BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

In the Matter of:	)	
STANDARD FOR THE DISPOSAL OF COAL COMBUSTION RESIDUALS IN SURFACE IMPOUNDMENTS: PROPOSED NEW 35 ILL. ADMIN. CODE 845	)	PCB 2020-019 (Rulemaking - Water)

NOTICE OF ELECTRONIC FILING

To: Attached Service List

PLEASE TAKE NOTICE that on August 27, 2020, I electronically filed with the Clerk of the Illinois Pollution Control Board ("Board") the **TESTIMONY OF ANDREW REHN** and **ATTACHMENTS**, copies of which are served on you along with this notice. Attachments are being filed separately due to size restrictions.

Dated: August 27, 2020

Respectfully Submitted,

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)
	)
STANDARDS FOR THE DISPOSAL OF	) R 20-19
COAL COMBUSTION RESIDUALS IN	) (Rulemaking – Land)
SURFACE IMPOUNDMENTS:	)
PROPOSED NEW 35 ILL. ADM. CODE	)
845	)

PRE-FILED TESTIMONY OF ANDREW REHN

I am a water resources engineer at Prairie Rivers Network. I began full time at Prairie Rivers Network in November of 2015, shortly after receiving my Master's Degree in Civil Engineering at the University of Illinois in Urbana Champaign, where I had also studied as an undergraduate. Prairie Rivers Network sought out an engineer to have someone on staff with a technical background who could review permits and industry plans, such as coal ash closure plans or NPDES permits. Most of my work at Prairie Rivers Network has been focused on coal ash, and I believe my perspective will be helpful to the Board in this rulemaking.

In my time at Prairie Rivers Network, I have made it my goal to understand, and share understanding, about the coal ash problem in Illinois. To that end, I have spent years collecting information about coal ash across the state and organizing that information. My search has included the US EPA Structural Stability Assessments following the massive Kingston coal ash pond collapse, NPDES Permits, Illinois EPA violation notices, closure plans, federal CCR rule documentation, and more. To disseminate that information to the public, I created a database with a searchable map interface to allow the public to see the physical location of coal ash ponds and access available technical information. Unfortunately, that map is no longer accessible because Google stopped supporting application that connected the database to the map.

I also engage with communities near coal ash ponds across the state, offering support when closure plans are proposed or helping prepare for NPDES permit hearings. I help community members expeditiously access technical information by assisting with FOIA requests and other information collection tasks, and I meet with community members to discuss that information. In that way, I see my role as crucial in the regulatory process. This seems problematic to me. The public should not need assistance from a full-time staff person at a non-profit in order to properly engage in the regulatory process. The process should be set up so that community members are able to easily access the necessary information on their own.

In my role at Prairie Rivers Network, I have also reviewed many of the technical documents – such as proposed NPDES permits and closure plans – that Illinois EPA reviews and approves. I have submitted comments on these technical documents and raised questions that the Agency has not considered. I suspect that I am often only the second or third pair of eyes that do a full review of the technical documentation. It is my understanding that at some point Illinois EPA's groundwater division had approximately one full time employee's worth of staff time for coal ash issues – which is about the same full time employee capacity as Prairie Rivers Network to work on the coal ash issue. In addition to adding capacity, I have also found that I, and other community members and NGO staffers, often bring a different perspective that the Agency has not considered in its evaluation of coal ash documentation.

I. Illinois's Coal Ash Problem

There is well documented impact to groundwater from coal ash sites in Illinois, and it is not just from the impoundments. In 2018, Prairie Rivers Network partnered with Earthjustice, Environmental Integrity Project, and Sierra Club to collect the groundwater monitoring data from dozens of industry reports released to comply with the federal CCR rule. I helped to manually copy the Illinois groundwater monitoring results into a database, and prepare a report based on those results, which we called *Cap and Run: Toxic Coal Ash Left Behind by Big Polluters Threatens Illinois Water*. When available, we also included groundwater data retrieved under FOIA from Illinois EPA for sites not covered by the federal rule at the time. We reported on groundwater quality at coal ash sites near 24 power plants in Illinois, and found that 22 of the 24 coal ash sites had pollutants above health-based thresholds, namely EPA's presumptive groundwater protection standards and Illinois's Class I groundwater quality standards, which apply to potential drinking water. We found that industry's own reporting showed that coal ash impoundments in Illinois were leaking pollutants like arsenic, boron, cadmium, cobalt, lead, selenium, and thallium at unsafe levels.

Not all the pollution we reported was related to coal ash impoundments. The monitoring also included groundwater near coal ash landfills, as is required under the federal rule, and we found that the landfills were also impacting groundwater. For example, at the Duck Creek landfill, arsenic, cobalt, lead, and lithium were all found above health-based thresholds. At Hennepin, lithium and molybdenum were found over health-based thresholds. At Newton, arsenic was found over health-based thresholds. Clearly, landfills are also a problem that needs to be addressed in Illinois.

I also reviewed the liner status for the impoundments in Illinois reported for the federal CCR rule. I found that the vast majority of Illinois coal ash impoundments submitting reports do not have liners that meet federal requirements. I know that many of the impoundments that did not report are also unlined.

Lastly, copying the published groundwater data into a spreadsheet was surprisingly difficult, as many of the reports were not provided in a machine-readable format and copying data to spreadsheets required using Acrobat's text recognition tool on the documents and continuous quality control to ensure the recognized characters were correct. Having the data in spreadsheet form is critical to run analytics to better understand or visualize the pollution from coal ash. The proposed rule should require industry to submit machine-readable results. Data sets should be submitted in written <u>and</u> spreadsheet form to allow easy analysis of the data.

II. Structural Stability & Safety Factor Assessment

In 2016, coal ash owners released reports on the safety factors of their coal ash ponds. As I understand it, each coal ash impoundment must meet or exceed a minimum safety factor. This analysis is done for several different loading conditions, which I understand to mean circumstances under which the impoundment might fail.

When owners and operators posted those safety factor reports in 2016, I collected the reports for impoundments in Illinois. While none of the impoundments failed to meet their minimum safety factors, many were very close. Ash Pond No. 1 at Coffeen met the minimum long-term loading safety factor (1.50) exactly, and other ponds, such as the East Ash Pond at Joppa and the Ash Pond at Edwards, were just a small fraction above the minimum requirements. Both Edwards and Joppa were rated as high hazard potential impoundments, which means that a loss of life is likely in the case of failure. Overall, the industry reports I reviewed showed ash ponds at Coffeen, Dallman, Edwards, Joliet 29, Joppa, Kincaid, Newton, and Waukegan to be within 10% of the minimum required safety factor for one or more loading conditions. I am including those reports as attachments to my testimony. (*See* Attachments 1 - 8).

Third party review of safety factor reports is critical to ensure their accuracy. I understand that the calculations that go into safety factor assessments typically require some assumptions to account for the unknowns present in the real world, which could sway the result one way or the other. I know that assumptions are necessary in most engineering assessments. However, given the potential for these assumptions to sway the results of the analysis and how close some of the impoundments are to not meeting their safety factors, a third party must review the assessment to see if the assumptions are reasonable and the calculations are otherwise accurate. Even in situations where there is no ill-intent, engineers can simply make mistakes and a mistake here could have devastating consequences. We need more educated eyes on the reports to protect against such errors or inappropriate assumptions.

Safety factor analyses alone, which provide a snapshot of an impoundment's slope stability at one moment in time, do not account for all structural stability risks at coal ash impoundments. Factors outside such as an eroding river or likely subsidence can rapidly change conditions at an impoundment and threaten collapse regardless of whether safety factors were met not long before. For example, at the Vermilion site, coal ash sits on banks of the Middle Fork and the river is eroding those banks. Likewise, at Vermilion and other coal ash ponds in Illinois, there are old coal mine shafts located below, or near, the impoundments which could collapse, destabilizing the impoundment. This sort of structural stability threat should be included in the scope of things considered for the Illinois rule. Additionally, the eroding river at the Vermilion site is an example of why structural stability cannot be a one-time analysis. As environmental factors change, so do the stability risks.

III. Closure by Cap

While we have waited many long years for state rules regarding coal ash clean-up and closure, coal ash impoundments in Illinois have been closing. To my knowledge, Venice, Hutsonville, Crawford, Meredosia, Duck Creek, Hennepin, Coffeen, Baldwin, Wood River, and Grand Tower all have approved closure plans for one or more coal ash impoundments on site. In all cases (with the possible exception of Crawford where I don't know what happened), a cap has been part of the approved closure plan. Illinois EPA has yet to approve a closure plan that requires closure by removal of all coal ash impoundments at a site. In part, this may be due to the way I've seen Illinois EPA regulate coal ash sites, which is to request more information about industry proposals until the company refines their solution to something that Illinois EPA can accept. If this back and forth becomes a stalemate, Illinois EPA might deploy its only prescriptive tool – an enforcement action. In my opinion, this regulatory method incentivizes industry to do a lackluster job in their initial offering, trying to find the cheapest option that will get approval and having no real reason to do a comprehensive analysis. Industry can start low and slowly raise the bar until Illinois EPA approves. The solution to this problem is rules that establish comprehensive requirements for the alternatives analysis such that all the options are fully vetted from the outset. If the Agency and the public have the opportunity to review the full set of closure or corrective action options in one comprehensive document, they will be far better equipped to evaluate which options best protect public health and the environment and require that the best option be chosen.

IV. Accounting for Coal Ash in Illinois

It is critical that the coal ash rules require accessible and comprehensive documentation of coal ash in Illinois. From the public's perspective, tracking the coal ash problem in Illinois has been challenging. When I first started at Prairie Rivers Network in early 2015, I searched for a database of coal ash information to give a comprehensive look at the coal ash situation in Illinois. I was looking to answer basic questions: where are the ponds? What are their boundaries? How much ash is stored at each site? How many are at each site? No such database existed. I had to pieces things together through web searches and FOIA requests. Eventually, the federal CCR rule started to provide useful information, but the coverage was still incomplete.

I accumulated answers through FOIA requests to Illinois EPA and the federal CCR rule disclosures. While I found some answers about coal ash sites in Illinois, the information I collected was incomplete and occasionally contradictory, such as information concerning the boundaries of the coal ash ponds. For example, at Hennepin, I've seen the ponds marked in two different ways. (*See* Attachment 9, Hennepin US EPA Assessment, and Attachment 10, Hennepin History of Construction). Additionally, some reports and documentation reveal old coal ash ponds - areas which are now growing trees - that pose an unknown threat. For example, the US EPA Assessment identifies an old "capped" pond at the Joppa plant (Attachment 11, Joppa US EPA Assessment), and there's another pond labeled "old ash pond (decommissioned)" at the closed Meredosia site. (Attachment 12, Meredosia US EPA Assessment). In fact, in a 2016 closure plan for the other two ponds at Meredosia, the consultant seems unsure about anything related to the pond and dismisses it out of hand: "A third ash pond referred to as the 'Old Ash Pond' was reportedly closed, and will not be further discussed in this report." (Attachment 13, Meredosia 2016 closure plan). The final rules must close these knowledge gaps and allow the public to see a clear inventory of coal ash in Illinois, so the risks can be tracked and accounted for.

For this rule, documents that are required to be posted online should be clear and easily accessible. Having one website vs. two websites is less important than clarity. If there is only one website, the Board should require that the website itself indicate the documents that are compliance documents for the federal rules and the documents that are compliance documents for the state rules. Therefore, it may be easier to have two websites, but those sites should link to each other so that navigating between them is simple. Another major accessibility concern is requiring an account to view the information. This is an unnecessary barrier that stifles public access to the documentation. Requiring an account and log-in information to view the page should not be allowed (even if anyone could theoretically get an account).

V. The Value of Public Input

Public input is a necessary part of the regulatory process. I've seen firsthand how public input can help inform Illinois EPA's and other agencies' regulatory decisions in ways that lead to better protection of communities and the environment. In 2012, Illinois EPA issued Dynegy a violation notice for groundwater pollution caused by the coal ash ponds at the Vermilion Power Station. However, the violation notice did not lead to Agency action and was left unresolved for years. It wasn't until 2018, six years after the violation notice was issued, that an email from a concerned member of the public spurred Illinois EPA into inspecting the seeps at the site. That email came from Pam Richart, who visited the site frequently by canoe and was able to document the seeps and the eroding riverbank, raising the alarm to the agency in a photo-documented email. Following her email, Illinois EPA sent inspectors, issued a second violation notice, and has referred the case to the attorney general. Without the persistence of the public acting as a watchdog, I fear the agency would not have been convinced to take these steps to address the pollution along the Middle Fork.

Also at the Middle Fork site, community voices raised concerns when the Army Corps proposed a Nationwide Permit[1] for a plan to dump a huge volume of rocks on the banks of the river to attempt to stop erosion. Community members noted that the pile of rocks would have marred the scenic value of the river, going against the National Scenic River designation and leaving the real

[1] A Nationwide Permit is a fast-tracked version of the Army Corp's 404 Permit.

problem at the site unsolved. Following the public outcry, the Army Corps took a second look at the bank armoring proposal and realized that there was more to the proposal and the site. The Army Corps pressed Dynegy for more answers about their proposal, and after some back and forth between the Corps and Dynegy, the company decided to withdraw their proposal.

Another example of the impact of public scrutiny concerns Midwest Generation's proposal to dump coal ash from several coal plants into the Lincoln Stone Quarry. Members of the public caught wind of this proposal in summer 2017. Multiple interested parties submitted comments on the proposal, including the Will County Land Use Department (*see* Attachment 14) and a coalition of environmental groups that included Prairie Rivers Network and a local group of volunteer activists called Citizens Against Ruining the Environment (*see* Attachment 15). The comments raised concern about the risks of adding more waste to a facility that was already leaking. Eventually, Midwest Generation withdrew their proposal to dump more ash into Lincoln Stone Quarry. In my opinion, this was due to the public comments that were submitted, as I am not aware of any other reason why the proposal was withdrawn.

In fact, without the relentless effort of members of the public, we probably wouldn't be here at this rulemaking today. Residents of Vermilion and Champaign county worked to inform Senator Scott Bennett, Representative Carol Ammons, and Representative Mike Marron about the dangers of coal ash at the Vermilion Power Station and opened their eyes to the problem of coal ash. These legislators went on to be the champions of the Coal Ash Pollution Prevention Act. Members of the public, largely from coal ash communities, came to Springfield for the release of Cap and Run, and again on coal ash lobby day,[2] to speak to their legislators about the need for Illinois to take charge of its own destiny for coal ash impoundments, rather than rely solely on federal government. These voices helped build the momentum to pass the Coal Ash Pollution Prevention Act with bi-partisan support, leading to this rulemaking.

Illinois EPA staff, both during the listening sessions and at the January stakeholder meeting, have attested to the benefit of public input in their draft rules.

Public scrutiny can also help keep the public and the environment safe by creating more opportunities for technical review. Such review supplements the Agency's efforts when it does not have the time or resources to dig deep. For example, Steven Campbell, a hydrogeologist, submitted a public comment to the US EPA regarding changes to the 5ft uppermost aquifer criteria in the federal rule. (Attachment 16). In his comment, he highlighted the dynamic nature of groundwater tables and used the Waukegan Power Station in Illinois, which is experiencing a rising groundwater table, as an example of why location standards need to be continually re-assessed. Mr. Campbell raised significant concerns regarding Midwest Generation's claims that

[2] Coal ash lobby day was an effort to facilitate the public engaging their legislators in Springfield by bringing folks to the capital on the same day.

they meet the aquifer location restriction (*see* Attachment 17) even though the uppermost aquifer is clearly within 5 feet of the coal ash, and elevated an important issue related to coal ash protections to regulators' attention. This sort of technical analysis submitted by concerned members of the public can help the Agency –or the Board – make better, more informed decisions. To give another example, the Illinois EPA reviewed (and ultimately approved) the closure plan for impoundments on the east side of the Hennepin Power Station last year. Written comments that I provided for the closure plan prompted the Illinois EPA to solicit additional information from Vistra. In short, additional scrutiny can help identify weaknesses in industry's proposals and can help protect the public.

VI. Transportation by Rail and Barge

Another area that I have looked into as part of my work at Prairie Rivers Network is the transportation options that might be available for moving coal ash when the pond is closed by removal – that is, by excavating the ash and moving it to a safer place. In many of the closure plans that I have reviewed, trucks have been the only transportation method assessed as part of an assessment of removal. Using free spatial data available through ESRI's online database, I mapped the approximate locations of rail spurs relative to coal ash impoundments and landfills. (*See* Attachment 18). The goal of the exercise was to better understand how many of the power plants in Illinois have relatively easy access to rail. I found that Waukegan, Will County, Joliet 9 (Lincoln Stone Quarry), Hennepin, Edwards, Powerton, Duck Creek, Havana, Meredosia, Dallman, Kincaid, Coffeen, Wood River, Venice, Newton, Baldwin, Prairie State Generating Station, Marion, and Joppa all have rail spurs located on the property (in most cases) or less than a mile way (in a few cases). Given the real opportunity for rail transport at many of these sites and different pollution and safety risks of transport by truck versus other options, the rules should require industry to consider rail as one of multiple transportation options when evaluating removal of coal ash. Additionally, many of the sites are along major rivers with significant barge traffic, including the Illinois and the Mississippi, indicating that transporting coal ash by barge is likely a reasonable alternative to consider as well at many sites.

VII. Fugitive Dust

I understand there are risks related to moving and transporting coal ash for both workers and communities, including those next to the ash ponds, along transportation routes, and near the site ultimately receiving the ash. For example, I have read Ron Sahu's report "Comments on Fugitive Dust Management and Lack of Air Monitoring As Part of Coal-Ash Removal Project at NIPSCO Michigan City Generating Station (MCGS)" (Attachment 19), which stated that ash could become airborne during "removal from the ponds; processing after removal from the ponds such as drying to reduce moisture content; loadout onto haul trucks; during transportation; and during placement at the destination." The report identifies dust (PM_{10} and $PM_{2.5}$) and radioactive material as risks during removal and identifies the need for detailed dust control plans and dust monitoring to accompany these activities. The need is also present in Illinois and the rules should provide for robust monitoring and detailed, specific dust controls.

VIII. Groundwater Contact

Documents that I have reviewed when gathering data about coal ash impoundments in Illinois make clear that groundwater is contacting coal ash at many of the coal ash impoundments in Illinois. The 2018 groundwater modeling report for the Vermilion Power Station clearly states that "areas of ash within the [North Ash Pond System] and [Old East Ash Pond] are in contact with groundwater." (Attachment 20, p. 2). A slide in a presentation that Agency staff gave to Senator Bennett last year, at a meeting that I attended, states that the capped ash ponds at the Venice coal plant are in intermittent contact with groundwater. (*See* Attachment 21, Except of R. Cobb Presentation).[3] Additionally, a technical memorandum attached to the original 2010 closure plans also makes that groundwater contact clear: "Boron mass enters groundwater via two mechanisms: year-round leaching as precipitation and snow melt water percolates vertically through the ash, and occasional leaching when groundwater elevation rises to a level higher than the base of ash and flows horizontally through the material." (Attachment 22 – Technical Memorandum 6. Groundwater Modeling of Venice Former Ash Ponds, p. 5). The Hutsonville Closure Plan also identifies groundwater flowing through coal ash: "Where coal ash is encountered within the shallow groundwater zone. groundwater flows horizontally through the ash. Only Ash Pond D was deep enough to have horizontal groundwater migration through the coal ash" and illustrates the point with a graphic on the following page. (Attachment 23, Excerpt of Hutsonville Closure Plan Pond A, pdf pp. 281, 282). At Lincoln Stone Quarry, it is well known that coal ash is in contact with groundwater (*see* Attachment 14, Will County Land Use Department Comments) and the quarry failed the aquifer location restriction by 50 feet (*see* Attachment 24, LSQ location restrictions). In fact, it is my understanding that Midwest Generation must run pumps continuously to attempt to stop pollution from spreading off-site. The pumps pull the groundwater pollution plume back and pump the water back into the quarry. Instances like this make me wary of pump-based solutions to pollution. For how long do we expect those pumps to run? Forever?

One challenge I've faced in trying to determine if groundwater is intersecting with coal ash is a lack of data. The bottom elevation of the coal ash, meaning the lowest elevation that you can find coal ash at a particular point in space, is often not reported. The bottom elevation of coal ash ponds is used to determine if groundwater contact is occurring. By comparing the ash bottom elevation to the groundwater surface measurements (which are available in the federal CCR reporting and other locations), it is often possible to determine whether groundwater contact is present. A spatial map of the bottom elevation of the coal ash in impoundments should be included with the groundwater elevation measurements reported in hydrogeological

[3] In contrast, the same presentation included a slide stating that ash ponds at the Havana plant are not in contact with groundwater. *See* Attachment 21 at p. 2.

investigations. This information is critical for the public, as well as the Agency, to understand the risks of coal ash ponds now and in the future for Illinois. The federal rules require a determination of the distance between coal ash and the uppermost aquifer, so industry should have this information already available at sites where the rule applies. In fact, many impoundments in Illinois have already posted documentation showing that the required separation between the impoundment and the aquifer is not present. (*See* Attachments 24 – 33).

IX. Flooding and Floodplains

Another way ash is exposed to water is flooding. Rising river levels can raise the local groundwater table into the coal ash ponds. The impoundment does not need to be overtopped by floodwaters for coal ash to be exposed. Flooding also leads to rising groundwater from below. For example, the satellite image currently used by ArcGIS's surface imagery shows that the coal ash ponds at the Pearl Station were nearly underwater in a 2013 flood. In the satellite image, the impoundment has become an island in the floodplain. The image can be seen on page 13 of the Coal Ash Rail and Landfill report I put together. (*See* Attachment 18).

Using the FEMA 100-year floodplain maps available through the ArcGIS online database, I mapped the FEMA 100-year and 500-year floods (1% and 0.2% chance floods) compared to coal ash ponds in Illinois. While I was not able to find FEMA 100-year flood data for every coal ash site in Illinois, the maps I made show that Dallman, Grand Tower, Hennepin, Hutsonville, Meredosia, Pearl Station, and Vermilion would all be inundated partially or completely according to the FEMA 100-year floodplain maps. (*See* Attachments 34-40).

I am concerned that these risks will only grow with time. I have attended presentations and reviewed documentation that states that floods will change, and are changing, with the changing climate. The Illinois State Water Survey evaluates rainfall frequency in a document titled Bulletin 70. In March 2019, the ISWS published an update to Bulletin 70 titled "Frequency Distributions of Heavy Precipitation in Illinois: Updated Bulletin 70". In the document, the ISWS notes that, heavy precipitation events are anticipated to increase in Illinois. (*See* Attachment 41). The Midwest section of the National Climate Assessment notes that "Increasing precipitation, especially heavy rain events, has increased the overall flood risk, causing disruption to transportation and damage to property and infrastructure. (*See* Attachment 42). Therefore, the 1% chance flood tomorrow will be bigger than the 1% flood today. If so, the risk of coal ash in floodplains being exposed to water will grow.

X. Coal Ash Outside of Impoundments

The Board must develop rules regulating more than just coal ash *impoundments*. Coal ash ends up in coal ash landfills, dumps, piles at coal mines, various re-use sites, and more. All of these types of coal ash sites have problems. We've seen the groundwater impacts from coal ash landfills due to the federal rule reporting. I've heard concerns from communities living downwind of a coal ash pile stored at a coal mine who have seen their animals get sick since the piles started. I know, from our legal action against NRG, that coal ash does not always end up in impoundments and can be found in other places on power plant sites. I've seen old coal ash sites marked on maps of power plant sites, such as the "old ash pond (decommissioned)" at Meredosia, that are not even counted in Illinois EPA's latest inventory of ponds. I've seen satellite images of a huge pile of coal ash at a re-use facility near Powerton where the ash is seemingly strewn along the railroad tracks. These types of coal ash sites pose all the same problems that we find at the coal ash impoundments. The Board should propose comprehensive regulations that solve the coal ash problem.

Signed:

Dated: August 27, 2020

ATTACHMENT LIST FOR TESTIMONY OF ANDREW REHN

1. Coffeen Ash Pond Safety Assessment
2. Dallman Safety Assessment
3. Edwards Safety Assessment
4. Joliet 29 Safety Factor
5. Joppa Safety Assessment
6. Kincaid Safety Assessment
7. Newton Safety Assessment
8. Waukegan Safety Assessment
9. Hennepin US EPA CCW Assessment Report
10. Hennepin History of Construction
11. Joppa US EPA Assessment
12. Meredosia US EPA Assessment
13. 2016 Meredosia Closure Plan
14. Will County Land Use Department Comments
15. Comments on MWG application for LSQ Permit
16. Campbell Expert Report EPA 2020 Proposed Permitting Rule for CCR Facilities
17. Waukegan Location Standards
18. Coal Ash Rail and Landfill Report
19. Final MCGS Dust and Air Monitoring
20. Groundwater Monitoring and Modeling Report Vermilion
21. Excerpt of Illinois EPA's Ash Impoundment Strategy Progress Report 2019
22. Venice Technical Memorandum No. 6
23. Excerpt of Hutsonville Closure Plan Pond A
24. Lincoln Stone Quarry Location Restrictions
25. Coffeen Location Restriction Demonstration Ash Pond No. 1 2018
26. Coffeen Location Restriction Demonstration GMF Gypsum S 2018
27. Coffeen Location Restriction Demonstration GMF Recycle Pond 2018
28. Dallman Lakeside Location Restrictions
29. 2018 E.D. Edwards Location Restriction Demonstration Ash Pond
30. 2018 Havana Location Restriction Demonstration East Ash Pond Cells 1, 2, 3, 4
31. 2018 Hennepin Location Restriction Demonstration East Ash Pond
32. 2018 Kincaid Location Restriction Demonstration Ash Pond
33. Will County Location Restrictions
34. Dallman Floodplain Map
35. Grand Tower Floodplain Map
36. Hennepin Floodplain Map
37. Hutsonville Floodplain Map
38. Meredosia Floodplain Map
39. Pearl Station Floodplain Map
40. Vermilion Floodplain Map
41. Frequency Distributions of Heavy Precipitation in Illinois: Updated Bulletin 70
42. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II

CERTIFICATE OF SERVICE

The undersigned, Jennifer L. Cassel, an attorney, certifies that I have served by email the Clerk and by email the individuals with email addresses named on the Service List provided on the Board's website, available at https://pcb.illinois.gov/Cases/GetCaseDetailsById?caseId=16858, a true and correct copies of the the **TESTIMONY OF ANDREW REHN** and **ATTACHMENTS** before 5 p.m. Central Time on August 27, 2020. The number of pages in the email transmission is 1,804 pages.

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The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 1

AECOM

Submitted to
Illinois Power Generating Company
134 Cips Lane
Coffeen, IL 62017

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Ash Pond No. 1

At Coffeen Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that Ash Pond No. 1 at the Illinois Power Generating Company Coffeen Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). Ash Pond No. 1 is located near Coffeen, Illinois in Montgomery County, approximately 0.3 miles east of the Coffeen Power Station. Ash Pond No. 1 serves as the primary wet impoundment basin for bottom ash produced by the Coffeen Power Station.

Ash Pond No. 1 is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of Ash Pond No. 1. The exploration consisted of hollow-stem auger borings, cone penetration tests, piezometers, and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at Ash Pond No. 1 consist of medium stiff to stiff lean clay embankment fill, overlying medium stiff to stiff weathered loess clay, overlying a thin zone of very soft clay, which in turn overlies very stiff to hard glacial till. The phreatic surface within the subsurface is typically at the ground surface at the toe of the embankment and near the embankment/foundation interface beneath the crest.

Five (5) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Ash Pond No. 1 dikes. As a result, this loading condition is not applicable to Ash Pond No. 1.

Results of the Initial Safety Factor Assessments, for the critical cross-section for each loading condition, are listed in **Table 1** (i.e., the table identifies the lowest calculated factor of safety for any one of the five analyzed cross sections for each loading condition).

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.50
Maximum Surcharge Pool Loading	(ii)	1.40	1.49
Seismic	(iii)	1.00	1.03
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Generating Company; Coffeen Power Station; Ash Pond No. 1

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER JR.
Printed Name

10/13/16
Date

VICTOR ALBERT MODEER JR.
062-0?3112
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS
11/30/17

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1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 2

City Water, Light & Power
Ash Impoundments
Springfield, Sangamon County, Illinois

Initial Safety Factor Assessment for Coal Combustion Residuals Surface Impoundments

October 2016

Prepared for:
City Water, Light & Power
3100 Stevenson Drive
Springfield, Illinois 62703

Prepared by:
ANDREWS
ENGINEERING INC

3300 Ginger Creek Drive
Springfield, IL 62711
Tel: (217) 787-2334; Fax: (217) 787-9495

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TABLES

APPENDICES

1. INTRODUCTION

City Water, Light and Power (CWLP) Lakeside Ash Pond and Dallman Ash Pond are coal combustion residuals (CCR) surface impoundments. An Initial Safety Factor Assessment of the CCR surface impoundments was conducted as required by 40 CFR Part 257.73:

257.73(e): *Periodic safety factor assessments. (1) The owner or operator must conduct an initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in paragraphs (e)(1)(i) through (v) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.*

257.73(f): *(1) Initial assessments. Except as provided by paragraph (f)(2) of this section, the owner or operator of the CCR unit must complete the initial assessments required by paragraphs (a)(2), (d), and (e) of this section no later than October 17, 2016. The owner or operator has completed an initial assessment when the owner or operator has placed the assessment required by paragraphs (a)(2), (d), and (e) of this section in the facility's operating record as required by § 257.105(f)(5), (10), and (12).*

Analysis is performed herein for the Initial Safety Factor Assessment of the existing ash ponds at Springfield City Water, Light and Power, Lakeside and Dallman Ash Ponds, Springfield, Illinois, as required per 40 CFR 257.73(e). Based upon historical geotechnical data and the existing conditions of the ash ponds, all factors of safety exceed the regulatory minimums as demonstrated within this report.

Information reviewed for this report includes the following documents:

- Coal Ash Impoundment Site Assessment Final Report (May 2011)
- Historical Aerial Photographs (April 1995 – March 2014)
- Engineering Report: Proposed Embankment Modification; CWLP Ash Disposal Area (July 1987).
- Construction Grading Plan for the Dallman Ash Pond (August 1976)

2. BACKGROUND

CWLP operates a series of ash and lime sludge clarification or settling ponds east of the power plant complex in Springfield, Illinois. The ponds are operated under National Pollutant Discharge Elimination System (NPDES) Permit Number IL0024767.

The Lakeside Ash Pond is primarily a diked embankment with some incising along the east perimeter and was placed into service prior to 1958. The original Lakeside Ash Pond was been divided into four separate ponds since it was expanded vertically in 1988: three lime softening ponds and the settling pond. The current Lakeside Ash Pond is approximately 27.6 acres and ceased receiving ash in 2009.

The second impoundment, the Dallman Ash Pond, which is a diked embankment, was placed into service in approximately 1976 and is approximately 34.5 acres. Fly ash and bottom ash are sluiced to the Dallman Ash Pond with raw lake water.

Settled water from both the Dallman Ash Pond and Lakeside Ash Pond flow into opposite sides of a Clarification Pond before being discharged, typically, to Sugar Creek at Outfall 004.

3. GEOMETRY OF THE STRUCTURES

According to personal interviews with CWLP staff, the most recent change made to the CCR surface impoundment was a vertical expansion to the Lakeside Ash Pond system in 1988. The vertical expansion consists of berms built on top and inside of the existing embankments in such a way that the toe of the outer slope of the expansion berms match up with the top of the inner slope of the existing embankments, typically identified as upstream construction. The vertical expansion berms are approximately ten feet in height.

A site map drawing containing an aerial photograph and approximate boundaries for all of the CWLP CCR Units, including the ash and lime softening ponds, is provided in Appendix A.

No changes to the geometry of the structures are applicable for this report. No changes are apparent due to structure movement or deformation.

4. GEOTECHNICAL INFORMATION

4.1 Lakeside Ash Pond Geotechnical Data

A review of the historical documents found a previous geotechnical investigation and stability analysis, which was conducted prior to the upstream construction of Lakeside Ash Pond. The results of that geotechnical investigation are utilized within this assessment of the safety factors. Additionally, a literature review of technical papers was conducted to determine the geotechnical parameters for the fly ash within the impoundments. Provided in Table 1 are highly conservative geotechnical parameters based upon the previous geotechnical investigation utilized in the static and seismic slope stability model.

Included in Appendix B are copies of the historical soils logs and cross sections that support the geotechnical parameters provided in Table 1. Technical papers supporting the ash geotechnical parameters are included in Appendix C.

TABLE 1

Lakeside Ash Pond

Soil Description	Density (pcf)	Total Strengths (Short Term)		Effective Strengths (Long Term)	
		ϕ (degrees)	c (psf)	ϕ' (degrees)	c (psf)
Ash	100	15	0	25	0
Embankment	120	0	1,400	32	145
Sandy Silty Clay w/Clayey Silt	120	0	1,800	32	190
Sandy Silty Clay	120	0	1,000	32	190
Shale	130	0	2,000	0	2,000

4.2 Dallman Ash Pond Geotechnical Data

A review of the historical documents revealed the original construction plans, with cross sections provided, was completed. More recent site investigations have been conducted in the area during the installation of piezometers, which provide the stratigraphic and in situ strengths of earthen materials that correlate well with the Lakeside Ash Ponds geotechnical data. The historical data have been used to develop conservative geotechnical parameters for slope stability analysis as provided below in Table 2.

Included in Appendix D are copies of the boring log and cross section that support the geotechnical parameters provided in Table 2.

TABLE 2

Dallman Ash Pond

Soil Description	Density (pcf)	Total Strengths (Short Term)		Effective Strengths (Long Term)	
		ϕ (degrees)	c (psf)	ϕ' (degrees)	c (psf)
Ash	100	15	0	25	0
Embankment	120	0	1,400	32	145
Rip-Rap	140	40	0	40	0
Silty Clay	120	0	1,800	32	190
Clayey Silt	120	0	1,400	32	190
Sandy Silty Clay	120	0	1,000	32	190
Sand w/Silt	120	34	0	34	0
Shale	130	0	2,000	0	2,000

4.3 Seismic Ground Motion

CWLP is susceptible to potential seismic activity as provided by the USGS Earthquake Hazards Program. Included in Appendix E of this geotechnical engineering report is the 2008 National Seismic Hazard Mapping Program's Probabilistic Seismic Hazard Analysis for the site (Latitude 39.762 North, Longitude 89.597 West). The Peak Horizontal Ground Acceleration is approximately 0.09965 g. The maximum acceleration of (aHmax = 0.10g) was selected for use in stability calculations.

5. SLOPE STABILITY ANALYSIS

The static and seismic slope stability model utilized for the following analysis was the Morgenstern and Price Circular Search Method within the Slope/W computer-based slope stability modeling software. Morgenstern and Price satisfies all conditions of equilibrium.

The periodic safety factor assessment requires that each CCR unit document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors. The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50. The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40. The calculated seismic factor of safety must equal or exceed 1.00. For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

The Lakeside and Dallman Ash Ponds are not susceptible to liquefaction since the embankments are constructed of a sandy silty clay, thus analyses for each are not included below. Liquefaction occurs in fine grained non-cohesive soils. The embankments at CWLP are constructed of cohesive soils.

5.1 Lakeside Ash Pond Slope Stability

The slope stability analysis was performed on a critical cross section, previously identified as Section 2 in the Engineering Report: Proposed Embankment Modification; CWLP Ash Disposal Area (July 1987)., Based upon a review of this report and existing conditions, Section 2 appears to remain the critical cross section. Section 2 is located on the north side of the Lakeside Ash Pond next to the Clarification Pond. For a very conservative analysis, the slope was analyzed as if the Clarification Pond was drained and dredged back to the pre-existing grades of approximately 535 feet MSL.

The Lakeside Ash Pond is not susceptible to liquefaction since the embankment is constructed of a sandy silty clay; thus, analysis is not included below.

5.1.1 Long-Term Static Slope Stability Analysis

The long-term static slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The long-term analysis utilizes the effective shear strength parameters, which are the drained condition. The long-term static slope stability analysis found that the factor of safety for the most critical failure surface was 1.532. The critical failure surface and stability report are included in Appendix F-1. This analysis verifies that Lakeside exceeds the factor of safety for the long-term, maximum storage pool loading condition and the maximum surcharge pool loading condition since the analysis was performed filled with ash and the pool elevation matching the top of the embankment.

5.1.2 Short-Term Static Slope Stability Analysis

The short-term static slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The short-term analysis utilizes the total shear strength parameters, which are the undrained condition. The short-term static slope stability analysis found that the factor of safety for the most critical failure surface was 1.640. The critical failure surface and stability report are included in Appendix F-2.

5.1.3 Seismic Slope Stability Analysis

The seismic slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The seismic analysis utilizes the total shear strength parameters, which are the undrained condition since a seismic event occurs in a short period of time. In addition, a horizontal acceleration of 0.10g was utilized within the modeling to represent the peak horizontal ground acceleration anticipated for CWLP. The seismic slope stability analysis found that the factor of safety for the most critical failure surface was 1.260. The critical failure surface and stability report are included in Appendix F-3. This analysis verifies that Lakeside exceeds the seismic factor of safety with maximum surcharge pool loading condition.

5.2 Dallman Ash Pond Slope Stability

The slope stability analysis was performed on a critical cross section based upon a review of the historical construction diagrams, cross sections and the available stratigraphic data. Section 10+00 is located on the north side of the Dallman Ash Pond near the relocated Sugar Creek. For a very conservative analysis, the slope was analyzed as if Sugar Creek had nearly zero flow at approximately 520 feet MSL.

5.2.1 Long-Term Static Slope Stability Analysis

The long-term static slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The long-term analysis utilizes the effective shear strength parameters, which are the drained condition. The long-term static slope stability analysis found that the factor of safety for the most critical failure surface was 2.245. The critical failure surface and stability report are included in Appendix G-1. This analysis verifies that Dallman exceeds the factor of safety for the long term, maximum storage pool loading condition and the maximum surcharge pool loading condition since the analysis was performed filled with ash and the pool elevation matching the top of the embankment.

5.2.2 Short-Term Static Slope Stability Analysis

The short-term static slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The short-term analysis utilizes the total shear strength parameters, which are the undrained condition. The short-term static slope stability analysis found that the factor of safety for the most critical failure surface was 2.897. The critical failure surface and stability report are included in Appendix G-2.

5.2.3 Seismic Slope Stability Analysis

The seismic slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The seismic analysis utilizes the total shear strength parameters, which are the undrained condition since a seismic event occurs in a short period of time. In addition, a horizontal acceleration of 0.10g was utilized within the modeling to represent the peak horizontal ground acceleration anticipated for CWLP. The seismic slope stability analysis found that the factor of safety for the most critical failure surface was 1.754. The critical failure surface and stability report are included in Appendix G-3. This analysis verifies that Dallman exceeds the seismic factor of safety with maximum surcharge pool loading condition.

6. SUMMARY

The analyses indicate that Lakeside and Dallman Ash Ponds provide factors of safety equal to or greater than minimum values as required by 40 CFR 257.73(e). This is predicated upon the assumption that cohesive and frictional shear strengths of materials meet or exceed those used in the analyses. Table 3 below provides a summary of the slope stability results.

TABLE 3

Slope Stability Results

Cross Section	Stability Model Results	40 CFR 257.73 Minimum F.S.
Lakeside Long Term Static	1.532	1.5
Dallman Long Term Static	2.245	
Lakeside Short Term Static	1.640	1.4
Dallman Short Term Static	2.897	
Lakeside Seismic	1.26	1.0
Dallman Seismic	1.754	

7. STATEMENT

This Initial Safety Factor Assessment for Coal Combustion Residuals Surface Impoundments was completed for CWLP by Andrews Engineering, Inc. in accordance with the requirements under 40 CFR Part 257.73(e) and 257.73(f).

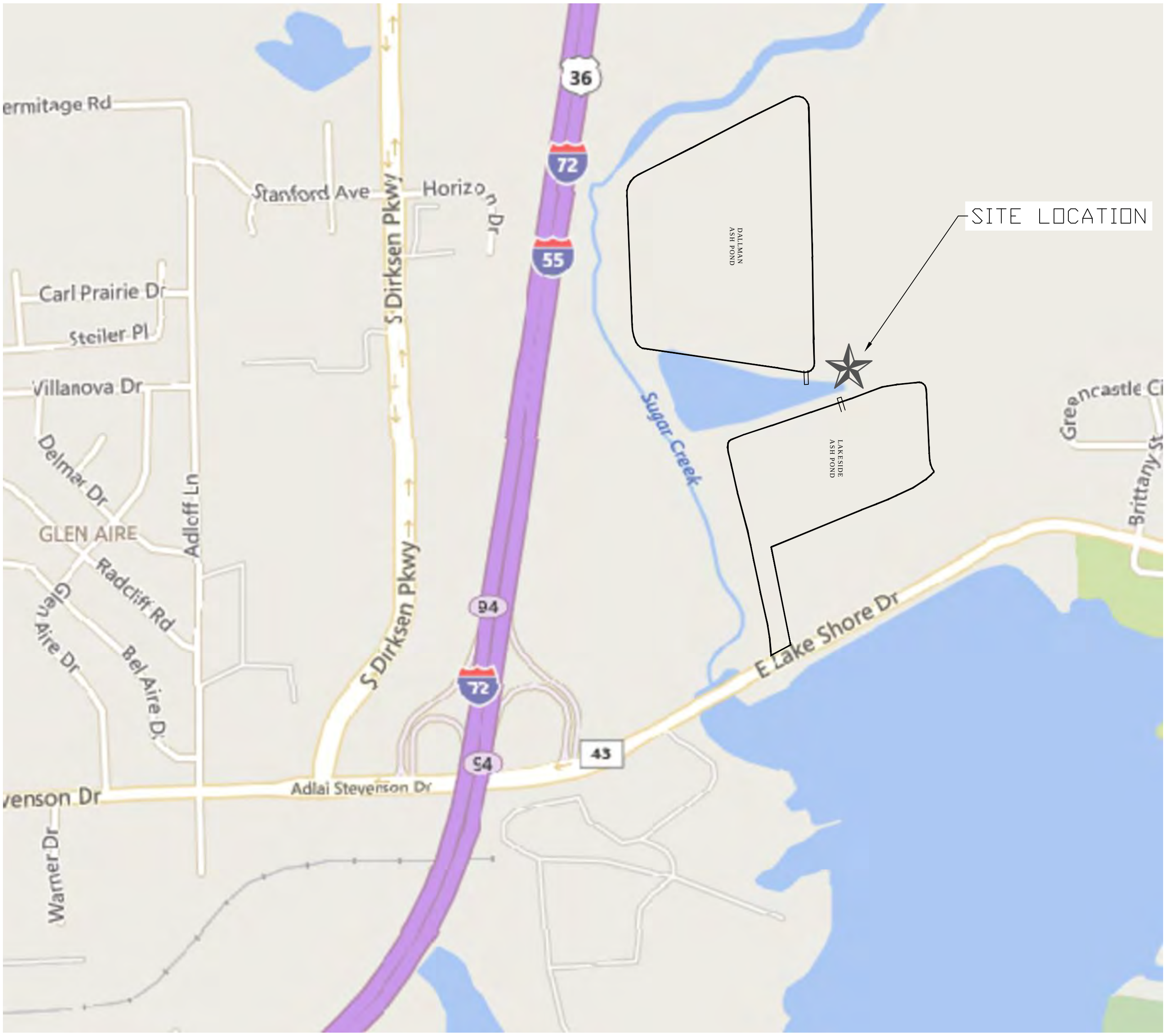
Paul M. Van Metre, P.E.

10-13-2016
Date

STATE OF ILLINOIS
PAUL VAN METRE 062-064175
REGISTERED PROFESSIONAL ENGINEER

APPENDIX A

Site Map



SITE LOCATION

N

0 500 1000 2000

SCALE: IN FEET

NOTE:
BASE IMAGE DERIVED FROM BING

ANDREWS ENGINEERING, INC. 3300 Ginger Creek Drive, Springfield, IL 62711-7233 Tel (217) 787-2334 Fax (217) 787-9495 Pontiac, IL • Naperville, IL • Indianapolis, IN • Warrenton, MO Professional Design Engineering and Land Surveying Firm #184-001541	SITE LOCATION MAP	DATE: OCTOBER 2016
	PLANS PREPARED FOR CWLP SPRINGFIELD, SANGAMON COUNTY, ILLINOIS	PROJECT ID: 150077/0011
APPROVED BY: PMV DESIGNED BY: PMV DRAWN BY: RMC		SHEET NUMBER: FIG. 1

NO.	DATE	REVISIONS DESCRIPTION	BY

ANDREWS ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184001541

APPROVED BY: PMV DESIGNED BY: PMV DRAWN BY: MPN

CWLP COAL COMBUSTION RESIDUALS SURFACE IMPOUNDMENTS

PLANS PREPARED FOR
CITY, WATER, LIGHT & POWER
SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016

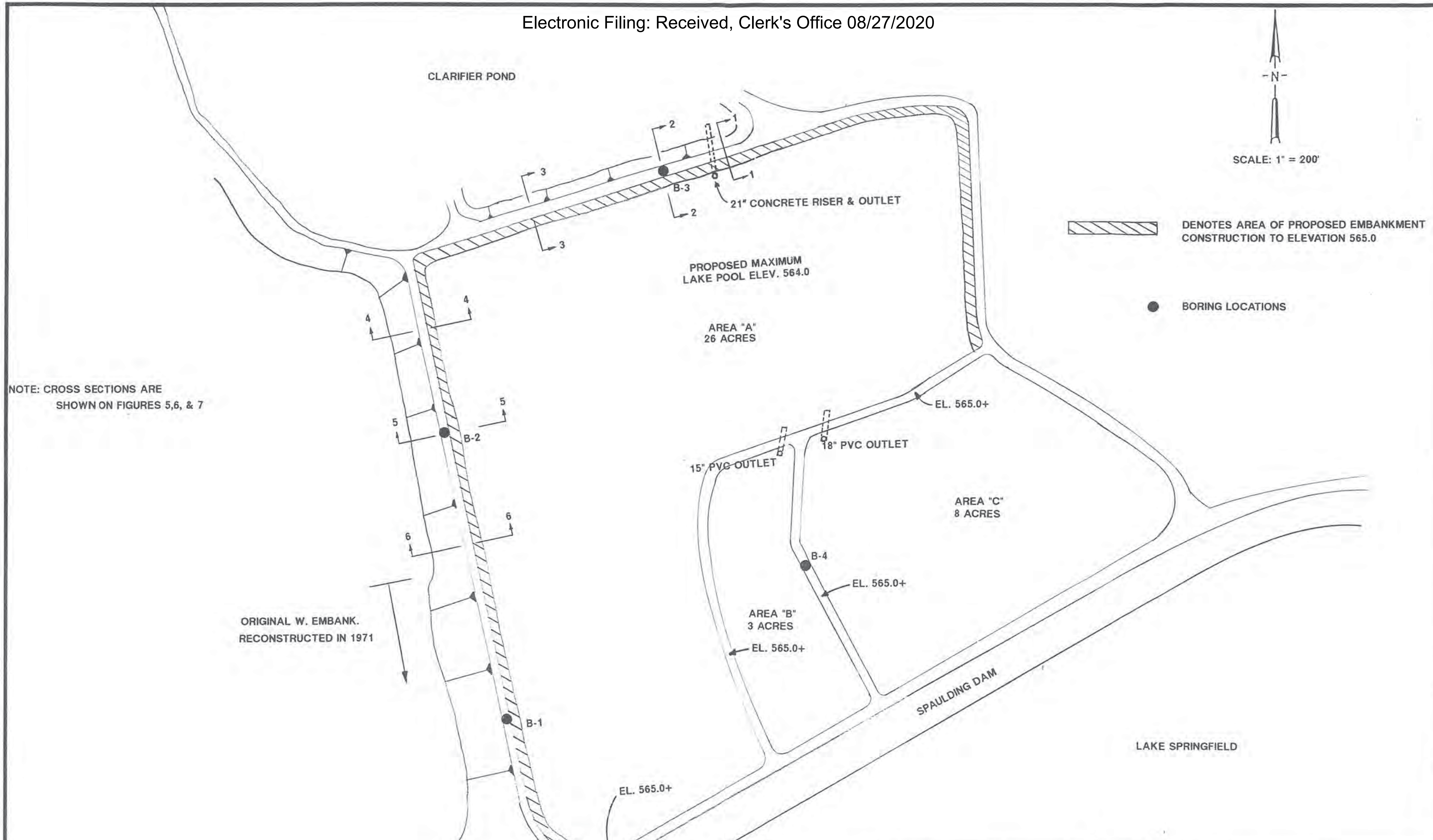
PROJECT ID: 150077/0011

SHEET NUMBER:

FIG. 2A

APPENDIX B

Lakeside Soils Logs and Cross Section



PLAN VIEW

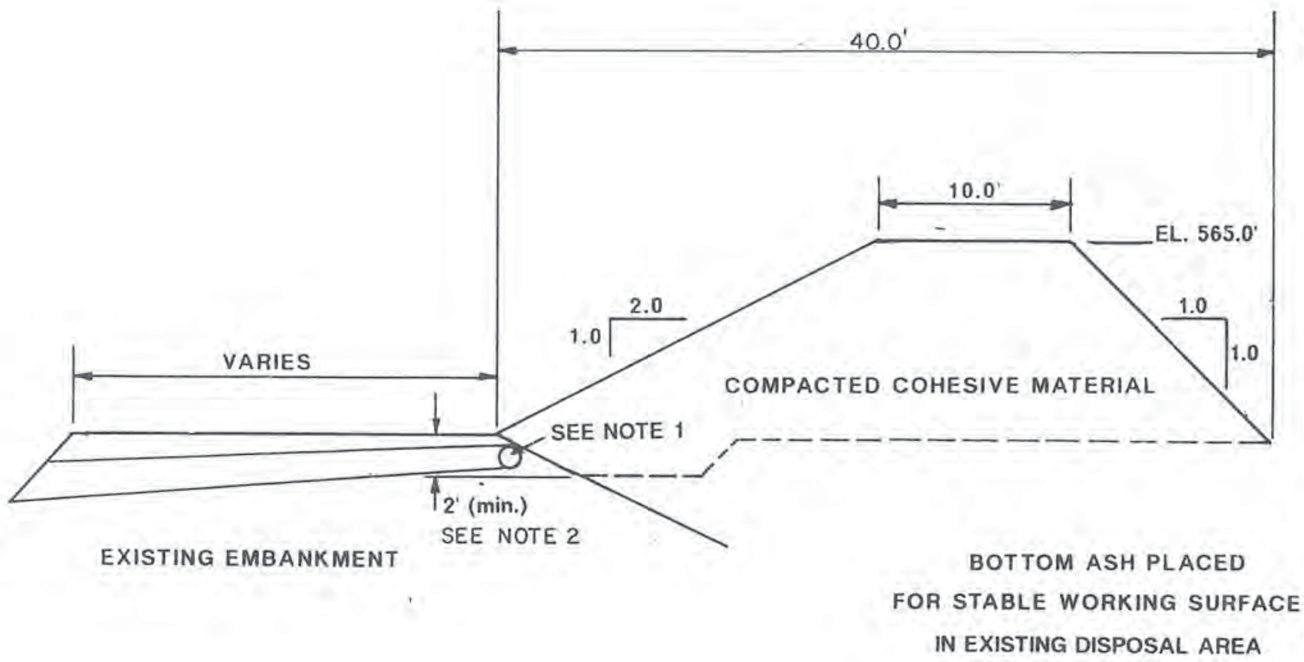
HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014

FIGURE 1



TYPICAL SECTION

NOTE: 1 - FILTER FABRIC WRAPPED PERFORATED CORRUGATED DRAINAGE PIPE WITH NON-PERFORATED OUTLETS INTO CLARIFIER POND. PIPE IS SURROUNDED WITH BED OF BOTTOM ASH

NOTE: 2 - COMPACTED COHESIVE MATERIAL "KEYED" INTO STABLE WORKING SURFACE A MINIMUM DEPTH OF 2 ft. FOR SEEPAGE CONTROL

EMBANKMENT CONFIGURATION	PROPOSED EMBANKMENT MODIFICATONS CWLP ASH DISPOSAL AREA SPRINGFIELD, ILLINOIS
HANSON ENGINEERS INCORPORATED SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL	JOB NO. 87S3014 FIGURE 2

HANSON ENGINEERS INCORPORATED

LABORATORY SOIL TEST DATA

OPERATOR CMP

DATE June-2-1987

JOB NO.

PROJECT NAME AND LOCATION
CWL&P
Ash Pond Study
Springfield, Illinois

BOR.	SAMP.	DEPTH	ELEV.	N	STRENGTH TESTS Qu	M	P	W	γ_w	γ_D	SPECIAL TESTS	SAMPLE DESCRIPTION
Ground Surface Elev-557.6												
1	1	2'-6"	555.1	14				6				Bottom Ash
	2	5'-0"	552.6	3				10				" "
	3	7'-6"	550.1	5				31				" " / dk. gray v.f. sandy silt
	4	10'-0"	547.6	1				79				Drk. gray v.f. sandy silt.
	5	12'-6"	545.1	4	0.92	B	0.8	33				Gray v.f. sandy silty clay.
	6	15'-0"	542.6	4			3.6	67				Gray silty f. sand. (fly ash).
	7	17'-6"	540.1	9				46				Fly ash.
	8	20'-0"	537.6	8				61				" " .
	9	22'-6"	535.1	5	0.71	Sh	1.3	26				Yel. brn. & gray v.f. sandy silty clay / ox. spots.
	10	25'-0"	532.6	15	2.27	B	1.8/3.8	21				Mix colored v.f. sandy silty clay (tr. f.-c. sand & f. gravel)
	11	27'-6"	530.1	9	1.86	B	2.4	27				Drk. gray v.f. sandy silty clay.
	12	30'-0"	527.6	8	0.50	B	0.6	33				" " " " " " " .
Ground Surface Elev = 555.5												
2	1	2'-6"	553.0	21	5.89	BSp	4.5+	14				Brn. gray v.f. sandy silty clay / ox. spots.
	2	5'-0"	550.5	20	2.27	B	2.4	27				Yel. brn & gray v.f. sandy silty clay (tr. ox. spots.)
	3	7'-6"	548.0	10	1.86	B	2.2	29				Grn. & drk. brn v.f. sandy silty clay (tr. ox. spots.)
	4	10'-0"	545.5	12	2.68	BSh	2.4	25				Yel brn & gray v.f. sandy silty clay / ox. spots.
	5	12'-6"	543.0	13	2.68	B	2.9	27				Grn. gray clay (tr. silt & ox. spots.)
	6	15'-0"	540.5	12	2.33	B	2.4	28				Brn. gray v.f. sandy silty clay / ox. spots.
	7	17'-6"	538.0	15	1.94	BSh	2.6	27				Yel. brn & gray v.f. sandy silty clay (tr. chard pts.)
	8	20'-0"	535.5	14	2.27	B	2.5	28				" " & " " " " " " (" " ")
	9	22'-6"	533.0	15	2.68	B	2.8	28				" " & " " " " " " (" " ")
	10	25'-0"	530.5	9	1.16	B	1.1	26				" " & " " " " clayey silt / chard. pts.
	11	27'-6"	528.0	8	0.54	B	0.6	23				" " & " " " " silt (tr. chard pts.)
	12	30'-0"	525.5	6	0.89	B	0.7	24				" " & " " " " " " / chard pts.
	13	35'-0"	520.5	5	0.78	B	0.8	23				" " & " " " " " " & brn. f.-m. sand.
	14	40'-0"	515.5	19				14				Brn. gray f.-m. sand.
	14A	40'	515.5	19				29				Gray shaley clay.

Figure 8

OPERATOR CMP

DATE June-2-1987

JOB NO.

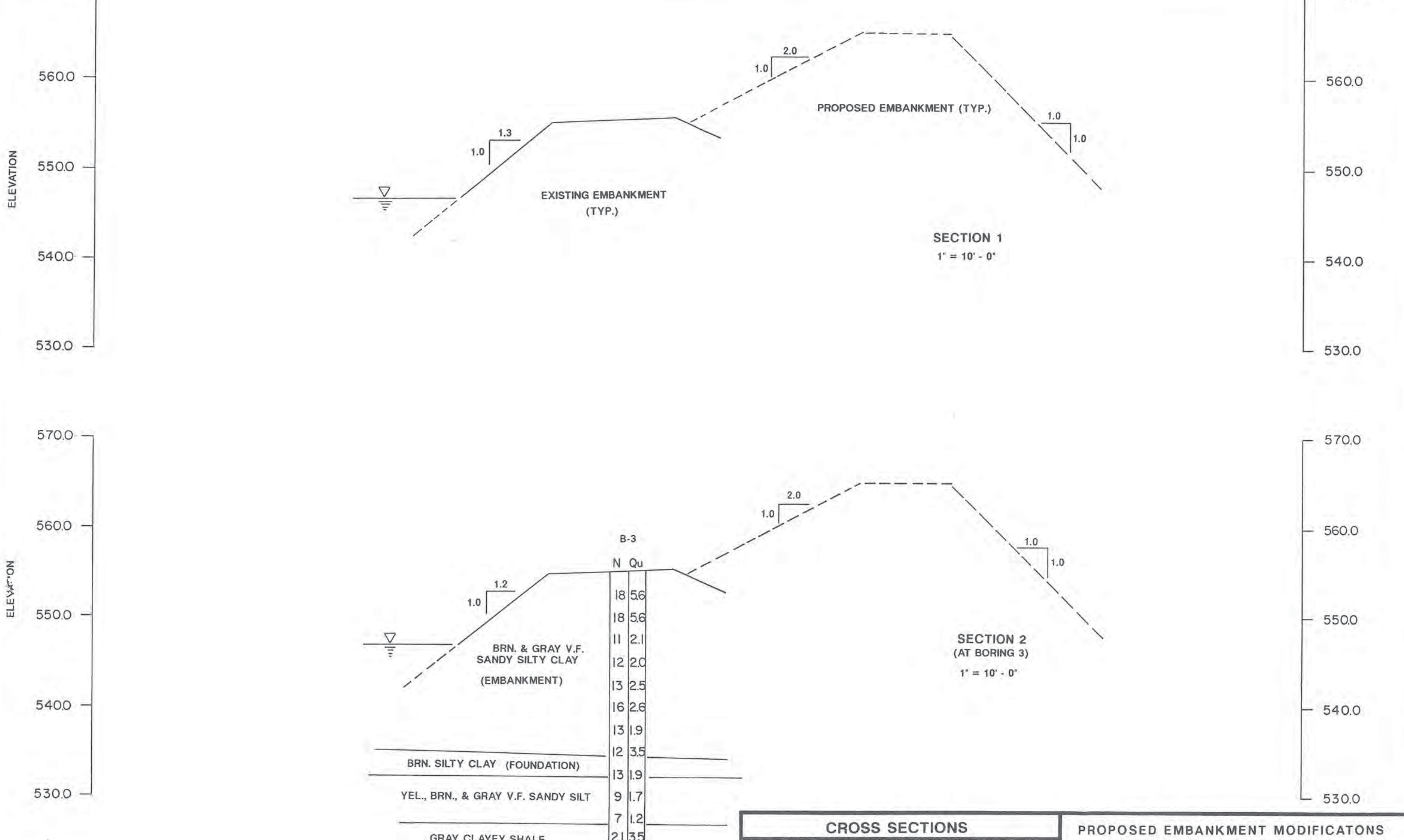
HANSON ENGINEERS INCORPORATED

LABORATORY SOIL TEST DATA

PROJECT NAME AND LOCATION
CWL&P
Ash Pond Study
Springfield, Illinois

BOR.	SAMP.	DEPTH	ELEV.	N	STRENGTH TESTS Qu	M	P	W	γW	γD	SPECIAL TESTS	SAMPLE DESCRIPTION
	Ground Surface Elev=555.2											
3	1	2'6"	552.7	18	5.56	BSh	4.5+	21				Brn.&drk.brn. v.f. sandy silty clay (tr. chard. pts. & sm. roots)
	2	5'0"	550.2	18	5.62	BSp	4.5+	22				Drk. gray clay (tr. chard. pts. & sm. roots.)
	3	7'6"	547.7	11	2.13	BSh	2.4	26				Yel. brn. & gray. v.f. sandy silty clay (tr. chard pts.)
	4	10'0"	545.2	12	1.94	BSh	2.1	29				" " & drk. gray clay (tr. ox. spots.)
	5	12'6"	542.7	13	2.52	B	2.6	25				" " & gray v.f. sandy silty clay (tr. chard. pts.)
	6	15'0"	540.2	16	2.62	B	2.6	26				Drk. gray v.f. sandy silty clay.
	7	17'6"	537.7	13	1.86	B	1.6	28				Yel. brn. & gray v.f. sandy silty clay (tr. chard. pts.)
	8	20'0"	535.2	12	3.50	BSh	3.0/4.5+	21				Drk. gray v.f. sandy silty clay.
	9	22'6"	532.7	13	1.94	B	2.2	28				Yel brn & gray v.f. sandy silty clay & clayey silt / chard. pts.
	10	25'0"	530.2	9	1.71	B	1.7	26				" " & " " " " silt / chard. pts.
	11	27'6"	527.7	7	1.24	B	1.2	27				" " & " " " " " / " ".
	12	30'0"	525.2	21	3.49	B	3.6	26				Brn. gray clay.
	Ground Surface Elev=566.2											
4	1	2'6"	563.7	5	3.05	Sh	2.8	20				Yel. brn. & gray v.f. sandy silt.
	2	5'0"	561.2	11	1.71	Sp	2.7	25				" " & " " " " " & fly ash.
	3	7'6"	558.7	7	1.65	BSh	2.2	13				" " & " v.f.-m. sandy silt (tr. c. sand.)
	4	10'0"	556.2	10	1.47	BSh	1.9	22				" " & " clay / brn. silty f. sand (tr. fly ash.)
	5	12'6"	553.7	8				18				Fly ash.
	6	15'0"	551.2	7				27				" ".
	7	17'6"	548.7	1				94				Drk. gray silty v.f. sand (fly ash.)
	8	20'0"	546.2	2				108				" " " " " " (" ")
	9	25'0"	541.2	1				129				" " " " " " (" ")
	10	30'0"	536.2	16	2.68	B	2.3	31				" " v.f. sandy silty clay.

Figure 4



CROSS SECTIONS

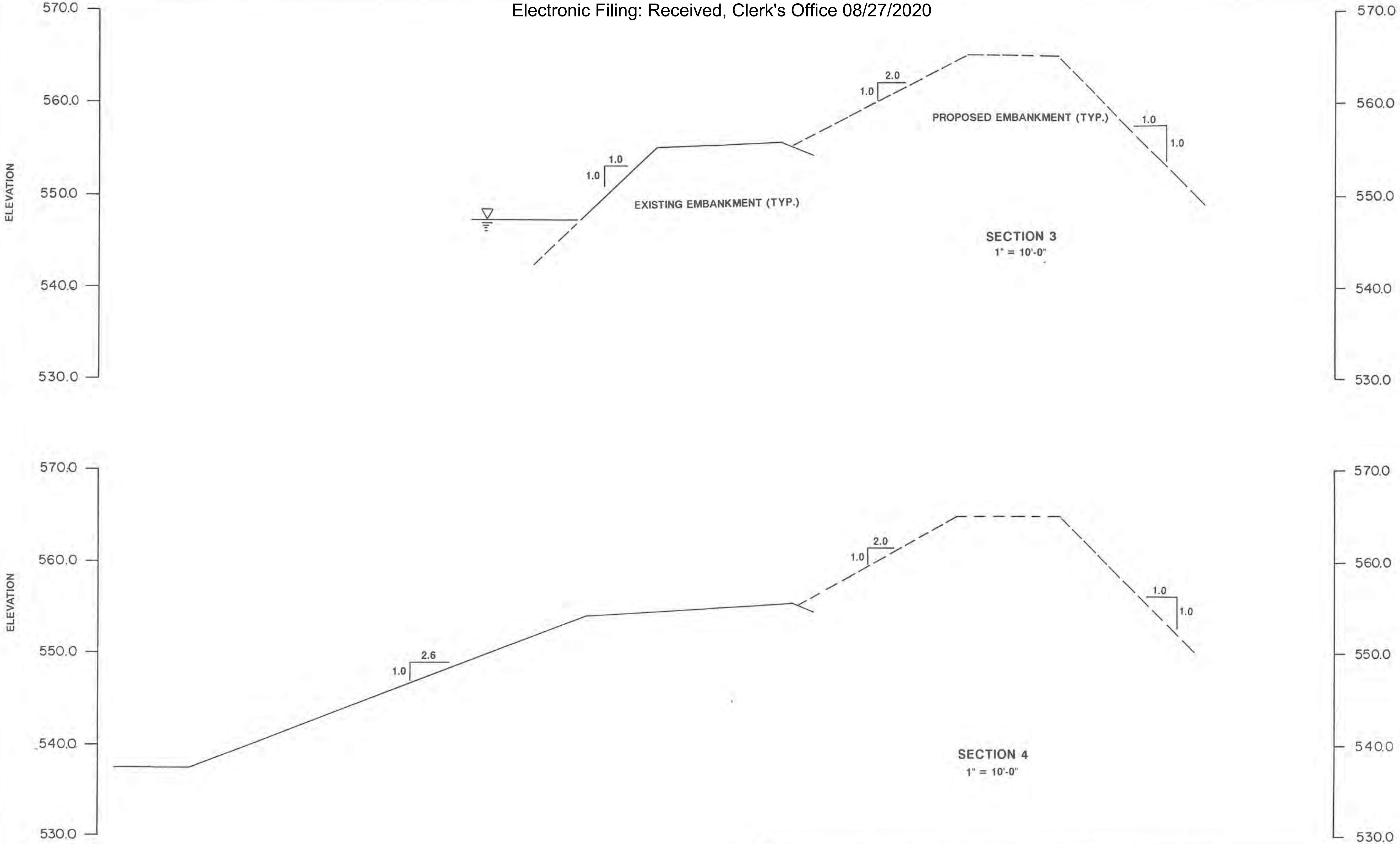
HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014

FIGURE 5



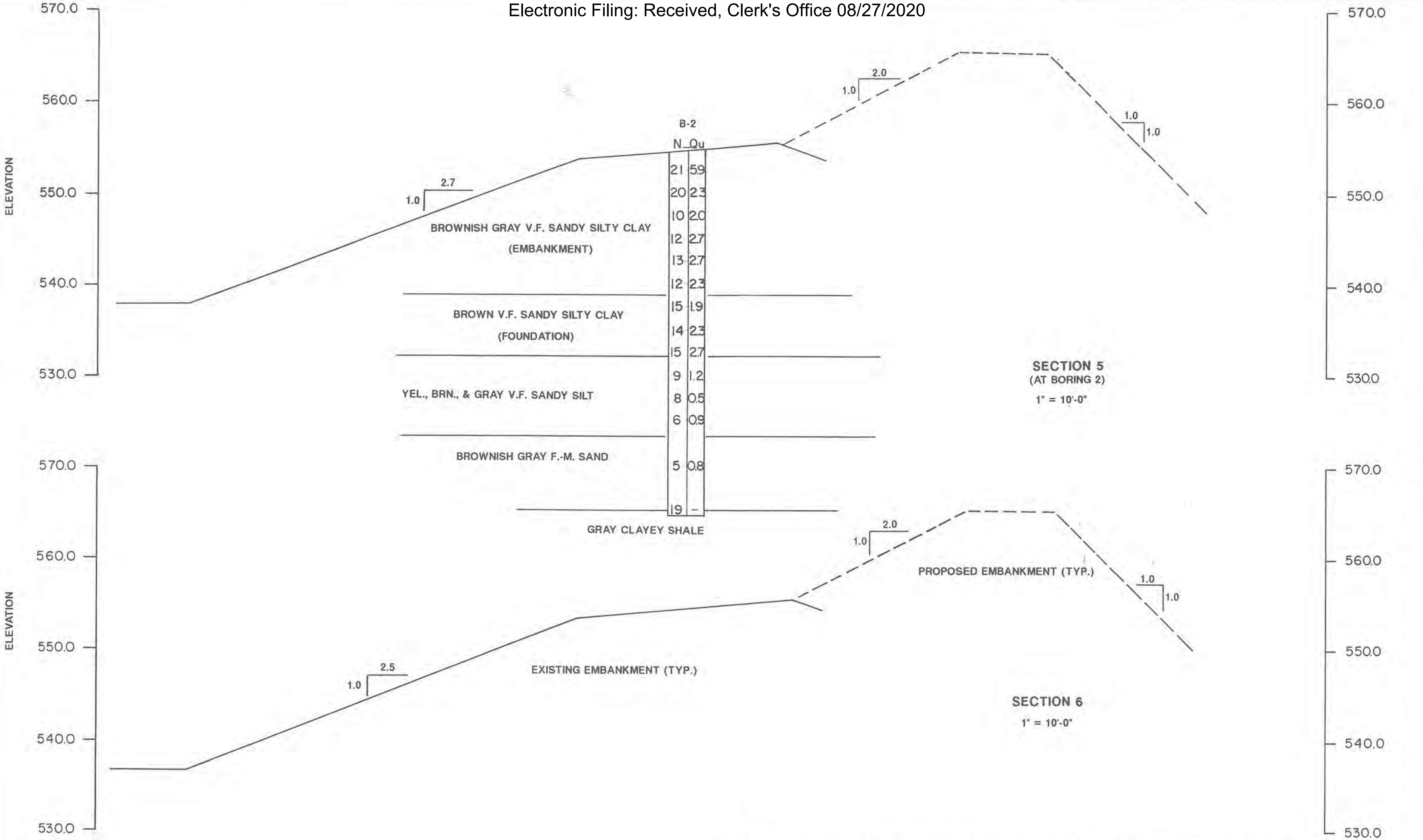
CROSS SECTIONS

HANSON ENGINEERS INCORPORATED

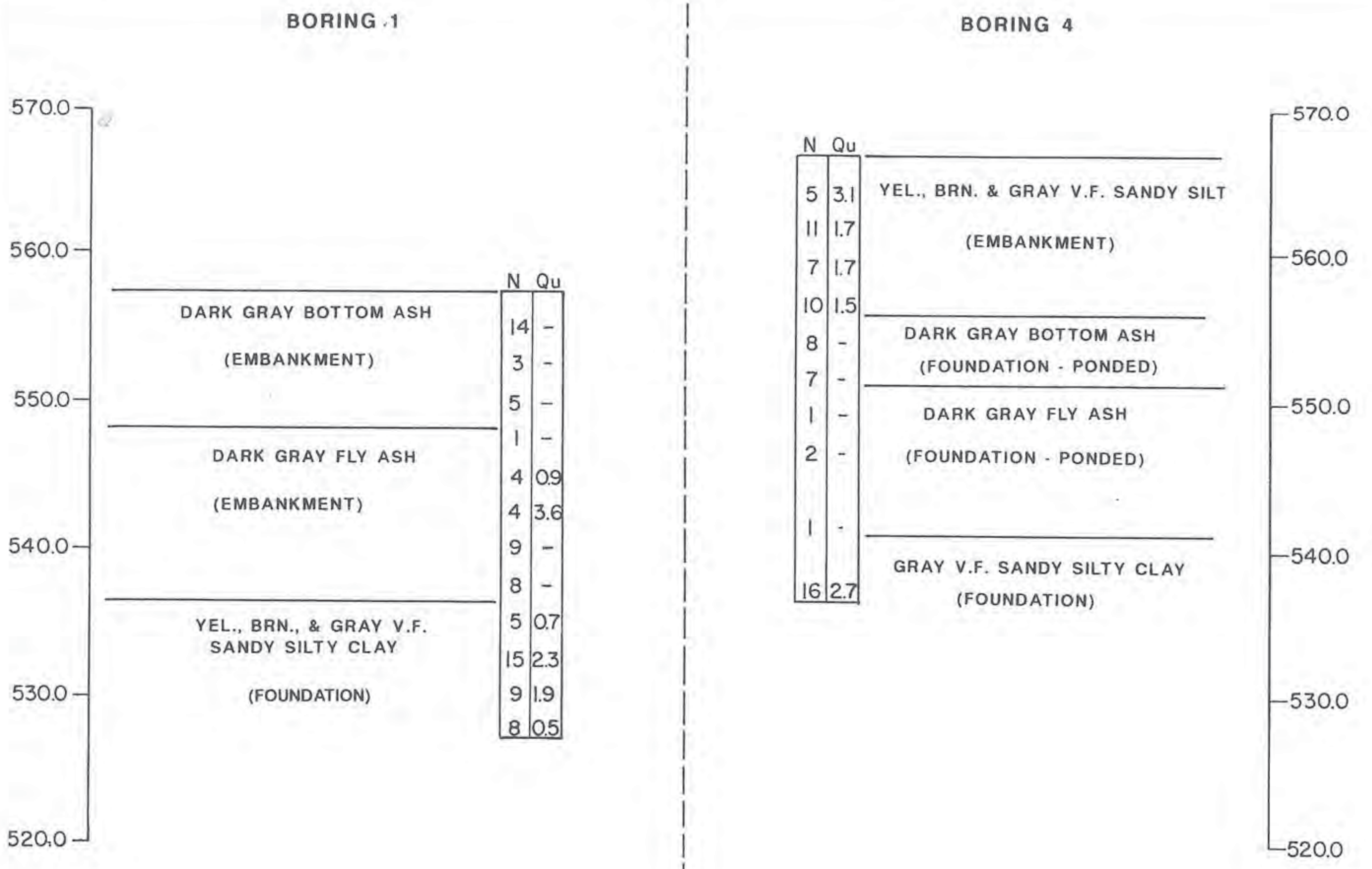
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 6



CROSS SECTIONS	PROPOSED EMBANKMENT MODIFICATONS CWLP ASH DISPOSAL AREA SPRINGFIELD, ILLINOIS
HANSON ENGINEERS INCORPORATED SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL	JOB NO. 87S3014 FIGURE 7



BORING PROFILES

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014

FIGURE 8

APPENDIX A

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-1
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
				6-7-7	1	ss	14"	--		
	Blk. bot. ash, tr. f. gravel									
				3-2-1	2	ss	8	--		
	fill moist-wet		5							
				3-2-3	3	ss	10	--		WATER 5-18-87
										DD 5.0' 8:45am BAR 20.5' 10:15am AAR 4.6' 10:35am
		9.2		2-1-0	4	ss	12	--		DWL 4.0' 6:35pm
	Blk. fly ash		10							
				2-2-2	5	ss	15	0.8		
	wet									
			15	6-2-2	6	ss	14	0.9		
				4-4-5	7	ss	18	--		
				3-5-3	8	ss	18	--		
			20							

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-1
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
				3-2-3	9	ss	18"	1.2	
		23.1							
	Green gray silty clay, tr. f.m. sand, tr. f. gravel moist		25	6-8-7	10	ss	18	4.5+	
		25.7							
	Dk. gray silty clay			4-4-	11	ss	18	3.1	
	moist								
		30.0	30	3-4-4	12	ss	18	2.0	
	END OF BORING 30.0'								

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-2
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
	10" white rock, brn. gray silty clay fill moist	3.3		8-10-11	1	ss	15"	4.5+		
	Light brn. silty clay ~~fill moist~~	5.8	5	8-9-11	2	ss	16	3.0		
	Brn. green blk. silty clay fill moist			3-5-5	3	ss	15	2.1		WATER 5-18-87
			10	3-5-7	4	ss	16	2.4		DD 28.5' 12:00pm BAR 18.5' 1:55pm AAR WCI 15.0' 2:
				3-6-7	5	ss	13	2.0		Dwl 14.0' 6:30pm
			15	3-5-7	6	ss	18	1.7		
				5-6-9	7	ss	18	3.2		
			20	5-6-8	8	ss	18	3.2		

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1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
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LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-2
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
		22.7		4-6-9	9	ss	18"	3.5		
	Brn. gray silty clay, tr. f. sand moist	25.4	25	3-3-6	10	ss	18	1.8		
	Brn. gray clayey silt, some f. sand, occas. 1-3" f. sand seams a wet			3-4-4	11	ss	18	1.5		
		31.5	30	2-3-3	12	ss	18	0.5		
	Brn. f.m. sand wet		35	2-2-3	13	ss	18	1.2		
	~~Brn. f.m. sand wet~~	39.8 ~~40.0~~	40	11-11-12	14	ss	18	2.5		
	END OF BORING 40.0'									

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-3
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
	5" white rock, brn. gray blk. silty clay fill moist			7-6-12	1	ss	14"	4.5+		
		4.5		6-9-9	2	ss	18	4.5+		
	Blk. silty clay fill moist		5							
				5-5-6	3	ss	16	1.7		WATER 5-18-87
		8.3								DD 24.0' 3:50pm BAR 12.4' 4:05pm AAR 10.0' 4:25pm
	Brn. green blk. silty clay fill moist			3-4-8	4	ss	17	2.5		
			10							DWL 9.5' 6:45pm
				3-6-7	5	ss	18	2.2		
		17.9								
	Blk. gray silty clay fill moist			3-6-8	6	ss	18	2.4		
			15							
				5-6-7	7	ss	18	2.3		
				3-4-8	8	ss	18	3.0		
		20.6	20							

CENTRAL ILLINOIS DRILLING COMPANY
1020 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-3
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
	Brn. gray silty clay moist-wet			5-6-9	9	ss	18"	2.0		
			25	3-4-5	10	ss	18	2.0		
		28.2		3-3-4	11	ss	18	1.6		
	Gray brn. clay, little silt moist	30.0	30	6-9-12	12	ss	18	3.8		
	END OF BORING 30.0'									

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-4
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
	Brn. silty clay			3-3-2	1	ss	10"	3.5		
	fill moist	4.0								
	Brn. gray blk. silty clay			4-5-6	2	ss	12	3.2		
			5							
	fill moist			3-3-4	3	ss	10	2.5		WATER 5-18-87 DD 11.0' 5:15pm BAR 22.0' 6:00pm AAR 9.8' 6:30pm DWL 9.5' 6:50pm
				3-5-5	4	ss	13	2.5		
		10.5	10							
	Blk. bot, ash			5-4-4	5	ss	18	--		
	fill wet			5-4-3	6	ss	16	--		
		15.2	15							
	Blk. fly ash			1-1-0	7	ss	18	0.2		
	fill wet			0-0-2	8	ss	.8	0.2		
			20							

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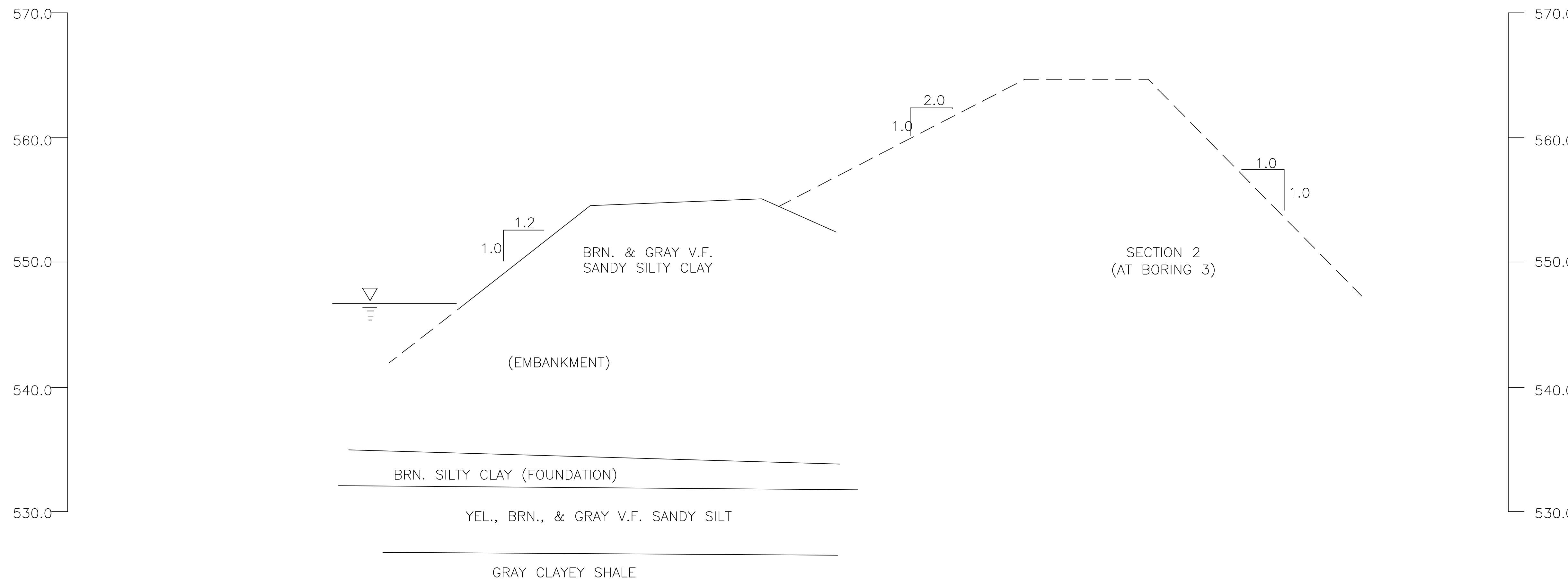
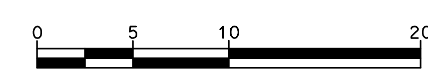
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-4
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
		25.5	~~25~~	1-0-1	9	ss	18"	0.5		
	Blk. gray clay, tr. silt moist	30.0	30	4-6-10	10	ss	18	3.3		
	END OF BORING 30.0'									





NOTES:
CROSS-SECTION BASED ON CONSTRUCTION PLAN DRAWINGS INCLUDED IN ENGINEERING REPORT PROPOSED EMBANKMENT MODIFICATIONS, HANSON ENGINEERS, INC., JULY 1987

NO.	DATE	REVISIONS DESCRIPTION	BY

ANDREWS ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184001541

APPROVED BY: PMV DESIGNED BY: PMV DRAWN BY: RMC

LAKESIDE ASH POND CROSS-SECTION 2

PLANS PREPARED FOR
CITY, WATER, LIGHT & POWER
SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016
PROJECT ID: 150077/0011
SHEET NUMBER:
X-SEC.

APPENDIX C

Fly Ash Technical Papers

Engineering Characteristics of Coal Combustion Residuals and a Reconstitution Technique for Triaxial Samples

Nicholas A. Lacour

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science

In

Civil Engineering

Adrián Rodriguez-Marek, Chair

Joseph Dove

James Martin

19 June, 2012

Blacksburg, Virginia

Keywords: coal combustion residuals, fly ash, bottom ash, surface impoundments

Engineering Characteristics of Coal Combustion Residuals and a Reconstitution Technique for Triaxial Samples

Nicholas Alexander Lacour

ABSTRACT

Traditionally, coal combustion residuals (CCRs) were disposed of with little engineering consideration. Initially, common practice was to use a wet-scrubbing system to cut down on emissions of fly ash from the combustion facilities, where the ash materials were sluiced to the disposal facility and allowed to sediment out, forming deep deposits of meta-stable ash. As the life of the disposal facility progressed, new phases of the impoundment were constructed, often using the upstream method. One such facility experienced a massive slope stability failure on December 22, 2008 in Kingston, Tennessee, releasing millions of cubic yards of impounded ash material into the Watts Bar reservoir and damaging surrounding property. This failure led to the call for new federal regulations on CCR disposal areas and led coal burning facilities to seek out geotechnical consultants to review and help in the future design of their disposal facilities. CCRs are not a natural soil, nor a material that many geotechnical engineers deal with on a regular basis, so this thesis focuses on compiling engineering characteristics of CCRs determined by different researchers, while also reviewing current engineering practice when dealing with CCR disposal facilities. Since the majority of coal-burning facilities used the sluicing method to dispose of CCRs at one point, many times it is desirable to construct new "dry-disposal" phases above the retired ash impoundments; since in-situ sampling of CCRs is difficult and likely produces highly disturbed samples, a sample reconstitution technique is also presented for use in triaxial testing of surface impounded CCRs.

Acknowledgments

I would like to thank Dr. Adrián Rodriguez-Marek, my advisor, for his guidance throughout my thesis work and throughout my academic career at Virginia Tech. I would also like to thank my parents for their encouragement and support throughout my entire academic career. Lastly, I would like to thank my grandmother for passing on my great-grandparents' rock collection that first sparked my interest in geology and undoubtedly led to my interest in geotechnical engineering.

Contents

List of Figures

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Chapter 1

Introduction and Background

Ever since the promulgation of the Resource Conservation and Recovery Act in 1976, there has been debate on the proper waste classification of coal combustion by-products. They have traditionally been disposed of in a fashion similar to that of mine tailings wastes. However, the failure of the Kingston Fossil Plant's main disposal cell on December 22, 2008 has once again led to discussions on how to properly regulate the disposal of these materials. From an engineering standpoint, geotechnical engineers have very little experience with coal combustion wastes, which have some unique engineering properties that set them apart from naturally occurring soils. A comprehensive literature review and compilation of engineering properties of coal combustion residual materials is consolidated and compared between researchers from different nations. Additionally, a triaxial sample reconstitution technique is proposed for surface impounded coal combustion residuals (different types of coal combustion residuals are addressed in section 1.1) which minimizes particle segregation and ensures constant density across the height of the sample. This chapter presents an introduction to the thesis and presents a brief summary of the December 22, 2008 slope stability failure at the Tennessee Valley Authority's (TVA's) Kingston power plant, which served as an inspiration for this thesis.

1.1 Introduction

Coal is the most commonly used fuel in generating electrical energy in the United States. In 2009, coal-powered steam turbines produced 45% of the almost 4 trillion kilowatt-hours of consumed energy in the US (Energy Information Administration 2010). With the burning of such large quantities of coal, there is naturally also a large amount of ash and other byproducts. The four main types of byproducts of burnt coal as described by the Environmental Protection Agency (EPA 2011) are:

Fly Ash: mostly spherical silt to clay-sized particles composed mostly of silica removed from plant exhaust gases through the use of electrostatic precipitators or bag-houses with secondary scrubber systems.

Bottom Ash: coarse, porous, angular fine sand to fine gravel-sized particles of agglomerated ash formed in pulverized ash furnaces.

Boiler Slag: molten bottom ash collected at the base of slag tap and cyclone type furnaces that is quenched with water, causing it to fracture, crystallize, and form pellets. It is composed of hard, black, angular particles that have a smooth, glassy appearance.

Flue Gas Desulfurization (FGD) Material: product of a process used for reducing SO_2 emissions from the gas system of a coal-fired boiler. Depending on the scrubbing process, the material is either predominantly calcium sulfite ($CaSO_3$), calcium sulfate ($CaSO_4$), or a mixture of the two. It consists of small, fine, particles. Calcium Sulfate FGD material can be used in place of gypsum ($CaSO_4 \cdot 2H_2O$) in wallboard manufacturing or in cement production, while calcium sulfite can be used as embankment and road base material.

There are beneficial reuses for each of these byproducts, though generation almost always outweighs demand. In order to avoid confusion, when referring to these byproducts, the definitions outlined by EPA (*Federal Register* 2010) will be used. When referring to burnt-coal byproducts being beneficially used, the term Coal Combustion Products (CCPs) will be used, while Coal Combustion Residuals (CCRs) will be used when referring to byproducts that are destined for disposal.

Use of CCPs are unique to the application in which they are being utilized. Therefore, the focus of this thesis is on the geotechnical engineering properties and design and monitoring considerations for CCR landfills and surface impoundments.

Depending on the type of system used to remove fly ash from and/or to desulfurize the exhaust gases of boilers used in electricity generation, CCRs have traditionally been disposed of using either a dry (or, more accurately, a moisture conditioned) placement method or a hydraulic sluicing method . Again referring to EPA definitions (*Federal Register* 2010), any disposal area where CCRs are disposed of using a dry method will be referred to as a CCR landfill, while any area that CCRs are disposed of hydraulically will be referred to as a CCR surface impoundment. A CCR surface impoundment is a disposal area much akin to a mine tailings dam disposal area, or to a dredge spoil area. While CCR landfill wastes are placed using backhoes or other heavy equipment and compacted in a moist condition, CCR surface impoundment wastes are simply the result of a wet-scrubbing removal system for fly ashes; the effluent from these wet-scrubbing processes is then often mixed with bottom ashes and hydraulically placed in a disposal area contained by some sort of dike system.

As a result of the Kingston Fossil Plant failure, EPA found it necessary to reexamine regulatory policies regarding the disposal of CCRs:

With the promulgation of 42 U.S.C. §6901 (1976), commonly known as the Resource Conservation and Recovery Act (RCRA), CCRs were not initially specified as hazardous (subtitle C) or solid wastes (subtitle D). In 1980, the Solid Waste Disposal Act amendments to RCRA were enacted, one of which was the “Bevill Amendment”, 42 U.S.C. §6921 (b)(3)(A)(i). This amendment temporarily exempted CCRs from subtitle C regulation, classifying them as subtitle D, which is subject to state regulation. In 1988, EPA released a report entitled *Wastes from the Combustion of Coal by Electric Utility Power Plants* in which they concluded that the four above-mentioned CCRs did not exhibit hazardous characteristics according to RCRA regulations and would therefore not be regulated under Subtitle C. However, it was not until August 9, 1993 that EPA issued the final regulatory determination applicable to these CCRs (*Federal Register* 1993), stating that regulation of them as hazardous wastes was unwarranted (Dockter and Jagiella 2005).

Most recently, on June 21, 2010, EPA announced their intent to regulate CCRs generated from the combustion of coal at electric utilities under the RCRA. The EPA announcement introduced two options:

- EPA would reverse the 1993 and 2000 exemptions of CCRs under the Bevill Amendment and list them as special wastes subject to regulation under subtitle C of RCRA when they are destined for disposal in landfills or surface impoundments.
- EPA would leave the Bevill determination in place while regulating the disposal of CCRs under subtitle D of RCRA by issuing national minimum criteria.

Regardless of the chosen alternative, EPA is also proposing to establish dam safety requirements in order to address the stability of CCR surface impoundments to prevent catastrophic releases like that at the TVA Kingston plant. EPA has suggested the adoption of the Hazard Potential Classification System for Dams, developed by the U.S. Army Corps of Engineers, since it would be relatively straightforward in its application to surface impoundments.

The main purpose of this thesis is to consolidate current published material on the properties of CCRs and to quantify the variability within the engineering properties of CCRs between countries, individual power plants, and CCR types. Furthermore, CCR impoundment areas are plentiful across the U.S. and power generating companies would prefer to begin dry disposal of CCRs directly over retired CCR surface impoundments. In order to do this, a geotechnical site investigation must be performed, in which the static and dynamic shear strengths of the surface impounded materials are analyzed. Since CCRs tend to be non-plastic in nature, undisturbed sampling is often difficult, time consuming, costly, and anything but "undisturbed." Therefore, a second objective of this thesis is to analyze a slurry deposition specimen reconstitution technique that is easier and less costly than undisturbed sampling, in order to determine if this specimen reconstitution technique forms samples of uniform relative density without particle segregation.

1.2 Kingston Fossil Plant Failure

The Kingston Fossil Plant is a coal-fired electrical power plant constructed and operated by the Tennessee Valley Authority (TVA). Construction on the facility began in 1951 and the first coal-fired electrical unit began in 1954. Ash slurries were initially released into a slack water area created by a two dikes with a gap in-between to allow water from the Watts Bar Reservoir to enter. The ash slurries and the waters of the reservoir were then allowed to commingle until the two dikes were connected in 1958, separating the reservoir and the ash disposal area. This slack water area collected silt and clay sediments from the period of 1942 to 1954; after 1954, disposed ash was added to the silts and clays being deposited and with the construction of the closure dike, additional clay runoff sediment was deposited along with the runoff silts, reservoir clays, and disposed ash. This formed a slick, weak layer found by AECOM to be a major contribution to the ash disposal area's failure in December of 2008 (Walter and Butler 2009).

The AECOM Root Cause Analysis report attributed the failure as most likely due to creep in the aforementioned weak layer due to active loading in a dredge cell contained within the disposal area. This creep caused an initial failure of various disposal phase dikes founded on older disposed ash deposits, which, in turn, caused progressive failure of upstream ashes, leading to undrained loading and subsequent failure of the downstream ash material and disposal area perimeter dike. The upstream progressive failure stopped upon reaching a former divider dike within the disposal area. The estimated ash released in the failure was 5.4 million cubic yards. Figure 1 provides an aerial photograph of the disposal area before and after the slope failure.

Figure 1: Aerial photographs comparing the Kingston Fossil Plant ash disposal area before and after the massive slope failure on December 22, 2008.

While this failure may have occurred because of a very unique site condition, AECOM did note in their Root Cause Analysis report that "extensive void ratio data in un-failed areas of the Dredge Cells showed a lack of significant consolidation of the wet ash with depth," which would indicate that strength would not increase significantly with depth in the disposed ash material. This property also raises the question of stability of these sort of disposal areas under dynamic loading. If surface-impounded coal ashes do not tend to increase in density with depth, this could leave a very deep, potentially liquefiable layer of CCRs at a given site, rather than just a single liquefaction-prone layer (which is usually the case in naturally-deposited soils).

The entire Root Cause Analysis report and other investigatory data for the Kingston Fossil Plant failure can be accessed on the TVA website at http://www.tva.gov/kingston/rca/.

1.3 Outline

This thesis is composed of eight chapters. The first chapter introduces the background as well as inspiration for the thesis topic. Chapters two and three provide consolidated research results on the static and dynamic engineering properties of CCRs, respectively. Chapter four discusses similarities between mine tailings disposal areas and CCR disposal areas and provides some guidance on how monitoring techniques developed for mine tailings disposal areas can be directly applied or slightly modified so that they can be applied to CCR disposal areas. Chapters five and six address how slope stability and settlement analyses can differ for CCR materials as opposed to naturally occurring soils. Chapter seven provides a review of common triaxial reconstitution techniques used on granular materials, while also analyzing a reconstitution technique to determine if it produces homogenous samples in terms of grain size distribution and relative density with height. Finally, chapter eight provides some final observations for each chapter, as well as a summary of topics that require further research in the future.

Chapter 2

Engineering Characterization of CCRs

Index and mechanical properties of soils provide the basic information required to design earth retaining structures, foundations, and earthen embankments and to perform slope stability analyses; determining the index properties and running field and laboratory tests to determine these properties is the first step in any geotechnical engineering application. In any given region, there is a large body of literature from past projects describing the local soils that engineers can use as a resource to accelerate this initial process. CCRs, however, are not a natural soil and have characteristics that make their behavior in certain situations markedly different than natural soils of similar grain size; additionally, coal ashes can vary considerably from one site to another based on differences in the coal source, coal preparation methods, type of power plant unit, and combustion temperatures (Yudbhir and Honjo 1991). This chapter outlines some of the major differences in the properties of CCRs as compared to other soils and compiles some CCR characteristics obtained from published technical literature. Additionally, test data from engineering reports for five specific coal combustion plants in the U.S. are included; however, information identifying the specific plants has been omitted at the request of the plant operators. These five plants are referred to as Site 1 through Site 5 consistently throughout this thesis.

2.1 Specific Gravity

Perhaps one of the most unusual characteristics of CCRs is their wide range of specific gravities. While some CCRs may have specific gravities of around 2.7 or even 2.8, some have been reported to have specific gravities as low as 1.47. Table 1 provides some values of specific gravity (G_s) determined for CCRs by researchers in different countries.

Table 1: Reported specific gravities of CCRs from different countries

Reference	Type of CCR	Country	G_s
Martin et al. (1990)	Fly Ash	USA	2.03-2.49
Tu et al. (2007)		USA	2.10-2.40
Kim and Prezzi (2008)		USA	2.30-2.81
Site 3		USA	2.42-2.71
Site 4		USA	2.21-2.73
Sridharan et al. (1998)		India	1.95-2.31
Pandian and Balasubramonian (1999)		India	1.97-2.55
Prashanth et al. (1999)		India	2.03-2.67
Sridharan et al. (2001)		India	2.07-2.55
Trivedi and Sud (2004)		India	1.72-2.03
Pandian (2004)		India	1.95-2.55
Das and Yudhbir (2005)		India	2.14-2.62
Prakash and Sridharan (2006)		India	1.95-2.55
Prakash and Sridharan (2009)		India	1.66-2.55
Jakka et al. (2010)		India	2.18-2.27
Raymond (1961)		UK	2.05-2.26
Sherwood (1975)		UK	1.90-2.37
Indraratna and Nutalaya (1991)		Canada	1.90-2.90
		Thailand	2.27-2.45
Kolay and Kismoor (2009)		Malaysia	2.11-2.31
Muhardi et al. (2010)		Malaysia	2.50-2.70
Site 1	Surface Imp.	USA	2.13-2.30
Site 2		USA	2.16-2.26
Site 3		USA	2.55-2.62
Site 4		USA	2.20-2.47
Site 5		USA	2.29-2.61

Reference	Type of CCR	Country	G_s
Sridharan et al. (1998)		India	1.91-2.15
Sridharan et al. (2001)		India	1.96-2.66
Trivedi and Sud (2002)		India	1.60-2.10
Trivedi and Sud (2004)		India	1.98-2.00
Pandian (2004)		India	1.91-2.50
Prakash and Sridharan (2006)		India	1.91-2.50
Bera et al. (2007)		India	2.16-2.23
Prakash and Sridharan (2009)		India	1.64-2.66
Skarzynska et al. (1989)		UK	2.10-2.24
		Poland	1.90-2.31
Seals et al. (1972)	Bottom Ash	USA	2.28-2.78
Sridharan et al. (1998)		India	1.82-2.15
Sridharan et al. (2001)		India	1.98-2.19
Pandian (2004)		India	1.82-2.15
Prakash and Sridharan (2006)		India	1.66-2.17
Prakash and Sridharan (2009)		India	1.47-2.19
Jakka et al. (2010)		India	2.50-2.59
Kolay and Kismoor (2009)		Malaysia	2.09-2.32

Despite the wide range of specific gravities observed for CCRs, most researchers recognize that they usually have a specific gravity lower than that of natural soils (Prakash and Sridharan 2009, Trivedi and Singh 2004b, Tu et al. 2007). It logically follows that since the unit weight of CCRs is less than that of natural soils, horizontal earth pressures in CCRs will be less than that of natural soils as well. Prakash and Sridharan (2009) cite this as a property that makes them ideal for use as backfill material for retaining structures or as a lightweight fill in other construction applications.

Many factors contribute to variability in the specific gravity of coal ashes, such as the parent coal and the combustion and cooling processes. Figure 1 compares variability of the specific gravity of different coal ashes from different countries. Additionally, some of the research studies done on ash from several different plants have a much higher variability than studies done on specific sites, indicating that variability in the specific gravity of CCRs within a given plant is lower than the specific gravity of CCRs within the country where that plant is in. Examining Figure 2, it is interesting to note the clear difference in the mean values of specific gravity between US coal ashes and Indian coal ashes; this may be due to higher iron contents in

US coals. Table 2 provides percentages of major constituent oxides in CCRs from different countries by weight, which shows how much the mineralogy of CCRs can vary between countries, another factor that can account for high variability in the specific gravity of CCRs from different countries (Yudbhir and Honjo 1991). Loss on ignition (LOI) for the CCRs is also reported in Table 2, that is, the loss in mass of the samples upon strong heating.

Table 2: Percentages by weight of major oxide constituents of CCRs from different countries (after Yudbhir and Honjo 1991).

Constituents	USA	UK	Canada	India	Thailand	Japan	Hong Kong	China	Australia	S. Africa	Poland	Germany
SiO_2	28-59	37-54	37-59	13-64	27-34	50-62	38-77	44-55	44-73	40-53	43-52	48
Al_2O_3	7-38	17-33	12-24	14-31	19-28	22-30	14-46	20-32	16-33	24-35	19-34	25
Fe_2O_2	4-42	6-22	3-39	3-24	20-24	4-7	1-18	1-17	3-6	5-11	1-13	7
CaO	0-13	1-27	1-13	1-34	11-16	3-7	0-16	5-9	0-9	5-10	2-9	3
LOI	0-48	0-27	0-10	0-16	0-2	1-6	4-8	3-9	1-9	2-11	2-10	-
Glass Content	54-87	54-87	54-95	-	-	56-58	-	29-40	49-60	29-43	-	-

Note: LOI = loss on ignition

2.2 Consolidation Properties and Volume Stability

CCRs have historically been disposed of in two major ways: collected from boilers hydraulically and diverted to a surface impoundment or collected through electrostatic precipitators or flue gas desulfurization systems and dry-placed into CCR landfills. In either of these disposal alternatives, there is traditionally no defined level of compactive effort used and depending on future uses of the disposal sites, the consolidation characteristics of CCRs can be of interest to geotechnical engineers. Again, since CCRs are not naturally occurring soils, there has been little testing on their consolidation properties and volume stability. Table 3 provides compression and recompression indices and coefficients of consolidation determined by different researchers.

Few researchers report a value for the recompression index; in a disposal area, there would not necessarily be an unloading-reloading process during normal operations. Whenever recompression indices are reported, it is usually in reference to reuse of CCRs in construction applications. Furthermore, the recompression indices reported are extraordinarily low. The reported values of coefficient of consolidation, c_v, are highly variable, as might be expected for materials that have non-typical stress histories. Furthermore, it is important to note that values of

c_v cannot be determined using the traditional Taylor or Casagrande methods, since the majority of deformation for laboratory consolidation tests is complete within one minute; therefore, it is necessary to take deformation readings at very small time intervals (Yudbhir & Honjo 1991). It is also important to note that reported values of c_v mean little independent of the vertical effective stress at which that value was recorded, since the coefficient of consolidation is dependent on both the compressibility of the material and the permeability of the material, based on Terzaghi's original one-dimensional consolidation equation:

$$c_v = \frac{1}{\gamma_w}\frac{k_v}{m_v} \tag{1}$$

where c_v = coefficient of consolidation
γ_w = unit weight of water
k_v = vertical coefficient of permeability
m_v = coefficient of compressibility

Since both k_v and m_v generally decrease with increasing overburden stress, but not necessarily at the same rate, it is hard to relate the coefficient of consolidation to the compression and recompression indices in a general manner. Consequently, the values of c_v reported in Table 3 should not be taken as "typical" values, because of how c_v is mathematically defined.

Some of the variability of compression and recompression indices and coefficient of consolidation of CCRs can be attributed to the type of CCR. For example, it is logical to assume that bottom ash would have a higher coefficient of consolidation, since it has a higher hydraulic conductivity and a lower compressibility than fly ash. For this reason, variability plots for fly ash and surface impounded ash have been presented separately from those for bottom ash. Figures 3 through 5 present variability plots for the compression and recompression indices for different types of CCRs. Since the recompression index of bottom ash is rarely determined by researchers, the variability plot for recompression index includes fly ash, surface impounded ash, and bottom ash. Figure 6 presents a variability plot for the coefficient of consolidation for CCRs at different placement conditions.

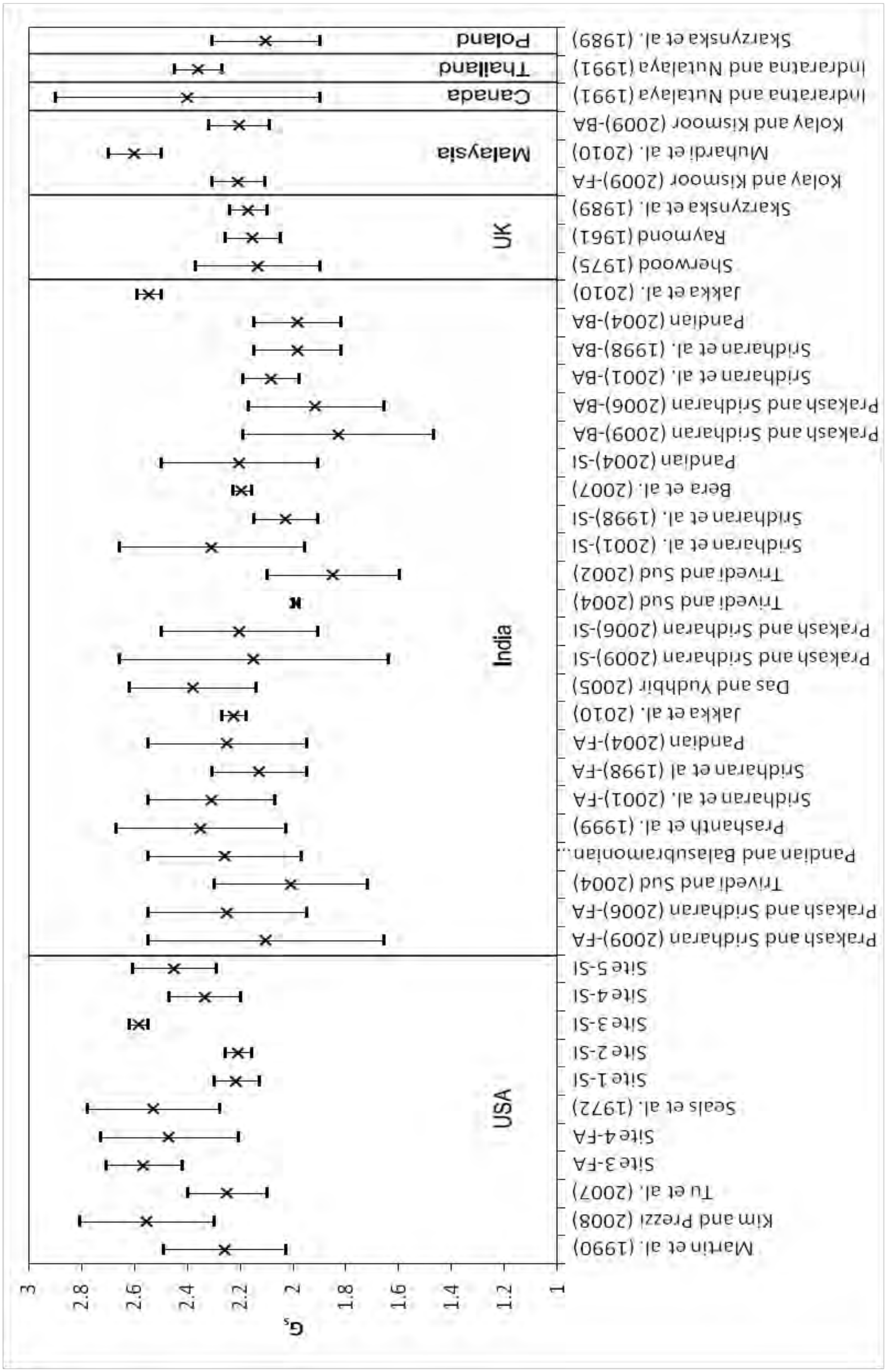

Figure 2: Variability plot for the specific gravities determined by studies performed in different countries.

Table 3: Compression and recompression indices and coefficients of consolidation for CCRs reported by different researchers.

