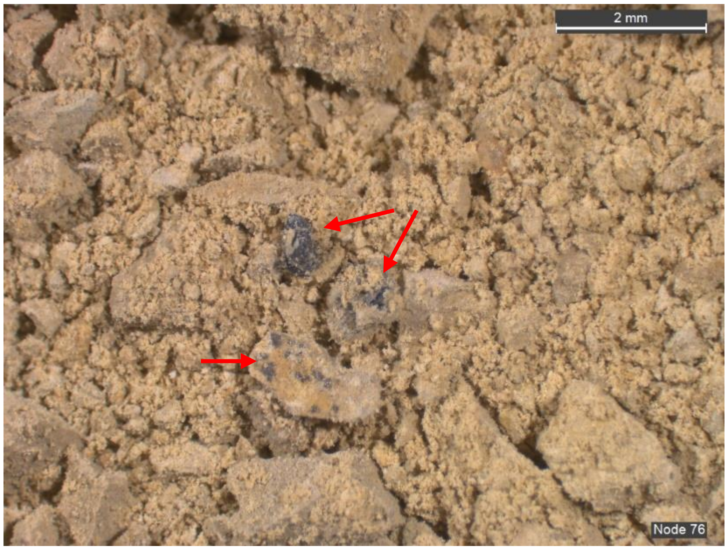


Fig. 11 Node 76 – Dark particles are CCR. The sample mainly consists of yellow clay and pale gray clay.

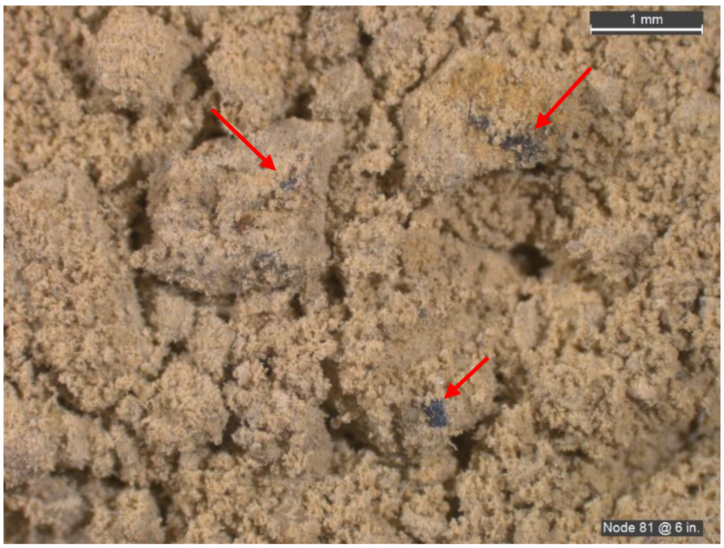


Fig. 12 Node 81 6 in. – Dark patches are CCR embedded in clay. The sample mainly consists of clay.

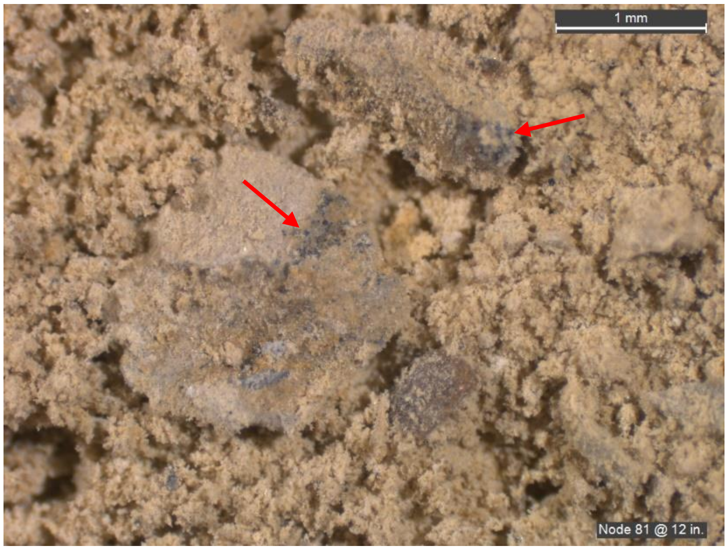


Fig. 13 Node 81 12 in. – Dark patches are CCR embedded in clay. The sample mainly consists of clay.