Reference	Type of CCR	Country	C_c	C_r	C_v (cm^2/s)	Vertical Stress (psi)
Tu et al. (2007)	FA Resed.	USA	0.0390-0.0640	0.0035-0.0072	2.00-70.0	0.203-150
Site 1	SI	USA	0.080-0.710	0.0100-0.0300	-	0.694-111
Pandian and Balasubramonian (1999)	FA	India	-	-	0.00200-0.0802	0.73-116
Trivedi and Sud (2002)	SI/MH	India	0.00600-0.0100	0.000300-0.00300	-	3.34-116
Kaniraj and Gayathri (2004)	FA Comp.	India	0.0410-0.0840	0.00800	0.080-2.00	1.42-182
Pandian (2004)	FA	India	0.0490-0.284	-	1.16×10^{-5}-1.27×10^{-4}	7.12-113
	SI	India	0.0520-0.300	-	2.93×10^{-7}-8.17×10^{-4}	0.00-56.9
	BA	India	0.0570-0.484	-	7.57×10^{-7}-3.35×10^{-5}	0.00-56.9
Madhyannapu et al. (2008)	FA Resed.	India	0.100-0.167	0.00400-0.00800	-	
Prakash and Sridharan (2009)	FA Comp.	India	-	-	0.140-3.25	-
	SI Comp.	India	-	-	0.960-10.0	-
	BA Comp.	India	-	-	1.43-10.15	-
Jakka et al. (2010)	FA Comp.	India	0.079-0.246	0.018-0.023	-	7.26-29.0
	BA Comp.	India	0.051-0.059	0.013-0.024	-	7.26-29.0
Kolay and Kismoor (2009)	FA Comp.	Malaysia	0.0490-0.0510	-	-	319-2467
	SI Comp.	Malaysia	0.0780	-	-	319-2468
	BA Comp.	Malaysia	0.103-0.113	-	-	319-2469
Muhardi et al. (2010)	FA Comp.	Malaysia	0.150	-	3.00×10^{-5}-1.53×10^{-4}	-
	BA Comp.	Malaysia	1.54	-	-	-
Yudhbir and Honjo (1991)	FA Comp.	-	0.0300-0.375	-	-	-
	FA SI	-	0.0650-0.610	-	-	-
	FA SID	-	0.610-0.885	-	-	-
CAPCO (1990)	FA Comp.	Hong Kong	-	-	9.51×10^{-3}-1.90^{-2}	-
Haws et al. (1985)	FA Comp.	UK	-	-	9.51×10^{-4}-6.34×10^{-3}	-
Koo (1991)	FA Comp.	Thailand	-	-	3.17×10^{-4}-7.61×10^{-3}	-

FA = fly ash
BA = bottom ash
SI = surface impoundment ash
SID = surface impoundment/loose dry dump ash
MH = mixed hopper ash
Comp. = compacted
Resed. = resedimented

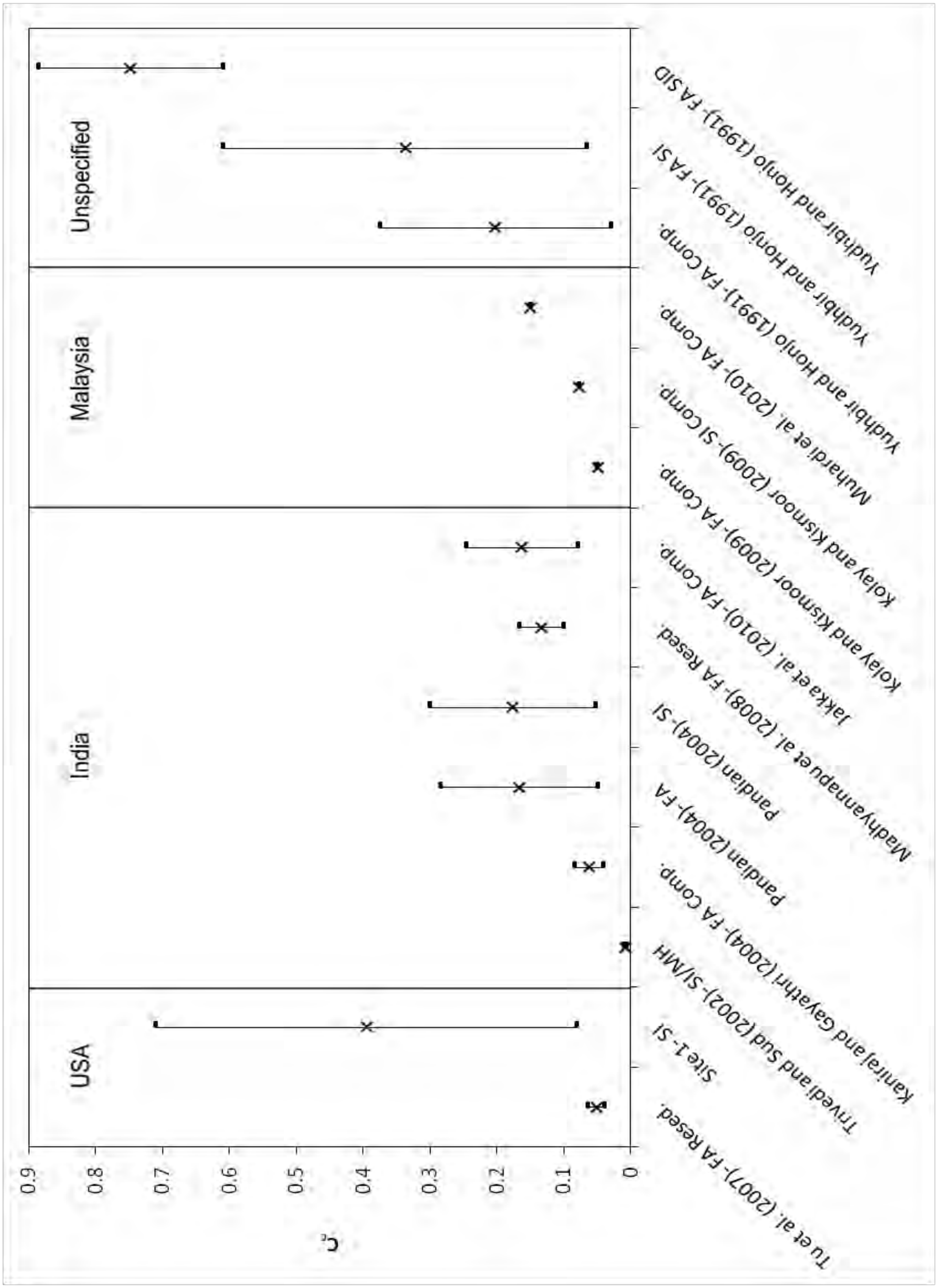

Figure 3: Variability plot for the compression indices of studies done on fly ashes and surface impounded ashes.

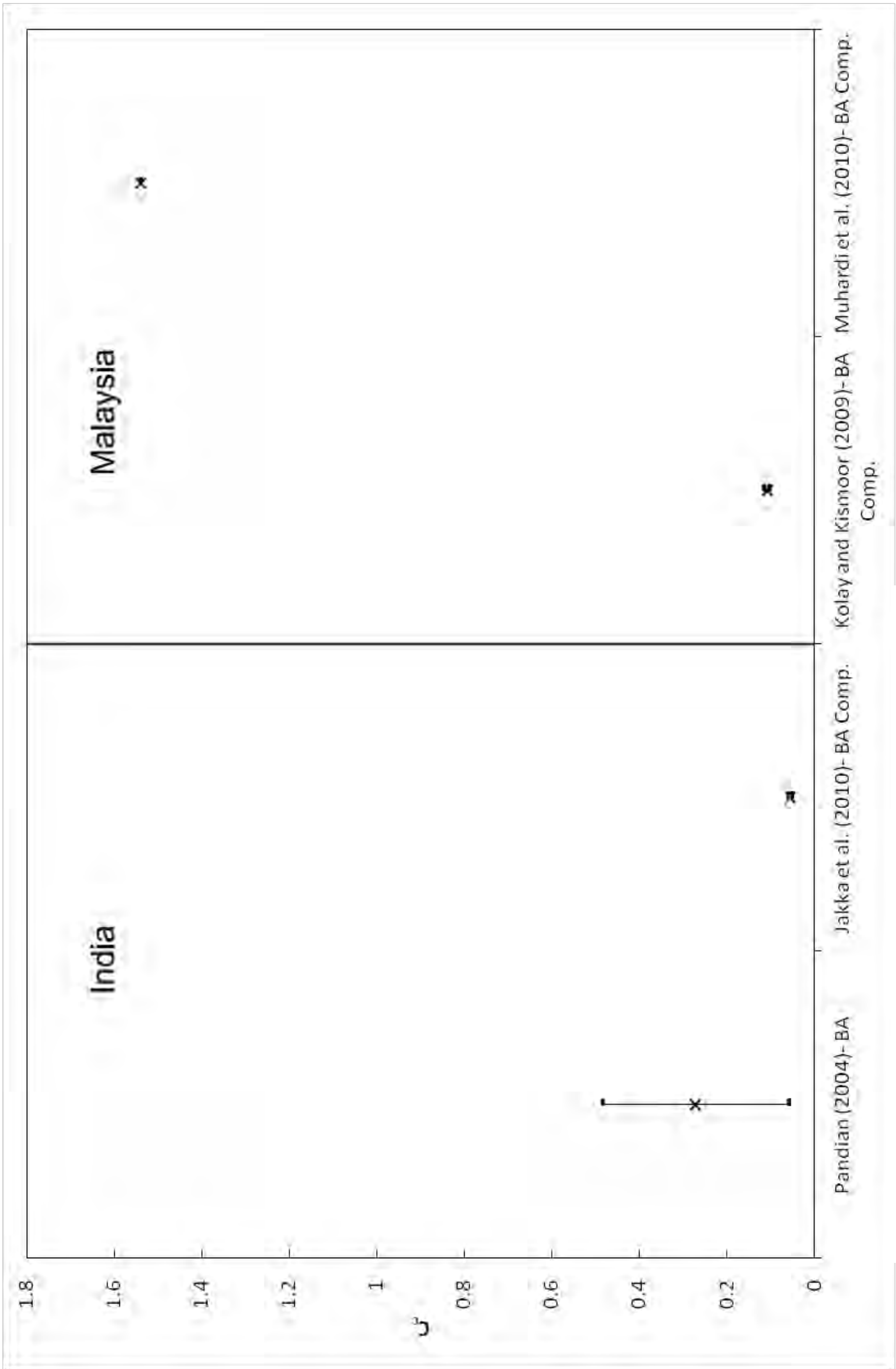

Figure 4: Variability plot of the compression indices for studies done on bottom ashes.

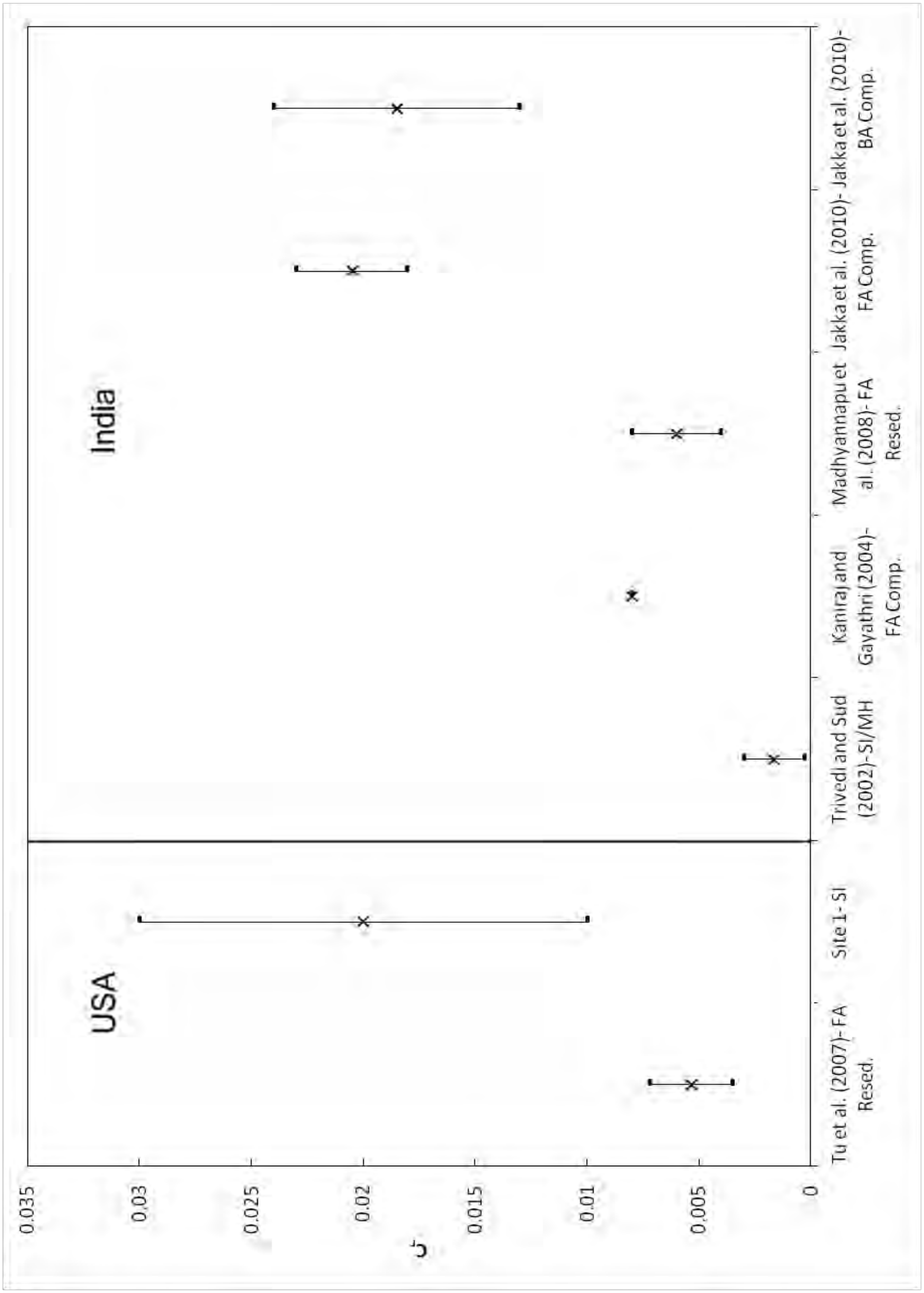

Figure 5: Variability plot of the recompression indices for studies done on fly ashes, bottom ashes, and surface impounded ashes

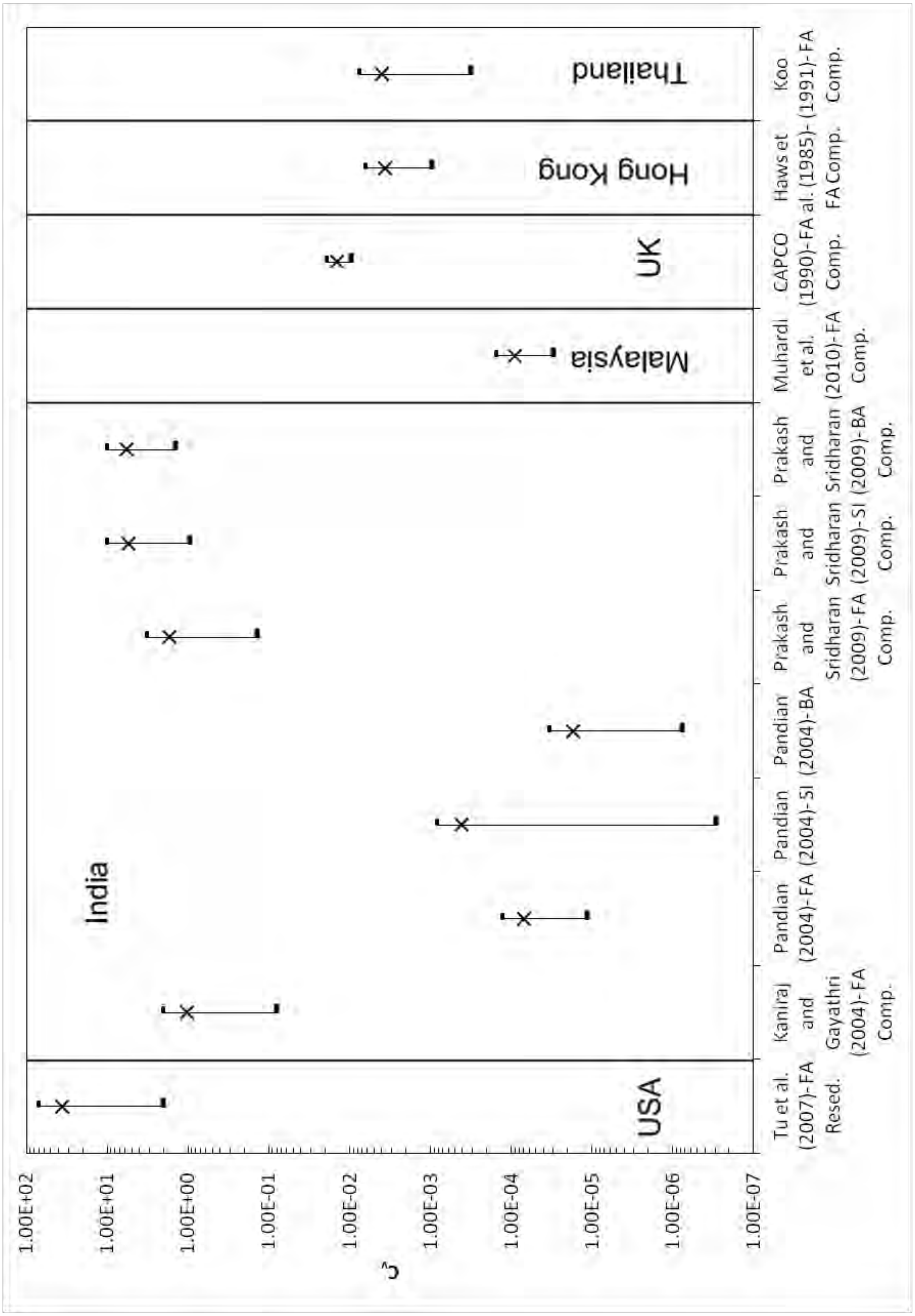

Figure 6: Variability plot for the coefficient of consolidation of studies done on fly ash, bottom ash, and surface impounded ash.

If structures are to be built on former CCR disposal areas or dry-disposed ashes are to be placed on hydraulically-placed deposits, volume stability of CCRs can also be of engineering concern. Swell, shrink, and collapse potentials are the three main types of volume instability examined for soils.

According to Sridharan and Prakash (2009), the swell potential of a soil can be examined through the use of the free swell ratio (FSR) which is defined as

$$FSR = \frac{V_d}{V_k} \tag{2}$$

where V_d = sediment volume of 10 g of oven-dried soil that passes a 425 μm sieve placed in a 100 ml jar which is then filled with de-aired water.

V_k = a sample identical to V_d except the solute is carbon tetrachloride or kerosene.

Note: a fume hood is required if there are any hazardous materials associated with the samples being tested

The swell potential can be determined based on the ranges of FSR as outlined in Table 4:

Table 4: Classification of Soils based on FSR (adapted from Sridharan and Prakash 2000)

FSR	Soil Type	Swell Potential
≤1.0	Nonswelling	Negligible
1.0-1.5	Mixture of swelling and nonswelling	Low
1.5-2.0	Swelling	Moderate
2.0-4.0	Swelling	High
>4.0	Swelling	Very High

Additionally, ASTM D4829 (2003), "Standard Test Method for Expansion Index of Soils," provides a standardized method of determining the swell potential of soils based on the expansion index (EI_{50}). In order to determine the EI_{50} of a soil, a dried soil sample must first be mixed with distilled water to the approximate optimum moisture content and allowed to sit in an air-tight container for at least 16 hours. Then, the conditioned soil is compacted in a 4.01 inch diameter mold in two two-inch lifts using 15 well-distributed blows of a 5.5 lb, 2.00 inch diameter rammer dropped from a height of 12 inches. Once the sample degree of saturation (S) is measured to be within 40% to 60%, the sample is loaded into a consolidometer and consolidated for 10 minutes under a load of 1.0 psi before the initial reading on the dial indicator is taken. The specimen is then inundated with distilled water while periodic readings of the dial indicator are made in accordance with test D2435 (2003) for 24 hours or until the rate of expansion becomes less than 0.0002 inches per hour. The EI of a soil is then defined as

$$EI_{50} = EI_{meas} - (50 - S_{meas}) \cdot \frac{65 + EI_{meas}}{220 - S_{meas}} \tag{3}$$

where S_{meas} = the degree of saturation measured in the test

and

$$EI_{meas} = \frac{\Delta H}{H_1} \cdot 1000 \tag{4}$$

where ΔH = the change in height ($D_2 - D_1$) of the sample, mm
H_1 = initial height, mm
D_1 = initial dial reading, mm
D_2 = final dial reading, mm

The shrink potential of soils is usually assessed based on that soil's shrinkage limit, which is outlined in ASTM D4943 (2002) and calculated according to equation 5:

$$SL = w - \left[\frac{(V - V_d) \cdot \rho_w}{m_s}\right] \cdot 100 \tag{5}$$

where w = moisture content of the soil at the time it was placed in the dish (%)
V = the volume of the wet soil pat = volume of the dish
V_d = volume of the dry soil pat
ρ_w = density of water
m_s = mass of the dry soil pat

However, CCRs are generally non-plastic and ASTM D4943 is only applicable when the soil is cohesive in nature. Based on the fact that CCRs generally have a uniform gradation it can be assumed that they would have a high shrinkage limit (Prakash and Sridharan, 2009).

The collapse potential of a soil is the percent change in volume of a specimen after inundation. It is usually determined using oedometer tests and, as a result, can either be expressed mathematically in terms of height or void ratio, according to equation 6.

$$C_p = \frac{\Delta h}{h_0} = \frac{\Delta e}{(1 + e_0)} \tag{6}$$

where Δh = change in height of the specimen upon inundation
h_0 = the height of the specimen prior to inundation
Δe = change in void ratio of the specimen upon inundation
e_0 = void ratio of the specimen prior to inundation

Since collapse potential can change given different applied stress levels and overconsolidation states, there are any number of typical collapse potential values for a given soil, depending on the in-situ stress and the preconsolidation pressure of the soil. Generally, if the collapse potential is below 1%, there is no danger of collapse of soil structure (Mudhyannapu et al. 2008, Trivedi and Sud 2004).

It is important to note that collapse potential increases dramatically for some dry-disposed coal ashes when tested in a moist condition as opposed to a dry condition; even soils that classify as non-collapsible in a dry condition can become collapsible in a moist condition. This is due to the presence of soluble substances not present in the coal ashes disposed of using wet disposal methods (Trivedi and Sud 2004).

2.3 Hydraulic Conductivity

An important soil property for seepage calculations for earthen embankments is hydraulic conductivity. This is an especially important property for CCR surface impoundments, since they tend to be deposited in a meta-stable structure. In addition, the CCRs are often used to construct embankments as the surface impoundments are raised. Hydraulic conductivity of CCRs deposited in surface impoundments can display anisotropy as a result of its cyclic, lacustrine-style deposition. For engineering purposes, the hydraulic conductivity of both the compacted embankment material and the disposed CCR material will be of interest, as these values are used in erosion analyses. Table 5 presents hydraulic conductivities of different types of CCRs from different countries as determined by various researchers. Due to the fact that there are different disposal methods for CCRs and different types of CCRs that are often co-disposed of, there is a wide variety of placement conditions, each of which can potentially create a different soil fabric and therefore a different range of hydraulic conductivities.

The CCRs were divided into two groups in order to assess variability in hydraulic conductivity: fly ash and surface impounded ash/bottom ash. This was done because oftentimes surface impounded ash is made up of both fly ash and bottom ash; this fact, coupled with its loose placement condition ensures hydraulic conductivity will be at the material's naturally highest value. Figures 7 and 8 are variability plots hydraulic conductivity of fly ashes and surface impounded ash/bottom ash from different countries, as determined by different researchers. It is important to note that not all researchers specified whether it fly ash tested was class c or class f (class c exhibits self-cementing properties); this fact could be a further contributor to the variability in values of hydraulic conductivity of fly ashes.

Table 5: Values of hydraulic conductivity for different CCRs for different countries as determined by different researchers (adapted from Prakash Sridharan 2009)

Reference	Country	CCR Type	Testing Condition	k (cm/s)
Seals et al. (1972)	USA	BA	Relative density = 50%	5.0×10^{-3} to 0.094
McLaren and DiGioia (1987)		Class F FA	$\gamma_{d\,max\_SP}$, $\gamma_{d\,max\_MP}$	1.3×10^{-5}
		Class F FA	SI or poorly compacted	1.8×10^{-5}
		Class C FA	$\gamma_{d\,max\_SP}$, $\gamma_{d\,max\_MP}$	1.1×10^{-5}
Martin et al. (1990)		FA	$\gamma_{d\,max\_SP}$	1.8×10^{-5} to 1.2×10^{-4}
		BA	$\gamma_{d\,max\_SP}$	1.2×10^{-3}
Yudbhir and Honjo (1991)		Class C FA	$\gamma_{d\,max}$	1.0×10^{-7} to 2.0×10^{-7}
		Class F FA	$\gamma_{d\,max}$	2.0×10^{-6} to 6.0×10^{-5}
Glogowski et al. (1992)		Eastern US FA	-	1.9×10^{-5}
		Western US FA	-	3.1×10^{-5}
Site 1		SI	Undisturbed	1.1×10^{-3} to 1.7×10^{-2}
Site 3		FA-SI	Undisturbed	7.0×10^{-7} to 6.5×10^{-7}
		BA	Bulk Recompacted	2.3×10^{-6}
Site 4		FA-Comp.	Undisturbed	1.3×10^{-7} to 8.2×10^{-5}
		SI	Undisturbed	1.6×10^{-5} to 6.3×10^{-5}
Site 5		FA-Comp.	Undisturbed	1.5×10^{-5} to 8.0×10^{-4}
		SI	Undisturbed	4.8×10^{-6} to 4.0×10^{-4}
Pandian and Balasubramonian (1999)	India	FA	Compacted to 0.95 $\gamma_{d\,max}$ and saturated	1.4×10^{-5} to 4.2×10^{-4}
Kaniraj and Gayathri (2004)		FA	$\gamma_{d\,max}$	4.7×10^{-6} to 6.0×10^{-6}
Prakash and Sridharan (2009)		FA	Compacted at $\gamma_{d\,max}$ and saturated	8.0×10^{-6} to 1.9×10^{-4}
		SI	-	5.0×10^{-5} to 9.6×10^{-4}
		BA	-	9.9×10^{-5} to 7.1×10^{-4}
Jakka et al. (2010)		FA	loose	7.0×10^{-7} to 2.1×10^{-6}
		FA	dense	3.5×10^{-7} to 9.4×10^{-7}
		BA	loose	6.0×10^{-6} to 1.3×10^{-5}
		BA	dense	1.4×10^{-6} to 3.7×10^{-6}
Indraratna et al. (1991)	Thailand	Class C FA	$\gamma_{d\,max\_SP}$	4.0×10^{-7} to 7.0×10^{-7}
		Class C FA	$\gamma_{d\,max\_SP}$, 2 weeks curing	$<10^{-7}$
Gray and Lin (1972)	UK	FA	$\gamma_{d\,max}$	5.0×10^{-7} to 8.0×10^{-5}
Porbaha et al. (2000)	Japan	FA	Slurry (e_i = 0.85 to 1.02)	10^{-5} to 10^{-4}
Skarzynska et al. (1989)	Poland	SI	-	1.5×10^{-5} to 5×10^{-5}
Chan et al. (1986)	Canada	FA	in situ	10^{-7} to 10^{-4}
		BA	-	4.8×10^{-4} to 3.4×10^{-3}
Gitari et al. (2009)	South Africa	FA	Air flush core samples, constant head	4.6×10^{-5} to 6.9×10^{-5}
		BA	Air flush core samples, constant head	8.1×10^{-5} to 4.9×10^{-4}
		FA/BA Dry Dump	Field Slug Tests	2.3×10^{-5} to 9.6×10^{-3}

Note: FA = fly ash; SI = surface impoundment ash; BA = bottom ash; OMC = optimum moisture content; e_i = initial void ratio; FA-SI = surface impounded fly ash; FA-DS = dry-stacked fly ash; FA Comp. = field-compacted fly ash

Figure 7: Variability plot of the hydraulic conductivity of fly ashes from different countries, as determined by different researchers.

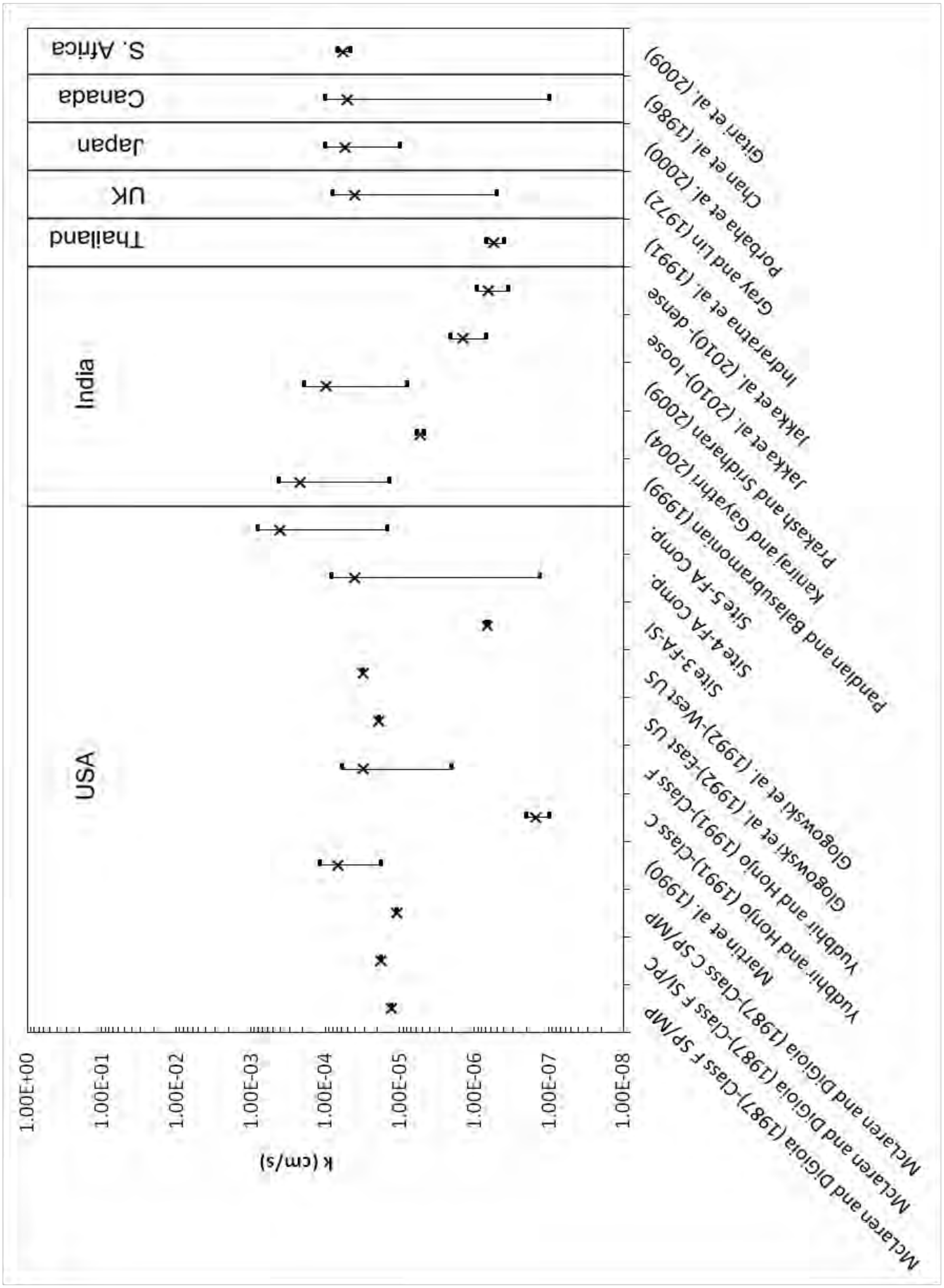

Figure 7: Variability plot of the hydraulic conductivity of fly ashes from different countries, as determined by different researchers.

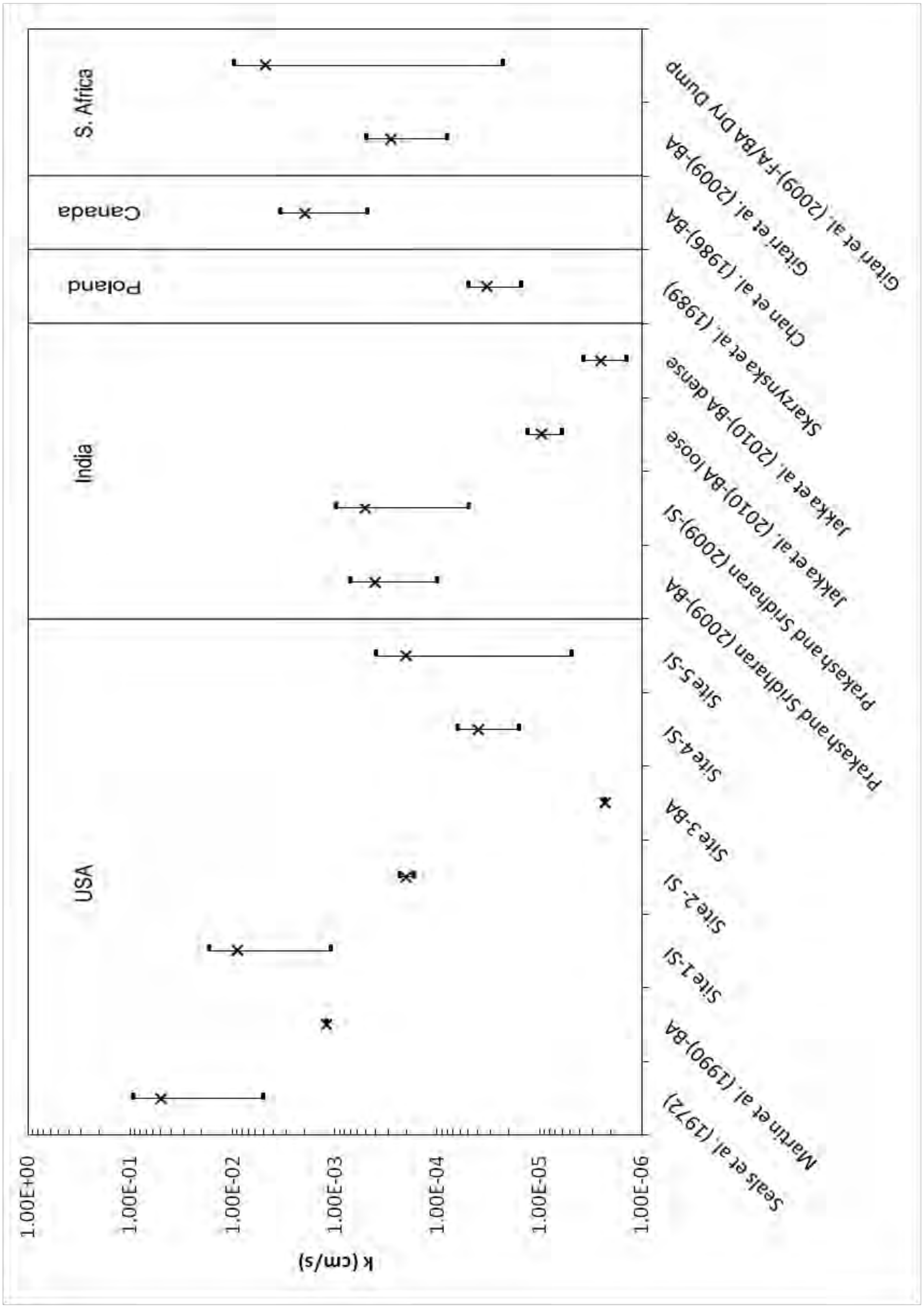

Figure 8: Variability plot of the hydraulic conductivity of surface impounded ashes and bottom ashes from different countries, as determined by different researchers.

2.4 Shear Strength

X-ray diffraction studies indicate that CCRs do not contain any of the clay minerals responsible for the cohesive portion of shear strength in soils (Trivedi and Singh 2004a, Trivedi and Singh 2004b, Ward and French 2005), which means that CCRs must derive their strength entirely from the frictional interaction between ash particles. Through the use of a scanning electron microscope (SEM), it is possible to study the morphological characteristics of coal ash particles and get an idea of their angularity, which would in turn offer clues as to the source of their frictional strength. As shown in Figures 9 and 10, bottom ash is much more angular than fly ash. In general, this can be associated with higher friction angles than fly ash at low confining stresses, which is usually the case. At high confining stresses, the higher angularity could lead to more particle breakage for bottom ash, and consequently to a larger degradation of their frictional resistance.

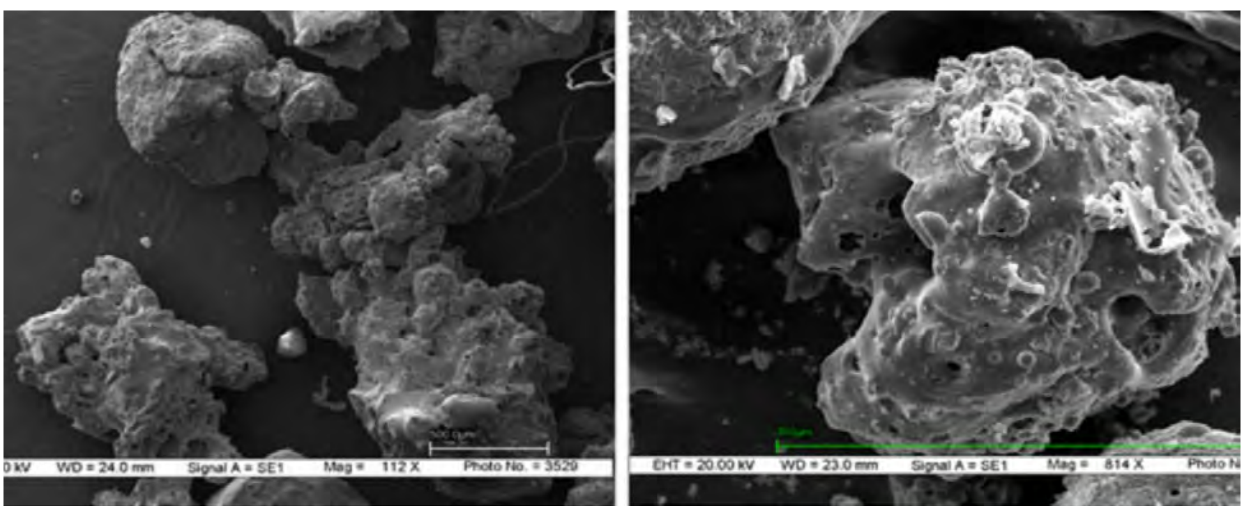

Figure 9: Micrographs of bottom ash particles magnified 112 and 373 times (Jakka et al. 2010)

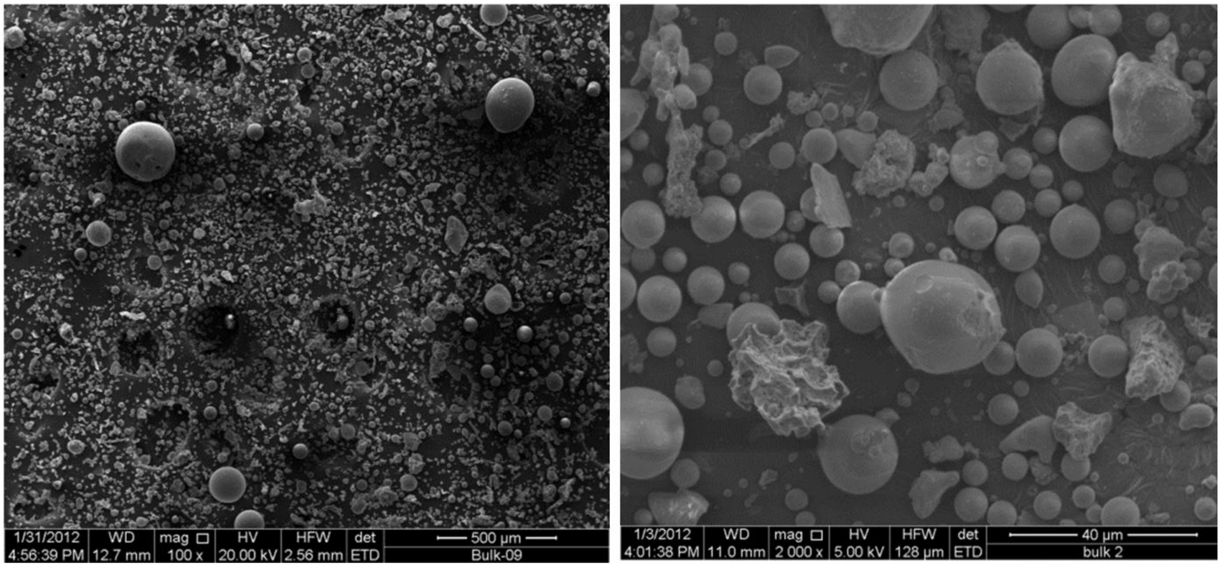

Figure 10: Micrographs of fly ash magnified 100 and 2,000 times (courtesy of Kevin Foster).

Shear strength parameters can be determined using several different laboratory test procedures. For CCRs, the most commonly performed tests are the direct shear test, consolidated drained triaxial test, and the consolidated undrained triaxial test. While the consolidated undrained triaxial test provides both effective and total stess strength parameters, most researchers only report effective strength parameters. This is undoubtedly because the rate of loading because of disposal is usually small enough that pore pressure dissipations are able to complete prior to the next disposal cycle; additionally, total strength parameters from CU tests can be misleading because of their dependence on the value of backpressure at which the specimen is sheared. Tables 6 through 8 report shear strength parameters of different CCRs from direct shear, consolidated drained, and consolidated undrained tests, respectively, reported in different studies. Figures 11 through 13 provide variability plots for the effective stress friction angles determined by various studies, compared on the basis of test type. Figures 14 through 16 provide variability plots on the basis of CCR type, while Figure 17 is a variability plot for the total stress parameters for all types of CCRs, since these parameters are not always reported. Variability plots were not made for values of cohesion since CCRs are usually reported to be non-plastic and the cohesions reported were either apparent cohesions of compacted, unsaturated samples or of samples that may have had self-cementing properties that would not be common to all disposed CCR materials. All acronymns used with the variability plots are consistent with those used in the Tables; for the Figures 14 through 16, DS, CD, and CU designate "direct shear test," "consolidated drained triaxial test," and "consolidated undrained triaxial test," respectively.

Table 6: Shear strength parameters determined by different researchers using the direct shear test.

Reference	Country	CCR Type	Condition	ϕ'_p (°)	c'_p (psf)
Kim & Prezzi (2008)	USA	FA	Comp. DoO	32.9-35.8	100-403
		FA	Comp. WoO	31.7-34.4	104-380
		FA	Comp. Sat.	30.2-34.5	58-276
Site 5		SI	Comp. Sat.	26.8-42.2	0
		SI	Undisturbed	23.4-35.4	0
Pandian (2004)	India	FA	Loose Dry	29.0-36.0	-
		SI	Loose Dry	29.0-34.0	-
		BA	Loose Dry	32.0-34.0	-
		FA	Loose Sat.	27.0-37.0	-
		SI	Loose Sat.	25.0-40.0	-
		BA	Loose Sat.	30.0-37.0	-
		FA	Comp.	28.0-42.0	205-819
		SI	Comp.	29.0-38.0	328-1024
		BA	Comp.	30.0-37.0	205-410
		FA	Comp. Sat.	28.0-41.0	-
		SI	Comp. Sat.	29.0-36.0	-
		BA	Comp. Sat.	30.0-37.0	-
Prakash &Sridharan (2009)		FA	Loose	29.0-33.0	-
		SI	Loose	30.0-33.0	-
		BA	Loose	31.0-34.0	-
		FA	Comp.	32.0-37.0	334-543
		SI	Comp.	30.0-33.0	272-334
		BA	Comp.	31.0-34.0	209-397
		FA	Comp. Sat.	32.0-35.0	0
		SI	Comp. Sat.	29.0-32.0	0
		BA	Comp. Sat.	30.0-33.0	0
Kolay & Kismoor (2009)	Malaysia	FA	Comp. Sat.	30.6-34.9	162-168
		SI	Comp. Sat.	26.2	70
		BA	Comp. Sat.	26.6	3.0-14
Muhardi et al. (2010)		FA	Comp.	23.0	251
		FA	Comp. Sat.	26.0	63
		BA	Comp.	32.0	79
		BA	Comp. Sat.	31.0	0

Note: ϕ'_p = peak effective friction angle; c'_p = peak effective cohesion; Comp. = compacted; Sat. = saturated; DoO = Dry of Optimum; WoO = Wet of Optimum

Table 7: Shear strength parameters determined by different researchers using the consolidated drained triaxial test.

Reference	Country	CCR Type	Condition	RC (%)	ϕ' (°)	c' (psf)
Kim & Prezzi (2008)	USA	FA	Reconst.	95	33.5-47.1	0
		FA	Reconst.	90	27.9-37.9	0
Site 5		SI	Reconst.	-	27.1-31.0	0
Pandian (2004)	India	FA	Reconst.	100	33.0-37.0	418-1942
		FA	Reconst.	100	33.0-43.0	0
Prakash &Sridharan (2009)		FA	Reconst.	95	33.0-43.0	0
Jakka et al. (2010)		FA	Reconst.	-	32.9-37.0	0
		BA	Reconst.	-	33.7-41.7	0
Muhardi et al. (2010)	Malaysia	FA	Reconst.	-	41.0	522
		BA	Reconst.	-	46.0	0
Indraratna et al. (1991)	Thailand	FA	Reconst.	-	26.0	731
		FA	Reconst. Pozz.	-	36.0	37594

Note: Reconst. = reconstituted; Pozz. = pozzolanic curing allowed to occur

Table 8: Shear strength parameters determined by different researchers using the consolidated undrained triaxial test.

Reference	Country	CCR Type	Condition	RC (%)	ϕ (°)	c (psf)	ϕ' (°)	c' (psf)
Site 1	USA	SI	Undist.	-	11.1-19.5	0-950	25.2-33.0	90-190
Site 2		SI	Undist.	-	12.0-45.5	640-2580	31.8-32.1	0-140
Site 3		FA	Reconst.		-	-	36.0	14.3
		SI	Undist.	-	-	-	39.6	0
		BA	Reconst.		-	-	41.0-44.0	0-261
Site 4		FA	DS, Undist.	-	3.4-37.7	200-1900	28.7-36.7	0-400
		SI	Undist.	-	18.3-27.4	400-1600	29.5-38.6	0-740
Prakash &Sridharan (2009)	India	FA	Reconst.	95	20.0-41.0	0	26.0-39.0	334-2005
		SI	Reconst.	95	25.0-34.0	0-1170	28.0-36.0	585-2109
		BA	Reconst.	95	24.0-35.0	0-564	24.0-35.0	585-1149
Jakka et al. (2010)		FA	Reconst.	-	-	-	22.3-38.5	0
		BA	Reconst.	-	-	-	32.2-42.6	0
Muhardi et al. (2010)	Malaysia	FA	Reconst.	-	41.0	710	-	-
		BA	Reconst.	-	44.0	0	-	-
Indraratna et al. (1991)	Thailand	FA	Reconst.	-	20.0	0	26.0	0

Note: Undist. = undisturbed; Reconst. = reconstituted; DS = dry-stacked in field

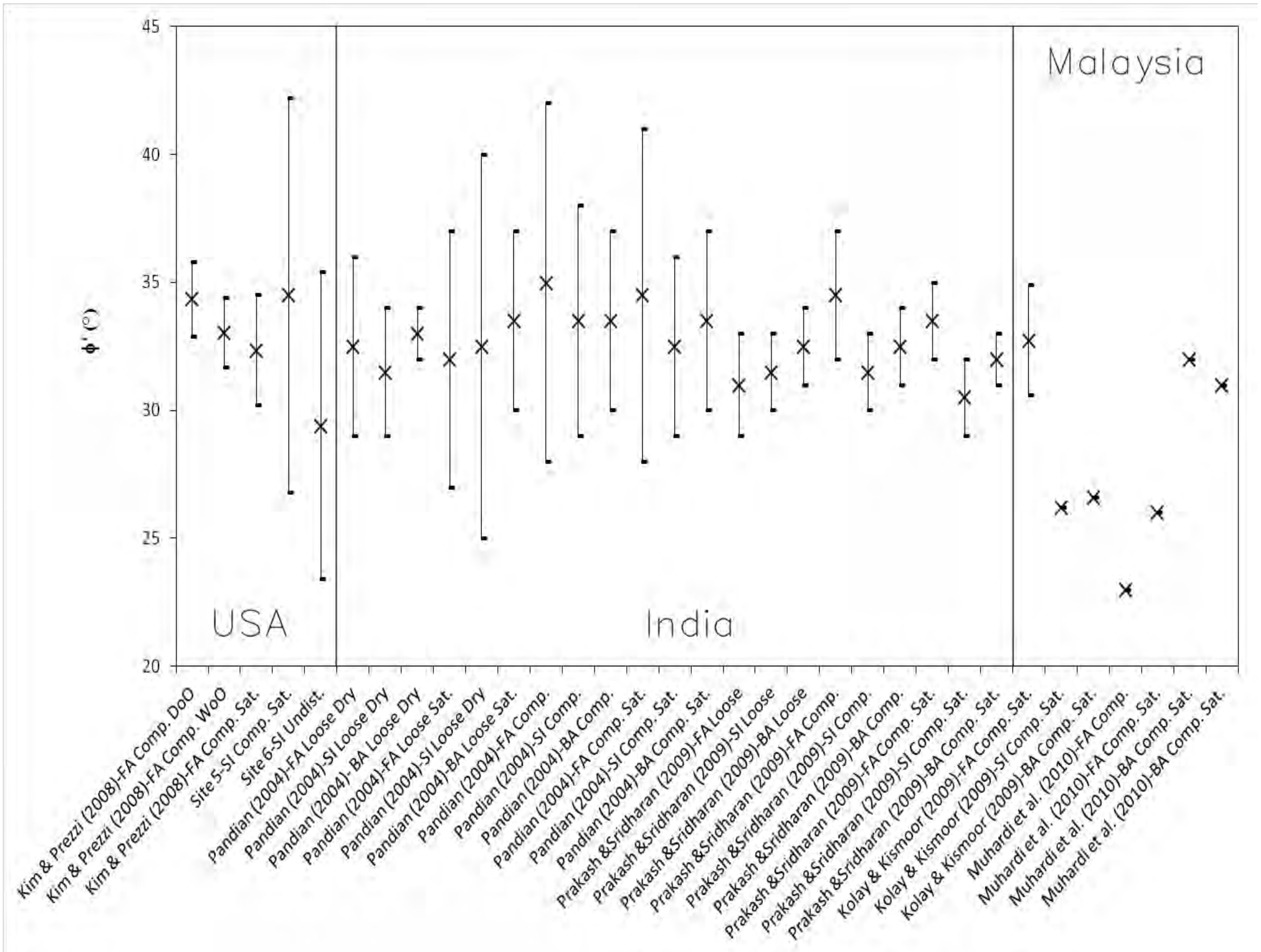

Figure 11: Variability plot of effective stress friction angle of various CCRs as determined by different researchers using the direct shear test.

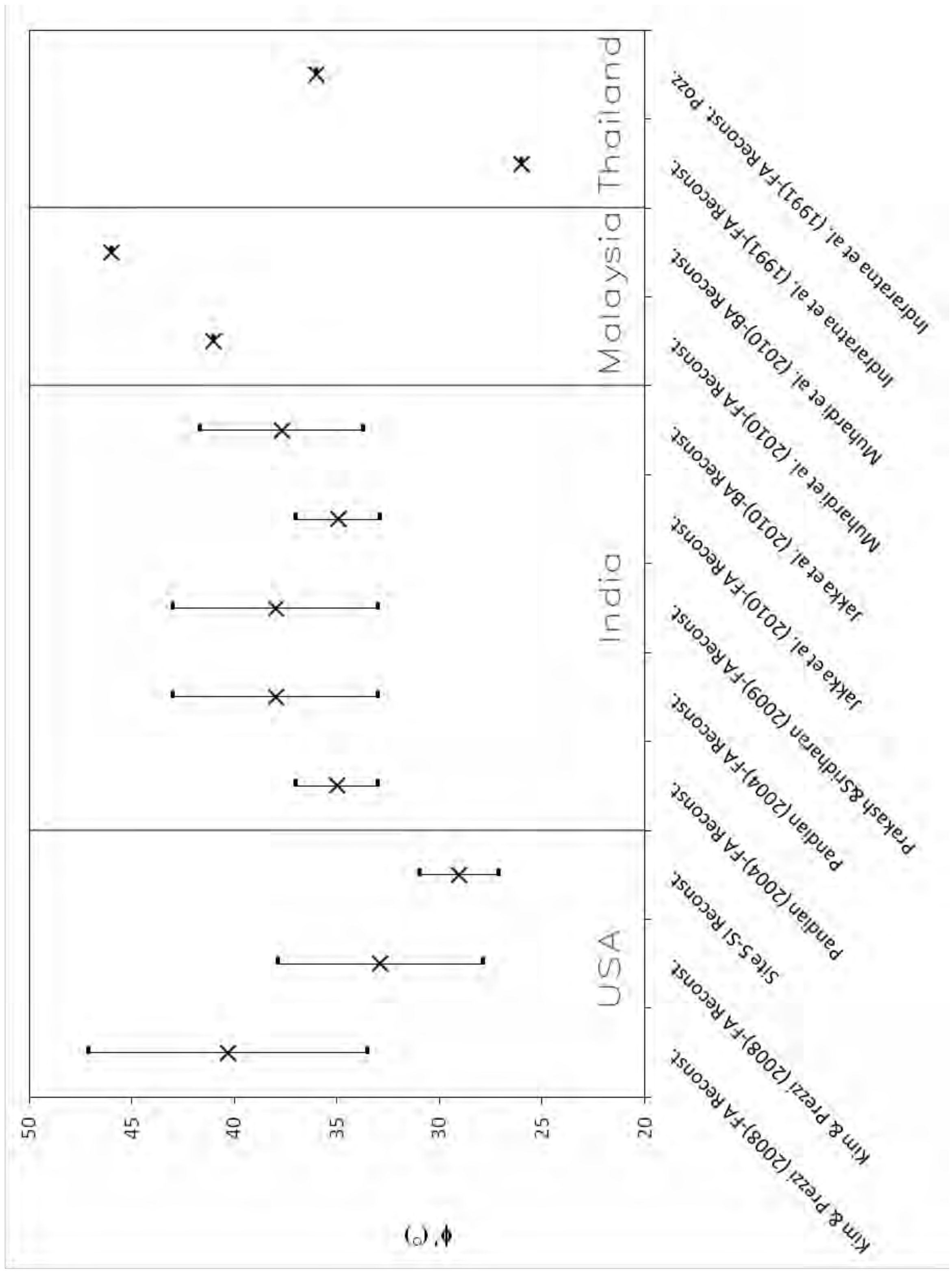

Figure 12: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated drained triaxial test.

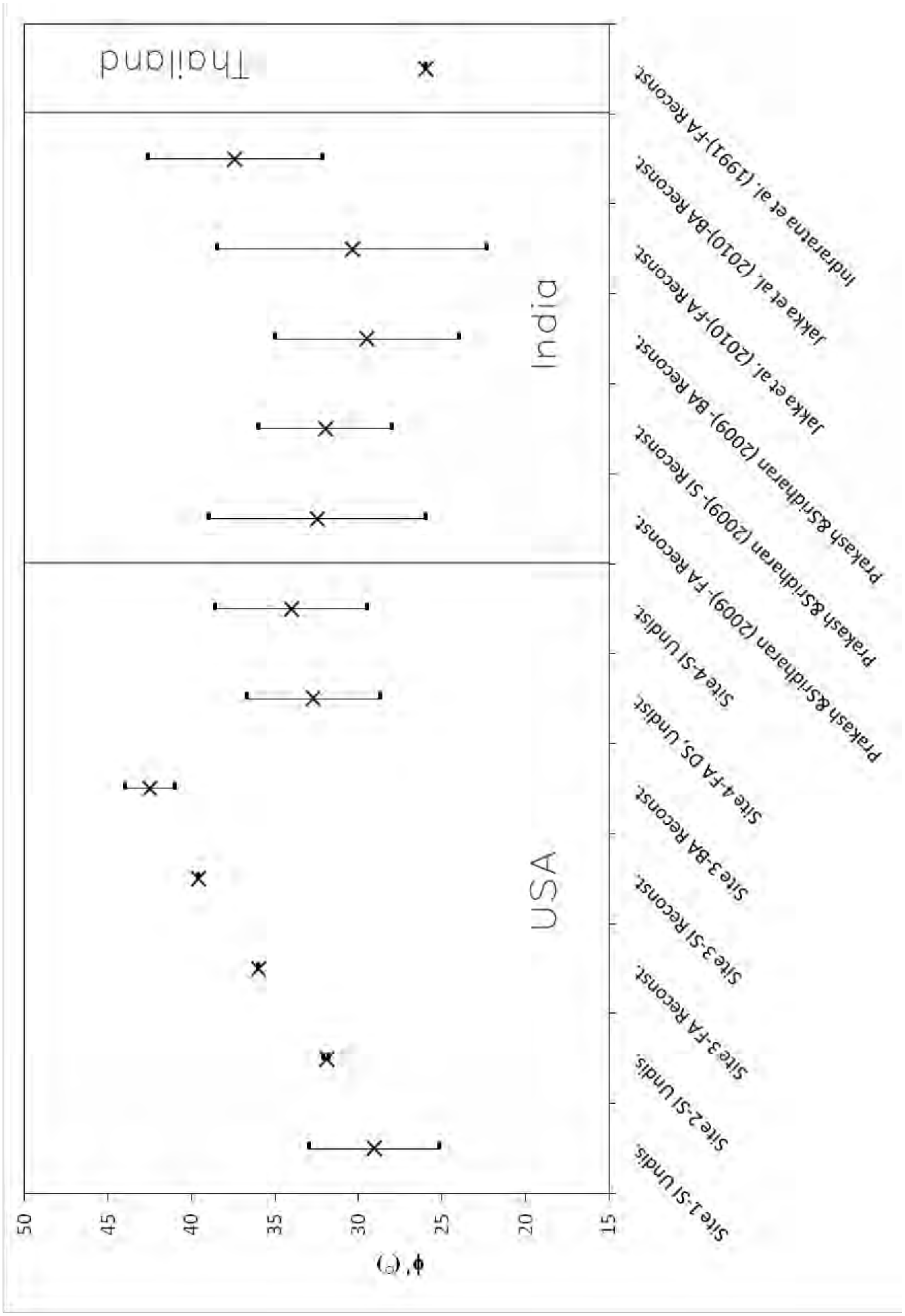

Figure 13: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated undrained triaxial test.

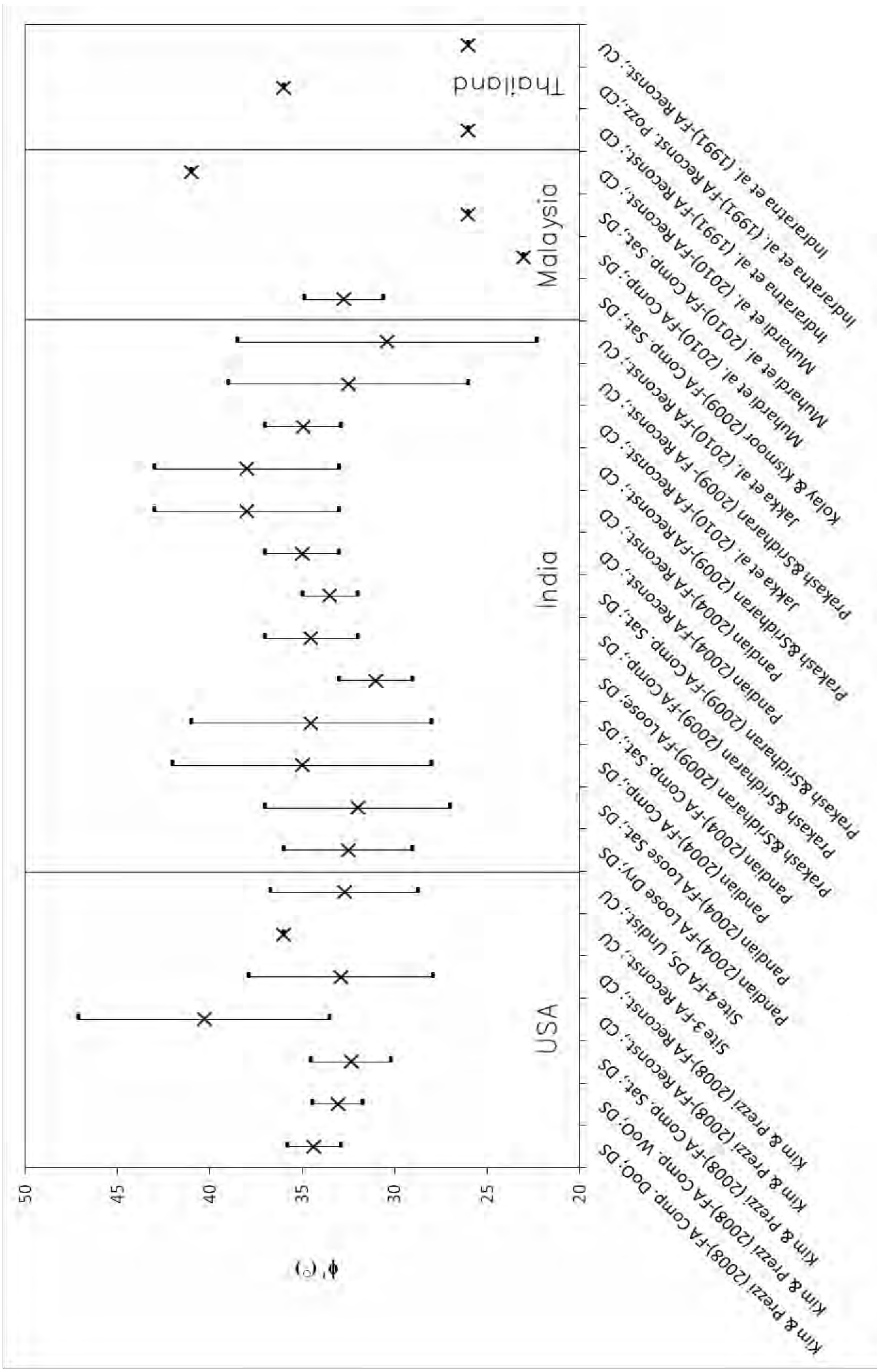

Figure 14: Variability plot of the effective stress friction angle of fly ashes for all shear strength tests performed by various researchers.

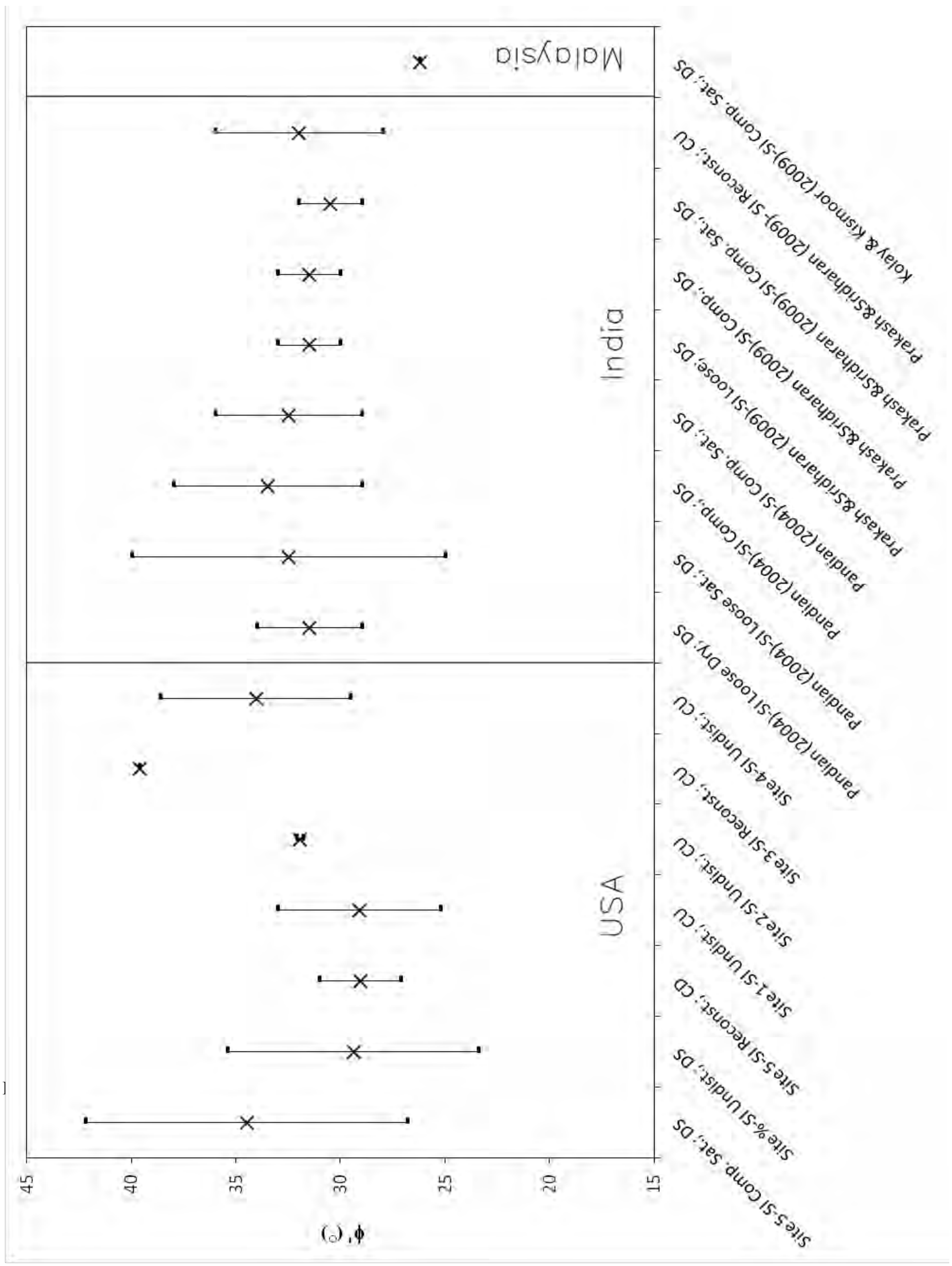

Figure 15: Variability plot of the effective stress friction angle of surface impounded ashes for all shear strength tests performed by various researchers.

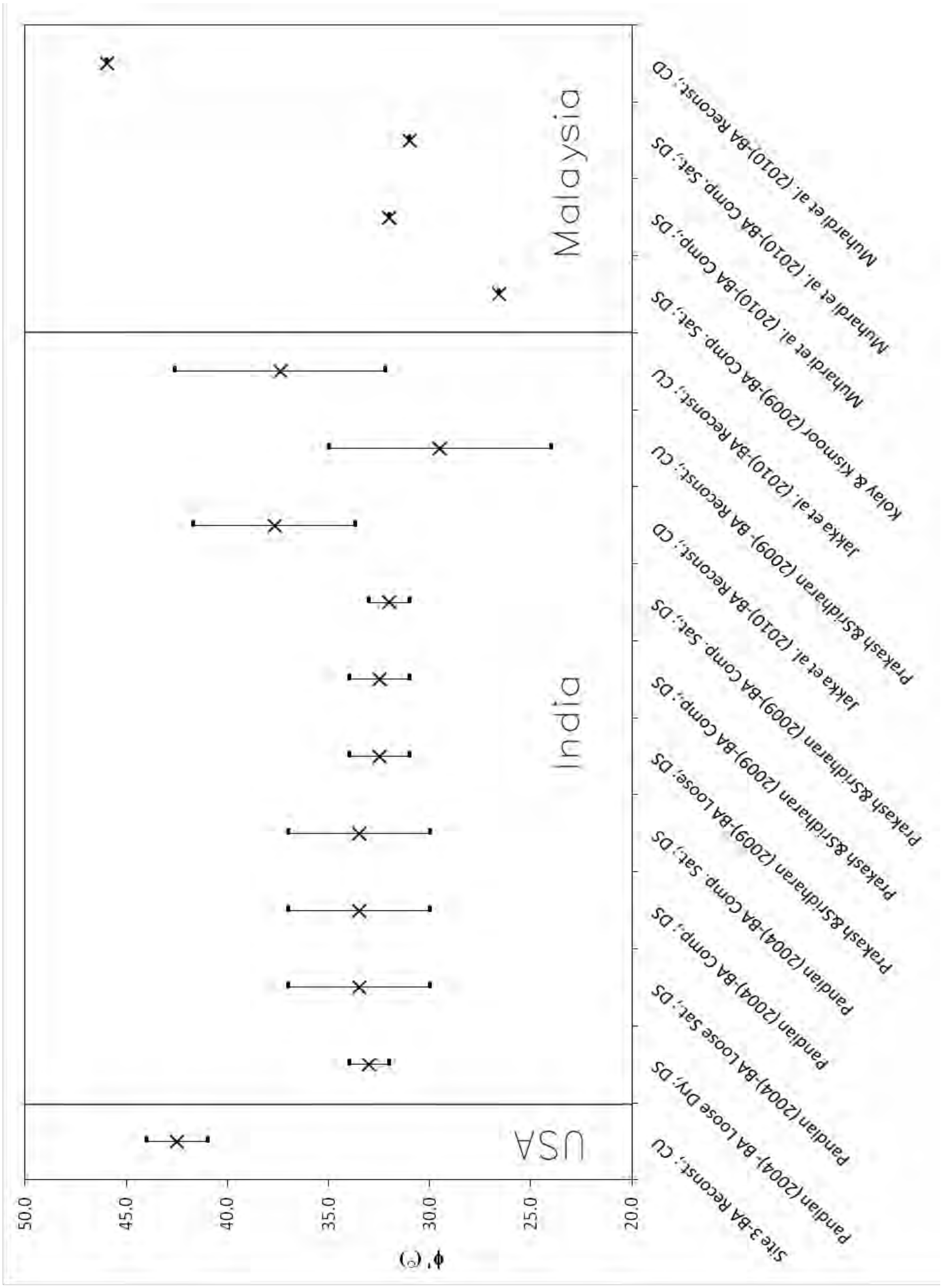

Figure 16: Variability plot of the effective stress friction angle of bottom ashes for all shear strength tests performed by various researchers.

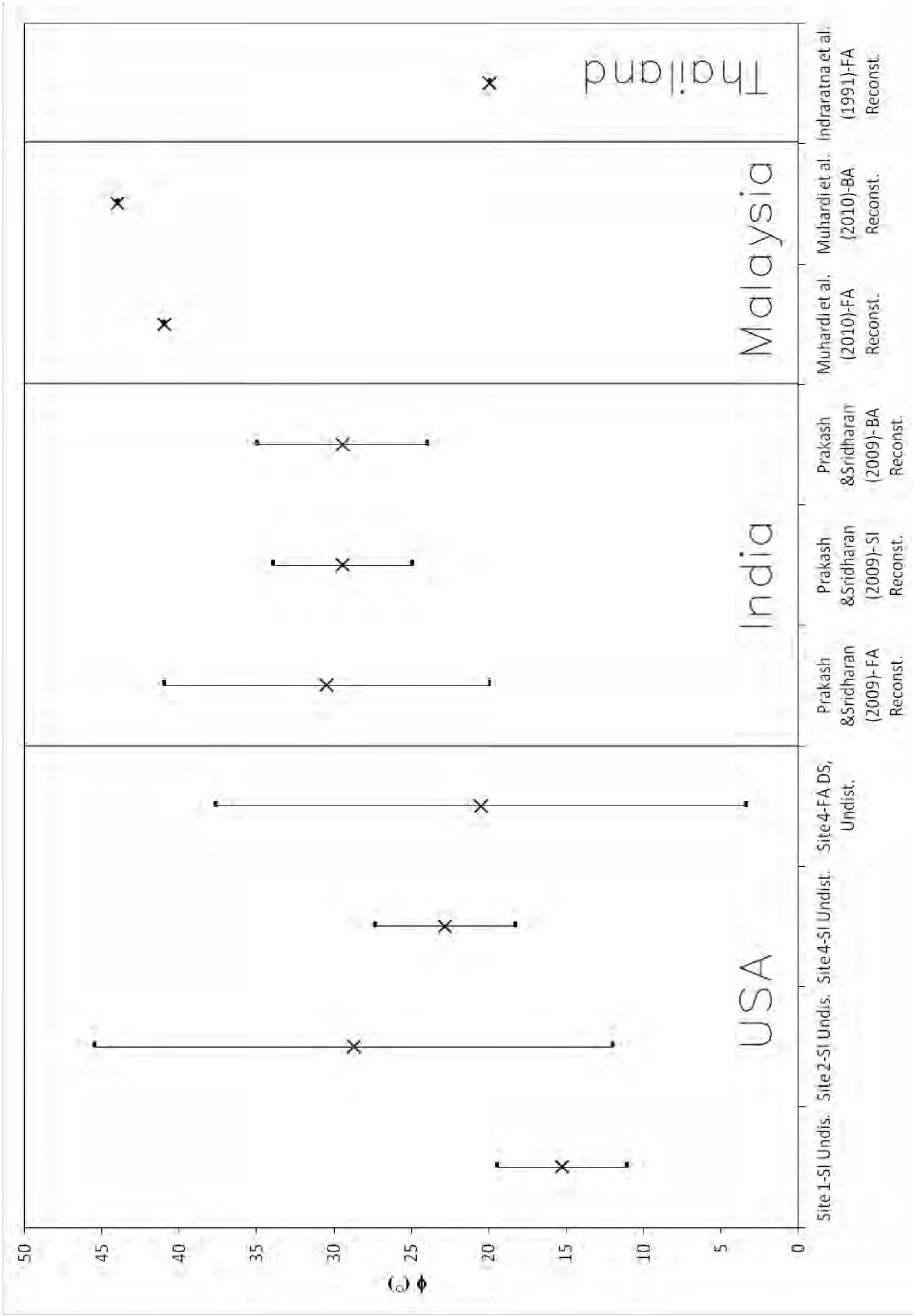

Figure 17: Variability plot of the total stress friction angle of all CCRs as determined by consolidated undrained triaxial tests performed by various researchers.

2.5 Compaction Characteristics

Since CCRs are often used in the construction of embankments for CCR disposal areas, an understanding of their compaction characteristics is necessary to control stability and seepage of the CCR disposal areas. A unique consideration when studying the compaction characteristics of CCRs is their generally low specific gravity. Since CCRs tend to have lower specific gravities and higher air voids than natural soils, their maximum dry density tends to be lower and their optimum moisture content higher than most natural soils (Bera et al. 2007, Prashanth et al. 1999, Trivedi and Singh 2004a). Trivedi and Singh (2004a) associate the high optimum water content of CCRs with the porous nature of the particles; most of the water is absorbed by the particles at lower water contents such that the particles are not workable until higher moisture contents. The lower dry density and higher corresponding water contents of CCRs results in a compaction curve that appears “flatter” than those of most natural fine-grained soils, as shown in Figure 18. The "A-Z soils" included in the plots for comparison are for natural soils from Ohio, as published by J. G. Joslin in the proceedings of the 1958 ASTM Symposium on Soil Testing in Highway Design and Construction.

Bera et al. (2007) also developed empirical models to predict the maximum dry density and optimum moisture content of a specific surface impounded ash, as long as both of these values are known for the standard proctor test:

$$MDD_E = 1.60783 \cdot MDD_{proc} + 1.85727\left(\frac{E}{E_{proc}}\right) - 6.89047 \tag{7}$$

$$OMC_E = 1.73090 \cdot OMC_{proc} - 9.01750\left(\frac{E}{E_{proc}}\right) - 25.33520 \tag{8}$$

where MDD_E = maximum dry density at a given applied energy
MDD_E = maximum dry density for a proctor test
E = amount of energy input for given condition
E_{proc} = amount of energy input for a proctor test
OMC_E = optimum moisture content for a given applied energy
OMC_{proc} = optimum moisture content for a proctor test

It should be noted, however, that these relationships were developed using test data from Indian CCRs. Therefore, before using these relationships, it should be verified that they apply to the specific CCRs in question.

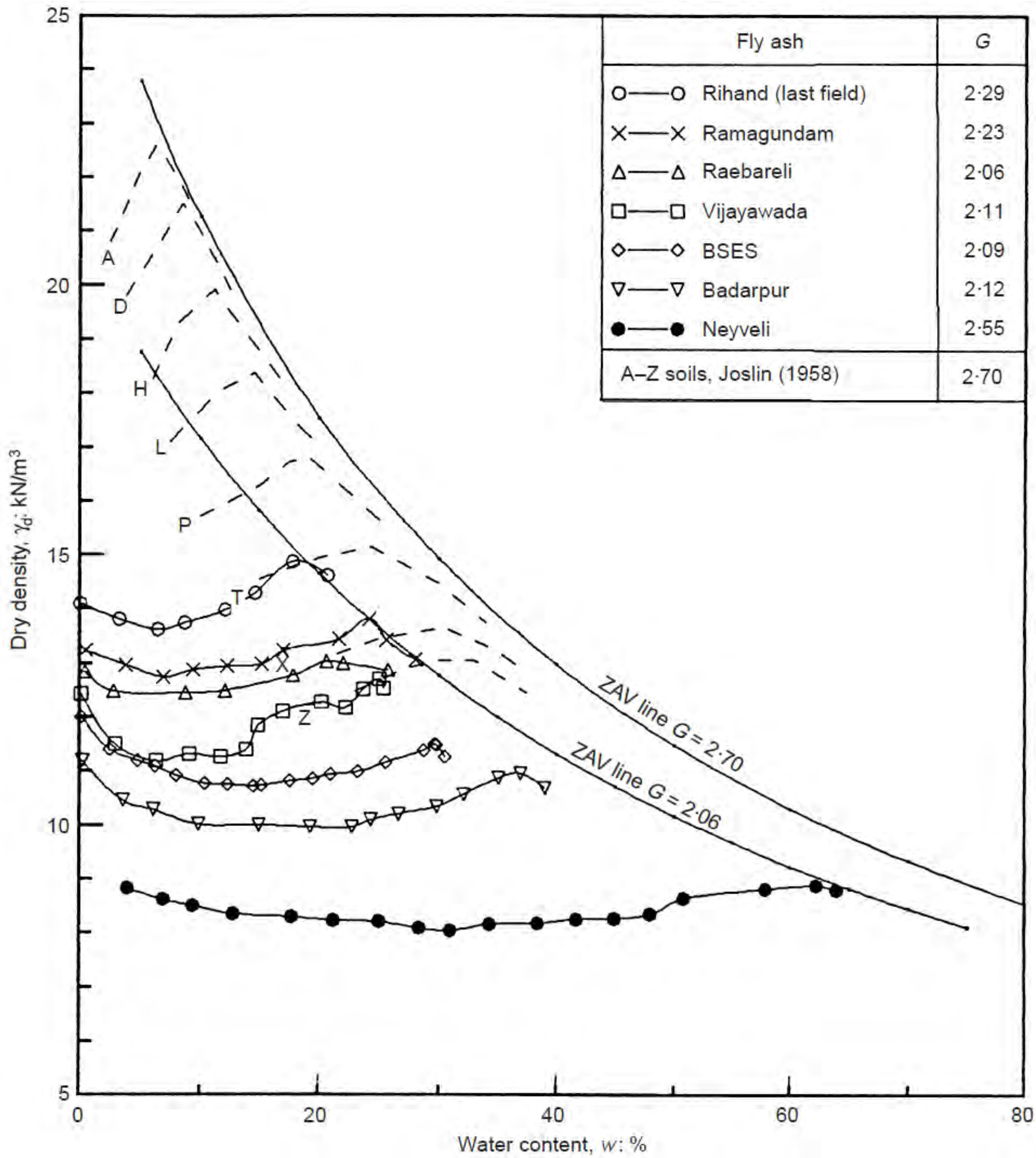

Figure 18(a): Compaction curves for different Indian fly ashes compared to those for several natural soils (Sridharan et al. 2001)

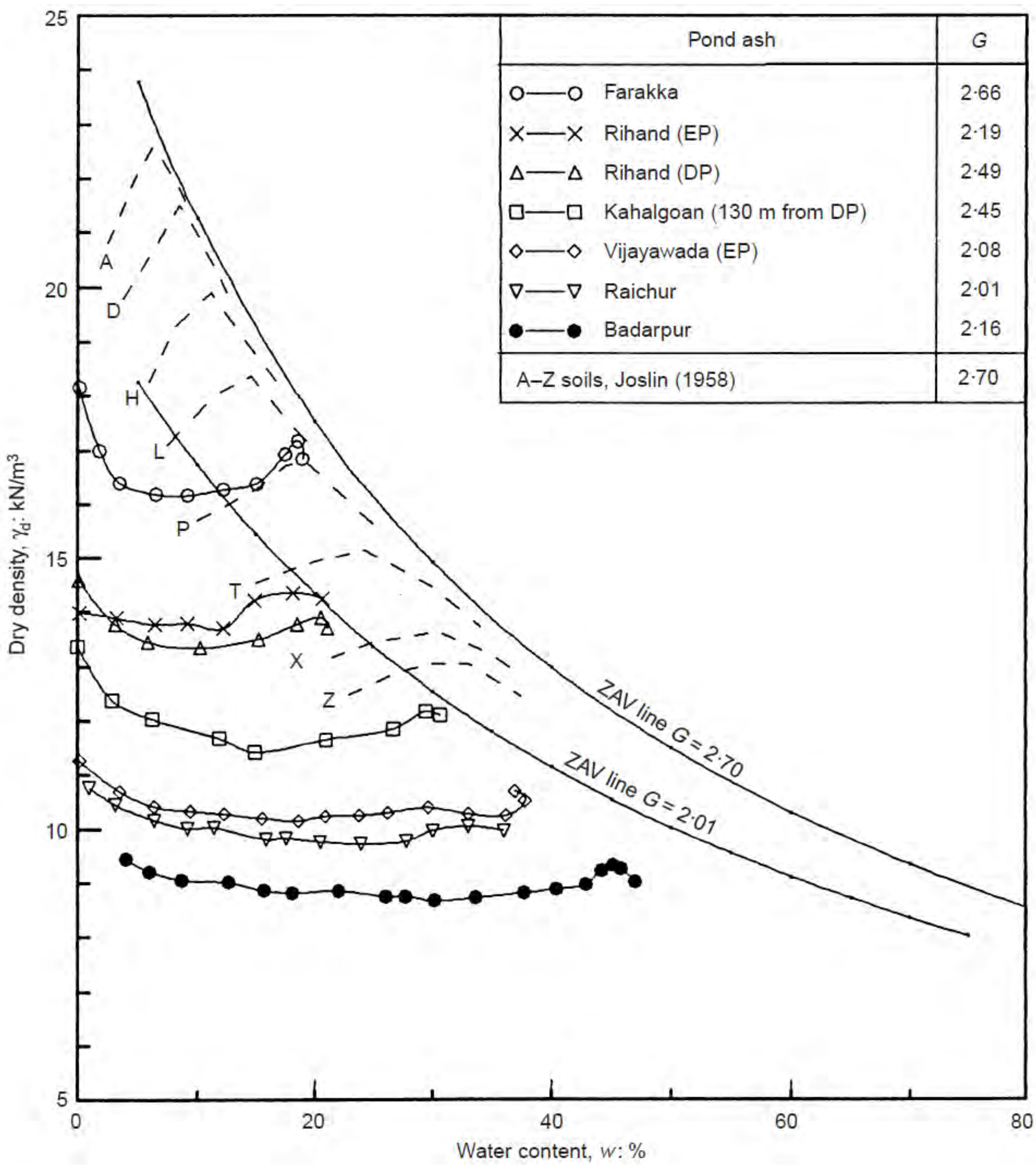

Figure 18(b): Compaction curves for different Indian surface impoundment ashes compared to those for several natural soils (Sridharan et al. 2001)

In Figures 17(a) and 17(b), the CCRs sometimes have a higher dry density at a dry condition (w = 0%). This is not a practical condition to use in construction or disposal situations, however, as there would be considerable dust pollution during placement (Sridharan et al. 2001).

Chapter 3

Dynamic Properties of CCRs

Regardless of the fact that CCRs are often composed of mostly fine-grained particles, they are still granular, non-plastic particles that exhibit no cohesion other than apparent cohesion in the moist state (Kaniraj and Gayathri 2004, Prakash and Sridharan 2009). Based on their grain-size, many CCRs could be classified as fine-grained soils, (which are commonly considered to have a lower liquefaction potential), but since these CCRs are also generally non-plastic, they have the potential of being liquefaction-prone. Liquefaction potential of CCRs is higher in the case of impounded CCRs, since these tend to exist at a saturated or nearly saturated state in-situ (and saturation is a necessary condition for liquefaction). In addition, the high moisture contents imply that impounded CCRs will have no negative pore pressures to help stabilize the soil mass under dynamic loading. Furthermore, the generally metastable structure of impounded CCRs makes their dynamic properties of great importance, even at low intensities of shaking. There have been a limited number of publications on the dynamic properties of CCRs; while this section presents and discusses currently published information on the dynamic properties of CCRs, there is still a need for further research in this area.

3.1 Cyclic Shear Strength Properties of CCRs

The most common laboratory test used to assess the dynamic properties of soils is the cyclic triaxial shear test. Cyclic triaxial testing apparatuses are expensive and provide very specific results, so very few commercial consultant firms own or even have access to them. Therefore, cyclic triaxial testing has traditionally been done at the academic level and has seen little use in commercial consulting. Given the specialized nature of the cyclic triaxial test, there is limited research published on the cyclic triaxial properties of CCRs. Since the cyclic shear strength properties of CCRs is a very specific topic, the research available on this topic is from academics of varied nationalities, all of whom have slightly different methods of analyzing the raw data; as a result, comparing results can be difficult.

Despite differences in how to analyze and present cyclic triaxial test results between researchers, it is useful to compare results using fundamental parameters of cyclic response, such as plots of excess pore pressure (usually excess pore pressure ratio) versus number of loading cycles, or plots of the cyclic stress ratio ($CSR = \sigma_d / 2\sigma_{3c}'$) versus number of loading cycles, which represents a measure of how the shear strength of the material in question degrades with cyclic loading. Figures 19 and 20 present some typical plots comparing excess pore pressures to the number of cycles to initial liquefaction, and Figures 21 through 23 present plots of CSR versus number of loading cycles to liquefaction (generally defined as 5% double-amplitude axial strain) for different surface impounded CCRs at different confining stresses and relative densities.

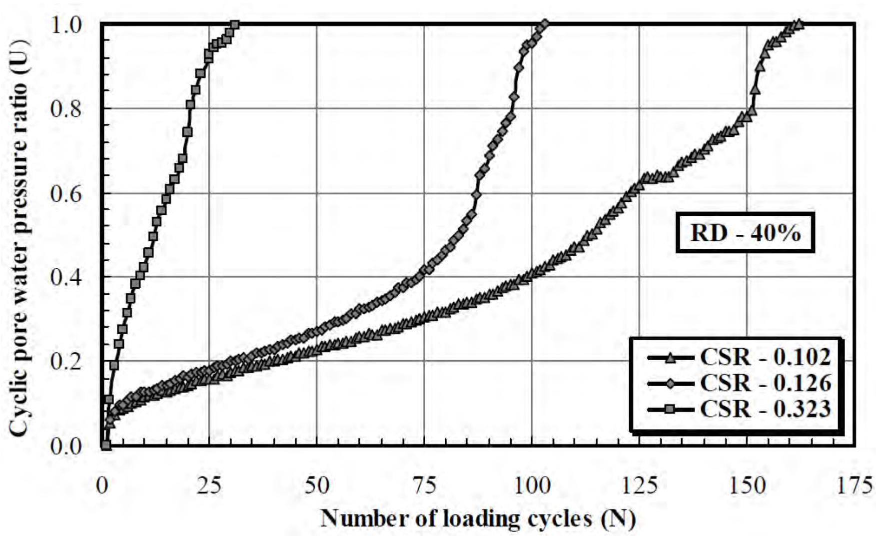

Figure 19: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at different cyclic stress ratios and 1 Hz loading frequency (Mohanty et al. 2010).

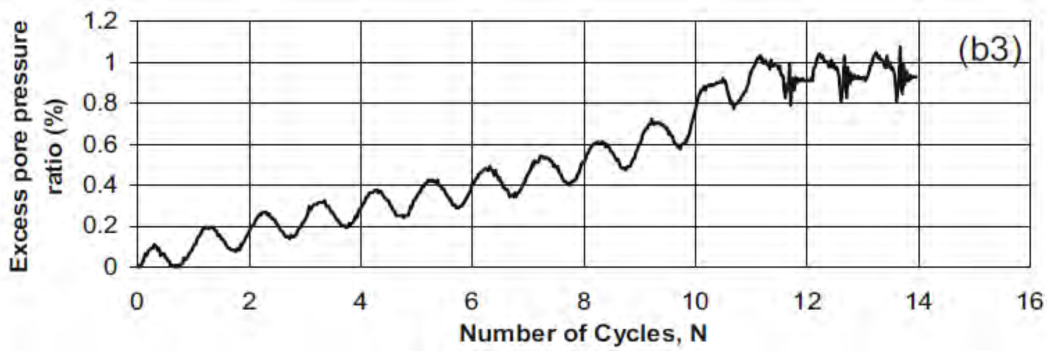

Figure 20: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at a cyclic stress ratio of 0.10 and confining pressure of 2214 psf and 0.1 Hz loading frequency (Jakka et al. 2010)

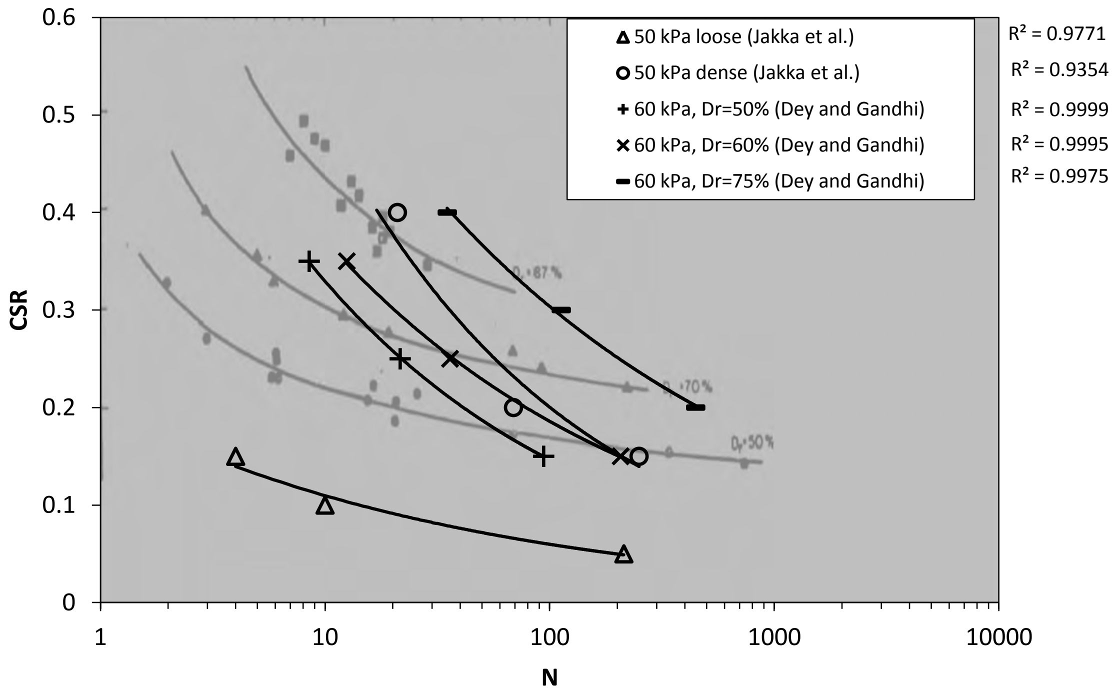

Figure 21: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at confining stresses close to 50 kPa. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Dey and Gandhi loaded specimens at 1 Hz. For comparison, curves for sands tested at the same confining pressure are superimposed (Mulilis et al 1976).

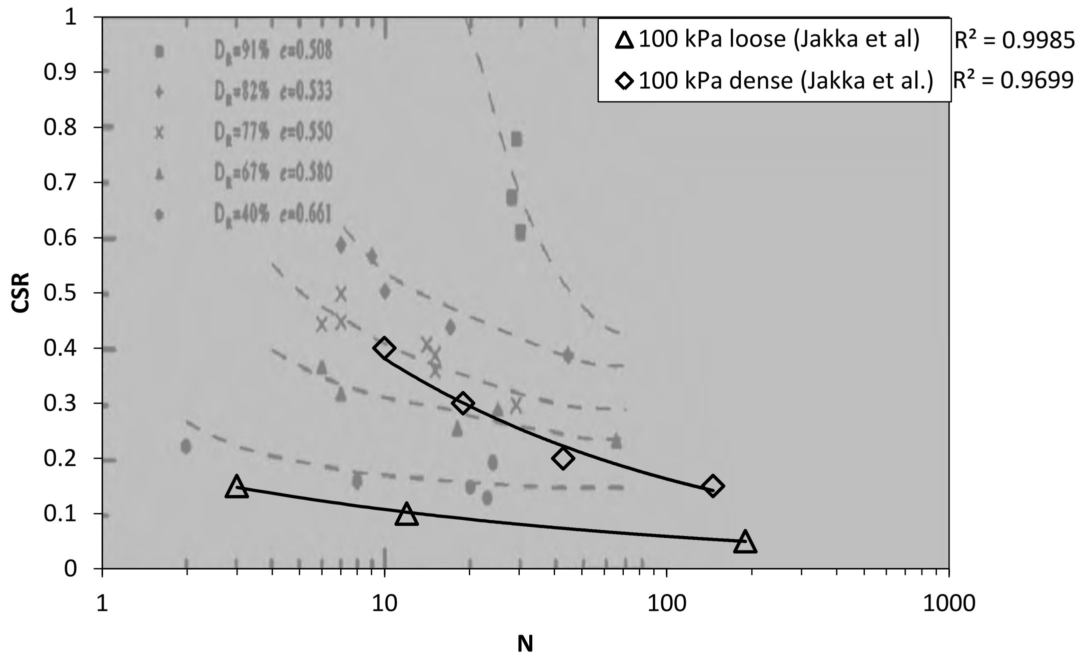

Figure 22: Plot of CSR versus number of loading cycles to liquefaction for surface impounded CCRs tested by Jakka et al (2010) at a confining pressure of 100 kPa. For comparison, curves for C778 sand at the same confining pressure are superimposed (Carraro et al 2003).

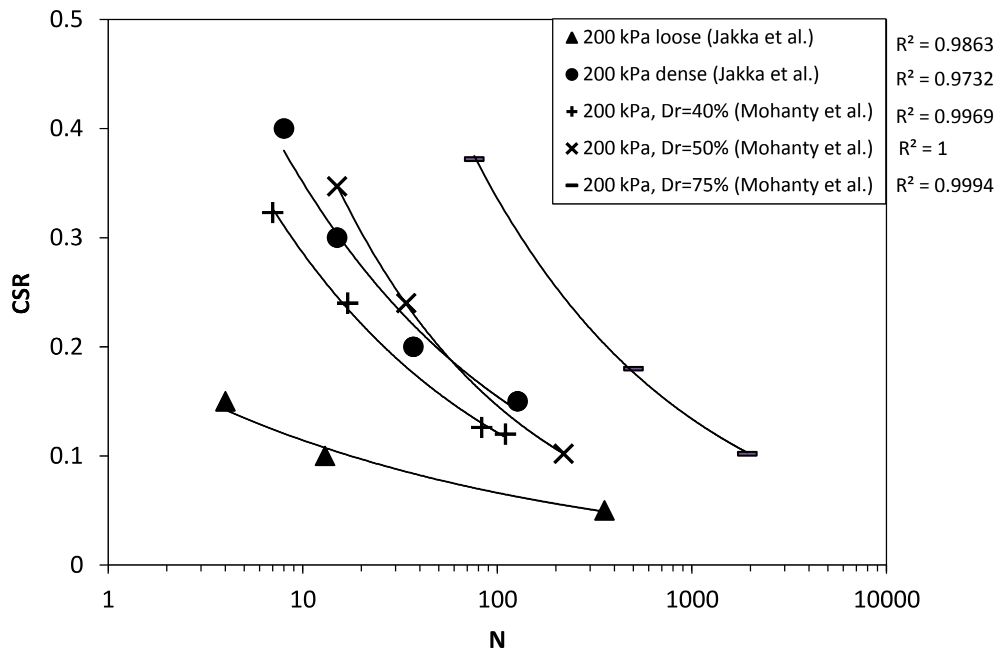

Figure 23: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at 200 kPa confining stress. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Mohanty et al. loaded specimens at 1 Hz.

For the two plots of CSR versus number of cycles to initial liquefaction where results for surface impounded CCRs are compared to tests done on sands, it is apparent that the CCRs tested tend to be more resistant to liquefaction than natural sands at higher CSRs, but less resistant to liquefaction at lower CSRs. As more cyclic triaxial tests are run on surface impounded CCRs, it will be more apparent as to whether this is an actual trend, or just an apparent trend in these three studies.

Lastly, many researchers include a plot of the hysteresis loops for a cyclically-tested triaxial sample. This is simply a plot of the deviator stress versus the axial strain through a single load cycle, at which point the plot begins again, creating a nearly-symmetrical shape about the origin of the plot. The area contained within all of these loops represents the cumulative energy dissipated by the soil being tested (Yoshimoto et al. 2006). The cumulative dissipated energy method was used by Towhata and Ishihara (1985) in order to analyze cyclic shear behavior and liquefaction strength of soils. Figure 24 shows a diagram illustrating the dissipation energy contained within a hysteresis loop.

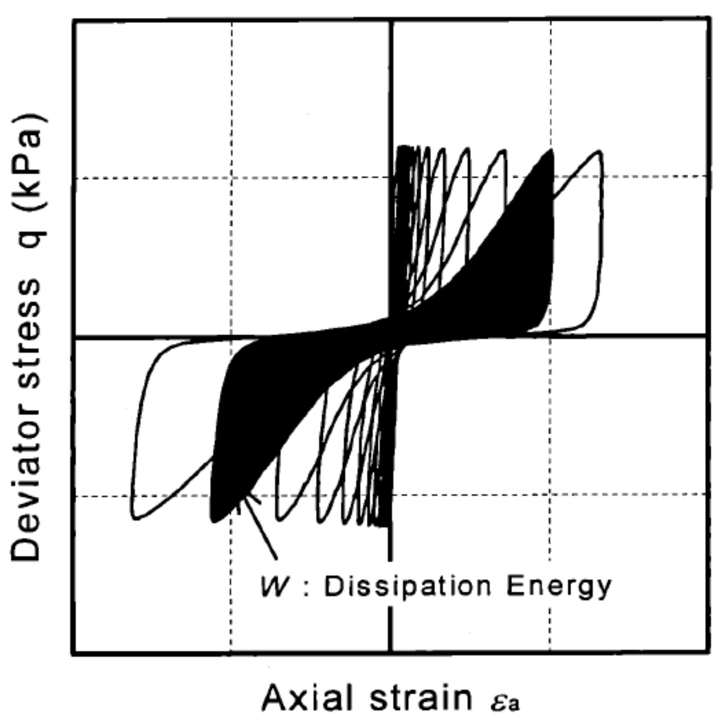

Figure 24: Example of how to determine the energy dissipated by a soil throughout a single loading cycle (Yoshimoto et al. 2006).

Chapter 4

CCR Failure Modes and Monitoring Practices

The critical failure mode for a CCR impoundment is not necessarily the same as for a CCR landfill, since differences in placement techniques for each have a significant effect on the fabric and shear strength properties of the CCRs. Determining the failure modes and developing monitoring practices for CCR impoundments can be done using the same methods as for mine tailings dams because of their similar structure. CCR landfills can be monitored much like any other earthen embankment (with material properties being the major difference), except that unlike most embankments, there is no end of construction until the landfill is retired.

4.1 Surface Impoundments

The observational method is a method of risk management outlined by Dr. Ralph Peck as the process of making design adjustments based on observed behavior in a given structure. The design can be adjusted to be either more or less conservative in order to optimize design (Martin and Davies 2000). This method of risk management is ideal for use with tailings dams since tailings dams are continuously constructed until they are retired; the same is true of CCR surface impoundments, which indicates that such methods could easily be applied to CCR surface impoundment monitoring programs. Figure 25 is a flow chart illustrating the risk management process utilizing the observational method, as applied to tailings dam design; however, the process is general enough that the same or a slightly modified flow chart could be used for surface impounding ash structures.

Another important consideration when developing a monitoring plan for surface impoundments is whether the dikes were constructed using the upstream or downstream methods, since use of the upstream method can lead to weaker dike foundations and an increased probability of sudden or catastrophic failure (Martin and Davies 2000). The upstream construction method consists of constructing the dike of a new phase of a disposal area partly on the top of the previous phase dike and partly on the upstream disposed material; contrarily, the downstream construction method consists of constructing the new phase dike partially on the previous phase dike and partially on land downstream of the disposal area. Figure 26 illustrates that the weaker foundations of mine tailings constructed using the upstream method is evident based on the prevalence of certain failure modes for upstream tailings dams as compared to other types of tailings dams (slope failure and earthquake failure constitute 59% of failure modes for upstream tailings dams, compared to 24% for other types of tailings dams).

Taking all of these factors into consideration, a sample surveillance plan schedule for a mine tailings impoundment is provided in Figure 27. As with the risk management chart presented in Figure 25, this flowchart is general enough that it could be used in its current form, or slightly modified in developing a surveillance plan for CCR surface impoundments.

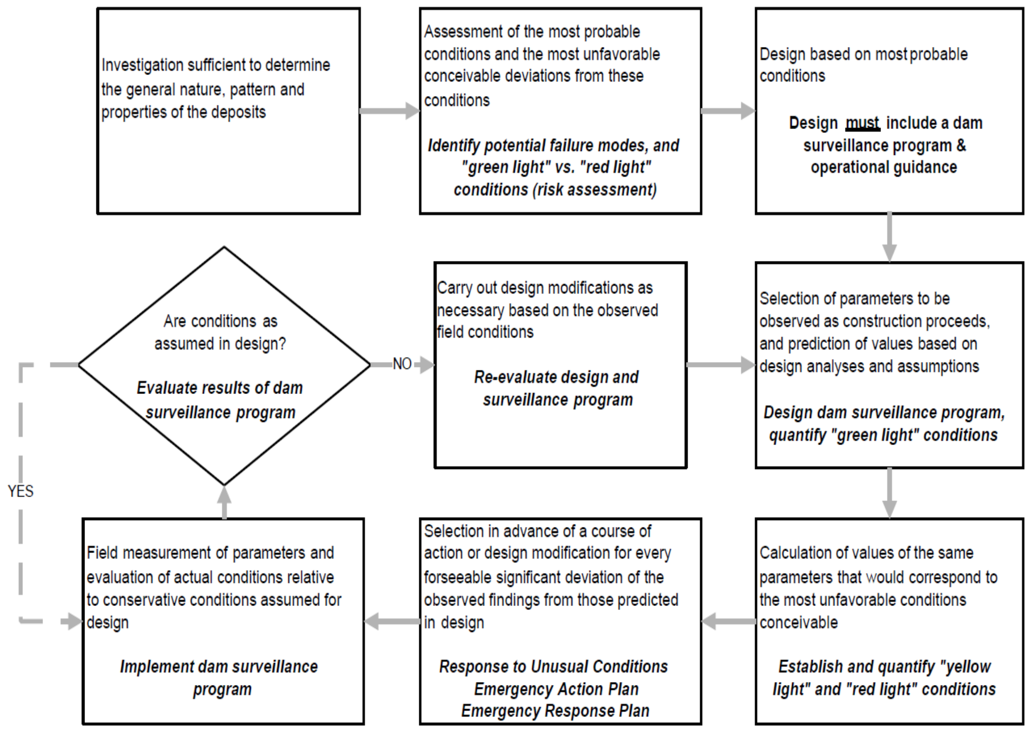

Figure 25: Flow chart illustrating risk management utilizing the observational method (after Martin and Davies 2000)

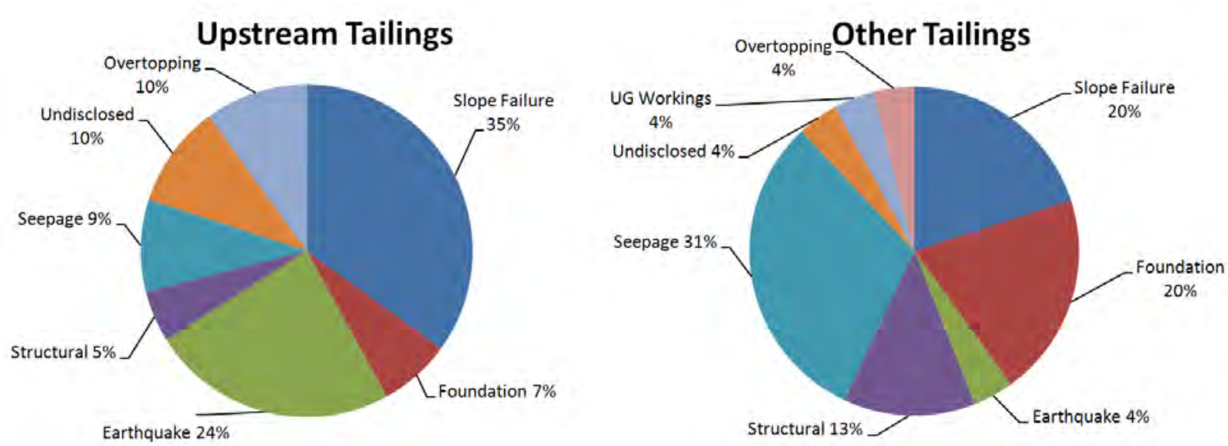

Figure 26: Comparison of failure modes of upstream mine tailings dams as compared to other types of mine tailings dams (modified from Martin and Davies 2000)

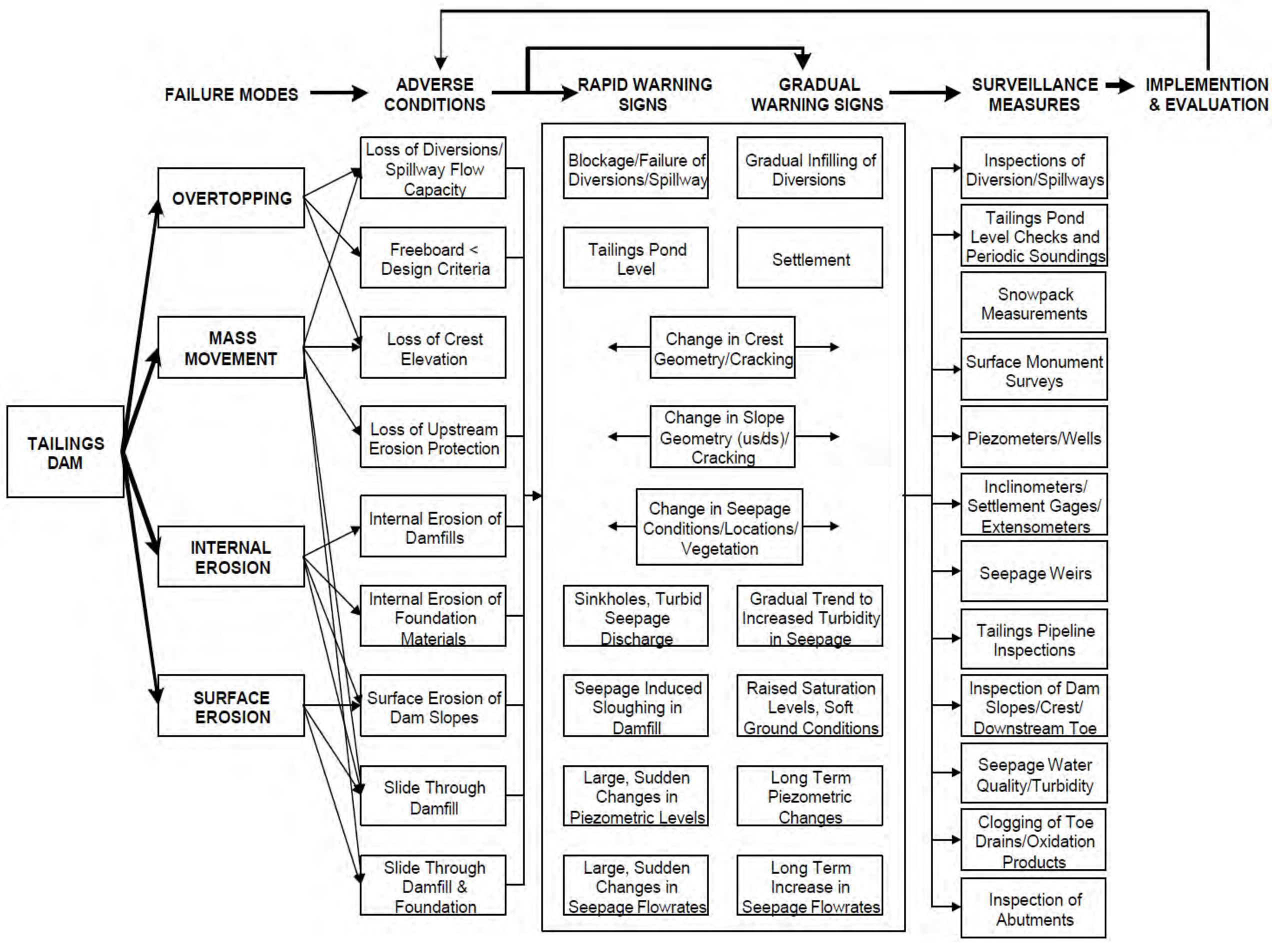

Figure 27: Sample surveillance plan schedule for a mine tailings impoundment (after Martin and Davies 2000)

Since CCR surface impoundments can have containment dikes constructed out of CCR material, natural soils, or a combination of both and these landfills have the potential to collect precipitation. An analysis procedure that can be used alongside the observational method is to treat them as earthen dams according to recommendations of the Bureau of Reclamation and the Army Corps of Engineers.

The Bureau of Reclamation's *Dam Safety Risk Analysis Best Practices Training Manual* (Scott et al. 2010) provides an overview in Chapter 1 of their recommended method for determining potential failure modes of dams for use in conducting risk analyses of dams. In Chapter 1, the authors identify determination of potential failure modes of dams as the basis for risk evaluations, making it one of the most important steps in risk analysis of a dam. They recommend a comprehensive and thorough review of all relevant background information such as, but not limited to, geology, design, analysis and construction documentation, flood and seismic loadings, operations, dam safety evaluations, and performance and monitoring documentation. Additionally, they recommend a site examination, including questioning of the operations personnel as to how unusual events are handled and what they consider to be the vulnerabilities of the structure. The data review process should include several qualified professionals from different disciplines to ensure a thorough investigation. Lastly, the authors outline three major parts in describing a potential failure mode:

- **The initiator**, or what causes the initiation or onset of the failure mode
- **Failure progression**, a step-by-step outline of mechanisms that lead to failure
- **The resulting impacts**, a description of the expected method and magnitude of a failure if it were to occur

For more in-depth guidance on determining failure modes and developing a risk analysis program for a specific structure, the U.S. Bureau of Reclamation's *Dam Safety Risk Analysis Best Practices Training Manual* can be accessed online at http://www.usbr.gov/ssle/damsafety/Risk/methodology.html, entitled "Complete Best Practices Document."

4.2 CCR Landfills

CCR landfills are generally placed at a moist state and compacted to some degree, being constructed in a similar manner to regular earthen embankments. As a result, they can be analyzed like any other earthen embankment, with special attention paid to the engineering properties and placement conditions of the CCR materials used in the embankment. The placement method for CCR materials in CCR landfills results in less uncertainty in their fabric and relative density, generally resulting in an overall more stable structure than with surface impoundments.

Ideally these compacted CCR embankments would remain well-drained, but depending on the geology of the site and variability in the hydraulic conductivity of the CCR materials, monitoring the groundwater table within these areas and how it is affected by rainfall patterns is good practice, unless it is clearly apparent that such monitoring is unnecessary. An additional consideration with CCR landfills is the need to continually condition the landfill surface with water in order to cut down on dust pollution and surface erosion. Ideally, slopes of CCR landfills should be seeded as soon as is feasible, in order to manage surface erosion and eliminate the need to continually condition the moisture of the slopes.

One unique case would be for sites where a CCR landfill is constructed over a retired surface impoundment. This is an appealing option to most CCR disposers, since land area can be reused, negating or delaying the need to purchase new land to construct a disposal area. Since the foundation material cannot be as well-characterized as the material being placed, a more rigorous design and monitoring procedure would be necessary, perhaps the same as or similar to those discussed in section 4.1.

4.3 Failure Modes

Failure modes for CCR surface impoundments and landfills include all of the usual failure modes for a dam or embankment. However, since disposal operations continue for years or decades, the need to continually monitor disposal areas for signs indicating the initiation of a particular failure mode is very important. Since surface impounded CCRs generally have a less stable structure than CCR landfills, they will generally tend to require more vigorous monitoring. Because of the differences in disposal methods between CCR surface impoundments and CCR landfills, the most likely failure modes will not be the same for each structure.

The most common failure modes for earthen dams and embankments include internal erosion or piping (of embankment or foundation materials), surface erosion leading to global instability, excessive seepage leading to an embankment breach, overtopping during a storm event, loss of freeboard due to excessive embankment settlements or subsidence, lateral movement of the embankment, and failure as a result of a seismic event (MSHA 2009; Martin and Davies 2000). Many of these failure modes are included in Figure 27, with common warning signs indicating the initiation of these failure modes.

The majority of these failure modes can be recognized with good monitoring practices, with the exception of failures due to seismic events, for obvious reasons. There is little data on the performance of CCR disposal areas during seismic events and also very little data on the dynamic properties of CCR materials. As a result, dynamic properties of CCRs is an area where further research and laboratory testing is required.

The overall uncertainty in the engineering properties of CCR materials make it necessary to be more vigilant with monitoring practices in order to recognize when different failure modes are initiated so that remedial actions can be taken to prevent costly failures, both on an economic and life scale. Since surface impoundments often most closely resemble tailings dams in their design, a good reference for monitoring practices and identifying failure modes for surface impoundments is the MSHA 2009 "Engineering and Design Manual: Coal Refuse Facilities," which can be accessed at:

http://www.msha.gov/Impoundments/DesignManual/ImpoundmentDesignManual.asp.

Chapter 5

Slope Stability of CCRs

The basic principles of slope stability and methods of assessing slope stability of CCR surface impoundments and landfills are the same as for naturally occurring soils; however, the results of these analyses can be very different based on the unique properties of CCR materials. For example, while an ash might have a high percentage of clay-sized particles, they rarely have any cohesion at all and may be very prone to erosion; many naturally occurring soils with clay-sized particles have a cohesive component of strength and are usually considered erosion resistant. In most instances, CCR disposal areas will not be loaded enough to incur excess pore pressures that will not be fully dissipated by the next loading cycle (the next workday). For this reason, it is generally only necessary to perform effective-stress steady-state shear strength slope stability analyses for CCR disposal areas. Special analyses, such as rapid draw-down analyses may be necessary as dictated by site geometry and design rainfall events.

5.1 Limit Equilibrium and Finite Element Analyses

The majority of slope stability analyses today are performed using commercial software programs that utilize limiting equilibrium analyses and/or finite element analyses of slope stability and seepage through slopes. It is good practice and the recommendation of the United

States Army Corps of Engineers (USACE) that some sort of check be done on the results of these software programs. In their Slope Stability Manual (EM 1110-2-1902), the USACE states that, "verification should be commensurate with the level of risk associated with the structure," and that one or more of the following methods should be used in verification of the initial analyses:

- Graphical (force polygon) method
- Spreadsheet calculations
- A second slope stability program
- Slope stability charts

The following example is of a slope stability analysis of a CCR surface impoundment using a limit equilibrium-based software program that also has a built-in finite element groundwater seepage option. The premise of this example is that a client wants to construct a dry-stacked CCR landfill on top of a retired surface impoundment. A thin layer with increased cohesion was included at the surface of all slopes in order to eliminate infinite slope failures that are solved with vegetation; this layer is not included in the table of strata properties, presented in Table 9.

Table 9: Summary of shear strength and hydraulic parameters used in CCR surface impoundment slope stability example.

Strata	γ (pcf)	N	σ_0' (tsf)	ϕ' (°)	c' (psf)	k (ft/s)	Sources
SI CCRs	92.0	N/A	N/A	25.2	0	2.55×10^{-6}	LT
Compacted CCRs	103.5	N/A	N/A	33.0	0	3.61×10^{-7}	Tables 6-8, Table 5
Embankment Fill	112.7	N/A	N/A	33.8	0	1.79×10^{-8}	LT
RR Embankment Fill	122.0	4.0	0.34	33.7	0	3.00×10^{-8}	Kulhawy and Mayne (1990)/LT
Alluvium	110.0	11.0	0.88	40.6	100	3.28×10^{-8}	Kulhawy and Mayne (1990)/LT
Saprolite	110.0	35.0	1.2	29.6	420	9.35×10^{-7}	LT
Partially Weathered Rock	120.0	N/A	N/A	30.0	500	3.28×10^{-9}	Assumed based on parent material
Bedrock	170.0	N/A	N/A	30.0	1.4×10^{5}	3.28×10^{-10}	Barton and Choubey (1977)

Note: LT = laboratory testing

Analyses were performed for six different conditions: three geometries, each with an in-situ water table and a hypothetical high water table. Figure 28 shows the in-situ subsurface conditions, while Figures 29 through 31 provide the output results with slip surfaces below specified factors of safety shown for the six geometries considered. All slip surfaces shown with a factor of safety value are the lowest factor of safety for that slope geometry.

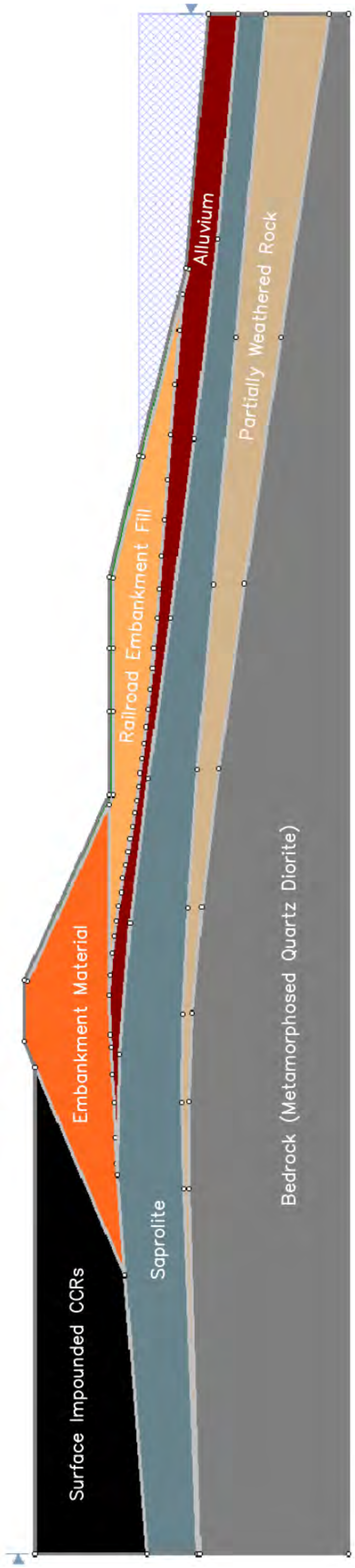

Figure 28: Subsurface profile of a slope stability example for an SI CCR embankment.

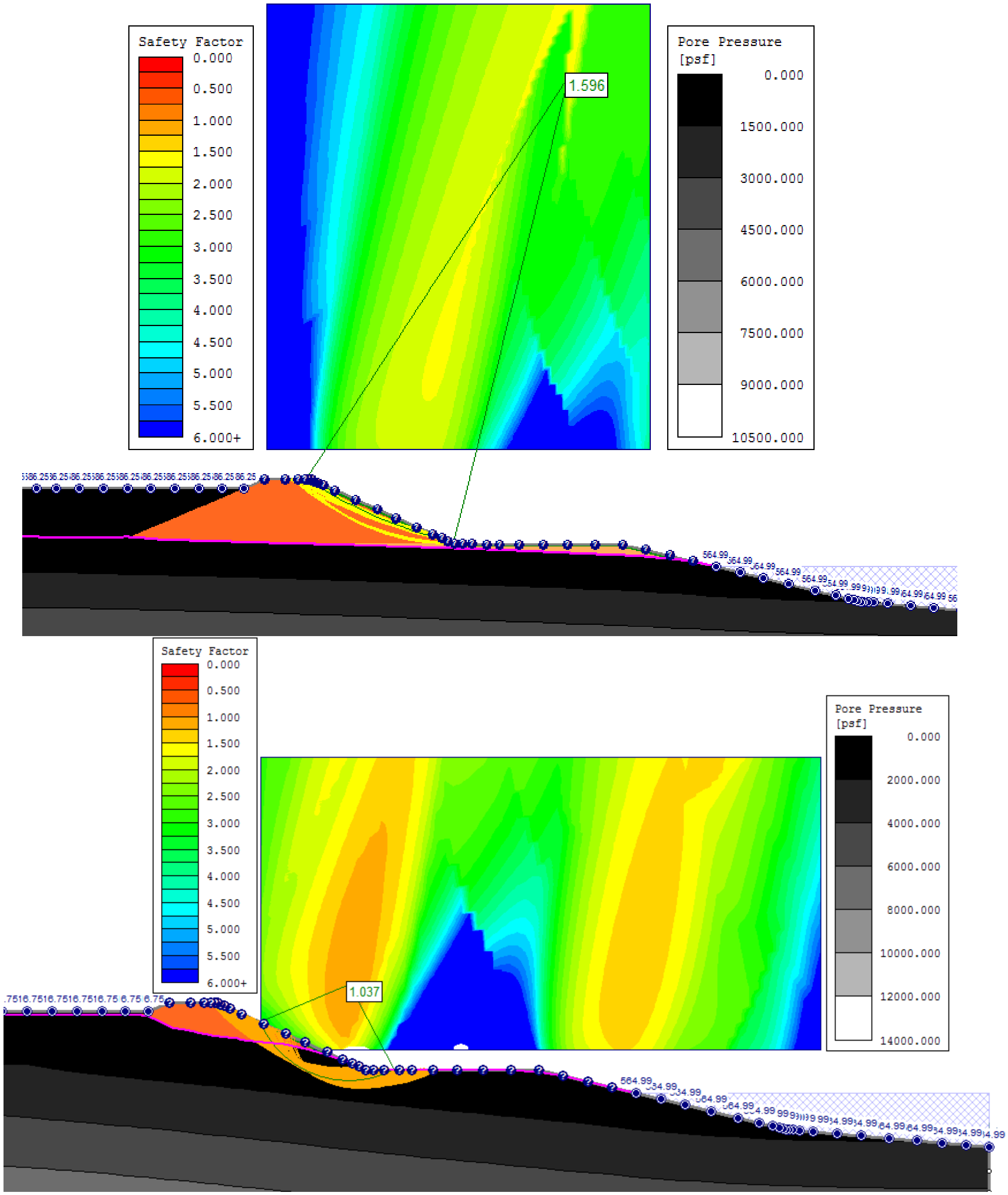

Figure 29: Analyses for the in-situ condition, first with the in-situ measured water table (above) and then with a hypothetical higher water table (below). Slip surfaces are shown for factors of safety below 1.7 for the above case and between 1.0 and 1.2 for the below case.

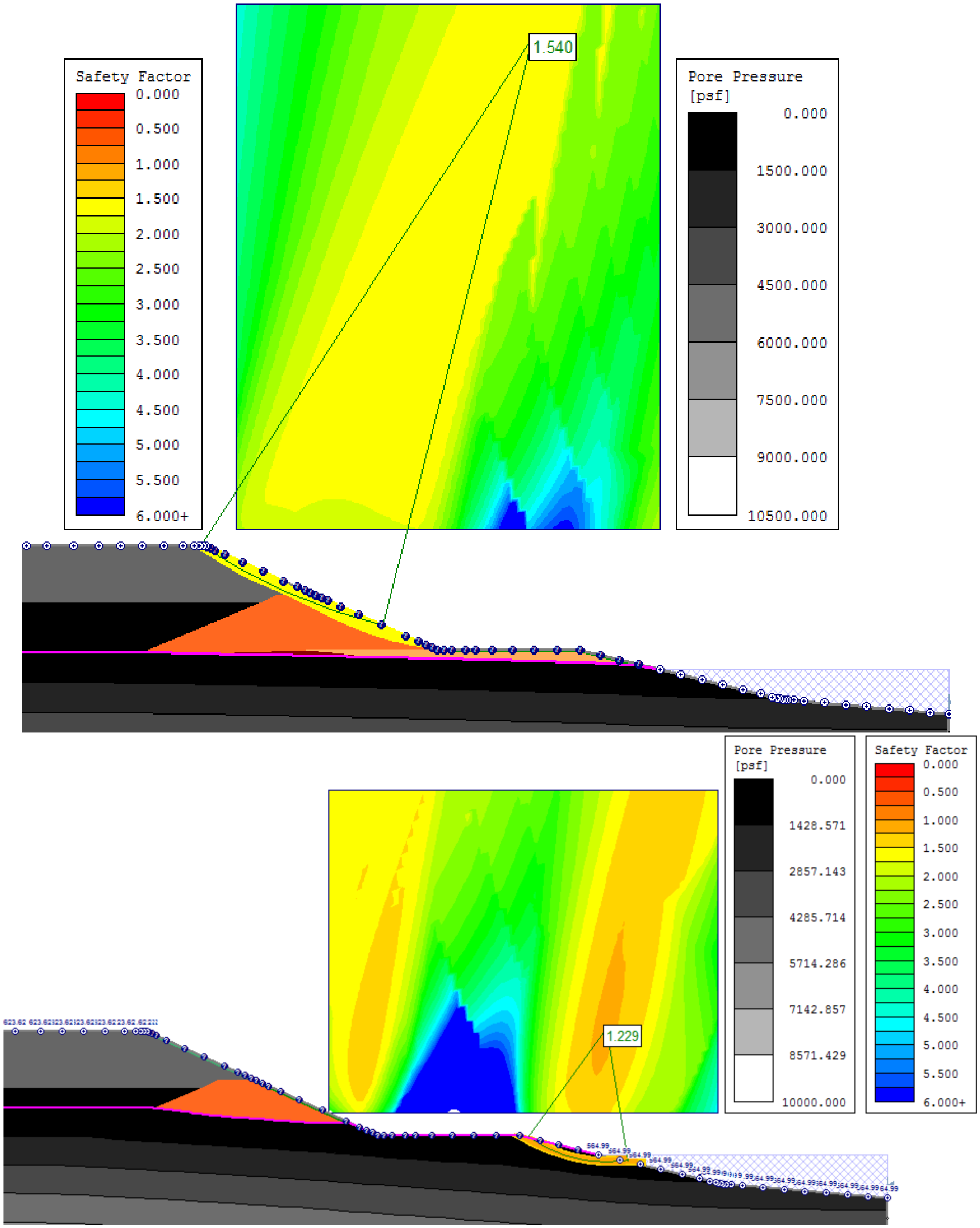

Figure 30: Analyses for an added upstream dry-disposed cell over the surface impoundment, for the in-situ water table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.6 are shown in the above case and between 1.2 and 1.3 for the below case.

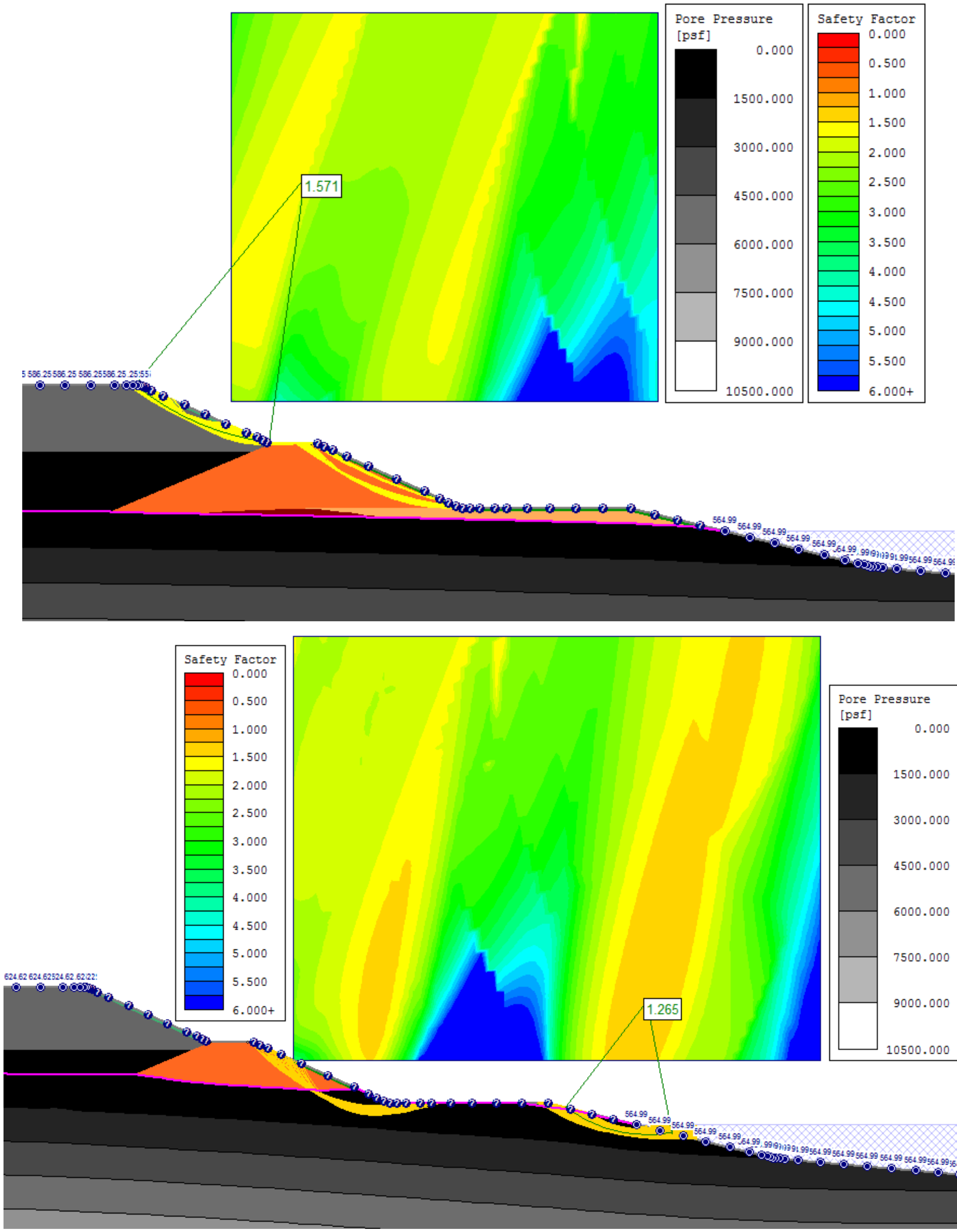

Figure 31: Analyses for an added upstream dry-disposed cell above the surface-impoundment for the in-situ groundwater table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.7 are shown for the above case and between 1.2 and 1.4 for the below case.

In all of the geometries considered in these analyses, a thin layer with a low cohesion was included in order to eliminate infinite slope failures that are easily remediated by keeping the slopes moist or vegetated. In addition, all of the geometries analyzed for the in-situ phreatic surface resulted in acceptable factors of safety, since the in-situ water table is so low compared to the site geometry. However, with a slight rise in the water level (perhaps as the result of a 100-year storm event), the factors of safety drop dramatically. This is the result of the fact that the embankment is constructed out of nonplastic soils that completely derive their strength from the frictional component of shear strength. As the water table rises, buoyancy effects decrease the effective overburden pressures in the geometry, thereby decreasing the slope shear strength and decreasing the factors of safety of all surfaces considered. Furthermore, the very low permeability of the embankment material makes this water table condition a real possibility, if no form of drainage through the slope is provided.

Chapter 6

Settlement Calculations for CCRs

It is common to see consolidation data reported for CCRs in research publications. However, given that CCRs often tend to be fairly free-draining, it would seem odd to use these values to determine settlement of CCRs, given that a structure or embankment were constructed over previously disposed CCRs. However, any methods developed to calculate settlements in sands are not necessarily applicable to CCRs or to silt-sized materials either. In this chapter, a comparison of common methods of calculating settlements will be made for CCRs at a specific site where a test fill was performed and actual CCR settlements monitored.

6.1 Test Fill Results

The results of a test fill of compacted, dry-placed fly ash performed over an approximately uniform 50 ft deep deposit of surface impounded ash was provided by S&ME. The test fill was 20 ft high and had lateral dimensions of 250 ft by 250 ft. The side-slopes all-around were 3H to 1V, making the entire footprint of the fill about 370 ft by 370 ft, or 136,900 ft^2. For the purposes of these analyses and the sake of simplicity this load will be characterized as a constant 20 ft load over the 250 ft square footprint of the test fill. The recorded settlements at the center of the test fill area were between 18.0 and 19.5 inches.

6.2 Settlement Calculation by Consolidation Theory

For increased accuracy, the surface impounded layer is divided into sub-layers and the settlements calculated for each layer and added together for the overall settlement. It is assumed that since the CCR material has not been loaded in the past that it is in the normally consolidated condition and that they unit weights of the surface impounded CCRs and dry-placed CCRs are 95 pcf and 100 pcf, respectively. Four sets of consolidation tests were performed on the impounded CCR material that made up the foundation for the test fill; the compression ratio for the test closest to the depth of the layer being considered is used in calculating the settlement in that layer. The water table is located 8 ft below the ground surface:

Table 10: Consolidation settlements calculated for test fill placed over a CCR surface impoundment.

Layer	T_L (ft)	D_{CL} (ft)	P_0 (psf)	ΔP (psf)	P_f (psf)	c_{ec}	S_i (in)
1	5	2.5	237.5	2000	2237.5	0.20225	11.82
2	10	10	587.7	2000	2587.7	0.20225	15.62
3	15	22.5	832.2	2000	2832.2	0.07299	6.99
4	20	40	1158.2	2000	3158.2	0.07299	7.63
						Σ	42.07

Note: T_L = layer thickness, D_{CL} = depth to center of layer, P_0 = initial stress condition, D_P = change in stress, P_f = final stress condition, and S_i = settlement for a specific layer

As displayed in Table 10, the settlements estimated using consolidation theory are just over twice the amount observed in the test fill. This is not really surprising since CCR materials do not tend to behave like soils where consolidation theory is used to calculate settlements; generally, plots of volumetric strain vs. normal stress from consolidation tests performed on CCRs do not have clearly log-linear portions corresponding to a recompression and compression ratio. As a result, depending on what values are assumed for $c_{\varepsilon c}$ and $c_{\varepsilon c}$, the settlement could either be greatly overestimated or underestimated, depending on different individuals' interpretations of the plot.

6.3 Settlement Calculation by D'Appolonia Method

The D'Appolonia (D'Appolonia et al. 1970) method of calculating settlements in sand is based on elasticity theory and can be applied to this sort of example with some moderate assumptions. Equation 8 is the equation developed by D'Appalonia et al. (1970):

$$\rho = \mu_0 \mu_1 \frac{qB}{M} \tag{9}$$

where ρ = settlement
μ_0, μ_1 = geometry factors from Figure 36
q = applied bearing pressure
B = footing width
M = 1-dimensional compression modulus

Figure 32 provides plots used to determine the geometry factors, while the applied bearing pressure and footing width are the same as determined in section 6.2. From logs of CPT tests performed at the test fill location, the average *M* measured over the depth of the CCR deposit was about 45 tsf (based on CPT correlations).

Given the dimensions of the test fill given in section 6.1 and Figure 32, μ_0 is estimated as 1.0 (since the fill is at the ground surface) and μ_1 would likely be around 0.14. The settlement can now be calculated as:

$$\rho = 1.0 \cdot 0.14 \cdot \frac{1 \text{ tsf} \cdot 250 \text{ ft}}{45 \text{ tsf}} = 0.777 \text{ ft} = 9.33 \text{ in}$$

The most obvious problems with applying this method to placement of a fill is that it was developed for shallow foundations, which are a rigid structure and it was developed for sands, while CCRs are usually classified as silts according to the USCS. Tan and Duncan (1991) cite that this method tends to underestimate settlements around 50% of the time, as it certainly does in this case.

Since this method underestimates the settlements observed at this site by about 50 percent, it may be useful to determine what value of compressibility modulus actually give an accurate settlement:

$$M = \mu_0 \mu_1 \frac{qB}{\rho} = 1.0 \cdot 0.14 \cdot \frac{1\ \text{tsf} \cdot 250\ \text{ft}}{1.5833\ \text{ft}} = 22.1\ \text{tsf}$$

This value for the compressibility modulus is equivalent to an average modulus calibrated to the observed settlements. While one data point is not sufficient to develop a correlation, if enough settlement tests were conducted for CCR materials, it would be possible to develop a CPT-*M* correlation that better predicts settlements than the one used in this investigation.

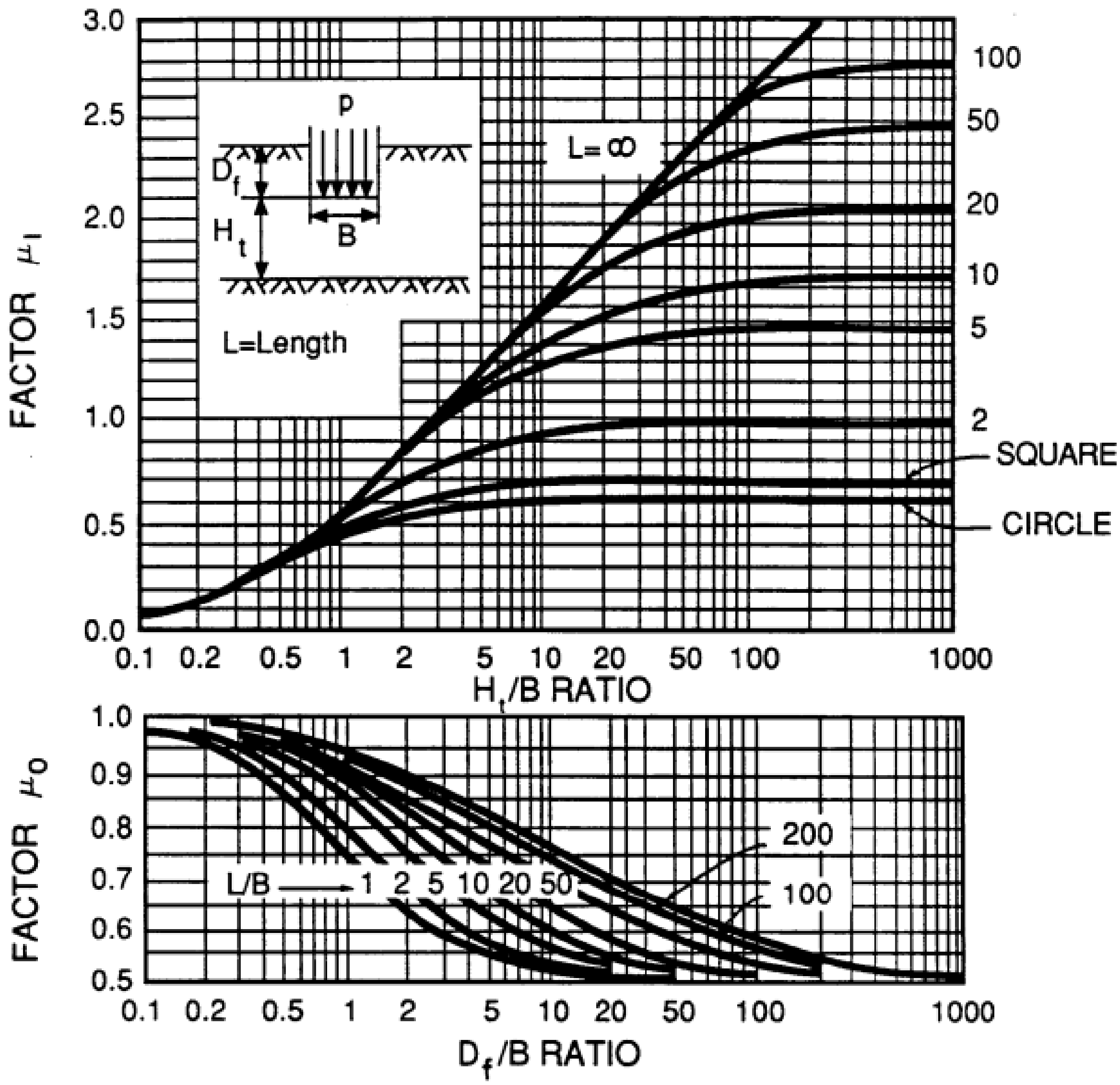

Figure 32: Plots published by D'Appolonia et al. (1970) to determine the values of the geometry factors to be used in footing settlement analyses.

6.4 Other Observations

As an alternative to specific methods of settlement calculations, if it is assumed that the fill is of large lateral extent, a basic calculation of settlement can be made using *M*, the pressure applied by the fill, and the depth of the soil strata being filled:

$$S = \frac{PZ}{M} \tag{10}$$

where P = the pressure applied as a result of the fill
Z = the depth of the soil where settlements are being considered

Again using a value of M = 45 tsf, the settlement is calculated as 13.33 inches. This is still an under-estimate of settlement for this test fill, but given that a CPT correlation for *M* in CCR materials was developed, it may be possible to calculate more precise estimates of settlement. Reduction factors could then be applied to equation 10 in order to attain an acceptable level of reliability.

A comparison of Young's modulus of soil (E_s) can also be made using Hooke's Law and the observed settlement:

$$E_s = \frac{PZ}{S} \tag{10}$$

where P = the pressure applied as a result of the fill
Z = the depth of the soil where settlements are being considered
S = the observed settlements after fill placement

versus the correlation of CPT tip resistance (q_t) to E_s used in Schmertmann's CPT settlement calculation method:

$$E_s \approx 2.5 \cdot q_t \tag{11}$$

Using Hooke's Law with a settlement of 19 inches and an applied fill pressure of 1 tsf, the E_s calculated is 31.6 tsf. Using the CPT correlation given in equation 11, the average CPT tip resistance over the depth of the CCR deposit below the test fill was about 17 tsf, which would return an E_s value of 42.5 tsf.

The accuracy of these values of E_s are questionable, however, Hooke's law assumes a linear-elastic stress-strain condition and the CPT correlation was developed for use with sandy soils. Ideally, CPT correlations should be developed specifically for CCR materials and E_s, which would require a large volume of CPT tests and data analysis.

Chapter 7

Reconstitution Technique for Surface Impounded CCRs

Sample reconstitution techniques try to balance process simplicity with matching the in-situ fabric of the soil as closely as possible. Some reconstitution techniques commonly used on sand and non-plastic silt materials include moist tamping methods, air and water-pluviated methods, and slurry deposited methods. In this chapter, a brief overview of these various methods is given and a technique not yet applied to coal ash materials is analyzed when used with surface impounded CCR materials (will be referred to as SI CCRs throughout this chapter).

7.1 Moist Tamping

The first moist tamping method was proposed by Ladd (1978) in a paper entitled "Preparing Test Specimens Using Undercompaction." In this method, specimens are formed by hand-tamping of moist soil (w% = 20% to 70%) in equal lifts within a triaxial sample split mold, while increasing the dry mass of soil in each subsequent lift. The soil samples should be mixed with water at least 16 hours prior to use and the lift thickness should not exceed 1 inch for specimens with a diameter of less than 4 inches. Ladd provided an equation to calculate the percent under-compaction for each layer placed:

$$U_n = U_{ni} - \left[\frac{(U_{ni} - U_{nt})}{n_t - 1} \times (n - 1)\right] \tag{11}$$

where U_{ni} = percent under-compaction selected for first layer
U_{nt} = percent under-compaction selected for final layer (normally zero)
n = number of layer being considered
n_i = first (initial) layer
n_t = total number of layers (final layer)

The U_{ni} of the first layer is usually between 0% for very dense specimens and 15% for very loose specimens. In order to determine the correct U_{ni}, a series of cyclic triaxial tests must be run with the same effective consolidation stresses and CSR, but with different values of U_{ni}. The specimen then observed during testing and the following observations indicate an inappropriate value of U_{ni}:

- Excessive necking or bulging in any part of the specimen during cyclic loading.
- Non-uniform vertical strains during unconsolidated-undrained loading.
- A honeycomb soil fabric structure at either end of the specimen.
- A non-uniform dry unit weight along the height of the specimen.

Other moist tamping techniques modify this method slightly, usually by either changing the method in which under-compaction is addressed or by defining a specific compaction energy to be used in compacting the sample. This method can be laborious if the correct value of U_{ni} must be determined, since a whole test regime must be completed. Additionally, with regards to hydraulically-placed soils, the fabric of the sample does not match in-situ conditions well.

7.2 Air/Water Pluviation

"Pluviation" or "raining" of soil is a technique first published by Kolbuszweski in 1948. In this technique, the soil is pluviated from a separate apparatus into the soil mold, either in a dry state, or in water. These apparatuses vary in complexity and have various opening sizes and diffuser designs. By controlling the flow rate of the soil through the diffuser and the fall height of the sand, it is possible to place the soil at varying relative densities (Rad and Tumay 1987).

While air-pluviated samples can provide relatively uniform specimens and is a good technique for modeling Aeolian deposits of poorly graded sands and silts, well-graded sands or sands with high fines content have a tendency to segregate. Furthermore, the fabric of the sample can be disturbed during the saturation phase of triaxial testing due to fines washing out of their original placement (Keurbis and Vaid 1988). Air-pluviation would not likely model the fabric of surface-impounded CCRs well, since these CCRs are deposited in a hydraulic environment. Furthermore, the high content of non-plastic fines in CCRs would make loss of soil due to dust very high.

Similarly, water-pluviated specimens form uniform samples of poorly graded soils, though usually at lower relative densities than air-pluviated specimens, since soils fall at a slower velocity through water than through air. However, with well-graded soils, or soils with high fines contents, particle segregation can be a problem with this technique (Keurbis and Vaid 1988). Particle segregation would also be an issue with surface impounded CCRs, since these tend to be a mixture of bottom ash and fly ash.

7.3 Slurry Deposition Techniques

Like the previous two methods, there are several different slurry deposition methods. The first slurry deposition method was first developed by Keurbis and Vaid (1988), which is the technique that is being assessed for use on surface impounded CCRs in this thesis, with some slight modifications. For the sake of avoiding any redundancy, the procedure for this technique will be outlined with specific reference to its use on SI CCRs, with departures from the original procedure of Keurbis and Vaid noted.

7.4 Slurry Deposition Technique Applied to SI CCRs

The basic premise of the slurry deposition technique is to form a lean (just enough water to allow for effective soil mixing), saturated slurry of soil that can then be deposited directly from a mixing tube into a triaxial split-mold, with minimal disturbance to the mixture. The slurry should be lean enough to avoid the development of sedimentation currents during the transfer from the mixing tube to the split-mold, but not so lean that mixing becomes difficult. In addition, the procedure ensures that the sample will be fully or very close to fully saturated upon completion. The samples are deposited very loosely initially and can be densified to higher relative densities by vibration. In their original slurry deposition method, Keurbis and Vaid recommend de-airing the soil-water mixture and then pluviating it into the mixing tube in order to better ensure saturation. However, CCRs can be fine enough that a considerable amount of the sample (of a specific grain-size) can be lost in the pluviation process. Therefore, the CCR samples prepared using this method are simply added to de-aired water directly into the mixing tube in order to minimize sample loss during the preparation process; if saturation ratios using this method are unacceptable, a soil-water mixture can de-aired under a vacuum or by boiling and then transferred directly to the mixing tube. The apparatus required for the CCR slurry deposition technique are as follows:

- Acrylic mixing tube, with an outer diameter slightly smaller than the target diameter of the sample being formed and a plug to seal off one end. The end opposite of the mixing tube will have rubber gasket seal glued around the rim. The other dimensions of this tube will be discussed later.

Figure 33: Acrylic mixing tube with a rubber stopper on one end and rubber gasket seal glued to the opposite end.

- A thin metal disk approximately the same diameter as the bottom porous disk used in testing.

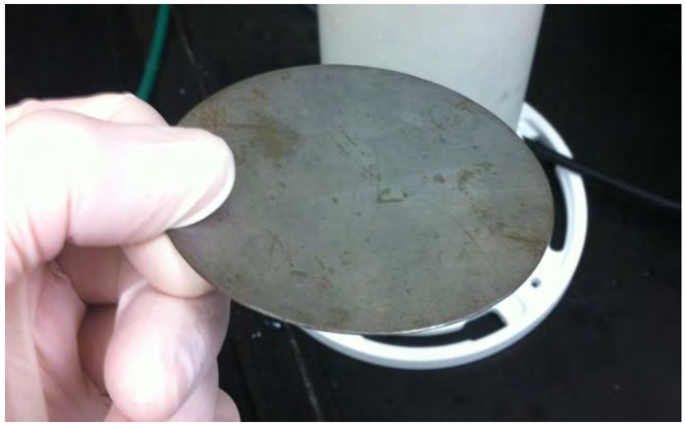

Figure 34: Thin metal disk approximately the same diameter of the bottom porous disk.

- A rubber or latex membrane with a smaller diameter than the mixing tube. Standard store-bought balloons can be cut to fit and are a cheap, readily available alternative.
- Water bath container for the acrylic mixing tube, large enough to completely submerge the mixing tube.

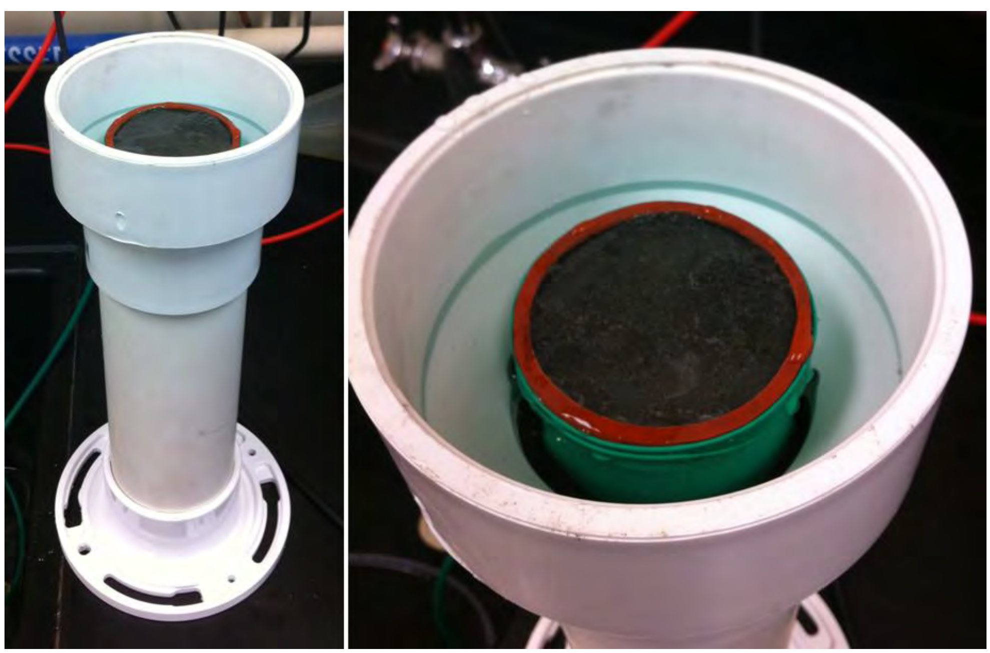

Figure 35: Water bath large enough to completely submerge the mixing tube and allow for easy placement of the porous disk and metal plate. The rubber membrane can also be seen rolled down around the mixing tube.

- Water bath container for the triaxial cell base-platen that can at least submerge the bottom drainage line and the porous disk when the mixing tube is placed on it.

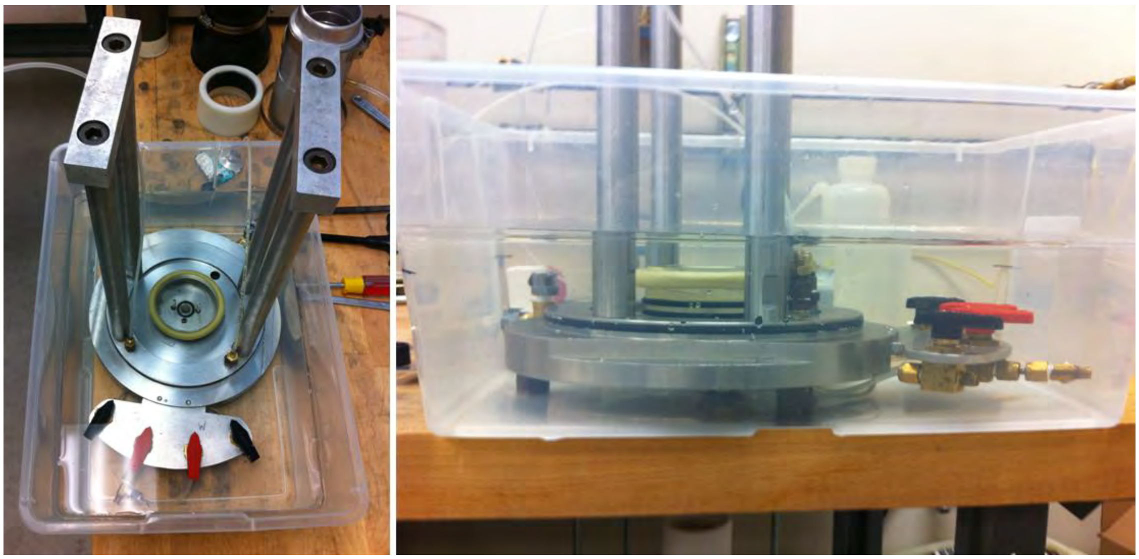

Figure 36: Water bath large enough to accommodate the bottom of the triaxial cell and submerge the bottom platen.

- A split-mold triaxial sample former.
- A collar that fits over the split-mold to accommodate the temporary increased volume of the sample when it is first placed.

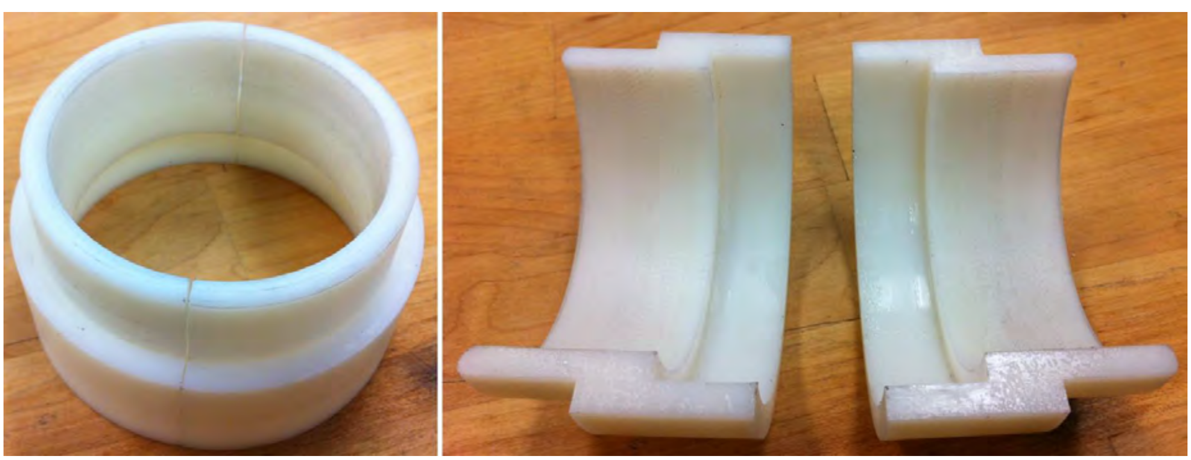

Figure 37: A custom-made split-collar to accommodate the additional volume of soil when the slurry is first placed in the specimen split-mold. This collar was machined out of nylon to fit the dimensions of the split-mold being used and the flexible collar used to accommodate the extra water volume when the slurry was placed.

- A small mechanical shaker or mallet to densify the sample once it is placed. If a mallet is used, a heavier mallet is best, as it transfers more energy than a standard rubber mallet.

In their original slurry-deposition method, Keurbis and Vaid made their soil-water mixtures using dried soil; for SI CCRs, this would be impractical because of the dust that would be lost in handling it in a dry state. Thus, it is recommended that the SI CCRs be mixed at a target water content in order to make it more workable. Once the soil is well-mixed, several small samples should be oven-dried to verify that the moisture content of the soil is homogenous.

The mixing tube should have the thin rubber membrane rolled down over the end with the rubber gasket seal and the other end plugged with the stopper. The moist CCR specimen is placed in the mixing tube, which should then be filled with de-aired water (some water can be in the tube prior to adding the moist soil in order to help collapse the structure of the moist CCRs and decrease their volume during placement in the tube). The mixing tube is now placed into the de-aired-water bath. Once the mixing tube is in the water-bath, a saturated, de-aired porous disk with a filter paper attached is placed on the open end, such that it is completely submerged in the water bath; some fines will escape the mixing tube while it is submerged and before the porous disk is placed over the opening (see Figure 38), so these fines should be put into a container to be oven-dried and weighed in order to adjust the dry mass of the sample.

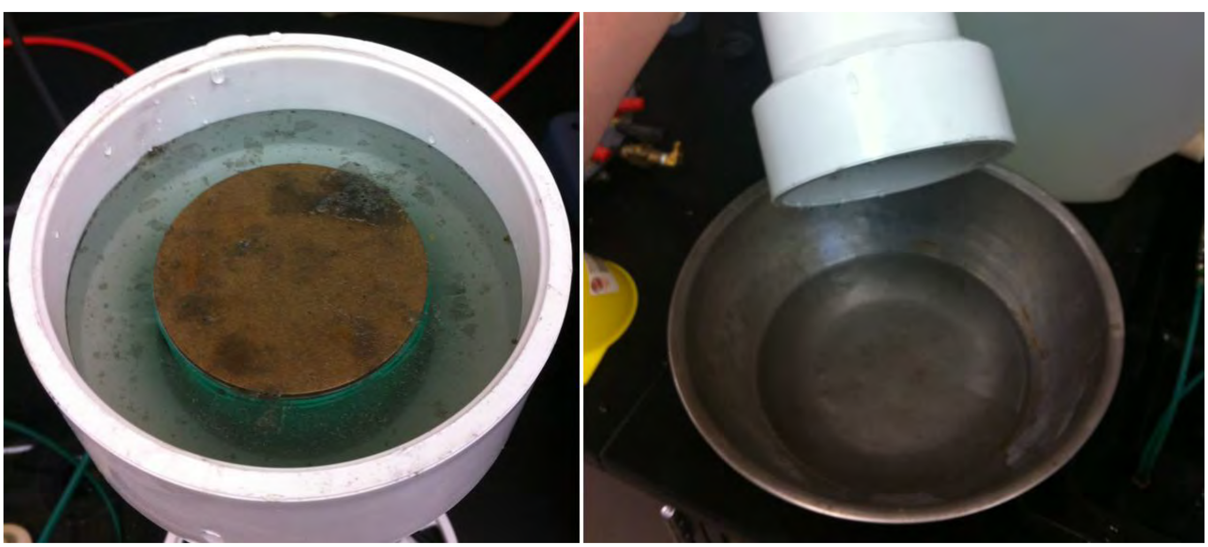

Figure 38: Placement of the porous disk and transferring of the fines lost in the water bath to a container to be oven-dried and weighed.

At this point, the thin rubber membrane is rolled over the porous disk, such that a small portion of the center of the disk is exposed. The thin, metal disk is now placed over the porous disk and membrane and the mixing tube is withdrawn from the water bath, while keeping firm pressure on the metal disk. The securing of the porous disk with the thin rubber membrane and placement of the metal disk are shown in Figure 39.

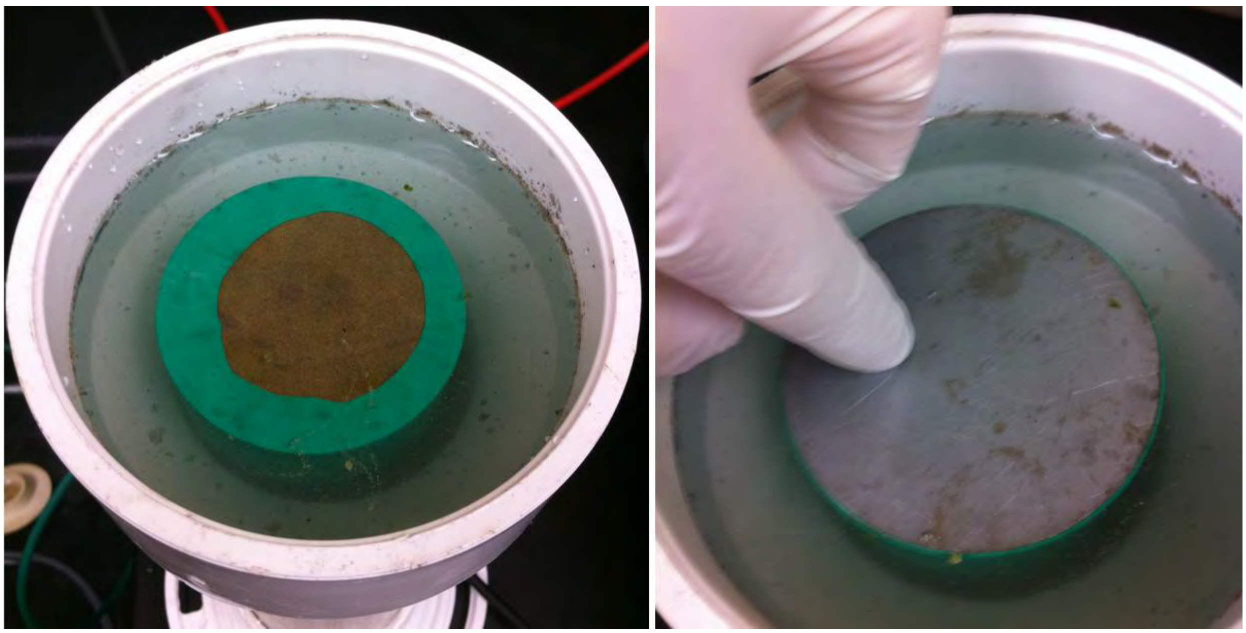

Figure 39: Securing of the porous disk with the thin rubber membrane and placement of the thin metal disk over the opening in the membrane.

Now the mixing tube is removed from the water bath while maintaining firm pressure on the thin metal disk and the soil slurry mixed vigorously, end-over-end for the next twenty minutes, to ensure homogeneity of the slurry. After twenty minutes has passed, the mixing tube is placed disk-end down and the mixture is allowed to settle to its loosest stable state. When the mixture has stabilized, the metal disk is removed (it should be held in place by suction when the mixing tube is lifted), the membrane rolled back to the edges of the porous stone, and the entire apparatus placed porous-disk-down onto the base platen, which is submerged in another de-aired water-bath. The rubber membrane around the mixing tube is now rolled up and off of the mixing tube. The sample membrane has been rolled down around and attached to the bottom platen with two o-rings prior to submerging the base platen in the de-aired water-bath and it is now rolled up and over the outside of the mixing tube. The entire bottom platen can now be removed from the water bath and the split mold formed around the mixing tube and sample membrane. Rolling of the membrane over the mixing tube and placement of the split mold and collars after removal of the triaxial cell base from the water bath is illustrated in Figure 40.

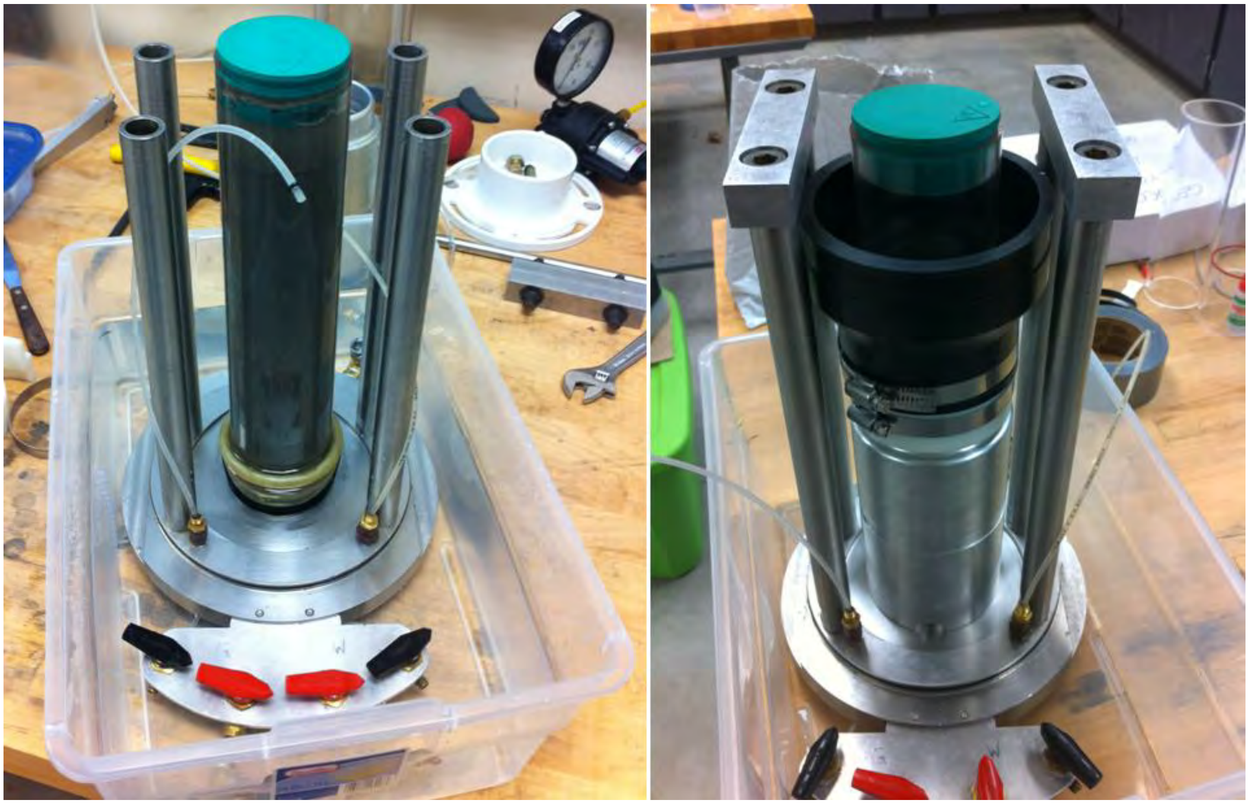

Figure 40: Rolling up the membrane around the mixing tube and placement of the specimen split-mold, the slurry extension collar, and the water extension collar after removal of the triaxial cell base from the water bath.

Once the extension collars for the split-mold is attached, a vacuum is applied between the split mold and the membrane; then, if additional volume is required to accommodate water volume, either a larger membrane can be secured using a hose clamp, or a flexible rubber PVC connection can be used (the flexible PVC connection was used in this experiment, as shown in the right-hand photograph in Figure 40). The last step before transferring the slurry to the split mold is to add a de-aired water bath to the split mold, outside of the mixing tube; this ensures minimal disturbance of the CCR material as it is transferred from the mixing tube to the split-mold. The rubber plug on the mixing tube can now be removed and the mixing tube slowly extruded, such that disturbance to the slurry is minimized as it is deposited in the split-mold. When the mixing tube has been fully extruded, the water level can be adjusted by allowing drainage through the drainage lines on the bottom platen (alternatively, some of the water and fines mixture at the top can be basted off and put into the same container as the fines from the mixing tube water bath and oven-dried and later weighed to save time). Once the water level has dropped enough to allow removal of the extra membrane or flexible PVC connection, the slurry can be densified by attaching the top platen (which also has a filter-paper applied), applying a small pressure, and vibrating the sample if necessary, while allowing excess pore pressures to dissipate through top and bottom drainage lines, as shown in Figure 41. This should be done such that the piezometric pressure is the same across the sample, which was postulated to form specimens of sand at uniform densities with height by Vaid and Negussey (1988).

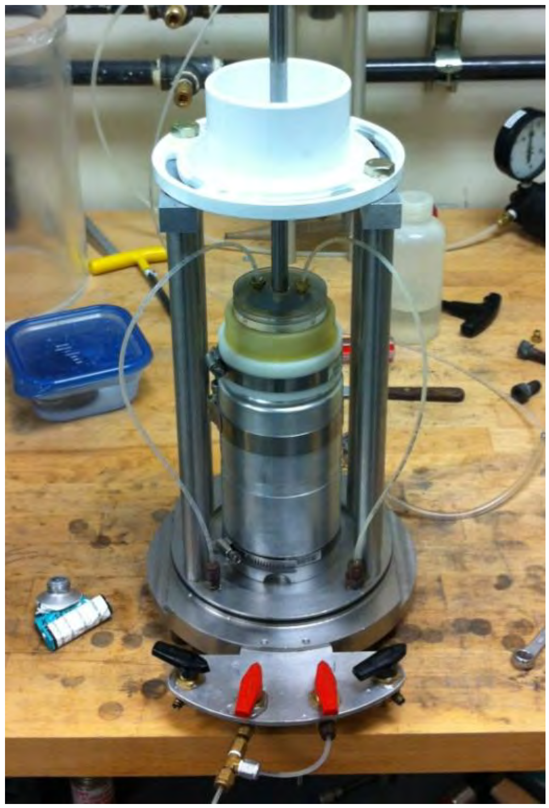

Figure 41: Setup used to densify SI CCR slurry-deposition samples. Notice that the short-circuit between the top and bottom drainage is being used to drain the sample as it is densified with the top platen applied. The top platen fits snugly enough into the extension collar to keep a water-proof seal. The white piece on the top of the triaxial base is simply a part to keep the piston plumb as the slight pressure is applied to the top of the sample during densification.

This vibrating can be accomplished with either a mechanical shaker or by tapping the side of the split mold gently with a mallet. However compaction of specimens to high relative densities can take quite a long time using a mallet, so a mechanical shaker would be preferable for SI CCR specimens. Once the target sample height is reached (and thereby the target sample volume reached), the extension collar is removed, the membrane is secured to the top platen with two o-rings, and a small vacuum pressure is applied to the sample to allow removal of the split mold. The dimensions of the sample are then measured and the sample is placed into the triaxial testing apparatus.

The dimensions of the acrylic mixing tube are determined based on the minimum density of the largest volume of soil that will be used in making a sample. That is, the length of the tube is determined based on the amount of soil required in forming the densest sample to be tested, placed at a zero percent relative density. Keurbis and Vaid found that this volume, increased by five to ten percent is sufficient to allow for adequate slurry mixing, while avoiding large particle sedimentation distances. A sample calculation determining the appropriate length for a mixing tube is included in the appendix.

7.5 Analysis of Slurry Deposition Technique with SI CCRs

In order to assess the slurry deposition technique as applied to SI CCRs, relative density and gradation were determined for the top, middle, and bottom portions of the sample. Since CCRs tend to be non-plastic and negative pore water pressures in a moist sample are not high enough to ensure no disturbance of fabric during the verification process, a gelatin solidification technique developed by Emery et al. (1973) for use with sand specimens was modified for use in this experiment. Gelatin was chosen as the solidifying agent because it is easily dissolved using heat after the volume of each individual slice of the specimen is determined. Then, by adding bromelain, a proteolytic enzyme, the gelatin is broken down, leaving a brittle crystal that can then be avoided when selecting a sample to run a hydrometer test on, and that can be washed out when the gradation is analyzed above the #200 sieve.

SI CCRs have a wide range of hydraulic conductivities (a result of how they are generated and placed), sometimes being similar to sands and other times being more similar to silts. For this reason, the time required to permeate these samples with a gelatin solution is much longer than for clean sand samples. As a result, it was determined that a lower concentration should be used than recommended by Emery et al., such that the solution remains a liquid at room temperature, but is solidified by surrounding the sample in the split mold with an ice-bath; this is explained in more detail in the following paragraphs.

Once the compaction of the slurry deposited sample was complete, height measurements were made at four locations (front, back, right, and left sides of the top platen) using the frame of the triaxial cell and a Mitutoyo micrometer. The height of the sample was determined by subtracting the thicknesses of all the component parts that are not soil from the heights measured from the bottom platen to the triaxial cell frame at four points (front, back, right, and left sides). This was done as a quality-control measure to ensure that the overall relative density across the sample was close to the target relative density. A 0.75% by-mass gelatin solution is then permeated through the specimen by applying an elevation head between the gelatin reservoir and bottom drainage lines of the specimen and allowing drainage through the top drainage lines (not more than 18 inches). About two specimen pore volumes were permeated through the specimen to ensure complete replacement of the pore fluid. After the gelatin flushing of the specimen was complete, the drainage lines were all closed and an ice-bath was packed around the specimen, as shown in Figure 42. For this experiment, the ice bath was maintained over the height of the sample for a period of four hours, which was found to be adequate to solidify the specimen.

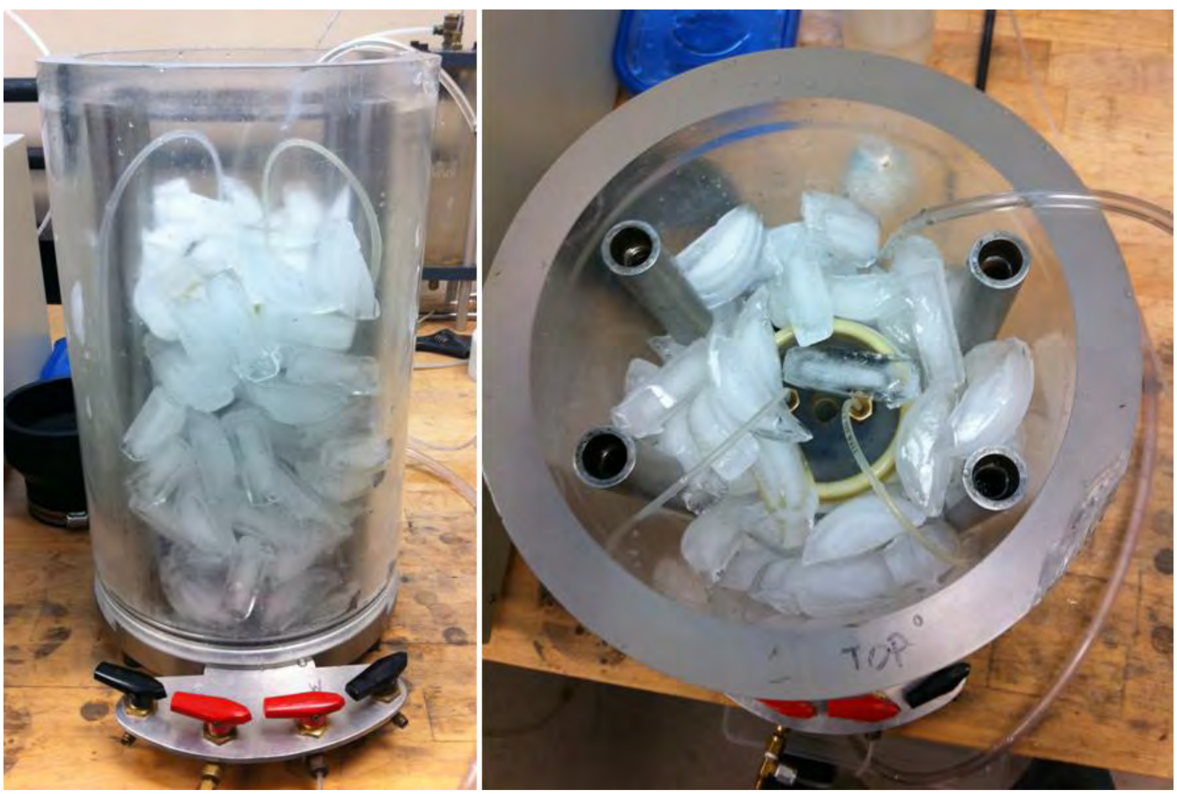

Figure 42: Ice bath placed around the compacted specimen for a period of four hours to set the gelatin.

After the four hours, the ice bath was removed and the specimen was removed from the split mold and taken out of the membrane, as shown in Figure 43, and cut into three approximately even-sized portions.

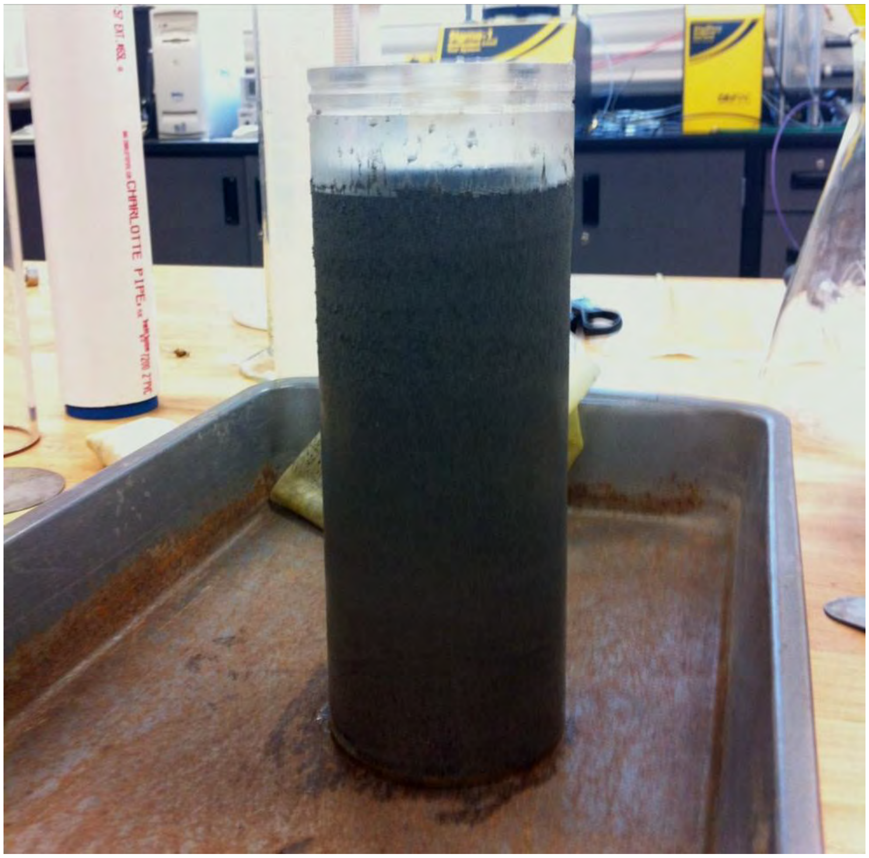

Figure 43: Specimen removed from the split mold and membrane following gelatin curing period.

The mass of these portions was taken and the volume determined using water displacement, as shown in Figure 44. These two measurements allow for the calculation of the density of each slice. It can be assumed that each of the slices is composed only of a mixture of gelatin and CCR material for the purposes of determining the relative density of each slice. The specific gravity of the gelatin solution was determined by permeating a portion of the solution through a piece of filter paper into a graduated cylinder and also placing this in an ice-bath for four hours, after which the mass and volume of the gelatin were measured and used to calculate the specific gravity at that temperature (ranged from 1.000 to 1.008). The specific gravity of the CCR material was determined according to ASTM D854, courtesy of Kevin Foster. Since the overall density of each slice is known, and the density of both component materials is known, it is possible to calculate the volume of each component according to equations 12 and 13.

$$V_{s\_slice} = \frac{\rho_{slice} \cdot V_{Slice} \frac{G_G M_{slice}}{\rho_{slice}}}{G_S - G_G} \tag{12}$$

where V_{s_slice} = volume of solids of the specimen slice
ρ_{slice} = density of the specimen slice
V_{slice} = volume of the specimen slice
G_G = specific gravity of the gelatin solution after ice-bath
M_{slice} = mass of the specimen slice
G_S = specific gravity of the CCR material

$$V_{g\_slice} = \frac{M_{slice}}{\rho_{slice}} - V_{s\_slice} \tag{13}$$

where V_{g_slice} = volume of gelatin of the specimen slice

Since it is assumed that the gelatin completely permeated the pore space of the sample, the volume of the gelatin is equal to the volume of voids in the slice and the void ratio can be calculated, which can then be used to calculate the relative density.

Once the densities of the slices has been determined, each slice is placed in its own container and allowed to dissolve (which will occur at room temperature), after which the Bromelain is added (a mass ratio of 1:10 of Bromelain to gelatin was found to be sufficient) and allowed to sit for two hours before placing it in an oven maintained at 110° C until it dried completely. ASTM D422-63 was followed in the particle-size analyses performed on each of the three slices for each sample, except for a few changes based on the properties of the CCR materials:

- The soil was not separated at the #10 sieve, since the material retained on the #10 sieve represented such a small portion of the sample. Additionally, in separating the samples at this sieve, there was the potential to lose specific particle sizes due to dust losses. Each of the hydrometer tests were separated on the #10 sieve following the test and the mass was adjusted accordingly for the hydrometer analysis calculations. This also eliminates the need to perform the calculation given in section 16 of the ASTM specification.

- A dry sample was used in each hydrometer test, since there would have been considerable time delays waiting for the specimen to dry at room-temperature (especially considering the presence of gelatin and bromelain in the specimens.

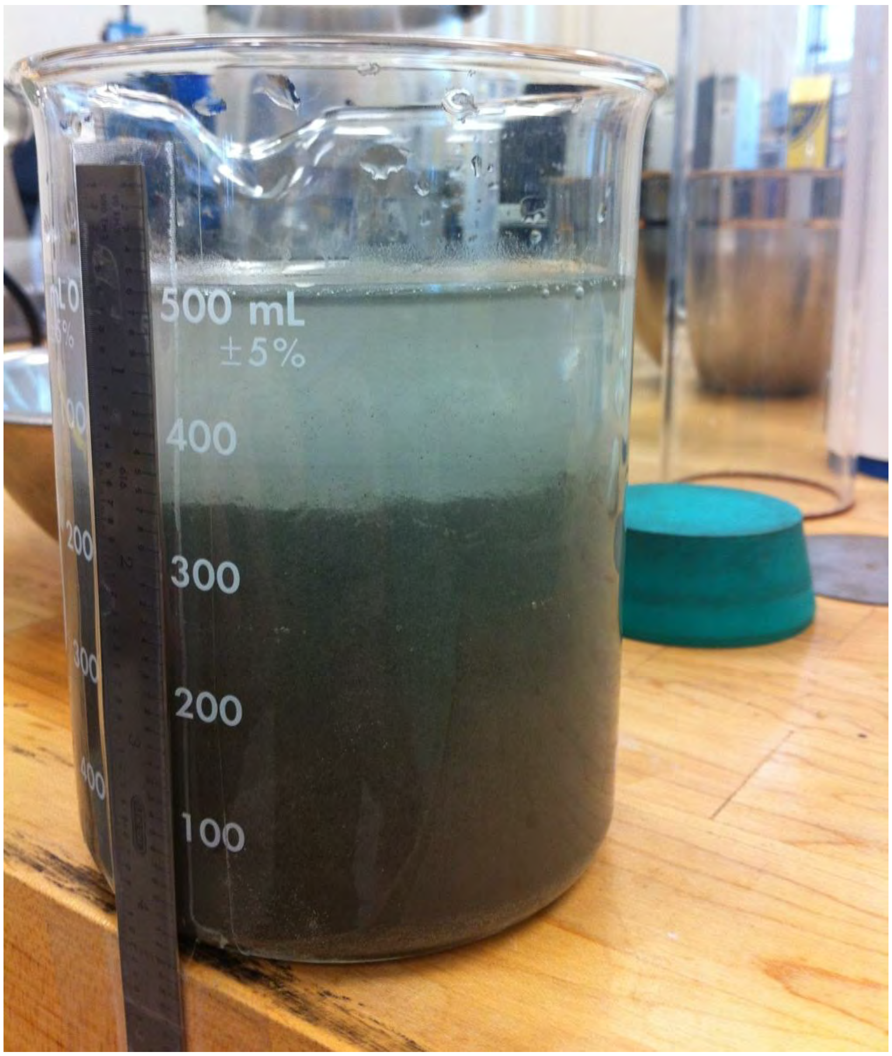

Figure 44: Each specimen slice volume was determined using water displacement. A 500 mL capacity beaker and a ruler incremented at 1/100" were used to do this. The vertical distance between a 100 mL addition of water to the beaker and the equation for the volume of a cylinder was used to calculate the diameter of the beaker; with the diameter known, it was determined that volumes could be measured accurately to ± 1.4 cm^3.

A dry sample of each of the slices could then be chosen to use in a hydrometer test (Bromelain-gelatin crystals were avoided in order to ensure they did not affect the results) to determine the grain size distribution for soil passing the #200 sieve. This soil was then added back to the rest of the dried specimen slice and washed on a #200 sieve to be included in a grain-size analysis for the particles with diameters greater than 75 μm.

Three different specimens were prepared, all at a target relative density of 70%. The first two specimens were deposited without a water bath within the split mold, while the last one was deposited with a water bath within the split mold. Table 11 makes a comparison of overall specimen slice densities and relative densities for the three specimens showing that, with or without a water bath inside the split mold, all three specimens had an increase in relative density down the height of the specimen. The top slice on the last specimen had not fully cured and as a result deformed some during the mass and volume measurements, undoubtedly resulting in the negative value of relative density. However, the bottom two slices of all three specimens are very consistent and the overall increase in relative density down the height of the specimen indicates that the densification technique that Vaid and Negussey (1988) cite as producing specimens of uniform density does not apply to SI CCR materials. Additionally, the very high values of relative density for all of the bottom slices indicate that the maximum and minimum void ratios determined for the material do not necessarily reflect the actual minimum and maximum void ratios; this could be the result of an inaccurate calculation of the specific gravity of the material, since that is a direct parameter for determining void ratio or an indication that the standards ASTM D4253 and D4254 are not appropriate methods for determining the minimum and maximum densities of CCR materials.

Table 11: Specimen relative density and density summary. The bottom two rows summarize relative density and density data for the entire specimen.

	Specimen 1		Specimen 2		Specimen 3	
	D_r	ρ (g/cm^3)	D_r	ρ (g/cm^3)	D_r	ρ (g/cm^3)
Top Slice	45%	1.63	27%	1.60	-13%	1.54
Middle Slice	93%	1.72	79%	1.69	76%	1.69
Bottom Slice	117%	1.78	113%	1.77	112%	1.77
Average	85%	1.71	73%	1.69	58%	1.67
From Dimensions	73%	-	70%	-	70%	-

The gradation curves presented for each specimen in Figures 45 through 47 show little segregation of particle size, with the most notable trend being that the bottom slice did tend to have a higher percentage of coarser particles within it; whether this phenomenon is solely the result of the placement method or the densification technique or whether both factors contribute is unclear and would require further study to determine. A comparison of the different slice gradations across specimens, presented in Figures 48 through 50, shows a very consistent gradation across the height of the sample between trials, indicating that this slight gradation difference is caused by a either the placement technique or the densification technique, though which of the one responsible cannot be stated with any certainty at this time. However, the effect of the placement technique and densification technique could be investigated easily through further testing. It is also interesting to note for specimen three, where a water-bath was used in the split-mold during slurry placement, that the gradations vary slightly more than for the two specimens, where a water-bath was not included. This may indicate that a water-bath allows sedimentation currents to form, while direct transfer without a water-bath minimizes the development of such currents. More reconstitutions would need to be made in order to perform meaningful statistical analyses on variation in gradation between samples made with and without water-baths to verify this claim. Lastly, Figure 51 plots all gradations on a single plot to make the extent of variation in the grain size distributions of the three specimens clear.

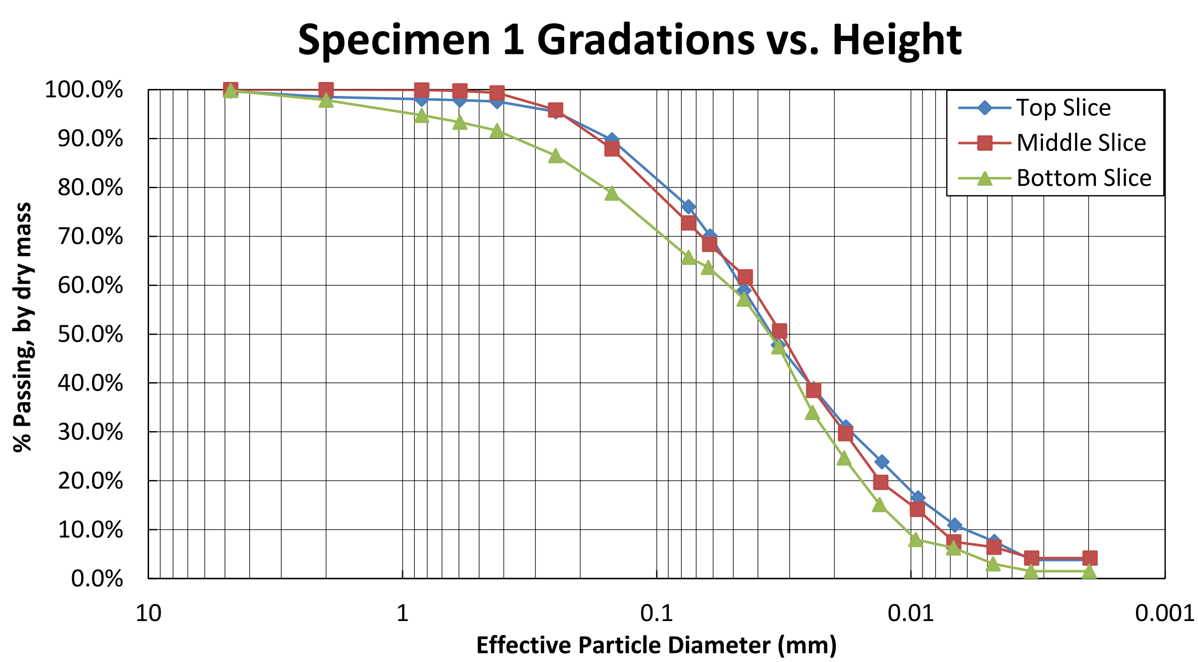

Figure 45: Plot comparing grain-size distributions across the height of specimen one.

While the results of the three reconstitutions performed for this thesis provide some insight, a statement cannot be made about the suitability of the slurry deposition method for use with SI CCRs at this time. However, it can be said that the densification technique used in this investigation is unsuitable for SI CCR materials; if an alternative densification method could be developed, a simple investigation could be undertaken to determine if the slight particle segregation observed in this investigation was due to the vibratory compaction technique used, or if it was the result of the slurry deposition technique itself.

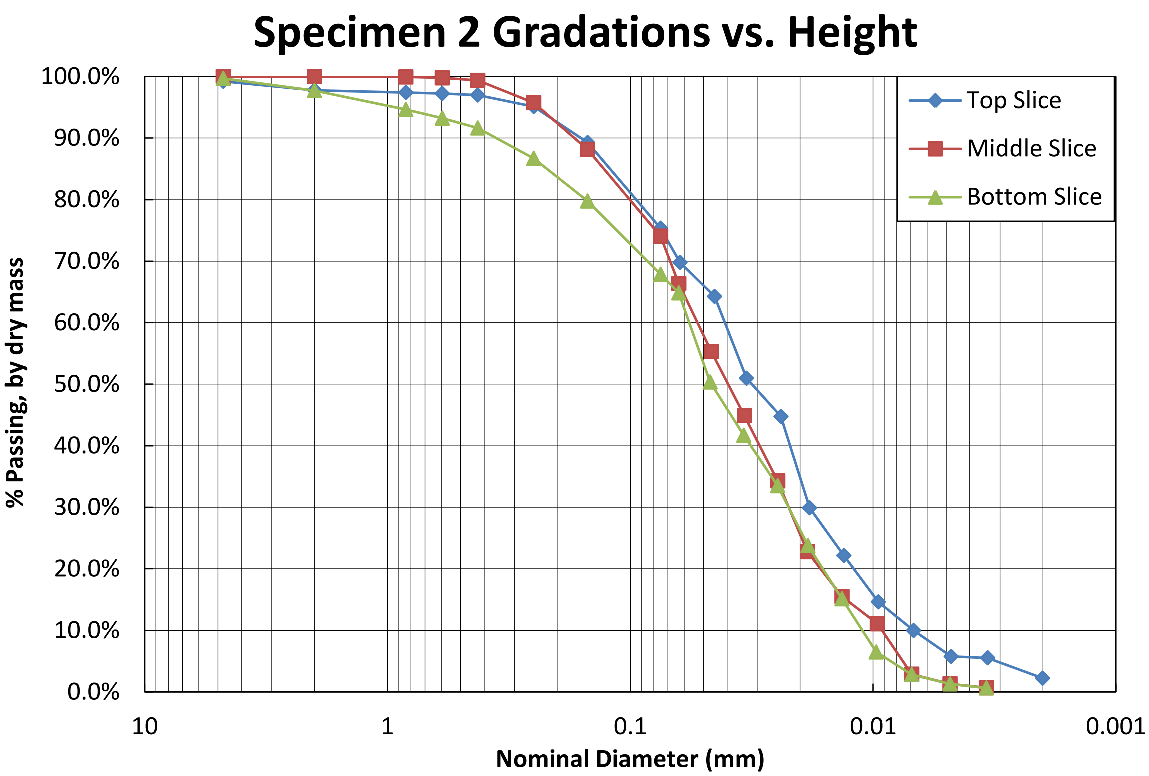

Figure 46: Plot comparing grain-size distribution across the height of specimen two.

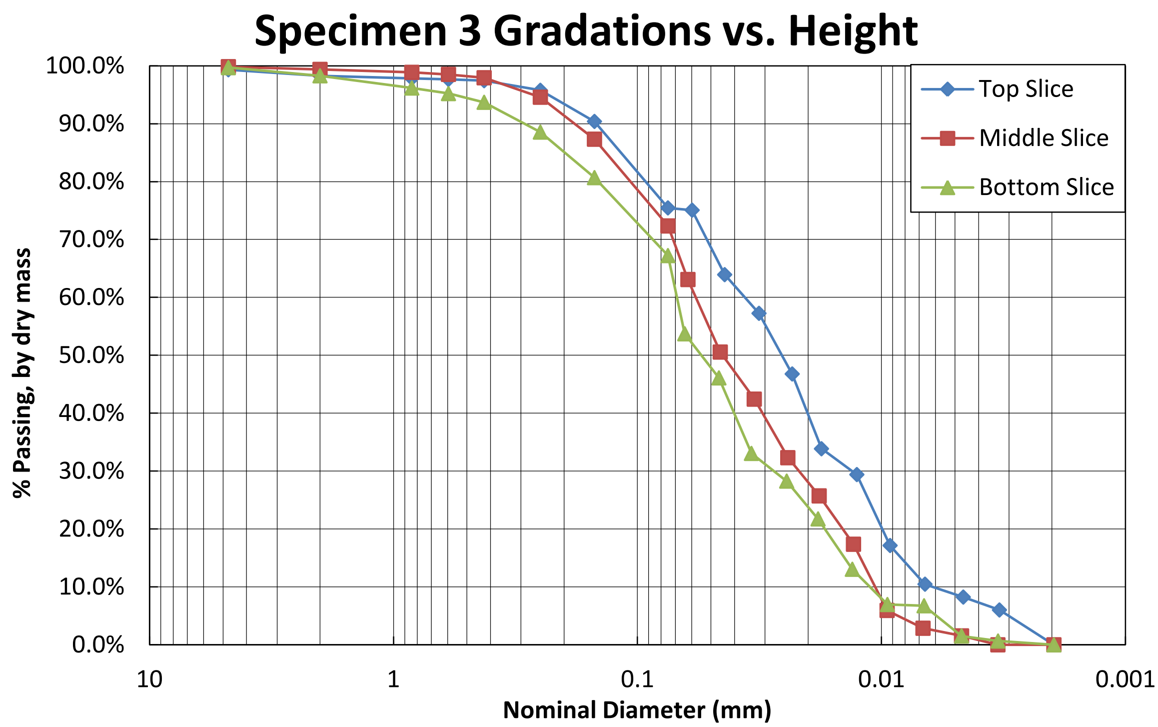

Figure 47: Plot comparing grain-size distribution across the height of specimen three.

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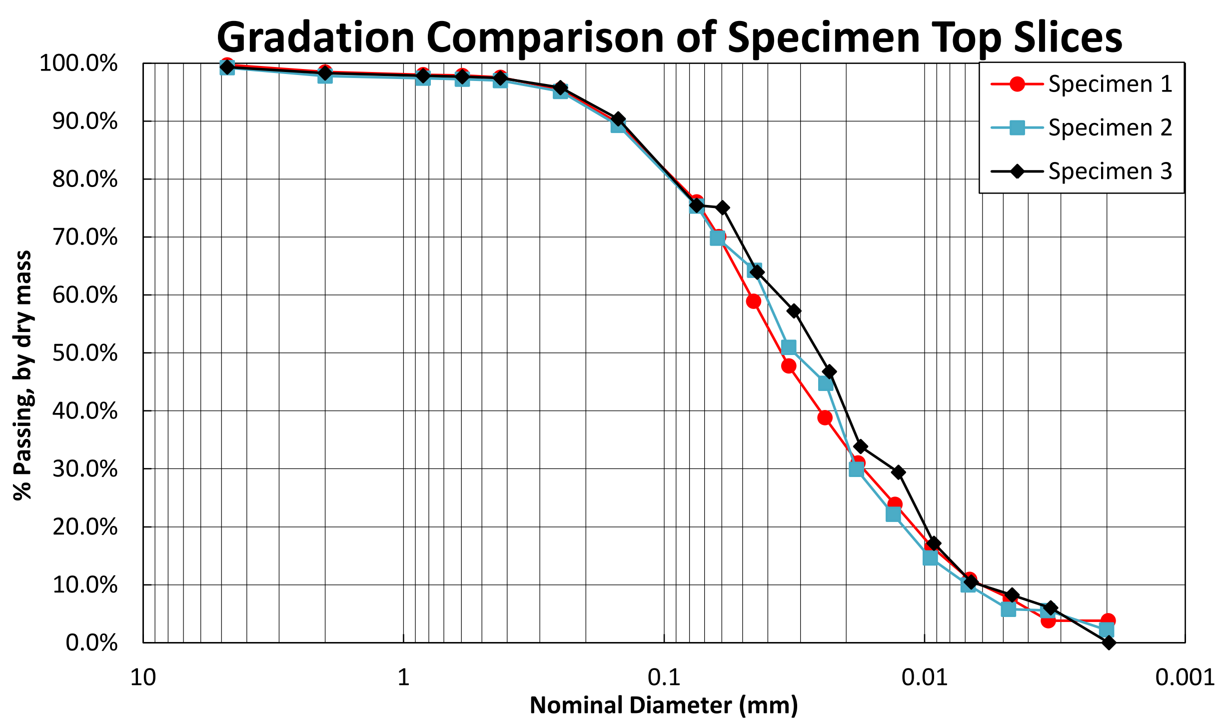

Figure 48: Plot comparing grain-size distributions of the top slices of all three specimens.

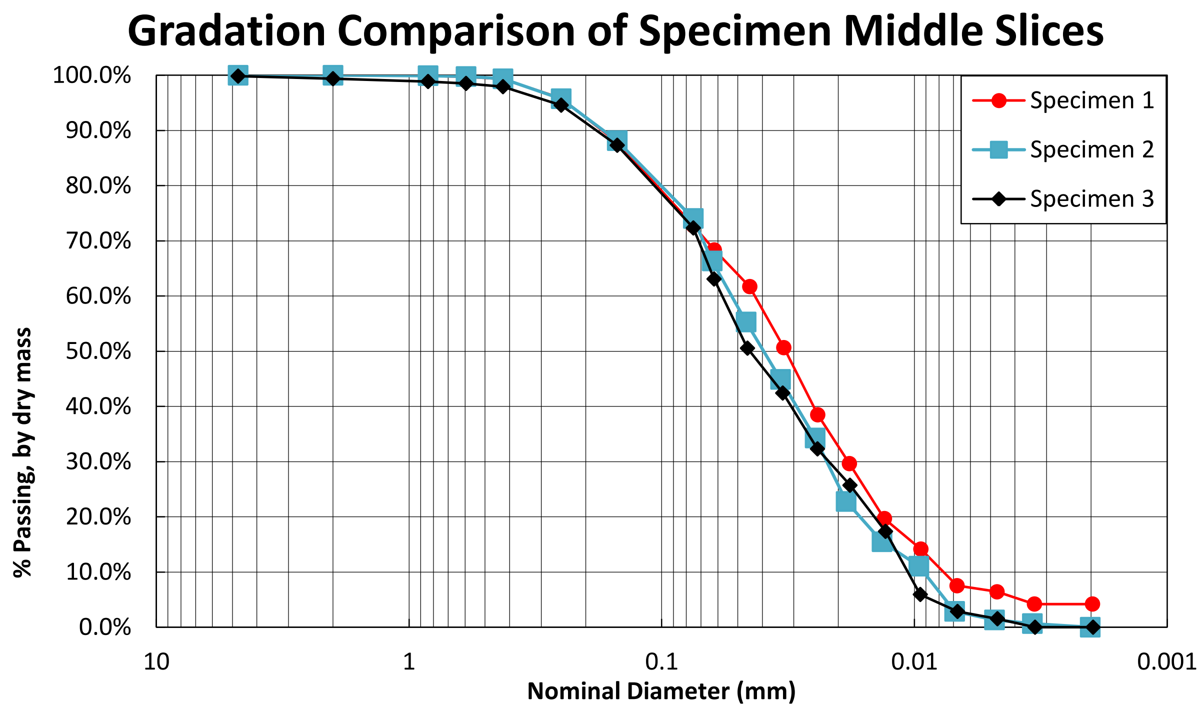

Figure 49: Plot comparing grain-size distribution of the middle slices of all three specimens.

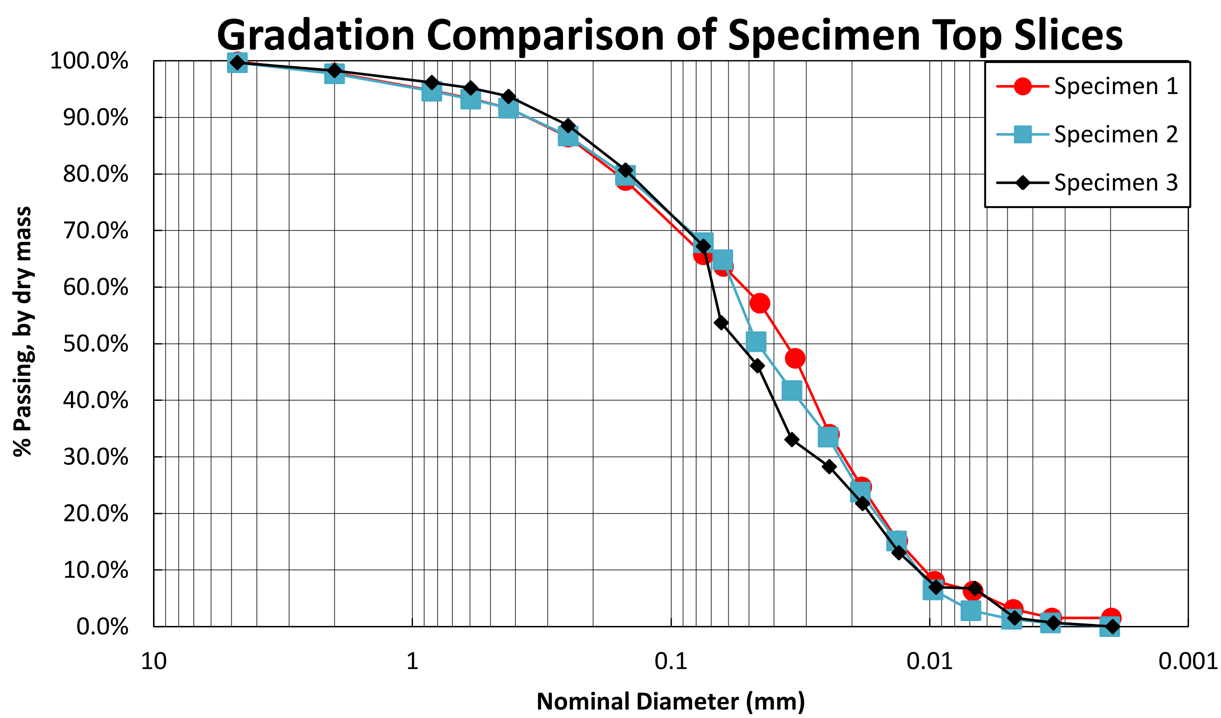

Figure 50: Plot comparing grain-size distribution for the bottom slices of all three specimens.

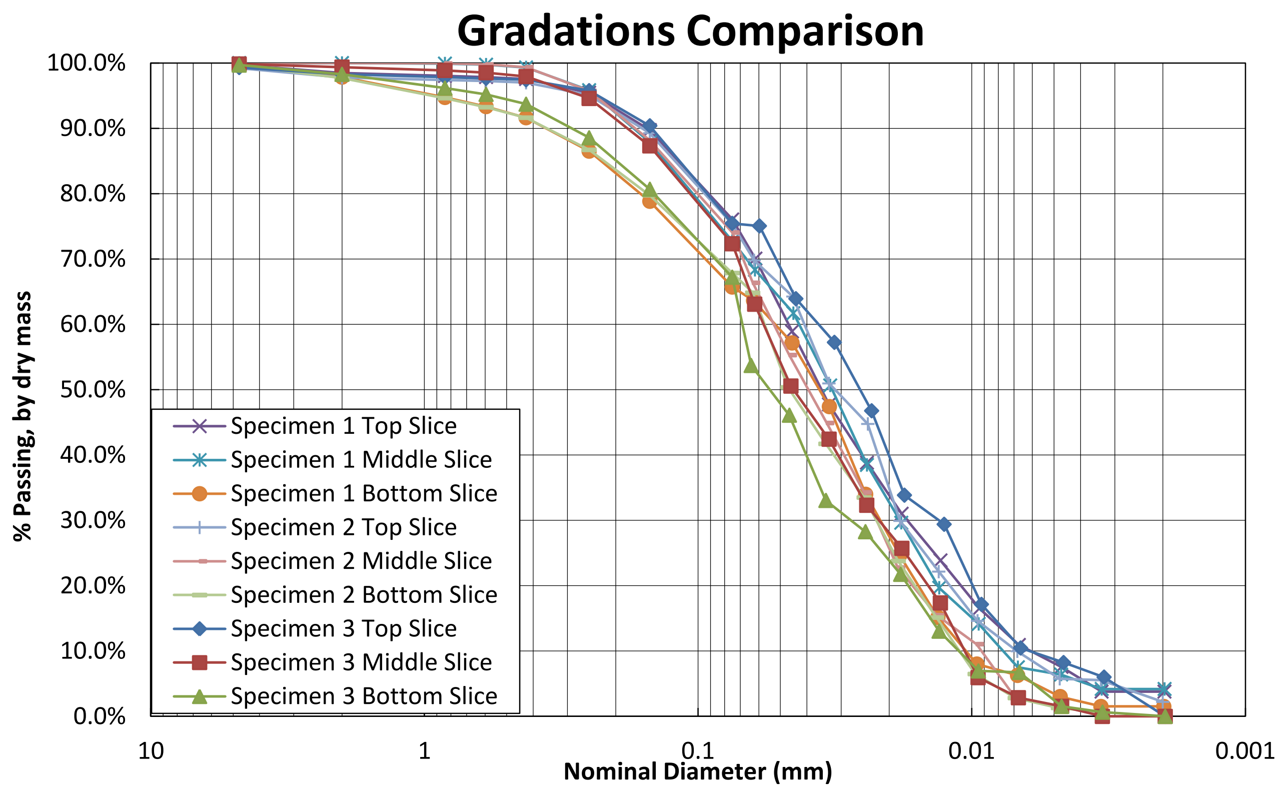

Figure 51: Comparison of all gradations for all three samples.

Examining Figure 51, it is obvious that a considerable amount of variability entered into gradation data with the portion of the graph that was determined using the hydrometer test. This may be the result of slight variations in temperature over the course of the test, regardless of the fact that the room temperature was thermostat-regulated. If temperature readings of the soil suspension had been take at each reading and used in calculating the values derived from Stokes' Law, this variability may have been reduced considerably. The maximum variability in the sieve analysis data for a given nominal diameter was about 10% by mass, while the maximum variability in the hydrometer analysis data for a given nominal diameter was about 25%.

Chapter 8

Conclusions

8.1 Engineering Characterization of CCRs

Geotechnical designs and analyses when working with CCRs are similar to those for natural soils in many respects. The physical and engineering properties of CCRs are what differentiate them from natural soils of similar grain size. Consequently, the single most important aspect of working with CCRs is determining their physical and engineering characteristics. As a result of current and past CCR disposal methods, determining variability in their properties across a given site is also important. As evidenced by the variability plots of the different engineering properties of CCRs, variability can vary greatly to very little within a specific site. However, since the coal source for a given site will inevitable vary, so will the engineering properties of the resulting ash. Because of the differences in properties of CCRs between given sites and from that of natural soils of similar grain size, a more thorough site investigation and laboratory testing schedule will almost always be necessary than for natural soils.

8.2 Dynamic Properties of CCRs

Being a mostly granular and non-plastic material, the characterization of the dynamic properties of CCRs is important to ensure that current and future CCR disposal areas are designed in order to withstand seismic events. Currently there is very little data on the dynamic properties of CCRs and the data that is available is usually from different countries, whose CCRs may not be similar enough in makeup to merit comparison with CCRs in the U. S.; more dynamic laboratory testing is required before such a conclusion can be made.

8.3 CCR Failure Modes and Monitoring Practices

The two main types of CCR disposal areas, surface impoundments and landfills, are very different in their construction and therefore are prone to different failure modes. As a result, monitoring practices should be tailored to the type of disposal area it applies to. Despite the fact that there is a lack of literature and precedence regarding monitoring of CCR disposal areas, their design tends to be similar enough to mine tailings dams that monitoring practices for tailings dams could easily be adapted and applied to CCR disposal areas. The flowcharts developed by Martin and Davies (2000) provide an excellent template that could be adapted to develop a site monitoring program for CCR disposal areas, especially for surface impoundments.

8.4 Slope Stability of CCRs

Slope stability analyses with CCRs are basically the same as for natural soils, except that there is usually an inherently higher degree of uncertainty in the CCR material. For that reason, analyses involving CCRs should have a degree of conservatism built into every step, unless there is evidence to indicate that such a measure is unnecessary. If the dikes containing surface impounded CCRs are built CCR materials, or other non-plastic soils that have the potential to have low hydraulic conductivity, then a sudden rise in the water table has a deleterious effect on the impoundment's performance. For this reason, if such conditions do exist, it is good practice to install drainage (if not already installed) to ensure a steady-state water table can be maintained.

8.5 Settlement Calculations for CCRs

Many researchers report compression and recompression indices for CCR materials. However, since CCRs generally do not have clearly log-linear values of compression and recompression indices, calculating settlements using consolidation theory can yield variable settlements, depending on different individuals' interpretation of standard consolidation tests.

The two methods for settlement of foundations in sand provide very similar results, underestimating settlement considerably. This is possibly the result of scale effects and differences in the mechanics of the materials (silt-sized particles that are the result of an industrial process rather than natural sands). In order to accurately say that none of these settlement calculation methods works well in CCR surface impounded materials, however, more test fills would need to be performed and analyzed in a similar fashion.

8.6 Slurry Deposition Technique Applied to SI CCRs

While it was not verified that the slurry deposition technique can be applied to SI CCR materials, the method shows promise based on the low variability of grain-size distribution across specimen height for the three specimens tested. However, a major drawback to this method is that the original densification method suggested by Keurbis and Vaid (1988), which was for sands and silty sands, does not appear to work for SI CCR material. Furthermore, more investigations would be required to determine whether the gradation differences observed in these three samples are due to particle migration during vibratory densification or to the actual deposition technique; if it is due to the former, a different densification method may make the slurry deposition method a very attractive reconstitution technique because it is relatively easy and has excellent repeatability, as evidenced in the results presented in Chapter 7. All spreadsheets used in specimen preparation and specimen analysis are provided in the appendix.