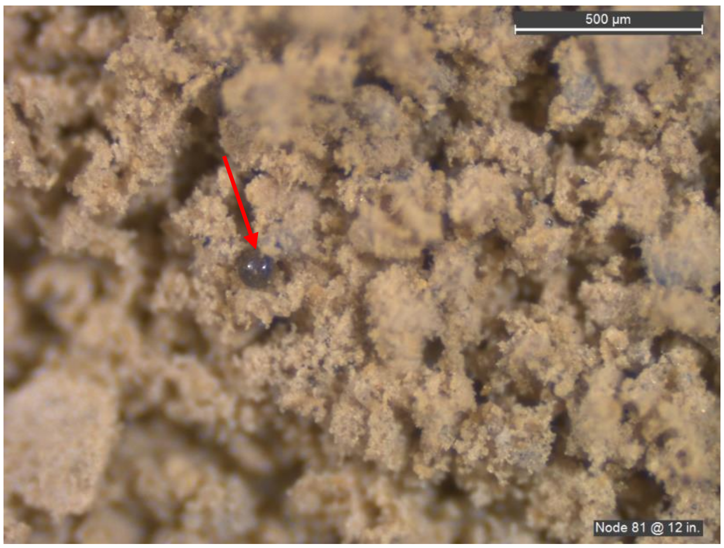


Fig. 14 Node 81 12 in. – Rare spherical glassy CCR particle.

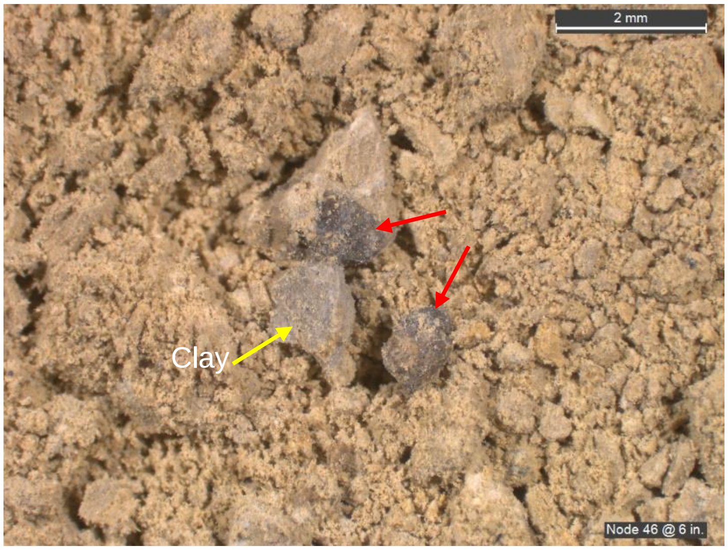


Fig. 15 Node 46 6 in. – Dark patch and dark particle are CCR. Gray particle is clay. The sample mainly consists of yellow clay.

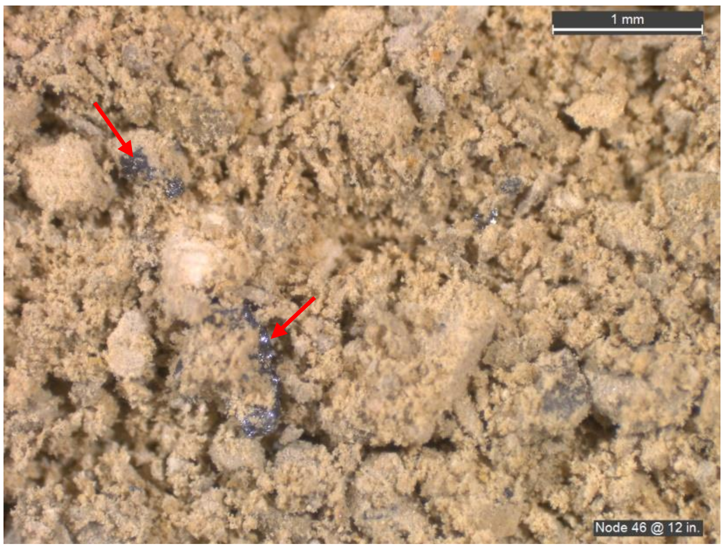


Fig. 16 Node 46 12 in. – Dark particles (arrows) are CCR. The sample mainly consists of yellow clay. Small amounts of quartz sand particles are also present.