8.7 Recommendations for Further Study

As discussed in Chapter two, since CCR materials are the result of an industrial process and not a naturally occurring soil, there is a variety of factors that can affect their engineering properties. Not being a naturally occurring soil, there is a comparatively small body of literature available that reports engineering properties of CCRs. Furthermore, these properties will not necessarily be comparable between different regions. It is therefore necessary to continue research in CCRs, especially with regards to the following:

- Effects of placement condition on the engineering properties of CCRs (i.e. surface impounded vs. moist-compacted).
- Variability in engineering properties of CCRs between disposal sites and within disposal sites (and how to best quantify variability for different properties).
- Dynamic properties of CCRs, to ensure that seismic design of CCR disposal areas is adequate and determine if some disposal areas are higher risk in the event of an earthquake.
- CPT correlations to determine engineering characteristics of CCR materials in-situ.
- The effect of time on the engineering properties of CCRs.
- Determining the most appropriate method to determine c_v of CCR materials, in order to determine if disposal loading rates may be cause for engineering concern.
- "Smarter" technologies that can be adapted to aid in monitoring CCR disposal areas that would better identify gradual changes that may not be readily apparent to daily inspectors.
- Further testing on slurry deposition reconstituted SI CCR samples to analyze soil fabric (a large enough body of tests to analyze statistically). The same method as used in this thesis could be used or methods to determine shear wave velocity across the height of the sample could be used.

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Appendix A

Sample Preparation and Fabric Analysis Spreadsheets

Sample Dimensions:

Note: Sample mold has bevelled top portion, so volume is calculated as two separate cylinders added together

H_{TC} =	0.72	inches	D_{TC} =	2.851	inches
H_{BC} =	5.465	inches	D_{BC} =	2.826	inches
T_{BS} =	0.112	inches	T_M =	0.012	inches
T_{TP} =	1.229	inches	T_{FP} =	0.007	inches

Where
H_{TC} = height of top cylinder
H_{BC} = height of bottom cylinder
D_{TC} = diameter of top cylinder
D_{BC} = diameter of bottom cylinder
T_M = latex membrane thickness
T_{BS} = thickness of bottom porous stone
T_{TP} = thickness of top platen
T_{FP} = thickness of filter paper

Measurements of Sample Height (Datum: cell frame):

Reading Loc.	Bottom Platen (in)	Top of Top Platen (in)	Sample Height (in)
Front	**12.247**	4.724	6.182
Back	**12.253**	4.724	6.188
Right	**12.249**	4.724	6.184
Left	**12.251**	4.724	6.186
		AVG:	6.185

So target volume, V_{TAR}, is:

V_{TAR} = 38.13 in^3
624.9 cm^3

Minimum and maximum void ratios and specific gravity of solids are:

e_{min} = 0.65
e_{max} = 1.2
G_S = 2.22

Mixing Tube Dimensions Calculation Sheet:

D_r =	100%	
e =	0.65	
% V_T Voids =	39%	
% V_T Solids =	61%	
Mass solids =	840.72	g
$V_{S\_100\%Dr}$ =	378.70	cm^3
$V_{V\_0\%Dr}$ =	454.44	cm^3
V_{TOT} =	833.14	cm^3
V_{TUBE} =	874.80	cm^3
	53.384	in^3
D_{TUBE} =	2.5	inches
H_{TUBE_req} =	10.88	inches

Where

% V_T Voids =	percent of sample volume occupied by void space
% V_T Solids =	percent of sample volume occupied by solids
$V_{S\_100\%Dr}$ =	Volume of solids to prepare a sample at 100% relative density
$V_{V\_0\%Dr}$ =	Volume of voids at a placement relative density of 0%
V_{TOT} =	Volume of soil to prepare a sample with a target relative density of 100% at an initial relative density of 0%
V_{TUBE} =	Volume of specimen mixing tube
D_{TUBE} =	Inner diameter of mixing tube
H_{TUBE_req} =	Height of mixing tube of specified diameter

Specimen 1 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.9	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	N/A	4.732	**12.247**	N/A	6.160
Back	N/A	4.7265	**12.253**	N/A	6.171
Right	N/A	4.728	**12.249**	N/A	6.166
Left	N/A	4.728	**12.251**	N/A	6.168

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	477.24	g
Net:	2.2	g
% Loss:	0.23%	

$G_{gelatin}$:		
Concentration :	0.75 % by mass	
Tare:	126.8	g
Gross:	224.5	g
Net:	97.7	g
Volume:	97.7	cm^3
$G_{gelatin}$:	1.000	

Approximate Placement D_r:		
D_{COLLAR} =	2.822	in
H_{SI_AVG} =	N/A	in
V_{CYL1} =	33.32	in^3
V_{CYL2} =	4.47	in^3
V_{CYL3} =	N/A	in^3
V_{TOT} =	N/A	in^3
V_{SOLIDS} =	N/A	in^3
V_{VOIDS} =	N/A	in^3
e =	N/A	
D_r =	N/A	

Approximate Densified D_r:		
V_{CYL2} =	4.315	in^3
V_{TOT} =	37.64	in^3
	616.74	cm^3
V_{SOLIDS} =	20.95	in^3
	343.29	cm^3
V_{VOIDS} =	16.69	in^3
	273.45	cm^3
e =	0.80	
D_r =	73.35%	

Note: Filter paper used between split-mold and membrane to see if vacuum was evenly distributed

Specimen 1 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100"}$ =	0.0872	in^3
	1.43	cm^3

Top Slice

Mass =	278.67	g
Weight =	0.614	lb
Volume =	10.46	in^3
	171.43	cm^3
Density =	0.059	lb/in^3
	1.63	g/cm^3
$Mass_{Ovendry}$ =	195.87	g
$Mass_{Ovenwash}$ =	46.9	g
$\%Pass_{\#200}$ =	76%	

		Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
Sieve Analysis		#4	4.75	0.6	0.3%	99.7%
		#10	2	2.4	1.5%	98.5%
Tare Name:	Tare 1	#20	0.841	0.9	2.0%	98.0%
Tare Mass (g):	329.2	#30	0.595	0.3	2.1%	97.9%
Tare + Dry Soil Mass (g):	525.1	#40	0.425	0.6	2.5%	97.5%
Tare + Dry Soil Mass After Washing (g):	360.3	#60	0.25	4.1	4.5%	95.5%
		#100	0.15	11.2	10.3%	89.7%
		#200	0.075	26.8	23.9%	76.1%
	Subtract this from $Mass_{Ovenwash}$ =>	Pan		1.9	100.0%	0.0%
			% lost:	0.00%		

		Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
Hydrometer Analysis		1	37	31.4	10.2	70%	0.0617
Time readings begin:	6/14/2012 8:23	2	32	26.4	11.0	59%	0.0453
Hydrometer Type:	152H	4	27	21.4	11.9	48%	0.0332
Composite Correction:	5.6	8	23	17.4	12.5	39%	0.0241
Dry mass of soil tested (g):	50.0	15	19.5	13.9	13.1	31%	0.0180
$M_{retained\ on\ \#10\ seive}$ (g):	1.2	30	16.3	10.7	13.6	24%	0.0130
Dry mass of soil past #10 (g):	48.8	60	13	7.4	14.2	17%	0.0094
W (dry mass of soil represented) (g):	49.6	120	10.5	4.9	14.6	11%	0.0067
Temperature (° F):	69	250	9	3.4	14.8	8%	0.0047
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11	500	7.3	1.7	15.1	4%	0.0034
K (ASTM eq. 4, based on temp and G_s):	0.0193	1440	7.3	1.7	15.1	4%	0.0020
% Passing #10 Sieve:	98.5%						

Middle Slice

Mass =	327.5	g
Weight =	0.722	lb
Volume =	11.59	in^3
	190.00	cm^3
Density =	0.062	lb/in^3
	1.72	g/cm^3
$Mass_{Ovendry}$ =	238.12	g
$Mass_{Ovenwash}$ =	64.9	g
$\%Pass_{\#200}$ =	73%	

		Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
Sieve Analysis		#4	4.75	0	0.0%	100.0%
		#10	2	0	0.0%	100.0%
Tare Name:	Tare 2	#20	0.841	0.2	0.1%	99.9%
Tare Mass (g):	332.6	#30	0.595	0.4	0.3%	99.7%
Tare + Dry Soil Mass (g):	570.7	#40	0.425	1	0.7%	99.3%
Tare + Dry Soil Mass After Washing (g):	386.6	#60	0.25	8.3	4.2%	95.8%
		#100	0.15	19	12.1%	87.9%
		#200	0.075	36	27.3%	72.7%
	Subtract this from $Mass_{Ovenwash}$ =>	Pan		2.5	100.0%	0.0%
			% lost:	0.00%		

		Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
Hydrometer Analysis		1	36.5	30.9	10.3	68%	0.0619
Time readings begin:	152H	2	33.5	27.9	10.8	62%	0.0448
Hydrometer Type:	6/14/2012 10:05	4	28.5	22.9	11.6	51%	0.0329
Composite Correction:	5.6	8	23	17.4	12.5	38%	0.0241
Dry mass of soil tested (g):	50	15	19	13.4	13.2	30%	0.0181
$M_{retained\ on\ \#10\ seive}$ (g):	0	30	14.5	8.9	13.9	20%	0.0131
Dry mass of soil past #10 (g):	50	60	12	6.4	14.3	14%	0.0094
W (dry mass of soil represented) (g):	50	120	9	3.4	14.8	8%	0.0068
Temperature (° F):	69	250	8.5	2.9	14.9	6%	0.0047
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11	500	7.5	1.9	15.1	4%	0.0033
K (ASTM eq. 4, based on temp and G_s):	0.0193	1440	7.5	1.9	15.1	4%	0.0020
% Passing #10 Sieve:	100.0%						

Bottom Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
			Sieve Analysis			#4	4.75	0.6	0.2%	99.8%	
Mass =	428.1	g				#10	2	6.5	2.2%	97.8%	
Weight =	0.944	lb	Tare Name:	Tare 3		#20	0.841	10.2	5.3%	94.7%	
Volume =	14.65	in^3	Tare Mass (g):	333.7		#30	0.595	4.6	6.7%	93.3%	
	240.00	cm^3	Tare + Dry Soil Mass (g):	662.1		#40	0.425	5.6	8.4%	91.6%	
Density =	0.064	lb/in^3	Tare + Dry Soil Mass After Washing (g):	436.2		#60	0.25	16.8	13.5%	86.5%	
	1.78	g/cm^3				#100	0.15	25.2	21.2%	78.8%	
						#200	0.075	43.1	34.3%	65.7%	
$Mass_{Ovendry}$ =	328.44	g			Subtract this from $Mass_{Ovenwash}$ =>	Pan		4.5	35.7%	64.3%	
$Mass_{Ovenwash}$ =	113.6	g									
$\%Pass_{\#200}$ =	65%						% lost:	0.30%			
						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	35	29.4	10.6	64%	0.0627
			Time readings begin:	152H		2	32	26.4	11.0	57%	0.0453
			Hydrometer Type:	6/14/2012 11:43		4	27.5	21.9	11.8	47%	0.0331
			Composite Correction:	5.6		8	21.3	15.7	12.8	34%	0.0244
			Dry mass of soil tested (g):	50		15	17	11.4	13.5	25%	0.0183
			$M_{retained\ on\ \#10\ seive}$ (g):	0.02		30	12.6	7	14.2	15%	0.0133
			Dry mass of soil past #10 (g):	49.98		60	9.3	3.7	14.8	8%	0.0096
			W (dry mass of soil represented) (g):	51.1		120	8.5	2.9	14.9	6%	0.0068
			Temperature (° F):	69		250	7	1.4	15.1	3%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	6.3	0.7	15.3	2%	0.0034
			K (ASTM eq. 4, based on temp and G_s):	0.0193		1440	6.3	0.7	15.3	2%	0.0020
			% Passing #10 Sieve:	97.8%							

Summary										
$\Sigma Mass_{Ovendry}$ =	762.43	g								
			Checks on Relative Density of Individual Slices:							
Mass =	1034.3	g								
Weight =	2.280	lb	Knowns:							
Volume =	36.70	in^3	V_{s1} =	171.43	cm^3	Slice 1:				
	601.43	cm^3	V_{s2} =	190.00	cm^3	V_{S_S1} =	87.90	cm^3	e_{S1} =	0.95
Density =	0.062	lb/in^3	V_{s3} =	240.00	cm^3	V_{G_S1} =	83.53	cm^3	D_{rS1} =	45%
	1.72	g/cm^3	m_{s1} =	278.7	g					
			m_{s2} =	327.5	g	Slice 2:				
M_{DRIED_FINES} =	2.24	g	m_{s3} =	428.1	g	V_{S_S2} =	112.71	cm^3	e_{S2} =	0.69
M_{DRY_SAMPLE} =	762.1	g	ρ_{S1} =	1.63	g/cm^3	V_{G_S2} =	77.29	cm^3	D_{rS2} =	93%
V_{SOLIDS} =	343.29	cm^3	ρ_{S2} =	1.72	g/cm^3					
	20.95	in^3	ρ_{S3} =	1.78	g/cm^3	Slice 3:				
V_{VOIDS} =	258.14	cm^3	G_s =	2.22		V_{S_S3} =	154.17	cm^3	e_{S3} =	0.56
	15.75	in^3	G_{gel} =	1.000		V_{G_S3} =	85.83	cm^3	D_{rS3} =	117%
e =	0.75								e_{avg} =	0.73
			M_{DRY_SAMPLE} =	787.6017474		V_{TOT} =	601.43	cm^3	D_{r_avg} =	85%
D_r =	81.5%									

Specimen 2 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.8	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	4.245	4.729	**12.247**	6.648	6.163
Back	4.245	4.728	**12.253**	6.653	6.170
Right	4.245	4.731	**12.249**	6.649	6.163
Left	4.246	4.725	**12.251**	6.650	6.171

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	476.3	g
Net:	1.3	g
% Loss:	0.13%	

$G_{gelatin}$:		
Concentration :	0.75 % by mass	
Tare:	126.8	g
Gross:	224.8	g
Net:	98	g
Volume:	98	cm^3
$G_{gelatin}$:	1.000	

Approximate Placement D_r:		
D_{COLLAR} =	2.825	
H_{IS_AVG} =	0.465	
V_{CYL1} =	33.66	in^3
V_{CYL2} =	4.52	in^3
V_{CYL3} =	2.86	in^3
V_{TOT} =	41.04	in^3
V_{SOLIDS} =	20.97	in^3
V_{VOIDS} =	20.07	in^3
e =	0.96	
D_r =	44%	

Approximate Densified D_r:		
V_{CYL2} =	4.36	in^3
V_{TOT} =	38.02	in^3
	622.98	cm^3
V_{SOLIDS} =	20.97	in^3
	343.69	cm^3
V_{VOIDS} =	17.04	in^3
	279.29	cm^3
e =	0.81	
D_r =	70.43%	

Specimen 2 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100"}$ =	0.087	in^3
	1.43	cm^3

Top Slice

Mass =	237	g
Weight =	0.522	lb
Volume =	9.07	in^3
	148.57	cm^3
Density =	0.058	lb/in^3
	1.60	g/cm^3
$Mass_{Ovendry}$ =	165.8	g
$Mass_{Ovenwash}$ =	41.1	g
$\%Pass_{\#200}$ =	75%	

Sieve Analysis

		Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
		#4	4.75	1.3	0.8%	99.2%
		#10	2	2.4	2.2%	97.8%
Tare Name:	Tare 4	#20	0.841	0.6	2.6%	97.4%
Tare Mass (g):	329.8	#30	0.595	0.3	2.8%	97.2%
Tare + Dry Soil Mass (g):	495.6	#40	0.425	0.4	3.0%	97.0%
Tare + Dry Soil Mass After Washing (g):	371.9	#60	0.25	3.1	4.9%	95.1%
		#100	0.15	9.7	10.7%	89.3%
		#200	0.075	23.1	24.7%	75.3%
	Subtract this from $Mass_{Ovenwash}$ =>	Pan		1	100.0%	0.0%
			% lost:	0.12%		

Hydrometer Analysis

		Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
		1	36.5	31.5	10.3	70%	0.0624
Time readings begin:	6/15/2012 17:13	2	34	29	10.7	64%	0.0450
Hydrometer Type:	152H	4	28	23	11.7	51%	0.0332
Composite Correction:	5	8	25.2	20.2	12.2	45%	0.0240
Dry mass of soil tested (g):	50.0	15	18.5	13.5	13.3	30%	0.0183
$M_{retained\ on\ \#10\ seive}$ (g):	1.2	30	15	10	13.8	22%	0.0132
Dry mass of soil past #10 (g):	48.8	60	11.6	6.6	14.4	15%	0.0095
W (dry mass of soil represented) (g):	49.9	120	9.5	4.5	14.7	10%	0.0068
Temperature (° F):	68	250	7.6	2.6	15.0	6%	0.0048
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11	500	7.5	2.5	15.1	6%	0.0034
K (ASTM eq. 4, based on temp and G_s):	0.0194	1440	6	1	15.3	2%	0.0020
% Passing #10 Sieve:	97.8%						

Middle Slice

Mass =	367.1	g
Weight =	0.809	lb
Volume =	13.25	in^3
	217.14	cm^3
Density =	0.061	lb/in^3
	1.69	g/cm^3
$Mass_{Ovendry}$ =	265.97	g
$Mass_{Ovenwash}$ =	69	g
$\%Pass_{\#200}$ =	74%	

		Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
Sieve Analysis		#4	4.75	0	0.0%	100.0%
		#10	2	0	0.0%	100.0%
Tare Name:	Tare 6	#20	0.841	0.2	0.1%	99.9%
Tare Mass (g):	329.8	#30	0.595	0.4	0.2%	99.8%
Tare + Dry Soil Mass (g):	595.8	#40	0.425	1.1	0.6%	99.4%
Tare + Dry Soil Mass After Washing (g):	400.0	#60	0.25	9.6	4.2%	95.8%
		#100	0.15	20.2	11.8%	88.2%
		#200	0.075	37.5	25.9%	74.1%
	Subtract this from $Mass_{Ovenwash}$ =>	Pan		1.7	100.0%	0.0%
			% lost:	0.00%		

		Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
Hydrometer Analysis		1	35	30	10.6	66%	0.0631
Time readings begin:	152H	2	30	25	11.4	55%	0.0463
Hydrometer Type:	6/15/2012 14:54	4	25.3	20.3	12.1	45%	0.0339
Composite Correction:	5	8	20.5	15.5	12.9	34%	0.0247
Dry mass of soil tested (g):	50	15	15.3	10.3	13.8	23%	0.0186
$M_{retained\ on\ \#10\ seive}$ (g):	0	30	12	7	14.3	15%	0.0134
Dry mass of soil past #10 (g):	50	60	10	5	14.7	11%	0.0096
W (dry mass of soil represented) (g):	50	120	6.3	1.3	15.3	3%	0.0069
Temperature (° F):	68	250	5.6	0.6	15.4	1%	0.0048
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11	500	5.3	0.3	15.4	1%	0.0034
K (ASTM eq. 4, based on temp and G_s):	0.0194	1440	5	0	15.5	0%	0.0020
% Passing #10 Sieve:	100.0%						

Bottom Slice

Mass =	435.44	g
Weight =	0.960	lb
Volume =	14.99	in^3
	245.71	cm^3
Density =	0.064	lb/in^3
	1.77	g/cm^3
$Mass_{Ovendry}$ =	331	g
$Mass_{Ovenwash}$ =	106.2	g
$\%Pass_{\#200}$ =	68%	

		Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
Sieve Analysis		#4	4.75	1.1	0.3%	99.7%
		#10	2	6.5	2.3%	97.7%
Tare Name:	Tare 5	#20	0.841	10.2	5.4%	94.6%
Tare Mass (g):	335.8	#30	0.595	4.6	6.8%	93.2%
Tare + Dry Soil Mass (g):	666.8	#40	0.425	5.3	8.4%	91.6%
Tare + Dry Soil Mass After Washing (g):	444.1	#60	0.25	16.3	13.3%	86.7%
		#100	0.15	23	20.2%	79.8%
		#200	0.075	39.4	32.1%	67.9%
	Subtract this from $Mass_{Ovenwash}$ =>	Pan		2.7	100.0%	0.0%
			% lost:	-0.06%		

		Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
Hydrometer Analysis		1	35	30	10.6	65%	0.0631
Time readings begin:	152H	2	28.3	23.3	11.7	50%	0.0469
Hydrometer Type:	6/15/2012 15:19	4	24.3	19.3	12.3	42%	0.0341
Composite Correction:	5	8	20.5	15.5	12.9	33%	0.0247
Dry mass of soil tested (g):	50	15	16	11	13.7	24%	0.0186
$M_{retained\ on\ \#10\ seive}$ (g):	0	30	12	7	14.3	15%	0.0134
Dry mass of soil past #10 (g):	50	60	8	3	15.0	6%	0.0097
W (dry mass of soil represented) (g):	51.2	120	6.3	1.3	15.3	3%	0.0069
Temperature (° F):	68	250	5.6	0.6	15.4	1%	0.0048
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11	500	5.3	0.3	15.4	1%	0.0034
K (ASTM eq. 4, based on temp and G_s):	0.0194	1440	5	0	15.5	0%	0.0020
% Passing #10 Sieve:	97.7%						

Summary										
$\Sigma Mass_{Ovendry}$ =	762.77	g								
			Checks on Relative Density of Individual Slices:							
Mass =	1039.5	g								
Weight =	2.292	lb	Knowns:							
Volume =	37.31	in^3	V_{s1} =	148.57	cm^3	Slice 1:				
	611.43	cm^3	V_{s2} =	217.14	cm^3	V_{S_S1} =	72.48	cm^3	e_{S1} =	1.05
Density =	0.061	lb/in^3	V_{s3} =	245.71	cm^3	V_{G_S1} =	76.09	cm^3	D_{rS1} =	27%
	1.70	g/cm^3	m_{s1} =	237.0	g					
			m_{s2} =	367.1	g	Slice 2:				
M_{DRIED_FINES} =	1.3	g	m_{s3} =	435.4	g	V_{S_S2} =	122.88	cm^3	e_{S2} =	0.77
M_{DRY_SAMPLE} =	763.0	g	ρ_{S1} =	1.60	g/cm^3	V_{G_S2} =	94.26	cm^3	D_{rS2} =	79%
V_{SOLIDS} =	343.69	cm^3	ρ_{S2} =	1.69	g/cm^3					
	20.97	in^3	ρ_{S3} =	1.77	g/cm^3	Slice 3:				
V_{VOIDS} =	267.74	cm^3	G_s =	2.22		V_{S_S3} =	155.51	cm^3	e_{S3} =	0.58
	16.34	in^3	G_{gel} =	1.000		V_{G_S3} =	90.20	cm^3	D_{rS3} =	113%
e =	0.78								e_{avg} =	0.80
			M_{DRY_SAMPLE} =	778.9496685		V_{TOT} =	611.43	cm^3	D_{r_avg} =	73%
D_r =	76.5%									

Specimen 3 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.8	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	4.447	4.735	**12.247**	6.446	6.157
Back	4.449	4.734	**12.253**	6.449	6.164
Right	4.451	4.734	**12.249**	6.443	6.160
Left	4.446	4.735	**12.251**	6.450	6.161

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	477.3	g
Net:	2.3	g
% Loss:	0.23%	

$G_{gelatin}$:		
Concentration:	0.75% by mass	
Tare:	126.8	g
Gross:	225.55	g
Net:	98.75	g
Volume:	98	cm^3
$G_{gelatin}$:	1.008	

Approximate Placement D_r:		
D_{COLLAR} =	2.825	
H_{IS_AVG} =	0.262	in
V_{CYL1} =	33.66	in^3
V_{CYL2} =	4.52	in^3
V_{CYL3} =	1.61	in^3
V_{TOT} =	39.79	in^3
V_{SOLIDS} =	20.95	in^3
V_{VOIDS} =	18.84	in^3
e =	0.90	
D_r =	55%	

Approximate Densified D_r:		
V_{CYL2} =	4.32	in^3
V_{TOT} =	37.98	in^3
	622.34	cm^3
V_{SOLIDS} =	20.95	in^3
	343.24	cm^3
V_{VOIDS} =	17.03	in^3
	279.10	cm^3
e =	0.81	
D_r =	70.34%	

Specimen 3 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100"}$ =	0.087	in^3
	1.43	cm^3

Top Slice

Mass =	257.6	g
Weight =	0.568	lb
Volume =	10.20	in^3
	167.14	cm^3
Density =	0.056	lb/in^3
	1.54	g/cm^3
$Mass_{Ovendry}$ =	174.8	g
$Mass_{Ovenwash}$ =	42.7	g
$\%Pass_{\#200}$ =	76%	

Sieve Analysis

Tare Name:	Tare 1
Tare Mass (g):	329.2
Tare + Dry Soil Mass (g):	504.0
Tare + Dry Soil Mass After Washing (g):	374.0

Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
#4	4.75	1.2	0.7%	99.3%
#10	2	1.8	1.7%	98.3%
#20	0.841	0.8	2.2%	97.8%
#30	0.595	0.3	2.3%	97.7%
#40	0.425	0.4	2.6%	97.4%
#60	0.25	2.9	4.2%	95.8%
#100	0.15	9.4	9.6%	90.4%
#200	0.075	26.1	24.5%	75.5%
Pan		2.6	100.0%	0.0%
	% lost:	-0.11%		

Subtract this from $Mass_{Ovenwash}$ => (Pan)

Hydrometer Analysis

Time readings begin:	6/16/2012 12:57
Hydrometer Type:	152H
Composite Correction:	5.3
Dry mass of soil tested (g):	50.0
$M_{retained\ on\ \#10\ seive}$ (g):	1.2
Dry mass of soil past #10 (g):	48.8
W (dry mass of soil represented) (g):	49.7
Temperature (° F):	71.6
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11
K (ASTM eq. 4, based on temp and G_s):	0.0190
% Passing #10 Sieve:	98.3%

Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
1	39	33.7	9.9	75%	0.0597
2	34	28.7	10.7	64%	0.0439
4	31	25.7	11.2	57%	0.0317
8	26.3	21	12.0	47%	0.0232
15	20.5	15.2	12.9	34%	0.0176
30	18.5	13.2	13.3	29%	0.0126
60	13	7.7	14.2	17%	0.0092
120	10	4.7	14.7	10%	0.0066
250	9	3.7	14.8	8%	0.0046
500	8	2.7	15.0	6%	0.0033
1440	5.3	0	15.4	0%	0.0020

Middle Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
			Sieve Analysis			#4	4.75	0.4	0.2%	99.8%	
Mass =	349.9	g				#10	2	1.2	0.6%	99.4%	
Weight =	0.771	lb	Tare Name:	Tare 2		#20	0.841	1.3	1.1%	98.9%	
Volume =	12.64	in^3	Tare Mass (g):	332.5		#30	0.595	0.9	1.5%	98.5%	
	207.14	cm^3	Tare + Dry Soil Mass (g):	588.8		#40	0.425	1.5	2.1%	97.9%	
Density =	0.061	lb/in^3	Tare + Dry Soil Mass After Washing (g):	406.4		#60	0.25	8.6	5.4%	94.6%	
	1.69	g/cm^3				#100	0.15	18.6	12.7%	87.3%	
						#200	0.075	38.4	27.7%	72.3%	
$Mass_{Ovendry}$ =	256.3	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		2.9	100.0%	0.0%	
$Mass_{Ovenwash}$ =	71.3	g									
$\%Pass_{\#200}$ =	72%						% lost:	0.16%			
						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	34	28.7	10.7	63%	0.0621
			Time readings begin:	152H		2	28.3	23	11.7	51%	0.0458
			Hydrometer Type:	6/16/2012 13:30		4	24.6	19.3	12.3	42%	0.0332
			Composite Correction:	5.3		8	20	14.7	13.0	32%	0.0242
			Dry mass of soil tested (g):	50		15	17	11.7	13.5	26%	0.0180
			$M_{retained\ on\ \#10\ seive}$ (g):	0		30	13.2	7.9	14.1	17%	0.0130
			Dry mass of soil past #10 (g):	50		60	8	2.7	15.0	6%	0.0095
			W (dry mass of soil represented) (g):	50.31409501		120	6.6	1.3	15.2	3%	0.0068
			Temperature (° F):	71.6		250	6	0.7	15.3	2%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.3	0	15.4	0%	0.0033
			K (ASTM eq. 4, based on temp and G_s):	0.0190		1440	5.3	0	15.4	0%	0.0020
			% Passing #10 Sieve:	99.4%							

Bottom Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
Mass =	410.1	g	Sieve Analysis			#4	4.75	1	0.3%	99.7%	
Weight =	0.904	lb				#10	2	4.4	1.7%	98.3%	
Volume =	14.12	in^3	Tare Name:	Tare 3		#20	0.841	6.6	3.8%	96.2%	
	231.43	cm^3	Tare Mass (g):	333.6		#30	0.595	3	4.8%	95.2%	
Density =	0.064	lb/in^3	Tare + Dry Soil Mass (g):	646.3		#40	0.425	4.7	6.3%	93.7%	
	1.77	g/cm^3	Tare + Dry Soil Mass After Washing (g):	441.7		#60	0.25	16.1	11.4%	88.6%	
						#100	0.15	24.6	19.3%	80.7%	
$Mass_{Ovendry}$ =	312.7	g				#200	0.075	42.1	32.8%	67.2%	
$Mass_{Ovenwash}$ =	103.1	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		5.4	100.0%	0.0%	
$\%Pass_{\#200}$ =	67%										
							% lost:	0.19%			
						Elapsed time (mi	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	30	24.7	11.4	54%	0.0640
			Time readings begin:	152H		2	26.5	21.2	11.9	46%	0.0463
			Hydrometer Type:	6/16/2012 14:03		4	20.5	15.2	12.9	33%	0.0341
			Composite Correction:	5.3		8	18.3	13	13.3	28%	0.0244
			Dry mass of soil tested (g):	50		15	15.3	10	13.8	22%	0.0182
			$M_{retained\ on\ \#10\ seive}$ (g):	0.02		30	11.3	6	14.4	13%	0.0132
			Dry mass of soil past #10 (g):	49.98		60	8.5	3.2	14.9	7%	0.0094
			W (dry mass of soil represented) (g):	50.9		120	8.4	3.1	14.9	7%	0.0067
			Temperature (° F):	71.6		250	6	0.7	15.3	2%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.6	0.3	15.4	1%	0.0033
						1440	5.3	0	15.4	0%	0.0020
			K (ASTM eq. 4, based on temp and G_s):	0.0190							
			% Passing #10 Sieve:	98.3%							

Summary										
$\Sigma Mass_{Ovendry}$ =	743.8	g								
			Checks on Relative Density of Individual Slices:							
Mass =	1017.6	g								
Weight =	2.243	lb	Knowns:							
Volume =	36.96	in^3	V_{s1} =	167.14	cm^3	Slice 1:				
	605.71	cm^3	V_{s2} =	207.14	cm^3	V_{S_S1} =	73.56	cm^3	e_{S1} =	1.27
Density =	0.061	lb/in^3	V_{s3} =	231.43	cm^3	V_{G_S1} =	93.58	cm^3	D_{rS1} =	-13%
	1.68	g/cm^3	m_{s1} =	257.6	g					
			m_{s2} =	349.9	g	Slice 2:				
M_{DRIED_FINES} =	2.3	g	m_{s3} =	410.1	g	V_{S_S2} =	116.40	cm^3	e_{S2} =	0.78
M_{DRY_SAMPLE} =	762.0	g	ρ_{S1} =	1.54	g/cm^3	V_{G_S2} =	90.74	cm^3	D_{rS2} =	76%
V_{SOLIDS} =	343.24	cm^3	ρ_{S2} =	1.69	g/cm^3					
	20.95	in^3	ρ_{S3} =	1.77	g/cm^3	Slice 3:				
V_{VOIDS} =	262.48	cm^3	G_s =	2.22		V_{S_S3} =	145.92	cm^3	e_{S3} =	0.59
	16.02	in^3	G_{gel} =	1.008		V_{G_S3} =	85.51	cm^3	D_{rS3} =	112%
e =	0.76								e_{avg} =	0.88
			M_{DRY_SAMPLE} =	745.65		V_{TOT} =	605.71	cm^3	D_{r_avg} =	58%
D_r =	79.1%									

Note: Top Slice not cured; bottom two slices were

APPENDIX D

Dallman Boring Log and Cross Section

psi Information To Build On
Engineering • Consulting • Testing

August 30, 2010

City Water, Light & Power
Environmental Health & Safety
201 East Lake Shore Drive
Springfield, Illinois 62712

Attn: Ms. Sue Corcoran
Tel: 217-757-8610
Fax: 217-757-8615

Re: Piezometer Installation
CWLP Ash Ponds
East Lake Shore Drive
Springfield, Illinois
PSI Report No. 0020522-1 Rev. 1 Page 1 of 22 (including attachments)

Dear Ms. Corcoran:

In general accordance with your instructions, Professional Service Industries, Inc. (PSI) has completed the installation of four (4) temporary piezometers at the periphery of CWLP's ash pond area in Springfield, Illinois. Additionally, certain laboratory analysis was performed, as was in situ hydraulic conductivity (slug) testing. The piezometer locations are identified on the attached location plan. Boring depths and static water levels are shown in the table below.

	AP-1	AP-2	AP-3	AP-4
Date drilled	4/21/2010	4/21/2010	4/21/2010	4/20/2010
Total boring depth (ft)	31.5	20	19.5	60
Piezometer depth from top of first casing above ground surface (ft)	33.15	19.47	19.63	58.93
Piezometer depth from ground surface (ft)	28.34	17.18	17.91	58.31
Well screen length (ft)	10	10	10	10
Static water level from ground surface (5/5/2010)	4.81	3.89	5.16	5.95

The borings were drilled to depths ranging from approximately 17.2 to 58.3 feet below the existing ground surface, respectively. It is PSI's understanding that the purpose for these soil borings is to aid CWLP in assessing the groundwater quality outside the existing CWLP ash ponds. The general boring locations were determined and located in the field by CWLP personnel. With the approval of Ms. Corcoran, AP-2 was offset to the north of the clarifier pond drainage pipe. Depths on the attached boring logs are relative to the ground surface at each boring location.

Water level observations were made during and upon completion of the boring operations and are noted on the boring logs presented herewith. In addition, static water levels were observed at the time of the slug testing. In relatively impervious soils, the accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the levels of the groundwater table and volumes of water will depend on the permeability of the soils.

Soil samples were visually classification in the field for logging purposes. The limited laboratory testing program included grain size analysis. Where soil tests are reported, they have been performed in accordance with generally acceptable or applicable standards. Sieve analysis worksheets are appended. Soil samples were conveyed to CWLP upon completion of the well installation activities.

A copy of the boring logs are appended. The stratification of the soils on the log represents the soil conditions in the actual boring location. Lines of demarcation represent the approximate boundaries between the soil types, but the transition may be gradual.

On May 5, 2010, in situ rising head hydraulic conductivity (slug) testing was performed on each of the four piezometers. Testing was conducted by rapidly removing one bailer (1 liter) of groundwater from the well while recording the rate of recovery using a Solinst 3001 level logger. Hydraulic conductivity was estimated using the Hvorslev method. Based on this method, the average hydraulic conductivity was estimated at 2.50E-02. Slug test results and hydraulic conductivity calculations are appended.

PSI appreciates the opportunity to perform these services and if we can be of further service, please contact our office at (217) 544-6663.

Respectfully submitted,
PROFESSIONAL SERVICE INDUSTRIES, INC.

James Gerloff, E.I.
Branch Manager

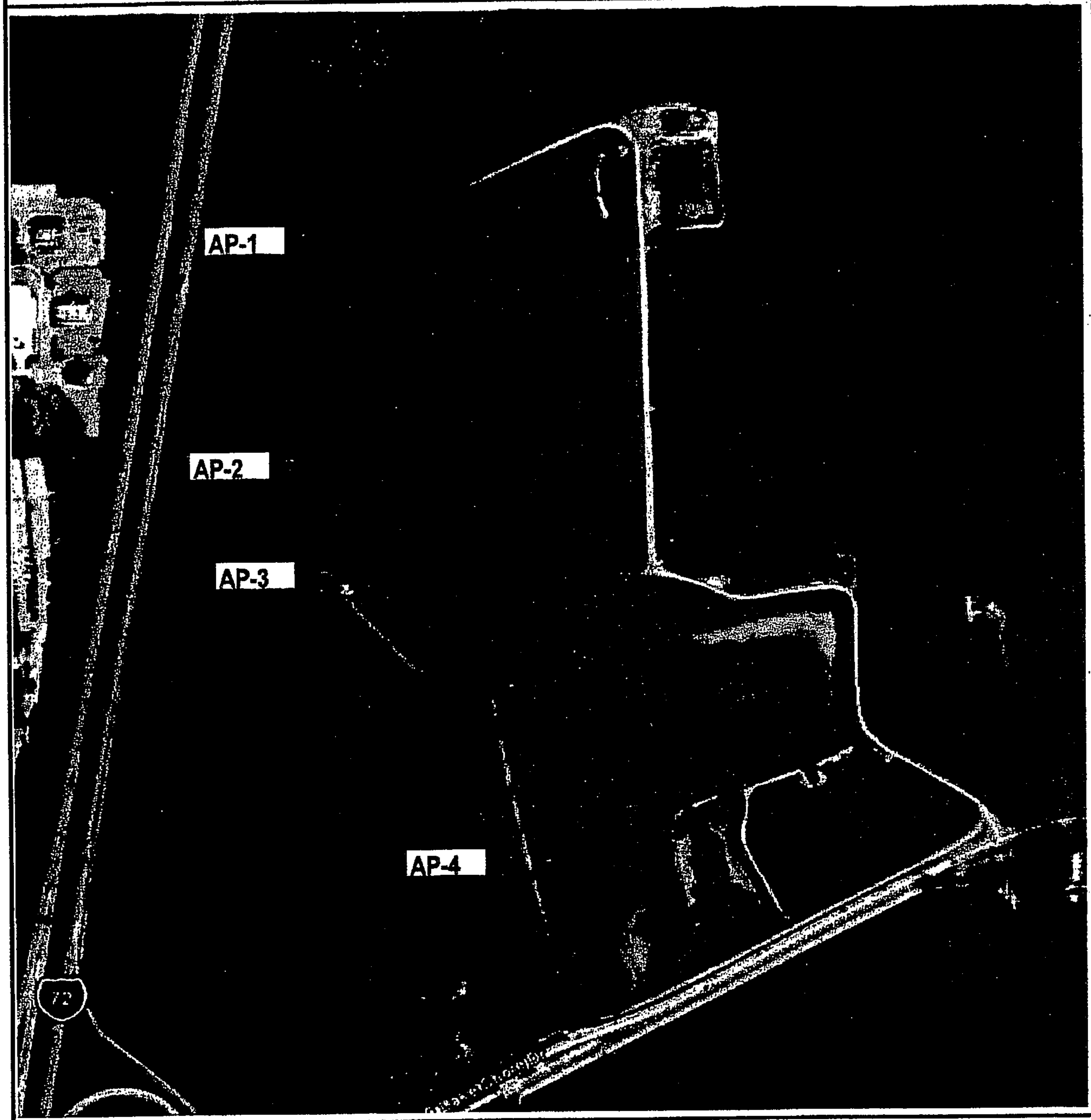
William P. Pongracz, P.E.
Vice President

Attachments:
Key to Symbols
Boring Logs (4 pages)
Piezometer Location Plan
In-Situ Hydraulic Conductivity Results (6 pages)
Sieve Analysis Worksheets (8 pages)

Distribution: (1) above

PIEZOMETER LOCATION PLAN

SOURCE:	DATE:	SCALE:	
Google © 2010 / DigitalGlobe © 2010	Nov-05	No Scale	



psi Information To Build On
Engineering • Consulting • Testing
480 North Street, Springfield, Illinois 62704
phone 217/544-6663 fax 217/544-6148

PIEZOMETER LOCATION PLAN

PSI PROJECT No.:	0020522
Project:	Piezometer Installation
Location:	CWLP Ash Pond East Lake Shore Drive Springfield, Illinois

KEY TO SYMBOLS

Fill (made ground)

USCS Low Plasticity Clay

USCS Silt

USCS Low Plasticity Sandy Clay

USCS Clayey Sand

USCS Well-graded Sand with Silt

USCS Poorly-graded Sand

USCS Well-graded Sand

HSA = Hollow Stem Auger

CFA = Continuous Flight Auger

SPT = Standard Penetration Test

DCP = Dynamic Cone Penetrometer

SS = Split-spoon Sampler

ST = Shelby Tube Sampler

RC = Rock Core

DD = Dry Density

LL = Liquid Limit

PL = Plastic Limit

Qu = Unconfined Compressive Strength

Qp = Pocket Penetrometer

RQD = Rock Quality Designation

REC'D = Rock Core Recovery Percentage

PID = Photo Ionic Detector (ppm)

MR* = Unable to determine depth of water due to mud rotary drilling methods

The borings were advanced into the ground using hollow stem augers. At regular intervals throughout the boring depths, soil samples were obtained with either a 1.4-inch I.D., 2.0-inch O.D., split-spoon sampler or a 3-inch diameter Shelby tube. The split-spoon sampler was first seated 6-inches to penetrate any loose cuttings and then driven an additional foot where possible with blows of a 140 pound hammer falling 30-inches. The number of hammer blows required to drive the sampler each 6-inch increment is recorded in the field. The penetration resistance "N-value" is redesignated as the number of hammer blows required to drive the sampler the final foot and, when properly evaluated, is an index to cohesion for clays and relative density for sands. The split-spoon sampling procedures used during this exploration are in general accordance with ASTM Designation D 1586.

Relatively undisturbed Shelby tube samples were obtained by forcing a section of 3-inch diameter steel tubing into the soil at the desired sampling levels. This sampling procedure was in general accordance with ASTM Designation D 1587. Each tube, together with the encased soil, was carefully removed from the ground, sealed and transported to the laboratory for testing.

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

LOG OF BORING AP-1

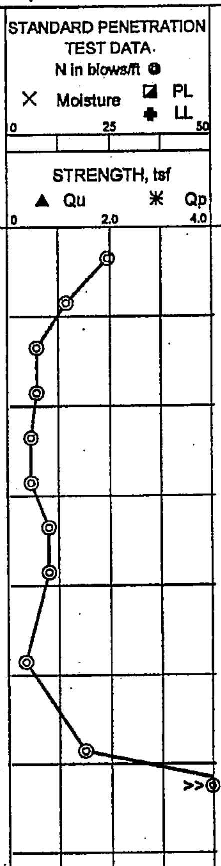
PSI Job No.:	0020522	Drilling Method:	Hollow Stem Auger
Project:	Piezometer Installation	Sampling Method:	Split Spoon
Location:	CWLP Ash Pond, East Lake Shore Drive, Springfield, Illinois	Hammer Type:	CME Automatic; ETR = 86%
		Boring Location:	See attached boring location plan.

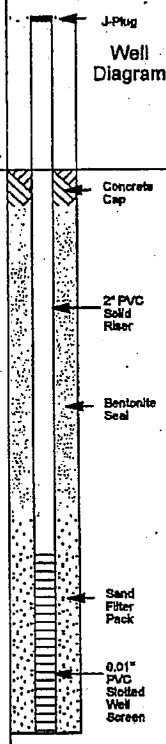
WATER LEVELS

While Drilling	9 feet
Upon Completion	N/A
Delay	N/A

Station: N/A
Offset: N/A

Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)
0	1	18	Dark brown silty CLAY, very stiff, slightly moist	CL	7-8-9 N_{60}=24
	2	18	Dark brown clayey SILT, stiff, slightly moist	ML	5-5-5 N_{60}=14
5	3	18	Gray clayey SILT, trace brown, firm, moist	ML	2-2-3 N_{60}=7
	4	18			2-2-3 N_{60}=7
10	5	18			1-2-2 N_{60}=6
	6	18	Gray silty CLAY, few brown sand, firm, saturated	CL	1-2-2 N_{60}=6
15	7	18	Gray sandy CLAY, stiff, saturated	CLS	4-3-4 N_{60}=10
	8	18	Blue-gray clayey SILT, soft to very stiff, moist to saturated	ML	3-3-4 N_{60}=10
20–25	9	18			1-2-1 N_{60}=4
	10	18	Gray SAND with SILT, medium dense/very stiff, saturated	SW-SM	6-7-6 N_{60}=19
30	11	6	Gray SHALE, hard, slightly moist	CL	50/6"
			Boring terminated ay -31.5'		





Completion Depth:	35.0 ft
Date Boring Started:	4/21/10
Date Boring Completed:	4/21/10
Logged By:	Rob Preuss
Drilling Contractor:	PSI, Inc.

Sample Types: Auger Cutting, Split-Spoon, Rock Core, Shelby Tube, Hand Auger, Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
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LOG OF BORING AP-2

PSI Job No.:	0020522
Project:	Piezometer Installation
Location:	CWLP Ash Pond, East Lake Shore Drive, Springfield, Illinois
Drilling Method:	Hollow Stem Auger
Sampling Method:	Split Spoon
Hammer Type:	CME Automatic; ETR = 86%
Boring Location:	See attached boring location plan.

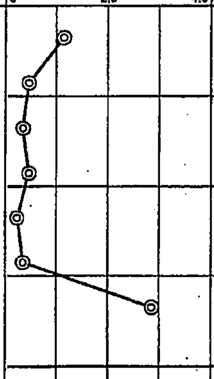
WATER LEVELS

While Drilling	9 feet
Upon Completion	N/A
Delay	N/A

Station: N/A
Offset: N/A

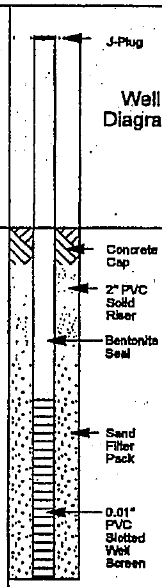
Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)
0	1	10	Dark brown silty CLAY, some sand, stiff, slightly moist (FILL)	CL	4-4-6 N_{60}=14
	2	8	Dark brown silty CLAY, soft to firm, moist	CL	2-2-2 N_{60}=6
5	3	6	Gray silty CLAY, soft to firm, moist	CL	1-1-2 N_{60}=4
	4	18	Gray clayey SILT, soft to firm, saturated	ML	2-2-2 N_{60}=6
10	5	18			2-1-1 N_{60}=3
	6	18			2-1-2 N_{60}=4
15	7	18	Light gray SAND, dense, saturated	SP	4-9-16 N_{60}=36
	8	14	Gray SHALE, hard, slightly moist	CL	19-24-50/2"
20			Boring terminate at -20'		

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✱ Qp
0 2.0 4.0



Additional Remarks

Well Diagram



Completion Depth:	20.0 ft
Date Boring Started:	4/21/10
Date Boring Completed:	4/21/10
Logged By:	Rob Preuss
Drilling Contractor:	PSI, Inc.

Sample Types: Auger Cutting, Split-Spoon, Rock Core, Shelby Tube, Hand Auger, Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
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LOG OF BORING AP-3

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

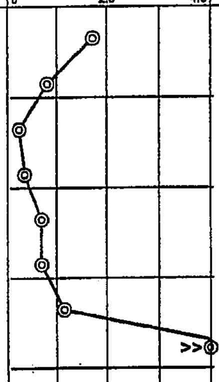
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Hammer Type: CME Automatic; ETR = 86%
Boring Location: See attached boring location plan.

WATER LEVELS
- While Drilling: None feet
- Upon Completion: N/A
- Delay: N/A

Station: N/A
Offset: N/A

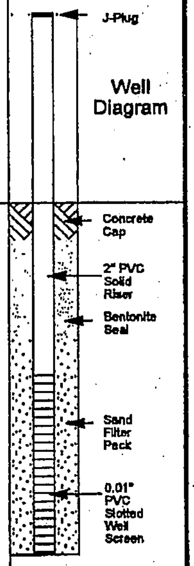
Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)
0	1	18	Dark brown silty CLAY, very stiff, slightly moist	CL	6-7-8 N_{60}=21
	2	18	Gray/brown clayey SILT, soft to stiff, moist to saturated	ML	3-3-4 N_{60}=10
5	3	18			1-1-1 N_{60}=3
	4	18	Gray clayey SILT, soft to very stiff, saturated	ML	2-1-2 N_{60}=4
10	5	18			2-2-4 N_{60}=9
	6	16			2-2-4 N_{60}=9
15	7	18			4-4-6 N_{60}=14
	8	10	Gray SHALE, hard, slightly moist	CL	32-50/3"
20			Boring terminated at -19.5		

STANDARD PENETRATION TEST DATA
N in blows/ft ⊙
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✱ Qp
0 2.0 4.0



Additional Remarks

Well Diagram



Completion Depth: 20.0 ft
Date Boring Started: 4/21/10
Date Boring Completed: 4/21/10
Logged By: Rob Preuss
Drilling Contractor: PSI, Inc.

Sample Types:
- Auger Cutting
- Split-Spoon
- Rock Core
- Shelby Tube
- Hand Auger
- Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
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LOG OF BORING AP-4

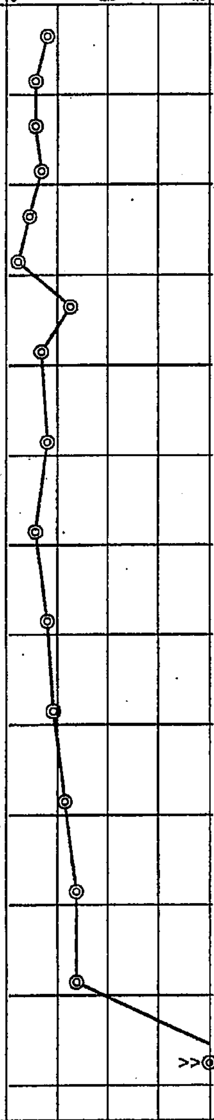
PSI Job No.:	0020522	Drilling Method:	Hollow Stem Auger
Project:	Piezometer Installation	Sampling Method:	Split Spoon
Location:	CWLP Ash Pond, East Lake Shore Drive, Springfield, Illinois	Hammer Type:	CME Automatic; ETR = 86%
		Boring Location:	See attached boring location plan.

WATER LEVELS	
While Drilling	11 feet
Upon Completion	N/A
Delay	N/A

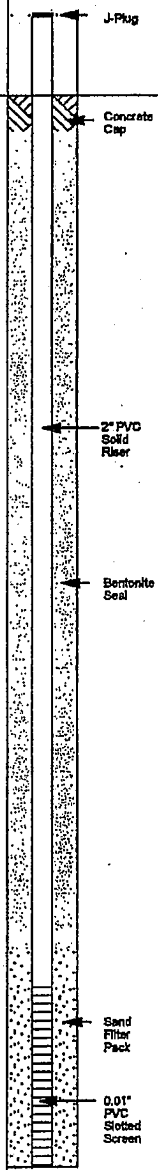
Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)
	0	Split-Spoon	1	17	Brown silty CLAY, some brown sand, firm to stiff, slightly moist (FILL)	CL	4-4-3 N_{60}=10
		Split-Spoon	2	18	Brown silty CLAY, trace roots, firm to stiff, moist (FILL)	CL	4-3-2 N_{60}=7
		Split-Spoon	3	10	Brown SILT, trace gray, firm to stiff, moist (FILL)	ML	6-3-2 N_{60}=7
		Split-Spoon	4	12	5" Brown SAND transitioning to Black FLY ASH at 9.4', stiff to very stiff, slightly moist (FILL)	SAND/FLY ASH	2-2-4 N_{60}=9
		Split-Spoon	5	18			2-2-2 N_{60}=6
		Split-Spoon	6	16			2-1-1 N_{60}=3
		Split-Spoon	7	16	Black FLY ASH, some fine sub-round gravel, stiff to very stiff, moist to saturated (FILL)	FLY ASH	6-6-5 N_{60}=16
		Split-Spoon	8	18			3-3-3 N_{60}=9
	20				Gray/green (organic?) CLAY, stiff, trace fine sand, moist to saturated	CL	
		Split-Spoon	9	1			3-3-4 N_{60}=10
		Split-Spoon	10	18	Brown/gray silty CLAY, fiorm to stiff, saturated	CL	2-2-3 N_{60}=7
		Split-Spoon	11	18	Gray SILT, stiff to very stiff, saturated	ML	3-3-4 N_{60}=10
		Split-Spoon	12	18			4-4-4 N_{60}=11
		Split-Spoon	13	18			4-4-6 N_{60}=14
		Split-Spoon	14	18			4-5-7 N_{60}=17
	50				Gray fine to coarse SAND, medium dense, saturated	SW	
		Split-Spoon	15	18			5-5-7 N_{60}=17
		Split-Spoon	16	1	Gray SHALE, hard, moist	CL	50/1"
	60				Boring terminated at -60'		

STANDARD PENETRATION TEST DATA: N in blows/ft; × Moisture; PL; LL (0, 25, 50). STRENGTH, tsf: ▲ Qu; ✳ Qp (0, 2.0, 4.0). Moisture, %. Additional Remarks.



Well Diagram



Completion Depth:	60.0 ft
Date Boring Started:	4/20/10
Date Boring Completed:	4/20/10
Logged By:	Rob Preuss
Drilling Contractor:	PSI, Inc.

Sample Types: Auger Cutting; Split-Spoon; Rock Core; Shelby Tube; Hand Auger; Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

In-Situ Hydraulic Conductivity Test Analysis
Utlizing the Hvorslev Slug Test Method[1]

GOVERNING EQUATION:
$K = (r^2 * \ln(L_e/R))/(2L_eT_o)$
K is the hydraulic conductivity (cm/sec)
r is the radius of the well casing (cm)
R is the radius of the borehole (cm)
L_e is the length of the well screen (cm)
T_o is the time it takes for the water level to rise or fall 37% of the initial change (sec)

CWLP Ash Ponds, East Lake Shore Drive, Springfield, Illinois In-Situ Hydraulic Conductivity Analysis[2]

Test Number	Test Type	L_e (ft)	L_e (cm)	T_o (min)	T_o (sec)	K (cm/sec)
AP-4	Rising Head	10.0	304.8	0.025	1.500	7.64E-02
AP-3	Rising Head	10.0	304.8	0.083	4.980	2.30E-02
AP-2.1	Rising Head	10.0	304.8	0.150	9.000	1.27E-02
AP-2.2	Rising Head	10.0	304.8	0.167	10.020	1.14E-02
AP-1	Rising Head	10.0	304.8	1.667	100.020	1.15E-03
					AVERAGE:	2.50E-02

CONSTANTS

r (inch)	r (cm)	R (inch)	R (cm)
2.0	5.08	8.0	20.3

HVORSLEV CALCULATIONS

Test	L_e/R (-)	$\ln(L_e/R)$ (-)	L_eT_o (cm*sec)	K (cm/sec)		
AP-4	15.00	2.71	4.57E+02	7.64E-02		
AP-3	15.00	2.71	1.52E+03	2.30E-02		
AP-2.1	15.00	2.71	2.74E+03	1.27E-02		
AP-2.2	15.00	2.71	3.05E+03	1.14E-02	AP-2 AVG:	1.21E-02
AP-1	15.00	2.71	3.05E+04	1.15E-03		

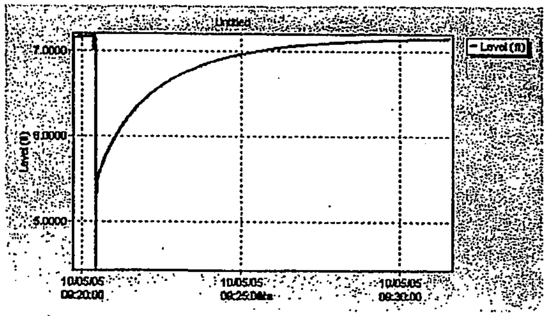
Notes:

[1] Hvorslev slug test method applied as described by C.W. Fetter in Applied Hydrology (Third Edition) published by Prentice-Hall in New Jersey in 1994 on pages 247-251.

[2] In-situ hydraulic conductivity tests conducted on monitoring wells, MW-1 thru MW-4 on May 5, 2010.

Solinst	3001	
Report generated:	5/11/2010	
Report from file:	...\mw-4.csv	
Serial number:	1032308	
Unit name:	Solinst 3001	
Test name:	AP-1	Test 1
Test defined on:	5/5/2010	
Test started on:	5/5/2010	9:20:28
Test stopped on:	5/5/2010	9:21:41
Data gathered using Linear testing		
Time between data points:	1	Seconds
Number of data samples:	75	
TOTAL DATA SAMPLES	75	
Channel number [1]		
Measurement type:	Level	
Unit	feet	
Channel number [2]		
Measurement type:	Temperature	
Unit	Deg C	
Sensor Range:		
Specific gravity:		
Mode:	TOC	
User-defined reference*:	33.15	Feet H2O
Referenced on:	test start	
Pressure head at reference:		Feet H2O

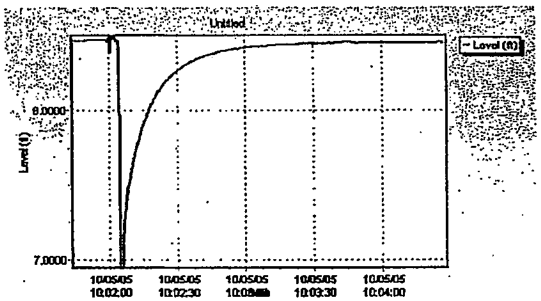
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	H/Ho	
1	5/5/2010	9:20:27	0	0.000		11.254	7.1703	25.980	0		TEST START
2	5/5/2010	9:20:28	1	0.017	0.000	11.252	5.298	27.852	1.8723	1	SLUG REMOVED
3	5/5/2010	9:20:29	2	0.033	0.017	11.254	5.3982	27.751	1.7711	0.945948833	
4	5/5/2010	9:20:30	3	0.050	0.033	11.254	5.4584	27.692	1.7119	0.914328868	
5	5/5/2010	9:20:31	4	0.067	0.050	11.257	5.4885	27.662	1.6818	0.898253485	
6	5/5/2010	9:20:32	5	0.083	0.067	11.255	5.519	27.631	1.6513	0.881963361	
7	5/5/2010	9:20:33	6	0.100	0.083	11.258	5.5421	27.608	1.6282	0.869625594	
8	5/5/2010	9:20:34	7	0.117	0.100	11.257	5.5658	27.584	1.6045	0.856967366	
9	5/5/2010	9:20:35	8	0.133	0.117	11.258	5.5919	27.558	1.5784	0.843027293	
10	5/5/2010	9:20:36	9	0.150	0.133	11.257	5.6074	27.543	1.5629	0.834748705	
11	5/5/2010	9:20:37	10	0.167	0.150	11.257	5.6237	27.526	1.5466	0.826042836	
12	5/5/2010	9:20:38	11	0.183	0.167	11.258	5.6423	27.508	1.528	0.81610853	
13	5/5/2010	9:20:39	12	0.200	0.183	11.259	5.6595	27.491	1.5108	0.806921968	
14	5/5/2010	9:20:40	13	0.217	0.200	11.258	5.676	27.474	1.4943	0.798109277	
15	5/5/2010	9:20:41	14	0.233	0.217	11.259	5.6922	27.458	1.4781	0.789456818	
16	5/5/2010	9:20:42	15	0.250	0.233	11.261	5.7084	27.442	1.4619	0.780804358	
17	5/5/2010	9:20:43	16	0.267	0.250	11.259	5.7226	27.427	1.4477	0.773220104	
18	5/5/2010	9:20:44	17	0.283	0.267	11.259	5.7383	27.412	1.432	0.764834695	
19	5/5/2010	9:20:45	18	0.300	0.283	11.26	5.7519	27.398	1.4184	0.757570902	
20	5/5/2010	9:20:46	19	0.317	0.300	11.259	5.766	27.384	1.4043	0.750040055	
21	5/5/2010	9:20:47	20	0.333	0.317	11.261	5.7815	27.369	1.3888	0.74176147	
22	5/5/2010	9:20:48	21	0.350	0.333	11.259	5.7955	27.355	1.3748	0.734284036	
23	5/5/2010	9:20:49	22	0.367	0.350	11.259	5.8088	27.341	1.3615	0.727180473	
24	5/5/2010	9:20:50	23	0.383	0.367	11.26	5.8224	27.328	1.3479	0.71991668	
25	5/5/2010	9:20:51	24	0.400	0.383	11.259	5.8355	27.315	1.3348	0.712919938	
26	5/5/2010	9:20:52	25	0.417	0.400	11.26	5.8489	27.301	1.3214	0.705762965	
27	5/5/2010	9:20:53	26	0.433	0.417	11.261	5.8621	27.288	1.3082	0.698712813	
28	5/5/2010	9:20:54	27	0.450	0.433	11.26	5.875	27.275	1.2953	0.691822892	
29	5/5/2010	9:20:55	28	0.467	0.450	11.261	5.8867	27.263	1.2836	0.685573893	
30	5/5/2010	9:20:56	29	0.483	0.467	11.26	5.8996	27.250	1.2707	0.678683972	
31	5/5/2010	9:20:57	30	0.500	0.150	11.259	5.9124	27.238	1.2579	0.67184746	
32	5/5/2010	9:20:58	31	0.517	0.500	11.259	5.9236	27.226	1.2467	0.665866613	
33	5/5/2010	9:20:59	32	0.533	0.517	11.259	5.9351	27.215	1.2352	0.659723336	
34	5/5/2010	9:21:00	33	0.550	0.533	11.26	5.9479	27.202	1.2224	0.652886824	
35	5/5/2010	9:21:01	34	0.567	0.550	11.259	5.9589	27.191	1.2114	0.647011697	
36	5/5/2010	9:21:02	35	0.583	0.567	11.258	5.9699	27.180	1.2004	0.64113657	
37	5/5/2010	9:21:03	36	0.600	0.583	11.259	5.9803	27.170	1.19	0.635581905	
38	5/5/2010	9:21:04	37	0.617	0.600	11.258	5.9928	27.157	1.1775	0.628905624	
39	5/5/2010	9:21:05	38	0.633	0.617	11.26	6.0028	27.147	1.1675	0.62356448	
40	5/5/2010	9:21:06	39	0.650	0.633	11.258	6.0142	27.136	1.1561	0.617475832	
41	5/5/2010	9:21:07	40	0.667	0.650	11.257	6.025	27.125	1.1453	0.611707526	
42	5/5/2010	9:21:08	41	0.683	0.667	11.259	6.0346	27.115	1.1357	0.606580142	
43	5/5/2010	9:21:09	42	0.700	0.683	11.258	6.0448	27.105	1.1255	0.601132297	
44	5/5/2010	9:21:10	43	0.717	0.700	11.259	6.0554	27.095	1.1149	0.595470811	
45	5/5/2010	9:21:11	44	0.733	0.717	11.258	6.0658	27.084	1.1045	0.589916149	
46	5/5/2010	9:21:12	45	0.750	0.733	11.259	6.0765	27.074	1.0938	0.58420128	
47	5/5/2010	9:21:13	46	0.767	0.750	11.257	6.0864	27.064	1.0839	0.578913636	
48	5/5/2010	9:21:14	47	0.783	0.767	11.257	6.096	27.054	1.0743	0.573786262	
49	5/5/2010	9:21:15	48	0.800	0.783	11.257	6.1055	27.045	1.0648	0.568712279	
50	5/5/2010	9:21:16	49	0.817	0.800	11.259	6.1144	27.036	1.0559	0.563958767	
51	5/5/2010	9:21:17	50	0.833	0.817	11.257	6.1235	27.027	1.0468	0.559098435	
52	5/5/2010	9:21:18	51	0.850	0.833	11.259	6.1332	27.017	1.0371	0.553917641	
53	5/5/2010	9:21:19	52	0.867	0.850	11.257	6.1423	27.008	1.028	0.549057309	
54	5/5/2010	9:21:20	53	0.883	0.867	11.256	6.1513	26.999	1.019	0.544250387	
55	5/5/2010	9:21:21	54	0.900	0.883	11.257	6.1613	26.989	1.009	0.538909363	
56	5/5/2010	9:21:22	55	0.917	0.900	11.258	6.1693	26.981	1.001	0.534636543	
57	5/5/2010	9:21:23	56	0.933	0.917	11.257	6.1786	26.971	0.9917	0.529669391	
58	5/5/2010	9:21:24	57	0.950	0.933	11.257	6.1869	26.963	0.9834	0.52523634	
59	5/5/2010	9:21:25	58	0.967	0.950	11.257	6.196	26.954	0.9743	0.520376006	
60	5/5/2010	9:21:26	59	0.983	0.967	11.258	6.2045	26.946	0.9658	0.515836137	
61	5/5/2010	9:21:27	60	1.000	0.983	11.257	6.213	26.937	0.9573	0.511296267	
62	5/5/2010	9:21:28	61	1.017	1.000	11.256	6.2215	26.929	0.9488	0.506756396	
63	5/5/2010	9:21:29	62	1.033	1.017	11.256	6.2287	26.921	0.9416	0.502910858	
64	5/5/2010	9:21:30	63	1.050	1.033	11.255	6.2371	26.913	0.9332	0.498424398	
65	5/5/2010	9:21:31	64	1.067	1.050	11.257	6.2466	26.903	0.9237	0.493350425	
66	5/5/2010	9:21:32	65	1.083	1.067	11.257	6.2524	26.898	0.9179	0.49025263	
67	5/5/2010	9:21:33	66	1.100	1.083	11.255	6.2615	26.889	0.9088	0.485392298	
68	5/5/2010	9:21:34	67	1.117	1.100	11.256	6.268	26.882	0.9023	0.481920632	
69	5/5/2010	9:21:35	68	1.133	1.117	11.255	6.2762	26.874	0.8941	0.477540992	
70	5/5/2010	9:21:36	69	1.150	1.133	11.255	6.2835	26.867	0.8868	0.473642045	
71	5/5/2010	9:21:37	70	1.167	1.150	11.255	6.2923	26.858	0.878	0.468941943	
72	5/5/2010	9:21:38	71	1.183	1.167	11.256	6.2979	26.852	0.8724	0.465950969	
73	5/5/2010	9:21:39	72	1.200	1.183	11.256	6.3053	26.845	0.865	0.461998611	
74	5/5/2010	9:21:40	73	1.217	1.200	11.255	6.3126	26.837	0.8577	0.458099664	
75	5/5/2010	9:21:41	74	1.233	1.217	11.254	6.3208	26.829	0.8495	0.453720074	

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\mw-3_1.csv
Serial number:	1032308
Unit name:	Solinst 3001
Test name:	AP-2 Test 1
Test defined on:	5/5/2010
Test started on:	5/5/2010 10:02:05
Test stopped on:	5/5/2010 10:02:58
Data gathered using Linear testing	
Time between data points:	1 Seconds.
Number of data samples:	55
TOTAL DATA SAMPLES	55
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	19.47 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

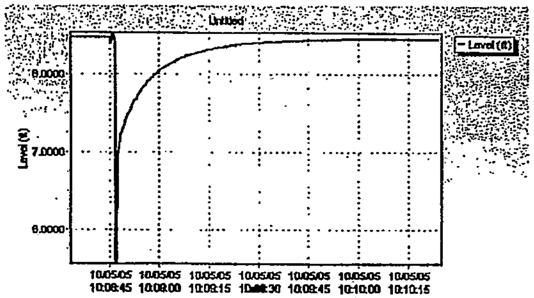
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	h/ho	
1	5/5/2010	10:02:04	0	0.000		11.23	8.4182	11.052	0	[illegible]	TEST START
2	5/5/2010	10:02:05	1	0.017	0.000	11.231	6.9143	12.556	1.5039	1	SLUG REMOVED
3	5/5/2010	10:02:06	2	0.033	0.017	11.231	7.2562	12.214	1.162	0.772557756	
4	5/5/2010	10:02:07	3	0.050	0.033	11.231	7.3727	12.097	1.0455	0.6951925	
5	5/5/2010	10:02:08	4	0.067	0.050	11.231	7.4828	11.987	0.9354	0.621982845	
6	5/5/2010	10:02:09	5	0.083	0.067	11.231	7.5707	11.899	0.8475	0.563534809	
7	5/5/2010	10:02:10	6	0.100	0.083	11.231	7.6472	11.823	0.771	0.512667066	
8	5/5/2010	10:02:11	7	0.117	0.100	11.231	7.715	11.755	0.7032	0.467584281	
9	5/5/2010	10:02:12	8	0.133	0.117	11.232	7.7747	11.695	0.6435	0.427887493	
10	5/5/2010	10:02:13	9	0.150	0.133	11.232	7.8285	11.642	0.5897	0.392113837	
11	5/5/2010	10:02:14	10	0.167	0.150	11.232	7.878	11.592	0.5402	0.359199415	
12	5/5/2010	10:02:15	11	0.183	0.167	11.231	7.9204	11.550	0.4978	0.331006051	
13	5/5/2010	10:02:16	12	0.200	0.183	11.232	7.9625	11.508	0.4557	0.303012168	
14	5/5/2010	10:02:17	13	0.217	0.200	11.232	8.0004	11.470	0.4178	0.277811025	
15	5/5/2010	10:02:18	14	0.233	0.217	11.232	8.0325	11.438	0.3857	0.25646682	
16	5/5/2010	10:02:19	15	0.250	0.233	11.232	8.0633	11.407	0.3549	0.235986436	
17	5/5/2010	10:02:20	16	0.267	0.250	11.231	8.0906	11.379	0.3276	0.217833633	
18	5/5/2010	10:02:21	17	0.283	0.267	11.23	8.1151	11.355	0.3031	0.201542656	
19	5/5/2010	10:02:22	18	0.300	0.283	11.23	8.1395	11.331	0.2787	0.185318173	
20	5/5/2010	10:02:23	19	0.317	0.300	11.23	8.1616	11.308	0.2566	0.170623047	
21	5/5/2010	10:02:24	20	0.333	0.317	11.23	8.1805	11.290	0.2377	0.158055722	
22	5/5/2010	10:02:25	21	0.350	0.333	11.229	8.2001	11.270	0.2181	0.14502294	
23	5/5/2010	10:02:26	22	0.367	0.350	11.229	8.2158	11.254	0.2024	0.134583416	
24	5/5/2010	10:02:27	23	0.383	0.367	11.229	8.2315	11.239	0.1867	0.124143893	
25	5/5/2010	10:02:28	24	0.400	0.383	11.229	8.2454	11.225	0.1728	0.114901257	
26	5/5/2010	10:02:29	25	0.417	0.400	11.228	8.2589	11.211	0.1593	0.105924596	
27	5/5/2010	10:02:30	26	0.433	0.417	11.228	8.2709	11.199	0.1473	0.097946342	
28	5/5/2010	10:02:31	27	0.450	0.433	11.227	8.2821	11.188	0.1361	0.090498038	
29	5/5/2010	10:02:32	28	0.467	0.450	11.228	8.2931	11.177	0.1251	0.083183722	
30	5/5/2010	10:02:33	29	0.483	0.467	11.227	8.3029	11.167	0.1153	0.076667332	
31	5/5/2010	10:02:34	30	0.500	0.150	11.226	8.3123	11.158	0.1059	0.070416916	
32	5/5/2010	10:02:35	31	0.517	0.500	11.226	8.3207	11.149	0.0975	0.064831438	
33	5/5/2010	10:02:36	32	0.533	0.517	11.225	8.3292	11.141	0.089	0.059178487	
34	5/5/2010	10:02:37	33	0.550	0.533	11.225	8.3355	11.135	0.0827	0.054990358	
35	5/5/2010	10:02:38	34	0.567	0.550	11.224	8.3418	11.128	0.0764	0.05080125	
36	5/5/2010	10:02:39	35	0.583	0.567	11.224	8.3491	11.121	0.0691	0.045947204	
37	5/5/2010	10:02:40	36	0.600	0.583	11.223	8.3548	11.115	0.0634	0.042157058	
38	5/5/2010	10:02:41	37	0.617	0.600	11.223	8.3615	11.109	0.0567	0.037701975	
39	5/5/2010	10:02:42	38	0.633	0.617	11.223	8.3654	11.105	0.0528	0.035108717	
40	5/5/2010	10:02:43	39	0.650	0.633	11.222	8.3729	11.097	0.0453	0.030121684	
41	5/5/2010	10:02:44	40	0.667	0.650	11.222	8.3761	11.094	0.0421	0.027993883	
42	5/5/2010	10:02:45	41	0.683	0.667	11.221	8.3803	11.090	0.0379	0.025201144	
43	5/5/2010	10:02:46	42	0.700	0.683	11.221	8.385	11.085	0.0332	0.022075836	
44	5/5/2010	10:02:47	43	0.717	0.700	11.22	8.3888	11.081	0.0294	0.019549172	
45	5/5/2010	10:02:48	44	0.733	0.717	11.22	8.3922	11.078	0.026	0.017288384	
46	5/5/2010	10:02:49	45	0.750	0.733	11.22	8.3959	11.074	0.0223	0.014828114	
47	5/5/2010	10:02:50	46	0.767	0.750	11.219	8.3983	11.072	0.0199	0.013232263	
48	5/5/2010	10:02:51	47	0.783	0.767	11.219	8.4029	11.067	0.0153	0.010173549	
49	5/5/2010	10:02:52	48	0.800	0.783	11.218	8.4042	11.066	0.014	0.00930913	
50	5/5/2010	10:02:53	49	0.817	0.800	11.218	8.4084	11.062	0.0098	0.006516391	
51	5/5/2010	10:02:54	50	0.833	0.817	11.218	8.4099	11.060	0.0083	0.005518984	
52	5/5/2010	10:02:55	51	0.850	0.833	11.218	8.4117	11.058	0.0065	0.004322096	
53	5/5/2010	10:02:56	52	0.867	0.850	11.218	8.4145	11.056	0.0037	0.00246027	
54	5/5/2010	10:02:57	53	0.883	0.867	11.217	8.416	11.054	0.0022	0.001462883	
55	5/5/2010	10:02:58	54	0.900	0.883	11.216	8.4182	11.052	0	0	

Solinst	3001	
Report generated:	5/11/2010	
Report from file:	...\mw-3_2.csv	
Serial number:	1032308	
Unit name:	Solinst 3001	
Test name:	AP-2	Test 2
Test defined on:	5/5/2010	
Test started on:	5/5/2010	10:08:48
Test stopped on:	5/5/2010	10:09:43
Data gathered using Linear testing		
Time between data points:	1	Seconds.
Number of data samples:	57	
TOTAL DATA SAMPLES	57	
Channel number [1]		
Measurement type:	Level	
Unit	feet	
Channel number [2]		
Measurement type:	Temperature	
Unit	Deg C	
Sensor Range:		
Specific gravity:		
Mode:	TOC	
User-defined reference*:	19.47	Feet H2O
Referenced on:	test start	
Pressure head at reference:		Feet H2O

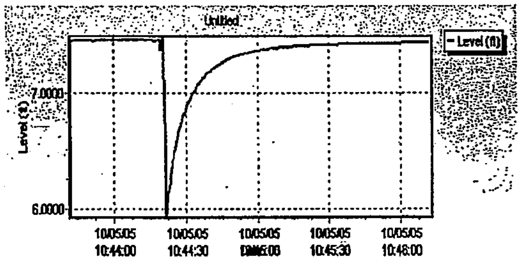
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	h/ho	
1	5/5/2010	10:08:47	0	0.000		11.111	8.4246	11.045	0	[illegible]	TEST START
2	5/5/2010	10:08:48	1	0.017	0.000	11.114	6.9757	12.494	1.4489	[illegible]	SLUG REMOVED
3	5/5/2010	10:08:49	2	0.033	0.017	11.114	7.2067	12.263	1.2179	0.840588707	
4	5/5/2010	10:08:50	3	0.050	0.033	11.116	7.3467	12.123	1.0779	0.743943881	
5	5/5/2010	10:08:51	4	0.067	0.050	11.117	7.4619	12.008	0.9627	0.664436089	
6	5/5/2010	10:08:52	5	0.083	0.067	11.117	7.5593	11.911	0.8653	0.597211678	
7	5/5/2010	10:08:53	6	0.100	0.083	11.117	7.6431	11.827	0.7815	0.539374698	
8	5/5/2010	10:08:54	7	0.117	0.100	11.118	7.7197	11.750	0.7049	0.486507005	
9	5/5/2010	10:08:55	8	0.133	0.117	11.121	7.7838	11.686	0.6408	0.442266547	
10	5/5/2010	10:08:56	9	0.150	0.133	11.12	7.8425	11.628	0.5821	0.401753064	
11	5/5/2010	10:08:57	10	0.167	0.150	11.12	7.8942	11.576	0.5304	0.366070812	
12	5/5/2010	10:08:58	11	0.183	0.167	11.123	7.9419	11.528	0.4827	0.333149286	
13	5/5/2010	10:08:59	12	0.200	0.183	11.123	7.9837	11.486	0.4409	0.304299814	
14	5/5/2010	10:09:00	13	0.217	0.200	11.123	8.0214	11.449	0.4032	0.278280076	
15	5/5/2010	10:09:01	14	0.233	0.217	11.124	8.0533	11.417	0.3713	0.256263372	
16	5/5/2010	10:09:02	15	0.250	0.233	11.124	8.0854	11.385	0.3392	0.234108834	
17	5/5/2010	10:09:03	16	0.267	0.250	11.125	8.1137	11.356	0.3109	0.214576875	
18	5/5/2010	10:09:04	17	0.283	0.267	11.125	8.1388	11.333	0.2878	0.198633446	
19	5/5/2010	10:09:05	18	0.300	0.283	11.127	8.1636	11.306	0.261	0.180138856	
20	5/5/2010	10:09:06	19	0.317	0.300	11.126	8.1829	11.287	0.2417	0.166816205	
21	5/5/2010	10:09:07	20	0.333	0.317	11.127	8.2006	11.269	0.224	0.154600041	
22	5/5/2010	10:09:08	21	0.350	0.333	11.127	8.2186	11.251	0.206	0.142176824	
23	5/5/2010	10:09:09	22	0.367	0.350	11.126	8.2347	11.235	0.1899	0.131064946	
24	5/5/2010	10:09:10	23	0.383	0.367	11.127	8.2493	11.221	0.1753	0.120988336	
25	5/5/2010	10:09:11	24	0.400	0.383	11.128	8.2622	11.208	0.1624	0.112085503	
26	5/5/2010	10:09:12	25	0.417	0.400	11.128	8.276	11.195	0.1486	0.103250742	
27	5/5/2010	10:09:13	26	0.433	0.417	11.128	8.2863	11.184	0.1383	0.095451722	
28	5/5/2010	10:09:14	27	0.450	0.433	11.128	8.2973	11.173	0.1273	0.087858756	
29	5/5/2010	10:09:15	28	0.467	0.450	11.13	8.3084	11.162	0.1162	0.080186771	
30	5/5/2010	10:09:16	29	0.483	0.467	11.13	8.3152	11.155	0.1094	0.075605666	
31	5/5/2010	10:09:17	30	0.500	0.150	11.128	8.3253	11.145	0.0993	0.068534751	
32	5/5/2010	10:09:18	31	0.517	0.500	11.13	8.3319	11.138	0.0927	0.063979571	
33	5/5/2010	10:09:19	32	0.533	0.517	11.132	8.3386	11.131	0.086	0.059355373	
34	5/5/2010	10:09:20	33	0.550	0.533	11.132	8.3487	11.121	0.0759	0.052384566	
35	5/5/2010	10:09:21	34	0.567	0.550	11.131	8.3532	11.117	0.0714	0.049278763	
36	5/5/2010	10:09:22	35	0.583	0.567	11.132	8.3595	11.111	0.0651	0.044930637	
37	5/5/2010	10:09:23	36	0.600	0.583	11.132	8.3639	11.106	0.0607	0.041893951	
38	5/5/2010	10:09:24	37	0.617	0.600	11.133	8.3697	11.100	0.0549	0.037880814	
39	5/5/2010	10:09:25	38	0.633	0.617	11.133	8.3747	11.095	0.0499	0.03443882	
40	5/5/2010	10:09:26	39	0.650	0.633	11.133	8.3806	11.089	0.044	0.030357665	
41	5/5/2010	10:09:27	40	0.667	0.650	11.134	8.3842	11.086	0.0404	0.027883222	
42	5/5/2010	10:09:28	41	0.683	0.667	11.134	8.3879	11.082	0.0367	0.02532956	
43	5/5/2010	10:09:29	42	0.700	0.683	11.134	8.3903	11.080	0.0343	0.023673131	
44	5/5/2010	10:09:30	43	0.717	0.700	11.135	8.3943	11.076	0.0303	0.020912416	
45	5/5/2010	10:09:31	44	0.733	0.717	11.134	8.3975	11.073	0.0271	0.018703844	
46	5/5/2010	10:09:32	45	0.750	0.733	11.135	8.3985	11.072	0.0261	0.018013666	
47	5/5/2010	10:09:33	46	0.767	0.750	11.135	8.4027	11.067	0.0219	0.016114916	
48	5/5/2010	10:09:34	47	0.783	0.767	11.136	8.4058	11.064	0.0188	0.012976361	
49	5/5/2010	10:09:35	48	0.800	0.783	11.136	8.4085	11.062	0.0161	0.011113878	
50	5/5/2010	10:09:36	49	0.817	0.800	11.136	8.4115	11.059	0.0131	0.009041342	
51	5/5/2010	10:09:37	50	0.833	0.817	11.136	8.4124	11.058	0.0122	0.008420181	
52	5/5/2010	10:09:38	51	0.850	0.833	11.137	8.4148	11.055	0.0098	0.006763762	
53	5/5/2010	10:09:39	52	0.867	0.850	11.138	8.4159	11.054	0.0087	0.006004555	
54	5/5/2010	10:09:40	53	0.883	0.867	11.138	8.4178	11.052	0.0068	0.004693216	
55	5/5/2010	10:09:41	54	0.900	0.883	11.137	8.4188	11.051	0.0058	0.004003037	
56	5/5/2010	10:09:42	55	0.917	0.900	11.137	8.4221	11.048	0.0025	0.001725447	
57	5/5/2010	10:09:43	56	0.933	0.917	11.138	8.4239	11.046	0.0007	0.000483125	

Solinst	3001	
Report generated:	5/11/2010	
Report from file:	...\mw-2_1.csv	
Serial number:	1032308	
Unit name:	Solinst 3001	
Test name:	AP-3	Test 1
Test defined on:	5/5/2010	
Test started on:	5/5/2010	10:44:21
Test stopped on:	5/5/2010	11:45:28
Data gathered using Linear testing		
Time between data points:	1	Seconds
Number of data samples:	69	
TOTAL DATA SAMPLES	69	
Channel number [1]		
Measurement type:	Level	
Unit	feet	
Channel number [2]		
Measurement type:	Temperature	
Unit	Deg C	
Sensor Range:		
Specific gravity:		
Mode:	TOC	
User-defined reference*:	19.83	Feet H2O
Referenced on:	test start	
Pressure head at reference:		Feet H2O

*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	h/ho	
1	5/5/2010	10:44:20	0	0.000		11.841	7.4264	12.204	0	[illegible]	TEST START
2	5/5/2010	10:44:21	1	0.017	0.000	11.841	4.946	14.684	2.4804	[illegible]	SLUG REMOVED
3	5/5/2010	10:44:22	2	0.033	0.017	11.841	6.031	13.599	1.3954	0.582570563	
4	5/5/2010	10:44:23	3	0.050	0.033	11.841	6.2314	13.399	1.195	0.481777133	
5	5/5/2010	10:44:24	4	0.067	0.050	11.839	6.374	13.256	1.0524	0.424286405	
6	5/5/2010	10:44:25	5	0.083	0.067	11.841	6.4939	13.136	0.9325	0.378947428	
7	5/5/2010	10:44:26	6	0.100	0.083	11.841	6.5956	13.034	0.8308	0.334846978	
8	5/5/2010	10:44:27	7	0.117	0.100	11.84	6.6811	12.949	0.7453	0.30047573	
9	5/5/2010	10:44:28	8	0.133	0.117	11.841	6.7553	12.875	0.5711	0.2705612	
10	5/5/2010	10:44:29	9	0.150	0.133	11.84	6.8204	12.810	0.606	0.244315433	
11	5/5/2010	10:44:30	10	0.167	0.150	11.837	6.8768	12.753	0.5496	0.221577165	
12	5/5/2010	10:44:31	11	0.183	0.167	11.839	6.9267	12.703	0.4997	0.201459442	
13	5/5/2010	10:44:32	12	0.200	0.183	11.837	6.9731	12.657	0.4533	0.182752782	
14	5/5/2010	10:44:33	13	0.217	0.200	11.837	7.0111	12.619	0.4153	0.167432872	
15	5/5/2010	10:44:34	14	0.233	0.217	11.839	7.0481	12.582	0.3783	0.152515723	
16	5/5/2010	10:44:35	15	0.250	0.233	11.836	7.0792	12.551	0.3472	0.139977423	
17	5/5/2010	10:44:36	16	0.267	0.250	11.837	7.1094	12.521	0.317	0.127801967	
18	5/5/2010	10:44:37	17	0.283	0.267	11.837	7.1355	12.495	0.2909	0.117278471	
19	5/5/2010	10:44:38	18	0.300	0.283	11.837	7.1579	12.472	0.2685	0.108248667	
20	5/5/2010	10:44:39	19	0.317	0.300	11.834	7.1803	12.450	0.2461	0.098217868	
21	5/5/2010	10:44:40	20	0.333	0.317	11.834	7.1981	12.432	0.2283	0.092041606	
22	5/5/2010	10:44:41	21	0.350	0.333	11.836	7.2175	12.413	0.2089	0.084220287	
23	5/5/2010	10:44:42	22	0.367	0.350	11.834	7.2342	12.396	0.1922	0.077487602	
24	5/5/2010	10:44:43	23	0.383	0.367	11.831	7.2477	12.382	0.1787	0.072044831	
25	5/5/2010	10:44:44	24	0.400	0.383	11.833	7.2613	12.369	0.1651	0.066561845	
26	5/5/2010	10:44:45	25	0.417	0.400	11.831	7.2733	12.357	0.1531	0.061723916	
27	5/5/2010	10:44:46	26	0.433	0.417	11.83	7.2842	12.346	0.1422	0.057328463	
28	5/5/2010	10:44:47	27	0.450	0.433	11.829	7.2947	12.335	0.1317	0.053096275	
29	5/5/2010	10:44:48	28	0.467	0.450	11.829	7.3038	12.326	0.1226	0.049427612	
30	5/5/2010	10:44:49	29	0.483	0.467	11.828	7.313	12.317	0.1134	0.045718433	
31	5/5/2010	10:44:50	30	0.500	0.150	11.83	7.3204	12.310	0.106	0.042736043	
32	5/5/2010	10:44:51	31	0.517	0.500	11.83	7.3277	12.302	0.0987	0.039781969	
33	5/5/2010	10:44:52	32	0.533	0.517	11.827	7.3358	12.294	0.0906	0.036626367	
34	5/5/2010	10:44:53	33	0.550	0.533	11.828	7.3408	12.289	0.0856	0.034610663	
35	5/5/2010	10:44:54	34	0.567	0.550	11.827	7.3465	12.284	0.0799	0.032212646	
36	5/5/2010	10:44:55	35	0.583	0.567	11.827	7.3529	12.277	0.0735	0.029632317	
37	5/5/2010	10:44:56	36	0.600	0.583	11.825	7.3567	12.273	0.0697	0.028100306	
38	5/5/2010	10:44:57	37	0.617	0.600	11.826	7.3618	12.268	0.0646	0.026044166	
39	5/5/2010	10:44:58	38	0.633	0.617	11.825	7.3666	12.263	0.0598	0.024108015	
40	5/5/2010	10:44:59	39	0.650	0.633	11.823	7.3705	12.260	0.0559	0.022536668	
41	5/5/2010	10:45:00	40	0.667	0.650	11.824	7.3748	12.255	0.0516	0.020803096	
42	5/5/2010	10:45:01	41	0.683	0.667	11.823	7.3783	12.252	0.0481	0.019392034	
43	5/5/2010	10:45:02	42	0.700	0.683	11.823	7.3814	12.249	0.045	0.018142235	
44	5/5/2010	10:45:03	43	0.717	0.700	11.821	7.3848	12.245	0.0416	0.016771488	
45	5/5/2010	10:45:04	44	0.733	0.717	11.82	7.3878	12.242	0.0386	0.015562006	
46	5/5/2010	10:45:05	45	0.750	0.733	11.82	7.3908	12.239	0.0356	0.014352624	
47	5/5/2010	10:45:06	46	0.767	0.750	11.819	7.3935	12.237	0.0329	0.013263199	
48	5/5/2010	10:45:07	47	0.783	0.767	11.818	7.3943	12.236	0.0321	0.012941681	
49	5/5/2010	10:45:08	48	0.800	0.783	11.817	7.3971	12.233	0.0293	0.011812611	
50	5/5/2010	10:45:09	49	0.817	0.800	11.816	7.3997	12.230	0.0267	0.010764393	
51	5/5/2010	10:45:10	50	0.833	0.817	11.819	7.4032	12.227	0.0232	0.009353333	
52	5/5/2010	10:45:11	51	0.850	0.833	11.816	7.4038	12.226	0.0226	0.009111434	
53	5/5/2010	10:45:12	52	0.867	0.850	11.817	7.4051	12.225	0.0213	0.008587325	
54	5/5/2010	10:45:13	53	0.883	0.867	11.816	7.4083	12.222	0.0181	0.00729721	
55	5/5/2010	10:45:14	54	0.900	0.883	11.815	7.4088	12.221	0.0176	0.007178262	
56	5/5/2010	10:45:15	55	0.917	0.900	11.813	7.411	12.219	0.0154	0.006208678	
57	5/5/2010	10:45:16	56	0.933	0.917	11.815	7.4116	12.218	0.0148	0.005966678	
58	5/5/2010	10:45:17	57	0.950	0.933	11.814	7.4149	12.215	0.0115	0.004636349	
59	5/5/2010	10:45:18	58	0.967	0.950	11.813	7.4155	12.215	0.0109	0.004364453	
60	5/5/2010	10:45:19	59	0.983	0.967	11.811	7.4162	12.214	0.0102	0.00411224	
61	5/5/2010	10:45:20	60	1.000	0.983	11.811	7.4176	12.212	0.0088	0.003547816	
62	5/5/2010	10:45:21	61	1.017	1.000	11.81	7.4187	12.211	0.0077	0.003104339	
63	5/5/2010	10:45:22	62	1.033	1.017	11.81	7.4192	12.211	0.0072	0.002902758	
64	5/5/2010	10:45:23	63	1.050	1.033	11.808	7.4215	12.209	0.0049	0.001975486	
65	5/5/2010	10:45:24	64	1.067	1.050	11.809	7.4218	12.208	0.0046	0.00186454	
66	5/5/2010	10:45:25	65	1.083	1.067	11.811	7.4231	12.207	0.0033	0.001330431	
67	5/5/2010	10:45:26	66	1.100	1.083	11.81	7.4244	12.206	0.002	0.000806322	
68	5/5/2010	10:45:27	67	1.117	1.100	11.809	7.424	12.206	0.0024	0.000967656	
69	5/5/2010	10:45:28	68	1.133	1.117	11.807	7.4257	12.204	0.0007	0.000282213	
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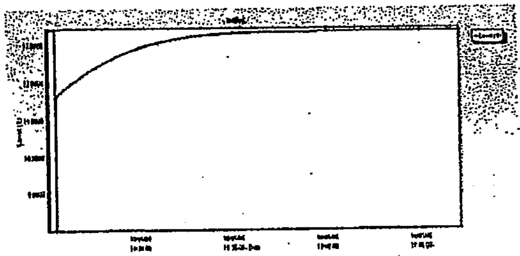
Solinst	3001	
Report generated:	5/11/2010	
Report from file:	...\MW-1.lev	
Serial number:	1032308	
Unit name:	Solinst 3001	
Test name:	AP-4	
Test defined on:	5/5/2010	
Test started on:	5/5/2010	11:25:32
Test stopped on:	5/5/2010	11:25:51
Data gathered using Linear testing		
Time between data points:	0.5	Seconds
Number of data samples:	41	
TOTAL DATA SAMPLES	41	
Channel number [1]		
Measurement type:	Level	
Unit	feet	
Channel number [2]		
Measurement type:	Temperature	
Unit	Deg C	
Sensor Range:		
Specific gravity:		
Mode:	TOC	
User-defined reference*:	59.93	Feet H2O
Referenced on:	test start	
Pressure head at reference:		Feet H2O

*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	h/ho	
1	5/5/2010	11:25:31	0	0.000		12.799	13.4081	45.522	0		TEST START
2	5/5/2010	11:25:31	0	0.000	0.000	12.789	11.9721	46.958	1.436		SLUG REMOVED
3	5/5/2010	11:25:32	0.5	0.008	0.008	12.794	8.02638	50.904	5.38172	[illegible]	
4	5/5/2010	11:25:32	1	0.017	0.017	12.785	11.2523	47.678	2.1558	0.400578254	
5	5/5/2010	11:25:33	1.5	0.025	0.025	12.79	11.5307	47.399	1.8774	0.34884758	
6	5/5/2010	11:25:33	2	0.033	0.033	12.781	11.5481	47.382	1.86	0.345614413	
7	5/5/2010	11:25:34	2.5	0.042	0.042	12.785	11.5979	47.332	1.8102	0.338380868	
8	5/5/2010	11:25:34	3	0.050	0.050	12.776	11.5927	47.337	1.8154	0.3373271	
9	5/5/2010	11:25:35	3.5	0.058	0.058	12.78	11.6036	47.326	1.8045	0.335301725	
10	5/5/2010	11:25:35	4	0.067	0.067	12.771	11.6202	47.310	1.7879	0.332217209	
11	5/5/2010	11:25:36	4.5	0.075	0.075	12.775	11.6344	47.296	1.7737	0.329578648	
12	5/5/2010	11:25:36	5	0.083	0.083	12.766	11.6361	47.294	1.772	0.329282764	
13	5/5/2010	11:25:37	5.5	0.092	0.092	12.771	11.6445	47.286	1.7636	0.327701924	
14	5/5/2010	11:25:37	6	0.100	0.100	12.763	11.6514	47.279	1.7567	0.326418606	
15	5/5/2010	11:25:38	6.5	0.108	0.108	12.767	11.6587	47.271	1.7494	0.325063363	
16	5/5/2010	11:25:38	7	0.117	0.117	12.758	11.6626	47.267	1.7455	0.324328687	
17	5/5/2010	11:25:39	7.5	0.125	0.125	12.762	11.669	47.261	1.7391	0.323149476	
18	5/5/2010	11:25:39	8	0.133	0.133	12.752	11.6739	47.256	1.7342	0.322238987	
19	5/5/2010	11:25:40	8.5	0.142	0.142	12.758	11.6794	47.251	1.7287	0.321217009	
20	5/5/2010	11:25:40	9	0.150	0.150	12.749	11.6836	47.246	1.7245	0.320436689	
21	5/5/2010	11:25:41	9.5	0.158	0.158	12.753	11.6884	47.242	1.7197	0.319544881	
22	5/5/2010	11:25:41	10	0.167	0.167	12.743	11.6921	47.238	1.716	0.318857168	
23	5/5/2010	11:25:42	10.5	0.175	0.175	12.748	11.6969	47.233	1.7112	0.31786528	
24	5/5/2010	11:25:42	11	0.183	0.183	12.739	11.7013	47.229	1.7068	0.317147678	
25	5/5/2010	11:25:43	11.5	0.192	0.192	12.745	11.7049	47.225	1.7032	0.316476747	
26	5/5/2010	11:25:43	12	0.200	0.200	12.735	11.7092	47.221	1.6989	0.315679748	
27	5/5/2010	11:25:44	12.5	0.208	0.208	12.74	11.7131	47.217	1.695	0.31496607	
28	5/5/2010	11:25:44	13	0.217	0.217	12.731	11.7157	47.214	1.6924	0.314471953	
29	5/5/2010	11:25:45	13.5	0.225	0.225	12.735	11.7212	47.209	1.6869	0.313448975	
30	5/5/2010	11:25:45	14	0.233	0.233	12.726	11.7248	47.205	1.6833	0.312781044	
31	5/5/2010	11:25:46	14.5	0.242	0.075	12.731	11.7288	47.201	1.6793	0.312037787	
32	5/5/2010	11:25:46	15	0.250	0.250	12.722	11.7311	47.199	1.677	0.311610416	
33	5/5/2010	11:25:47	15.5	0.258	0.258	12.727	11.7354	47.195	1.6727	0.310811413	
34	5/5/2010	11:25:47	16	0.267	0.267	12.719	11.7394	47.191	1.6687	0.310068157	
35	5/5/2010	11:25:48	16.5	0.275	0.275	12.723	11.743	47.187	1.6651	0.309389226	
36	5/5/2010	11:25:48	17	0.283	0.283	12.713	11.7467	47.183	1.6614	0.308711713	
37	5/5/2010	11:25:49	17.5	0.292	0.292	12.718	11.75	47.180	1.6581	0.308098628	
38	5/5/2010	11:25:49	18	0.300	0.300	12.709	11.7529	47.177	1.6552	0.307869665	
39	5/5/2010	11:25:50	18.5	0.308	0.308	12.714	11.7568	47.173	1.6513	0.30683499	
40	5/5/2010	11:25:50	19	0.317	0.317	12.705	11.7612	47.169	1.6469	0.306017407	
41	5/5/2010	11:25:51	19.5	0.325	0.325	12.709	11.7641	47.166	1.644	0.305478546	

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP Environmental Health & Safety

PROJECT: Piezometer Installation CWLP Ash Ponds Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-1, 3'-7'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	996.3	ASTM C136
Pan Weight:	93.2	
Original "Wet" Sample Mass (OSM):	903.1	
Total "Dry" Sample Mass (TSM) + Pan:	820.4	
Pan Weight:	93.2	
Total "Dry" Sample Mass (TSM):	727.2	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	182.6	
Pan Weight:	93.2	
Total "Dry" Washed Sample Mass (TWM), grams	89.4	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	0.4	0.4	0.1	99.9	NP
4.75 (4)	1.2	1.6	0.2	99.8	NP
2.36 (8)	3.0	4.6	0.6	99.4	NP
1.18 (16)	2.1	6.7	0.9	99.1	NP
0.6 (30)	5.3	12.0	1.7	98.3	NP
0.425 (40)	0.0	12.0	1.7	98.3	NP
0.3 (50)	7.9	19.9	2.7	97.3	NP
0.15 (100)	27.4	47.3	6.5	93.5	NP
0.075 (200)	39.3	86.6	11.9	88.1	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-1, 10'-15'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1030.6	ASTM C136
Pan Weight:	93.5	
Original "Wet" Sample Mass (OSM):	937.1	
Total "Dry" Sample Mass (TSM) + Pan:	814.4	
Pan Weight:	93.5	
Total "Dry" Sample Mass (TSM):	720.9	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	247.0	
Pan Weight:	93.5	
Total "Dry" Washed Sample Mass (TWM), grams	153.5	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.9	0.9	0.1	99.9	NP
6.3 (1/4)	0.9	1.8	0.2	99.8	NP
4.75 (4)	3.1	4.9	0.7	99.3	NP
2.36 (8)	21.1	26.0	3.6	96.4	NP
1.18 (16)	40.7	66.7	9.3	90.7	NP
0.6 (30)	31.2	97.9	13.6	86.4	NP
0.425 (40)	0.0	97.9	13.6	86.4	NP
0.3 (50)	14.4	112.3	15.6	84.4	NP
0.15 (100)	14.7	127.0	17.6	82.4	NP
0.075 (200)	25.6	152.6	21.2	78.8	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-2, 3'-7'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1706.4	ASTM C136
Pan Weight:	90.7	
Original "Wet" Sample Mass (OSM):	1615.7	
Total "Dry" Sample Mass (TSM) + Pan:	1381.0	
Pan Weight:	90.7	
Total "Dry" Sample Mass (TSM):	1290.3	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	420.6	
Pan Weight:	90.7	
Total "Dry" Washed Sample Mass (TWM), grams	329.9	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	3.5	3.5	0.3	99.7	NP
6.3 (1/4)	2.3	5.8	0.4	99.6	NP
4.75 (4)	2.7	8.5	0.7	99.3	NP
2.36 (8)	6.6	15.1	1.2	98.8	NP
1.18 (16)	7.0	22.1	1.7	98.3	NP
0.6 (30)	8.0	30.1	2.3	97.7	NP
0.425 (40)	0.0	30.1	2.3	97.7	NP
0.3 (50)	18.1	48.2	3.7	96.3	NP
0.15 (100)	119.7	167.9	13.0	87.0	NP
0.075 (200)	156.2	324.1	25.1	74.9	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT:	CWLP Environmental Health & Safety	PROJECT:	Piezometer Installation CWLP Ash Ponds Springfield, IL
DATE:	April 26, 2010	PSI REPORT NO.	0020522-1 Page 4 of 8

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-2, 9'-16'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1461.6	ASTM C136
Pan Weight:	173.0	
Original "Wet" Sample Mass (OSM):	1288.6	
Total "Dry" Sample Mass (TSM) + Pan:	1178.1	
Pan Weight:	173.0	
Total "Dry" Sample Mass (TSM):	1005.1	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	319.2	
Pan Weight:	173.0	
Total "Dry" Washed Sample Mass (TWM), grams	146.2	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	0.8	0.8	0.1	99.9	NP
4.75 (4)	1.2	2.0	0.2	99.8	NP
2.36 (8)	1.5	3.5	0.3	99.7	NP
1.18 (16)	2.8	6.3	0.6	99.4	NP
0.6 (30)	5.7	12.0	1.2	98.8	NP
0.425 (40)	0.0	12.0	1.2	98.8	NP
0.3 (50)	7.2	19.2	1.9	98.1	NP
0.15 (100)	42.1	61.3	6.1	93.9	NP
0.075 (200)	82.8	144.1	14.3	85.7	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand, Trace Subround Gravel	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-3, 3'-6'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	816.4	ASTM C136
Pan Weight:	94.6	
Original "Wet" Sample Mass (OSM):	721.8	
Total "Dry" Sample Mass (TSM) + Pan:	663.7	
Pan Weight:	94.6	
Total "Dry" Sample Mass (TSM):	569.1	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	195.2	
Pan Weight:	94.6	
Total "Dry" Washed Sample Mass (TWM), grams	100.6	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	2.5	2.5	0.4	99.6	NP
6.3 (1/4)	0.4	2.9	0.5	99.5	NP
4.75 (4)	0.4	3.3	0.6	99.4	NP
2.36 (8)	1.3	4.6	0.8	99.2	NP
1.18 (16)	3.6	8.2	1.4	98.6	NP
0.6 (30)	7.6	15.8	2.8	97.2	NP
0.425 (40)	0.0	15.8	2.8	97.2	NP
0.3 (50)	10.2	26.0	4.6	95.4	NP
0.15 (100)	31.7	57.7	10.1	89.9	NP
0.075 (200)	41.5	99.2	17.4	82.6	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT:	CWLP Environmental Health & Safety	PROJECT:	Piezometer Installation CWLP Ash Ponds Springfield, IL
DATE:	April 26, 2010	PSI REPORT NO.	0020522-1 Page 6 of 8

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-3, 10'-15'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1010.5	ASTM C136
Pan Weight:	104.2	
Original "Wet" Sample Mass (OSM):	906.3	
Total "Dry" Sample Mass (TSM) + Pan:	812.2	
Pan Weight:	104.2	
Total "Dry" Sample Mass (TSM):	708.0	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	250.7	
Pan Weight:	104.2	
Total "Dry" Washed Sample Mass (TWM), grams	146.5	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	1.8	1.8	0.3	99.7	NP
4.75 (4)	0.4	2.2	0.3	99.7	NP
2.36 (8)	3.4	5.6	0.8	99.2	NP
1.18 (16)	5.5	11.1	1.6	98.4	NP
0.6 (30)	7.4	18.5	2.6	97.4	NP
0.425 (40)	0.0	18.5	2.6	97.4	NP
0.3 (50)	16.6	35.1	5.0	95.0	NP
0.15 (100)	52.0	87.1	12.3	87.7	NP
0.075 (200)	56.8	143.9	20.3	79.7	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Composite of FLY ASH and Silty CLAY, With Fine to Coarse Sand, Trace Subround gravel	SAMPLED BY: PSI DATE SAMPLED: 4/20/2010
SAMPLE SOURCE: AP-4, 18'-23'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1931.9	ASTM C136
Pan Weight:	147.6	
Original "Wet" Sample Mass (OSM):	1784.3	
Total "Dry" Sample Mass (TSM) + Pan:	1596.1	
Pan Weight:	147.6	
Total "Dry" Sample Mass (TSM):	1448.5	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	752.6	
Pan Weight:	147.6	
Total "Dry" Washed Sample Mass (TWM), grams	605.0	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	8.2	8.2	5.6	94.4	NP
12.5 (1/2)	0.0	8.2	0.6	99.4	NP
9.5 (3/8)	2.5	10.7	0.7	99.3	NP
6.3 (1/4)	12.3	23.0	1.6	98.4	NP
4.75 (4)	10.8	33.8	2.3	97.7	NP
2.36 (8)	52.2	86.0	5.9	94.1	NP
1.18 (16)	144.3	230.3	15.9	84.1	NP
0.6 (30)	132.2	362.5	25.0	75.0	NP
0.425 (40)	0.0	362.5	25.0	75.0	NP
0.3 (50)	110.4	472.9	32.6	67.4	NP
0.15 (100)	75.1	548.0	37.8	62.2	NP
0.075 (200)	53.5	601.5	41.5	58.5	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT:	CWLP Environmental Health & Safety	PROJECT:	Piezometer Installation CWLP Ash Ponds Springfield, IL
DATE:	April 26, 2010	PSI REPORT NO.	0020522-1 Page 8 of 8

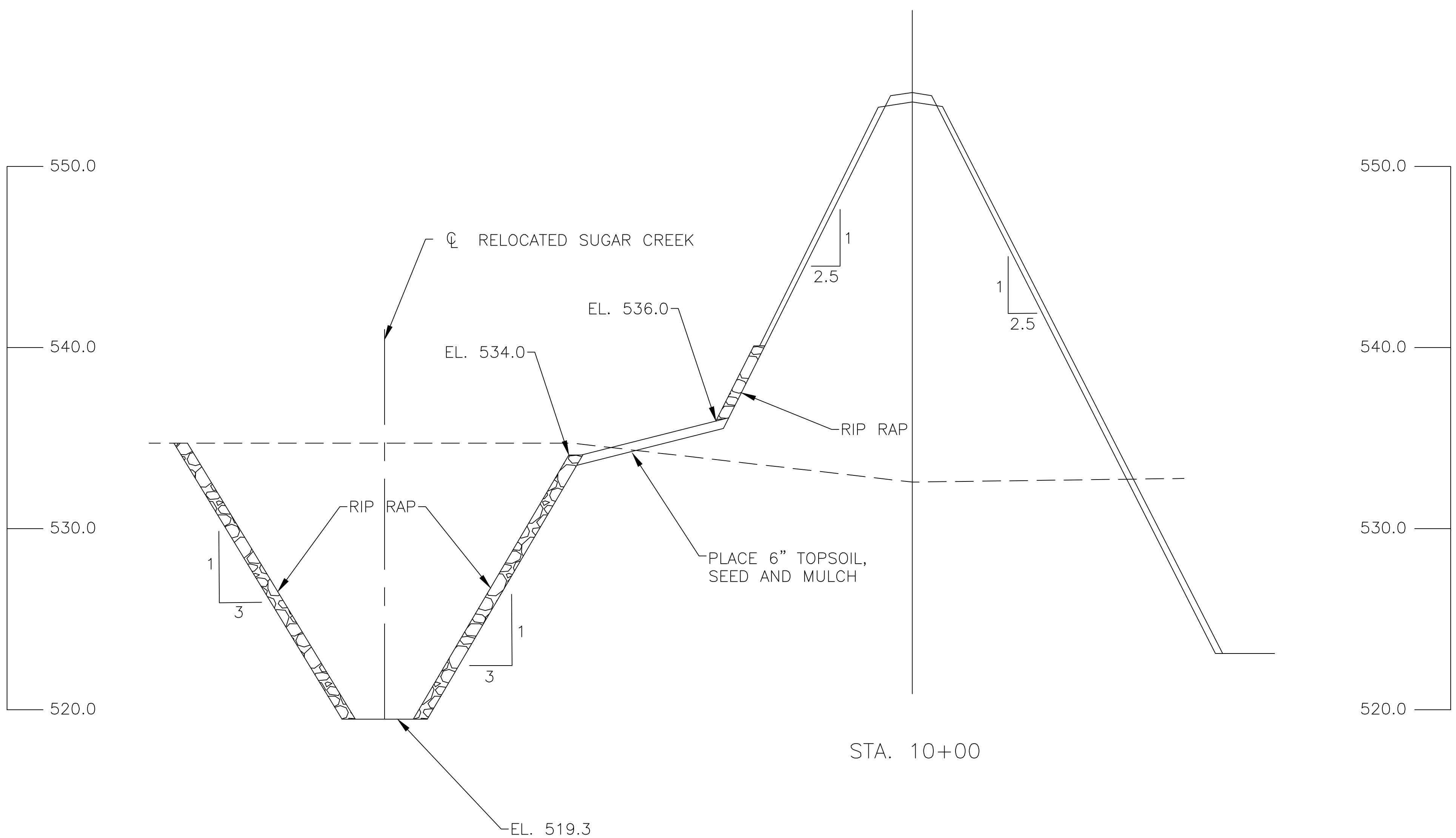
GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT With Fine to Coarse Sand, Trace Subround Gravel	SAMPLED BY: PSI DATE SAMPLED: 4/20/2010
SAMPLE SOURCE: AP-4, 45'-55'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS

		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1855.4	ASTM C136
Pan Weight:	99.7	
Original "Wet" Sample Mass (OSM):	1755.7	
Total "Dry" Sample Mass (TSM) + Pan:	1509.0	
Pan Weight:	99.7	
Total "Dry" Sample Mass (TSM):	1409.3	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	584.6	
Pan Weight:	99.7	
Total "Dry" Washed Sample Mass (TWM), grams	484.9	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	2.7	2.7	0.2	99.8	NP
6.3 (1/4)	6.7	9.4	0.7	99.3	NP
4.75 (4)	11.0	20.4	1.4	98.6	NP
2.36 (8)	31.4	51.8	3.7	96.3	NP
1.18 (16)	35.3	87.1	6.2	93.8	NP
0.6 (30)	55.9	143.0	10.1	89.9	NP
0.425 (40)	0.0	143.0	10.1	89.9	NP
0.3 (50)	162.8	305.8	21.7	78.3	NP
0.15 (100)	94.7	400.5	28.4	71.6	NP
0.075 (200)	82.5	483.0	34.3	65.7	NP
Pan					



HORIZ. 0 20 40 80
VERT. 0 4 8 16
SCALE: IN FEET

NOTES:
CROSS-SECTION BASED ON CONSTRUCTION PLAN DRAWINGS PREPARED BY BURNS & McDONNEL IN AUGUST 1976

NO.	DATE	REVISIONS DESCRIPTION	BY

ANDREWS ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184001541

APPROVED BY: PMV DESIGNED BY: PMV DRAWN BY: RMC

DALLMAN ASH POND CROSS-SECTION AT STA. 10+00

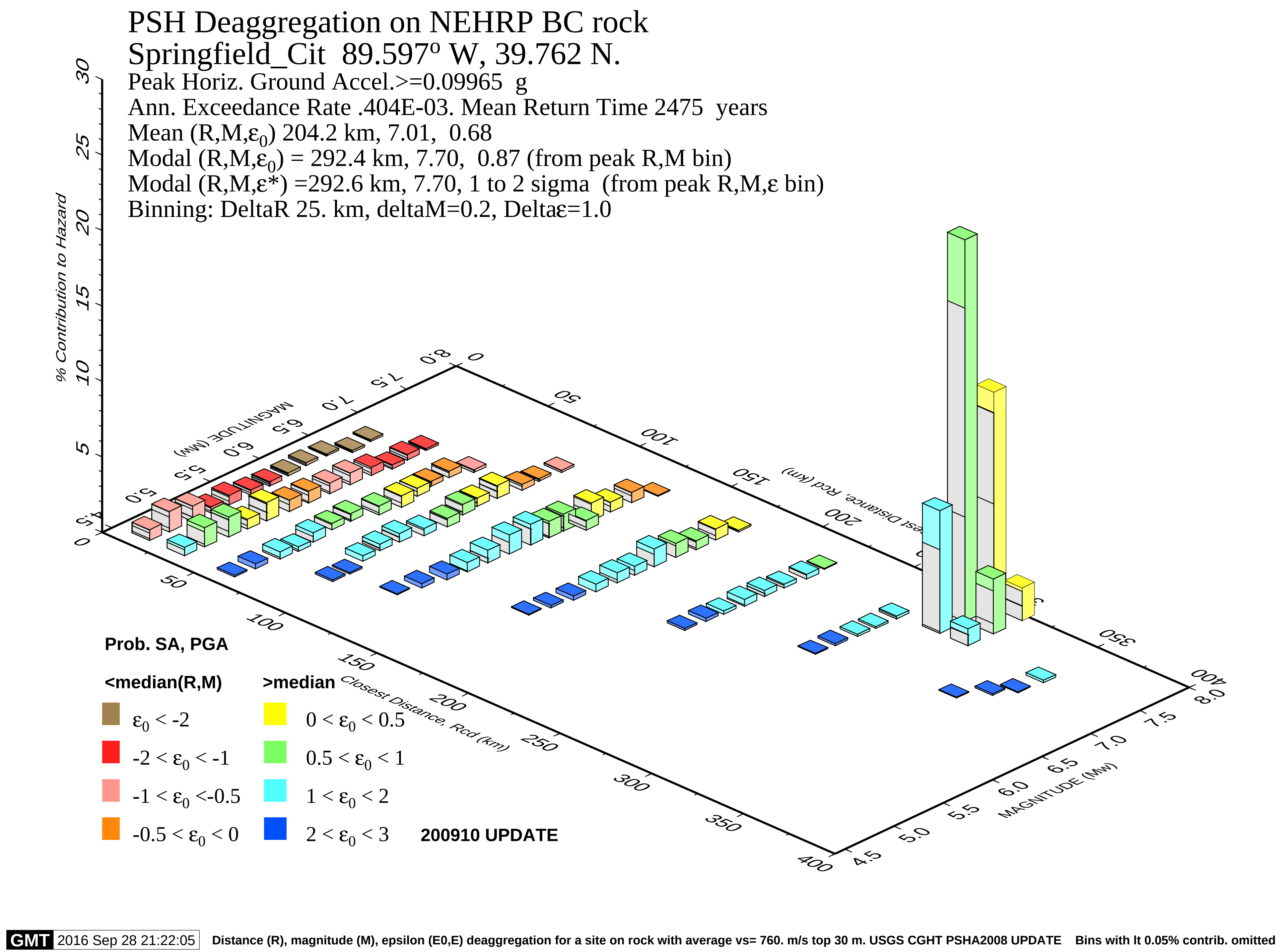
PLANS PREPARED FOR
CITY, WATER, LIGHT & POWER
SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016
PROJECT ID: 150077/0011
SHEET NUMBER:
X-SEC.

J:\S\Springfield CWLP\CWLP\dwg\DALLMAN X-SEC.dwg Tab: Layout1 Last Saved: October 7, 2016, by Ryan Curtis Plotted: Friday, October 07, 2016 4:17:38 PM

APPENDIX E

USGS Earthquake Hazards Program
Probabilistic Seismic Hazard Analysis

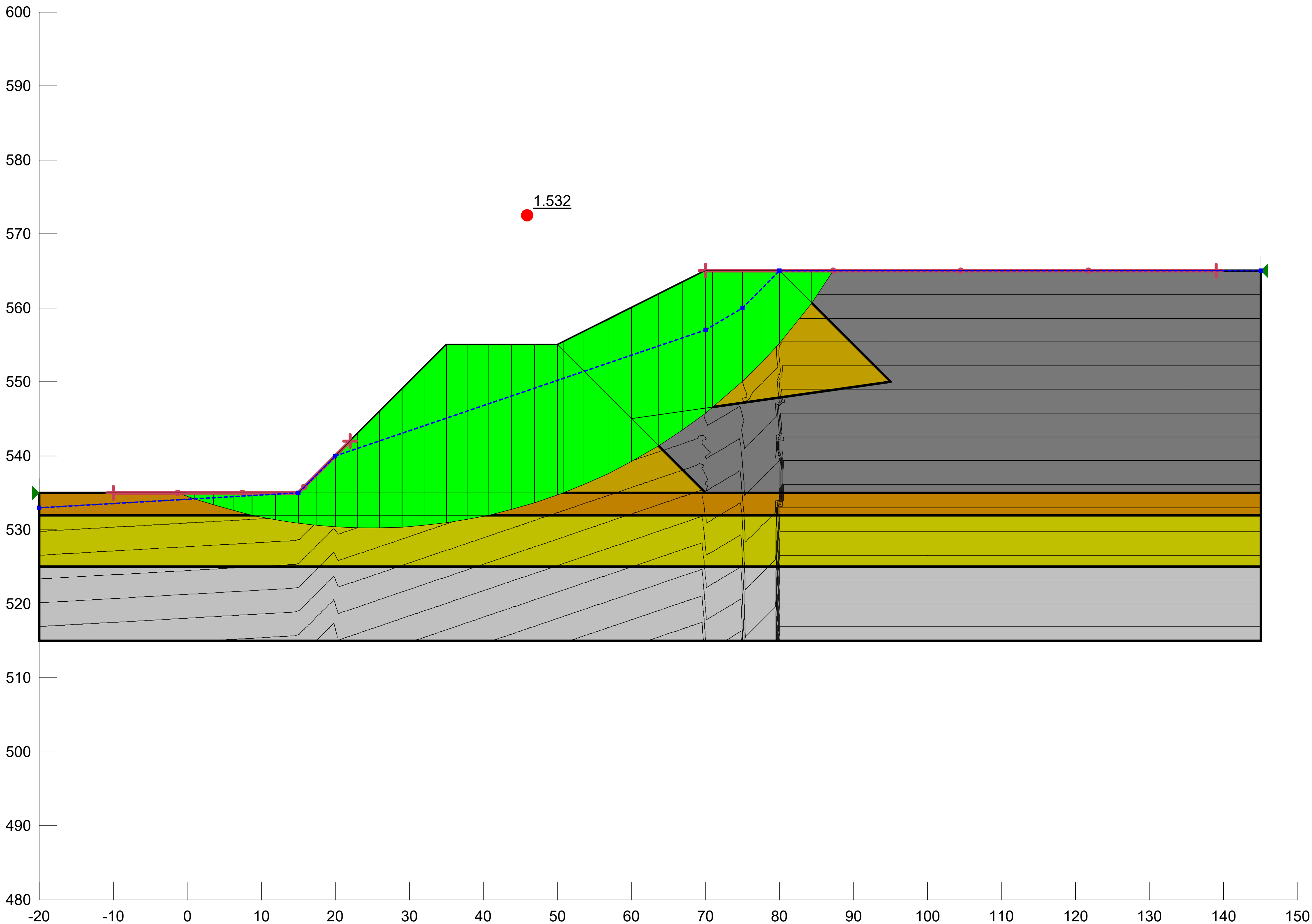

PSH Deaggregation on NEHRP BC rock
Springfield_Cit 89.597° W, 39.762 N.
Peak Horiz. Ground Accel.>=0.09965 g
Ann. Exceedance Rate .404E-03. Mean Return Time 2475 years
Mean (R,M,ε0) 204.2 km, 7.01, 0.68
Modal (R,M,ε0) = 292.4 km, 7.70, 0.87 (from peak R,M bin)
Modal (R,M,ε*) =292.6 km, 7.70, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0
% Contribution to Hazard
Closest Distance, Rcd (km)
MAGNITUDE (Mw)
Prob. SA, PGA
<median(R,M)
>median
ε0 < -2
-2 < ε0 < -1
-1 < ε0 <-0.5
-0.5 < ε0 < 0
0 < ε0 < 0.5
0.5 < ε0 < 1
1 < ε0 < 2
2 < ε0 < 3
200910 UPDATE
GMT 2016 Sep 28 21:22:05
Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

APPENDIX F

Lakeside Ash Pond Slope Stability Analysis

APPENDIX F-1

Long-Term Static Slope Stability Analysis


1.532
600
590
580
570
560
550
540
530
520
510
500
490
480
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

CWLP Lakeside Long Term Static

File Information

- File Version: 8.14
- Created By: Karl Finke
- Last Edited By: Karl Finke
- Revision Number: 47
- Date: 10/3/2016
- Time: 2:09:57 PM
- Tool Version: 8.14.1.10087
- File Name: CWLP Lakeside Long Term Section 2.gsz
- Directory: J:\CWLP Factor of Safety Report\SlopeW\
- Last Solved Date: 10/3/2016
- Last Solved Time: 2:09:59 PM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

CWLP Lakeside Long Term Static

- Description: CWLP Lakeside
- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1

Resisting Side Maximum Convex Angle: 1 °
Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 145 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb

Electronic Filing: Received, Clerk's Office 08/27/2020

Unit Weight: 130 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-10, 535) ft
Left-Zone Right Coordinate: (22, 542) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (139, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	20	540
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Electronic Filing: Received, Clerk's Office 08/27/2020

Points

	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft^2)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

Current Slip Surface

Slip Surface: 33
F of S: 1.532
Volume: 1,258.2941 ft^3
Weight: 150,210.74 lbs
Resisting Moment: 5,434,428.4 lbs-ft
Activating Moment: 3,545,823.9 lbs-ft
Resisting Force: 68,187.197 lbs
Activating Force: 44,512.413 lbs
F of S Rank: 1
Exit: (-1.2751263, 535) ft
Entry: (87.25, 565) ft
Radius: 73.560778 ft
Center: (24.754863, 603.80136) ft

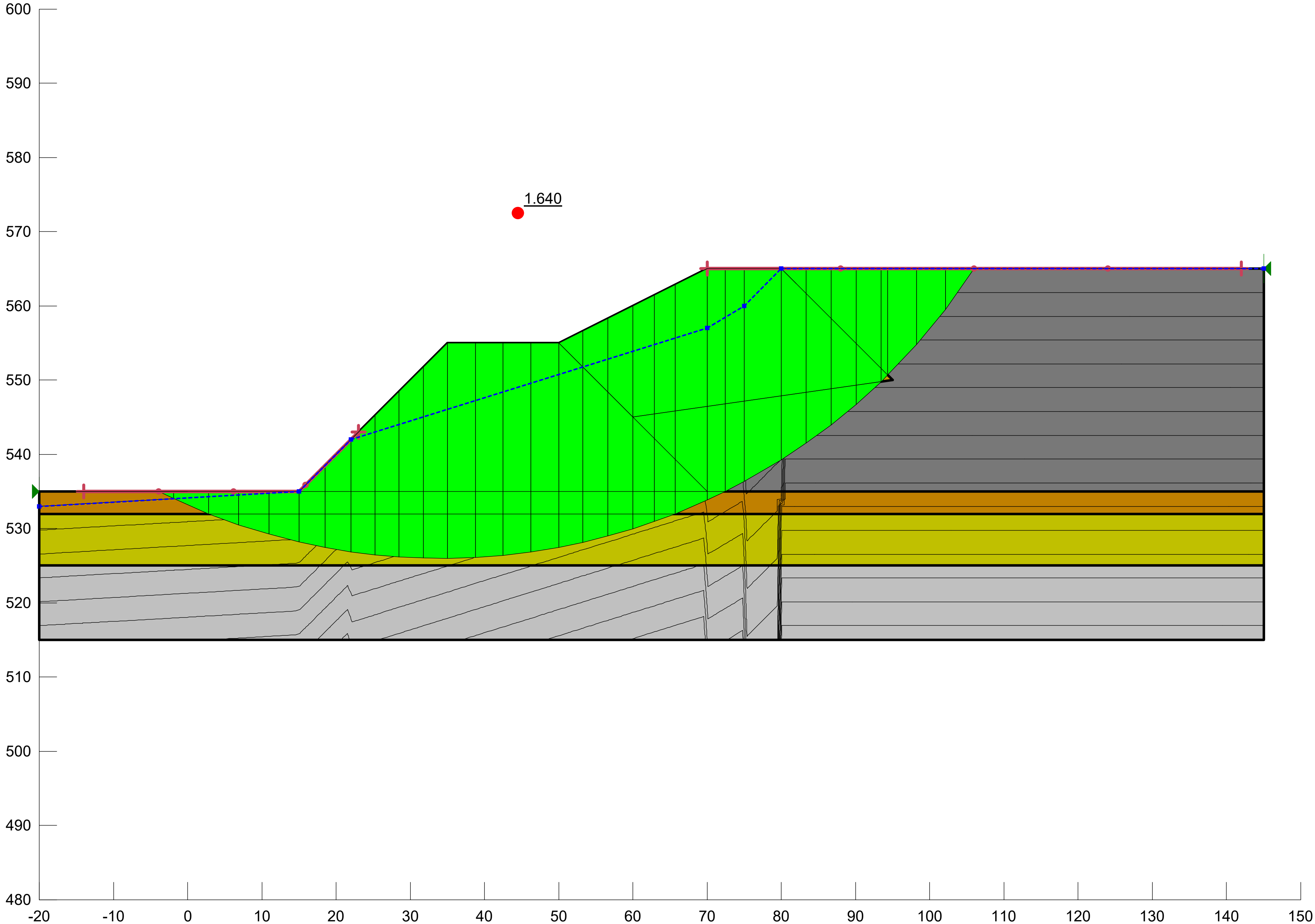
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-0.16048362	534.59869	-28.921787	116.63294	72.880347	190
Slice 2	2.2555676	533.77922	30.633885	239.91856	130.77557	190
Slice 3	4.8583846	532.99536	88.638254	357.95512	168.28786	190
Slice 4	7.4612017	532.31483	140.21555	463.62052	202.08585	190
Slice 5	10.321958	531.68791	189.37551	562.23057	232.9857	190
Slice 6	13.440653	531.13303	234.97122	647.75213	257.93414	190
Slice 7	16.25	530.74473	343.52879	872.41907	330.48732	190
Slice 8	18.75	530.49682	514.99863	1,237.8844	451.70913	190
Slice 9	21.5	530.32797	569.52187	1,633.4497	664.81587	190
Slice 10	24.5	530.25632	630.58214	2,026.2219	872.09255	190
Slice 11	27.5	530.30715	684.79174	2,374.6858	1,055.963	190
Slice 12	30.5	530.48071	732.13642	2,676.6103	1,215.0422	190
Slice 13	33.5	530.77789	772.56714	2,932.1543	1,349.4598	190
Slice 14	36.436779	531.18867	805.44064	2,961.7079	1,347.3854	190
Slice 15	39.310336	531.70991	830.93376	2,787.6141	1,222.6696	190
Slice 16	42.289263	532.3786	850.1832	2,595.7963	1,090.7801	190
Slice 17	45.373558	533.20762	862.4684	2,390.7241	954.96017	190
Slice 18	48.457853	534.1831	866.56169	2,182.7153	822.42405	190
Slice 19	50.392426	534.85408	865.82212	2,074.5141	755.2746	190
Slice 20	52.183471	535.56217	860.27695	2,045.1601	740.39712	145
Slice 21	55.186567	536.85367	845.14961	1,991.516	716.32925	145
Slice 22	58.395522	538.40841	819.21351	1,925.9735	691.58041	145
Slice 23	61.820519	540.29639	778.74635	1,813.4119	646.53076	145
Slice 24	65.230778	542.40704	725.54379	1,765.7584	485.06005	0
Slice 25	68.410259	544.62796	661.78492	1,717.5015	492.28874	0
Slice 26	70.482325	546.18359	509.56053	1,647.8538	530.79489	0
Slice 27	72.982325	548.32026	480.3485	1,367.3352	554.25078	145
Slice 28	76.25	551.30019	310.43404	1,075.0936	477.81232	145
Slice	78.75	553.87819	308.00034	862.30889	346.37042	145

29						
Slice 30	82.16908	557.94599	440.16994	557.72891	73.458995	145
Slice 31	85.79408	562.83092	135.35062	184.12653	22.744581	0

APPENDIX F-2

Short-Term Static Slope Stability Analysis



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140
150

CWLP Lakeside Short Term Static

File Information

- File Version: 8.14
- Created By: Karl Finke
- Last Edited By: Karl Finke
- Revision Number: 48
- Date: 10/3/2016
- Time: 2:12:27 PM
- Tool Version: 8.14.1.10087
- File Name: CWLP Lakeside Short Term Section 2.gsz
- Directory: J:\CWLP Factor of Safety Report\SlopeW\

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

CWLP Lakeside Short Term Static

- Description: CWLP Lakeside
- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °

Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 2,000 psf

Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-14, 535) ft
Left-Zone Right Coordinate: (23, 543) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (142, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	22	542
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Points

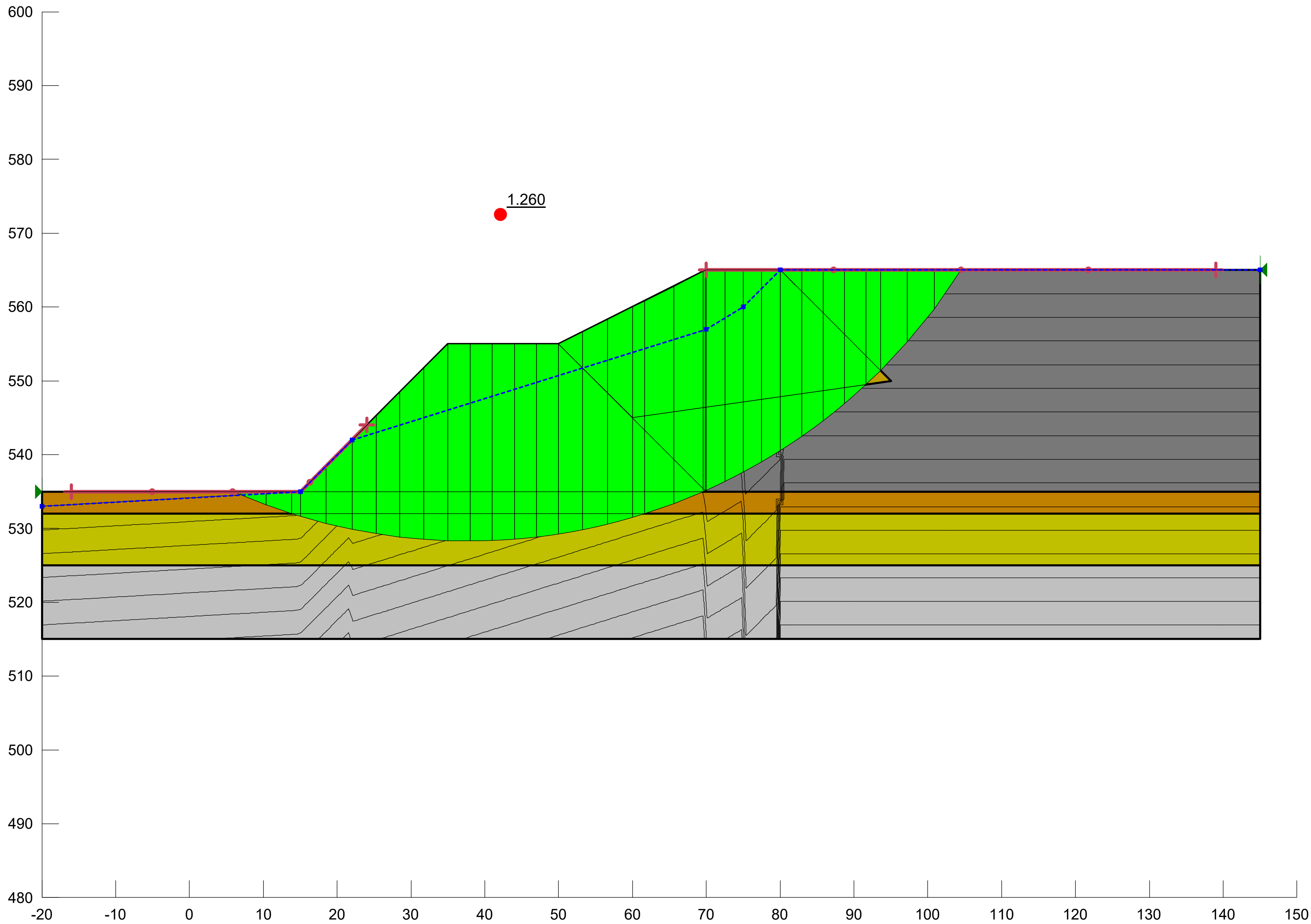
	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft^2)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

APPENDIX F-3

Lakeside Seismic Slope Stability Analysis



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150

CWLP Lakeside Short Term Seismic

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 52
Date: 10/3/2016
Time: 2:14:02 PM
Tool Version: 8.14.1.10087
File Name: CWLP Lakeside Short Term Seismic Section 2.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 2:14:06 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

CWLP Lakeside Short Term Seismic

Description: CWLP Lakeside
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1

Resisting Side Maximum Convex Angle: 1 °
Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb

Unit Weight: 130 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-16, 535) ft
Left-Zone Right Coordinate: (24, 544) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (139, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	22	542
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Electronic Filing: Received, Clerk's Office 08/27/2020

Seismic Coefficients

Horz Seismic Coef.: 0.1

Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft^2)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

Current Slip Surface

Slip Surface: 63

F of S: 1.260

Volume: 1,901.9136 ft^3

Weight: 220,860.5 lbs

Resisting Moment: 7,130,465.7 lbs-ft

Activating Moment: 5,657,637.6 lbs-ft

Resisting Force: 85,224.85 lbs

Activating Force: 67,622.745 lbs

F of S Rank: 1

Exit: (5.863961, 535) ft
Entry: (104.5, 565) ft
Radius: 79.109148 ft
Center: (37.720356, 607.41151) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	6.3985031	534.76952	-16.235239	666.78022	0	1,800
Slice 2	8.6540842	533.85892	48.417777	824.15224	0	1,800
Slice 3	12.096162	532.5894	139.61124	1,052.2735	0	1,800
Slice 4	14.408601	531.81762	195.83209	915.79274	0	1,000
Slice 5	16.75	531.15401	349.18995	1,237.5437	0	1,000
Slice 6	20.25	530.27641	622.35204	1,804.3101	0	1,000
Slice 7	23.625	529.58574	734.59908	2,313.1757	0	1,000
Slice 8	26.875	529.06648	821.85486	2,760.4465	0	1,000
Slice 9	30.125	528.68475	901.29201	3,161.9008	0	1,000
Slice 10	33.375	528.43857	973.0241	3,515.7678	0	1,000
Slice 11	36.5	528.32601	1,034.9389	3,637.264	0	1,000
Slice 12	39.5	528.33662	1,087.631	3,541.0214	0	1,000
Slice 13	42.5	528.46119	1,133.8449	3,421.4585	0	1,000
Slice 14	45.5	528.70025	1,173.5497	3,282.3533	0	1,000
Slice 15	48.5	529.05487	1,206.6858	3,127.2166	0	1,000
Slice 16	51.619048	529.55023	1,233.9353	3,039.0174	0	1,000
Slice 17	54.928571	530.21608	1,254.8771	3,014.6722	0	1,000
Slice 18	58.309524	531.04871	1,267.6066	2,974.7747	0	1,000
Slice 19	60.811756	531.75225	1,272.0639	2,922.9997	0	1,000
Slice 20	63.611822	532.68895	1,268.5574	2,836.2034	0	1,800
Slice 21	67.588442	534.18895	1,253.9299	2,627.4289	0	1,800
Slice 22	69.723473	535.0649	1,242.0626	2,534.1139	0	1,400
Slice 23	69.935097	535.15874	1,240.4874	2,588.738	361.26267	0
Slice 24	71.25	535.77273	1,008.3689	2,514.1676	403.47755	0
Slice 25	73.75	536.99738	1,021.0026	2,378.8723	363.8401	0
Slice 26	76.25	538.3342	714.97294	2,233.9803	407.0168	0

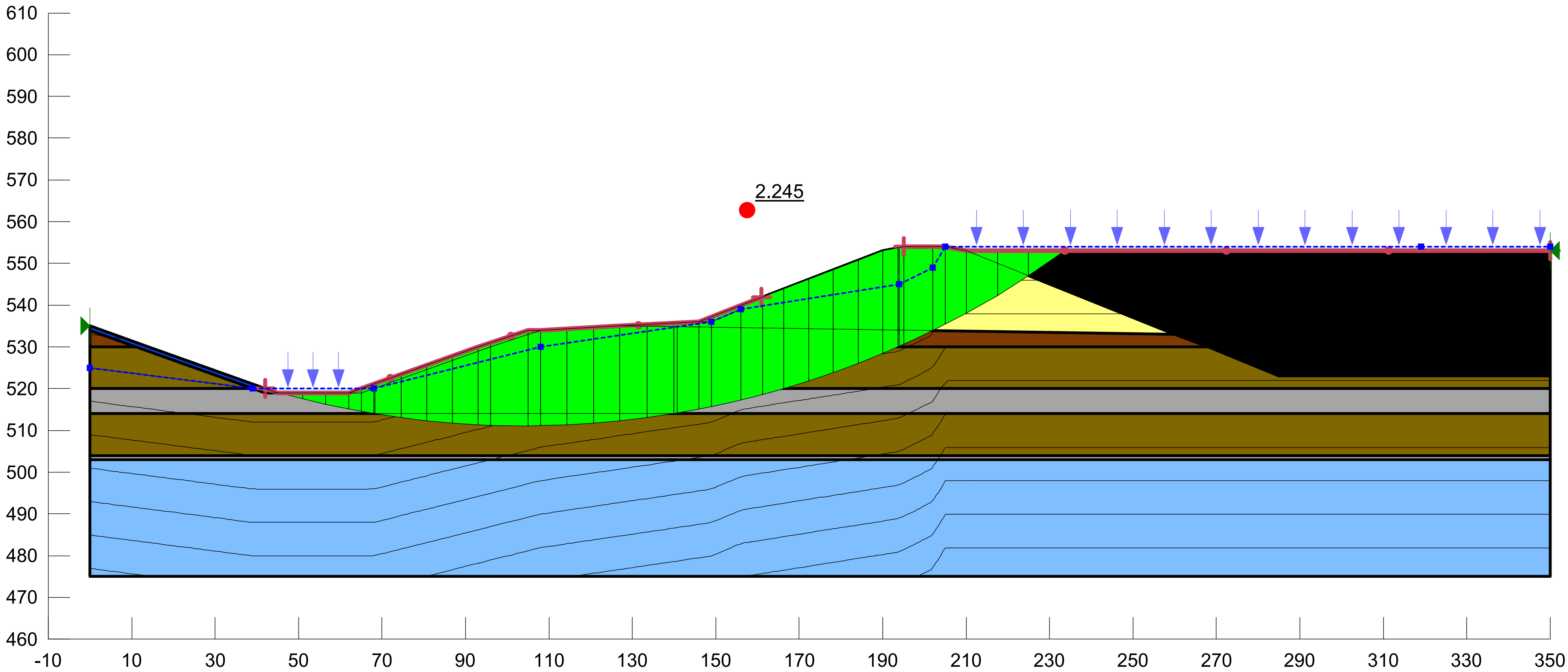
Slice 27	78.75	539.78986	747.55632	2,103.0434	363.20167	0
Slice 28	81.454318	541.51348	1,465.559	1,988.8949	140.22742	0
Slice 29	84.362954	543.54069	1,339.0611	1,797.0107	122.70723	0
Slice 30	87.27159	545.77183	1,199.8378	1,598.0888	106.71104	0
Slice 31	90.180226	548.23008	1,046.4432	1,386.8062	91.199981	0
Slice 32	92.613771	550.46311	907.10183	416.08203	-0	1,400
Slice 33	95.410831	553.34674	727.16315	925.16796	53.055228	0
Slice 34	99.046499	557.52099	466.69001	618.90263	40.785248	0
Slice 35	102.68217	562.37775	163.62838	227.05533	16.995201	0

APPENDIX G

Dallman Ash Pond Slope Stability Analysis

APPENDIX G-1

Long-Term Static Slope Stability Analysis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Dallman Long Term Static

File Information

- File Version: 8.14
- Created By: Karl Finke
- Last Edited By: Karl Finke
- Revision Number: 45
- Date: 10/3/2016
- Time: 2:45:37 PM
- Tool Version: 8.14.1.10087
- File Name: CWLP Dallman Long Term Static.gsz
- Directory: J:\CWLP Factor of Safety Report\SlopeW\
- Last Solved Date: 10/3/2016
- Last Solved Time: 2:45:42 PM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Dallman Long Term Static

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 145 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Electronic Filing: Received, Clerk's Office 08/27/2020

Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (195, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
Point 30	93	530
Point 31	68	520
Point 32	65	520
Point 33	65	519
Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 7

F of S: 2.245

Volume: 3,200.3592 ft³

Weight: 383,171.01 lbs

Resisting Moment: 36,423,187 lbs-ft

Activating Moment: 16,221,979 lbs-ft

Resisting Force: 158,991.47 lbs

Activating Force: 70,815.407 lbs

F of S Rank: 1

Exit: (45.522783, 519) ft

Entry: (233.67574, 553) ft

Radius: 221.12319 ft

Center: (104.14305, 732.21147) ft

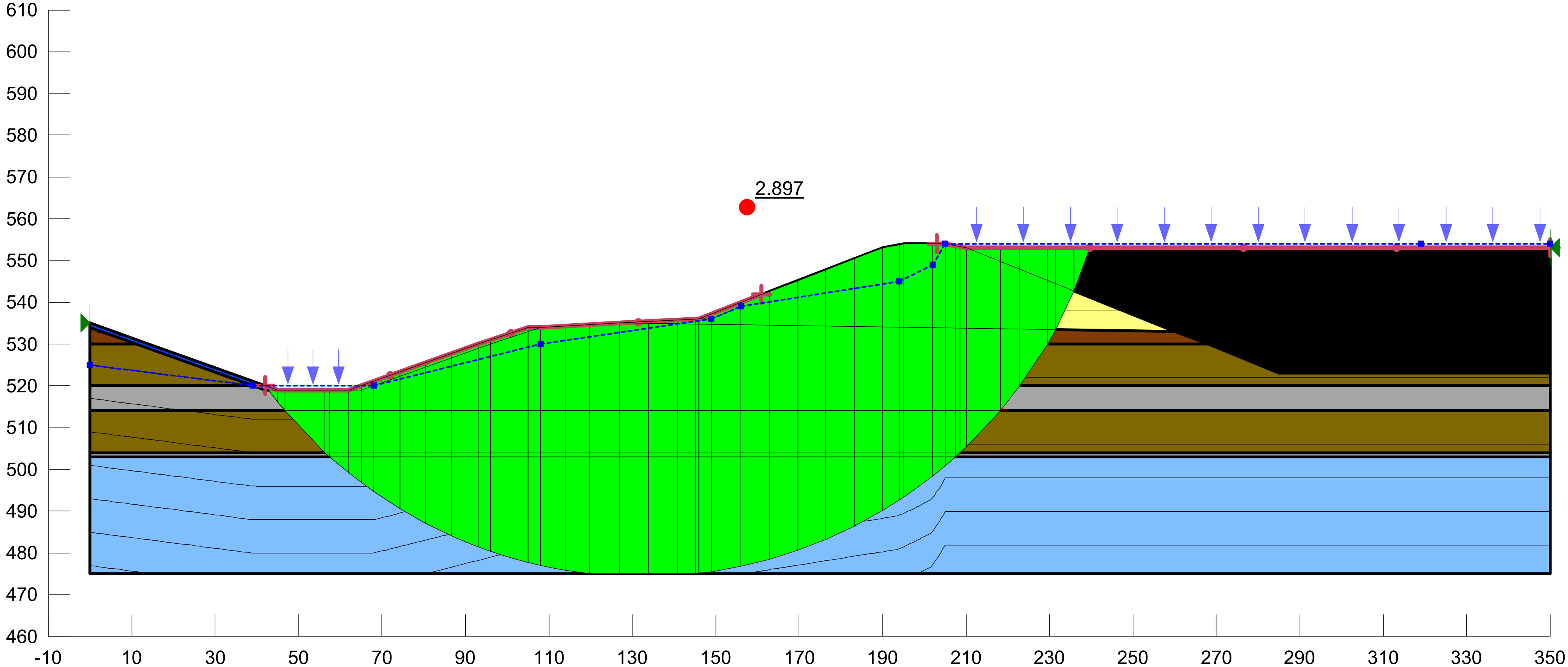
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	48.268985	518.28274	107.15674	178.87139	44.812287	190
Slice 2	53.761391	516.92283	192.01571	353.71493	101.04088	190
Slice 3	59.253797	515.71076	267.64836	511.69752	152.49884	190
Slice 4	63.5	514.86088	320.68133	660.9906	212.64883	190
Slice 5	66.5	514.32124	354.35436	839.15316	302.93591	190
Slice 6	68.188424	514.03105	375.40183	956.76282	363.27466	190
Slice 7	71.454742	513.5399	457.00431	1,171.6028	446.53067	190
Slice 8	77.61053	512.70776	604.96029	1,562.4615	598.31313	190
Slice 9	83.766318	512.05084	741.98189	1,926.5541	740.20288	190
Slice 10	89.922106	511.5676	868.16684	2,261.6771	870.76189	190
Slice 11	94.5	511.30374	956.04651	2,488.3181	957.46953	190
Slice 12	100.5	511.1641	1,058.3602	2,738.6197	1,049.9427	190
Slice 13	106.5	511.10593	1,155.5902	2,901.8597	1,091.1903	190

Slice 14	111.16667	511.22256	1,200.6293	2,877.0302	1,047.5315	190
Slice 15	117.5	511.51486	1,240.2241	2,843.683	1,001.9523	190
Slice 16	123.83333	511.98965	1,268.4315	2,784.2952	947.21677	190
Slice 17	130.22731	512.6562	1,285.2263	2,699.9685	884.02907	190
Slice 18	136.68194	513.51981	1,290.2789	2,592.4107	813.66226	190
Slice 19	140.33133	514.07002	1,289.2711	2,525.18	772.28159	190
Slice 20	143.3767	514.61303	1,283.1968	2,460.0575	735.38418	190
Slice 21	147.5	515.38596	1,272.6186	2,435.0091	726.34218	190
Slice 22	152.5	516.4704	1,312.2468	2,513.0909	750.37068	190
Slice 23	158.57153	517.90802	1,341.4759	2,572.8352	769.43867	190
Slice 24	163.71458	519.28057	1,306.5016	2,609.0957	813.95114	190
Slice 25	169.25034	520.91337	1,259.1564	2,631.83	857.74164	190
Slice 26	175.17882	522.83241	1,197.8192	2,639.2275	900.69184	190
Slice 27	181.10729	524.93876	1,124.7941	2,628.7031	939.74661	190
Slice 28	187.03576	527.2382	1,039.7203	2,600.2125	975.10375	190
Slice 29	191.80962	529.21848	963.18591	2,530.9234	979.63114	190
Slice 30	193.80962	530.08446	928.85427	2,475.0325	966.15936	190
Slice 31	194.5	530.39277	927.09136	2,455.6885	955.17346	190
Slice 32	198.5	532.26834	934.8556	2,265.3266	831.37054	190
Slice 33	203.5	534.67452	1,049.9097	2,031.1828	613.16748	145
Slice 34	207.5	536.75096	1,076.3401	1,798.7329	451.40109	145
Slice 35	213.74088	540.20827	860.60409	1,381.2735	325.35038	145
Slice 36	221.22264	544.6791	581.62409	853.3867	169.81613	145
Slice 37	229.31963	550.0073	249.14466	341.52741	43.078784	0

APPENDIX G-2

Short-Term Static Slope Stability Analysis



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530
520
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490
480
470
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190
210
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250
270
290
310
330
350

Electronic Filing: Received, Clerk's Office 08/27/2020

Dallman Short Term Static

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 40
Date: 10/3/2016
Time: 1:54:59 PM
Tool Version: 8.14.1.10087
File Name: CWLP Dallman Short Term Static.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 1:55:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dallman Short Term Static

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Electronic Filing: Received, Clerk's Office 08/27/2020

Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (203, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
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Point 31	68	520
Point 32	65	520
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Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Electronic Filing: Received, Clerk's Office 08/27/2020

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 9
F of S: 2.897
Volume: 9,136.4623 ft³
Weight: 1,093,861.8 lbs
Resisting Moment: 47,499,602 lbs-ft
Activating Moment: 16,395,280 lbs-ft
Resisting Force: 357,222.23 lbs
Activating Force: 123,292.08 lbs
F of S Rank: 1
Exit: (42, 520) ft
Entry: (239.67574, 553) ft
Radius: 112.36371 ft
Center: (132.46693, 586.64336) ft

Slip Slices

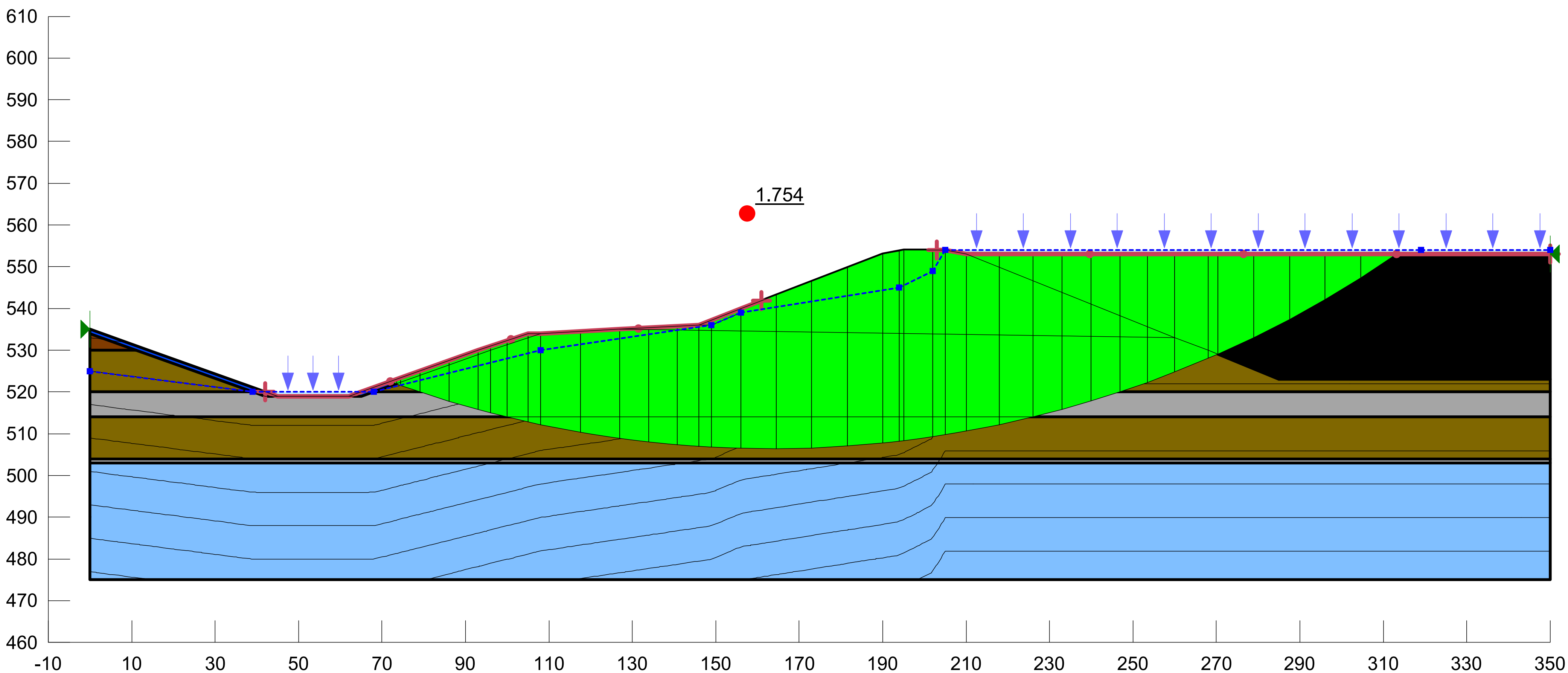
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	42.372628	519.5	31.2	73.027936	35.097806	0
Slice 2	43.872628	517.55435	152.60873	711.94304	0	1,000
Slice 3	45.871637	515.05435	308.60873	974.73547	0	1,000
Slice 4	51.540427	509	686.4	1,850.0351	0	1,400
Slice 5	56.88762	503.5	1,029.6	2,336.2148	881.32283	0
Slice 6	59.71883	501.06093	1,181.7983	3,000.1174	0	2,000
Slice 7	63.5	497.9554	1,375.5833	3,409.4613	0	2,000
Slice 8	66.5	495.70089	1,516.2646	3,784.4612	0	2,000
Slice 9	71.125	492.57502	1,760.0687	4,370.811	0	2,000
Slice 10	77.375	488.77803	2,094.5006	5,106.8708	0	2,000
Slice 11	83.625	485.50966	2,395.9473	5,767.5331	0	2,000
Slice 12	89.875	482.71971	2,667.54	6,353.5021	0	2,000
Slice 13	94.5	480.90039	2,853.2155	6,740.4066	0	2,000

Slice 14	100.5	479.02514	3,063.8314	7,152.3338	0	2,000
Slice 15	106.5	477.33213	3,263.075	7,458.84	0	2,000
Slice 16	110.94101	476.40154	3,371.4003	7,514.7108	0	2,000
Slice 17	116.82303	475.41364	3,486.7583	7,567.0138	0	2,000
Slice 18	123.38202	475	3,572.4641	7,392.9072	0	2,000
Slice 19	130.43835	475	3,636.9005	7,390.4633	0	2,000
Slice 20	137.31506	475	3,699.6965	7,383.8323	0	2,000
Slice 21	142.96161	475	3,751.2592	7,375.7445	0	2,000
Slice 22	145.58491	475.04879	3,772.1697	7,172.558	0	2,000
Slice 23	147.5	475.30011	3,773.9755	7,179.3671	0	2,000
Slice 24	152.5	476.13713	3,829.0431	7,210.3691	0	2,000
Slice 25	159.4	477.61149	3,864.1417	7,194.7724	0	2,000
Slice 26	166.2	479.52204	3,811.9215	7,137.3757	0	2,000
Slice 27	173	481.90854	3,730.0017	7,036.0639	0	2,000
Slice 28	179.8	484.80463	3,616.2836	6,889.9686	0	2,000
Slice 29	186.6	488.25558	3,467.9422	6,695.9509	0	2,000
Slice 30	192	491.37608	3,326.4275	6,468.2458	0	2,000
Slice 31	194.5	492.95696	3,263.0859	6,318.1096	0	2,000
Slice 32	198.5	495.83306	3,208.4168	5,963.0255	0	2,000
Slice 33	203.5	499.60223	3,238.4207	5,489.861	0	2,000
Slice 34	206.2481	501.91318	3,250.2175	5,189.8481	0	2,000
Slice 35	208.04624	503.5	3,151.2	5,153.528	1,350.5873	0
Slice 36	209.29814	504.65773	3,078.9575	4,990.2829	0	1,400
Slice 37	214.09529	509.65773	2,766.9575	4,364.4456	0	1,400
Slice 38	220.56223	517	2,308.8	3,606.2371	0	1,000
Slice 39	226.22135	525	1,809.6	2,420.3273	0	1,400

Slice 40	230.46996	531.7148	1,390.5962	1,289.2997	-0	1,800
Slice 41	233.64675	538.04232	995.7594	636.10168	-0	1,400
Slice 42	237.76908	547.82751	385.16317	531.44729	39.196713	0

APPENDIX G-3

Seismic Slope Stability Analysis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170
190
210
230
250
270
290
310
330
350

Dallman Short Term Seismic

File Information

- File Version: 8.14
- Created By: Karl Finke
- Last Edited By: Karl Finke
- Revision Number: 39
- Date: 10/3/2016
- Time: 2:01:36 PM
- Tool Version: 8.14.1.10087
- File Name: CWLP Dallman Short Term Seismic.gsz
- Directory: J:\CWLP Factor of Safety Report\SlopeW\
- Last Solved Date: 10/3/2016
- Last Solved Time: 2:01:42 PM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Dallman Short Term Seismic

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Electronic Filing: Received, Clerk's Office 08/27/2020

Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (203, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0.1
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
Point 30	93	530
Point 31	68	520
Point 32	65	520
Point 33	65	519
Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 42
F of S: 1.754
Volume: 6,598.2566 ft³
Weight: 766,725.5 lbs
Resisting Moment: 71,665,768 lbs-ft
Activating Moment: 40,847,042 lbs-ft
Resisting Force: 263,139.9 lbs
Activating Force: 149,983.87 lbs
F of S Rank: 1
Exit: (71.965012, 522.4875) ft
Entry: (313.22525, 553) ft
Radius: 265.53272 ft
Center: (162.97654, 771.93595) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	72.710494	522.21803	-64.921586	84.576094	70.967769	0
Slice 2	73.938352	521.77687	-18.238546	472.45788	0	1,400
Slice 3	76.758491	520.80259	86.550781	718.90818	0	1,400
Slice 4	82.57219	518.89551	296.24629	1,134.4225	0	1,000
Slice 5	89.524063	516.79035	536.05734	1,710.1262	0	1,000
Slice 6	94.5	515.38931	701.10704	2,105.3764	0	1,000
Slice 7	97.957845	514.49447	810.88759	2,362.8992	0	1,000
Slice 8	102.45784	513.40492	949.07567	2,767.0697	0	1,400
Slice 9	106.5	512.48332	1,069.641	2,986.2009	0	1,400
Slice 10	112.75	511.24165	1,213.8969	3,170.3135	0	1,400
Slice 11	122.25	509.5891	1,403.7668	3,429.6314	0	1,400
Slice 12	130.43835	508.42715	1,551.0464	3,605.8766	0	1,400
Slice 13	137.31506	507.6687	1,661.1696	3,715.8515	0	1,400

Slice 14	143.3767	507.14065	1,749.4733	3,787.6752	0	1,400
Slice 15	147.5	506.8589	1,804.7072	3,890.9901	0	1,400
Slice 16	152.5	506.63311	1,926.094	4,125.6573	0	1,400
Slice 17	160.25	506.45125	2,072.9157	4,430.4254	0	1,400
Slice 18	168.75	506.50004	2,153.6184	4,724.8943	0	1,400
Slice 19	177.25	506.8213	2,217.3194	4,975.4526	0	1,400
Slice 20	185.75	507.41601	2,263.9567	5,186.2206	0	1,400
Slice 21	192	508.00184	2,288.98	5,279.8551	0	1,400
Slice 22	194.5	508.28155	2,306.8313	5,276.83	0	1,400
Slice 23	198.5	508.81386	2,398.4152	5,183.9269	0	1,400
Slice 24	203.5	509.51802	2,619.6756	5,051.391	0	1,400
Slice 25	207.5	510.17489	2,734.6872	4,909.4629	0	1,400
Slice 26	214.00935	511.38541	2,659.1506	4,657.9989	0	1,400
Slice 27	222.02804	513.08535	2,553.0742	4,341.2089	0	1,400
Slice 28	229.50729	514.89814	2,439.9562	4,038.4685	0	1,000
Slice 29	236.4471	516.79547	2,321.5624	3,744.462	0	1,000
Slice 30	243.38691	518.89734	2,190.4062	3,435.4115	0	1,000
Slice 31	250.14261	521.14201	2,050.3384	3,081.8957	0	1,400
Slice 32	256.7142	523.52391	1,901.7079	2,742.488	0	1,400
Slice 33	264	526.40963	1,721.6393	2,341.8376	0	1,400
Slice 34	269.14655	528.55562	1,587.7296	2,046.5904	0	1,400
Slice 35	274.58632	531.04491	1,432.3974	2,013.5709	155.72496	0
Slice 36	283.17275	535.21394	1,172.2503	1,660.0611	130.7085	0
Slice 37	291.75918	539.77533	887.61932	1,267.4716	101.78111	0
Slice 38	300.3456	544.75278	577.02659	827.27814	67.054701	0
Slice 39	308.93203	550.17436	238.71985	329.37161	24.290066	0

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 3

AECOM

Submitted to
Illinois Power Resources
Generating, LLC
7800 S. Cilco Lane
Bartonville, IL 61607

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Ash Pond

At Edwards Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Ash Pond at the Illinois Power Resources Generating, LLC Edwards Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Ash Pond is located near Bartonville, Illinois in Peoria County, approximately 0.1 miles west of the Edwards Power Station. The Ash Pond serves as the wet impoundment basin for CCR material produced by the Edwards Power Station.

The Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Ash Pond. The exploration consisted of auger borings, cone penetrating testing, and laboratory program including index, strength, and consolidation testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Ash Pond consist of a soft to very stiff compacted ash and clay dike, overlying stiff alluvial clay, overlying soft to medium stiff alluvial clay, which in turn overlies shale bedrock. Phreatic water is typically located above the embankment/foundation interface beneath the crest of the dike, and at the embankment/foundation interface near the toe of the dike.

Ten (10) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Ash Pond dikes. As a result, this loading condition is not applicable to the Ash Pond at the Edwards Power Station.

Results of the Initial Safety Factor Assessments, for the critical cross-section, (i.e., the lowest calculated factor of safety out of the cross sections analyzed for each loading condition) are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessment

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.54
Maximum Surcharge Pool Loading	(ii)	1.40	1.54
Seismic	(iii)	1.00	1.08
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Resources Generating, LLC; Edwards Power Station; Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER JR
Printed Name

10/13/16
Date

VICTOR ALBERT MODEER JR.
062-043112
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS
11/30/17

About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

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The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 4

Geosyntec consultants

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STRUCTURAL STABILITY AND FACTOR OF SAFETY ASSESSMENT ASH POND 2 JOLIET 29 STATION OCTOBER 2016

This report presents the initial periodic structural stability and initial safety factor assessment of the Ash Pond 2 at the Joliet 29 Station (Site) in Joliet, Illinois (Figure 1). This report addresses the initial structural stability and safety factor assessment requirements of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257, Subpart D (referred to as the CCR Rule). These regulations were published in the Federal Register on 17 April 2015 and became effective on 19 October 2015. The Joliet 29 Station is owned and operated by Midwest Generation, LLC (Midwest Generation). Based on the results provided in this report, Ash Pond 2 meets the requirements of §257.73(d) and §257.73(e) of the CCR Rule.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec Consultants, Inc. (Geosyntec) in accordance with §257.73(d) and §257.73(e). Mr. Robert White reviewed this report in accordance with Geosyntec's senior review policy.

1. Regulation Requirements - §257.73

Structural integrity criteria for existing CCR impoundments is described in §257.73 and includes structural stability and factor of safety assessments. Ash Pond 2 meets the minimum size and capacity criteria under §257.73(b) and is subject to the periodic structural stability and safety factor assessments required.

2. Site Conditions

Ash Pond 2 is approximately 500 feet by 280 feet in plan area and is located approximately 70 feet south of U.S. Route 6, east of Pond 1, west of the east entrance to the Joliet 29 Station, and north of the silo building at the Site. The pond is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north toward U.S. Route 6. Ash Pond 2 is currently lined with a 60-mil high density polyethylene (HDPE) geomembrane. A concrete retaining wall is located along the southern perimeter of Ash Pond 2, north of the silo building.

Based on available documentation and discussions with site personnel, Ash Pond 2, in its current configuration, was constructed in the late 1970s. A history of construction for the pond was prepared in accordance with §257.73(c) and describes the design of the Ash Pond 2 and its construction (Geosyntec, 2016a).

3. Structural Stability Assessment

The following subsections address the components of §257.73(d)(1).

3.1 Foundations and Abutments – §257.73(d)(1)(i)

Site observations and construction documents show Ash Pond 2 is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north; however, Site investigations indicate that fill material may be present along the northern boundary. For engineering purposes, material located along the northern embankment is considered consistent with embankment fill. Native materials do not provide lateral support for the embankments and therefore the pond does not include abutments. The remainder of this section addresses the foundation materials for the pond's embankments.

Previous subsurface investigations performed at the Site indicate that the foundation materials underlying the embankments for Ash Pond 2 generally consist of approximately 20 to 30 feet of medium dense to very dense sand and gravel (Geosyntec, 2016b). Due to the granular nature of the foundation soils (sand and gravel), foundation settlement associated with the construction and operation of Ash Pond 2 is anticipated to be predominately elastic settlement, which would have likely occurred soon after construction in the late 1970s. Because of the age of the embankments (over 35 years old), it is very likely that any potential consolidation and secondary compression settlement has also occurred. Further, the Ash Pond 2 embankments were not constructed with abutments or separate engineered zones that would be most susceptible to the adverse effects of differential settlement. During the initial annual inspection performed for Ash Pond 2 in accordance with §257.83(b), no visual evidence of adverse effects resulting from settlement was observed (Geosyntec, 2016c). There are no proposed changes in operation which would increase loading conditions on the foundation; therefore, no significant settlement of the foundation materials underlying the embankments is anticipated to occur in the future and the settlement of the foundation is not anticipated to impact the integrity of the impoundment embankments.

A factor of safety against the triggering of liquefaction was calculated for saturated foundation materials underlying the Ash Pond 2 embankments. The factor of safety was calculated based methods outlined in Idriss and Boulanger (2008) using information obtained from field explorations, including borings, Cone Penetration Test (CPT) soundings, and laboratory data (Geosyntec, 2016b) and seismic data (Geosyntec, 2016d). The triggering analysis indicated a very low likelihood of liquefaction occurring in the foundation materials underlying the embankments (Geosyntec, 2016d).

3.2 Upstream Slope Protection – §257.73(d)(1)(ii)

Ash Pond 2 is lined with a 60-mil high density polyethylene (HDPE) geomembrane that protects the interior pond slopes from erosion, the effects of wave action, and mitigates effects of rapid drawdown.

3.3 Dike Compaction – §257.73(d)(1)(iii)

Because as-built construction documentation for Ash Pond 2 was not available at the time of this assessment, no quantitative evaluation of the degree of compaction of the embankments was performed. However, slope stability analyses show that the embankments for Ash Pond 2 are sufficient to withstand the range of loading conditions in the CCR unit (Geosyntec, 2016e).

3.4 Downstream Slope Protection – §257.73(d)(1)(iv)

The western downstream slope for Ash Pond 2 is the interior slope of Pond 1 and is lined with a geomembrane that provides erosion protection. Based on site observations in October 2015, the surfaces of eastern and southern downstream slopes for the Ash Pond 2 embankments consist of sandy gravel, gravelly sand, gravel, and some cobbles and include sparse vegetation. Based on site observations, the existing surface conditions of the slopes provide adequate slope protection.

3.5 Spillway – §257.73(d)(1)(v)

Ash Pond 2 was designed and constructed, and is operated and maintained, without an emergency spillway. Ash Pond 2 was constructed with elevated embankments on the south, east, and west perimeters. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north. There is a 5-foot high, non-structural berm that exists between Ash Pond 2 and US route 6, which prevents run-on from US route 6. There is no significant run-on to the basins. Inflows for the pond consist solely of regulated flows from plant operations and precipitation that falls within the surface area of the pond and embankment crests. Surface water levels are maintained by regulating inflow from plant operations and maintaining operating levels. An inflow design flood control system plan has been prepared to document that the Basins adequately manage flow from the 1,000 year flood event (Geosyntec, 2016f).

3.6 Structural Integrity of Hydraulic Structures – §257.73(d)(1)(vi)

Hydraulic structures passing through or beneath the embankments of Ash Pond 2 consist of outlet pipes associated with Pond 1 and Ash Pond 2, as presented in Figure 2. These pipes were inspected on 9 June 2016 by a company specializing in video camera pipe inspections. No significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris that would negatively affect operation of the pipes was observed during inspection of these outlet pipes.

3.7 Downstream Slopes Adjacent to Water Bodies – §257.73(d)(1)(vii)

The only water body adjacent to Ash Pond 2 is Pond 1, located west of Ash Pond 2. When operated, Pond 1 will impound water against the western downstream slope of Ash Pond 2. The slope stability analyses presented in Geosyntec (2016e) consider a "low pool" condition for Pond 1 where no water is present in Pond 1 to provide a stabilizing force on the downstream face of the western slope of Ash Pond 2.

When Pond 1 is operated and water is impounded against the downstream face of the western slope of Ash Pond 2, the impounded water is unlikely to infiltrate into the embankment because Pond 1 is lined with a 60-mil HDPE geomembrane. Therefore, a rapid drawdown condition is not applicable to the western embankment of Ash Pond 2 and was not analyzed.

3.8 Structural Stability Assessment Deficiencies - §257.73(d)(2)

No structural stability deficiencies associated with Ash Pond 2 were identified in this initial structural stability assessment and no corrective measures are required.

3.9 Annual Inspection Requirement - §257.83(b)(4)(ii)

In accordance with §257.83(b)(4)(ii), submittal of this structural stability assessment precludes the requirement of an annual inspection under §257.83(b) for Ash Pond 2 during the 2016 calendar year.

4. Safety Factor Assessment

This section describes the initial safety factor assessment for Ash Pond 2 and the methodology used to perform the assessment in accordance with §257.73(e)(1). This assessment summarizes slope stability analyses of the critical embankment cross-section, shown in Figure 3, and evaluation of stability of the retaining wall southeast of the pond.

4.1 Slope Stability Methodology

Limit equilibrium slope stability analyses were performed to evaluate the stability of the embankments for Ash Pond 2. The process involved performing two-dimensional analyses on the critical cross-section for Ash Pond 2 using Spencer's Method as coded in the computer program SLOPE/W (Version 8.15.4.11512, www.geoslope.com) which satisfies vertical and horizontal force equilibrium and moment equilibrium (Geosyntec, 2016e). For each cross section analyzed, the program searches for the sliding surface that produces the lowest factor of safety

(FS). Factor of safety is defined as the ratio of the shear forces/moments resisting movement along a sliding surface to the forces/moments driving the instability.

Subsurface stratigraphy, groundwater conditions, and engineering parameters for the embankment and foundation materials were developed based on previous subsurface investigations performed at the Site (Geosyntec, 2016b and Geosyntec, 2016e).

4.2 Slope Stability Analyses

Four cases were analyzed to satisfy the safety factor assessment requirements in §257.73(e) (Geosyntec, 2016e).

4.2.1 Static, Long-Term Maximum Storage Pool Loading – §257.73(e)(1)(i)

Pursuant to §257.73(e)(1)(i) a static, long-term condition with the maximum operating pool loading on the embankments was evaluated. For Ash Pond 2, this condition included a pool elevation at 2 feet below the top of the embankments (Geosyntec, 2016e).

4.2.2 Static, Maximum Storage Pool Loading – §257.73(e)(1)(ii)

The conditions for §257.73(e)(1)(ii) are identical to §257.73(e)(1)(i) with the exception of the pool elevation, which is set at the top of the embankment (Geosyntec, 2016e).

4.2.3 Seismic – §257.73(e)(1)(iii)

Pursuant to §257.73(e)(1)(iii), a seismic condition for Ash Pond 2 was also analyzed. Seismic stability was evaluated with a pseudostatic analysis that uses constant horizontal accelerations to represent the effects of earthquake shaking. The horizontal accelerations are represented in SLOPE/W by a horizontal seismic coefficient. The horizontal seismic coefficient used for analysis was based on a peak ground acceleration with a 2 percent probability of exceedance in 50 years (Geosyntec, 2016g).

4.2.4 Liquefaction – §257.73(e)(1)(i)

The Ash Pond 2 embankment soils are assumed to be unsaturated. Based on quarterly groundwater monitoring in the vicinity of Ash Pond 2, groundwater is approximately 8 feet below the bottom of the pond. Further, the embankments are lined with an HDPE geomembrane liner that limits infiltration into the embankments and makes saturation of the embankments unlikely. Because the embankment soils are unlikely to be saturated and therefore are not considered susceptible to liquefaction, the calculation of a factor of safety for post-liquefaction slope stability is not required.

4.3 Results

The results of the slope stability analysis for the critical cross section of the Ash Pond 2 embankments are summarized in Table 1 below and presented in Figures 4 through 6 (Geosyntec 2016e).

Table 1: Safety Factor Results

Section	Safety Factor			
	257.73(e)(1)(i)	257.73(e)(1)(ii)	257.73(e)(1)(iii)	257.73(e)(1)(iv)
1	≥1.50	≥1.40	≥1.00	N/A

The results of the slope stability analyses meet the minimum safety factors requirements presented in §257.73(e)(1)(i) through §257.73(e)(1)(iii).

4.4 Retaining Wall Analyses

Stability of the retaining wall located on the southwest portion of the southern embankment of Ash Pond 2 was also evaluated (Geosyntec, 2016h). Construction drawings for the wall and site observations indicate that it is a reinforced concrete cantilever type wall. As-built construction documentation for the wall was not available. Inputs for the analyses were based on information provided in the construction drawings and developed from subsurface investigations at the Site (Geosyntec, 2016h and Geosyntec, 2016b). Factors of safety for bearing capacity, overturning, and sliding were calculated for the wall and results indicate that the factors of safety exceed minimum industry standard values (Geosyntec, 2016h).

5. Limitations and Certification

This initial periodic structural stability and safety factor assessment meets the requirements of §257.73(d) and §257.73(e) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.

JANE W. SOULE
062-067766
LICENSED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS

Jane W. Soule

Jane W. Soule, P.E.
Illinois Professional Engineer No. 062-067766
Expiration Date: 11/30/2017

6. References

Geosyntec (2016a). History of Construction Report, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016b). Soil Properties Calculations, Joliet 29 Station, October.

Geosyntec (2016c). Annual Inspection Report, Ash Pond 2, Joliet 29 Station, 18 January 2016.

Geosyntec (2016d). Liquefaction Calculations, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016e). Slope Stability Calculations, Joliet 29 Station, October.

Geosyntec (2016f). Inflow Design Flood Control System Plan, Ash Pond 2, Joliet 29 Generating Station, October.

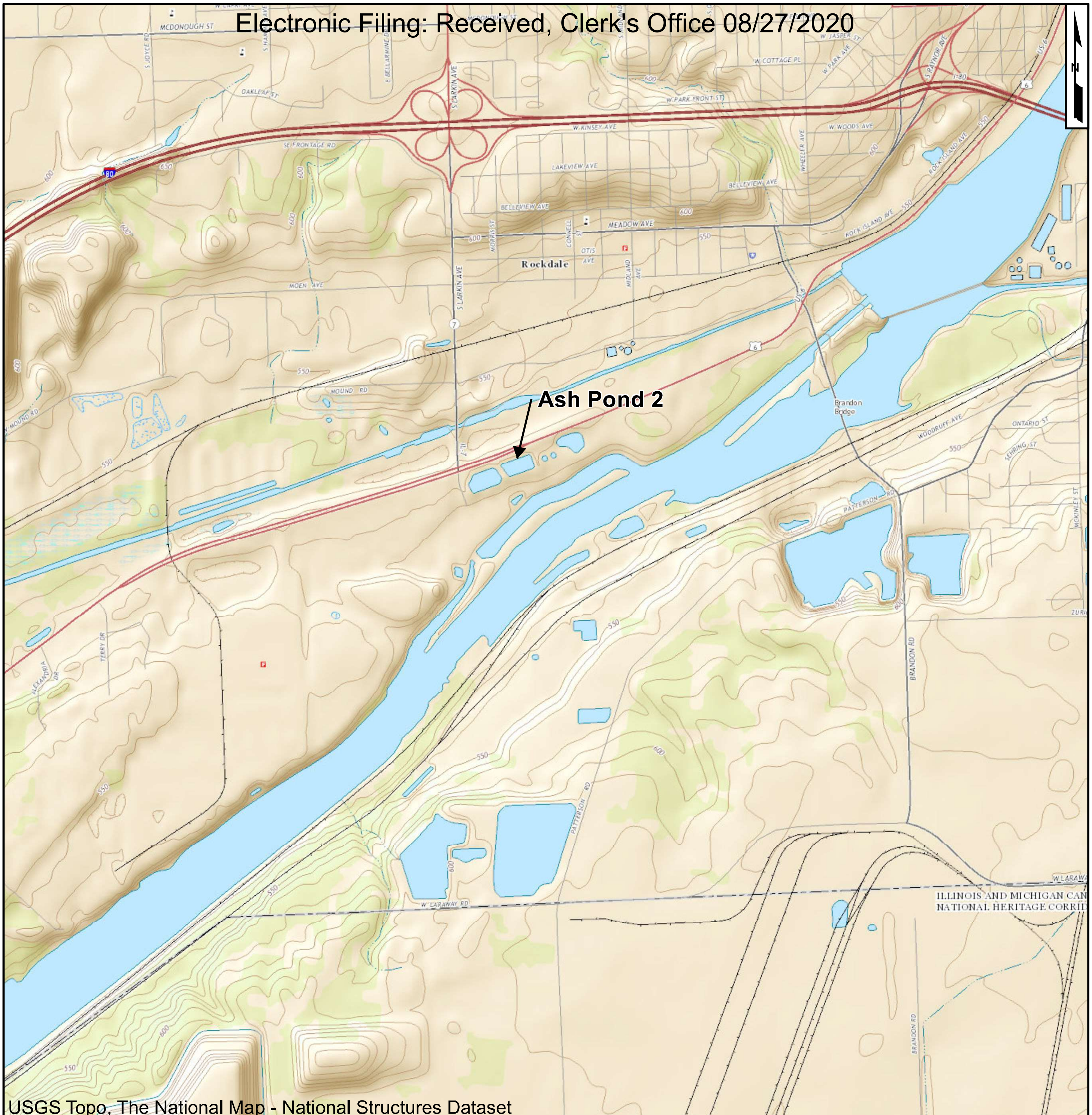
Geosyntec (2016g). Seismic Coefficient Calculations, Joliet 29 Station, October.

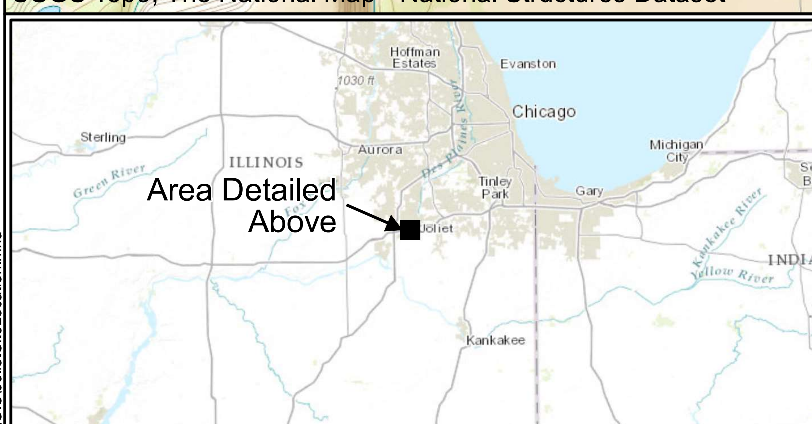
Geosyntec (2016h). Retaining Wall Calculations, Joliet 29 Station, October.

Idriss and Boulanger (2008). "Soil Liquefaction During Earthquakes". Earthquake Engineering Research Institute, MNO-12.

<u>Attachments</u>

Figure 1 – Site Location
Figure 2 – Hydraulic Structure Locations
Figure 3 – Critical Cross Section
Figure 4 – Slope Stability Output, Section 1 - 257.73(e)(1)(i)
Figure 5 – Slope Stability Output, Section 1 - 257.73(e)(1)(ii)
Figure 6 – Slope Stability Output, Section 1 - 257.73(e)(1)(iii)





2,000 1,000 0 2,000 Feet

Site Location

Ash Pond 2
Joliet 29 Station
Joliet, Illinois

Geosyntec consultants

San Diego	October 2016	Figure 1

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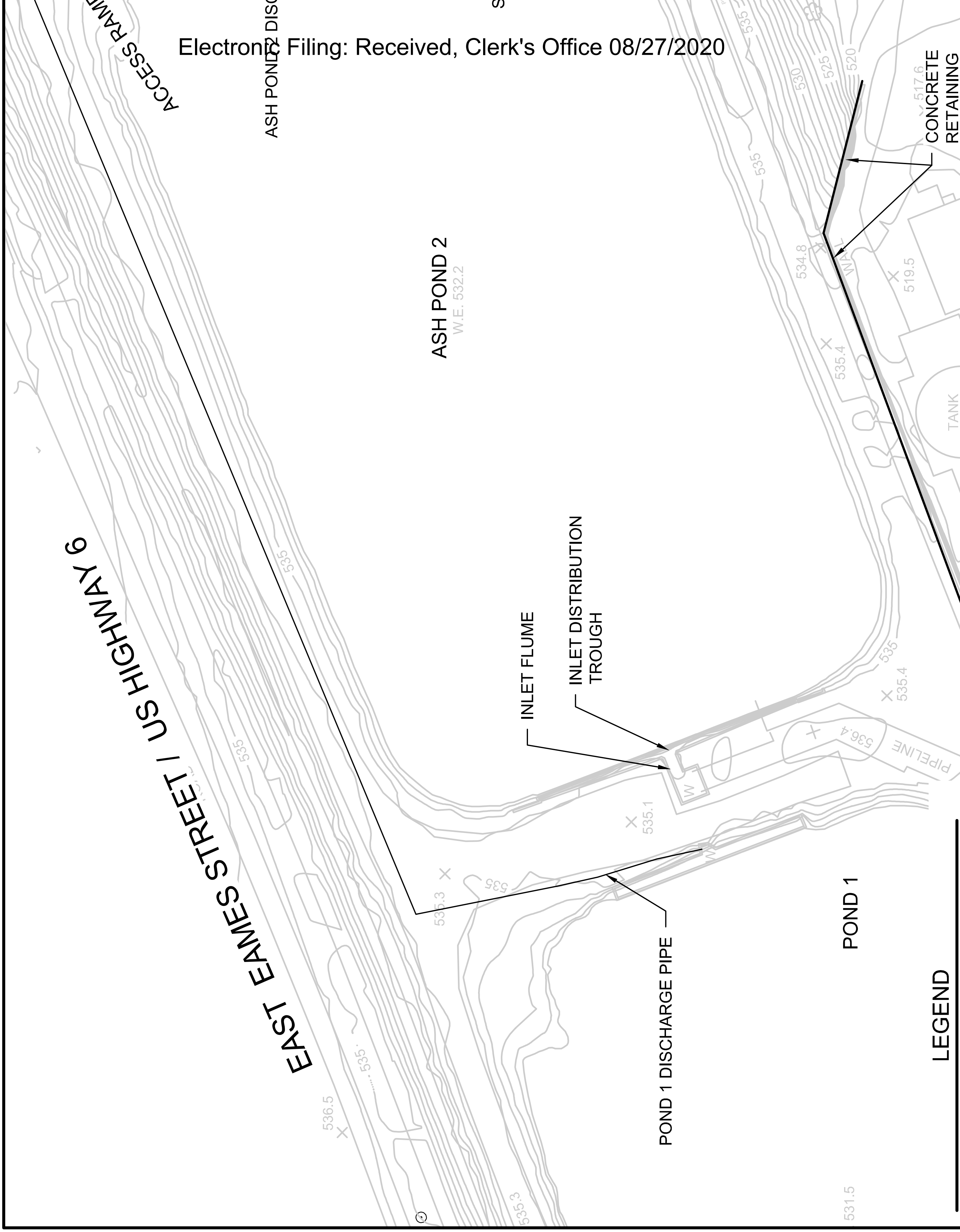
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ASH POND 2
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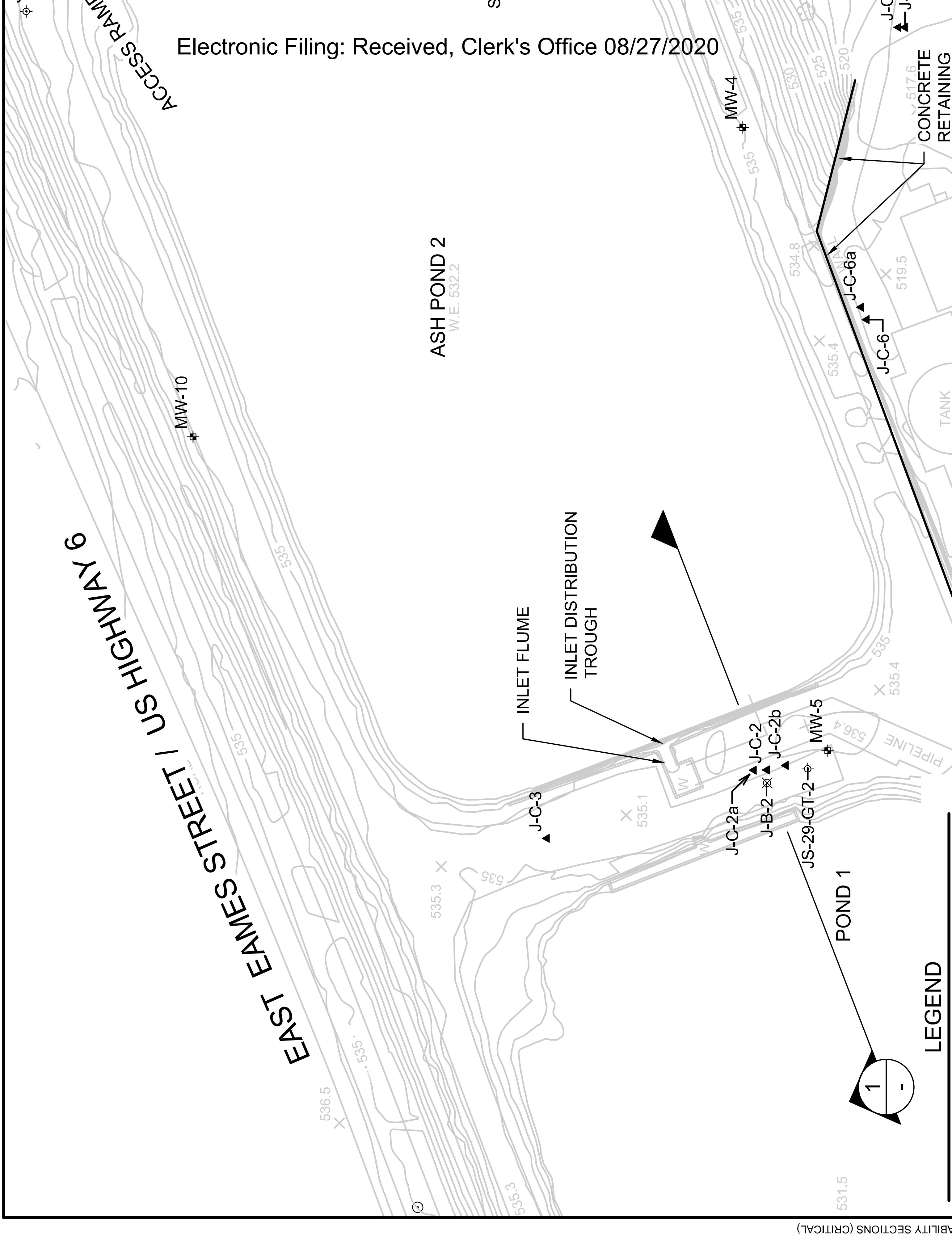
RETAINING
WALL
TANK
INLET FLUME
INLET DISTRIBUTION
TROUGH
PIPELINE
POND 1 DISCHARGE PIPE
POND 1
EAST EAMES STREET / US HIGHWAY 6
LEGEND
535
534.8
535.4
519.5
535.1
535.3
536.4
536.5
531.5


ASH POND 2
W.E. 532.2
ACCESS RAMP
EAST EAMES STREET / US HIGHWAY 6
MW-10
MW-4
MW-5
CONCRETE RETAINING
J-C-6a
J-C-6
TANK
INLET FLUME
INLET DISTRIBUTION TROUGH
J-C-3
J-C-2a
J-C-2
J-C-2b
J-B-2
JS-29-GT-2
PIPELINE
POND 1
LEGEND
1
-
535
536.5
535.3
535.1
535.4
534.8
519.5
517.6
536.4
531.5
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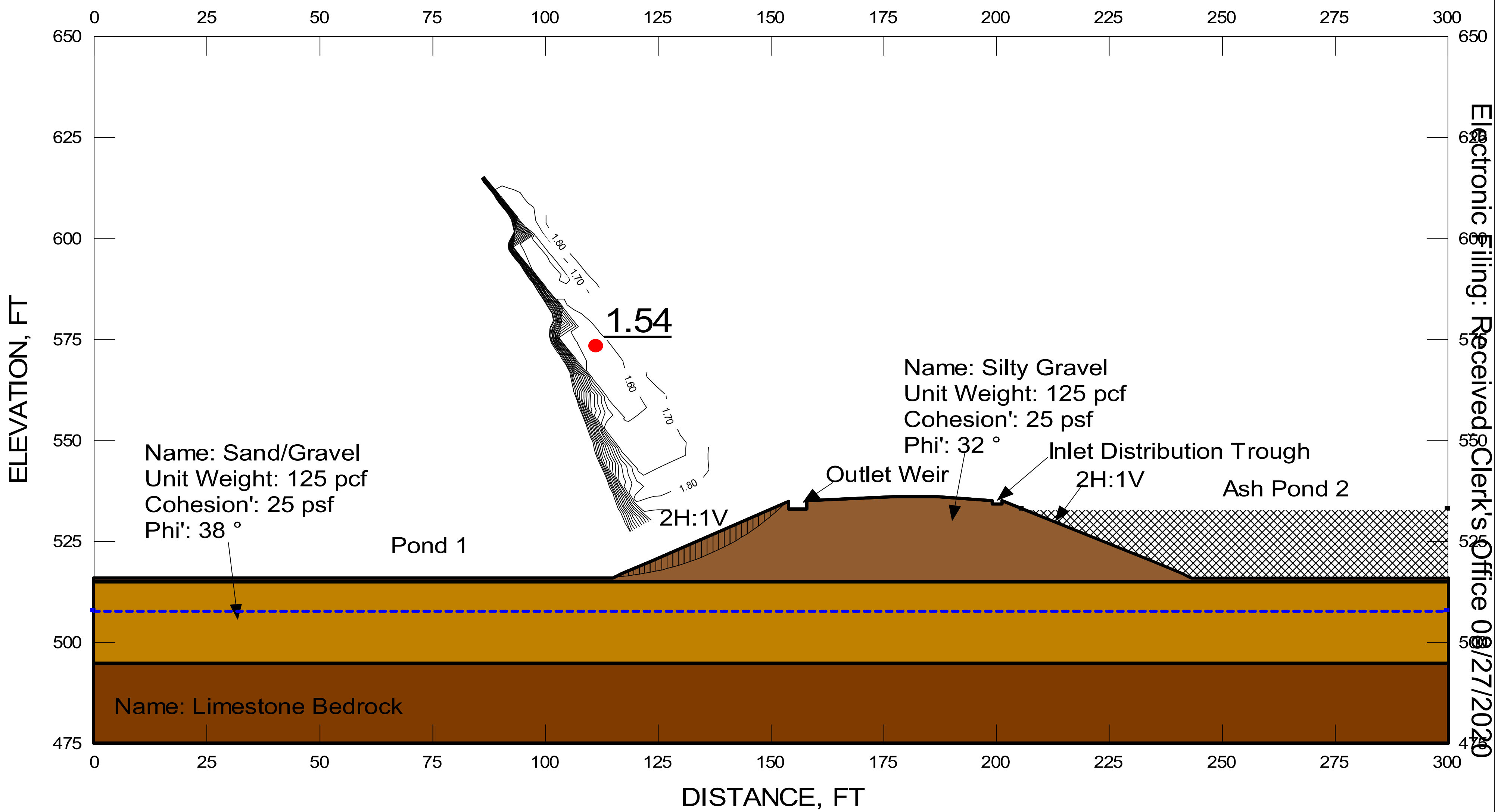
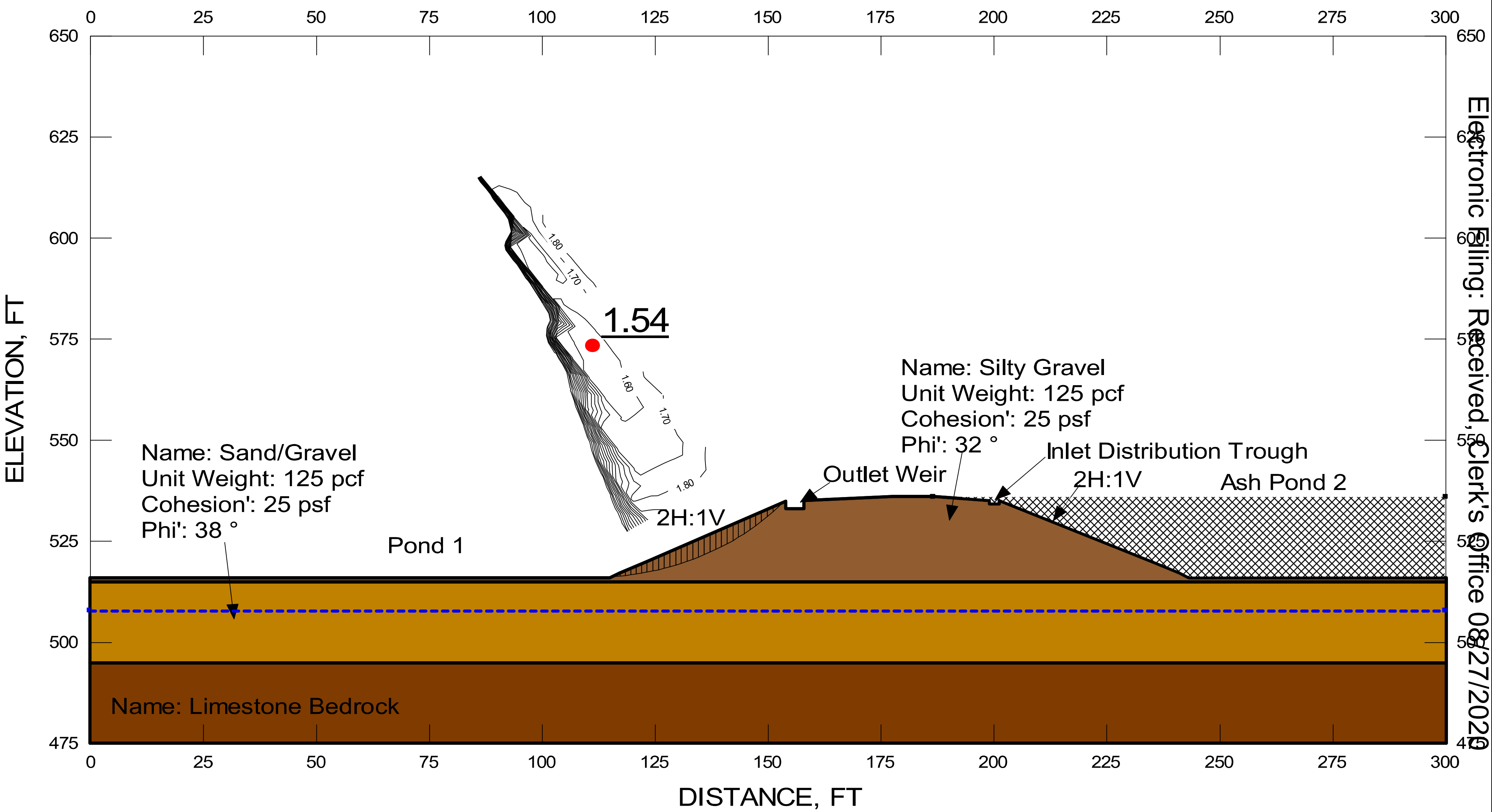
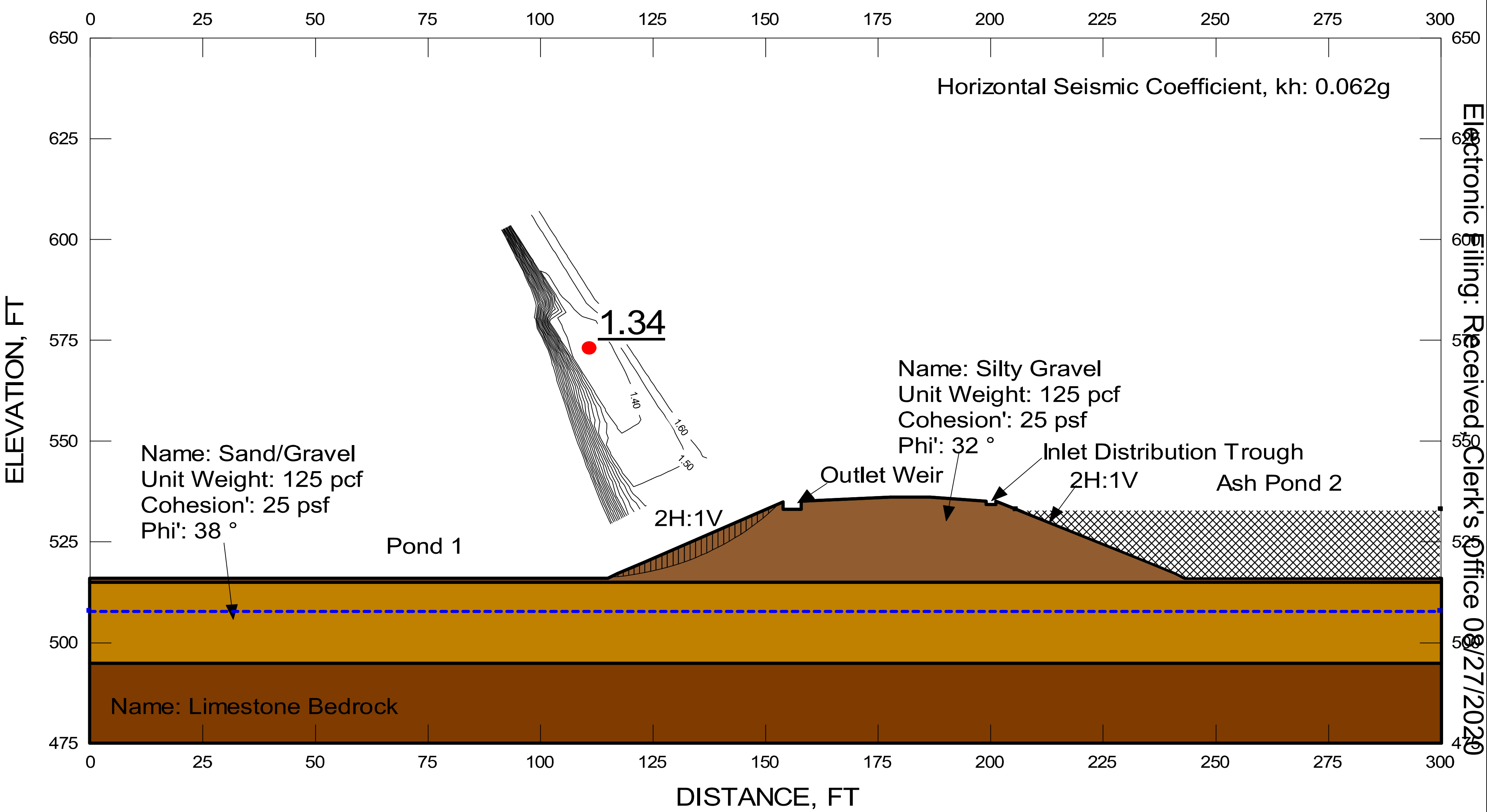


Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		FIGURE 4
	Project: Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name: Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading		FIGURE 5
	Project: Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name: Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	



Geosyntec consultants	Analysis	Section 1 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		FIGURE 6
	Project	Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name	Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 5

AECOM

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Submitted by
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October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

East Ash Pond

At Joppa Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the East Ash Pond at the Electric Energy, Inc. (EEI) Joppa Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The East Ash Pond is located near Joppa, Illinois in Massac County, approximately 0.1 miles northeast of the Joppa Power Station. The East Ash Pond serves as the ash impoundment basin for CCRs produced at the Joppa Power Station.

The East Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.
(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the East Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration testing with seismic wave velocity measurements and pore pressure dissipation testing, piezometer installation and monitoring, and a laboratory program including strength and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

The East Ash Pond embankment is generally medium stiff to stiff and overlies predominantly alluvial foundation materials. The alluvial foundation consists of soft to stiff clay overlying medium dense to dense sand. A zone of sluiced flyash that existed before the embankment dike was constructed was encountered below the compacted embankment in the southeast corner. The zone of sluiced flyash was modified by the installation of Deep Mixing Method (DMM) ground improvement technology using the wet soil mixing method. Explorations were terminated in the soil overburden and were not extended to bedrock. The phreatic surface is typically at or slightly above the embankment/foundation interface.

Six (6) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the CCR unit. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the East Ash Pond dikes. As a result, this loading condition is not applicable to the East Ash Pond at the Joppa Power Station.

Results of the Initial Safety Factor Assessments, for the critical cross-section for each loading condition (i.e., the lowest calculated factor of safety out of the cross sections analyzed for each loading condition), are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.59
Maximum Surcharge Pool Loading	(ii)	1.40	1.57
Seismic	(iii)	1.00	1.01
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the East Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Electric Energy, Inc.; Joppa Power Station; East Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 14, 2016 meets the requirements of 40 CFR §257.73.

Victor A. Modeer Jr

Printed Name

10/14/16

Date

VICTOR ALBERT MODEER JR.
062-043112
REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

11/30/17

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ATTACHMENT 6

Submitted to
Kincaid Generation, LLC
199 Route 104
Kincaid, IL 62540

Submitted by
AECOM
1001 Highlands Plaza Drive West
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St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Kincaid Ash Pond

At Kincaid Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Kincaid Ash Pond at the Kincaid Generation, LLC Kincaid Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Kincaid Ash Pond is located near Kincaid, Illinois in Christian County, approximately 0.1 miles northeast of the Kincaid Power Station. The Kincaid Ash Pond serves as the wet impoundment basin for CCR produced by the Kincaid Power Station.

The Kincaid Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Kincaid Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration tests, installation of piezometers, and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Kincaid Ash Pond consist of medium stiff to very stiff embankment fill (clay) overlying soft to very stiff clay foundation soils, which in turn overlies hard glacial till (clay). Phreatic water is typically at or slightly above the embankment/foundation interface.

Five (5) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Kincaid Ash Pond dikes. As a result, this loading condition is not applicable to the Kincaid Ash Pond.

Results of the Initial Safety Factor Assessments for the critical cross-section for each loading condition are listed in Table 1 (i.e. the table identifies the lowest calculated safety of factor calculated for any one of the five analyzed cross sections for each loading condition).

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.57
Maximum Surcharge Pool Loading	(ii)	1.40	1.57
Seismic	(iii)	1.00	1.27
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Kincaid Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Kincaid Generation, LLC; Kincaid Power Station; Kincaid Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER
Printed Name

10/13/16
Date

VICTOR ALBERT MODEER JR.
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OF
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ATTACHMENT 7

AECOM

Submitted to
Illinois Power Generating Company
6725 North 500th Street
Newton, IL 62448

Submitted by
AECOM
1001 Highlands Plaza Drive West
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St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Primary Ash Pond

At Newton Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Primary Ash Pond at the Illinois Power Generating Company Newton Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Primary Ash Pond is located near Newton, Illinois in Jasper County, approximately 0.2 miles southwest of the Newton Power Station. The Primary Ash Pond serves as the wet impoundment basin for CCR produced by the Newton Power Station.

The Primary Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Primary Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration testing, piezometer installation and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Primary Ash Pond consist of medium stiff to stiff embankment fill (clay) overlying stiff to hard clay, which in turn overlies very stiff to very hard glacial till. Phreatic water is above the embankment/foundation of the Primary Ash Pond.

Ten (10) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Primary Ash Pond dikes. As a result, this loading condition is not applicable to the Primary Ash Pond at the Newton Power Station.

Results of the Initial Safety Factor Assessments for the critical cross-section for each loading condition (i.e., the lowest calculated factor of safety out of the 10 cross sections analyzed for each loading condition) are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.66
Maximum Surcharge Pool Loading	(ii)	1.40	1.66
Seismic	(iii)	1.00	1.07
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Primary Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Generating Company; Newton Power Station; Primary Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER JR.
Printed Name

10/13/16
Date

VICTOR ALBERT MODEER JR.
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ATTACHMENT 8

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STRUCTURAL STABILITY AND FACTOR OF SAFETY ASSESSMENT
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2016

This report presents the initial periodic structural stability and initial safety factor assessment of the East and West Ash Basins (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois (Figure 1). This report addresses the initial structural stability and safety factor assessment requirements of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257, Subpart D (referred to as the CCR Rule). These regulations were published in the Federal Register on 17 April 2015 and became effective on 19 October 2015. The Waukegan Station is owned and operated by Midwest Generation, LLC (Midwest Generation). Based on the results provided in this report, the East and West Ash Ponds meet the requirements of §257.73(d) and §257.73(e) of the CCR Rule.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec Consultants Inc. (Geosyntec) in accordance with §257.73(d) and §257.73(e). Mr. Robert White reviewed this report in accordance with Geosyntec's senior review policy.

1. Regulation Requirements - §257.73

Structural integrity criteria for existing CCR impoundments is described in §257.73 and includes structural stability and factor of safety assessments. The East and West Ash Basins meet the minimum size and capacity criteria under §257.73(b) and are subject to the structural stability and safety factor assessments required.

2. Site Conditions

The Basins are co-located in the southeastern portion of the Waukegan Station. A divider berm extends north-south between the Basins. The Basins are irregular in shape, and each includes a finger berm extending from the northern boundary southward approximately 715 feet. The West Ash Basin is approximately 470 feet by 975 feet in plan dimensions with a total plan area of approximately 11.0 acres (including the finger berm and embankment crests). The East Ash Basin is approximately 470 feet by 1,030 feet in plan dimensions with a total plan area of approximately 11.8 acres (including the finger berm and embankment crests).

A retaining wall is located on the downstream side of the north embankment, north of the outlet structures for the Basins.

Based on available documentation and discussions with site personnel, the Basins, in their current configuration, were constructed in the late 1970s. A history of construction for the Basins was prepared in accordance with §257.73(c) and describes the design of the Basins and their construction (Geosyntec, 2016a).

3. Structural Stability Assessment

The following subsections address the components of §257.73(d)(1).

3.1 Foundations and Abutments – §257.73(d)(1)(i)

The East and West Ash Basins consist of fill embankments on all sides. The area west of the West Ash Basin includes fill graded to approximately the same elevation as the west embankment crest. Because no formational material provides lateral structural support for the embankments, there are no abutments associated with the Basins. The remainder of this section addresses the foundation materials for the East and West Ash Basins.

Previous subsurface investigations performed at the Site indicate the foundation materials underlying the embankments for the East and West Ash Basins generally consist of approximately 30 feet of dense, poorly graded sand with some gravel, and silt and silty sand associated with the Henry Formation (Geosyntec, 2016b). Due to the granular nature of the foundation soils (mostly sand and gravel), settlement associated with the construction and operation of the Basins is anticipated to be predominately elastic settlement, which would likely have occurred soon after construction in the late 1970s. Because of the age of the embankments (over 35 years old), the majority of potential consolidation and secondary compression settlement has likely already occurred. Further, the embankments of the Basins were not constructed with abutments or separate engineered zones that would be most susceptible to the adverse effects of differential settlement.

During the initial annual inspection performed for the Basins in accordance with §257.83(b), no visual evidence of adverse effects resulting from settlement was observed (Geosyntec, 2016c). There are no proposed changes in operation which would increase loading conditions on the foundation; therefore, no significant settlement of the foundation materials underlying the embankments is anticipated to occur in the future and the settlement of the foundation is not anticipated to impact the integrity of the impoundment embankments.

A factor of safety against the triggering of liquefaction was calculated for saturated foundation materials underlying the Basins' embankments. The factor of safety was calculated based methods outlined in Idriss and Boulanger (2008) using information obtained from field explorations, including borings, Cone Penetration Test (CPT) soundings, laboratory data (Geosyntec, 2016b), and seismic data (Geosyntec, 2016d). The liquefaction triggering analyses shows a very low likelihood of liquefaction occurring in the foundation materials underlying the embankments (Geosyntec, 2016d).

3.2 Upstream Slope Protection – §257.73(d)(1)(ii)

The West and East Basins are lined with a 60-mil high density polyethylene (HDPE) geomembrane that protects the interior basin slopes from erosion, the effects of wave action, and mitigates potential effects of rapid drawdown.

3.3 Dike Compaction – §257.73(d)(1)(iii)

Documentation of as-built construction conditions for the East and West Ash Basin embankments was not available at the time of this report. However, available construction drawings from 1977 indicated that embankment fill was to be compacted to a minimum of 95 percent relative compaction as determined by Modified Proctor testing. No recent quantitative evaluation of the degree of compaction of the embankments was performed on the embankments in their current state; however, slope stability analyses shows the embankments for the East and West Ash Basins are sufficient to withstand the range of loading conditions in the CCR units (Geosyntec, 2016e).

3.4 Downstream Slope Vegetation – §257.73(d)(1)(iv)

The northern and southern downstream slopes of the West and East Ash Basins are covered with established vegetation. The eastern downstream slope of the East Ash Basin has been recently covered in erosion control matting and seeded. Based on site observations, the existing surface conditions of the slopes provide adequate slope protection.

3.5 Spillway – §257.73(d)(1)(v)

The West and East Basins were designed and constructed, and are operated and maintained, without spillways. Inflows for the Basins consist solely of regulated flows from plant operations and precipitation that falls within the surface area of the Basins and embankment crests. There is no significant run-on to the Basins. Subsequently, surface water levels are maintained by regulating inflow from plant operations, regulating outflow quantities, and monitoring and maintaining freeboard to accommodate precipitation from the design storm event. An inflow design flood control system plan has been prepared to document that the Basins adequately manage flow from the design event (Geosyntec, 2016f).

3.6 Structural Integrity of Hydraulic Structures – §257.73(d)(1)(vi)

Hydraulic structures passing through or beneath the embankments of the East and West Ash Basins consist of six pipes and conveyance structures associated with the inlet and outlet structures of the Basins. These structures and pipes were inspected between 1 June 2016 and 7 June 2016 by a company specializing in video camera pipe inspections. Inspections consisted only of the length of the pipe or structure that passes through or beneath the Basins' embankments. The inspected structures and pipes related to the East and West Ash Basins are presented on Figure 2.

The video inspections showed no significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris that would negatively affect the operation of Pipes 1, 2, 3, and 5. The video inspections identified isolated areas of deformation and deterioration of Pipes 4E and 4W, which are 24-inch diameter concrete pipes with invert locations at the bottom of the outlet structures for the East and West Ash Basins, respectively. These pipes are located under the north embankment and are utilized for dewatering the outlet structure. Repairs were made to Pipe 4E to mitigate the isolated areas of deformation and deterioration identified during the inspection. The valve for controlling flow into Pipe 4W has been closed by Site personnel, and Pipe 4W will not be used until a repair is completed. Pipe 4W is not required for normal operation of the West Ash Basin.

3.7 Downstream Slopes Adjacent to Water Bodies – §257.73(d)(1)(vii)

Water bodies near the East and West Ash Basins include a drainage channel located south of the Basins and marsh area east of the Basins. Stability analyses presented in Section 3 demonstrate structural stability with the water body at a "low pool" condition where there is little or no stabilizing force present on the downstream slope of the embankments.

Significant inundation of the downstream slopes of the East and West Ash Basins from the water body is unlikely, and the generally coarse-grained embankment fill materials that are relatively free-draining make a rapid drawdown analysis not applicable. Therefore, a rapid drawdown condition is not anticipated to impact structural stability of the impoundment embankments.

3.8 Structural Stability Assessment Deficiencies - §257.73(d)(2)

A structural stability deficiency associated Pipe 4W was identified in this initial structural stability assessment. Geosyntec suggests relining the interior of the deficient portions of the pipe as a corrective action. The pipe will remain out of service until the repair is complete. Documentation detailing the corrective measures taken to repair the pipe will be prepared after the repair is complete.

3.9 Annual Inspection Requirement - §257.83(b)(4)(ii)

In accordance with §257.83(b)(4)(ii), submittal of this structural stability assessment precludes the requirement of an annual inspection under §257.83(b) for the East and West Ash Basins during the 2016 calendar year. Deficiencies identified in the initial annual inspection for the East and West Ash Basins were corrected as documented in the Notice of Remedy prepared in response to the initial annual inspection.

4. Safety Factor Assessment

This section describes the initial safety factor assessment for the East and West Ash Basins and the methodology used to perform the assessment in accordance with §257.73(e)(1). This assessment includes slope stability analyses of the critical embankment cross-sections for each basin, shown in Figure 3, and evaluation of stability of the retaining wall north of the Basins.

4.1 Slope Stability Methodology

Limit equilibrium slope stability analyses were performed to evaluate the stability of the embankments for the East and West Ash Basins. The process involved performing two-dimensional analyses on the critical cross-sections for each basin using Spencer's Method as coded in the computer program SLOPE/W (Version 8.15.4.11512, www.geoslope.com) which satisfies vertical and horizontal force equilibrium and moment equilibrium (Geosyntec, 2016e). For each cross section analyzed, the program searches for the sliding surface that produces the lowest factor of safety (FS). Factor of safety is defined as the ratio of the shear forces/moments resisting movement along a sliding surface to the forces/moments driving the instability.

Subsurface stratigraphy, groundwater conditions, and engineering parameters for the embankment and foundation materials were developed based on previous subsurface investigations performed at the Site (Geosyntec, 2016b and Geosyntec, 2016e).

4.2 Slope Stability Analyses

As presented in Table 1, four cases were analyzed to satisfy the safety factor assessment requirements in §257.73(e) (Geosyntec, 2016e).

4.2.1 Static, Long-Term Maximum Storage Pool Loading – §257.73(e)(1)(i)

Pursuant to §257.73(e)(1)(i) a static, long-term condition with the maximum operating pool loading on the embankments was evaluated. For the East and West Ash Basins, this condition included a pool elevation 2 feet below the lowest point of the embankment crest (Geosyntec, 2016e).

4.2.2 Static, Maximum Storage Pool Loading – §257.73(e)(1)(ii)

The conditions for §257.73(e)(1)(ii) are identical to §257.73(e)(1)(i) with the exception of the pool elevation, which is set at the lowest points of the embankment crest (Geosyntec, 2016e).

4.2.3 Seismic – §257.73(e)(1)(iii)

Pursuant to §257.73(e)(1)(iii), a seismic condition for East and West Ash Basins was also analyzed. Seismic stability was evaluated with a pseudostatic analysis that uses constant horizontal accelerations to represent the effects of earthquake shaking. The horizontal accelerations are represented in SLOPE/W by a horizontal seismic coefficient. The horizontal seismic coefficient used for analysis was based on a peak ground acceleration with a 2 percent probability of exceedance in 50 years (Geosyntec, 2016g).

4.2.4 Liquefaction – §257.73(e)(1)(iv)

The majority of the embankment soils for the East and West Ash Basins are not considered susceptible to liquefaction because saturation of the embankment soils is unlikely based on the presence of a geomembrane liner system. Based on the design phreatic surface discussed in Geosyntec (2016b), a limited portion of the bottom of the embankments may become saturated from groundwater. Liquefaction triggering analyses of these saturated embankment soils indicate that liquefaction and associated post-liquefaction shear strength loss is unlikely for the seismic design event (Geosyntec, 2016d). Because the likelihood of liquefaction and associated shear strength loss of the embankment soils is very low, post-liquefaction conditions are represented by the static factor of safety analyses.

4.3 Results

The results of the slope stability analysis for the critical cross sections of the East and West Ash Basin embankments are summarized in Table 1 below and presented in Figures 4 through 9 (Geosyntec 2016e).

Section	Safety Factor			
	257.73(e)(1)(i)	257.73(e)(1)(ii)	257.73(e)(1)(iii)	257.73(e)(1)(iv)
1	≥1.50	≥1.40	≥1.00	≥1.20
2	≥1.50	≥1.40	≥1.00	≥1.20

These results meet the factor of safety requirements presented in §257.73(e)(1)(i) through §257.73(e)(1)(iv).

4.4 Retaining Wall Analyses

Stability of the retaining wall located north of the East and West Ash Basins was also evaluated (Geosyntec, 2016h). Construction drawings for the wall were not available, but Geosyntec personnel observed that the wall is a metal bin wall, a form of gravity retaining structure similar to a crib wall, built by combining “bins”, or cells filled with soil. Inputs for the analyses were based on field observations and measurements of the wall the subsurface investigations at the

Site (Geosyntec, 2016h and Geosyntec, 2016b). Factors of safety for bearing capacity, overturning, and sliding were calculated for the wall based on methods for evaluating a cantilever retaining wall in Das (2007). Results show that the factors of safety for the wall exceed minimum industry standard values (Geosyntec, 2016h).

5. Limitations and Certification

This initial periodic structural stability and safety factor assessment meets the requirements of §257.73(d) and §257.73(e) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.

Jane W Soule

Jane W. Soule, P.E.
Illinois Professional Engineer No. 062-067766
Expiration Date: 11/30/2017

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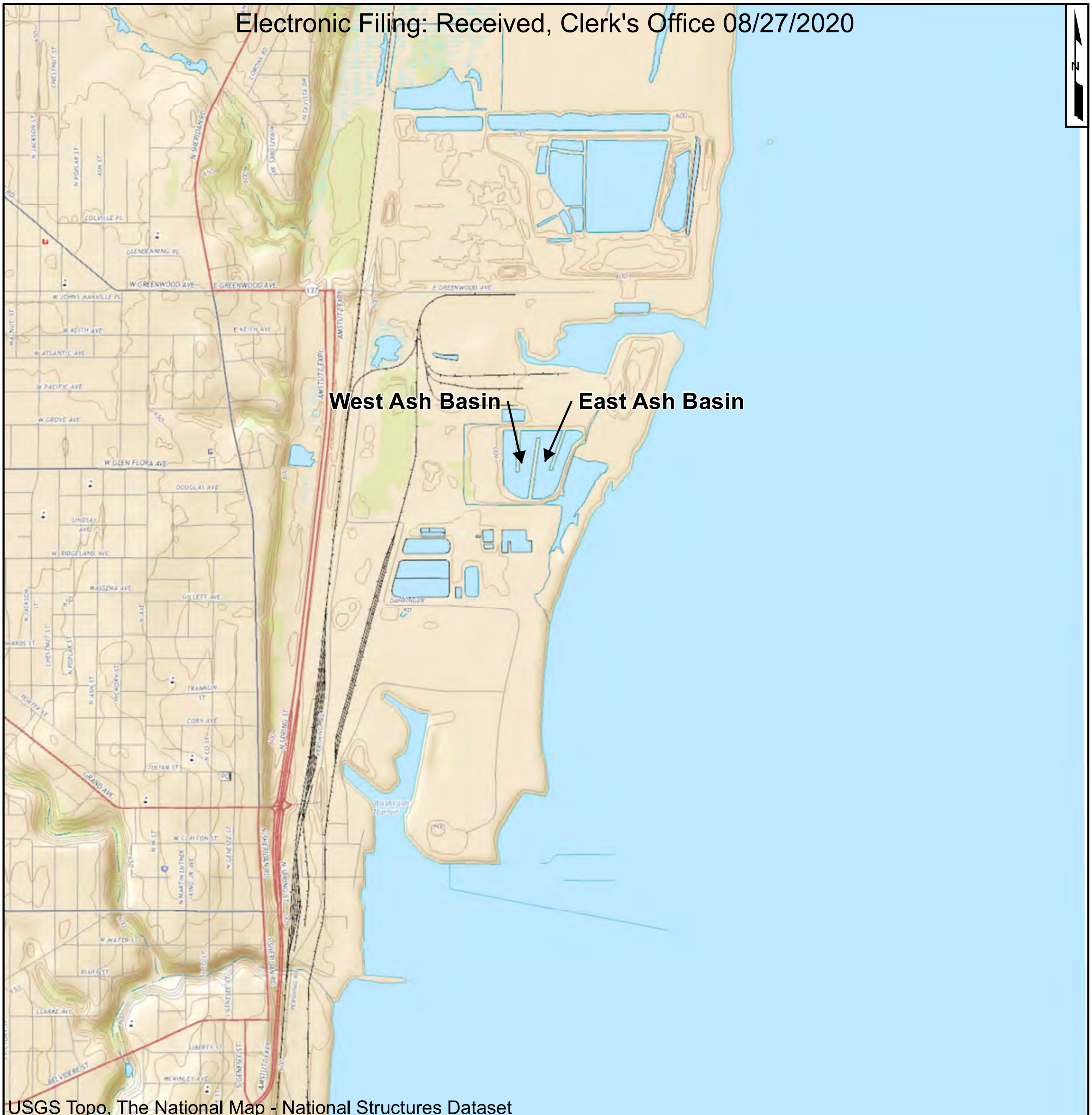
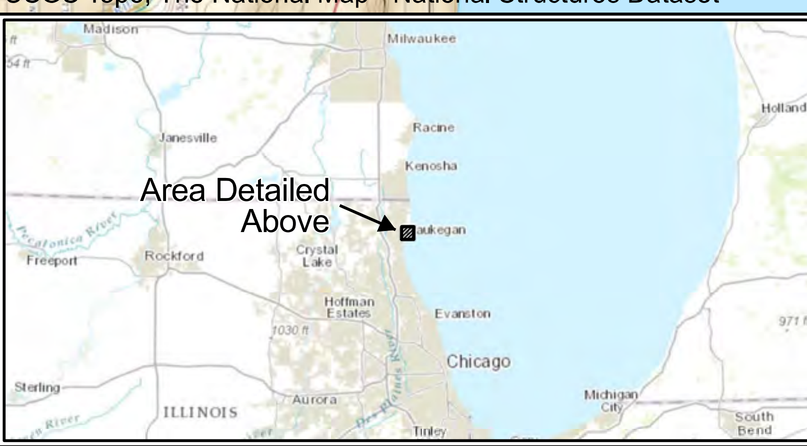
Idriss and Boulanger, 2008. "Soil Liquefaction During Earthquakes". Earthquake Engineering Research Institute, MNO-12.

<ins>Attachments</ins>





2,000 1,000 0 2,000 Feet

Site Location

East and West Ash Basins
Waukegan Station
Waukegan, Illinois

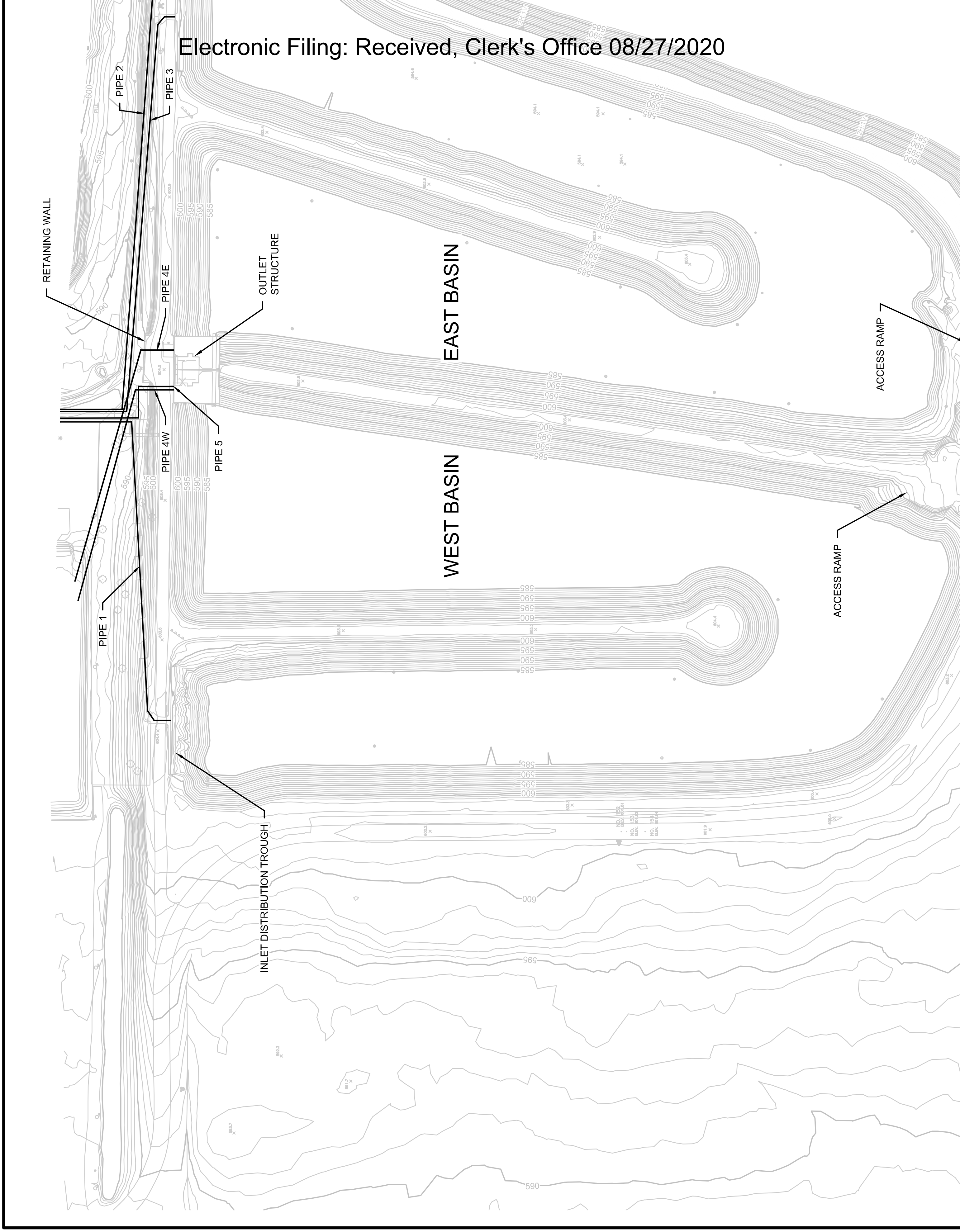
Geosyntec consultants

San Diego | October 2016

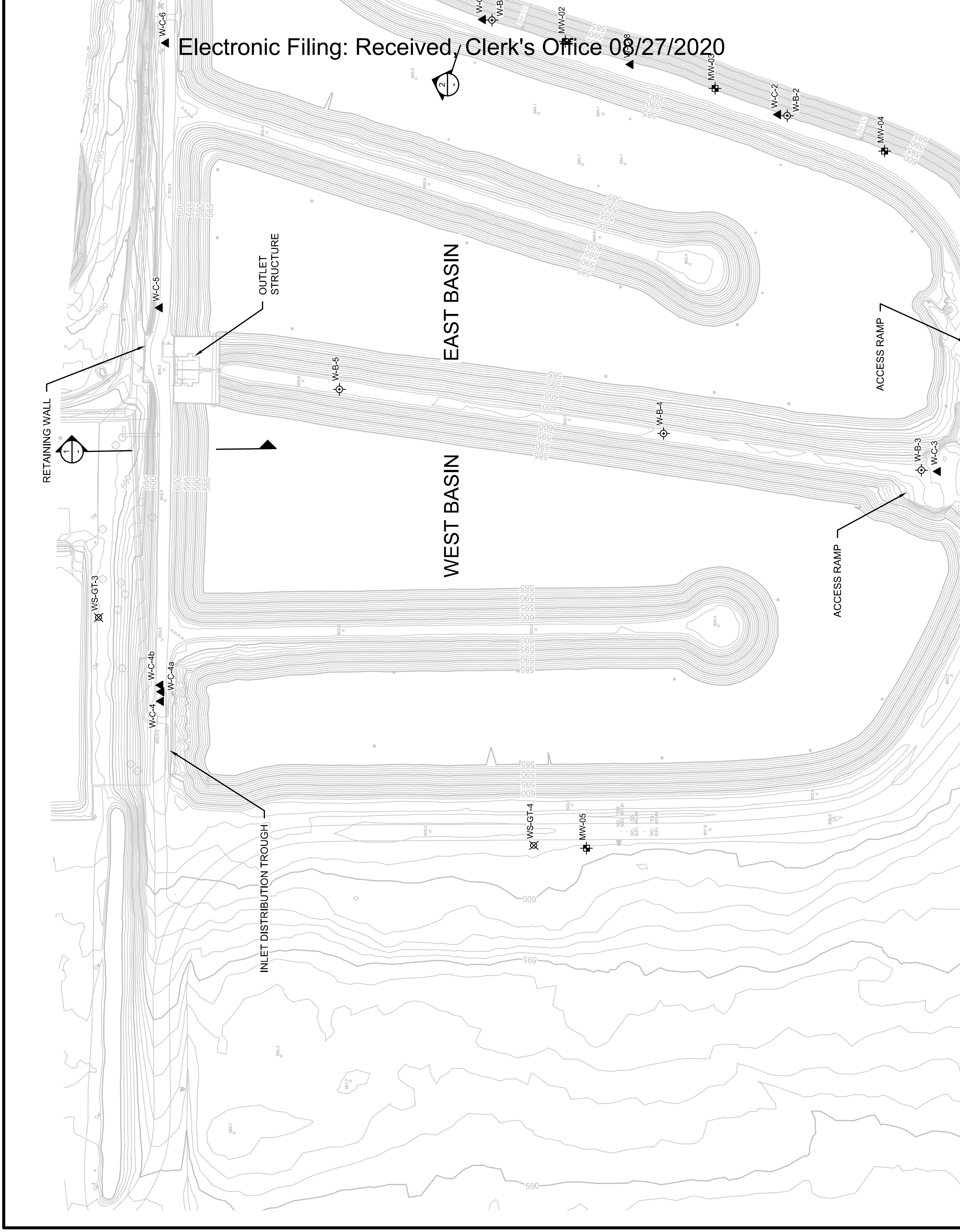
Figure

1

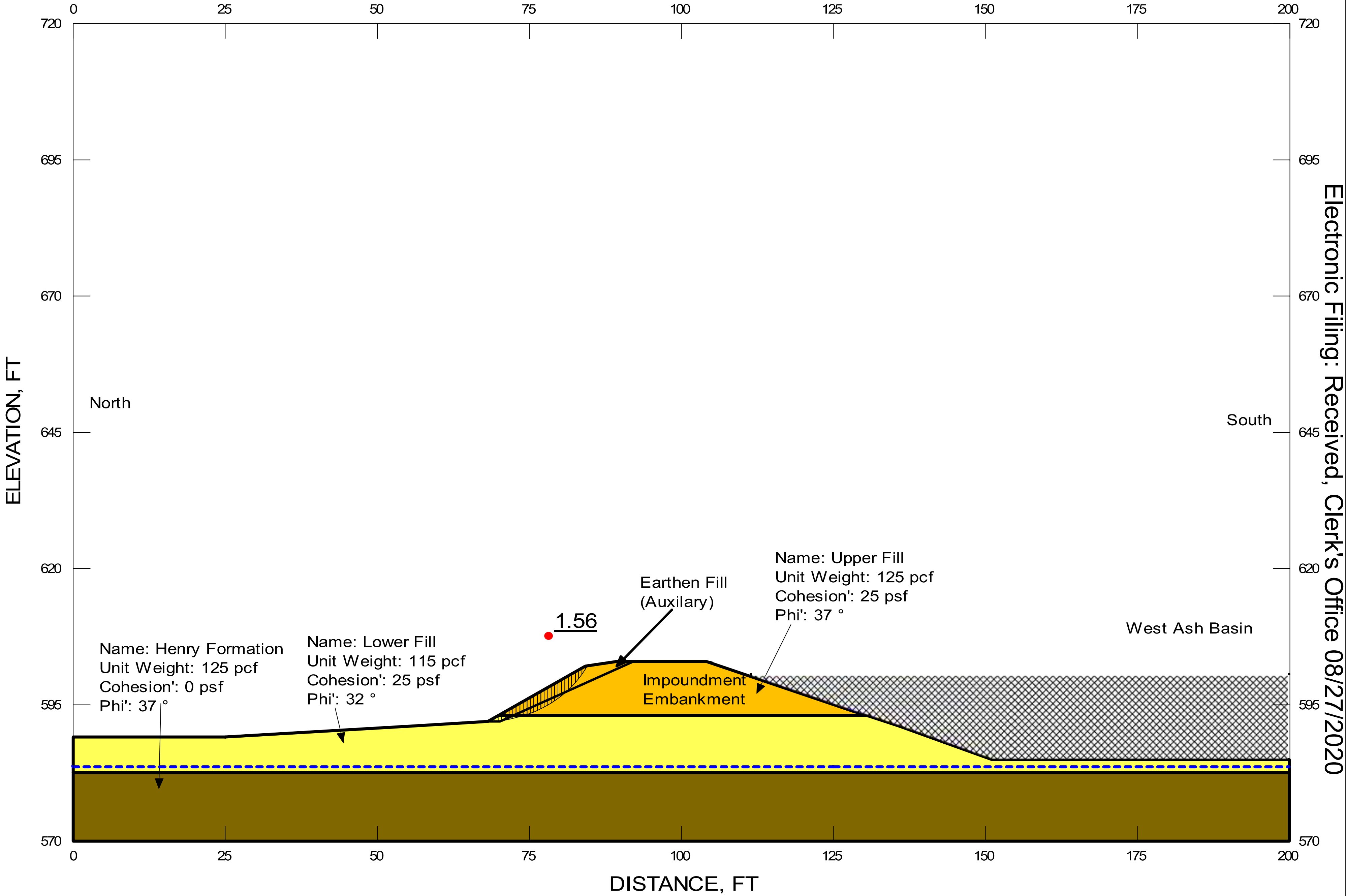
K:\GIS\WaukegantSiteLocation.mxd JGordon



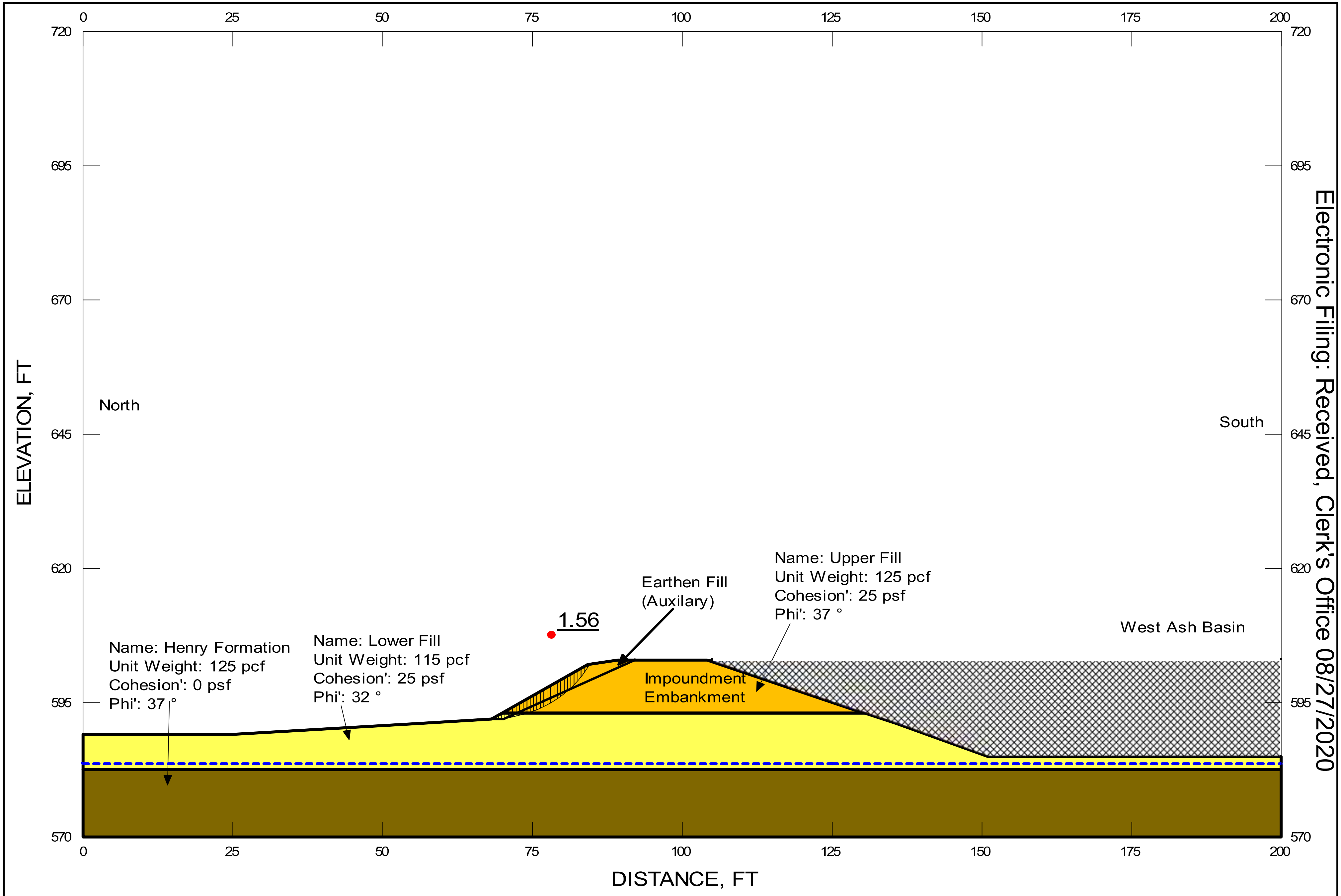
F02-PIPE LOCATIONS



F03–STABILITY SECTIONS 1–2



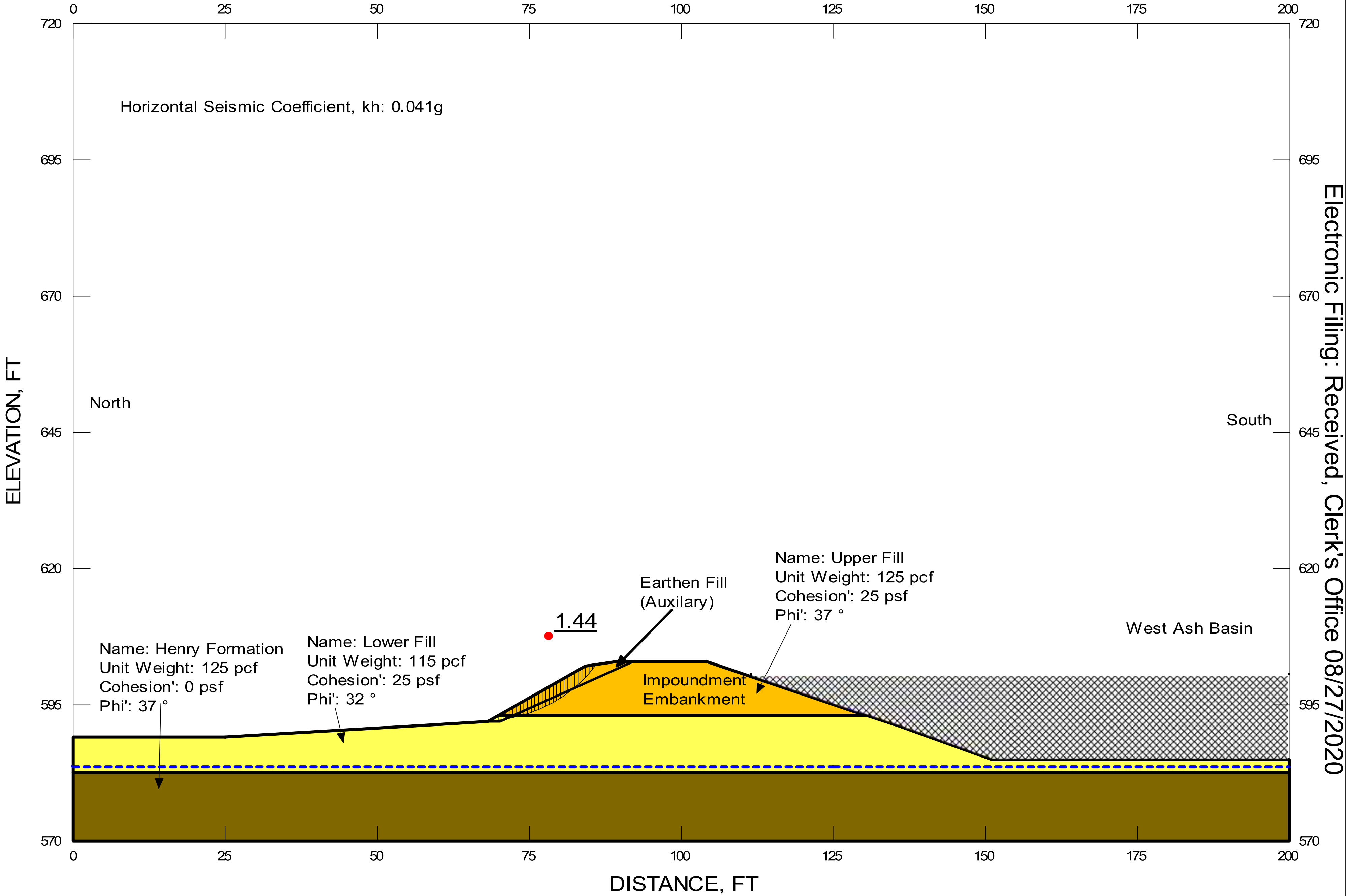
Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		FIGURE 4
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 1.gsz	Date: October 2016	



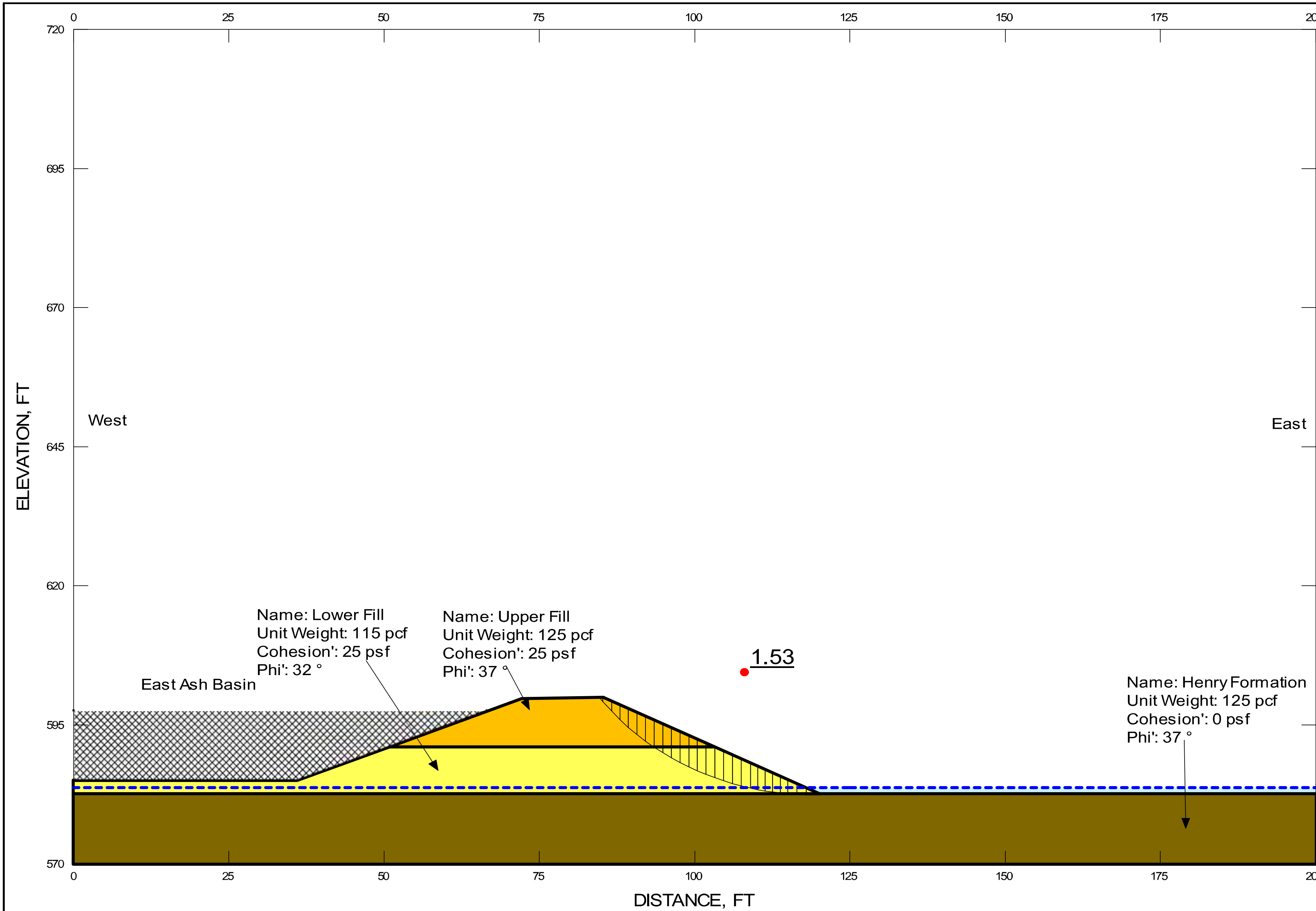
Geosyntec consultants

Analysis	Section 1 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading		
Project	Waukegan East and West Ash Basins	Analysis By	Jay Griffin
File Name	Waukegan Section 1.gsz	Date	October 2016

FIGURE
5



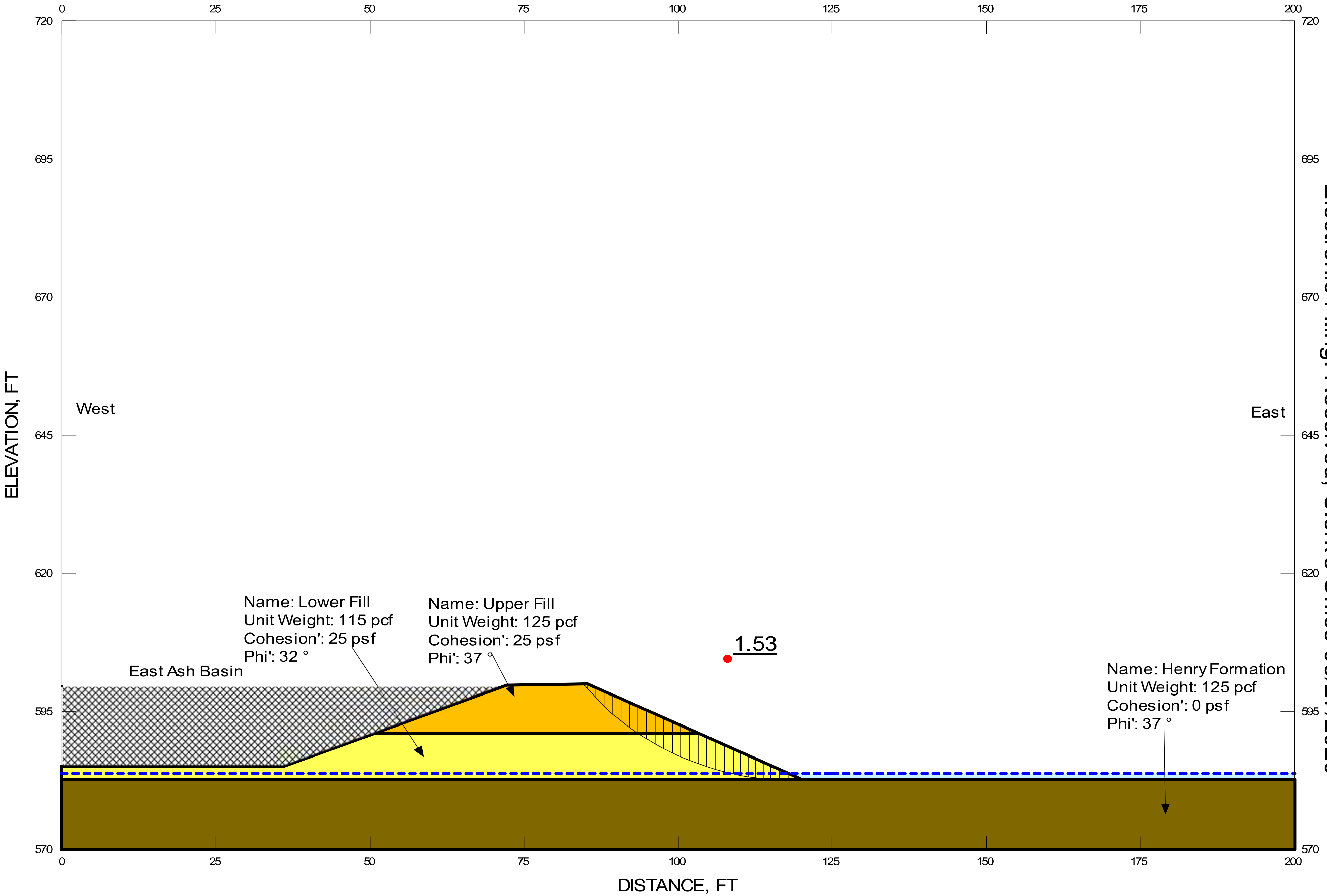
Geosyntec consultants	Analysis	Section 1 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		FIGURE 6
	Project	Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name	Waukegan Section 1.gsz	Date: October 2016	



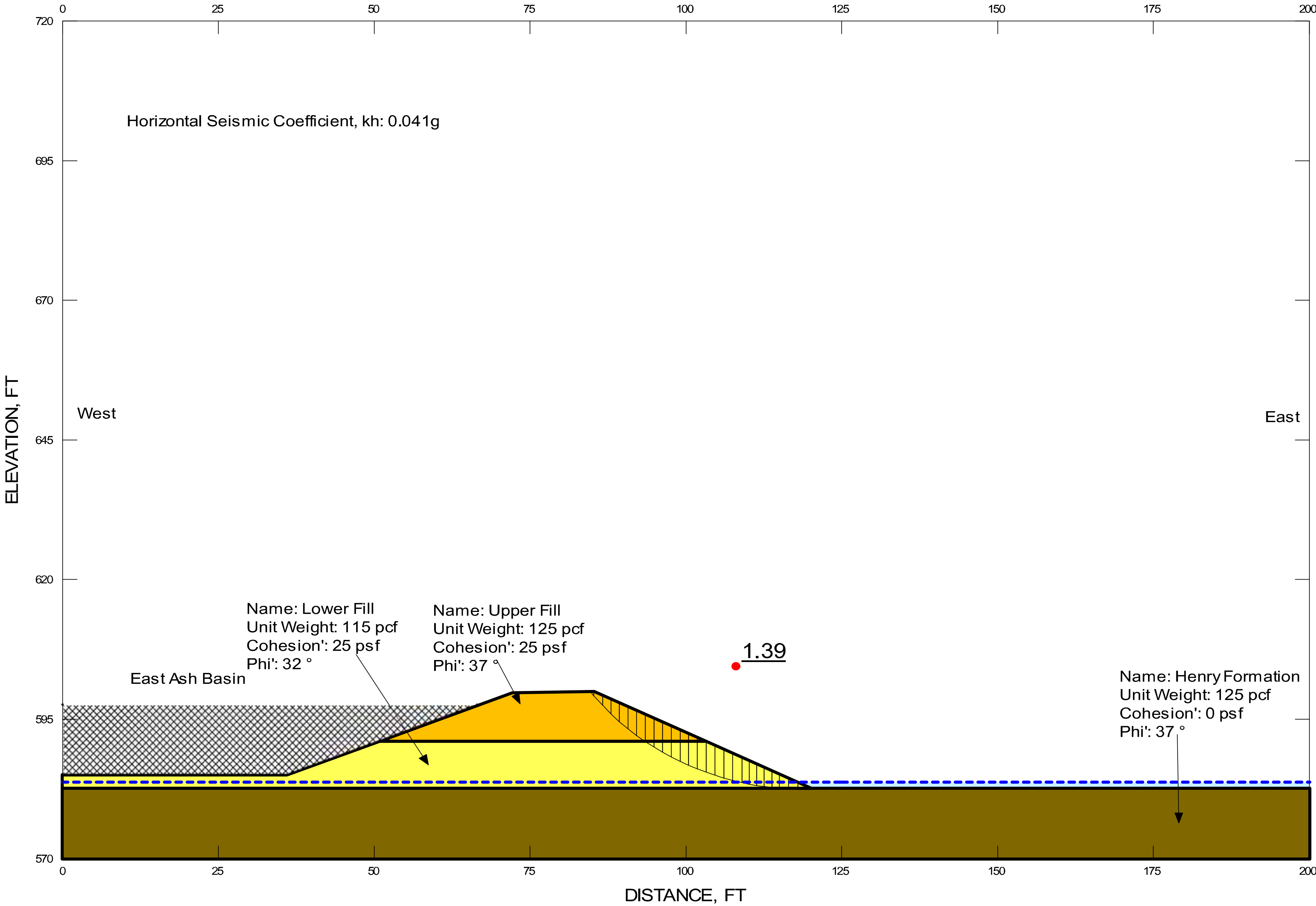
Geosyntec consultants

Analysis	Section 2 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		
Project	Waukegan East and West Ash Basins	Analysis By	Jay Griffin
File Name	Waukegan Section 2.gsz	Date	October 2016

FIGURE
7



Geosyntec consultants	Analysis: Section 2 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading			FIGURE 8
	Project: Waukegan East and West Ash Basins	Analysis By	Jay Griffin	
	File Name: Waukegan Section 2.gsz	Date	October 2016	



Geosyntec consultants

Analysis	Section 2 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		
Project	Waukegan East and West Ash Basins	Analysis By	Jay Griffin
File Name	Waukegan Section 2.gsz	Date	October 2016

FIGURE 9

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 9

FINAL REPORT
ROUND 10 DAM ASSESSMENT
DYNEGY MIDWEST GENERATION, LLC – HENNEPIN POWER STATION
ACTIVE EAST ASH POND SYSTEM, EAST ASH POND SYSTEM, WEST ASH POND SYSTEM
HENNEPIN, ILLINOIS

PREPARED FOR:

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

PREPARED BY:

GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, Ma 02062
GZA File No. 01.0170142.30

FINAL REPORT
ROUND 10 DAM ASSESSMENT
DYNEGY MIDWEST GENERATION, LLC – HENNEPIN POWER STATION
ACTIVE EAST ASH POND SYSTEM, EAST ASH POND SYSTEM, WEST ASH POND SYSTEM
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Norwood, Ma 02062
GZA File No. 01.0170142.30

GZA
GeoEnvironmental, Inc.

Engineers and Scientists

December 6, 2012
GZA File No. 170142.30

Mr. Stephen Hoffman
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

RE: FINAL Assessment of Dam Safety of Coal Combustion Surface Impoundments at the Hennepin Power Station

Dear Mr. Hoffman,

One Edgewater Drive
Norwood,
Massachusetts 02062
Phone: 781-278-3700
Fax: 781-278-5701
http://www.gza.com

In accordance with our proposal 01.P0000177.11 dated March 28, 2011, and U.S. Environmental Protection Agency (EPA) Contract No. EP10W001313, Order No. EP-B115-00049, GZA GeoEnvironmental, Inc. (GZA) has completed our assessment of the Hennepin Power Station Coal Combustion Waste (CCW) Impoundments located in Hennepin, Illinois. The site visit was conducted on May 23, 2011. The purpose of our efforts was to provide the EPA with a site specific assessment of the impoundments to assist EPA in assessing the structural stability of the impoundments under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). We are submitting one hard copy and one CD-ROM copy of this Final Report directly to the EPA.

Based on our visual assessment, and in accordance with the EPA's criteria, the Active East Ash Pond System, West Ash Pond System, and East Ash Pond System are currently in **POOR** condition in our opinion. Further discussion of our evaluation and recommended actions are presented in the Task 3 Dam Assessment Report. The report includes: (a) a completed Coal Combustion Dam Assessment Checklist Form for each Basin; (b) a field sketch; and (c) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A** and the Terms and Conditions of our contract agreement.

We are happy to have been able to assist you with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Task 3 Dam Assessment Report.

Sincerely,

GZA GeoEnvironmental, Inc.

Doug P. Simon, P.E
Geologic Engineer
doug.simon@gza.com

Patrick J. Harrison, P.E.
Senior Geotechnical Consultant
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Peter H. Baril, P.E. (MA)
Consultant Reviewer
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PREFACE

The assessment of the general condition of the dams/impoundment structures reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dams and/or impoundment structures was based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam and/or impoundment structures depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.

PATRICK J. HARRISON
062.034946
LICENSED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS

Patrick Harrison, P.E.

License No.: 062.034946
Senior Geotechnical Consultant
GZA GeoEnvironmental, Inc.

EXECUTIVE SUMMARY

This Assessment Report presents the results of a visual assessment of the Dynegy Midwest Generation, LLC. (Dynegy) – Hennepin Power Station (HPS) Coal Combustion Waste (CCW) Impoundments located at 13498 E 800th Street, Hennepin, Illinois. These assessments were performed on May 23, 2011 by representatives of GZA GeoEnvironmental, Inc (GZA), accompanied by representatives of Dynegy.

The HPS is a two-unit coal-fired power plant, with a maximum generating capacity of approximately 310 Megawatts. Commercial operation of the facility began in the 1950's. Earthen and fly ash embankment CCW Impoundments (Active East Ash Pond System, East Ash Pond System, and West Ash Pond System) were constructed in conjunction with the HPS facility for the purpose of storing and disposing non-recyclable CCW from the HPS facility and clarification of water prior to discharge.

The current HPS operations use the Active East Ash Pond (AEAPS) for disposal of CCW products. The AEAPS consists of three (3) pond units. The first two units, known as the Primary and Secondary Cells, were designed as two chambered wet ash ponds and placed in service in 1997. After several years of operation, the Primary Cell's settling efficiency was reduced due to ash deposition and a third pond, Pond 2 East (2E) was added to the system in 2010.

There are two impoundments areas at the HPS which have been decommissioned and include: 1) East Ash Pond System Ponds 2 and 4 (EAPS) which are located adjacent to AEAPS and have been out of service since 1995; and, 2) West Ash Pond System Ponds 1 and 3 (WAPS) which are located west of the HPS and have been out of service since 1997. Pond 2E was constructed within the eastern footprint of the decommissioned Pond 2 area of the EAPS. The remaining portion of the Pond 2 area of the EAPS has being permitted as a dry fly ash landfill facility.

Process water and sluiced CCW are currently discharged into the Primary Cell of the AEAPS, where the CCW is allowed to settle and water is discharged into Pond 2E. Solids are further settled in Pond 2E prior to water discharge to the adjoining Secondary Cell (refer to Figure 2). Water flows sequentially through the Primary Cell, Pond 2E, and the Secondary Cell prior to discharge through a 5 foot stoplog weir structure and into the system outlet works. The AEAPS final outlet works include a Parshall flume for flow measurement and a final sampling manhole. Flow is then discharged to the Illinois River through NPDES outfall 003.

For the purposes of this EPA-mandated assessment, the sizes of the impoundments were based on U. S. Army Corps of Engineers (COE) criteria. Based on the maximum crest height of 18 feet and a storage volume of approximately 36 acre-feet, the WAPS is classified as a **Small** sized structure. Based on the maximum crest height of 52 feet and a storage volume of approximately 1,560 acre-feet, the AEAPS is classified as an **Intermediate** sized structure. Because there was no pool area associated with the EAPS, no size classification was estimated for the EAPS.

According to guidelines established by the COE, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures and dams with a storage volume between 1,000 acre-feet and 50,000 acre-feet and/or a height between 40 feet and 100 feet are classified as Intermediate sized structures.

Under the EPA classification system, as presented on page 2 of the EPA check list (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the AEAPS, EAPS and the WAPS would be considered as having a **Significant** hazard potential. The hazard potential rating is based on no probable loss of human life due to failure and the potential environmental impacts outside of Utility owned property.

Assessments

In general, the overall condition of the EAPS impoundment was judged to be **POOR**. The EAPS impoundment was found to have the following deficiencies:

1. Trees were present along the upstream and downstream slopes;
2. Minor potholes and rutting along the crest gravel access road; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value and assumptions in the analysis about subsurface conditions should be verified.

In general, the overall condition of the AEAPS impoundments was judged to be **POOR**. The AEAPS impoundment was found to have the following deficiencies:

1. Minor potholes and rutting along the crest gravel access road;
2. Trees were present along the downstream slope of the northern embankment; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value.

In general, the overall condition of the WAPS impoundment was judged to be **POOR**. In GZA's professional opinion, the embankment(s) visually appear to be sound and no immediate remedial action appears to be necessary. However, based on EPA's assessment criteria, the impoundment has been given a POOR Condition Rating, because complete hydraulic and geotechnical computations were not provided/available for GZA's for review. Thus, the stability of the embankment(s) could not be independently verified. The WAPS impoundment was found to have the following deficiencies:

1. Thick vegetation and trees along the downstream slopes;
2. Minor potholes and rutting along the crest gravel access road;

3. Erosion along the downstream slope of the northern embankment;
4. No seepage and/or stability analysis has been performed for the WAPS; and
5. No hydraulic/hydrologic analysis has been performed to confirm adequate freeboard and decant capacity at the design storm event.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the impoundments. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of permits needs to be determined for activities that may occur under the jurisdiction of the appropriate regulatory agencies.

Studies and Analyses

GZA recommends that HPS/Dynegy conduct the following studies and analysis:

1. Conduct an analysis of the hydraulic/hydrologic condition of the WAPS to establish the rise in water level that occurs during the 100-year, 24-hour rain event to confirm that adequate freeboard is maintained and adequate decant and spillway capacity is available. The loading conditions established during the design storm event should be used in the evaluation of the seepage and stability evaluation of the embankments.

2. Perform a complete structural and seepage stability analysis of the WAPS impoundment including static, seismic and liquefaction loading.

3. Generate a remedial design to address the inadequate factor of safety along the northern embankment of the EAPS and AEAPS adjacent to the Illinois River.

Recurrent Operation & Maintenance Recommendations

GZA recommends the following operation and maintenance level activities:

1. Increased mowing of the grasses on the embankments to facilitate assessments and reduce the risk of burrowing animals;

2. Repair wave action erosion on the downstream slope of the WAPS;

3. Repair the potholes present in the gravel crest access roads. Grade the road to provide better drainage and reduce future potholing; and,

4. Clear trees and other deep rooted vegetation from the slopes and crests of the embankments.

Repair Recommendations

GZA recommends the following repairs to address observed deficiencies that may affect the stability of the embankments. The recommendations may require design by a professional engineer and construction contractor experienced in impoundment construction.

1. Pending the results of the hydraulic/hydrologic analysis, modify the design or operation of the WAPS to provide adequate capacity.

2. Pending the results of the complete seepage and stability analysis for the WAPS, modify the design or operation of the impoundments to provide conditions that result in embankments that meet the generally accepted factors of safety.

3. Based on the geotechnical results for the EAPS and AEAPS embankments, which produced inadequate minimum factors of safety, develop design modifications for those embankments along the Illinois River. These improvements are to result in the embankments meeting generally accepted factors of safety and protect the slope from future erosion.

Alternatives

There are no practical alternatives to the repairs itemized above.

ACTIVE EAST POND SYSTEM, EAST ASH POND SYSTEM AND WEST ASH POND SYSTEM
DYNEGY MIDWEST GENERATION LLC, HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

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FIGURES

APPENDICES

1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The United States Environmental Protection Agency (EPA), has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual assessment and develop a report of conditions for the Dynegy Midwest Generation,LLC, (Dynegy, Owner) Hennepin Power Station (HPS, Site) Coal Combustion Waste (CCW) Impoundments in Putnam County, Illinois. This assessment was authorized by the EPA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). This assessment and report were performed in accordance with Request for Quote (RFQ) RFQ-DC-16, dated March 16, 2011 and EPA Contract No. EP10W001313, Order No. EP-B11S-00049. The assessment generally conformed to the requirements of the Federal Guidelines for Dam Safety[1], and this report is subject to the limitations contained in **Appendix A** and the Terms and Conditions of our Contract Agreement.

1.1.2 Purpose of Work

The purpose of this investigation was to visually inspect and evaluate the present condition of the impoundments and appurtenant structures (the management unit) to attempt to identify conditions that may adversely affect their structural stability and functionality, to note the extent of any deterioration that may be observed, review the status of maintenance and needed repairs, and to evaluate the conformity with current design and construction standards of care.

The investigation was divided into five parts: 1) obtain and review available reports, investigations, and data from the Owner pertaining to the impoundment and appurtenant structures; 2) perform a review with the Owner of available design, assessment, and maintenance data and procedures for the management unit; 3) perform a visual assessment of the site; 4) prepare and submit a field assessment checklist; and 5) prepare and submit a draft and a final report presenting the evaluation of the structure, including recommendations and proposed remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix B**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and 6) condition rating.

[1] FEMA/ICODS, April 2004: http://www.ferc.gov/industries/hydropower/safety/guidelines/fema-93.pdf

1.2 Description of Project

1.2.1 Location

The HPS is located in Sections 26 and 27, Township 33 North, Range 2 West, in Putnam County, Illinois at approximately 41°18'11"N, 89°18'55"W. The HPS is adjacent to the Illinois River at river mile 211.5, approximately four (4) miles north of Hennepin, Illinois. The HPS CCW impoundments are located to the east and west of the power plant. A Site locus of the impoundments and surrounding area is shown in **Figure 1**. An aerial photograph of the impoundments and surrounding area is provided as **Figure 2**. The impoundments can be accessed by vehicles from earthen access roads from the HPS.

1.2.2 Owner/Caretaker

The CCW impoundments are owned by Dynegy Midwest Generation, LLC and operated by the HPS.

	Dam Owner/Caretaker
Name	Dynegy Midwest Generation, LLC, Hennepin Power Station
Mailing Address	13498 E 800th St Hennepin, IL 61327
City, State, Zip	Hennepin, Illinois 62327
Contact	Ted Lindenbusch
Title	Managing Director
E-Mail	Ted.Lindenbusch@dynegy.com
Daytime Phone	815-339-9210
Emergency Phone	911

1.2.3 Purpose of the Impoundments

The HPS is a two-unit coal-fired power plant, with a maximum generating capacity of approximately 310 Megawatts. Commercial operation of the facility began in the 1950's. Earthen and fly ash embankment CCW Impoundments (Active East Ash Pond System, East Ash Pond System, and West Ash Pond System) were constructed in conjunction with the HPS facility for the purpose of storing and disposing non-recyclable CCW from the HPS facility and clarification of water prior to discharge.

The current HPS operations use the Active East Ash Pond (AEAPS) for disposal of CCW products. The AEAPS consists of three (3) pond units. The first two units, known as the Primary and Secondary Cells, were designed as two chambered wet ash ponds and placed in service in 1997. After several years of operation, the Primary Cell's settling efficiency was reduced due to ash deposition and a third pond, Pond 2 East (2E) was added to the system in 2010.

There are two impoundments areas at the HPS which have been decommissioned and include: 1) East Ash Pond System Ponds 2 and 4 (EAPS) which are located adjacent to AEAPS and have been out of service since 1995; and, 2) West Ash Pond System Ponds 1 and 3 (WAPS) which are located west of the HPS and have been out of service since 1997. Pond 2E was constructed within the eastern footprint of the decommissioned Pond 2 area of the EAPS. The remaining portion of the Pond 2 area of the EAPS will be operated as a dry fly ash landfill facility. Impoundments that are not formally closed through the state and can impound water are within the purview of the EPA's assessment criteria.

Process water and sluiced CCW are currently discharged into the Primary Cell of the AEAPS, where the CCW is allowed to settle and water is discharged into Pond 2E. Solids are further settled in Pond 2E prior to water discharge to the adjoining Secondary Cell (refer to Figure 2). Water flows sequentially through the Primary Cell, Pond 2E, and the Secondary Cell prior to discharge through a 5 foot stoplog weir structure and into the system outlet works. The AEAPS final outlet works include a Parshall flume for flow measurement and a final sampling manhole. Flow is then discharged to the Illinois River through outfall 003.

1.2.4 Description of the EAPS Impoundment and Appurtenances

The EAPS was designed by Illinois Power Company. However, available information regarding the original design and/or construction of the EAPS was limited to drawings related to subsequent embankment modifications and references in various documents prepared by Civil & Environmental Consultants, Inc. (CEC) for the design and construction of Pond 2E. The following description of the EAPS is based on the limited available information and observations made by GZA during our Site visit.

Based on the available information, the embankments surrounding the EAPS were constructed in three phases. The original embankments were constructed in 1958, with subsequent modifications in 1978 and 1989. The original embankments were constructed to about elevation 474 feet (MSL) and the north, east and west sides of the EAPS were tied into the bluff on the south side which is also the northern embankment of the Primary and Secondary Cells. In 1978, the embankments were raised to elevation 484 feet (MLS), and to elevation 494 feet (MLS) in 1989. Typical sections of the 1989 embankment extensions are shown on **Figures 3 and 4**.

Borings were performed in 2009 by CEC in the area of the EAPS as part of the design for Pond 2E. Seven of the borings were drilled through the top of the 1989 embankment (at approximate elevation 494 (MLS)) and two borings through the 1978 embankment (at approximate elevation 484 (MLS)). The borings encountered gravelly clays and sands interbedded with layers of loose to medium dense sand, gravel and gravelly sands and clays; stiff to very stiff sandy and silty clays; and loose to very loose, moist to wet, laminated silt with zones of fly ash with a consistency of fine and/or silty sand. There was no evidence that the impoundment embankments were built over wet ash or slag. Several other borings drilled in the EAPS disposal area encountered CCW materials to depths ranging from about 24 to 35 feet below the existing surface grades or elevations ranging about 456 to 453 (MSL), respectively. The boring locations are provided on **Figure 5.**

The original embankment slopes of the EAPS were variable and appear to have been constructed with downstream and upstream slopes that range from approximately 2.5H:1V to about 1.5H:1V. The EAPS crest length is approximately 1 mile with a maximum height (from the lowest downstream toe elevation to the crest of the impoundment) of approximately 52 feet corresponding to a crest elevation of 494.0 (MSL). The upstream and downstream slopes of the raised embankments sections were constructed at approximately 2.5H:1V.

A dry ash landfill has been constructed on the western portion of the Pond 2 area of the EAPS. The landfill has been constructed with a liner placed on the existing ash fill that was subsequently covered with several feet of ash during construction of Pond 2E. The landfill is permitted to extend to a height of 66 feet above the current embankment corresponding to an elevation of approximately 560 feet (MSL). Please note that the embankments of the EAPS are not regulated as a dam by the Illinois Department of Water Resources.

1.2.5 Description of the AEAPS Primary Cell, Secondary Cell and Appurtenances

The embankments of the Primary Cell and Secondary Cells were designed by Illinois Power Company. The following description of the impoundment is based on information provided in various Illinois Power Company Drawings and Documents, various Design Documents prepared by Civil & Environmental Consultants, Inc. (CEC), other information received from HPS, and observations made by GZA during our Site visit.

The AEAPS Primary and Secondary Cells are located east of the HPS and were originally constructed by reshaping an area that was an existing gravel pit to form the current surface impoundment. The ground elevation surrounding most of gravel pit at the time of construction was described to be equal to or greater than the maximum elevation proposed for the impoundments. The northeast corner of the impoundment however required the construction of an embankment with a portion of it being approximately 20 feet above the existing ground level. This area was described as having uneven natural terrain and was stabilized by leveling the existing ground surface and adding fill to the leveled elevation. The natural slopes in this area gave the northeast corner a height of about 32 feet.

The AEAPS Primary and Secondary Cells function as sedimentation basins for coal combustion wastes (CCW) including bottom ash, fly ash, miscellaneous station low volume waste, and coal pile runoff streams which are piped from the plant and discharged into the impoundment. Fly ash is conditioned and transported dry to the primary cell. The CCW enters the Primary Cell through two 12 inch diameter HDPE pipes and two 10 inch diameter steel pipes which are located near the northeast corner of the Primary Cell. Miscellaneous station low volume waste streams and coal pile runoff also enter the Primary Cell to the west of the northeast corner. The CCW settles in the Primary Cell and flow through the pond is discharged into Pond 2E through an 18 inch diameter reinforced concrete pipe (RCP) outlet structure which is located near the northeast corner of the Primary Cell.

The Secondary Cell receives flow from Pond 2E through a 24 inch diameter RCP which is located near the northwest corner of the Secondary Cell. Flow from the Secondary Cell is discharged through a five foot stop log weir structure into a 36 inch diameter RCP which conveys the flows into the final outlet works and into the Illinois River through outfall structure 003. The locations of the discharge pipes and structures are shown in **Figure 6**. Details of the discharge pipes and structures are shown on **Figures 7 and 8**. Prior to the construction of Pond 2E, flow through the Primary Cell was discharged into the Secondary Cell through a five-foot stoplog decant structure. The decant structure was abandoned as part of the construction of Pond 2E.

The AEAPS Primary and Secondary Cells consist of sand and gravel earthen embankments with a crest length of approximately 0.6 miles and 0.4 miles, respectively and a maximum height (from the lowest downstream toe elevation to the crest of the impoundment) of approximately 32 feet corresponding to a crest elevation of 494.0 Mean Sea Level (MSL). The bottom of the impoundments is at approximately Elevation 458.0 (MSL). The embankments of the cells were constructed in 1995 and 1996 and placed in service in 1997 with 4-foot horizontal to one-foot vertical (4H:1V) upstream and downstream slopes consisting of native sand and gravel materials. There was no evidence that the impoundment embankments were built over wet ash or slag. A 4-foot thick clay liner was constructed on the bottom of the cells and up the upstream side slopes of the cells to a height of approximately 20 feet above the base of the impoundments. The upper 12 feet of the upstream slopes were not lined at the time of the initial construction. After construction, operating water levels in the cells were maintained at or below the top elevation of the clay liner. Over the next several years, CCW filled the Primary Cell to levels that required that the upstream liner be raised to provide full depth operating levels for CCW transport, clarification and deposition. The liner in both cells was raised in 2003 by extending the existing liner up the upstream slopes from the original 20 foot level an additional 12 feet to the top of the crest. The construction of the extended liner consisted of 45-mil HDPE geomembrane over a 12-inch layer of compacted clay. A typical section for the liner extension is shown in **Figure 9.**

The intermediate embankment between the AEAPS Primary and Secondary Cells is regulated by the Illinois Department of Transportation, Division of Water Resources (IDOT/DWR) as a small-size, Class III dam under permit no. 21922, issued November 10, 1994. According to guidelines established by the DWR, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures. *Class III* structures are those for which failure has a low probability of causing loss of life or substantial environmental damage.

Instrumentation near the AEAPS Primary and Secondary Cells include six groundwater monitoring wells, numbered 12 through 16, which are located as shown on **Figure 6**.

1.2.6 Description of the AEAPS Pond 2E and Appurtenances

Pond 2E was constructed within the footprint of the eastern portion of Pond 2 of the EAPS and follows the same history as the EAPS, as discussed in Section 1.2.4, until 2009. Construction of Pond 2E began in 2009 and was completed in 2010. CCW flows are discharged directly from the Primary Cell into Pond 2E along with surface water runoff from EAPS Pond 2. Flow is routed from the Primary Cell through Pond 2E and into the Secondary Pond before discharging to the Illinois River through the system outlet works. According to HPS personnel, Pond 2E was designed to increase the efficiency of the existing pond system by adding additional storage and settling capacity. The associated design plans and calculations for a dry ash landfill which would be located on the EAPS west of Pond 2E have been submitted to IEPA Bureau of Land Management. It should be noted that a landfill permit approval is not required. Once the dry ash landfill has been constructed, Pond 2E will provide sediment control, storm flow storage, and leachate detention.

Pond 2E is located on the eastern portion of the decommissioned EAPS Pond 2 and was constructed by excavating and removing a portion of the ash fill. Flow is routed from the AEAPS Primary Cell to Pond 2E through an 18 inch diameter reinforced concrete pressure pipe

(RCPP) discharge culvert which was installed during the construction of Pond 2E. Operational flows exit Pond 2E through the principal spillway, a 2-foot wide by 1-foot tall orifice, of Pond 2E's concrete outlet structure. The concrete outlet structure includes an auxiliary spillway which is a 3-foot wide by 1-foot tall weir, and an emergency spillway which is a 6-foot by 4-foot drop inlet. The principal and auxiliary spillways were designed to pass the 100-year frequency storm without the emergency spillway functioning. Flows through all three spillways are discharged through a 24-inch diameter RCP into the Secondary Cell.

Pond 2E's earth embankment structure is approximately 11 feet to 52 feet high and 1300 feet long. It has a crest elevation of approximately 494 feet (MLS) and an upstream face with a 3H:1V (horizontal: vertical) slope. A 60-mil smooth HDPE geomembrane was installed on the bottom and upstream slopes of Pond 2E. The liner also caps the underlying ash along the eastern portion of the former ash impoundment. A concrete culvert and headwalls were installed on the southwest side of Pond 2E to allow inflow from the Primary Cell. A gate valve was installed on the Primary Cell headwall to provide flow control, if required, for repairs. A plan view and typical sections of the Pond 2E embankments and other details are provided on **Figures 7 and 8**.

Instrumentation near the AEAPS Pond 2E includes groundwater monitoring wells, numbered 12 through 16, which are located as shown on **Figure 6**.

1.2.7 Description of the WAPS Impoundment and Appurtenances

The WAPS is located to the west of the HPS and based on available records was designed by Illinois Power Company. The following description of the impoundment is based on information provided on various Illinois Power Company drawings, information received from Dynegy and observations made by GZA during our site visit. Information for the original design and construction of the WAPS was limited to drawings which were prepared for the 1989 raise of the original impoundment embankments.

The original WAPS was constructed in 1950's and designated as Ponds 1 and 3. The ponds appear to have been constructed as unlined earthen embankments which consist of sand and gravel materials. The north embankment of WAPS abuts the south bank of the Illinois River. The general height of the original embankments (from the lowest downstream toe elevation to the top of the impoundment) was about 10 feet, corresponding to a crest elevation of 460.0 (MSL). The WAPS embankments were raised in 1989 by adding an average of 5 feet of new fill to the existing embankments, increasing the crest elevation to 465.0 (MSL). There was no evidence that the impoundment embankments were built over wet ash or slag. The perimeter of the WAPS was also extended at that time to enclose Ponds 1 and 3 into a single pond. The crest length of the combined ponds is about 1.2 miles. The WAPS was decommissioned in 1995 and was not receiving or discharging flows at the time of GZA's site visit. The WAPS is not regulated as a dam by the IDNR.

Instrumentation near the WAPS includes groundwater monitoring wells numbered as follows; 21 through 27, 31 through 36 and, L1 and L4, which are located as shown on **Figure 10**. The wells are monitored quarterly and as a condition of the 1996 IEPA approved Closure Work Plan (CWP) for the WAPS.

1.2.8 Operations and Maintenance

The impoundments are operated and maintained by HPS personnel. Operation of the Primary Cell, Secondary Cell and Pond 2E includes periodic adjustment of the decant elevations and includes monitoring of groundwater and repair of the gravel access roads as needed.

Discharges of the HPS facility are regulated by the EPA under the National Pollutant Discharge Elimination System (NPDES) Permit No. IL0001554. A portion of outer embankments of Primary and Secondary Cell of the AEAPS are considered to be a dam that is regulated by the Illinois Department of Natural Resources, Office of Water Resources under permit number DS2004119. As part of the dam permit, there is an Operation and Maintenance Plan that was developed for the Primary and Secondary Cells. That plan includes regular mowing, vegetation management, semi-annual assessments, and assessments by a register professional engineer every 5 years.

An operation and maintenance plan was developed by CEC for Pond 2E. The plan included information about the frequency and scope of periodic assessments. The plan requires assessment of the impoundment on a quarterly basis by HPS staff and every 5 years by a registered professional engineer. The plan also requires maintenance of an emergency drawdown pump at the facility.

1.2.9 Size Classification

For the purposes of this EPA-mandated assessment, the sizes of the impoundments were based on U. S. Army Corps of Engineers (COE) criteria. Based on the maximum crest height of 18 feet and a storage volume of approximately 36 acre-feet, the WAPS is classified as a **Small** sized structure. Based on the maximum crest height of 52 feet and a storage volume of approximately 1,560 acre-feet, the AEAPS is classified as an **Intermediate** sized structure. Because there was no pool area associated with the EAPS, no size classification was estimated for the EAPS.

According to guidelines established by the COE, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures and dams with a storage volume between 1,000 acre-feet and 50,000 acre-feet and/or a height between 40 feet and 100 feet are classified as Intermediate sized structures.

1.2.10 Hazard Potential Classification

Under the EPA classification system, as presented on page 2 of the EPA check list (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the AEAPS, EAPS and the WAPS would be considered as having a **Significant** hazard potential. The hazard potential rating is based on no probable loss of human life due to failure and the potential environmental impacts outside of Utility owned property. The hazard rating for the AEAPS differs from the hazard rating given to the Primary and Secondary Cells by the IDNR due to the inclusion of Pond 2E in the AEAPS since IDNR rating.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

The existing impoundments are surrounded by exterior dikes with crest elevations that are above the surrounding geographical features. This confines the rainfall sub-basin areas to the impoundment areas themselves resulting in no additional overland flow being introduced to the system.

1.3.2 Reservoir

Based on estimates made by GZA[2], the WAPS has a surface area of 2 acres and a storage volume of approximately 36 acre feet at a pool elevation of 455.6 feet MSL. The AEAPS has a surface area of approximately 30 acres and a storage volume of approximately 1,560 acre feet at a pool elevation of 489.5 feet MSL. The EAPS no longer actively impounds water and therefore a reservoir volume was not calculated. The pool areas observed on GZA's May 23, 2011 Site visit are consistent with the surfaces areas noted above.

1.3.3 Discharges at the Impoundment Sites

According to HPS personnel, under normal operating conditions, approximately 2.4 million gallons of water per day (MGD) are discharged from the Secondary Cell to the Illinois River.

1.3.4 General Elevations (feet – MSL)

Elevations were taken from design drawings, reports, and data provided by HPS. Elevations were based upon the USGS topographic map MSL vertical datum.

AEAPS Impoundment

Primary Cell

A. Top of Embankment (Minimum)	± 494 feet
B. Upstream Water at Time of Assessment	± 489.5 feet
C. Downstream Tail Water at Time of Assessment	485.2 feet (Pond 2E)
D. Maximum Pond Water Elevation	489.5 feet

Secondary Cell

A. Top of Embankment (Minimum)	± 494 feet
B. Upstream Water at Time of Assessment	479.5 feet
C. Downstream Tail Water at Time of Assessment	448 feet (Illinois River)
D. Maximum Pond Water Elevation	480.5 feet

[2] Surface area estimates generated using Google Earth Professional software and available aerial photographs.

Pond 2E

A. Top of Embankment (Minimum)	±494 feet
B. Upstream Water at Time of Assessment	485.2 feet
C. Downstream Tail Water at Time of Assessment	479.5 feet (Secondary Cell)
D. Maximum Pond Water Elevation	480 feet

EAPS Impoundment

A. Top of Embankment (Minimum)	494 feet
B. Upstream Water at Time of Assessment	N/A
C. Downstream Tail Water at Time of Assessment	442 feet
D. Maximum Pond Water Elevation	Unknown

WAPS Impoundment

A. Top of Embankment (Minimum)	465.0 feet
B. Upstream Water at Time of Assessment	455.6 feet
C. Downstream Tail Water at Time of Assessment[3]	± 448 feet
D. Maximum Pond Water Elevation	Unknown

1.3.5 Design and Construction Records and History

The EAPS and WAPS were designed by Illinois Power Company. However, available information regarding the original design and/or construction of the EAPS was limited to drawings related to subsequent embankment modifications and references in various documents prepared by CEC for the design and construction of Pond 2E. The documentation included information about the dimensions of the slopes and the materials used but not about the construction techniques or quality control during construction.

Construction of Pond 2E was documented in a December 2010 report generated by CEC. The report included documentation of the excavation of Pond 2E into the existing ash and construction of the liner on the upstream slopes. The construction did not include modification of the embankments of the existing pond.

1.3.6 Operating Records

No operating records of the impoundments were provided to GZA.

1.3.7 Previous Assessment Reports

The HPS personnel perform visual assessments of the impoundments on a weekly basis and the assessment results are documented in a field log book. Every 5 years the Primary and Secondary Cells are inspected by a consulting engineer. GZA was provided with the 5-year assessments reports from 2001, 2006, and 2010 in Appendix D. The assessment completed March 29, 2010 was conducted by Mr. Kenneth M. Berry, P.E. of URS and indicated no deficiencies for the Primary and Secondary Cells at that time. Observed deficiencies at the WAPS include thick vegetation and trees.

[3] Downstream tail water elevation based on visual estimates made by GZA during the Site Visit.

2.0 ASSESSMENT

2.1 Visual Assessment

The HSP impoundments were inspected on May 23, 2011 by Patrick J. Harrison, P.E., and Douglas P. Simon, P.E. (Wisconsin), of GZA GeoEnvironmental, Inc., and accompanied by Phil Morris of Dynegy. The weather was partly cloudy with temperatures in the 70°s to 80°s Fahrenheit. Photographs to document the current conditions of the impoundments were taken during the assessment and are included in **Appendix E**. The water levels in the impoundments at the time of the assessment were as provided in Section 1.3.4. Underwater areas were not inspected, as this level of investigation was beyond of GZA's scope of services. Copies of the EPA Checklists are included in **Appendix C**.

With respect to our visual assessment, there was no evidence of prior releases, failures, or repairs observed by GZA for most of the impoundment areas. It appeared that the downstream slope of the northwestern embankment of the WAPS had been regraded within the last year.

2.1.1 EAPS Impoundment General Findings

In general, the HPS EAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 6**.

2.1.2 EAPS Upstream Slope (Photos 18, 22, 24, and 74)

The northern portion of the EAPS has been permitted for a dry ash landfill and the upstream slopes are covered with ash along that portion of the impoundment. The southern portion of the EAPS that includes the former Pond 4 is no longer active. The upstream embankments along that portion of the EAPS were generally vegetated with grass that had not been recently mowed. Trees up to 12 inches in diameter were present on the slope.

2.1.3 EAPS Crest of Impoundment (Photos 32 though 35, 45, 52, 71 through 73)

The crest of the EAPS Impoundment generally had a gravel access road along the northern portion of the impoundment. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 494 feet MSL. No significant settlement was observed at the time of our assessment. There was no water present in the EAPS at the time of our assessment.

2.1.4 EAPS Downstream Slope (Photos 25 through 28, 55 through 57, 69, and 70)

The downstream slope of the impoundment was generally covered in thick grass vegetation making it difficult to observe during our assessments. In addition, the rough terrain and steep slopes along the northern portion of the impoundment created a personnel safety risk to access the slope. Therefore, our observations along that portion of the impoundment were limited to that which could be observed from the crest of the 1979 embankment. Trees up to 24 inches in diameter generally characterized northern embankment along the Illinois River. No grass was present along that portion of the embankment. The western and southwestern embankment was generally covered with grass that had not been recently mowed. No unusual movement or displacement was observed on the slope.

2.1.5 EAPS Discharge Pipes (Photo 44)

The EAPS no longer functions as an active ash impoundment and no CCW sluice piping is present. Storm water drains have been installed along portions of the perimeter of the permitted landfill as shown in Photo 44. The drains appeared to be in good condition at the time of our assessment.

2.1.6 AEAPS Impoundment General Findings

In general, the HPS AEAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 6**.

2.1.7 AEAPS Upstream Slope (Photos 35 through 43, 45 through 53)

The water surface elevation at the time of assessment was approximately at elevation 489.5 feet, 489.0 feet, and 479.5 feet MSL in the Primary Cell, Pond 2E and Secondary Cell, respectively. Therefore, the lower portion of the upstream slope was below the water level and not visible. Where visible, the upstream slope of Pond 2E was covered with a HDPE liner that was in good condition. The upstream slopes of the Primary and Secondary Cells were generally covered with grass above the water level.

2.1.8 AEAPS Crest of Impoundment (Photos 35 through 43, 45 through 53)

The crest of the AEAPS Impoundment was generally covered by a gravel access road. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 494 feet MSL. No significant settlement was observed at the time of our assessment. There was approximately 4 feet to 14 feet of free board at the time of our assessment.

2.1.9 AEAPS Downstream Slope (Photos 29 through 31)

The AEAPS Impoundment shares a common embankment with the EAPS along the western portion of the impoundment and is incised along the southern portion. Therefore, no downstream slope was visible or present along those portions of the impoundment. The northern embankment of the impoundment abuts the Illinois River and is characterized by trees up to 24-inches in diameter. The eastern embankment was covered with grass that had not been recently mowed.

2.1.10 AEAPS Discharge Structures (Photos 58 through 68)

GZA observed the outlet structures that transmit flow from the Primary Cell to Pond 2E and then to the Secondary Cell. Based on our observations, the structures appeared to be in good condition with no defects noted. GZA also observed the condition of the decant structure in the Secondary Cell and the partial flume. Both structures appeared to be in good condition based on our observations.

2.1.11 WAPS Impoundment General Findings

In general, the HPS WAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 10**.

2.1.12 WAPS Upstream Slope (Photos 18, 22, and 24)

The eastern portion of the WAPS has been filled with ash and the upstream slopes along that portion were not visible. The water surface elevation at the time of assessment was approximately at elevation 455.6 feet MSL along the western portion of the impoundment. Therefore, the lower portion of the upstream slope was below the water level and not visible. Where visible, the upstream slope was generally vegetated with grass that had not been recently mowed. Trees and shrubs up to 4 inches in diameter were noted along several portions of the upstream slope.

2.1.13 WAPS Crest of Impoundment (Photos 14 through 20)

The crest of the WAPS Impoundment was generally covered by a gravel access road. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 460 feet MSL. No significant settlement was observed at the time of our assessment. There was approximately 8 feet of free board at the time of our assessment.

2.1.14 WAPS Downstream Slope (Photos 1 through 13)

The downstream slope of the impoundment was generally wooded along the northern portion of the impoundment adjacent to the Illinois River. Trees up to 24-inches in diameter were present along the downstream slope of the northern embankment. The remaining embankments were generally covered with grass that had not been recently mowed. Trees up to 12 inches in diameter were noted along the southern embankment and smaller trees and shrubs were noted along the eastern embankment. There was erosion (likely due to wave action) of the downstream slope of the northern embankment.

2.1.15 WAPS Discharge Pipes (Photos 21 and 22)

The decant structure for the WAPS Impoundment consists of a 12-inch diameter steel pipe with a trash rack as shown in Photo 21. The pipe discharges into the Illinois River and the discharge pipe is shown in Photo 22. The decant and discharge portions of the pipe appeared to be in good condition at the time of our assessment.

2.2 Caretaker Interview

Maintenance of the impoundments is the responsibility of HPS personnel. GZA met with HPS personnel and discussed the operations and maintenance procedures, regulatory requirements, and the history of the impoundments since their construction. Information gathered during that discussion is reflected in this report.

2.3 Operation and Maintenance Procedures

As discussed in Section 1.2.7, HPS personnel are responsible for the regular operations and maintenance of the impoundments. No formal maintenance plan has been developed for the WAPS and EAPS impoundments. An operation and maintenance plan for the Primary and Secondary Cells has been developed along with a separate operation and maintenance plan for Pond 2E. Based on our discussions with HPS personnel, the roadways and slopes are repaired as needed.

2.4 Emergency Action Plan

An Emergency Action Plan (EAP) has not been developed for the impoundments. An emergency action plan is not required for Class III structure per Illinois regulations. Note that the hazard potential classification for the dam is discussed in Section 1.2.11.

2.5 Hydrologic/Hydraulic Data

Illinois Power Company performed a hydrologic/hydraulic analysis in 1994 for the AEAP Primary and Secondary Cells as part of the original impoundment design. The results are provided in the "Hennepin Power Station Ash Surface Impoundment, Hydrologic/Hydraulic Analysis" report. The analysis was used to determine the maximum discharge rates and water elevations the facility would obtain and also to size the discharge piping and determine the required freeboard.

A hydrologic/hydraulic analysis was also conducted in 2009 by CEC for the AEAP Primary and Secondary Cells and for Pond 2E. The results are provided in the "Engineering Basis of Design, Application for a Permit to Construct a New Leachate and Storm Water Runoff Collection Pond, Dynegy – Hennepin Power Station, Hennepin, Illinois" report. In addition to the HPS operating flows and the future effects from the new landfill portion of the EAPS, the ponds were determined by CEC to have sufficient capacity to safely pass the 24-hour 25-year and the 24-hour 100-year frequency rainfall events with a minimum free-broad of more than 2 feet,

Based on the available information, a hydrologic/hydraulic analysis has not been performed for the WAPS.

GZA did not perform an independent assessment of the hydraulics and hydrology for the impoundments as this was beyond our scope of services.

2.6 Structural and Seepage Stability

Illinois Power Company performed a stability and seepage analysis for the AEAP Primary and Secondary Cells as part of the original impoundment design. The results are provided in the "Hennepin Power Station Ash Surface Impoundment, Geotechnical/Structural Design" report. Based on the results of the stability analysis, the factor of safety was calculated for several load conditions. The critical load conditions were determined to be the end of construction and rapid drawdown conditions. Both static and seismic conditions were evaluated. The results indicted minimum static and seismic factors of safety of 2.0 and 1.7, respectively for the upstream embankments and 2.3 and 2.0, respectively for the downstream embankments. The results for the original embankments were within the range of acceptable factors of safety for the types of embankments and load conditions evaluated.

CEC performed a stability analysis for a section of the existing EAPS 1979 embankment as part of the new landfill design. The 1979 embankment is common to the AEAP and the EAP; the ponds were separated into different units in association with the construction of Pond 2E at a later date. Since the embankment is common to both impoundments, we would expect the CEC analyses for the 1979 embankment for the EAP are to be applicable to the 1979 embankment for the AEAP. Based on the results provided, the calculated factor of safety against wedge failure of the 1978 embankment without seismic loading was 1.009. After submittal of the draft report, Dynegy provided additional analysis and discussion for the 1978 embankment. The additional analysis indicated a factor of safety of 1.4 for static loading conditions. This result is less than generally acceptable factors of safety of 1.5 for the types of embankments and load conditions evaluated, in GZA's opinion. In addition, it is our opinion that the assumption of the discontinuity of the stream bed deposits in the analysis should be verified.

No engineering evaluation is available for the WAPS embankments which were designed by Illinois Power Company.

GZA did not perform an independent assessment of the hydraulics and hydrology for the impoundments as this was beyond our scope of services.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, the overall condition of the EAPS impoundment was judged to be **POOR**. The EAPS impoundment was found to have the following deficiencies:

1. Trees were present along the upstream and downstream slopes;
2. Minor potholes and rutting along the crest gravel access road; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value and assumptions in the analysis about subsurface conditions should be verified.

In general, the overall condition of the AEAPS impoundments was judged to be **POOR**. The AEAPS impoundment was found to have the following deficiencies:

1. Minor potholes and rutting along the crest gravel access road;
2. Trees were present along the downstream slope of the northern embankment; and,

3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value.

In general, the overall condition of the WAPS impoundment was judged to be **<u>POOR</u>**. In GZA's professional opinion, the embankment(s) visually appear to be sound and no immediate remedial action appears to be necessary. However, based on EPA's assessment criteria, the impoundment has been given a POOR Condition Rating, because complete hydraulic and geotechnical computations were not provided/available for GZA's for review. Thus, the stability of the embankment(s) could not be independently verified. The WAPS impoundment was found to have the following deficiencies:

1. Thick vegetation and trees along the downstream slopes;
2. Minor potholes and rutting along the crest gravel access road;
3. Erosion along the downstream slope of the northern embankment;
4. No seepage and/or stability analysis has been performed for the WAPS; and
5. No hydraulic/hydrologic analysis has been performed to confirm adequate freeboard and decant capacity at the design storm event.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the impoundments. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of permits needs to be determined for activities that may occur under the jurisdiction of the appropriate regulatory agencies.

3.2 <u>Studies and Analyses</u>

GZA recommends that HPS/Dynegy conduct the following studies and analysis:

1. Conduct an analysis of the hydraulic/hydrologic condition of the WAPS to establish the rise in water level that occurs during the 100-year, 24-hour rain event to confirm that adequate freeboard is maintained and adequate decant and spillway capacity is available. The loading conditions established during the design storm event should be used in the evaluation of the seepage and stability evaluation of the embankments.

2. Perform a complete structural and seepage stability analysis of the WAPS impoundment including static, seismic and liquefaction loading.

3. Generate a remedial design to address the inadequate factor of safety along the northern embankment of the EAPS and AEAPS adjacent to the Illinois River.

3.3 <u>Recurrent Operation & Maintenance Recommendations</u>

GZA recommends the following operation and maintenance level activities:

1. Increased mowing of the grasses on the embankments to facilitate assessments and reduce the risk of burrowing animals;

2. Repair wave action erosion on the downstream slope of the WAPS;

3. Repair the potholes present in the gravel crest access roads. Grade the road to provide better drainage and reduce future potholing; and,

4. Clear trees and other deep rooted vegetation from the slopes and crests of the embankments.

3.4 Repair Recommendations

GZA recommends the following repairs to address observed deficiencies that may affect the stability of the embankments. The recommendations may require design by a professional engineer and construction contractor experienced in impoundment construction.

1. Pending the results of the hydraulic/hydrologic analysis, modify the design or operation of the WAPS to provide adequate capacity.

2. Pending the results of the complete seepage and stability analysis for the WAPS, modify the design or operation of the impoundments to provide conditions that result in embankments that meet the generally accepted factors of safety.

3. Based on the geotechnical results for the EAPS and AEAPS embankments, which produced inadequate minimum factors of safety, develop design modifications for those embankments along the Illinois River. These improvements are to result in the embankments meeting generally accepted factors of safety and protect the slope from future erosion.

3.5 Alternatives

There are no practical alternatives to the repairs itemized above.

4.0 ENGINEER'S CERTIFICATION

I acknowledge that the management unit referenced herein, the HPS WAPS, AEAPS, and EAPS Impoundments have been assessed to be in **POOR** condition on May 23, 2011.

Patrick J. Harrison, P.E.
Senior Consultant

FIGURES

SOURCE: U.S.G.S. QUADRANGLE MAP
DEPUE, IL (1966)
PHOTOREVISED (1979)

NO.	ISSUE/DESCRIPTION	BY	DATE

PREPARED BY:

GZA GeoEnvironmental, Inc.
Engineers and Scientists
20900 SWENSON DRIVE, SUITE 150
WAUKESHA, WISCONSIN 53186
(262) 754-2560

SITE LOCATION MAP

PREPARED FOR:

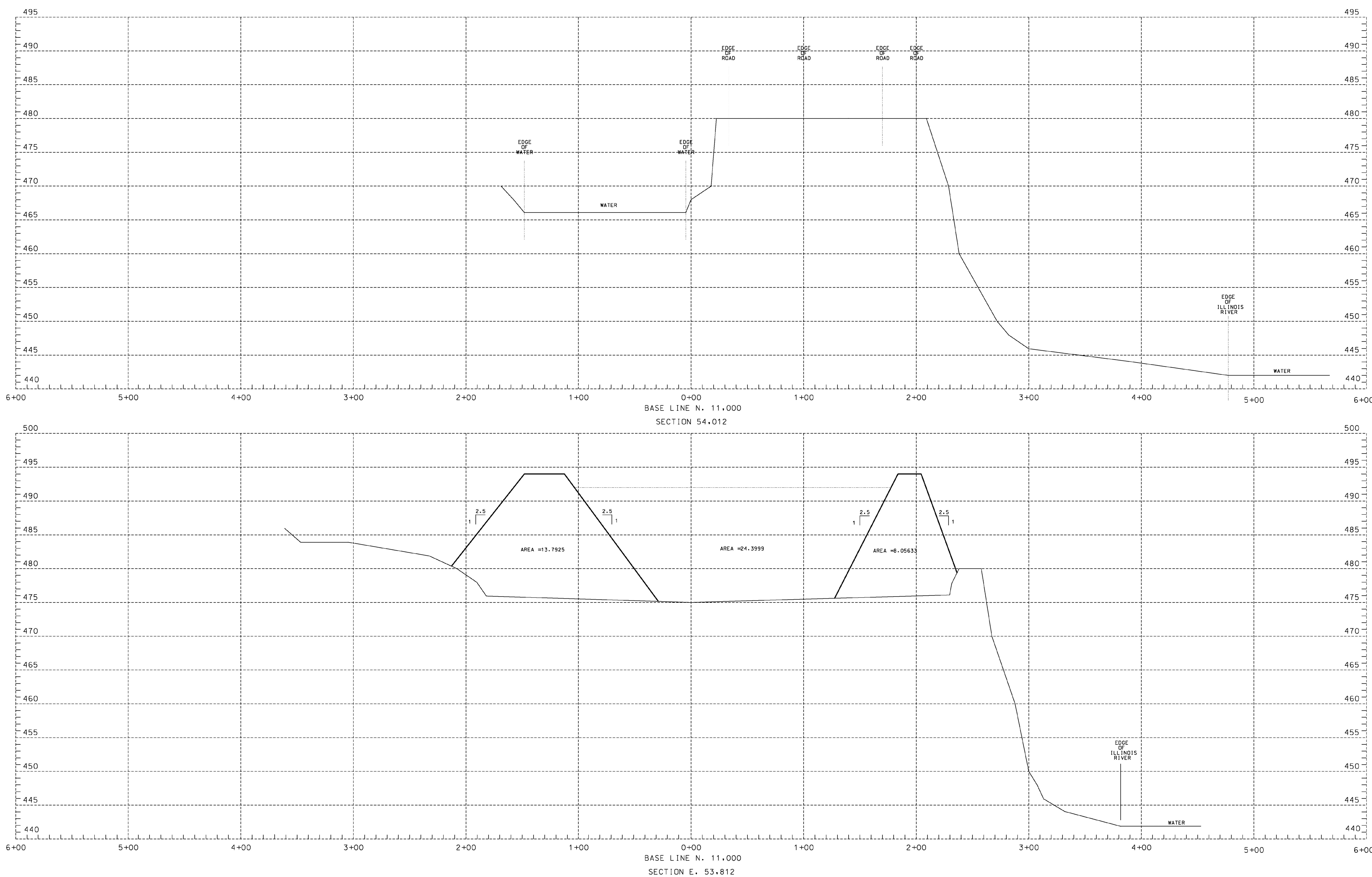
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

FIGURE
1
SHEET NO.

PROJ MGR: DPS	REVIEWED BY: PJH	CHECKED BY: DS	DATE	PROJECT NO.	REVISION NO.
DESIGNED BY: DS	DRAWN BY: CLK	SCALE: 1 : 24000	12/12/11	01.0170142.30	

GZA-J:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\SITE LOCATION.dwg [FIGURE 1 - SITE LOCATION] December 12, 2011 - 9:23am justin.hegarty


SOURCE: DIGITAL ORTHOPHOTO/AERIAL IMAGERY PRODUCED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) AND RETRIEVED THROUGH USE OF A PROFESSIONAL LICENSE OF THE GOOGLE EARTH MAPPING PROGRAM.
DATA ACCESSED JULY 2011
Feet
200 100 0 200
N
E
S
W
HENNEPIN POWER STATION
POND 2E
EAST ASH POND
SECONDARY CELL
PRIMARY CELL
WEST ASH POND
LEGEND
APPROXIMATE IMPOUNDMENT BOUNDARY
GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186
Phone: (262) 754-2560 Fax: (262) 754-9711
DYNEGY MIDWEST GENERATION, LLC
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS
OVERALL ASH BASIN PLAN
PROJ. MGR.: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DWG. Date: 12-12-2011
Job NO.: 01.0170143.30
FIGURE NO.: 2



NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-11-89
CK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-1
APP		

REV. NO. | DESCRIPTION | BY | DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin ♦ 53186 ♦ Phone (262) 754-2560 ♦ Fax (262) 754-9711
www.gza.com

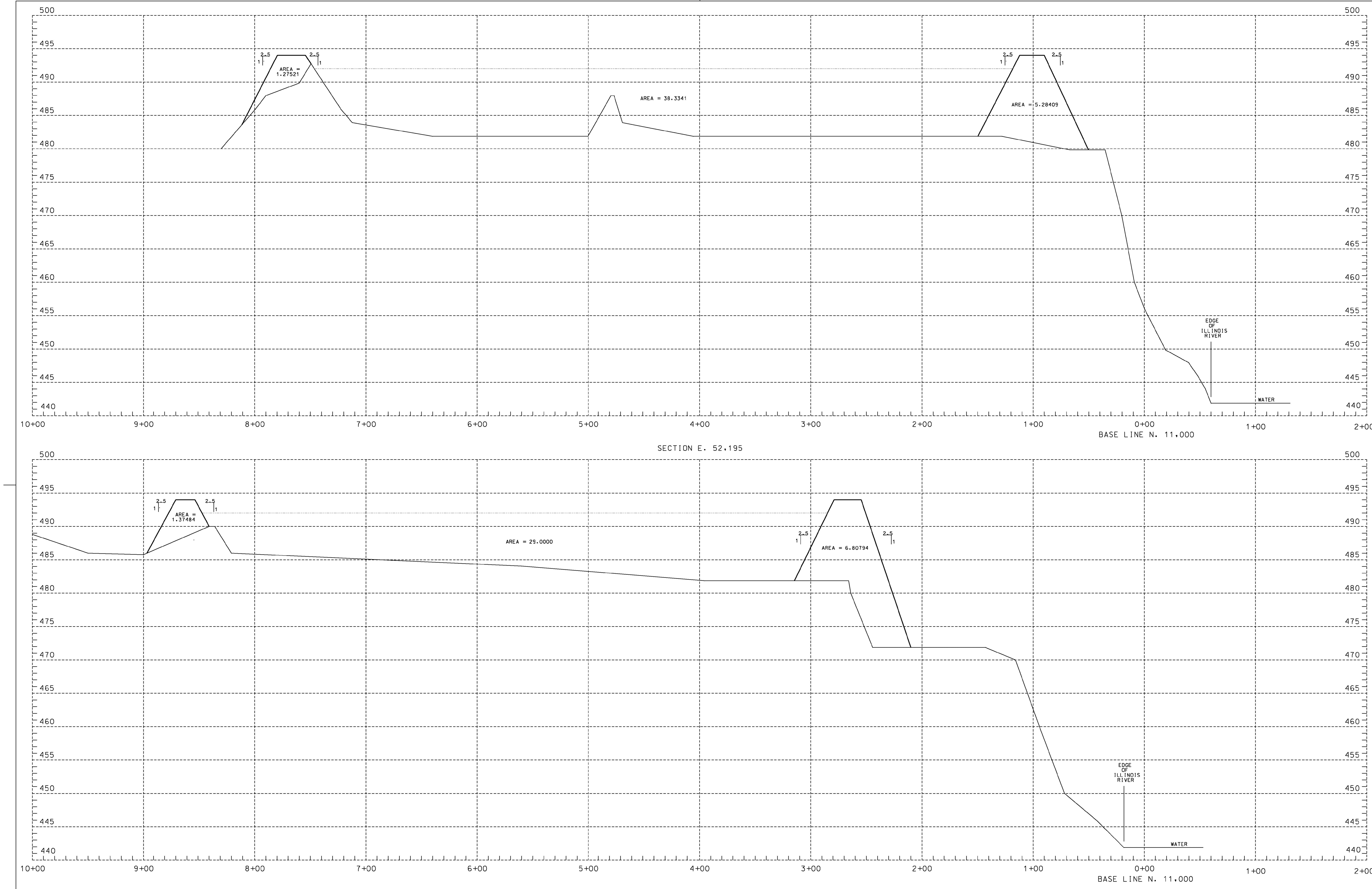
NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

EAST ASH POND TYPICAL SECTIONS OF 1989 EMBANKMENT RAISE

JOB NO.
01.0170142.30

FIGURE NO.
3



NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

ILLINOIS POWER COMPANY
DECATUR
CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM | CAD WJM | DATE 1-12-89 | SCALE 1"=5' V. 1"=30' H. | PLOTTED 03-08-90 | CE-HEN1-B458-5

NOTE: IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

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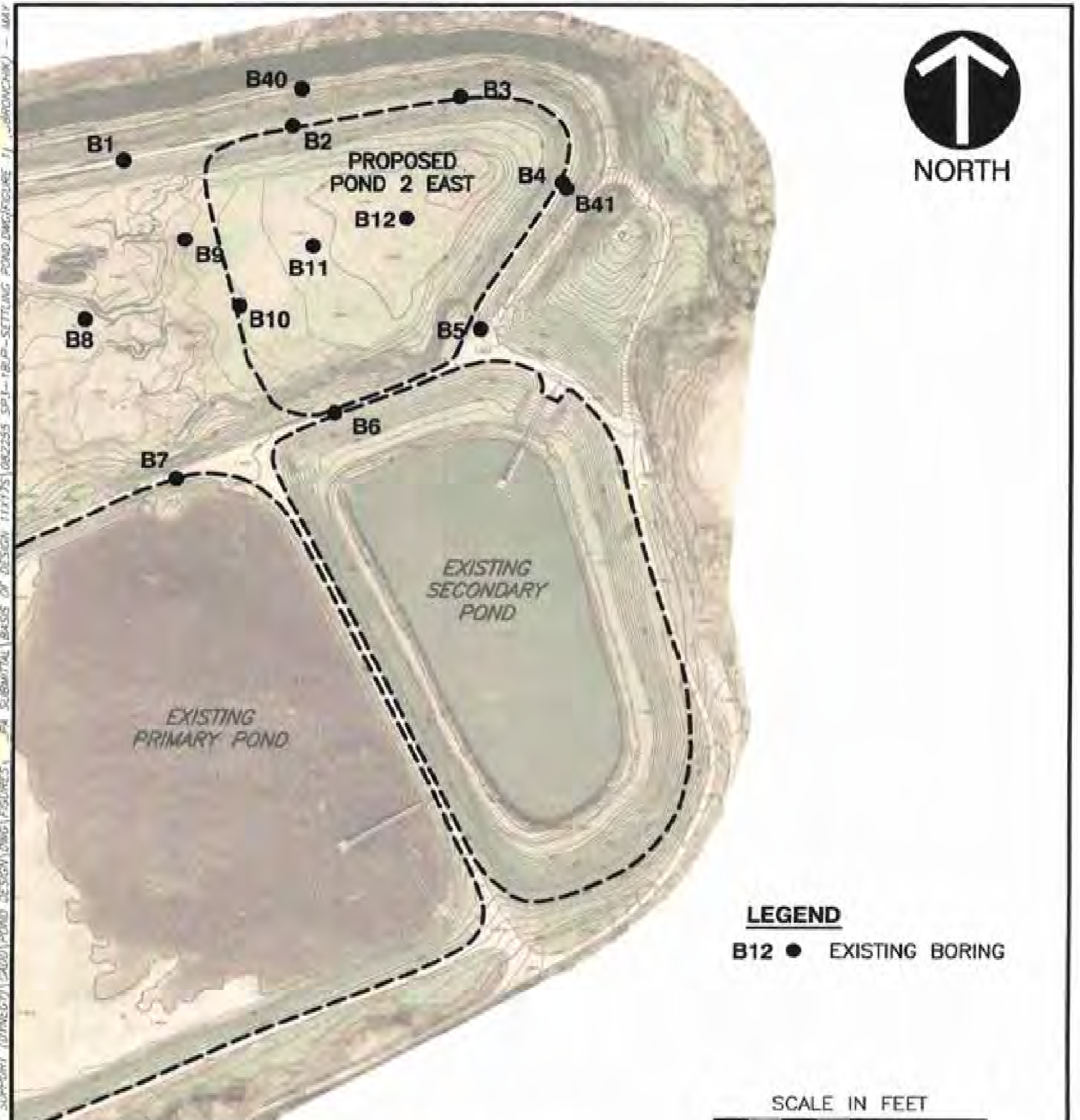
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

EAST ASH POND ADDITIONAL
SECTIONS OF 1989 EMBANKMENT RAISE

JOB NO. 01.0170142.30

FIGURE NO. 4

Drawing Name: J:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\Scanned Figures - Hennepin.dwg Last Modified: Dec 13, 2011 - 10:42am Plotted on: Dec



LEGEND

B12 ● EXISTING BORING

SCALE IN FEET

0 200 400

DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

* HAND SIGNATURE ON FILE

REFERENCE

1. TOPOGRAPHIC SURVEY PERFORMED BY SURDEX CORPORATION, FLOWN ON OCTOBER 26, 2008.

CEC
Civil & Environmental Consultants, Inc.
5910 Harper Road, Suite 106 · Solon, OH 44139
440-287-0157 · 866-507-2324
www.cecinc.com

DYNEGY
HENNEPIN POWER STATION
PROPOSED POND 2 EAST
BASIS OF DESIGN

BORING LOCATION PLAN

DRAWN BY: WRM	CHECKED BY: MDJ	APPROVED BY: PCC*	FIGURE NO.:
DATE: MAY 19, 2009	DWG SCALE: 1"=200'	PROJECT NO: 082-255	4

REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

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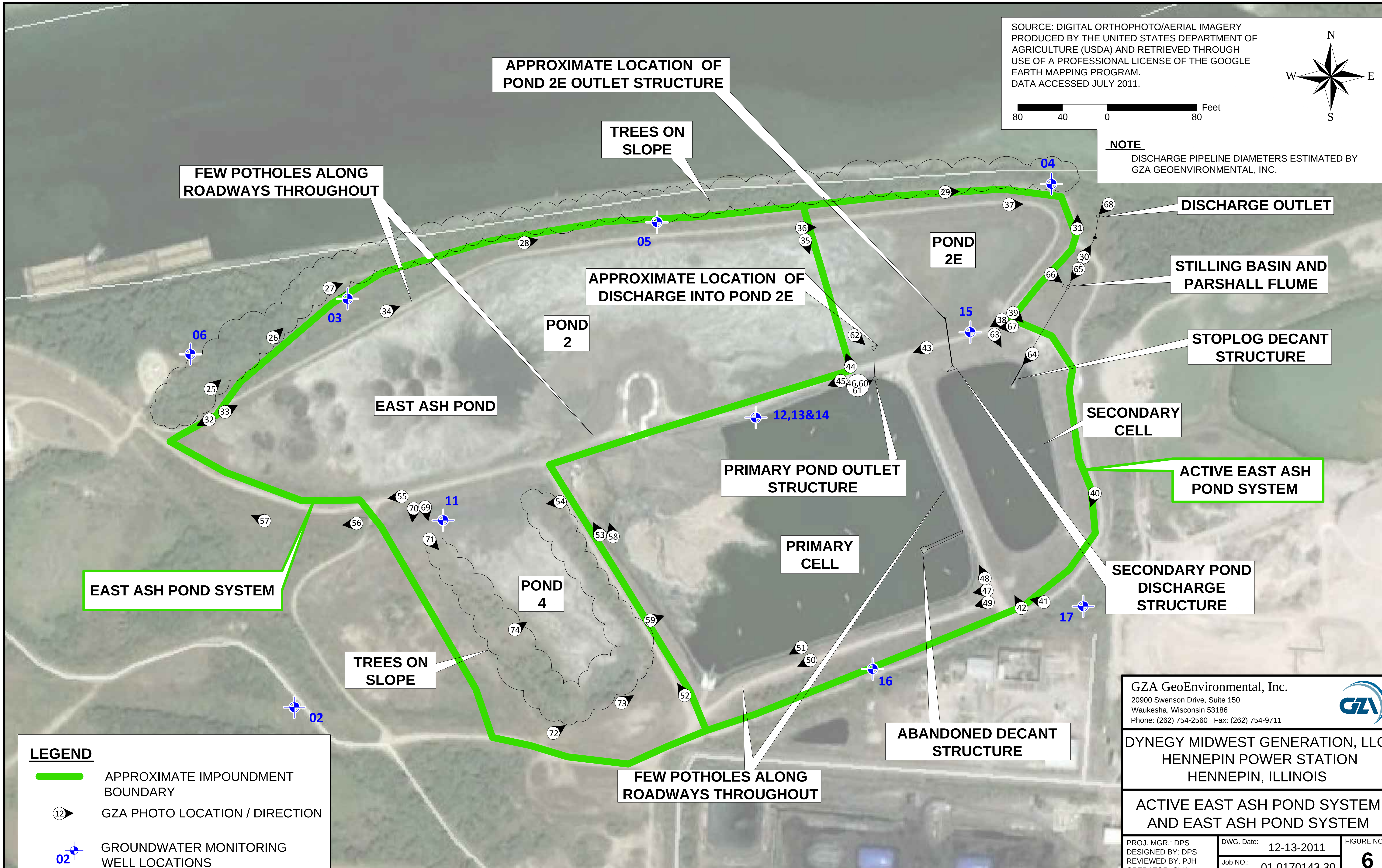
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

BORING LOCATION PLAN

JOB NO.
01.0170142.30

FIGURE NO.
5



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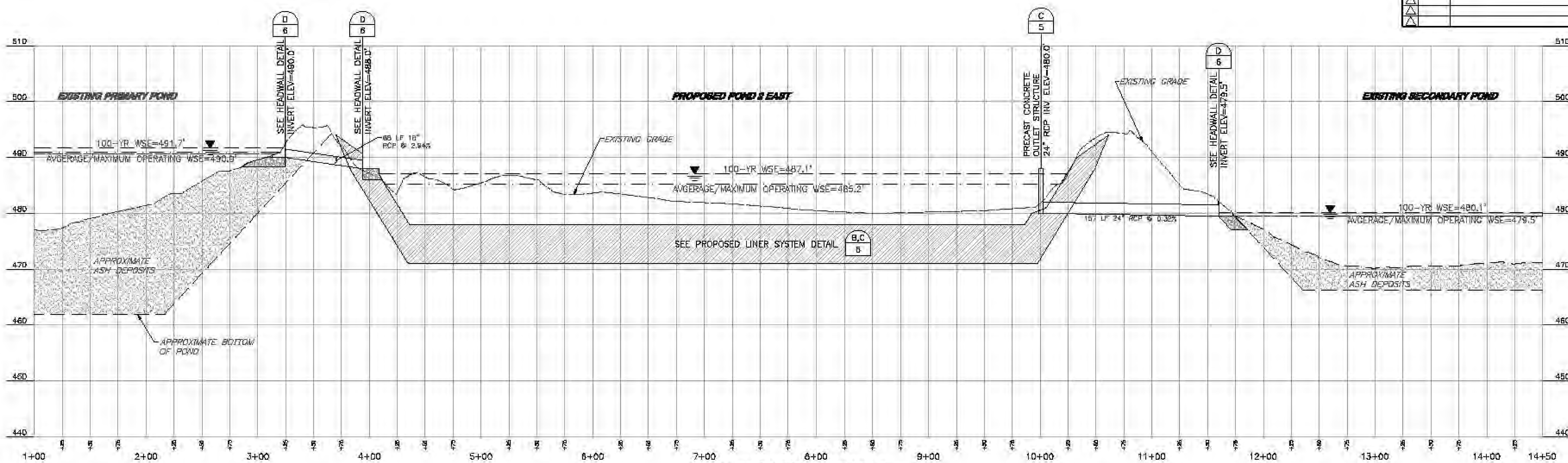
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186
Phone: (262) 754-2560 Fax: (262) 754-9711

DYNEGY MIDWEST GENERATION, LLC
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

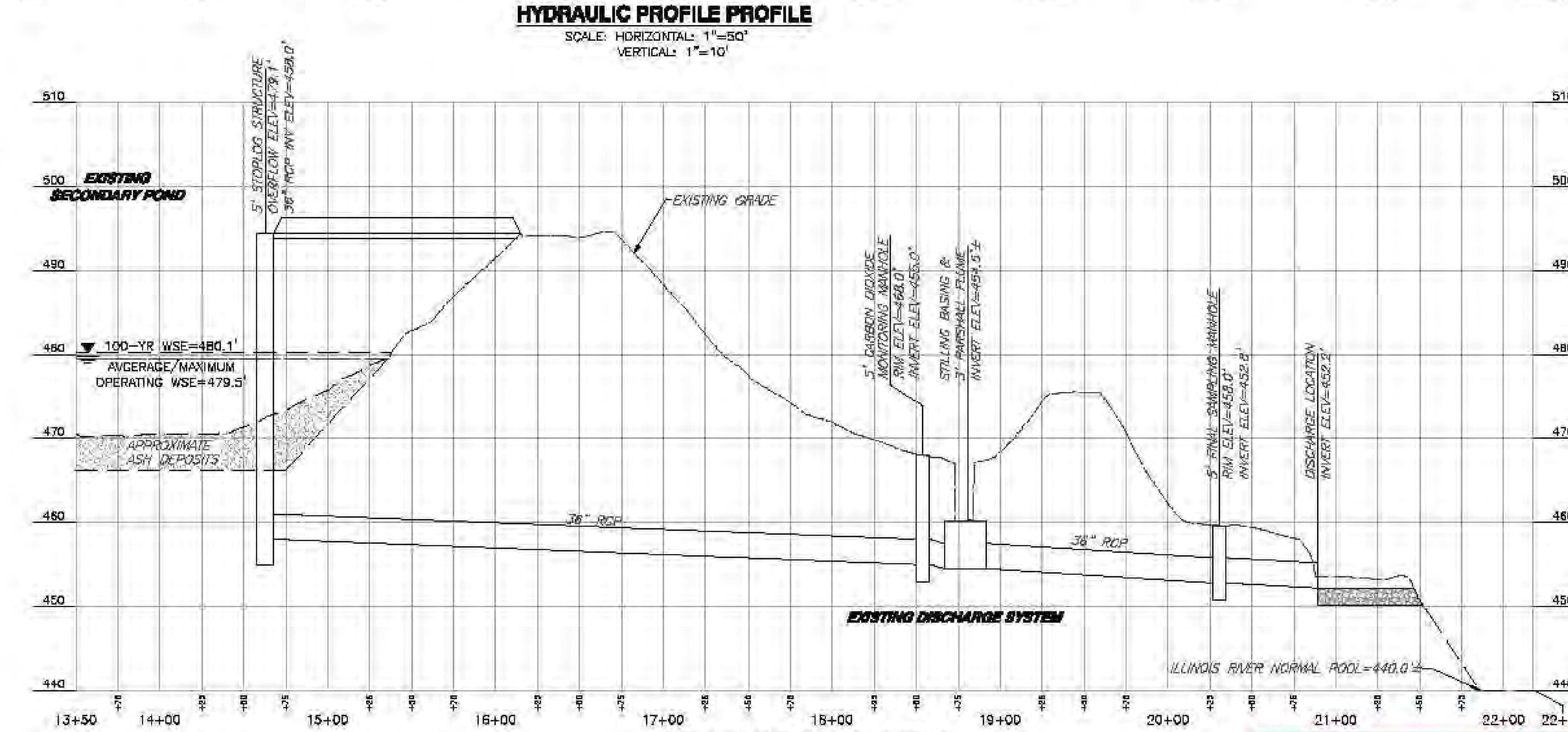
ACTIVE EAST ASH POND SYSTEM
AND EAST ASH POND SYSTEM

PROJ. MGR.: DPS DESIGNED BY: DPS REVIEWED BY: PJH OPERATOR: CLK	DWG. Date: 12-13-2011 Job NO.: 01.0170143.30	FIGURE NO.: 6



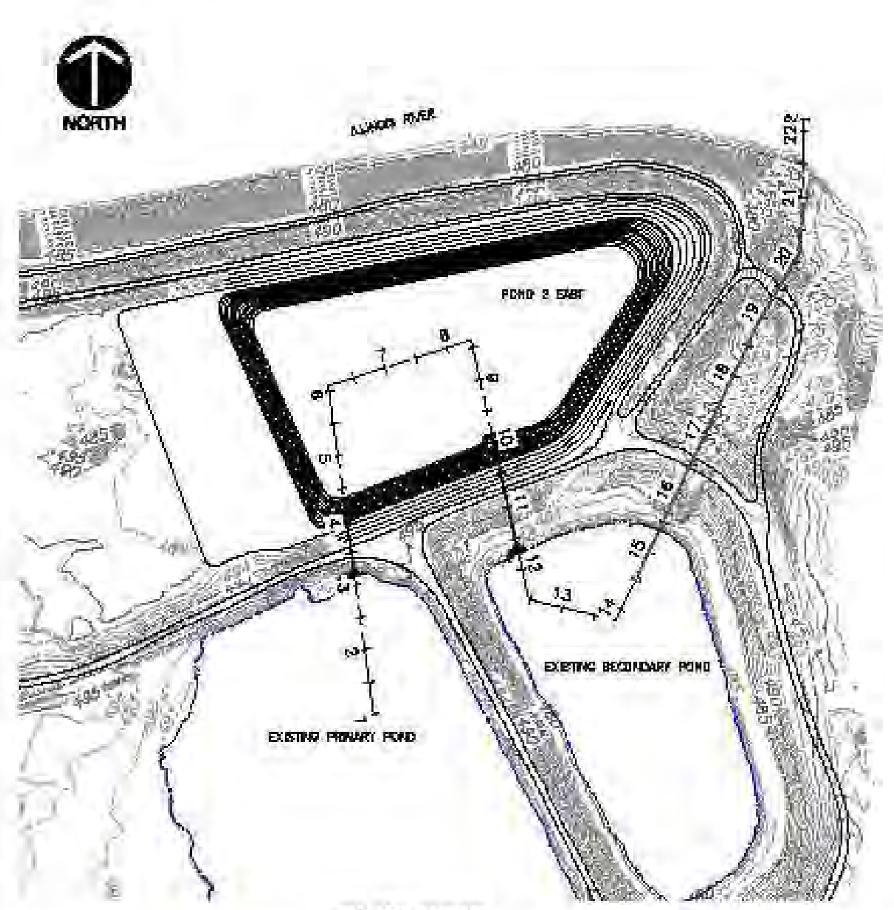
HYDRAULIC PROFILE PROFILE

SCALE: HORIZONTAL: 1"=50'
VERTICAL: 1"=10'



HYDRAULIC PROFILE PROFILE

SCALE: HORIZONTAL: 1"=50'
VERTICAL: 1"=10'



PLAN VIEW

SCALE: 1"=200'

SCALE IN FEET

DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

DRAFT

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION

REVISION RECORD		
NO	DATE	DESCRIPTION

CEC

Civil & Environmental Consultants, Inc.

www.cecinc.com

DYNEGY HENNEPIN POWER STATION POND 2 EAST PERMIT

HYDRAULIC PROFILE

DRAWING NO. 4

SHEET 4 OF 7

REV. NO. | DESCRIPTION | BY | DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-8-11

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Waukesha, Wisconsin 53186 Phone (262) 754-2560 Fax (262) 754-9711
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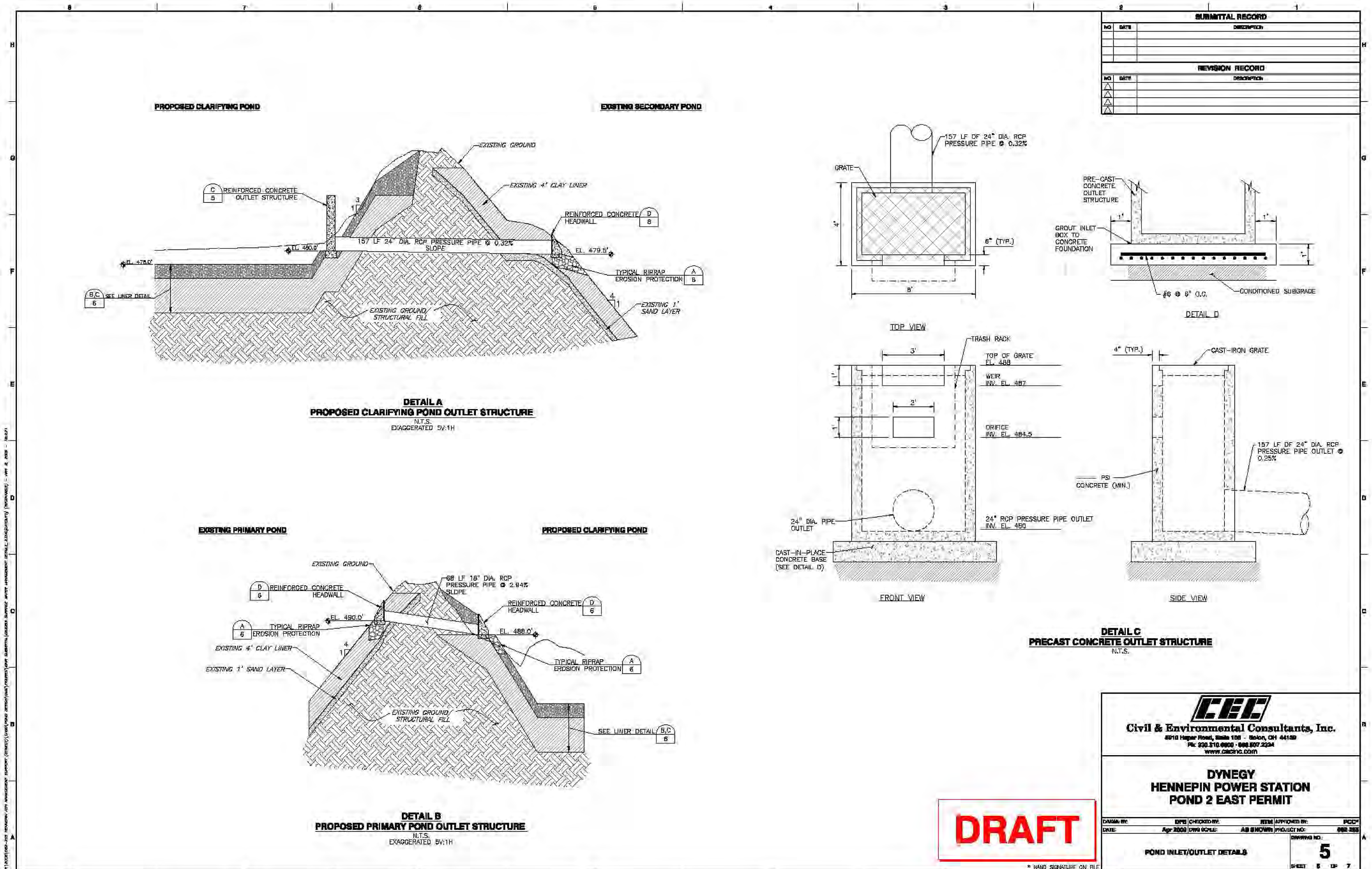
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

POND 2E PROFILES AND DETAILS

JOB NO. 01.0170142.30

FIGURE NO. 7



REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
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REVIEWED BY: PJH
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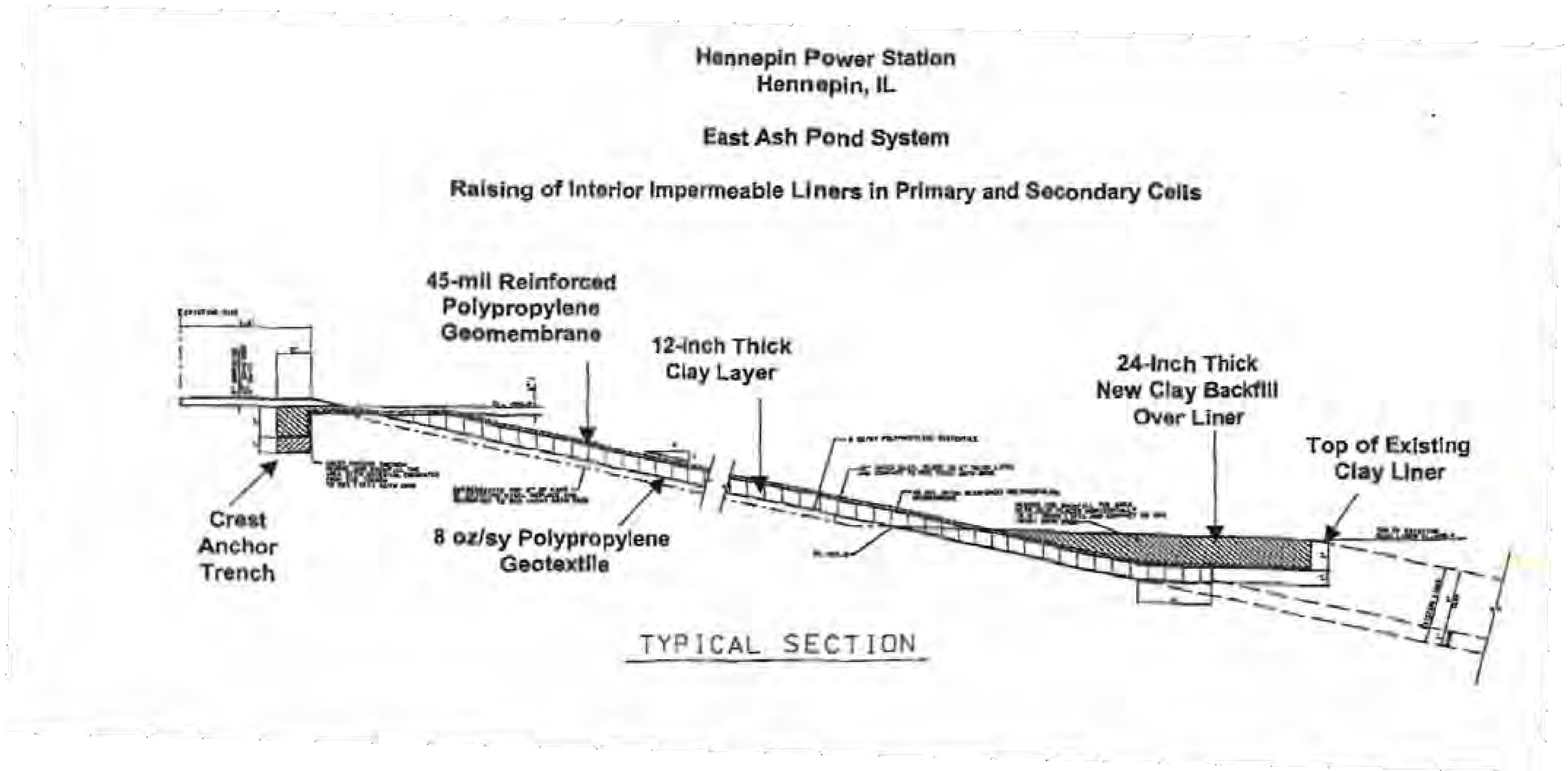
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

POND 2E STRUCTURE DETAILS

JOB NO.
01.0170142.30

FIGURE NO.
8



REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
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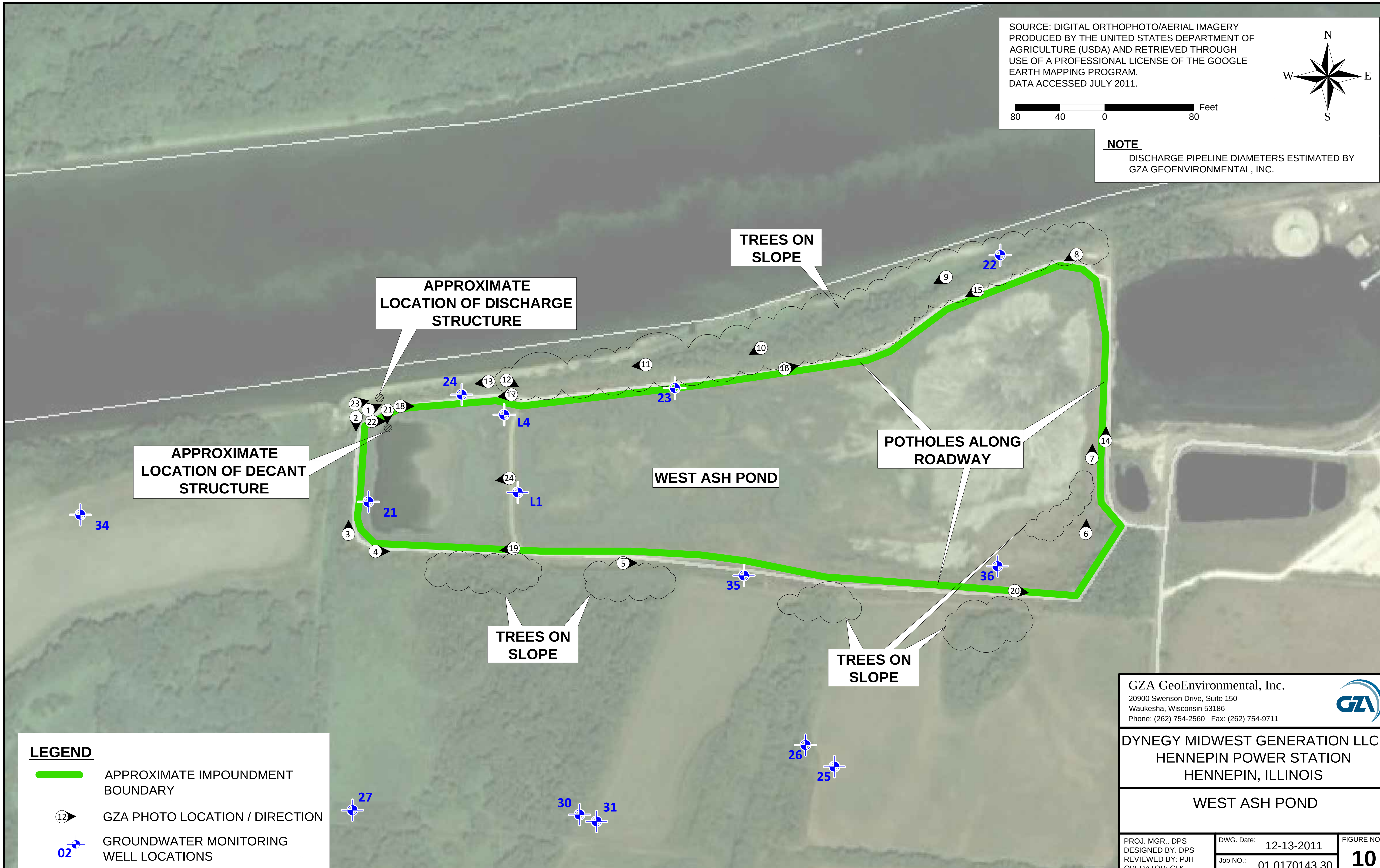
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

TYPICAL SECTION OF LINER EXTENSION

JOB NO.
01.0170142.30

FIGURE NO.
9



GZA-J:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\SITE PLANS.dwg [fig 10] December 13, 2011 - 10:40am justin.hegarty

APPENDIX A

LIMITATIONS

DAM ENGINEERING & VISUAL ASSESSMENT LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the United States Environmental Protection Agency (EPA).

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by Dynegy Midwest Generation, LLC (Dynegy) (and their affiliates) as well as Federal, state, and local officials and other parties referenced therein. GZA has also relied on other parties which were available to GZA at the time of the assessment. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be noted that the reported condition of the Ash Ponds is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the Ash Ponds reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam or embankment depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam or embankment will continue to represent the condition of the dam or embankment at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA's comments on the history, hydrology, hydraulics, and embankment stability for the Ash Ponds are based on a limited review of available design documentation for the Hennepin Power Station. Calculations and computer modeling used in these analyses were not available and were not independently reviewed by GZA.

7. This report has been prepared for the exclusive use of EPA for specific application to the existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

8. This dam inspection verification report has been prepared for this project by GZA. This report is for broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

9. The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

APPENDIX B

DEFINITIONS

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to references published by the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, the Department of the Interior Bureau of Reclamation, or the Federal Emergency Management Agency.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate there from, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

SATISFACTORY - No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR - Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR - A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

UNSATISFACTORY - Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

Hazard Potential

(In the event the impoundment should fail, the following would occur):

LESS THAN LOW HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

LOW HAZARD POTENTIAL: Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

SIGNIFICANT HAZARD POTENTIAL: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

HIGH HAZARD POTENTIAL: Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

APPENDIX C

INSPECTION CHECKLISTS

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	East Ash Impoundment	Operator's Name:	Dynegy Midwest Generation, LLC
Unit I.D.:	NPDES IL 0001554	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)? See Note Below			19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)? See Note Below			20. Decant Pipes: See Note Below		
4. Open channel spillway elevation (operator records)?			Is water entering inlet, but not exiting outlet?		
5. Lowest dam crest elevation (operator records)?	494.0		Is water exiting outlet, but not entering inlet?		
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?		
7. Is the embankment currently under construction?	✓		21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place? See Note Below			From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches? See Note Below			Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?			22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

2. No pool, decant, or open channel spillway is present in the East Ash Impoundment.

7. Dynegy has received a permit to construct a landfill over an inactive portion of Pond 2 and is referred to as the East Ash Impoundment.

8. Based on boring logs and observations.

9. Largest tree diameter noted was approximately 30 inches.

Items 12, 14, 15 and 20 do not apply to this impoundment.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Date May 23, 2011 Doug P. Simon, P.E.

Impoundment Name East Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment East Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ______

	Yes	No	
Is impoundment currently under construction?	X		Dynergy is building a land-fill on the impoundment.
Is water or ccw currently being pumped into the impoundment?		X	

IMPOUNDMENT FUNCTION: This impoundment has been inactive since 1995 and stores CCW from plant operations prior to 1995.

Nearest Downstream Town : Name Hennepin
Distance from the impoundment 4 miles
Impoundment
Location: Longitude 89 Degrees 18 Minutes 28 Seconds
Latitude 41 Degrees 18 Minutes 10 Seconds
State IL County Putnam County

Does a state agency regulate this impoundment? YES X NO ______

If So Which State Agency? The Illinois Environmental Protection Agency regulates the environmental concerns associated with the impoundment through a Closure Protocol.

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

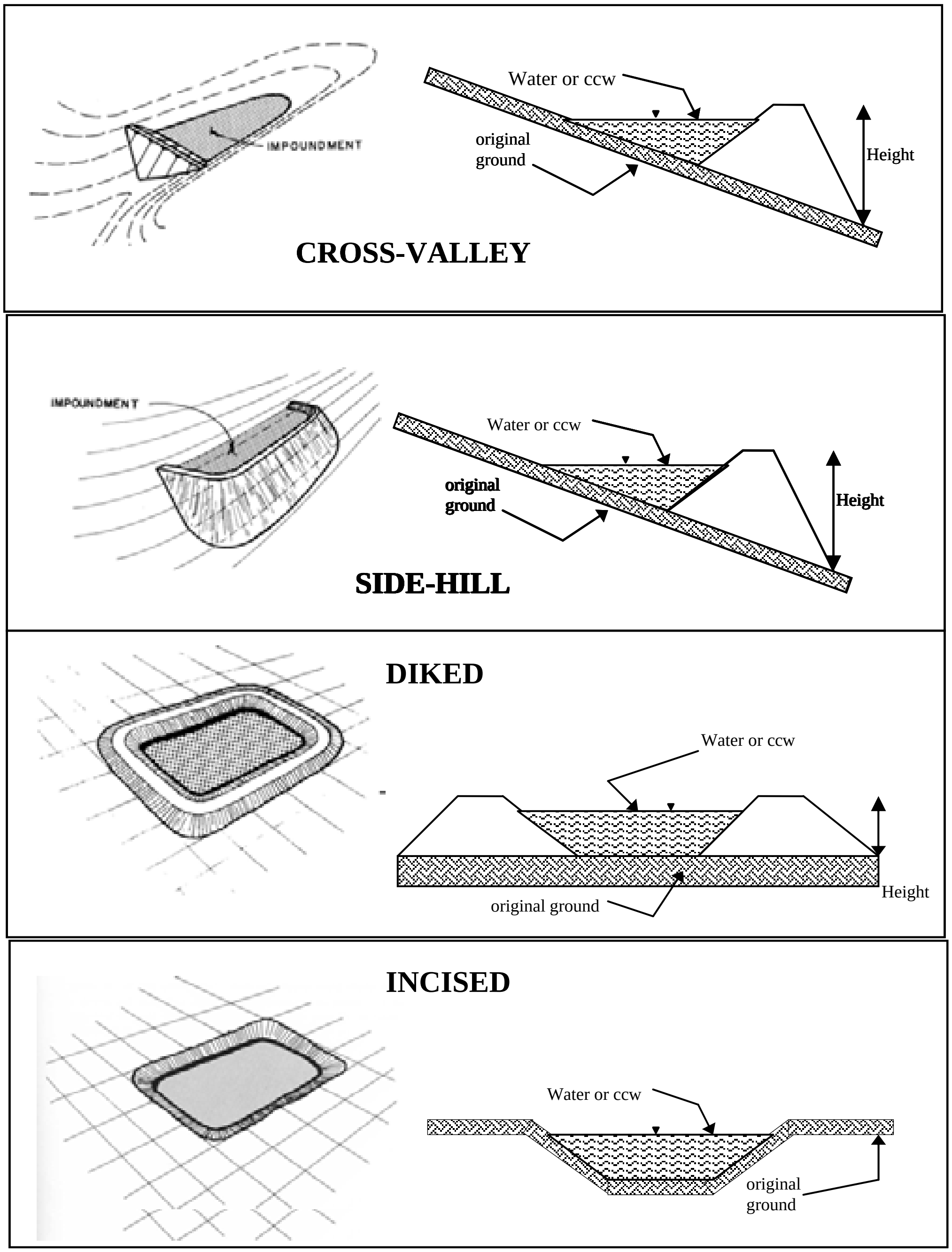
_X____ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

The Illinois River abuts the northern embankment of the East Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

CONFIGURATION:



_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_X_ Combination Incised/Diked

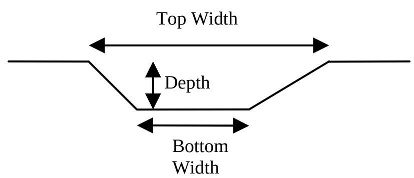
Embankment Height 52 feet   Embankment Material Compacted Native Fill
Pool Area No Pool acres   Liner None Present
Current Freeboard NA feet   Liner Permeability __________

TYPE OF OUTLET (Mark all that apply)

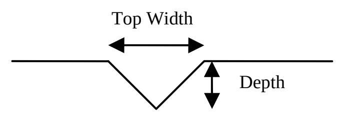
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width

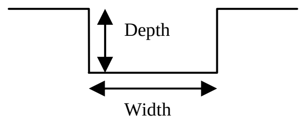
TRAPEZOIDAL



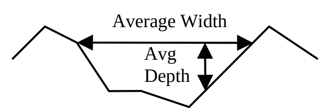
TRIANGULAR



RECTANGULAR

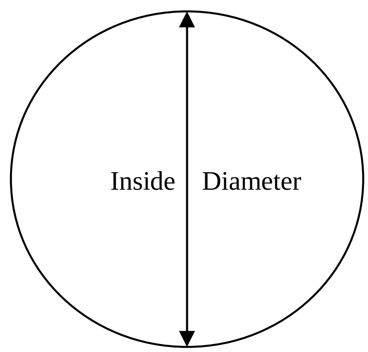


IRREGULAR



_____ **Outlet**

_____ inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _______ NO _______

_X_ **No Outlet**

_____ **Other Type of Outlet** (specify) ________________________________

The Impoundment was Designed By Illinois Power Company
____

Has there ever been a failure at this site? YES ___________ NO ___X_______

If So When? ______________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X____

If So When? ______________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower
Phreatic water table levels based on past seepages or breaches
at this site? YES ________NO __X______

If so, which method (e.g., piezometers, gw pumping,...)? ______________________

If so Please Describe : ____

  US Environmental Protection Agency

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	Active Ash Impoundment	Operator's Name:	Dynergy Midwest Generation, LLC
Unit I.D.:	IL50363	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)? See Note Below	489.5		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	489.5		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)? See Note Below			Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	494.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

2. There are three ponds that make up this impoundment. The elevation provided refers to that in the Primary pond which is also the highest elevation as referenced in the Operation and Maintenance Plan.
4. No open channel spillway was present.
8. Based on available soil borings.
9. Largest tree diameter noted was approximately 30 inches.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Date May 23, 2011 Doug P. Simon, P.E.

Impoundment Name Active Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment Active Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ______

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Settlement of CCW that is sluiced into the impoundment.

Nearest Downstream Town : Name Hennepin
Distance from the impoundment 4 miles
Impoundment
Location: Longitude 41 Degrees 18 Minutes 00 Seconds
Latitude 89 Degrees 18 Minutes 13 Seconds
State IL County Putnam County

Does a state agency regulate this impoundment? YES X NO ______

If So Which State Agency? The Illinois Department of Natural Resources regulates discharge of water through NPDES permit and a portion of the Impoundment as a regulated dam.

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

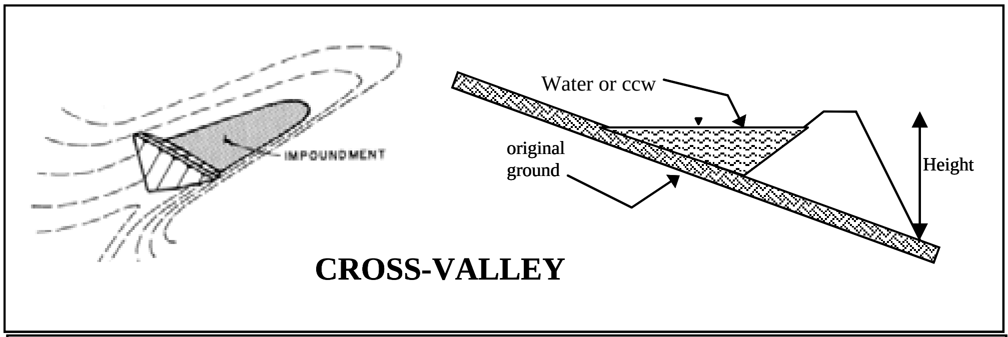
__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

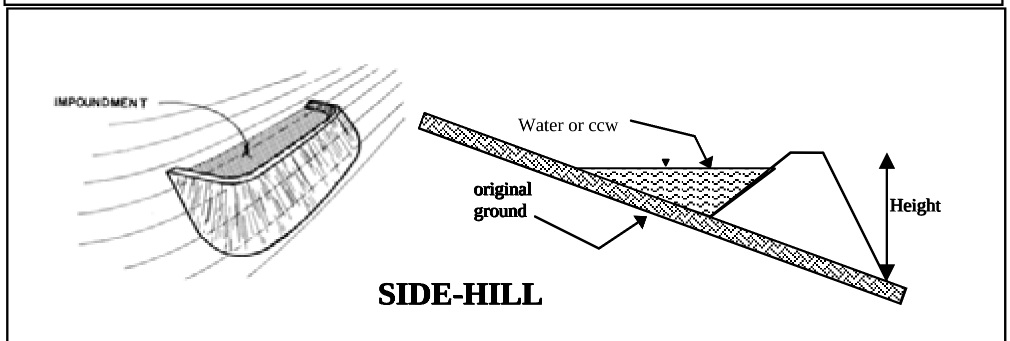
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

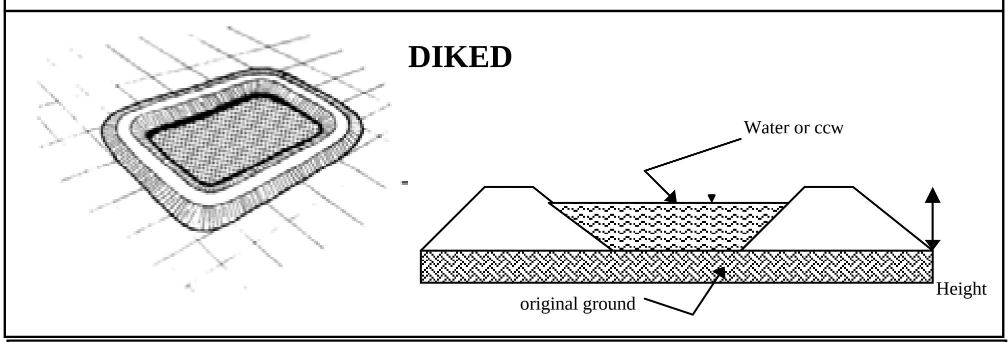
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

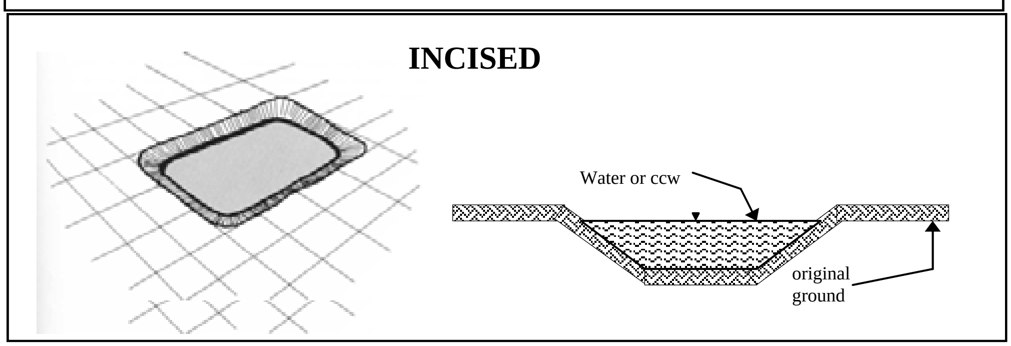
The Illinois River abuts the northern embankment of the Active Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

CONFIGURATION:









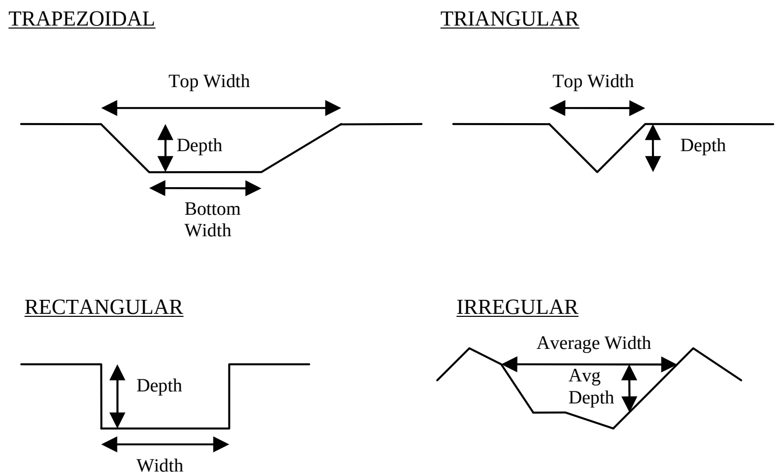
_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
X Combination Incised/Diked

Embankment Height 52 feet Embankment Material Compacted Native Fill
Pool Area 30 acres Liner Clay/HDPE
Current Freeboard 3.5 feet Liner Permeability __________

TYPE OF OUTLET (Mark all that apply)

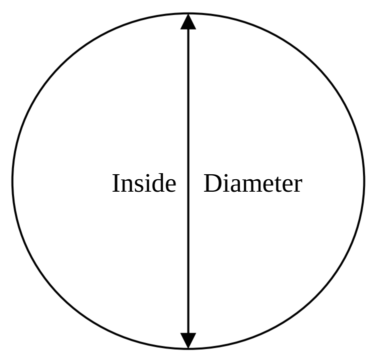
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



__X__ **Outlet**

_____ inside diameter
Varies: See Below.



Material
_____ corrugated metal
_____ welded steel
_X___ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES ________ NO __X____

_____ **No Outlet**

There are three ponds that make up the active ash pond. The outlet diameters vary from approximately 12 inches to 30 inches.

_____ **Other Type of Outlet** (specify) ___________________________________

The Impoundment was Designed By ____
____

Has there ever been a failure at this site? YES ___________ NO ____X_______

If So When? ______________________________

If So Please Describe : ____

Has there ever been significant seepages at this site?   YES ________ NO __X____

If So When? ______________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? ______________________

If so Please Describe : ____

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	West Ash Impoundment	Operator's Name:	Dynergy Midwest Generation, LLC
Unit I.D.:	NPDES IL 0001554	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	455.6		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	455.6		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)? See Note Below			Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	460.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear? See Note Below		
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?		✓	From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments

4. No open channel spillway was present.

8. Based on boring logs and observations.

9. Largest tree diameter noted was approximately 30 inches.

20(c). No water was entering or exiting the impoundment.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Date May 23, 2011 Doug P. Simon, P.E.

Impoundment Name West Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment West Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ____

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?		X

IMPOUNDMENT FUNCTION: This impoundment has been inactive since 1995 and stores CCW from plant operations prior to 1995.

Nearest Downstream Town : Name Hennepin, Illinois
Distance from the impoundment 4 miles
Impoundment
Location: Longitude 89 Degrees 19 Minutes 28 Seconds
Latitude 41 Degrees 18 Minutes 00 Seconds
State IL County Putnam

Does a state agency regulate this impoundment? YES X NO ____

If So Which State Agency? The Illinois Environmental Protection Agency regulates discharge from the impoundment through the NPDES permit.

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

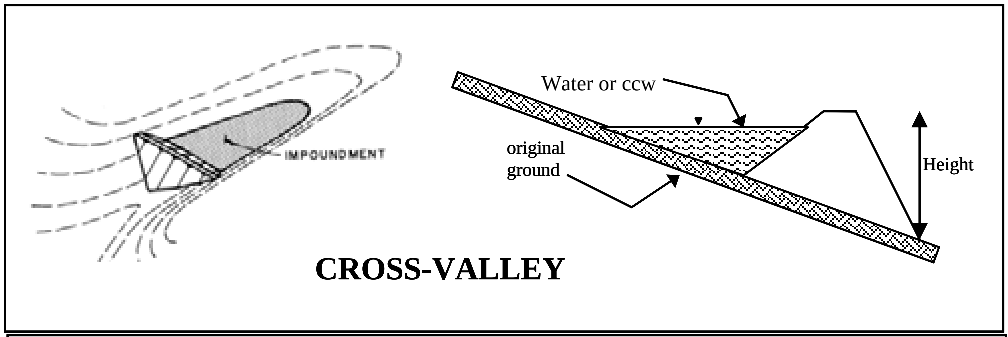
_x____ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

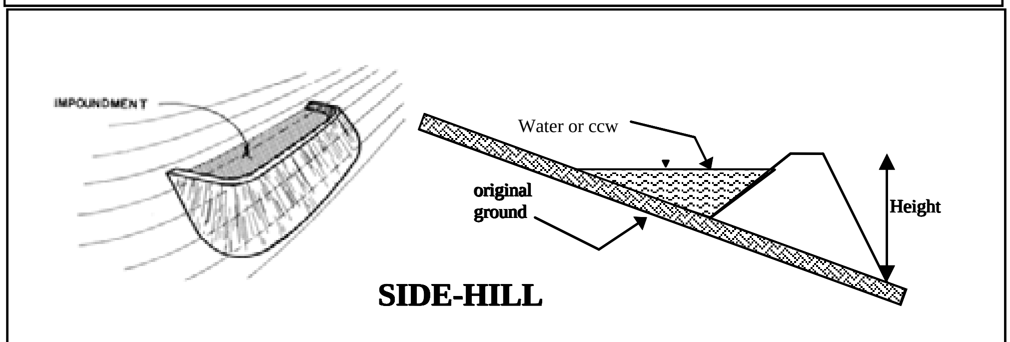
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

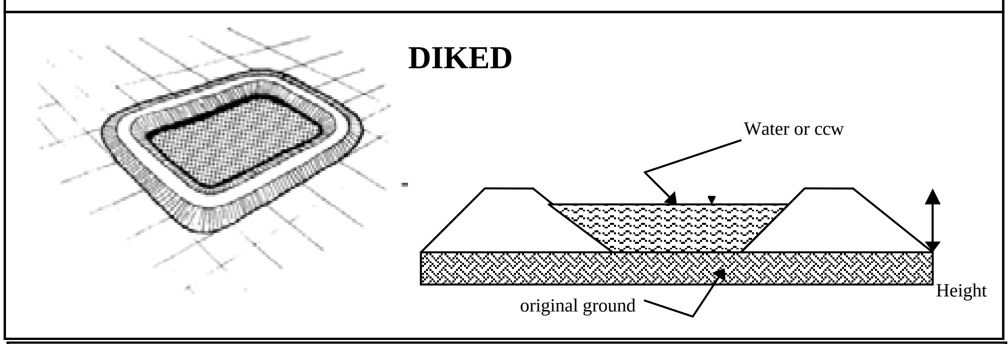
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

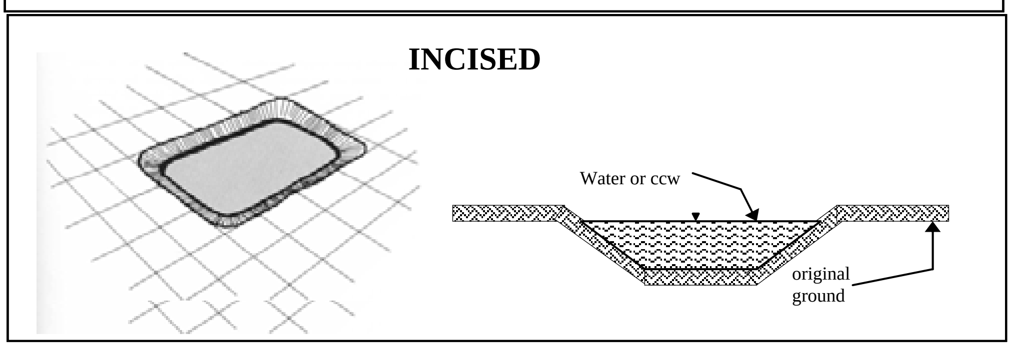
The Illinois River abuts the northern embankment of the West Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

<u>CONFIGURATION</u>:









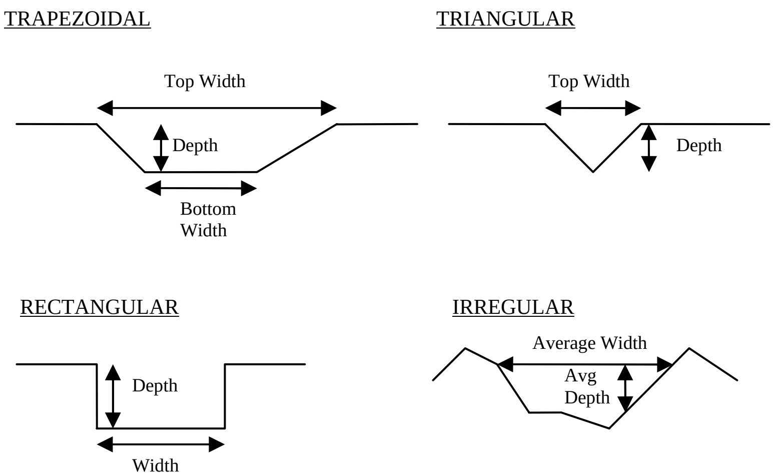
_____ Cross-Valley
_____ Side-Hill
_X___ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height ___18___ feet Embankment Material Compacted Native Fill
Pool Area ___2___ acres Liner ___None Present___
Current Freeboard ___4.4___ feet Liner Permeability ___Unknown___

<u>TYPE OF OUTLET</u> (Mark all that apply)

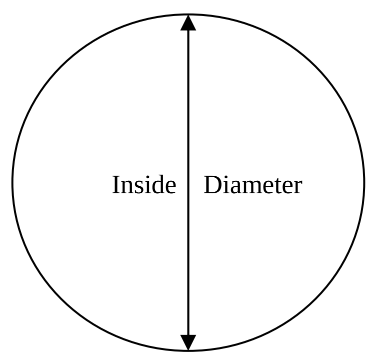
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



__X__ **Outlet**

12 in. inside diameter



Material
_____ corrugated metal
__X__ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _______ NO __X____

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ________________________________

The Impoundment was Designed By Sargent & Lundy
____

Has there ever been a failure at this site? YES ___________ NO ____X_______

If So When? ______________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X____

If So When? ______________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? ______________________

If so Please Describe : ____

APPENDIX D

PREVIOUS INSPECTION REPORTS

Dynegy Midwest Generation, Inc.
2828 North Monroe Street
Decatur, Illinois 62526-3269

DYNEGY

December 31, 2001

Mr. Dennis L. Kennedy, P.E.
Senior Water Resources Engineer
Illinois Department of Natural Resources
Office of Water Resources
524 South Second Street
Springfield, IL 62701-1787

Dear Mr. Kennedy:

Hennepin Power Station; East Ash Pond
Dam Safety Permit No. 21922
Dam I.D. No. IL50363

2001 Five-Year Inspection Report

Enclosed is a signed copy of the 2001 inspection report for the Hennepin Power Station's east ash pond dam. Mr. Jeffrey Lamb, professional civil engineer with Dynegy-Illinois Power's Engineering and Technical Services Department, conducted the professional engineer inspection on November 27, 2001. This inspection is required by Section 702.40(b)(5) of the Rules for the Construction and Maintenance of Dams and the conditions of IDNR Permit No. 21922.

The inspection report shows that the overall condition of the facility is good. The only minor maintenance that needs to be conducted is the continued removal of sapling trees on the embankments. This will be conducted as a part of routine maintenance during next year. Sapling tree removal was also conducted as a part of routine maintenance during the previous five years as recommended in the 1996 inspection report.

An Owner's Maintenance Statement, signed by Mr. James G. Dodson, Plant Manager, Hennepin Power Station, is also included.

If you have any questions regarding this report, please contact me at 217/872-2359.

Sincerely,
Dynegy Midwest Generation

Thomas L. Davis

Thomas L. Davis, P.E.
Senior Environmental Professional

bc: J.G.Dodson, w/att., S-10
J.P.Augspols w/att., S-10
B.J. Marshall/T.E. Tuttle/File: Hennepin PS Dam Inspection Reports, w/att., A-05

Illinois Power Company
500 South 27th Street
Decatur, Il 62521-2200

November 30, 2001

Mr. B. J. Marshall
Dynegy Midwest Generation
2828 N. Monroe St.
Decatur, IL 62526

ILLINOIS POWER
Part of the DYNEGY Performance Team

RE: Hennepin Power Station
Hennepin Ash Surface Impoundment
2001 Dam Inspection

Dear Brett:

Enclosed is the dam inspection report for the Hennepin Ash Improvement. The inspection was performed on Wednesday, November 27, 2001. John Augspol from the plant accompanied me on the inspection.

The following items need attention (Condition Code IM or MM).

Item	Issue	Remediation
Embankment	Scattered trees/saplings on or near the clay liner around perimeter of primary & final ponds	Spray to kill, cut down later

Please forward the inspection form to the plant for execution of the Owner's Maintenance Statement by the Plant Manager.

If you have any questions, please call me.

Sincerely,

J. B. Lamb, P.E.
Manager Civil Engineering

Enclosure

Cc: J. G. Dodson w/o attachments S-10
J. P. Augspol w/attachments S-10
CS 491417

Dam Inspection Report

Name of Dam Hennepin Ash Surface Impoundment Dam ID No. IL 50363

Permit Number 21922 Class of Dam III

Location NE 1/4 Section 26 Township 33 N Range 2W of 3rd PM

Owner Dynegy Midwest Generation 815-339-9210
Name Telephone Number (Day)

RR#1 Box 200 AA 815-339-9215
Street Telephone Number (Night)

Hennepin 61327-9737 County Putnam
City Zip Code

Type of Dam Homogeneous Earthen Dam @ 4' Clay liner on upstream face

Type of Spillway Drop Structure @ Stop logs

Date(s) Inspected November 28, 2001

Weather When Inspected Overcast @ mild wind

Temperature When Inspected 39° F

Pool Elevation When Inspected Primary 481.51 Final 479.59

Tailwater Elevation When Inspected NA

Inspection Personnel:

Jeffry E Lamb Manager Civil Engineering
Name Title

John P. Augspol Chemist
Name Title

Name Title

Name Title

JEFFRY E. LAMB 37890 REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

Jeffry E Lamb 11/28/01

Professional Engineer's Seal

The Department of Nautural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	GC	NE	
Vertical and Horizontal Alignment of Crest	GC	NE	
Unusual Movement or Cracking At or Beyond Toe	GC	NE	
Sloughing or Erosion of Embankment and Abutment Slopes	GC	OB	Small erosion rills @ SEc of primary pond upstream + @SWc of final pond upstreamface
Upstream Face Slope Protection	GC	NE	
Seepage	GC	NE	
Filter and Filter Drains	NA		

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	GC	NE	
Embankment Drainage Ditches	GC	NE	
Vegetative Cover	GC	MM	Scattered small trees + saplings on liner - Spray to Kill and remove after dead.
Other (Name)			
Other			
Other			
Other			

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage			
Structure to Abutment/ Embankment Junctions			
Water Passages			
Foundation		NA	
Surface Cracks in Concrete Surfaces			
Structural Cracking			
Vertical and Horizontal Alignment			

CONCRETE OR MASONRY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints			
Contruction Joints			
Spalling of Concrete			NA
Filters, Drains, etc.			
Riprap			
Other (Name)			

IF THE DAM IS GATED - Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris			
Side Slope Stability			
Slope Protection			
Other (Name)			NA
Other			
Other			
Other			

PRINCIPAL SPILLWAY

☒ Drop Inlet Spillway
Ponds 1+2

☐ Overflow Spillway Structure

☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	GC	OB	Beam Seats for walkway at drop structures have spalled or cracked surface concrete. Observe for any further spalling/cracking of concrete support.
Structure to Embankment Junction	NI underwater	NE	
Drains		NA	
Seepage Around or Into Structure			
Surface Cracks	GC	NE	
Structural Cracks	GC	NE	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	GC	NE	
Construction Joints	GC	NE	
Filter and Filter Drains			
Trash Racks	NA		
Bridge and Piers	GC	OB	Surface rust beginning to appear on beams + bolts.
Differential Settlement	GC	NE	
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☒ Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	GC	NE	
Joint Separation	NI buried + underwater	NE	
Seepage Around of Into Conduit	NI buried + underwater	NE	
Surface Cracks	NI buried + underwater	NE	
Structural Cracks	NI buried + underwater	NE	
Trash Racks	NA		
Differential Settlement	GC	NE	
Alignment	GC	NE	
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation			
Structure to Embankment Junction			
Construction Joints			
Expansion and Contraction Joints			NA
Differential Settlement			
Surface Cracks			
Structural Cracks			
Wall Alignment			
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

[X] Principal Spillway
Ponds 1&2 Stop Logs

[ ] Dewatering

[ ] Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NI underwater	NE	
Gate Seals	NI underwater	NE	
Gate and Frame	GC	NE	
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)			
Other			

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation			
Joint Separation			
Seepage Around or Into Conduit			
Intake Structure			NA
Outlet Structure			
Outlet Channel			
Riprap			
Other (Name)			
Other			

ENERGY DISSIPATOR

☐ Principal Spillway ☐ Outlet Works

Type: 36" Φ RCC Pipe Discharges into a ripraped basin.

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	GC	NE	
Construction Joints	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Differential Alignment	NA		
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	GC	NE	
Outlet Channel	NA		
Debris	NA		
Other (Name)			
Other			
Other			
Other			

EMERGENCY SPILLWAY

☐ Earth

Other:Name ______________________

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion			
Weeds, Logs, Other Obstructions			
Side Slope Sloughing			
Vegetation		NA	
Sedimentation			
Riprap			
Settlement of Crest			
Downstream Channel			
Other (Name)			

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION November 28, 2001

DATE OF LAST INSPECTION November 12, 1996

1. EARTH EMBANKMENT DAMS

Repaired gate latch on primary pond outlet structured noted in last inspection.

2. CONCRETE MASONRY DAMS

3. PRINCIPAL SPILLWAY

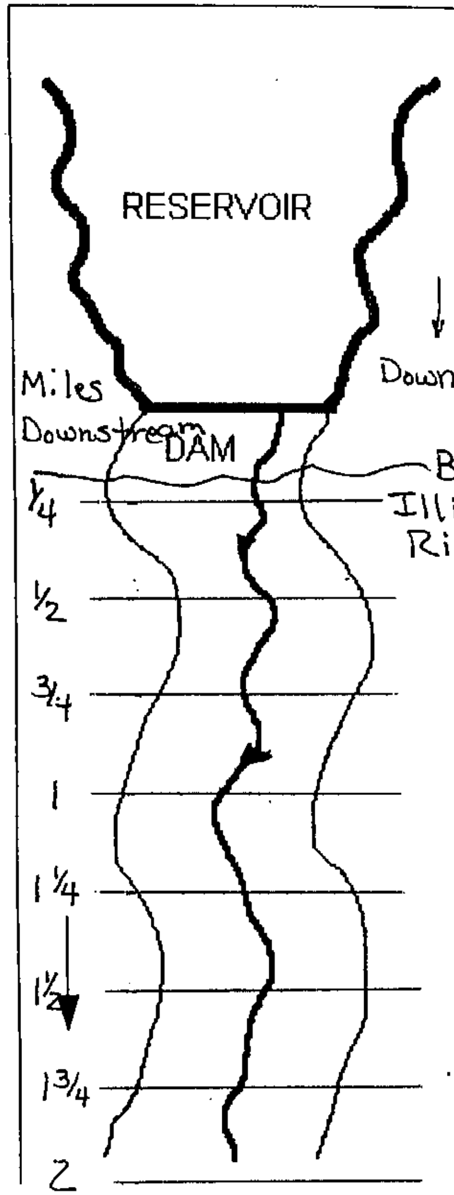
4. OUTLET WORKS

5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN < 1/4 MILES

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss of Life Potential			Economic Loss Potential		
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPECTED
0 to 1/4													X			X		
1/4 to 1/2																		
1/2 to 3/4																		
3/4 to 1																		
1 to 1-1/4					NA													
1-1/4 to 1-1/2																		
1-1/2 to 1-3/4																		
1-3/4 to 2																		
OVER 2																		

SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM



The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, ____________________, owner of Hennepin Ash Impoundment dam, Dam Identification Number IL 50363, in Putnam County, am maintaining the dam in accordance with the accepted maintenance plan which is part of Permit Number 21922.

James G Dodson
Signature

12/27/01
Date

Owner's Operation and Maintenance Plan Statement

I, ____________________, owner of Hennepin Ash Impoundment dam, Dam Identification Number IL 50363, in Putnam County, have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP), which is part of, Permit Number 21922.

I ( ) have enclosed the appropriate revisions or

(✓) have determined that no revisions to the plan are necessary.

James G Dodson
Signature

12/27/01
Date

The Department of Nautural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

Dynegy Midwest Generation, Inc
2828 North Monroe Street
Decatur, IL 62526 3269
Phone 217.876.3900 fax 217.876 7475
www.dynegy.com

December 11, 2006

DYNEGY

Mr. Mike Diedrichsen, Acting Manager
Downstate Regulatory Programs
Division of Water Resources Management
Office of Water Resources
Illinois Department of Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271

Dear Mr. Diedrichsen:

Hennepin Power Station; East Ash Pond
Dam Safety Permit No. DS2004119
Dam I.D. No. IL50363

2006 Five-Year Inspection Report

Enclosed is a signed copy of the 2006 inspection report for the Hennepin Power Station's east ash pond dam. Mr. Joseph P. Kimlinger, and Illinois-registered professional civil engineer (no. 062-049181) with Dynegy Midwest Generation's Construction and Maintenance Department, conducted the professional engineer inspection of the embankments and outlet structures on November 20, 2006. This inspection is required by Section 3702.40(b)(5) of the Rules for the Construction and Maintenance of Dams and the conditions of IDNR Permit No. DS2004119.

The inspection report shows that the overall condition of the east ash pond system is good. The only minor maintenance that needs to be conducted is the continued removal of sapling trees on the embankments. This will be conducted as a part of routine maintenance during 2007. Sapling tree removal was also conducted as a part of the routine maintenance performed during the previous five years as recommended in the 2001 inspection report. Some spalling of concrete and rusting of steel walkway beams was also noted.

An Owner's Maintenance Statement, signed by Mr. James G. Dodson, Plant Manager, Hennepin Power Station, is also included.

If you have any questions regarding this report, please contact me at 217/872-2354 or Tom Davis at 217-872-2315.

Sincerely,
Dynegy Midwest Generation, Inc.

Rick D. Diericx
Sr. Director – Operations Environmental Compliance
Environmental Health and Safety

Dam Inspection Report

Name of Dam: Hennepin PS, Ash Surface Impoundment   Dam ID No.: IL 50363

Permit Number: DS2004119   Class of Dam: III

Location: NE 1/4   Section: 26   Township: 33N   Range: 2W of 3rd PM

Owner:

Dynegy Midwest Generation	815-339-9210
Name	Telephone Number (Day)
RR1, Box 200 AA	815-339-9215
Street	Telephone Number (Night)
Hennepin, IL 61327	County: Putnam
City Zip Code	

Type of Dam: Homogeneous Earthen Dam with clay and geosynthetic/clay liner

Type of Spillway: Drop structure and stop logs

Date(s) Inspected: November 20, 2006

Weather When Inspected: Sunny and Breezy

Temperature When Inspected: 36 deg. F

Pool Elevation When Inspected: Primary 481.5; Secondary 479.6

Tailwater Elevation When Inspected: NA

Inspection Personnel:

Name	Title
Joseph P. Kimlinger P.E.	Construction Manager
John Augspols	Sr. Env & Chem. Engineer

JOSEPH P. KIMLINGER
062-049161
REGISTERED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS

12/7/06
LIC EXPIRES 11/30/07

Professional Engineer's Seal

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected - list the reason for non-inspection under deficiencies

---

All Condition Codes will be listed with the following abbreviations:

P = Primary Cell
S = Secondary (polishing) Cell

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking At or Beyond Toe	NE	NA	
Sloughing or Erosion of Embankment and Abutment Slopes	GC	NA	
Upstream Face Slope Protection	GC	NA	
Seepage	NE	NA	
Filter and Filter Drains	NA		

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	GC	NA	
Vegetative Cover	OB	Some small trees and saplings near the embankment	Observe the small trees and saplings and spray to kill or remove as time allows. No issue at this time.
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment/ Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONRY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters, Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED - Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

[X] Drop Inlet Spillway [ ] Overflow Spillway Structure [ ] Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	OB	Some spalling of concrete near walkway beam supports.	Observe the concrete condition in the outfall structures, primarily near the beam seats. Contact a certified engineer if condition worsens.
Structure to Embankment Junction	NI	Underwater	
Drains	NA		
Seepage Around or Into Structure	NI	Underwater	
Surface Cracks	NE	NA	
Structural Cracks	NE	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

(Continued)

☒ Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	GC	NA	
Filter and Filter Drains	NA		
Trash Racks	NA		
Bridge and Piers	OB	Rust forming on bridge beams and connections.	Observe and contact a certified engineer if condition worsens.
Differential Settlement	NE	NA	
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

[x] Conduit [ ] Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Joint Separation	NE	NA	
Seepage Around of Into Conduit	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	
Trash Racks	NA		
Differential Settlement	NE	NA	
Alignment	GC	NA	
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

☒ Principal Spillway ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NI	Underwater	The sill and seals are located under stop logs and could not be inspected.
Gate Seals	NI	Underwater	
Gate and Frame	GC	NE	Stop logs and guides were in good condition.
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway
Type:

☒ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	GC	NA	
Construction Joints	GC	NA	
Surface Cracks	NE	NA	
Structural Cracks	NE	NA	
Differential Alignment	NE	NA	
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☒ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	GC	NA	
Outlet Channel	GC	NA	
Debris	NE	NA	
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth

Other:Name ____________________

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs, Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION November 20, 2006

DATE OF LAST INSPECTION November 28, 2001

1. EARTH EMBANKMENT DAMS

The pond level was raised in 2004 with the extension of the liner. The liner extension consisted of one foot of clay overlain with a polypropylene liner.
Minor erosion repairs, mowing and general maintenance have been performed during the last five years.

2. CONCRETE MASONRY DAMS

NA

3. PRINCIPAL SPILLWAY

NA

4. OUTLET WORKS

NA

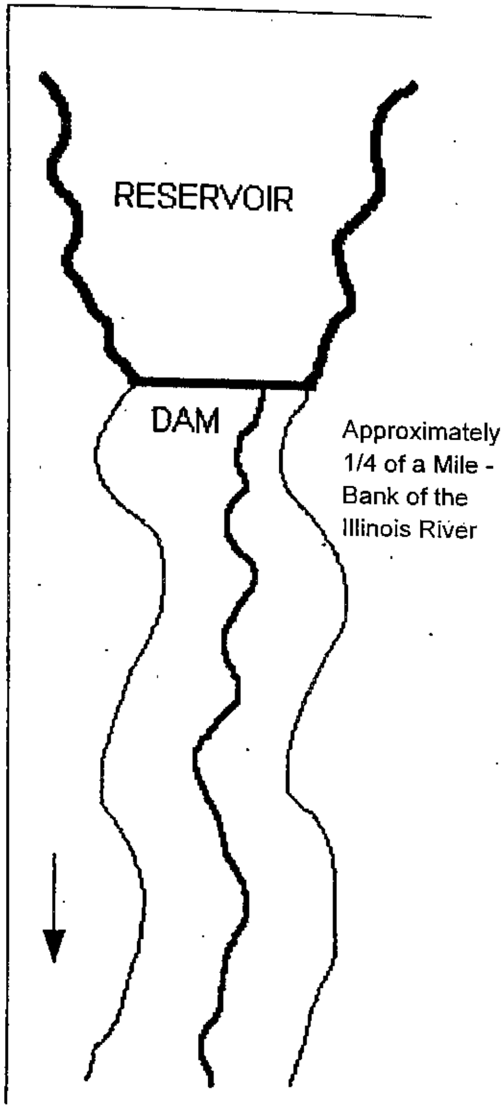
5. EMERGENCY SPILLWAY

NA

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss of Life Potential			Economic Loss Potential		
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPECTED
0 to 1/4	0	0	0	0	0	0	0	0	0	0	0	0	X			X		
1/4 to 1/2																		
1/2 to 3/4																		
3/4 to 1																		
1 to 1-1/4																		
1-1/4 to 1-1/2																		
1-1/2 to 1-3/4																		
1-3/4 to 2																		
OVER 2																		

SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM



The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, James G. Dodson, owner of Hennepin PS Ash Surface Impoundment dam,

Dam Identification Number IL 50363, in Putnam County,

am maintaining the dam in accordance with the accepted maintenance plan which is part of

Permit Number DS2004119.

James G. Dodson
Signature

Dec. 7, 2006
Date

Owner's Operation and Maintenance Plan Statement

I, James G. Dodson, owner of Hennepin PS Ash Surface Impoundment dam,

Dam Identification Number IL 50363, in Putnam County,

have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP), which is part of, Permit Number DS2004119.

I [ ] have enclosed the appropriate revisions or

[X] have determined that no revisions to the plan are necessary.

James G. Dodson
Signature

Dec. 7, 2006
Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the Rivers, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

Close Window

Tracking Detail

Your package has been delivered.

Tracking Number:	1Z V9W 975 03 4525 747 6
Type:	Package
Status:	**Delivered**
Delivered on:	12/13/2006 9:51 A.M.
Signed by:	PATTERSON
Location:	MAIL ROOM
Delivered to:	US
Shipped or Billed on:	12/12/2006
Service Type:	GROUND
Weight:	1.00 Lb

Package Progress

Location	Date	Local Time	Description
SPRINGFIELD, IL, US	12/13/2006	9:51 A.M.	DELIVERY
	12/13/2006	5:01 A.M.	OUT FOR DELIVERY
	12/13/2006	4:05 A.M.	ARRIVAL SCAN
DECATUR, IL, US	12/13/2006	1:26 A.M.	DEPARTURE SCAN
DECATUR, IL, US	12/12/2006	10:08 P.M.	ARRIVAL SCAN
	12/12/2006	8:30 P.M.	DEPARTURE SCAN
	12/12/2006	6:58 P.M.	ORIGIN SCAN
US	12/12/2006	2:52 P.M.	BILLING INFORMATION RECEIVED

Tracking results provided by UPS: 12/13/2006 3:26 P.M. EST (USA)

NOTICE: UPS authorizes you to use UPS tracking systems solely to track shipments tendered by or for you to UPS for delivery and for no other purpose. Any other use of UPS tracking systems and information is strictly prohibited.

Close Window

Dynegy Midwest Generation
SHIPMENT DETAIL REPORT
12/12/06 01:52 PM

Pickup Date: 12/12/06
Pickup Record No.: 2819375 39 2

UPS Account No.: V9W975
Sorted By:Order of Shipment

Name/Address	Shipment Detail		Options	Reference Rate Charges	
Ship To: James Eiseman Bluegrass Generation 3095 Commerce Parkway LA GRANGE KY 40031-8799	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS NEXT DAY AIR 1 No LTR Prepaid	Shipment Service Charge:	$	17.28
	Tracking No.: Package Type:	1ZV9W9750145360045 UPS Letter	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	17.28 **17.28** 17.28
Ship To: Deirdre K. Hirner IL Environmental Regulatory Group 3150 Roland Ave. SPRINGFIELD IL 62703	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$	3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750343581655 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	3.93 3.93 3.93
Ship To: Julie Armitage IL Environmental Protection Agency Bureau of Air 1021 North Grand Ave., East SPRINGFIELD IL 62794-9276	Service Type: Total Packages. Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$	3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750344879467 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	3.93 **3.93** **3.93**
Ship To: Mr. Mike Diedrichsen Illinois Dept. of Natural Resources Office of Water Resources Division of Water Resources Mgtmnt One Natural Resources Way SPRINGFIELD IL 62702-1270	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge.	$	3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750345257476 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	3.93 **3.93** 3.93
Ship To: Fiscal Svcs Section, Receipts #2 IL Environmental Protection Agency 1021 North Grand Ave., East SPRINGFIELD IL 62794-9276	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$	3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750345399680 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	3.93 3.93 **3.93**
Ship To: Dynegy Midwest Generation 22228 Network Place CHICAGO IL 60673-1222	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$	4.02
	Tracking No.: Package Type: Weight:	1ZV9W9750345270095 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ $ $	4.02 **4.02** 4.02

bc: J.G.Dodson, w/o att – Hennepin Station
J.P.Augspols w/att. - Hennepin Station
~~T.L.Davis~~/Hennepin PS Dam Inspection Reports, w/att., Decatur
Rick Diericx Reading File - Decatur

Dam Inspection Report

Name of Dam Hennepin PS, East Ash Surface Impoundment **Dam ID No.** IL 50363

Permit Number DS2004119 **Class of Dam** III

Location NE 1/4 **Section** 26 **Township** 33N **Range** 2W of 3rd PM

Owner Dynegy Midwest Generation
Name

815-339-9210
Telephone Number (Day)

RR1, Box 200 AA
Street

815-339-9215
Telephone Number (Night)

Hennepin, IL 61327
City **Zip Code**

County Putnam

Type of Dam Homogeneous Earth Dam with clay and geosynthetic/clay liner

Type of Spillway Drop structure and stop logs

Date(s) Inspected March 29, 2010

Weather When Inspected Sunny

Temperature When Inspected 60 degrees F

Pool Elevation When Inspected Primary 481.5, Secondary 479.6

Tailwater Elevation When Inspected NA

Inspection Personnel:

Name	Title
Kenneth M Berry, P.E.	Sr Proj Engr (URS)
Phil L. Morris, P.E.	Environmental Professional
John Augspols	Plant Engineer

KENNETH MONROE BERRY
0062-051918
REGISTERED PROFESSIONAL ENGINEER
STATE OF ILLINOIS
Kenneth M Berry
5/26/2010

Professional Engineer's Seal

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non.-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams.

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected -list the reason for non-inspection under deficiencies

---

All Condition Codes will be listed with the following abbreviations:

P = Primary Cell

S = Secondary (polishing) Cell

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking' At or Beyond Toe	NE	NA	
Sloughing or Erosion of Embankment and Abutment Slopes	NE	NA	
Upstream Face Slope Protection	NA	NA	No slope protection
Seepage	NE	NA	
Filter and Filter Drains	NA	NA	No evidence of internal filters or drains

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	GC	NA	
Vegetative Cover	NE	NA	
Other (Name)	NA		
Other –	NA		
Other -	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment! Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONARY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters; Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED – Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	NI	Underwater	
Drains	NA	NA	
Seepage Around or Into Structure	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	

IF THE SPILLWAY IS GATED FILL OUT THE SPILLWAY SECTION

PRINCIPAL SPILLWAY
(Continued)

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	NA	NA	
Filter and Filter Drains	NA	NA	
Trash Racks	NA	NA·	
Bridge and Piers	NE	NA	
Differential Settlement	NE	NA	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

x Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Joint Separation	NI	NA	
Seepage Around of Into Conduit	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	
Trash Racks	NA	NA	
Differential Settlement	NI	Underwater	
Alignment	NI	Underwater	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

x Principal Spillway ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill (Stoplogs)	NI	Underwater	
Gate Seals (Stoplogs)	NI	Underwater	
Gate and Frame (Stoplogs)	GC	NA	
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE'	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion. Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway x Outlet Works
Type:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	NE	NA	
Construction Joints	NE	NA	
Surface Cracks	NE	NA	
Structural Cracks	NI	Underwater	
Differential Alignment	NE	NA	
Expansion and Contraction Joints	NI	Underwater	

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	NE	NA	
Outlet Channel	NE	NA	
Debris	NE	NA	
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth ☐ Other: Name ____________

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs, Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION March 29, 2010

DATE OF LAST INSPECTION March 19, 2009

1. EARTH EMBANKMENT DAMS

Minor erosion repairs, mowing, tree cutting, and general maintenance have been performed.

2. CONCRETE MASONARY DAMS

3. PRINCIPAL SPILLWAY

4. OUTLET WORKS

5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES.

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss Of Life Potential			Economic Loss Potential			SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPRECTED	
0 to ¼		0	0	0	0	0	0	0	0	0	0	0	x			x			
¼ to ½																			
½ to ¾																			
¾ to 1																			
1 to 1 ¼																			
1 ¼ to 1 ½																			
1 ½ to 1 ¾																			
1 ¾ to 2																			
OVER 2																			

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, Ted Lindenbusch, owner of Hennepin PS East Ash Surface Impoundment dam, Dam Identification Number IL 50363, in Putnam County, am maintaining the dam in accordance with the accepted maintenance plan which is part of Permit Number DS2004119.

Signature

Date

Owner's Operation and Maintenance Plan Statement

I, Ted Lindenbusch, owner of Hennepin PS East Ash Surface Impoundment dam, Dam Identification Number IL 50363, in Putnam County, have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP), which is part of Permit Number DS2004119.

I ☐ have enclosed the appropriate revisions or

☐ have determined that no revisions to the plan are necessary.

Signature

Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purposes as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation on non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams."

Dam Inspection Report

Name of Dam Hennepin PS, West Ash Surface Impoundment **Dam ID No.** N/A

Permit Number N/A **Class of Dam** N/A

LocationNE **Section** **Township** **Range**

Owner Dynegy Midwest Generation
Name

815-339-9210
Telephone Number (Day)

RR1, Box 200 AA
Street

815-339-9215
Telephone Number (Night)

Hennepin, IL 61327
City **Zip Code**

County Putnam

Type of Dam Homogeneous Earth Dam

Type of Spillway Drop structure

Date(s) Inspected March 29, 2010

Weather When Inspected Sunny

Temperature When Inspected 60 degrees F

Pool Elevation When Inspected Unknown

Tailwater Elevation When Inspected NA

Inspection Personnel:

Kenneth M Berry, P.E. Sr Proj Engr (URS)
Name **Title**

Phil L. Morris, P.E. Environmental Professional
Name **Title**

John Augspols Plant Engineer
Name **Title**

KENNETH MONROE BERRY
0062-051918
REGISTERED PROFESSIONAL ENGINEER
STATE OF ILLINOIS

Kenneth Monroe Berry
5/26/2010

Professional Engineer's Seal

Name **Title**

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act. 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non.-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams.

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected -list the reason for non-inspection under deficiencies

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking' At or Beyond Toe	NI	Underwater	
Sloughing or Erosion of Embankment and Abutment Slopes	OB/MM	Vegetation was high and thick – limited ability to observe.	Sporadic riverbank erosion observed towards the south. Recommend placement of rip rap to repair.
Upstream Face Slope Protection	OB	Vegetation was high and thick, so not able to observe.	Cut vegetation and observe.
Seepage	NE	Mostly underwater	
Filter and Filter Drains	NA	NA	

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	NE	NA	
Vegetative Cover	MM	High vegetation and Sporadic trees	Cut vegetation on interior to facilitate inspection and limit roots. Do not cut trees on river bank since they provide erosion protection from the river.
Other (Name)	NA		
Other –	NA		
Other -	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment! Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONARY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters; Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED – Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NI	High vegetation	
Structure to Embankment Junction	NI	High vegetation	
Drains	NA	NA	
Seepage Around or Into Structure	NI	High vegetation	
Surface Cracks	NI	High vegetation	
Structural Cracks	NI	High vegetation	

IF THE SPILLWAY IS GATED FILL OUT THE SPILLWAY SECTION

PRINCIPAL SPILLWAY
(Continued)

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	NA	NA	
Filter and Filter Drains	NA	NA	
Trash Racks	NA	NA	
Bridge and Piers	NA	NA	
Differential Settlement	NA	NA	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

x Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NI	Inaccessible	
Joint Separation	NI	Inaccessible	
Seepage Around of Into Conduit	NI	Inaccessible	
Surface Cracks	NI	Inaccessible	
Structural Cracks	NI	Inaccessible	
Trash Racks	NA	NA	
Differential Settlement	NI	Inaccessible	
Alignment	NI	Inaccessible	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

☐ Principal Spillway ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NA		
Gate Seals	NA		
Gate and Frame	NA		
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE'	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion. Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway ☐ Outlet Works

Type:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Differential Alignment	NA		
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	NA		
Outlet Channel	NA		
Debris	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth ☐ Other: Name ____________

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs. Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION March 29, 2010

DATE OF LAST INSPECTION March 19, 2009

1. EARTH EMBANKMENT DAMS

Unknown.

2. CONCRETE MASONARY DAMS

3. PRINCIPAL SPILLWAY

4. OUTLET WORKS

5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES.

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss Of Life Potential			Economic Loss Potential			SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPRECTED	
0 to ¼		0	0	0	0	0	0	0	0	0	0	0	x			x			
¼ to ½																			
½ to ¾																			
¾ to 1																			
1 to 1 ¼																			
1 ¼ to 1 ½																			
1 ½ to 1 ¾																			
1 ¾ to 2																			
OVER 2																			

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, Ted Lindenbusch , owner of Hennepin PS West Ash Surface Impoundment dam,

Dam Identification Number __________, in Putnam County,

am maintaining the dam in accordance with the accepted maintenance plan

which is part of Permit Number__________________.

____
Signature

____
Date

Owner's Operation and Maintenance Plan Statement

I, Ted Lindenbusch , owner of Hennepin PS West Ash Surface Impoundment dam,

Dam Identification Number __________, in Putnam County,

have reviewed the operation and maintenance plan including the Emergency

Action Plan (EAP), which is part of Permit Number_________.

I ☐ have enclosed the appropriate revisions or

☐ have determined that no revisions to the plan are necessary.

____
Signature

____
Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purposes as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation on non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams."

APPENDIX E

PHOTOGRAPHS

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 1	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Downstream slope of the West Ash Pond System (WAPS) Impoundment.

Photo No. 2	Date: 5/23/11

Direction Photo Taken:
South

Description:
Downstream slope of the WAPS.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 3	Date: 5/23/11
Direction Photo Taken: North	
Description: Downstream slope of the WAPS.	

Photo No. 4	Date: 5/23/11
Direction Photo Taken: East	
Description: Downstream slope of the WAPS.	

GZA GeoEnvironmental, Inc. | **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 5 | **Date:** 5/23/11

Direction Photo Taken:
East

Description:
Downstream slope of the WAPS.

Photo No. 6 | **Date:** 5/23/11

Direction Photo Taken:
North

Description:
Crest and downstream slope of the WAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 7 **Date:** 5/23/11

Direction Photo Taken:
North

Description:
Crest and downstream slope of the WAPS.

Photo No. 8 **Date:** 5/23/11

Direction Photo Taken:
West

Description:
Crest and downstream slope of the WAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 9	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Downstream slope of the WAPS.	

Photo No. 10	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Downstream slope of the WAPS.	

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
11	5/23/11

Direction Photo Taken:
Southwest

Description:
Downstream slope of the WAPS.

Photo No.	Date:
12	5/23/11

Direction Photo Taken:
Southeast

Description:
Downstream slope of the WAPS.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 13	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Downstream slope of the WAPS.	

Photo No. 14	Date: 5/23/11
Direction Photo Taken: North	
Description: Toe access road along the eastern portion of the WAPS.	

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
15	5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the WAPS.

Photo No.	Date:
16	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the WAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
17	5/23/11

Direction Photo Taken:
West

Description:
Crest of the WAPS.

Photo No.	Date:
18	5/23/11

Direction Photo Taken:
East

Description:
Crest and upstream slope of the WAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 19 **Date:** 5/23/11 **Direction Photo Taken:** West **Description:** Crest and upstream slope of the WAPS.	

Photo No. 20 **Date:** 5/23/11 **Direction Photo Taken:** Northeast **Description:** Crest and upstream slope of the WAPS.	

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 21	Date: 5/23/11
Direction Photo Taken: South	
Description: Decant structure in the WAPS.	

Photo No. 22	Date: 5/23/11
Direction Photo Taken: Southeast	
Description: Decant structure in the WAPS.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	**Site Location: Hennepin Power Station Hennepin, Illinois**	**Project No.** 01.0170142.30

Photo No. 23 — **Date:** 5/23/11 **Direction Photo Taken:** Northeast **Description:** Discharge pipe from the WAPS into the Illinois River.	
Photo No. 24 — **Date:** 5/23/11 **Direction Photo Taken:** West **Description:** Upstream slope and ponded water in the WAPS.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 25	Date: 5/23/11
Direction Photo Taken: Northeast	
Description: Downstream slope of the EAPS.	

Photo No. 26	Date: 5/23/11
Direction Photo Taken: Northeast	
Description: Downstream slope of the EAPS.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 27	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the 1978 embankment and downstream slope of the 1995 embankment along the EAPS.

Photo No. 28	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the 1978 embankment and downstream slope of the 1995 embankment along the EAPS.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 29 **Date:** 5/23/11

Direction Photo Taken: East

Description: Crest of the 1978 embankment and downstream slope of the 1995 embankment near Pond 2E.

Photo No. 30 **Date:** 5/23/11

Direction Photo Taken: North

Description: Downstream slope of Pond 2E.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 31 | **Date:** 5/23/11

Direction Photo Taken:
Northwest

Description:
Downstream slope of Pond 2E along crest of the 1978 embankment.

Photo No. 32 | **Date:** 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the EAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 33	Date: 5/23/11
Direction Photo Taken: Northeast	
Description: Crest and upstream slope of the EAPS.	

Photo No. 34	Date: 5/23/11
Direction Photo Taken: Northeast	
Description: Crest and upstream slope of the EAPS.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 35 **Date:** 5/23/11

Direction Photo Taken:
South

Description:
Crest of embankment between the EAPS and Pond 2E.

Photo No. 36 **Date:** 5/23/11

Direction Photo Taken:
East

Description:
Crest and upstream slope of Pond 2E.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 37	Date: 5/23/11

Direction Photo Taken:
Southeast

Description:
Crest and upstream slope of Pond 2E.

Photo No. 38	Date: 5/23/11

Direction Photo Taken:
West

Description:
Crest of the embankment between Pond 2E and Secondary Cell.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 39	Date: 5/23/11
Direction Photo Taken: Southeast	
Description: Crest and upstream slope of the Secondary Cell.	

Photo No. 40	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Crest and upstream slope of the Secondary Cell.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 41	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Secondary Cell.

Photo No. 42	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Secondary Cell.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 43 **Date:** 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the embankment between Pond 2E and the Secondary Cell.

Photo No. 44 **Date:** 5/23/11

Direction Photo Taken:
Northwest

Description:
Upstream slope of the EAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 45	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Crest and upstream slope of the Primary Cell.	

Photo No. 46	Date: 5/23/11
Direction Photo Taken: East	
Description: Upstream slope of the Primary Cell.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 47	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Upstream slope of the Primary Cell.	

Photo No. 48	Date: 5/23/11
Direction Photo Taken: Northwest	
Description: Upstream slope of the Primary Cell near the decant structure.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 49	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Crest and upstream slope of the Primary Cell.	

Photo No. 50	Date: 5/23/11
Direction Photo Taken: Southwest	
Description: Crest and upstream slope of the Primary Cell.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
51	5/23/11

Direction Photo Taken:
Southwest

Description:
Upstream slope of the Primary Cell.

Photo No.	Date:
52	5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Primary Cell.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 53 **Date:** 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Primary Cell.

Photo No. 54 **Date:** 5/23/11

Direction Photo Taken:
West

Description:
Downstream slope of the EAPS.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 55 | **Date:** 5/23/11

Direction Photo Taken:
West

Description:
Crest and downstream slope of the EAPS.

Photo No. 56 | **Date:** 5/23/11

Direction Photo Taken:
West

Description:
Downstream slope of the EAPS.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
57	5/23/11

Direction Photo Taken:
Northwest

Description:
Downstream slope of the EAPS.

Photo No.	Date:
58	5/23/11

Direction Photo Taken:
North

Description:
Discharge pipe into the northwest portion of the Primary Cell.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 59	Date: 5/23/11

Direction Photo Taken:
East

Description:
Old decant structure in the Primary Cell.

Photo No. 60	Date: 5/23/11

Direction Photo Taken:
East

Description:
Discharge pipe into the Primary Cell near the northeast corner.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	**Site Location:** **Hennepin Power Station Hennepin, Illinois**	**Project No.** 01.0170142.30

Photo No. **61** | **Date:** 5/23/11

Direction Photo Taken:
East

Description:
Decant structure in the Primary Cell.

Photo No. **62** | **Date:** 5/23/11

Direction Photo Taken:
Southeast

Description:
Discharge pipe from the Primary Cell to Pond 2E.

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 63 **Date:** 5/23/11

Direction Photo Taken:
South

Description:
Decant structure in the Secondary Cell.

Photo No. 64 **Date:** 5/23/11

Direction Photo Taken:
Down

Description:
Decant structure in the Secondary Cell.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 65 **Date:** 5/23/11

Direction Photo Taken:
Southwest

Description:
Surface features of the flume structure in the discharge line from the Secondary Cell to the Illinois River.

Photo No. 66 **Date:** 5/23/11

Direction Photo Taken:
Down

Description:
Flume structure in the discharge line from the Secondary Cell to the Illinois River.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 67 **Date:** 5/23/11

Direction Photo Taken:
West

Description:
Crest of the interior embankment in the AEAPS with the Pond 2E decant structure shown.

Photo No. 68 **Date:** 5/23/11

Direction Photo Taken:
Southwest

Description:
Outfall at the Illinois River.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 69	Date: 5/23/11
Direction Photo Taken: Southeast	
Description: Downstream slope of EAPS near Pond 4.	

Photo No. 70	Date: 5/23/11
Direction Photo Taken: South	
Description: Downstream slope of the EAPS near Pond 4.	

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 71	Date: 5/23/11

Direction Photo Taken:
Southeast

Description:
Crest of the EAPS near Pond 4.

Photo No. 72	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS near Pond 4.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 73 **Date:** 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS looking over the Primary Cell.

Photo No. 74 **Date:** 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS near Pond 4.

APPENDIX F

REFERENCES

REFERENCE LIST HENNEPIN POWER STATION

Civil & Environmental Consultants, Inc. "Application for a Permit to Construct a New Leachate and Storm Water Runoff Collection Pond, Dynegy-Hennepin Power Station Hennepin, Illinois". Date July 2009.

Civil & Environmental Consultants, Inc. "Pond 2 East Construction Completion Report, Hennepin Power Station, Hennepin, Putnam County, Illinois". Date December 2010.

Sargent & Lundy Engineers. "Roadways at Plant Site, General Location Plan, Hennepin, Power Station, Illinois Power Company, Hennepin, Illinois," Drawing No.B-9. Dated March 27, 1953.

Sargent & Lundy Engineers. "Roadways at Plant Site, General Location Plan, Hennepin, Power Station, Illinois Power Company, Hennepin, Illinois," Drawing No.B-11. Dated March 27, 1953.

Illinois Power Company. "Hennepin Power Station Ash Surface Impoundment Hydrologic/Hydraulic Analysis" Dated September 1994.

Illinois Power Company. "Hennepin Power Station Ash Surface Impoundment Geotechnical/Structural Design" Dated September 1994.

Illinois Power Company, Decatur. "West Ash Pond Topographic Survey, Hennepin Power Station." Drawing No. E-HEN1-B451. Dated September 29, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B452. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HENI-B453. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B454. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B455. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B456. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B457. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections, East Ash Pond Extension" Hennepin Station." Drawing No. CE-HEN1-B458-1. Dated January 11, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-2. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-3. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-4. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-5. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-6. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-7. Dated January 12, 1989.

Illinois Power Company, Decatur. “East Ash Pond Topographic Survey, Hennepin Power Station.” Drawing No. E-HEN1-B450. Dated September 27. 1987.

Illinois Power Company, Decatur. “Area Site Plan, Hennepin Power Station.” Drawing No. CE-HEN1-C4. Dated January 10, 1994.

Illinois Power Company, Decatur. “Survey Plan Ash Impoundment”, Hennepin Station.” Drawing No. CE-HEN1-C5.1. Dated September 20 1994.

Illinois Power Company, Decatur. “Survey Plan Ash Impoundment”, Hennepin Station.” Drawing No. CE-HEN1-C5.2. Dated September 20 1994.

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Illinois Power Company, Decatur. “Cross Sections, 1995 Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7-1. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.9. Dated October 5, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.10. Dated October 5, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12. Dated July 21, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12A. Dated July 24, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12B. Dated July 24, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.15. Dated October 10, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.16. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.17. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.18. Dated October 12, 1993.

Dynegy Midwest Generation, LLC . “Hennepin Revised Stability Analysis for Section P2-1”; Email correspondence from Mr. Phil Morris. Dated October 22, 2012.

PREFACE

The assessment of the general condition of the dams/impoundment structures reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dams and/or impoundment structures was based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam and/or impoundment structures depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.

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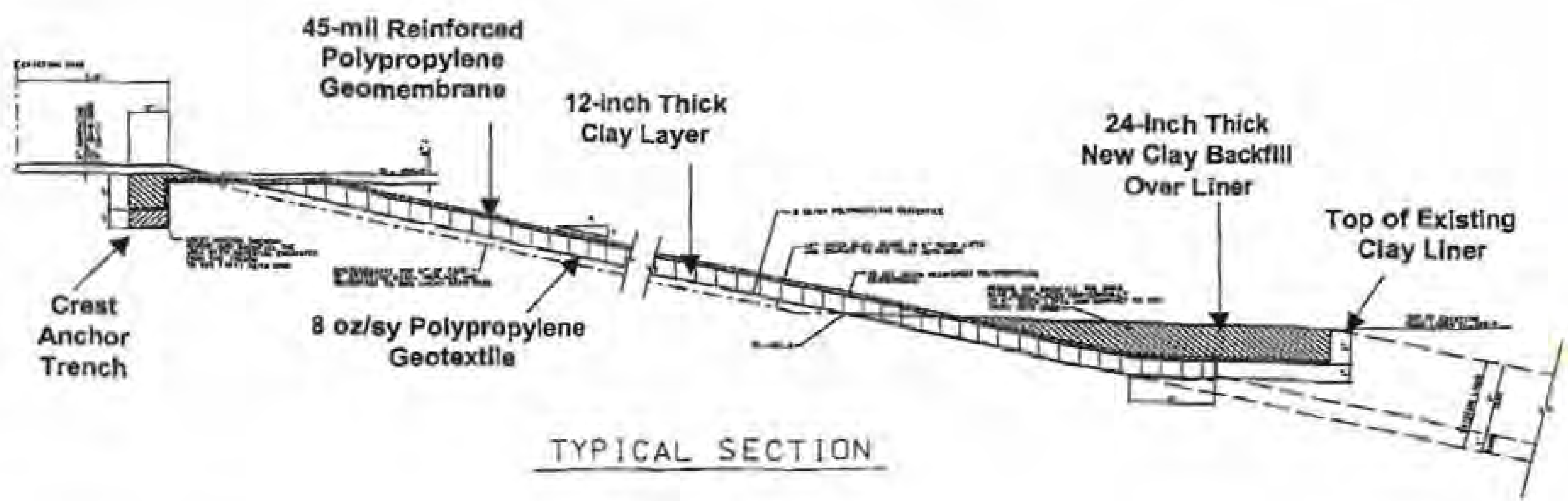
Hennepin Power Station
Hennepin, IL

East Ash Pond System

Raising of Interior Impermeable Liners in Primary and Secondary Cells



TYPICAL SECTION

REV. NO. | DESCRIPTION | BY | DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin • 53186 • Phone (262) 754-2560 • Fax (262) 754-9711
www.gza.com

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

TYPICAL SECTION OF LINER EXTENSION

JOB NO.
01.0170142.30

FIGURE NO.
9

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 10a

AECOM

October 2016

Dynegy Midwest Generation, LLC
13498 E 800th St.
Hennepin, IL 61327

RE: History of Construction
USEPA Final CCR Rule, 40 CFR § 257.73(c)
Hennepin Power Station
Hennepin, Illinois

On behalf of Dynegy Midwest Generation, LLC, AECOM has prepared the following history of construction for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station in accordance with 40 CFR § 257.73(c).

BACKGROUND

40 CFR § 257.73(c)(1) requires the owner or operator of an existing coal combustion residual (CCR) surface impoundment that either (1) has a height of five feet or more and a storage volume of 20 acre-feet or more, or (2) has a height of 20 feet or more to compile a history of construction by October 17, 2016 that contains, to the extent feasible, the information specified in 40 CFR § 257.73(c)(1)(i)–(xii).

The history of construction presented herein was compiled based on existing documentation, to the extent that it is reasonably and readily available (see 80 Fed. Reg. 21302, 21380 [April 17, 2015]), and AECOM's site experience. AECOM's document review included construction drawings, geotechnical investigations, operation and maintenance information, etc. for Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station.

HISTORY OF CONSTRUCTION

§ 257.73(c)(1)(i): The name and address of the person(s) owning or operating the CCR unit; the name associated with the CCR unit; and the identification number of the CCR unit if one has been assigned by the state.

Owner: Dynegy Midwest Generation, LLC

Address: 1500 Eastport Plaza Drive
Collinsville, IL 62234

CCR Units: Old West Polishing Pond
Old West Ash Pond (Pond No. 1 and Pond No. 3)
Ash Pond No. 2
East Ash Pond, IDNR Dam ID No. IL50363

The Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 do not have a state assigned identification number.

§ 257.73(c)(1)(ii): The location of the CCR unit identified on the most recent USGS 7$^{1}/_{2}$ or 15 minute topographic quadrangle map or a topographic map of equivalent scale if a USGS map is not available.

The locations of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond have been identified on an USGS 7-1/2 minute topographic quadrangle map in **Appendix A**.

§ 257.73(c)(1)(iii): A statement of the purpose for which the CCR unit is being used.

The following captures the purpose of each CCR unit:

- The Old West Polishing Pond (inactive) was used to store and dispose fly ash and bottom ash and is currently being used to clarify stormwater runoff from the Old West Ash Pond prior to discharge in accordance with the station's NPDES permit.
- The Old West Ash Pond (inactive) was used to store and dispose fly ash and bottom ash.
- The Ash Pond No. 2 (inactive) was used to store and dispose fly ash, bottom ash, and other non-CCR waste streams including coal pile runoff.
- The East Ash Pond is being used to store and dispose bottom ash, fly ash, and other non-CCR waste and to clarify process water prior to discharge in accordance with the station's NPDES permit.

Notice of intent to close the Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 was provided in November 2015.[1]

[1] This history of construction report was prepared on a facility-wide basis for CCR surface impoundments at the Hennepin Power Station. The inclusion of the Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 in this history of construction report does not concede and should not be construed to concede that the Old

§ 257.73(c)(1)(iv): The name and size in acres of the watershed where the CCR unit is located.

The Hennepin Power Station and the above-referenced CCR units are located at the western edge of the Depue Lake-Illinois River Watershed with a 12-digit Hydrologic Unit Code (HUC) of 071300010804 and a drainage area of 44,525 acres (USGS 2016).

§ 257.73(c)(1)(v): A description of the physical and engineering properties of the foundation and abutment materials on which the CCR unit is constructed.

Physical properties of the foundation materials for the Old West Polishing Pond and Old West Ash Pond are described as cohesive material underlain by granular material. The cohesive material consists of lean clay, gravelly clay, silt, clayey silt, and sandy silt. The consistency of the cohesive material varies from very soft to medium stiff. The granular material consists of silty sand and clayey gravel. The relative density of the granular materials varies from loose to very dense and generally increases with depth. An available summary of the engineering properties of the foundation materials for the Old West Polishing Pond and Old West Ash Pond is presented in **Table 1** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 1. Summary of Material Engineering Properties for the Old West Polishing Pond and Old West Ash Pond

Layer	Unit Weight (pcf)	Total (undrained) Shear Strength Parameters		Effective (drained) Shear Strength Parameters	
		ϕ (deg)	*c (psf)*	*ϕ' (deg)*	*c' (psf)*
CL (soft)	120	0	500	28	0
CL (medium stiff gravely clay)	120	28	0	28	0
ML (soft to medium stiff)	125	28	0	28	0
CL-ML (very soft)	120	0	400	26	0
SM (very loose)	125	28	0	28	0
GC (dense)	130	34	0	34	0
GC (very dense)	130	36	0	36	0
Fill: GC (very dense)	130	34	50	34	0

West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 are subject to the Design Criteria or all Operating Criteria in the CCR Rule.

The Old West Polishing Pond and Old West Ash Pond are enclosed impoundments with dikes and do not have abutments.

Physical properties of the foundation and abutment materials for Ash Pond No. 2 and the East Ash Pond are described as gravel materials with varying amounts of silt and clay. The relative density of the gravel is medium dense to very dense. An available summary of the engineering properties of the foundation materials for Ash Pond No. 2 and the East Ash Pond is presented in **Table 2** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 2. Summary of Foundation and Abutment Material Engineering Properties for the Ash Pond No. 2 and East Ash Pond

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Alluvial Foundation	135	0	38	0	38

§ 257.73(c)(1)(vi): A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR unit; the method of site preparation and construction of each zone of the CCR unit; and the approximate dates of construction of each successive stage of construction of the CCR unit.

Physical properties of the embankment materials for the Old West Polishing Pond and Old West Ash Pond are described as gravel with occasional zones of clayey sand and lean clay. The gravel has a general relative density of very dense. An available summary of the engineering properties of the embankment materials for the Old West Polishing Pond and Old West Ash Pond is presented in **Table 1** above. The engineering properties are based on previous geotechnical explorations and laboratory testing.

The physical properties of Ash Pond No. 2 embankment construction materials are described in this paragraph. The original embankments are constructed of sand with varying amounts of coal pieces and gravel. The initial embankment raise is constructed of silty clay, clayey sand, sand, and gravel and the later embankment raise is constructed with layers of lean clay, silty clay, clayey silt, clayey, and gravel. An available summary of the engineering properties of the embankment materials for Ash Pond No. 2 is presented in **Table 3** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 3. Summary of Construction Material Engineering Properties for Ash Pond No. 2

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Fill: GP-GM (medium dense)	125	0	32	0	32
Fill: CL (hard)	120	0	32	4000	0
Fill: ML (hard)	120	0	32	4500	0
Fill: SC (medium dense)	120	0	28	0	28

Physical properties of the embankment materials for the East Ash Pond are described as clayey silt and clay. The consistency of both the clayey silt and clay ranges from stiff to hard. The original pond surface is lined with a 4-foot thick compacted clay layer of 1.0 x 10^{-7} cm/s underlain by a 1-foot thick sand layer. The liner system of the embankment raise consists of a (from top to bottom) 45 mil reinforced polyethylene geomembrane, a 1-foot thick clay layer, and an 8 oz/sy polypropylene geotextile. A typical cross section profile of the liner system is shown on drawing C-56 presented in **Appendix B**. An available summary of the construction material engineering properties for the East Ash Pond is presented in **Table 4** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 4. Summary of Construction Material Engineering Properties for the East Ash Pond

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Embankment Fill	105	30	32	2500	0
Liner System	120	60	30	2500	0

The method of site preparation and construction of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and the original East Ash Pond are not reasonably and readily available. Site preparation and construction of the 2003 East Ash Pond liner raise were completed in accordance with the applicable construction specification (see § 257.73(c)(1)(xi) below).

Reasonably and readily available approximate dates of construction of each successive stage of construction of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are provided in **Table 5** below.

Table 5. Approximate dates of construction of each successive stage of construction.

Date	Event
1951 to 1952	Construction of historical Ash Pond No. 1
1958	Construction of Ash Pond No. 2
Late 1960's	Construction of historical Ash Pond No. 3
1978	Embankment raise of Ash Pond No. 2
1985	Embankment raise of Ash Pond No. 2 to elevation 484 feet and Ash Pond No. 3 (Old West Ash Pond) to elevation 460 feet
1988 to 1989	Embankment raise of Old West Ash Pond to elevation 465 feet that merged historical Ash Pond No. 1 and Ash Pond No. 3 into one single pond and created the Old West Polishing Pond
1989	Embankment raise of Ash Pond No. 2 to elevation 494 feet
1995 to 1996	Construction of East Ash Pond
2003	Embankment liner raise of East Ash Pond
2009 to 2010	Eastern portion of Ash Pond No. 2 was removed to facilitate construction of the Leachate Pond
2011	Landfill Cell 1 was constructed over placed CCR in Ash Pond No. 2 adjacent to the Leachate Pond
2014	North Embankment tree removal, grading, and vegetation re-establishment of Ash Pond No. 2

§ 257.73(c)(1)(vii): At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR unit, detailed dimensional drawings of the CCR unit, including a plan view and cross sections of the length and width of the CCR unit, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection, in addition to the normal operating pool surface elevation and the maximum pool surface elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment, and any identifiable natural or manmade features that could adversely affect operation of the CCR unit due to malfunction or mis-operation.

Drawings that contain items pertaining to the requested information for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are listed in **Table 6** below. Items marked as "Not Available" are items not found during a review of the reasonably and readily available record documentation.

Table 6. List of drawings containing items pertaining to the information requested in § 257.73(c)(1)(vii).

	Old West Polishing Pond	Old West Ash Pond	Ash Pond No. 2	East Ash Pond
Dimensional plan view (all zones)	HEN1-B460-2	HEN1-B460-1 to 2	HEN1-B461, HEN1-C117	HEN1-C55
Dimensional cross sections	HEN1-B452 to B457	HEN1-B452 to B457	HEN1-B458-1 to 7, Berm Modification Drawings 7 to 9	HEN1-C56 to C59
Foundation Improvements	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Drainage Provisions	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Spillways and Outlets	Not Available	Not Available	Not Applicable	HEN1-C8 to C9, HEN1-C109, HEN1-C113
Diversion Ditches	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Instrument Locations	Figure 2D	Figure 2C	Figure 2A	Figure 2B
Slope Protection	Not Available	Not Available	Berm Modification Drawings 3 to 9	HEN1-C56 to C59
Normal Operating Pool Elevation	Not Available	Not Available	Not Available	Not Available
Maximum Pool Elevation	Not Available	Not Available	Not Available	Not Available
Approximate Maximum Depth of CCR in 2016	11 feet	15 feet	46 feet	35 feet

All drawings referenced in **Table 6** above can be found in **Appendix B** and **Appendix C**.

Based on the review of the drawings listed above, no natural or manmade features that could adversely affect operation of these CCR units due to malfunction or mis-operation were identified.

§ 257.73(c)(1)(viii): A description of the type, purpose, and location of existing instrumentation.

Existing instrumentation consists of open-standpipe piezometers installed in 2015. The purpose of the piezometers is to measure the pore water pressures within the embankments of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond. There are seven (7) existing piezometers within the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond. A location map of the existing instrumentation is presented in **Appendix C**.

§ 257.73(c)(1)(ix): Area-capacity curves for the CCR unit.

Area-capacity curves for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are not reasonably and readily available.

§ 257.73(c)(1)(x): A description of each spillway and diversion design features and capacities and calculations used in their determination.

The Old West Polishing Pond contains a 24-inch diameter corrugated metal pipe (CMP) outlet that discharges stormwater to the Illinois River in accordance with the station's NPDES permit. Current capacity and calculation information for the Old West Polishing Pond's discharge capability is not reasonably and readily available.

The Old West Ash Pond contains a 24-inch dia. pipe culvert. Stormwater collected within the CCR unit drains via surface flow and through the pipe culvert into the Old West Polishing Pond. Current capacity and calculation information for the Old West Ash Pond's discharge capability is not reasonably and readily available.

The Ash Pond No. 2 does not contain a spillway or diversion feature. Stormwater collected within the CCR unit drains via surface flow into the East Ash Pond. Current capacity and calculation information for the Ash Pond No. 2's discharge capability is not reasonably and readily available.

The East Ash Pond contains two outlet structures. The southeast outlet is a 5-foot wide stop-log structure that is connected to a 36-inch diameter reinforced concrete pipe (RCP). The 36-inch diameter RCP discharges into the East Polishing Pond. The northeast outlet, located on the northeast corner of the East Ash Pond, is a headwall structure connected to an 18-inch diameter RCP. The 18-inch diameter RCP discharges into the East Leachate Pond. In 2016, the discharge capacity of the East Ash Pond was evaluated using HydroCAD 10 software modeling a 1,000-year, 24-hour rainfall event. The model results indicate that the East Ash Pond has enough storage capacity and will not overtop the embankment during the 1,000-year, 24-hour storm event. The results of the HydroCAD 10 analysis are presented below in **Table 7**.

Table 7. Results of HydroCAD 10 analysis

	East Ash Pond
Approximate Minimum Berm Elevation[1] (ft)	493.0
Approximate Emergency Spillway Elevation[1] (ft)	Not Applicable
Starting Pool Elevation[1] (ft)	490.4
Peak Elevation[1] (ft)	492..2
Time to Peak (hr)	12.5
Surface Area (ac)	6.5
Storage[2] (ac-ft)	8.4

Note: 1. Elevations are based on NAVD88 datum
2. Storage given is from Starting Pool Elevation to Peak Elevation.

§ 257.73(c)(1)(xi): The construction specifications and provisions for surveillance, maintenance, and repair of the CCR unit.

The construction specifications for Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and the original East Ash Pond are not reasonably and readily available. The construction specification for the 2003 East Ash Pond liner raise is located in *Specification J-2616, Rev. A* (presented in **Appendix D**).

The provisions for surveillance, maintenance, and repair of the Old West Polishing Pond and Old West Ash Pond are located in *Hennepin Power Station; West Ash Disposal Pond Maintenance Plan* (2013) (presented in **Appendix E**). The provisions for surveillance, maintenance, and repair of Ash Pond No. 2 are located in *Hennepin Power Station; Old East Ash Disposal Pond Maintenance Plan* (2013) (presented in **Appendix F**). The provisions for surveillance, maintenance, and repair of the East Ash Pond are located in *Hennepin Power Station; East Ash Disposal Pond Maintenance Plan* (2014) (presented in **Appendix G**).

The operations and maintenance plans for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are currently being revised by Dynegy Midwest Generation, LLC.

§ 257.73(c)(1)(xii): Any record or knowledge of structural instability of the CCR unit.

There is no record or knowledge of structural instability of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station.

AECOM

LIMITATIONS

The signature of AECOM's authorized representative on this document represents that to the best of AECOM's knowledge, information and belief in the exercise of its professional judgment, it is AECOM's professional opinion that the aforementioned information is accurate as of the date of such signature. Any recommendation, opinion or decisions by AECOM are made on the basis of AECOM's experience, qualifications and professional judgment and are not to be construed as warranties or guaranties. In addition, opinions relating to environmental, geologic, and geotechnical conditions or other estimates are based on available data and that actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

Sincerely,

Claudia Prado
Project Manager

Victor Modeer, P.E., D.GE
Senior Project Manager

REFERENCES

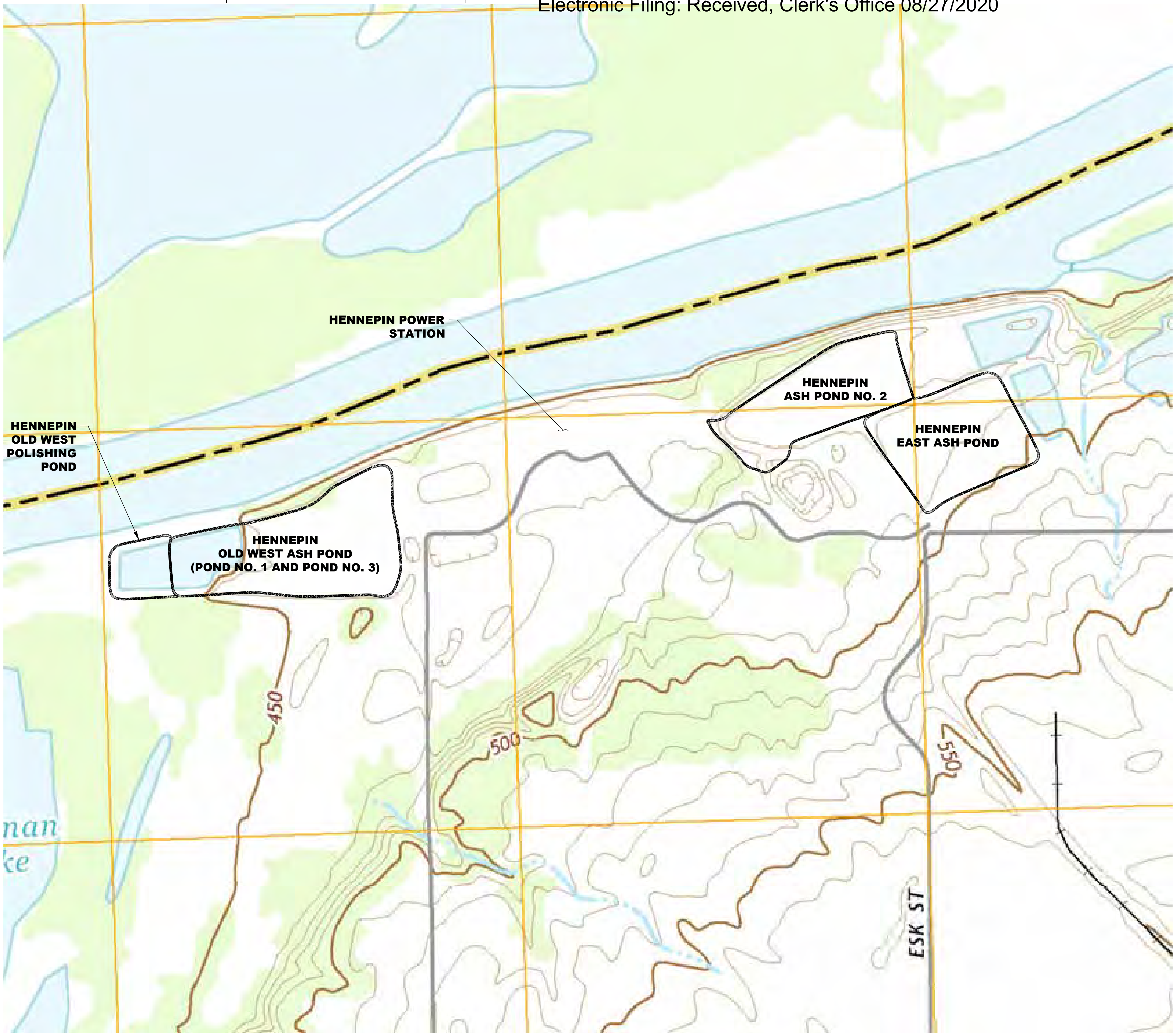
United States Environmental Protection Agency (USEPA). (2015). *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule.* 40 CFR Parts 257 and 261, 80 Fed. Reg. 21302, 21380 April 17, 2015.

United States Geological Survey (USGS). (2016). The National Map Viewer. http://viewer.nationalmap.gov/viewer/. USGS data first accessed in March of 2016.

APPENDICES

Appendix A: History of Construction Vicinity Map
Appendix B: Hennepin Power Station Drawings
Appendix C: Hennepin Power Station Piezometer Locations
Appendix D: Specification J-2616, Rev. A, Primary Ash Pond Modifications
Appendix E: Hennepin Power Station; West Ash Disposal Pond Maintenance Plan (2013)
Appendix F: Hennepin Power Station; Old East Ash Disposal Pond Maintenance Plan (2013)
Appendix G: Hennepin Power Station; East Ash Disposal Pond Maintenance Plan (2014)

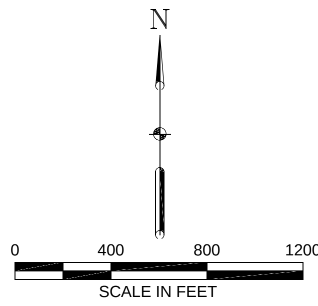
Appendix A: History of Construction Vicinity Map



LEGEND

CCR UNITS

SOURCE:
MAP PROVIDED FROM ELECTRONIC USGS DIGITAL RASTER GRAPHIC 7.5 MINUTE TOPOGRAPHIC MAP OF DEPUE ILLINOIS, REVISED 2015.



AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY MIDWEST GENERATION, L.L.C.
13498 East 800th Street
Hennepin, IL 61327

HISTORY OF CONSTRUCTION

HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

ISSUED FOR BIDDING — DATE BY

ISSUED FOR CONSTRUCTION — DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	60489731
DRAWN BY:	DJD
DESIGNED BY:	DJD
CHECKED BY:	MN
DATE CREATED:	2016-04-13
PLOT DATE:	
SCALE:	1" = 400'
ACAD VER:	2014

SHEET TITLE

HISTORY OF CONSTRUCTION VICINITY MAP

01

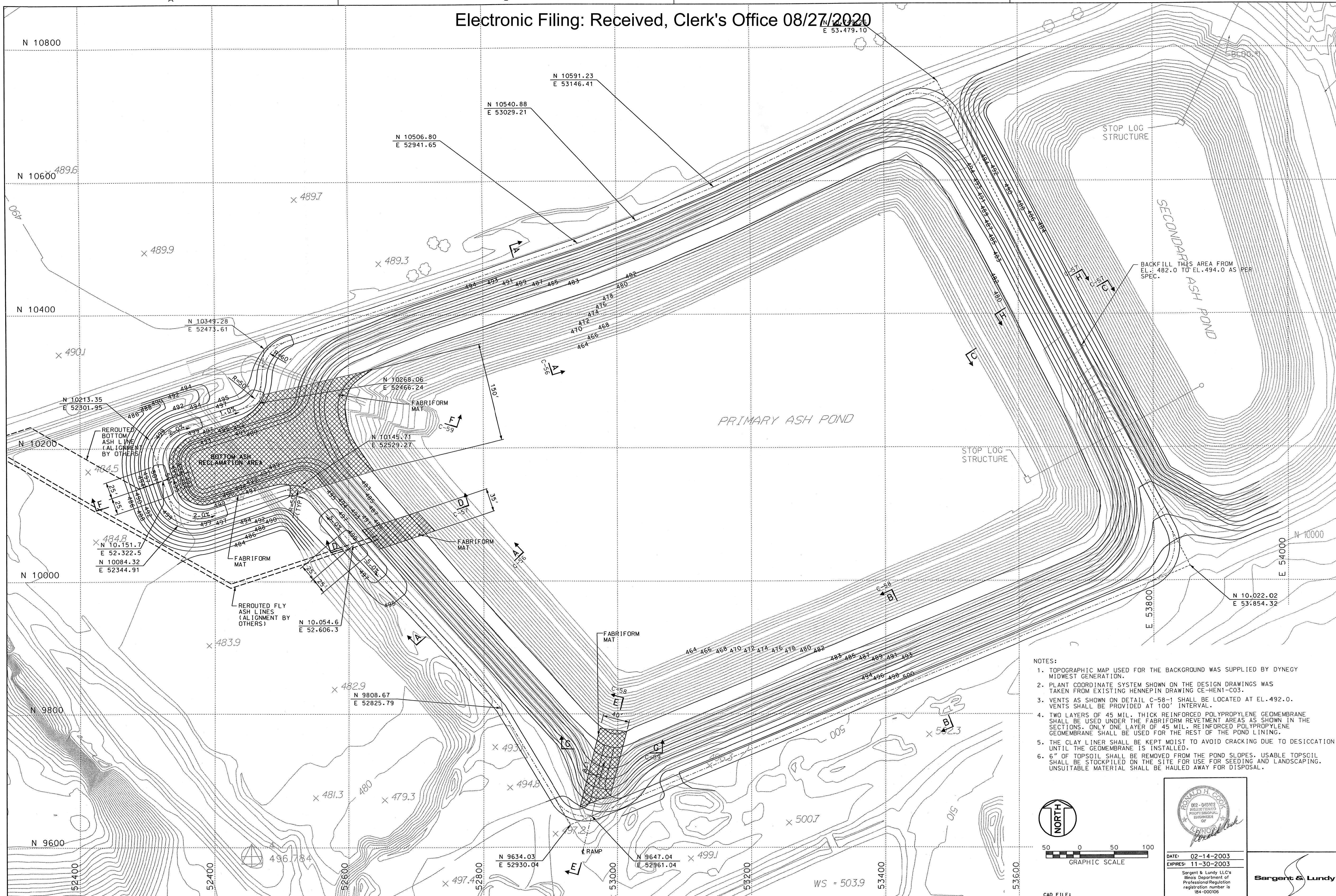
AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\13_Construction History\04 Technical Production\4_Hennepin\Reference Documents\Vicinity Location Map References\Figures\C-01 History of Construction Vicinity Map (Hennepin) – MJN.dwg NANAK, MATT, 9/28/2016 4:11 PM

Appendix B: Hennepin Power Station Drawings

1. “Plan of Primary Ash Pond, Modification to Primary Ash Pond”, Drawing No. C-55, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
2. “Sections and Details – Sheet 1, Modification to Primary Ash Pond”, Drawing No. C-56, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
3. “Sections and Details – Sheet 2, Modification to Primary Ash Pond”, Drawing No. C-57, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
4. “Sections and Details – Sheet 3, Modification to Primary Ash Pond”, Drawing No. C-58, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
5. “Sections and Details – Sheet 4, Modification to Primary Ash Pond”, Drawing No. C-59, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
6. “Cross Sections of Ash Pond Berm Extension, Sta 1+00, 5+00 & 9+50”, Drawing No. E-HEN1-B452, Revision 0, 4 November, 1997, Illinois Power Company.
7. “Cross Sections of Ash Pond Berm Extension, Sta 14+25, 20+80 & 26+00”, Drawing No. E-HEN1-B453, Revision 0, 4 November, 1997, Illinois Power Company.
8. “Cross Sections of Ash Pond Berm Extension, Sta 30+00, 35+00 & 39+00”, Drawing No. E-HEN1-B454, Revision 0, 4 November, 1997, Illinois Power Company.
9. “Cross Sections of Ash Pond Berm Extension, Sta 40+00, 42+00, 44+90”, Drawing No. E-HEN1-B455, Revision 0, 4 November, 1997, Illinois Power Company.
10. “Cross Sections of Ash Pond Berm Extension, Sta 47+00, 51+00 & 56+00”, Drawing No. E-HEN1-B456, Revision 0, 4 November, 1997, Illinois Power Company.
11. “Cross Sections of Ash Pond Berm Extension, Sta 61+50”, Drawing No. E-HEN1-B457, Revision 0, 4 November, 1997, Illinois Power Company.
12. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-1, Revision 0, 8 March, 1990, Illinois Power Company.
13. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-2, Revision 0, 8 March, 1990, Illinois Power Company.
14. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-3, Revision 0, 8 March, 1990, Illinois Power Company.
15. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-4, Revision 0, 8 March, 1990, Illinois Power Company.
16. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-5, Revision 0, 8 March, 1990, Illinois Power Company.
17. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-6, Revision 0, 8 March, 1990, Illinois Power Company.
18. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-7, Revision 0, 8 March, 1990, Illinois Power Company.
19. “Plan-Unit #1 Ash Pond Extension, Sheet #1”, Drawing No. E-HEN1-B460-1, 2 February, 1988, Illinois Power Company.
20. “Plan-Unit #1 Ash Pond Extension, Sheet #2”, Drawing No. E-HEN1-B460-2, 2 February, 1988, Illinois Power Company.

Appendix B: Hennepin Power Station Drawings (continued)

21. “Contour and Grading Plan, Unit #2 Ash Pond Extension”, Drawing No. CE-HEN1-B461, Revision 0, 8 March, 1990, Illinois Power Company.
22. “Pond 2 East, Flexible Membrane Liner and Structures”, Drawing No. HEN1-C109, Revision 0, 28 July, 2010, Civil & Environmental Consultants, Inc.
23. “Pond 2 East, Details”, Drawing No. HEN1-C113, Revision 0, 28 July, 2010, Civil & Environmental Consultants, Inc.
24. “Landfill Phase 1 Construction, Existing Conditions”, Drawing No. HEN1-C117, Revision 0, 28 November, 2010, Civil & Environmental Consultants, Inc.
25. “Layout-Pond Discharge Structures, 1995 Ash Facility”, Drawing No. CE-HEN1-C8, Revision 0, 17 September, 1996, Illinois Power Company.
26. “Details: Pond Discharge Structure, 1995 Ash Facility”, Drawing No. CE-HEN1-C9, Revision 0, 17 September, 1996, Illinois Power Company.
27. “East Berm Modification, Existing Site Conditions”, Drawing No. 3, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
28. “East Berm Modification, Proposed Site Plan”, Drawing No. 4, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
29. “East Berm Modification, Proposed Grading Plan 1 of 2”, Drawing No. 5, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
30. “East Berm Modification, Proposed Grading Plan 2 of 2”, Drawing No. 6, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
31. “East Berm Modification, Proposed Sections Sta 1+00 to 15+00”, Drawing No. 7, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
32. “East Berm Modification, Proposed Sections Sta 16+00 to 23+50”, Drawing No. 8, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
33. “East Berm Modification, Berm and Erosion Control Details”, Drawing No. 9, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.



NOTES:

1. TOPOGRAPHIC MAP USED FOR THE BACKGROUND WAS SUPPLIED BY DYNEGY MIDWEST GENERATION.
2. PLANT COORDINATE SYSTEM SHOWN ON THE DESIGN DRAWINGS WAS TAKEN FROM EXISTING HENNEPIN DRAWING CE-HEN1-C03.
3. VENTS AS SHOWN ON DETAIL C-58-1 SHALL BE LOCATED AT EL.492.0. VENTS SHALL BE PROVIDED AT 100' INTERVAL.
4. TWO LAYERS OF 45 MIL. THICK REINFORCED POLYPROPYLENE GEOMEMBRANE SHALL BE USED UNDER THE FABRIFORM REVETMENT AREAS AS SHOWN IN THE SECTIONS. ONLY ONE LAYER OF 45 MIL. REINFORCED POLYPROPYLENE GEOMEMBRANE SHALL BE USED FOR THE REST OF THE POND LINING.
5. THE CLAY LINER SHALL BE KEPT MOIST TO AVOID CRACKING DUE TO DESICCATION UNTIL THE GEOMEMBRANE IS INSTALLED.
6. 6" OF TOPSOIL SHALL BE REMOVED FROM THE POND SLOPES. USABLE TOPSOIL SHALL BE STOCKPILED ON THE SITE FOR USE FOR SEEDING AND LANDSCAPING. UNSUITABLE MATERIAL SHALL BE HAULED AWAY FOR DISPOSAL.

DATE: 02-14-2003
EXPIRES: 11-30-2003
Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	——

SCALE: 1"=50'
DWN. M.DOWNS DATE 02-12-03
CHK. V.PATEL DATE 02-14-03
APPV. DATE

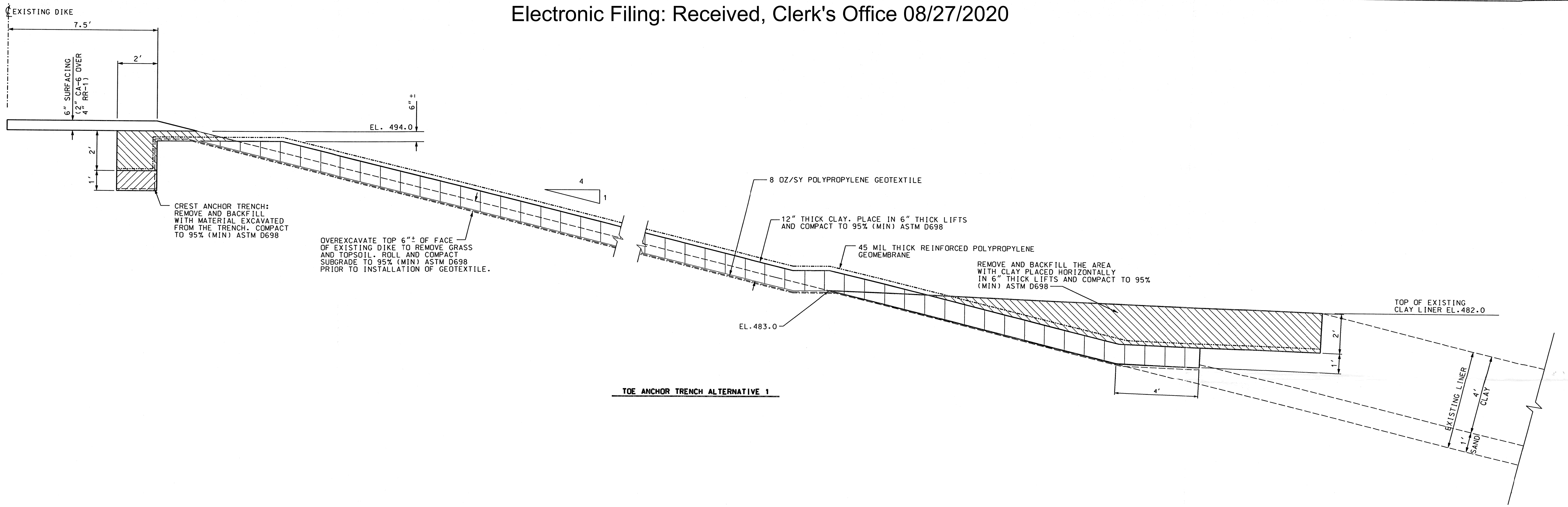
DYNEGY

PLAN OF PRIMARY ASH POND

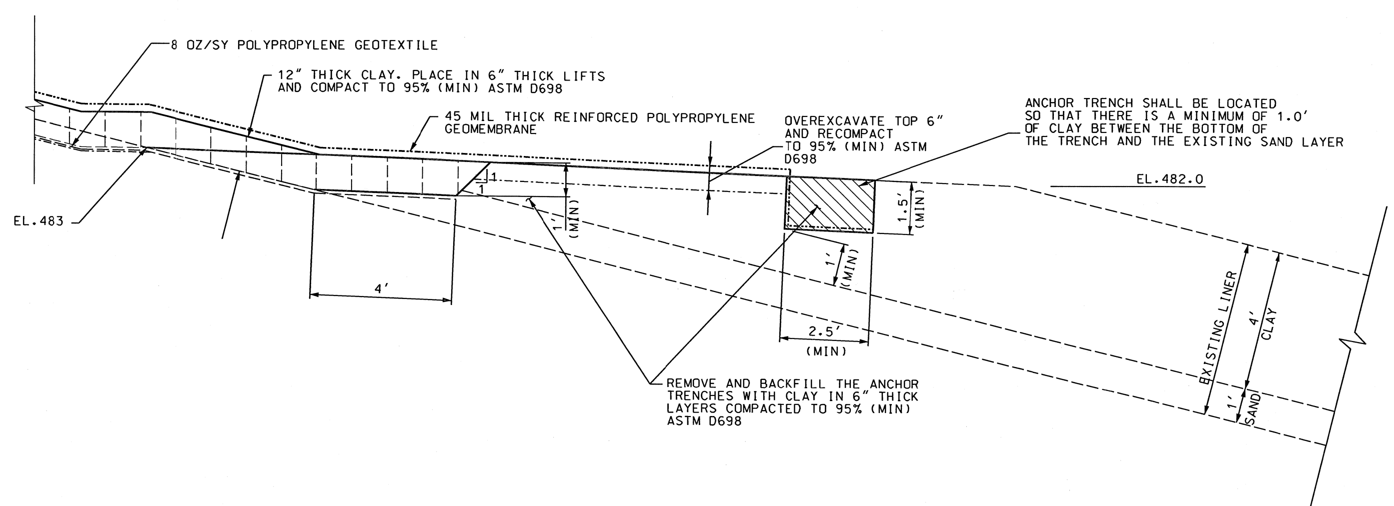
MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-55
REV. 0.1

E-WOR1-E157-1.DGN VAV
07-10-2001
02-13-03 ALS



TOE ANCHOR TRENCH ALTERNATIVE 1



TOE ANCHOR TRENCH ALTERNATIVE 2

SECTION A

SEE DWG C-55

GRAPHIC SCALE HOR 1/2"=1'-0"

GRAPHIC SCALE VER 1/2"=1'-0"

NOTES:

1. CONTRACTOR SHALL BE RESPONSIBLE FOR CHECKING EXISTING ELEVATIONS AND DIMENSIONS PRIOR TO FABRICATION OF THE GEOMEMBRANE LINER.
2. CONTRACTOR MAY USE EITHER ALTENATIVE 1 OR ALTERNATIVE 2 AS APPROVED BY THE BUYER FOR ALL TOE ANCHOR TRENCH DETAILS.
3. DIMENSIONS WERE TAKEN FROM TYPICAL SECTION ON DRAWING CH-HEN1-C6.1 DATED 12-9-93.

RONALD H. COOK 062-048802 REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003
Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

REFERENCE DRAWINGS

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0.1	02-14-2003	FOR PERMIT	MED	VP	—						

SCALE:
DWN. M.DOWNS DATE 02-12-02
CHK. V.PATEL DATE 02-14-03
APPV. DATE

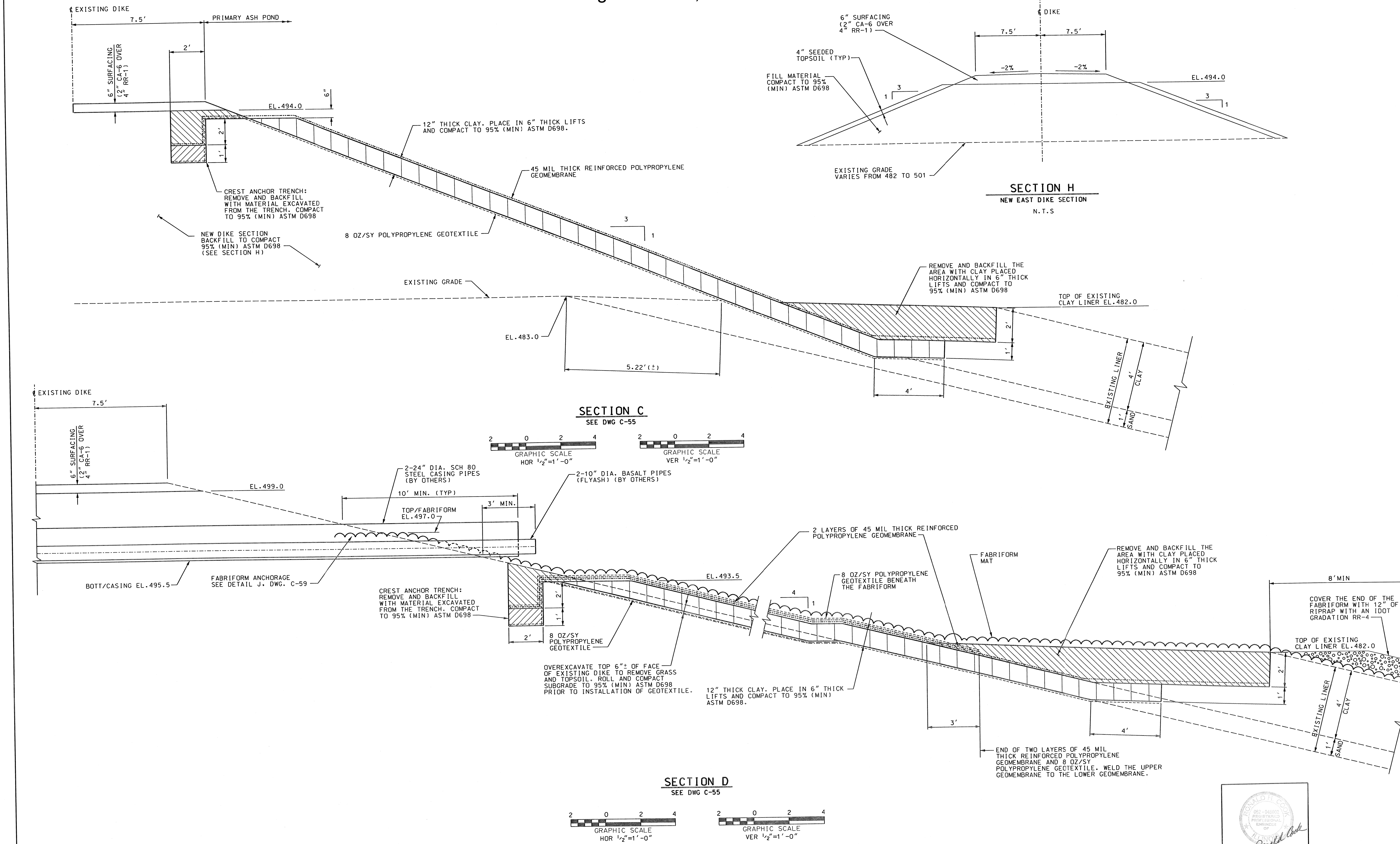
DYNEGY

SECTIONS AND DETAILS - SHEET 1

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-56 REV. 0.1

E-WDR1-E157-1.DGN VAV
07-10-2001
02-13-03 ALS



DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
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SCALE: 1/2"=1'-0"
DWN. M.DOWNS DATE 02-12-02
CHK. V.PATEL DATE 02-14-03
APPV. DATE

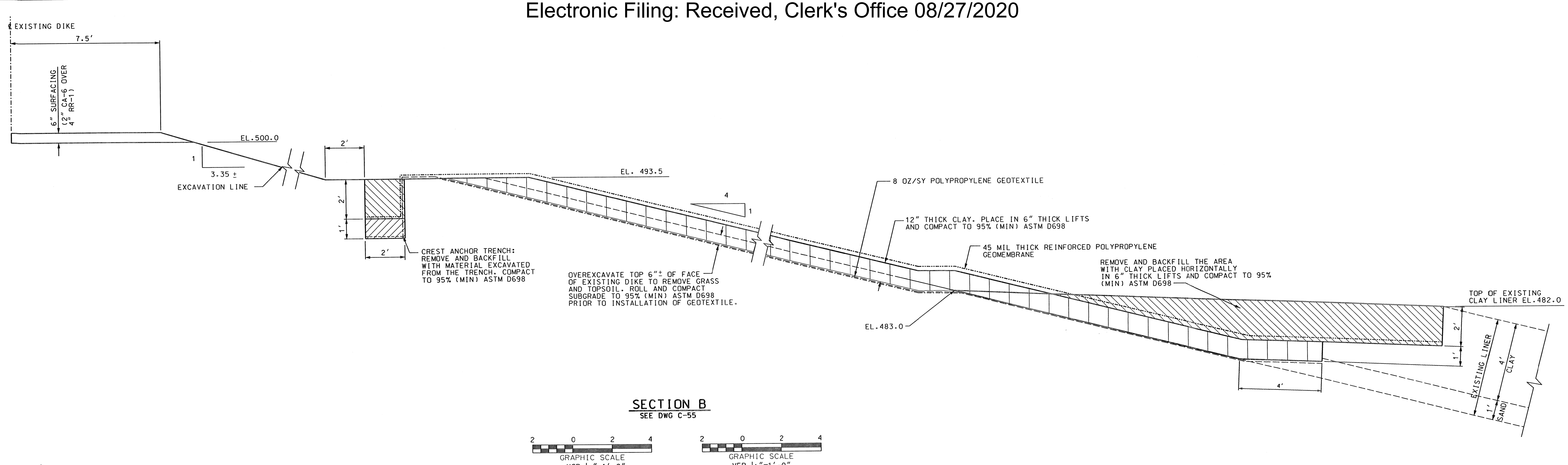
DYNEGY

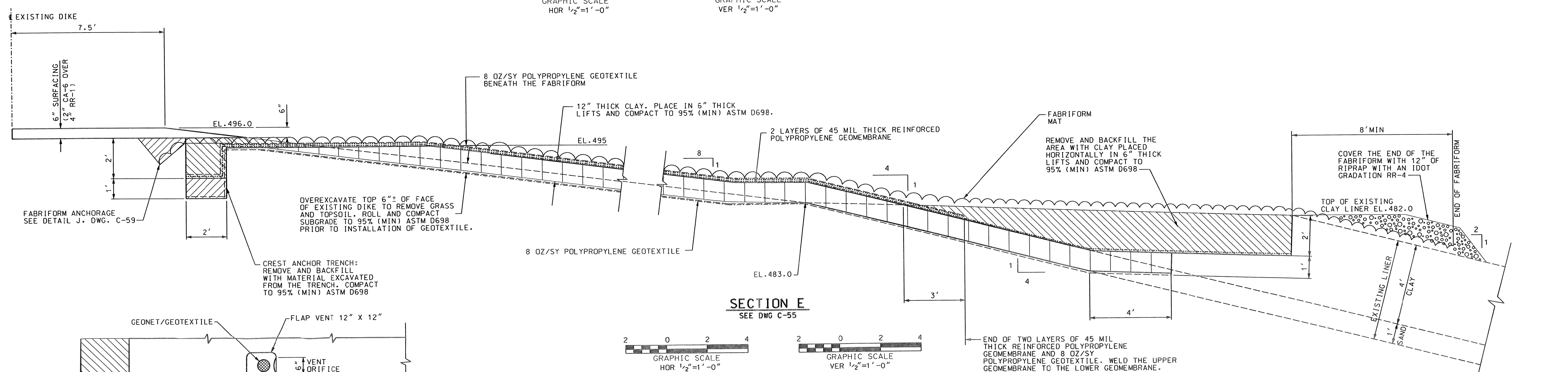
SECTIONS AND DETAILS - SHEET 2

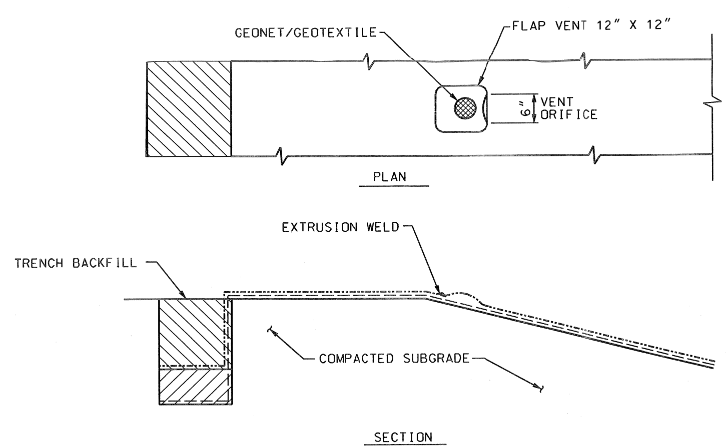
MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-57
REV. 0.1

02-13-03 ALS







DETAIL C-58-1
MAXIMUM INTERVAL SHALL BE 100'

RONALD H. COOK 062-045833 REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	—

SCALE: 1/2"=1'-0"
DWN. M.DOWNS DATE 02-14-03
CHK. V.PATEL DATE 02-14-03
APPV. DATE

DYNEGY

SECTIONS AND DETAILS - SHEET 3

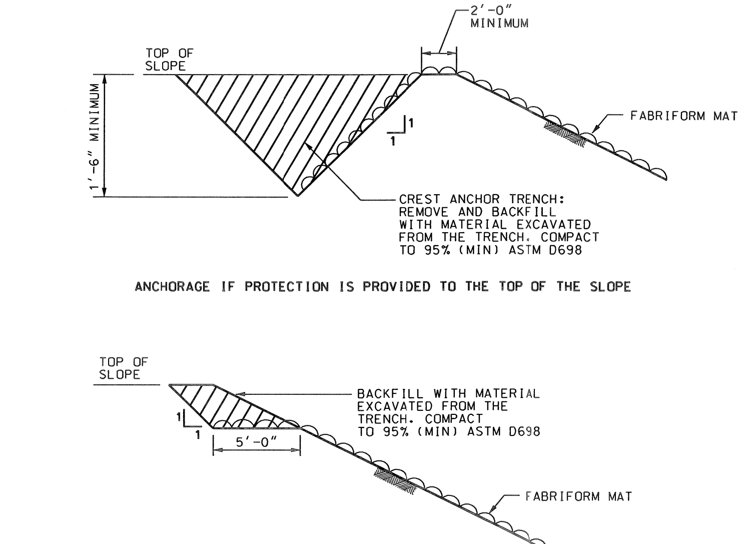
MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-58
REV. 0.1

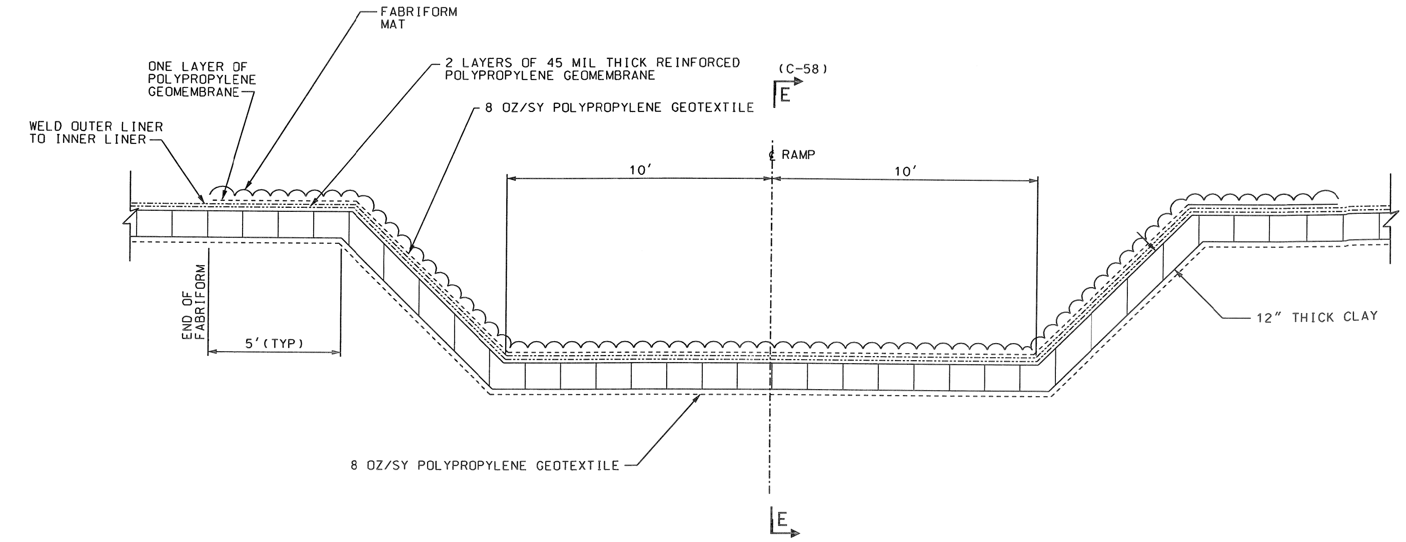
02-12-03 ALS
E-WDR1-E157-1.DGN VAV
07-10-2001

A B C D

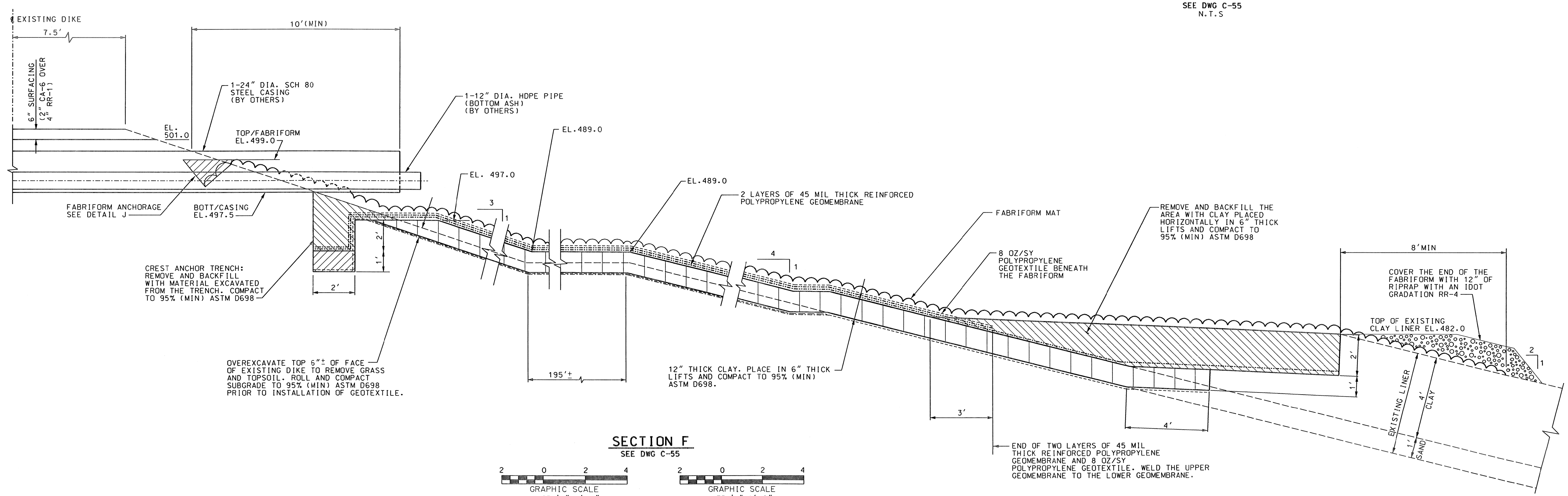
1 2 3 4



DETAIL J
ANCHORAGE FOR FABRIFORM MAT
N.T.S.



SECTION G
SEE DWG C-55
N.T.S



SECTION F
SEE DWG C-55

2 0 2 4
GRAPHIC SCALE
HOR 1/2"=1'-0"

2 0 2 4
GRAPHIC SCALE
VER 1/2"=1'-0"

RONALD H. COOK
062-048800
REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003
Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

REFERENCE DRAWINGS

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0.1	02-14-2003	FOR PERMIT	MED	VP	——						

SCALE: 1/4"=1'-0"
DWN. M.DOWNS DATE 02-12-02
CHK. V.PATEL DATE 02-14-03
APPV. DATE

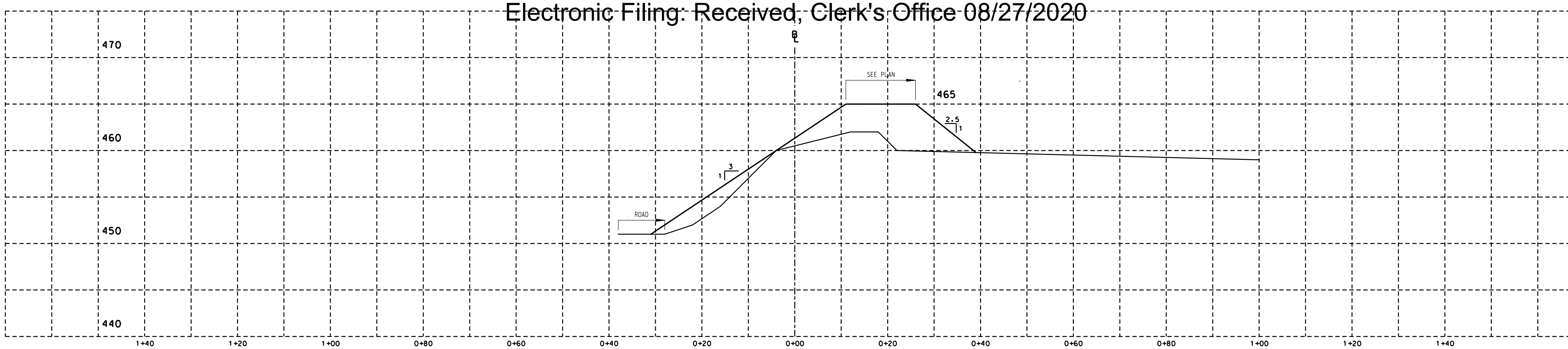
DYNEGY

SECTIONS AND DETAILS - SHEET 4

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-59
REV. 0.1

E-WDR1-E157-1.DGN VAV
07-10-2001
02-13-03 ALS



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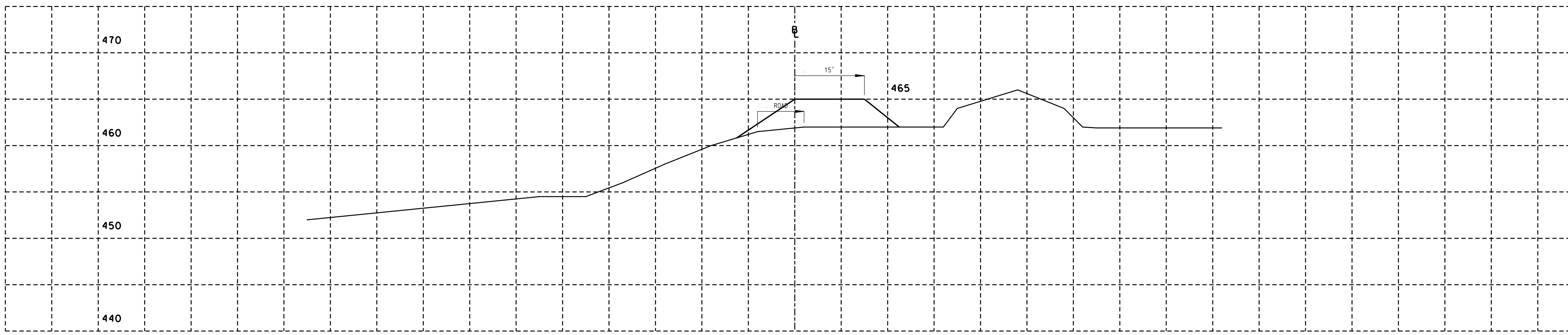

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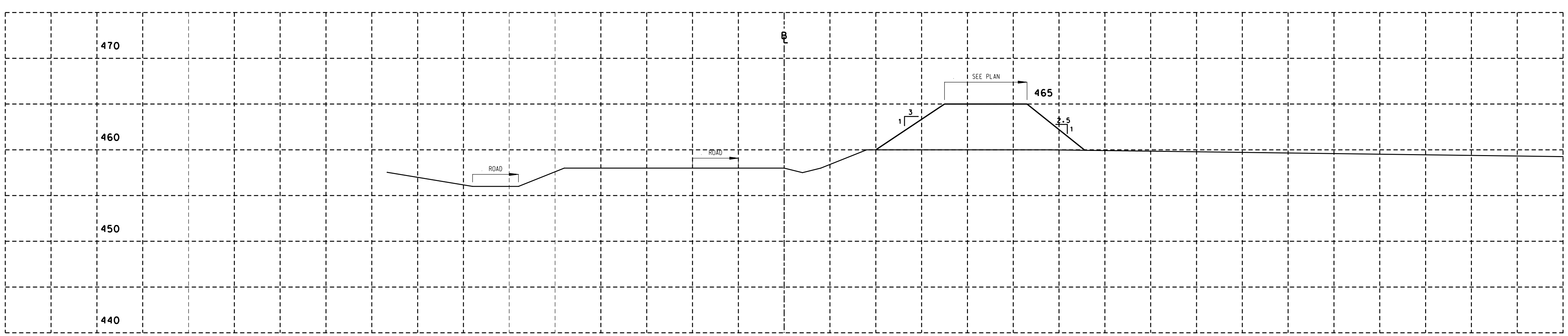


STATION 1+00

LEDGEND

- REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- WATER LINE
- ✳ ESTIMATED ELEVATION

E-HEN1-B452

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

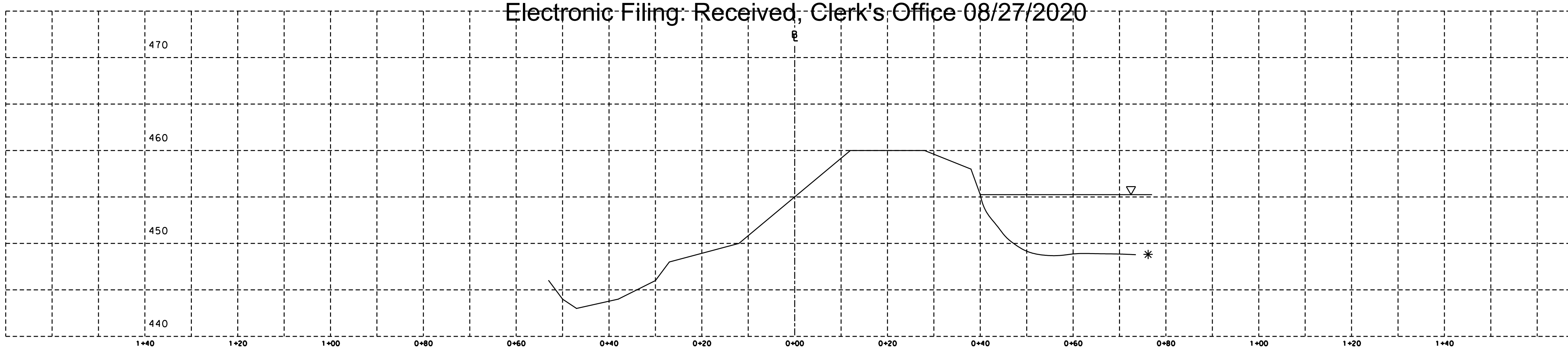
0

ILLINOIS POWER COMPANY
DECATUR

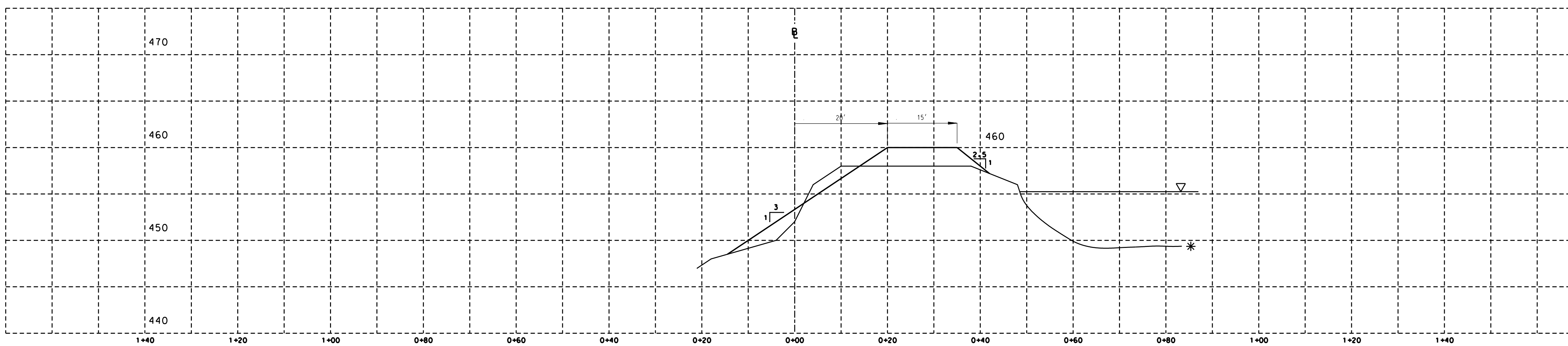
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 1+00, 5+00 & 9+50
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B452
APP		

COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 26+00



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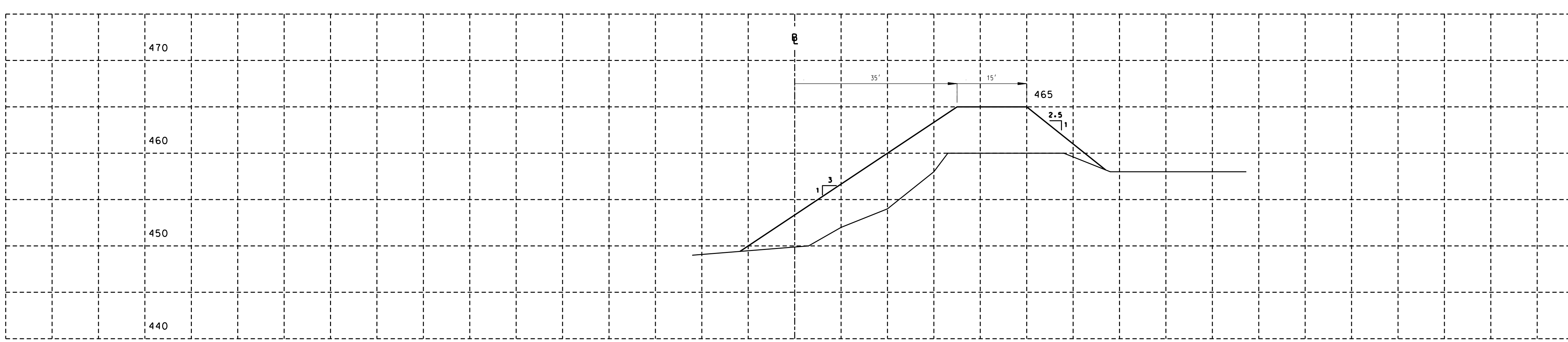


STATION 14+25

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- * ESTIMATED ELEVATION

E-HEN1-B453

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

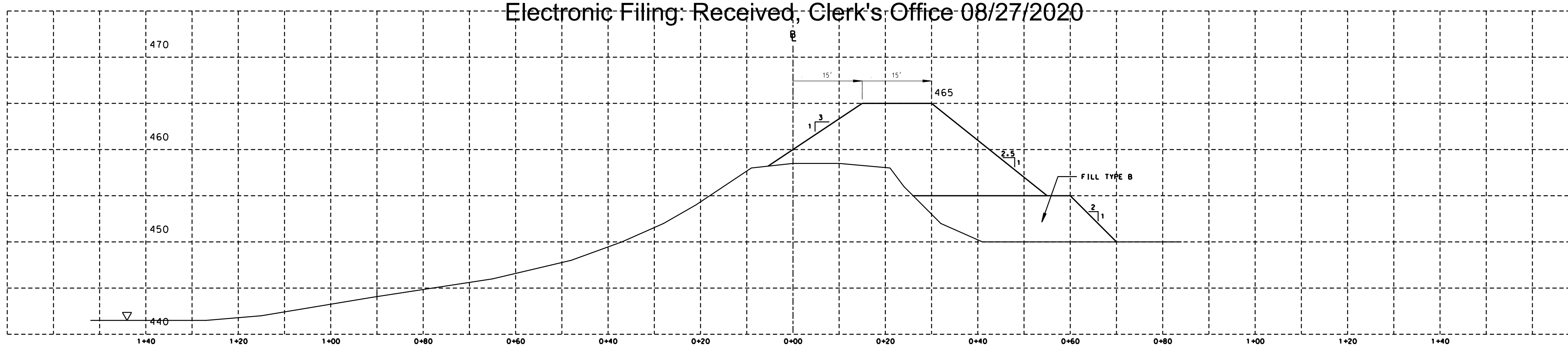
0

ILLINOIS POWER COMPANY
DECATUR

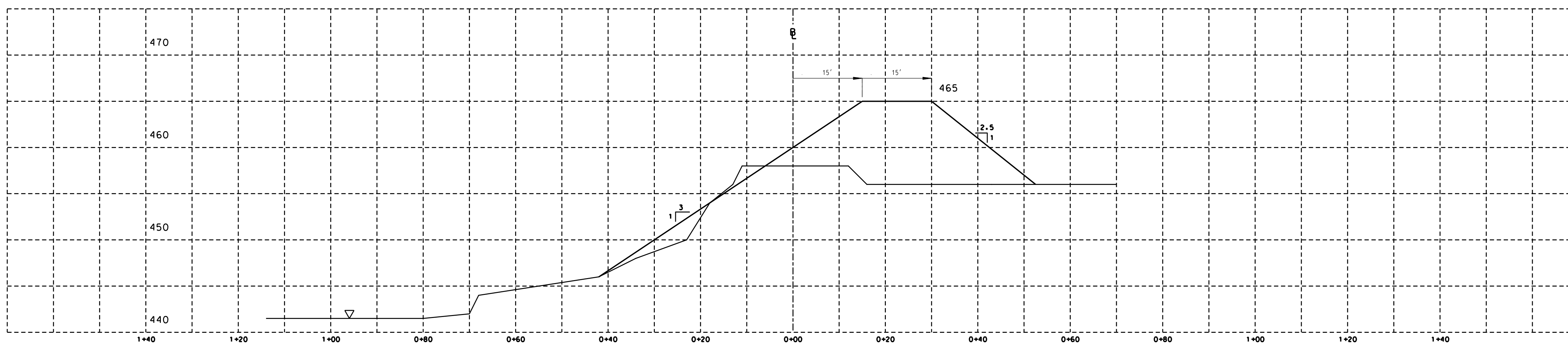
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 14+25, 20+80 & 26+00
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B453
APP		

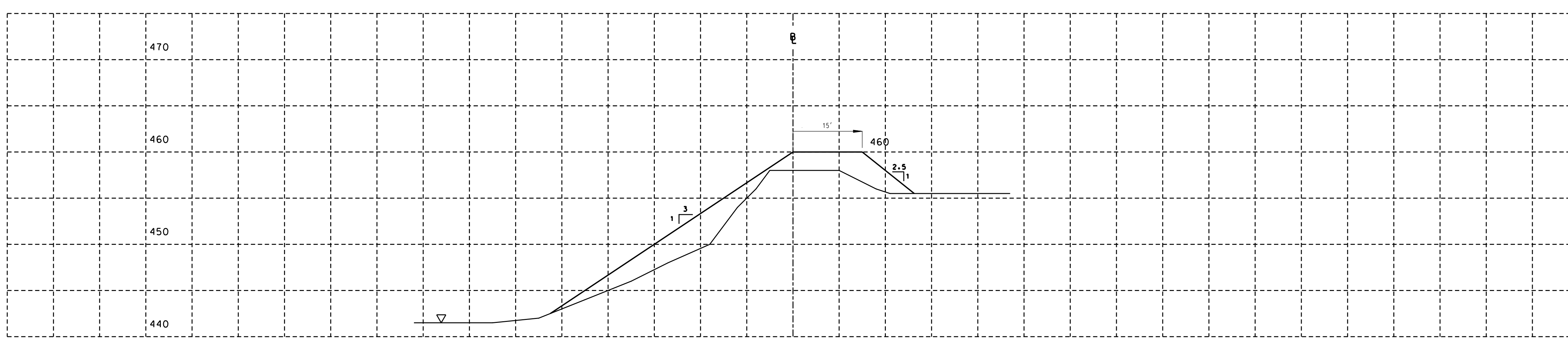
COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 39+00



STATION 35+00



STATION 30+00

LEDGEND

- REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- WATER LINE
- ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

0

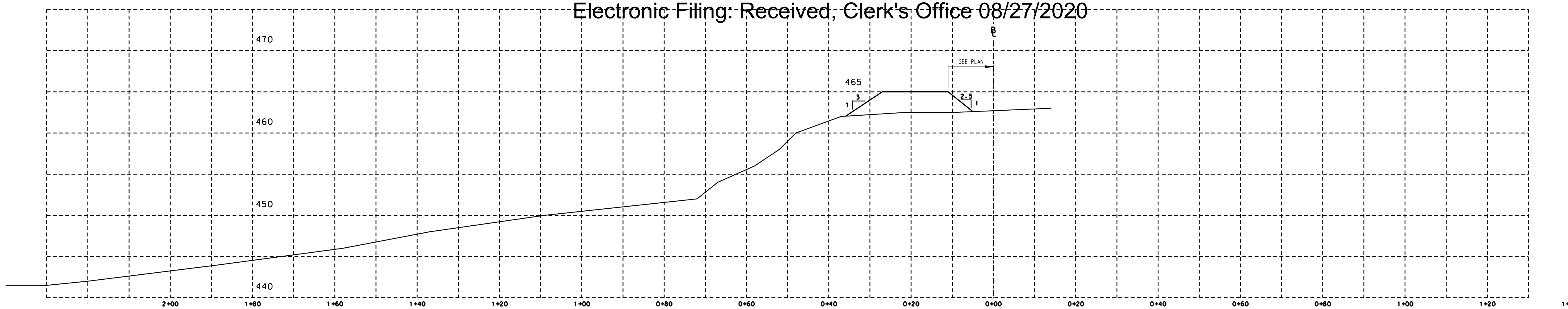
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 30+00, 35+00 & 39+00
HENNEPIN POWER STATION

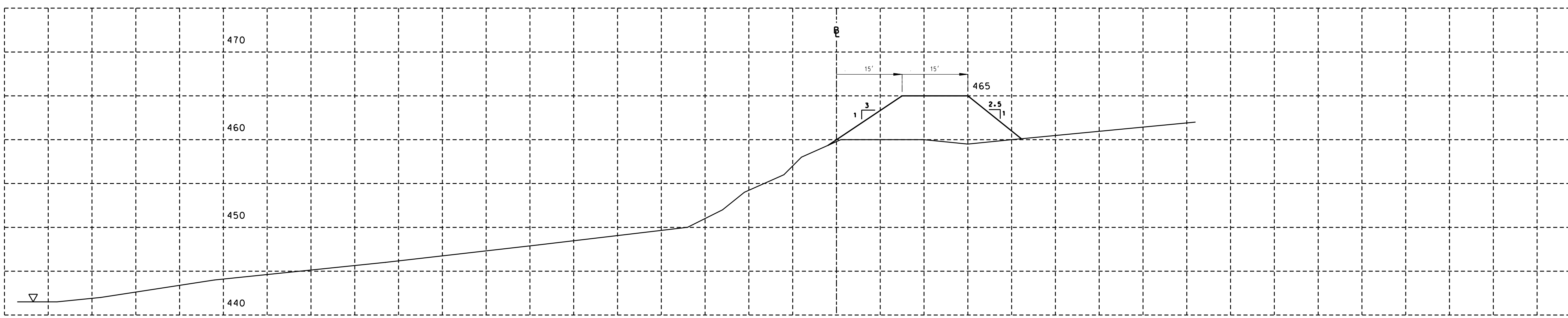
DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B454
APP		

E-HEN1-B454

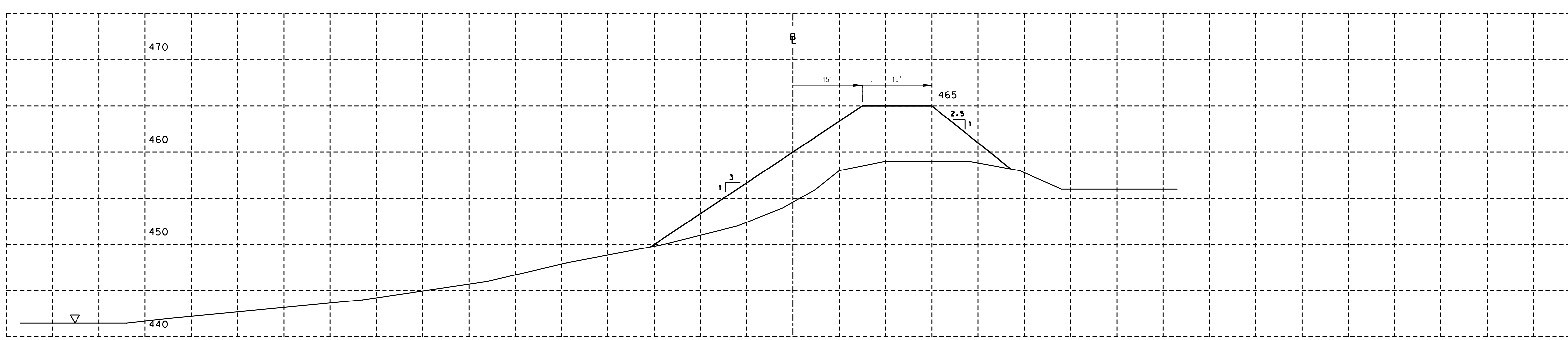
COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 44+90



STATION 42+00



STATION 40+00

LEDGEND

- REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- WATER LINE
- * ESTIMATED ELEVATION

E-HEN1-B455

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

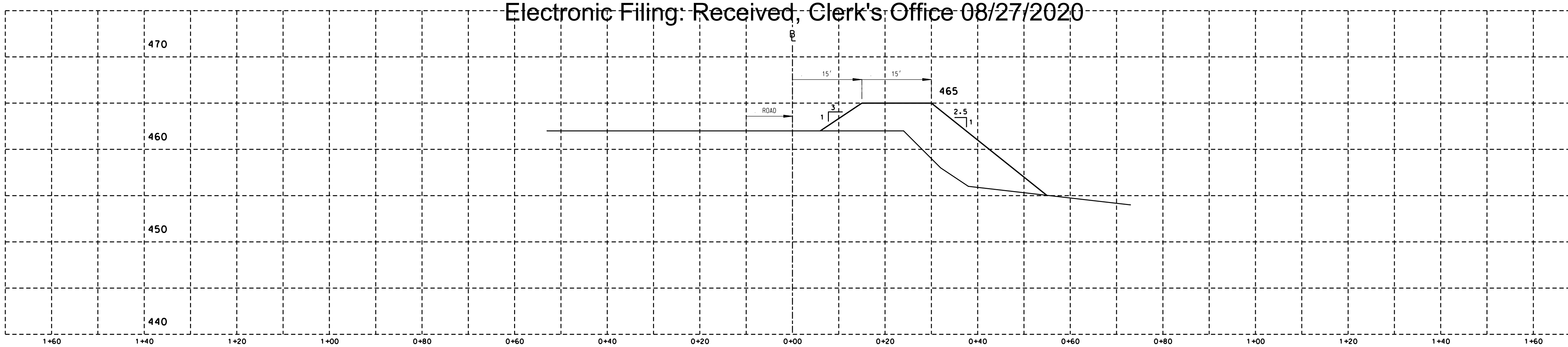
0

ILLINOIS POWER COMPANY
DECATUR

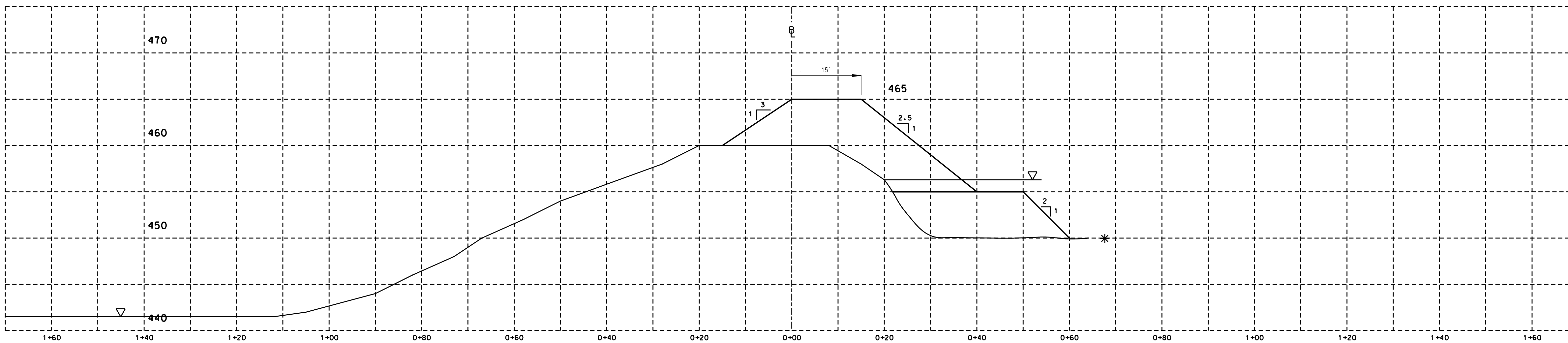
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 40+00, 42+00 & 44+90
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B455
APP		

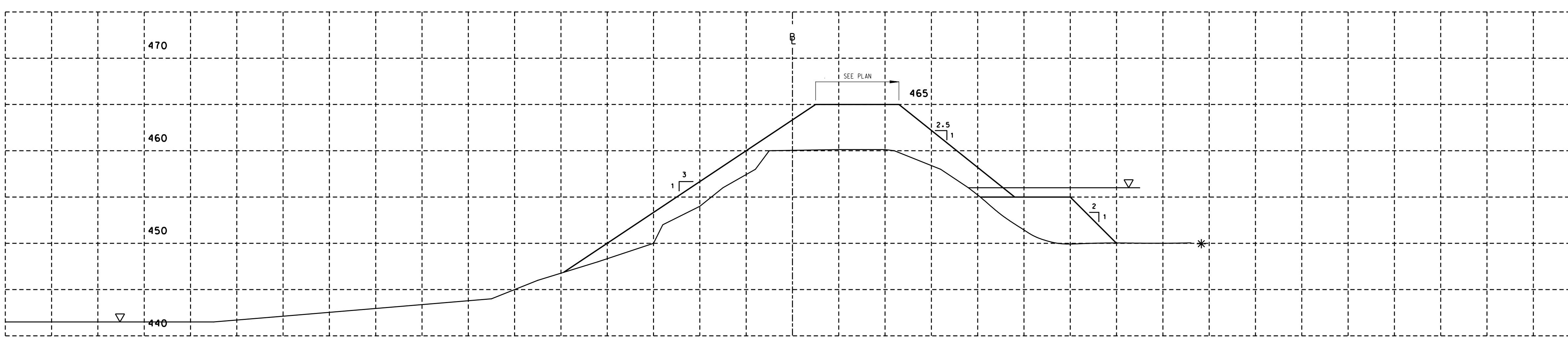
COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 56+00



STATION 51+00



STATION 47+00

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- * ESTIMATED ELEVATION

E-HEN1-B456

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

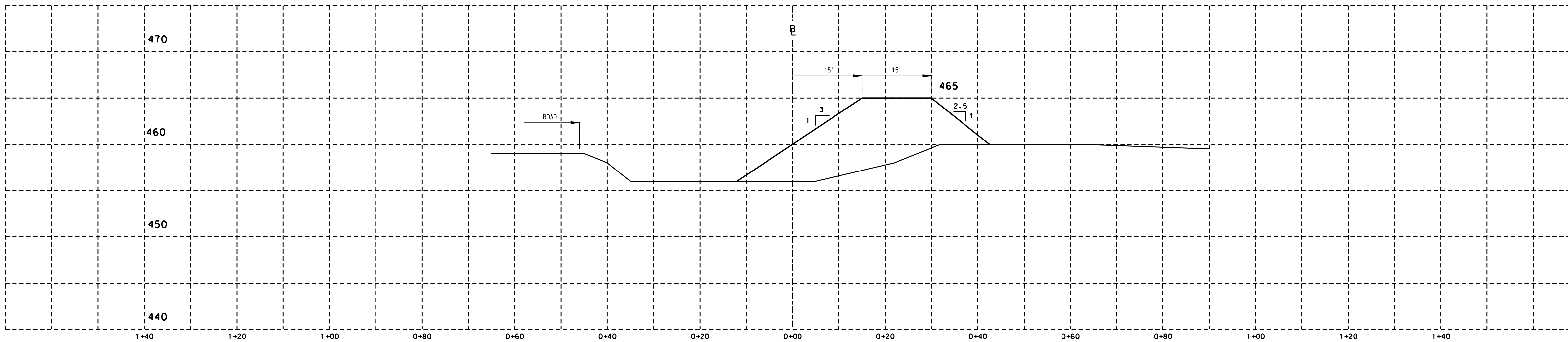
0

ILLINOIS POWER COMPANY
DECATUR

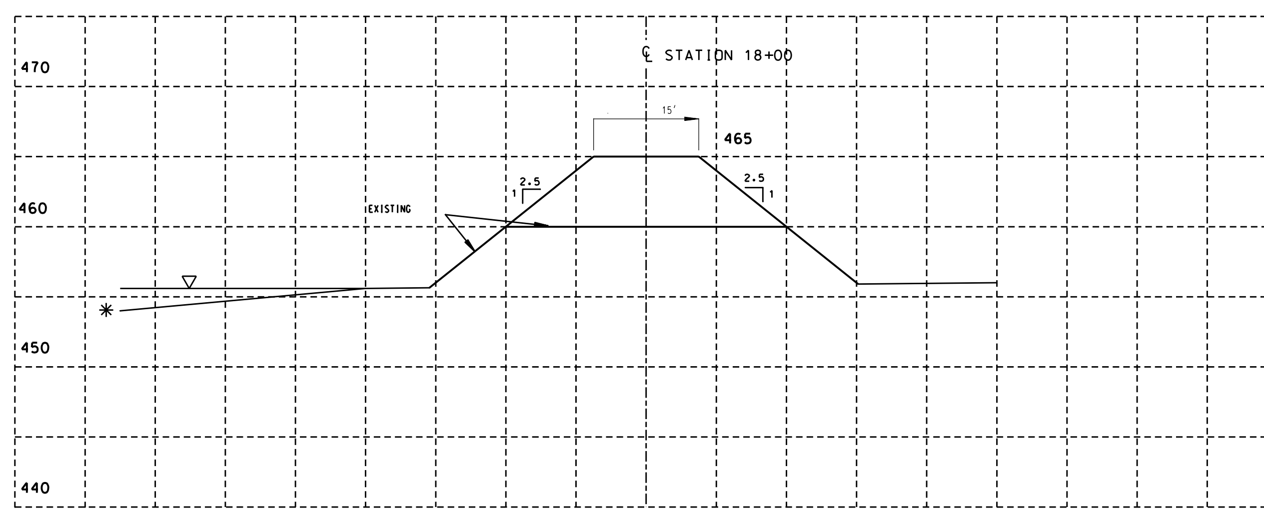
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 47+00, 51+00 & 56+00
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B456
APP		

COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 61+50



SECTION A-A

LEDGEND

REFERENCE BASE LINE SHOWN ON PLAN

OLD BERM

NEW BERM

WATER LINE

ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
- -CONSTRUCTION
- -RECORD

0

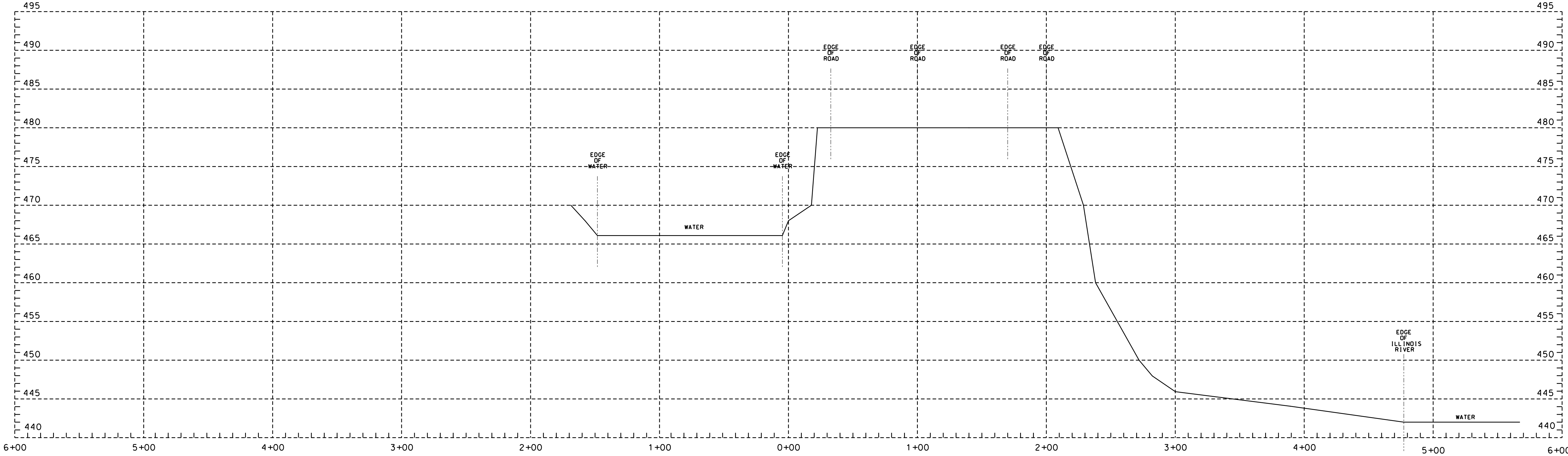
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 61+50
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H.1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B457
APP		

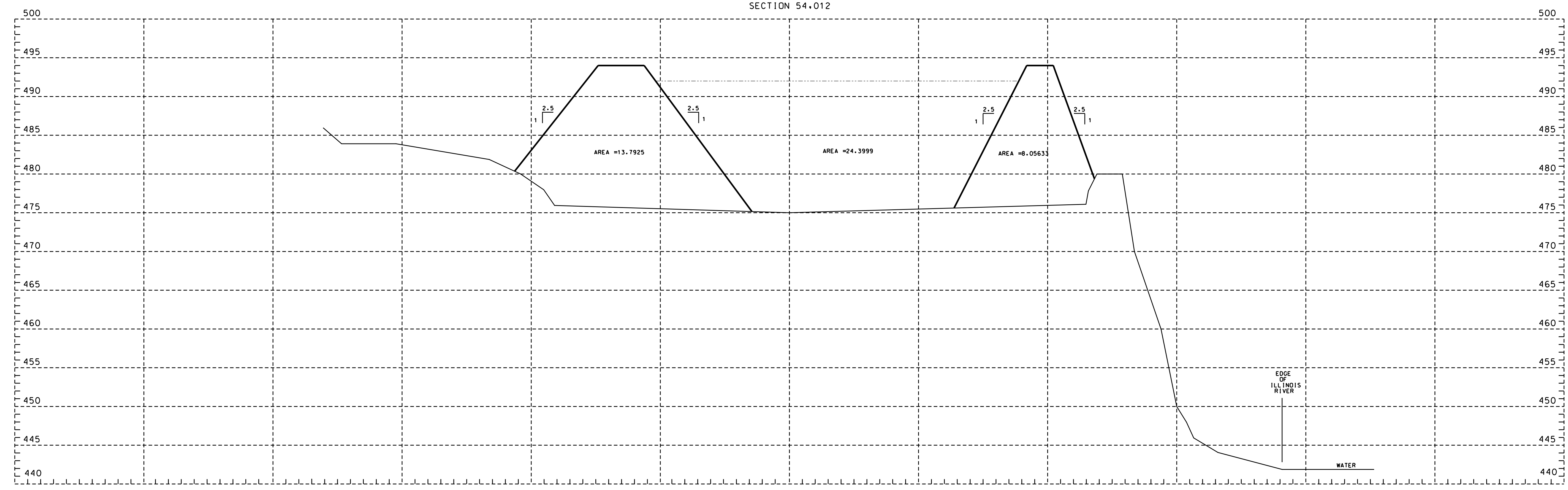
E-HEN1-B457

COMPUTER DWG. - DO NOT REVISE MANUALLY



BASE LINE N. 11.000

SECTION 54.012



BASE LINE N. 11.000

SECTION E. 53.812

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

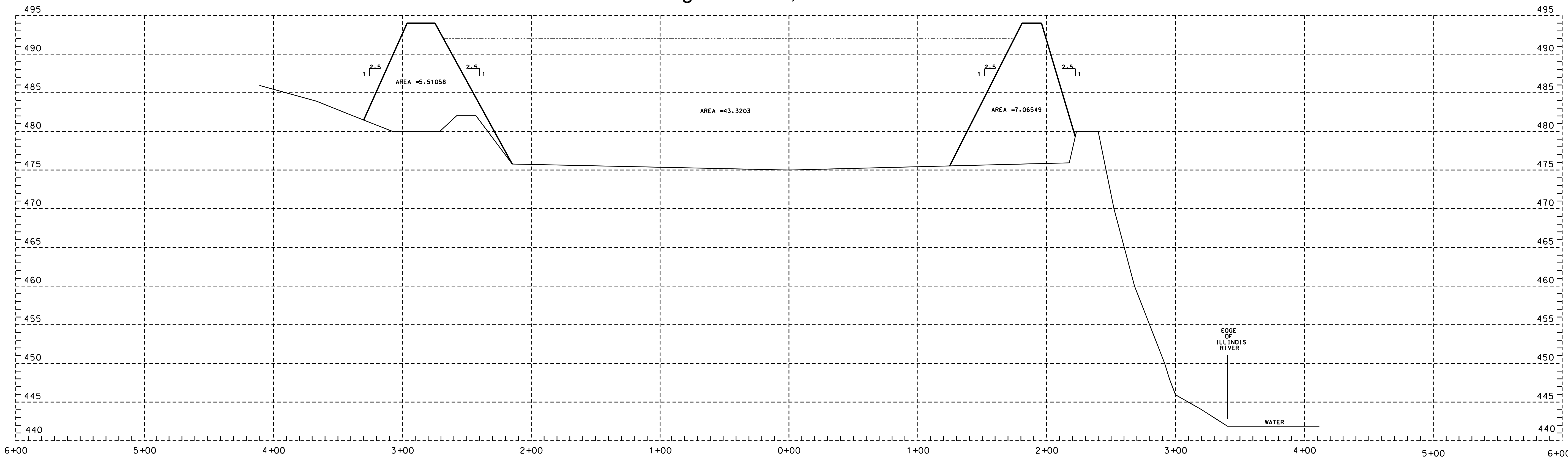
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

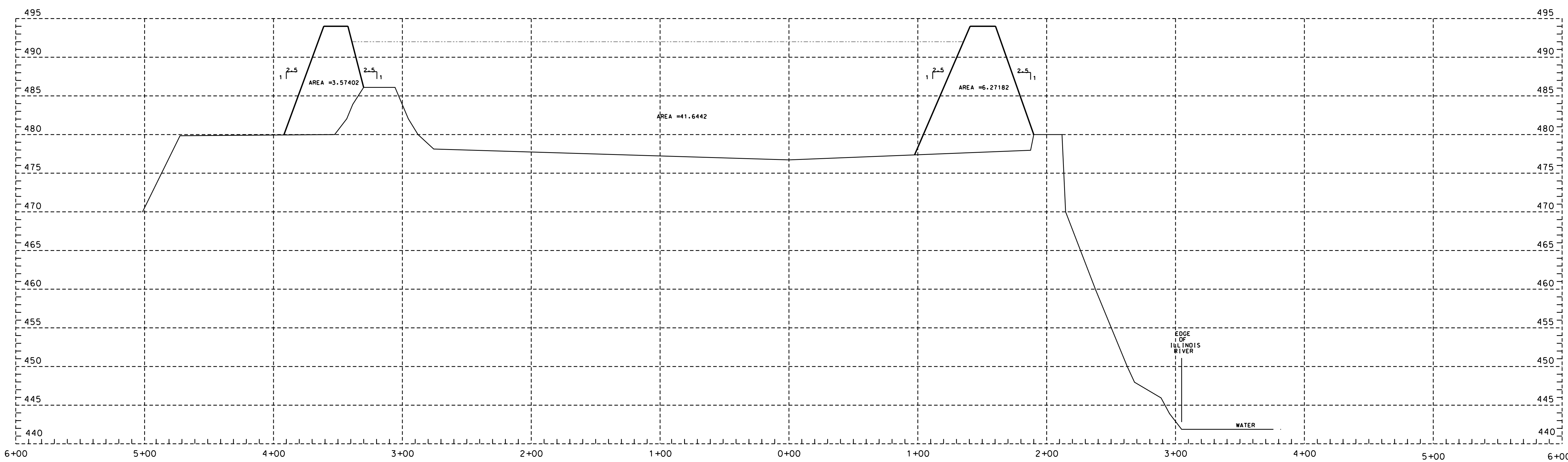
CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-11-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-1
APP		



BASE LINE N. 11,000

SECTION E. 53,692



BASE LINE N. 11,000

SECTION E. 53,492

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

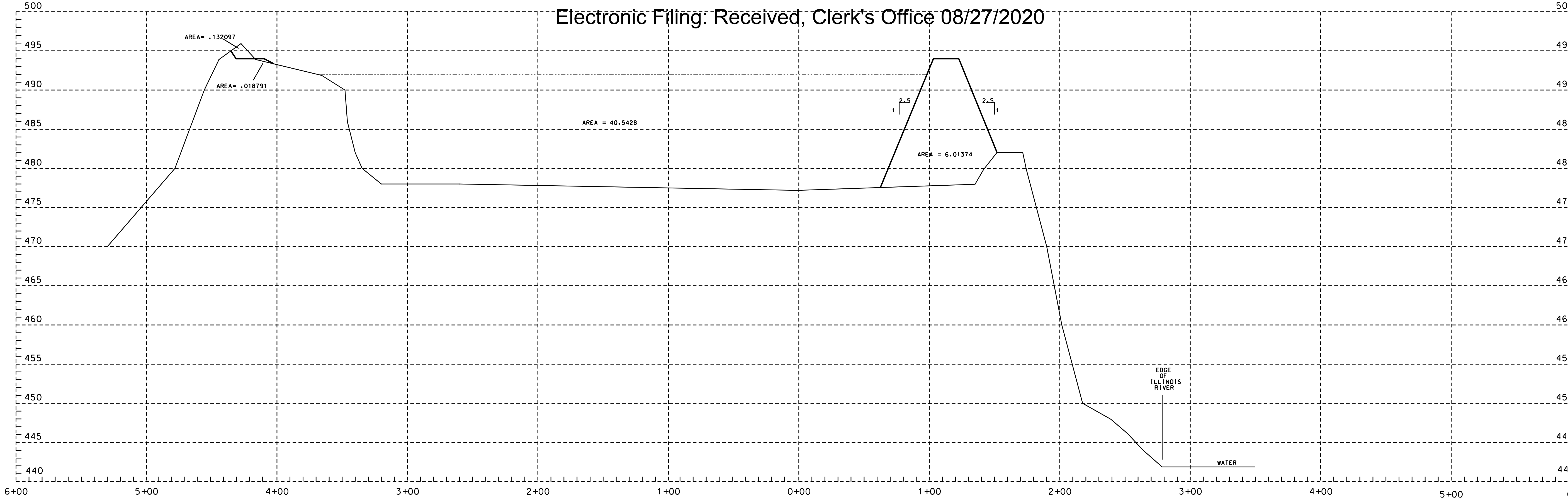
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

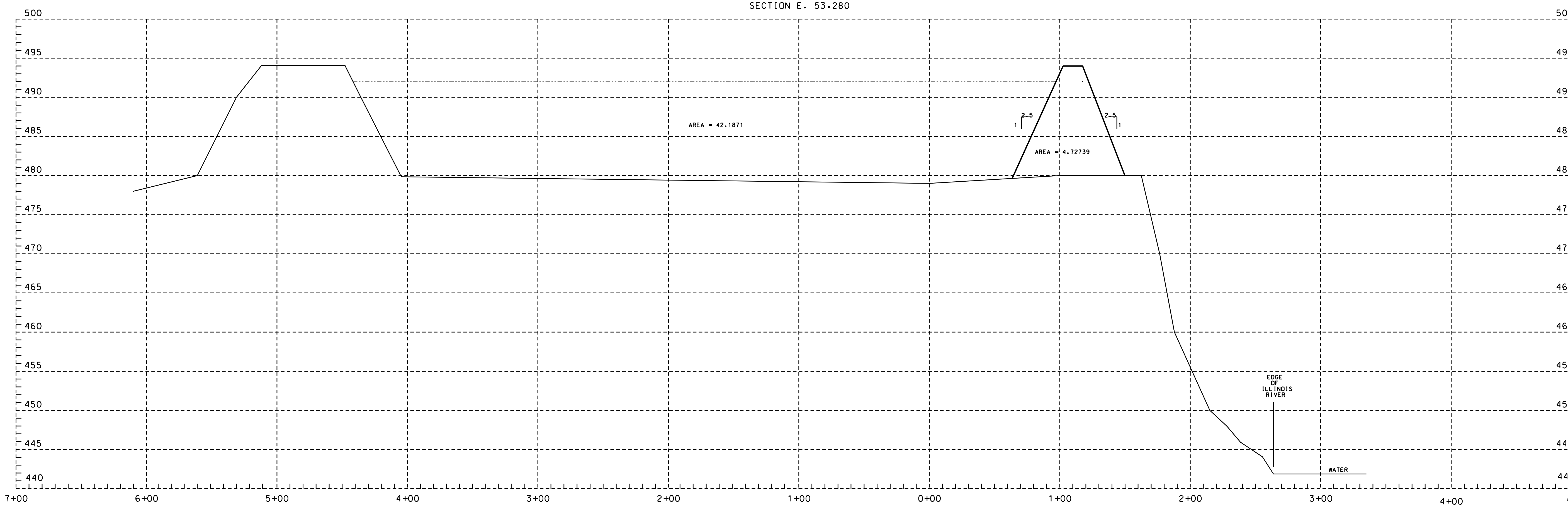
CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-2
APP		



BASE LINE N. 11.000

SECTION E. 53.280



BASE LINE N. 11.000

SECTION E. 53.080

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

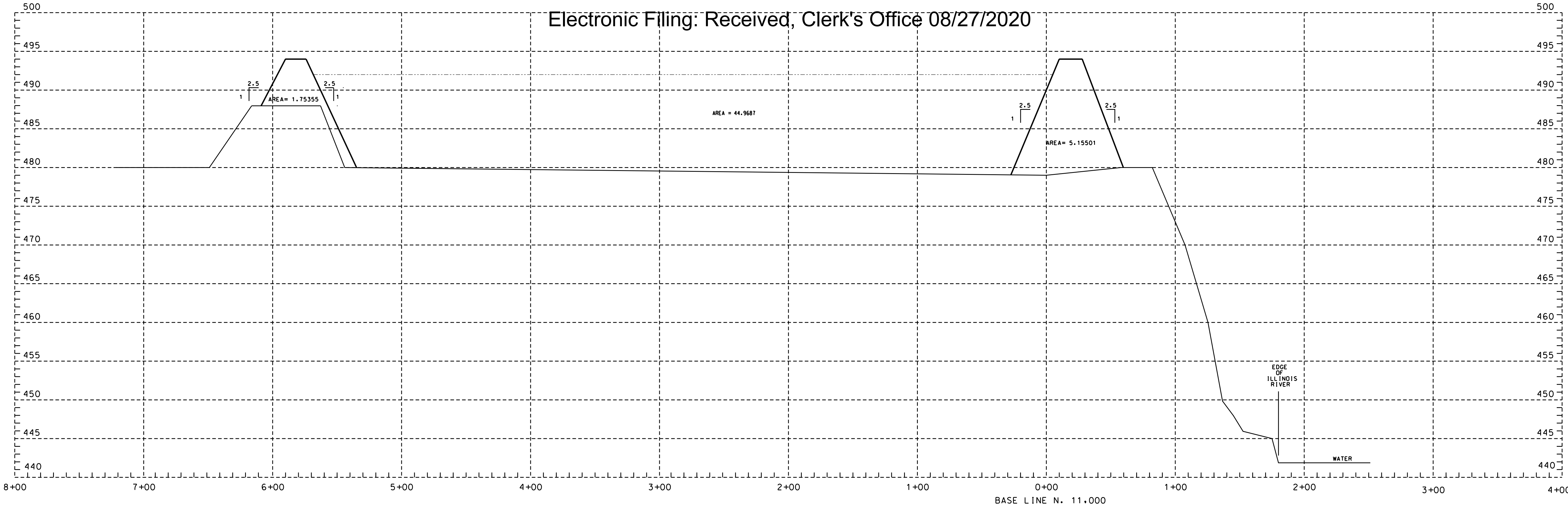
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

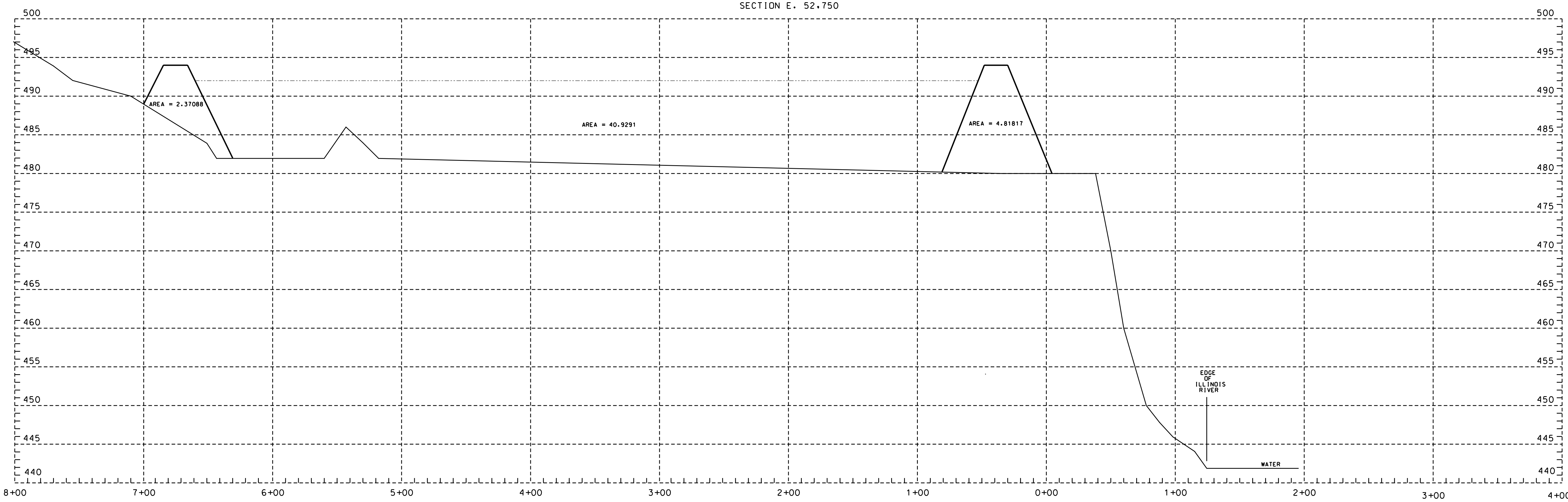
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-3
APP		



SECTION E. 52,750



SECTION E. 52,448

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

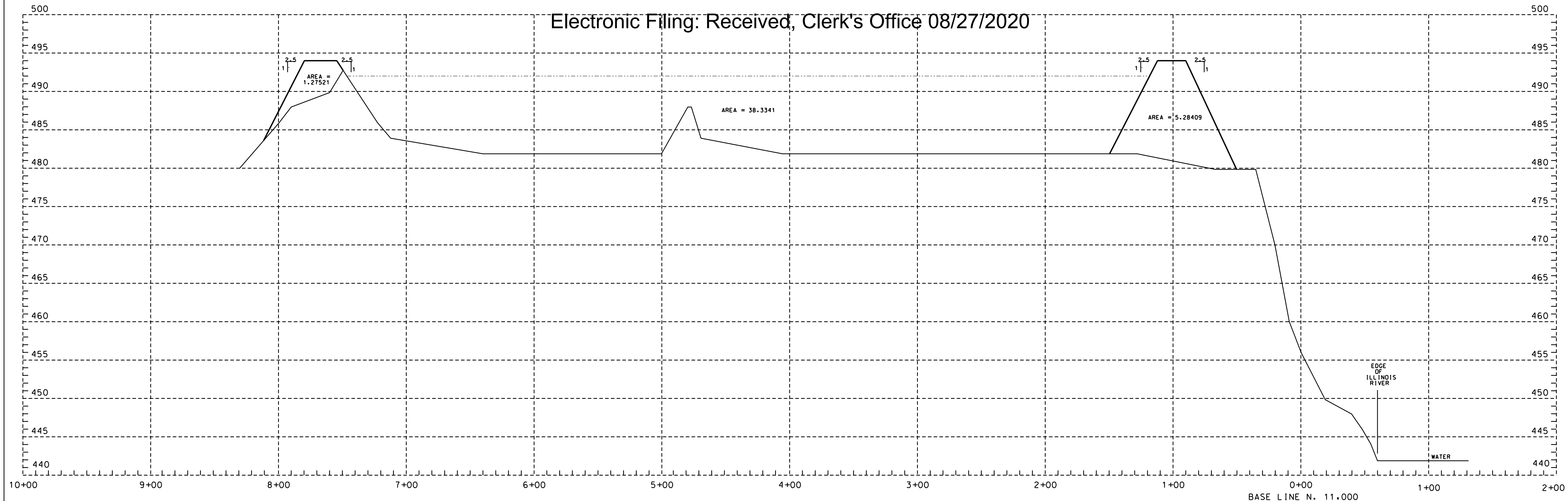
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-4
APP		



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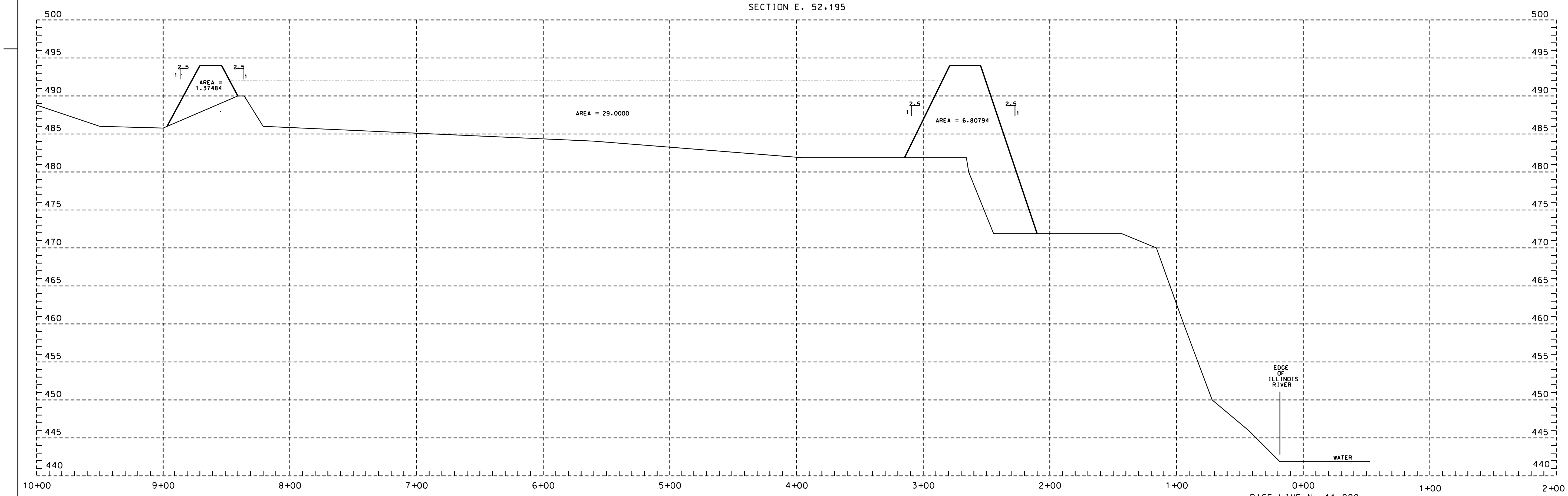


SECTION E. 51.920

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

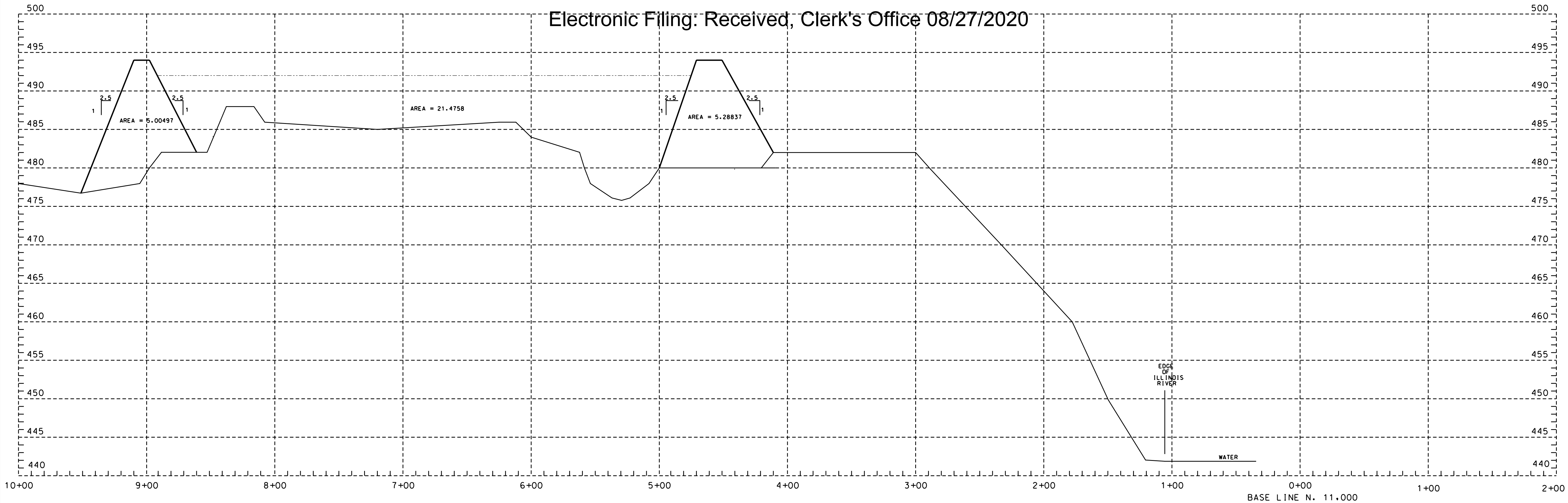
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

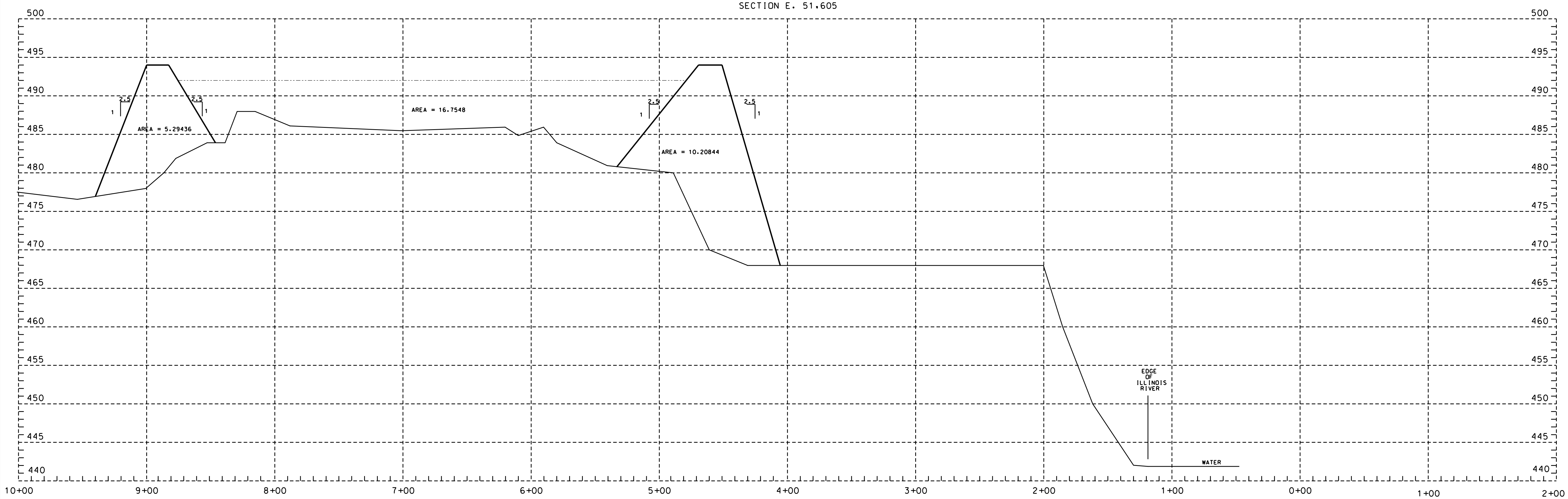
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-5
APP		



SECTION E. 51,605



SECTION E. 51,552

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

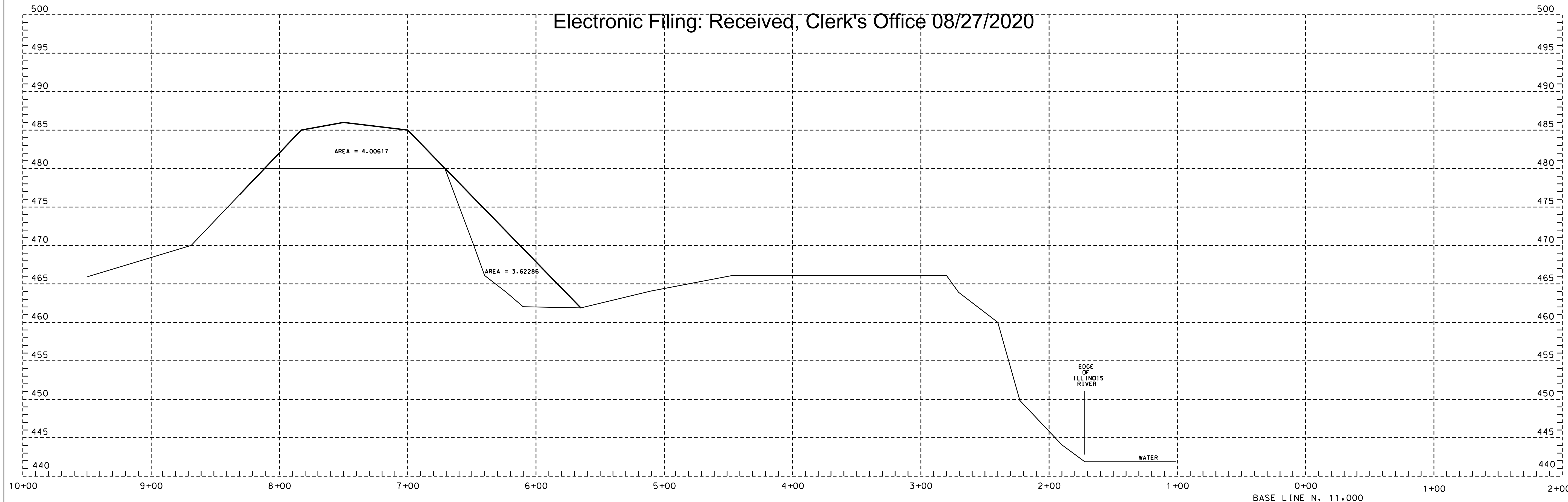
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-6
APP		



SECTION E. 51,285

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

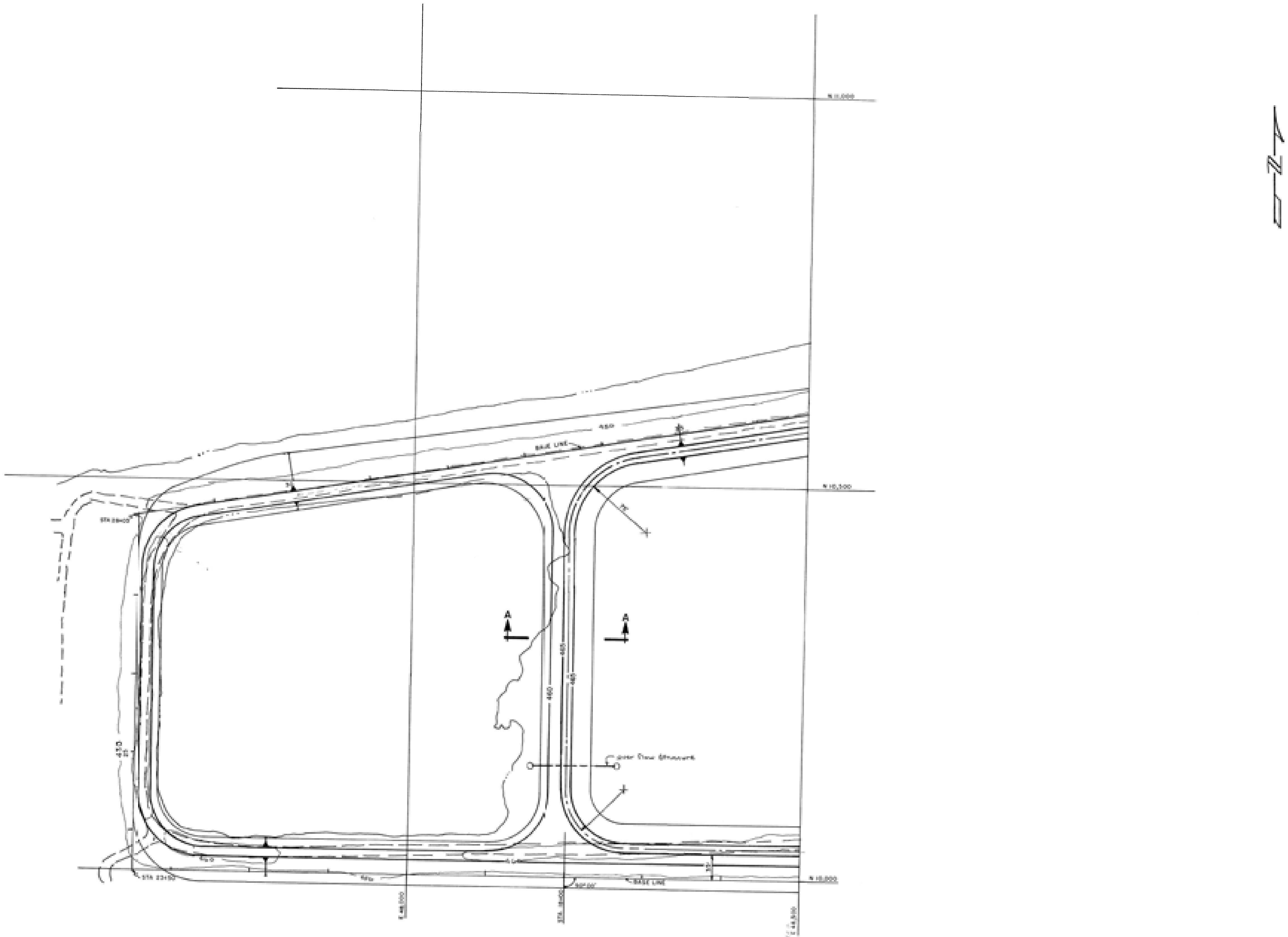
DR WJM	CAD WJM	DATE 1-12-89
OK	CKD	SCALE 1"=5' V. 1"=30' H.
APP	PLOTTED 03-08-90	CE-HEN1-B458-7
APP		

ILLINOIS POWER COMPANY

DECATUR

PLAN-UNIT#1 ASH POND EXTENSION
HENNEPIN POWER STATION
SHEET # 1

E-HEN1-B460-1



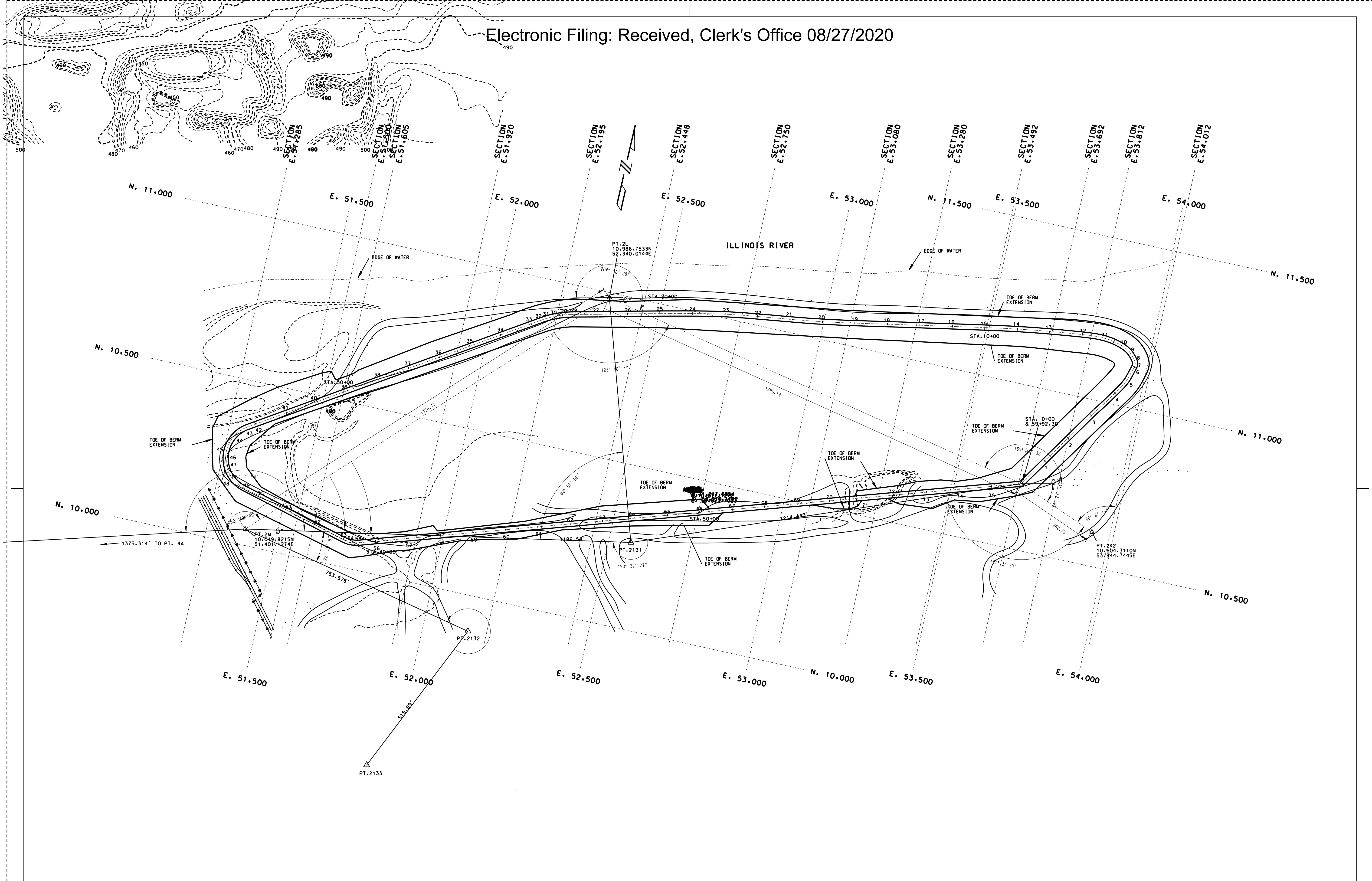
ILLINOIS POWER COMPANY

DECATUR

PLAN - UNIT#1 ASH POND EXTENSION
HENNEPIN POWER STATION
SHEET #2

E-HEN1-B460-2

PLATE NO. 1



NOTE: TOPO WAS DIDGITIZED FROM DWG. CE-HEN1-B-450 DATED 11-4-87

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

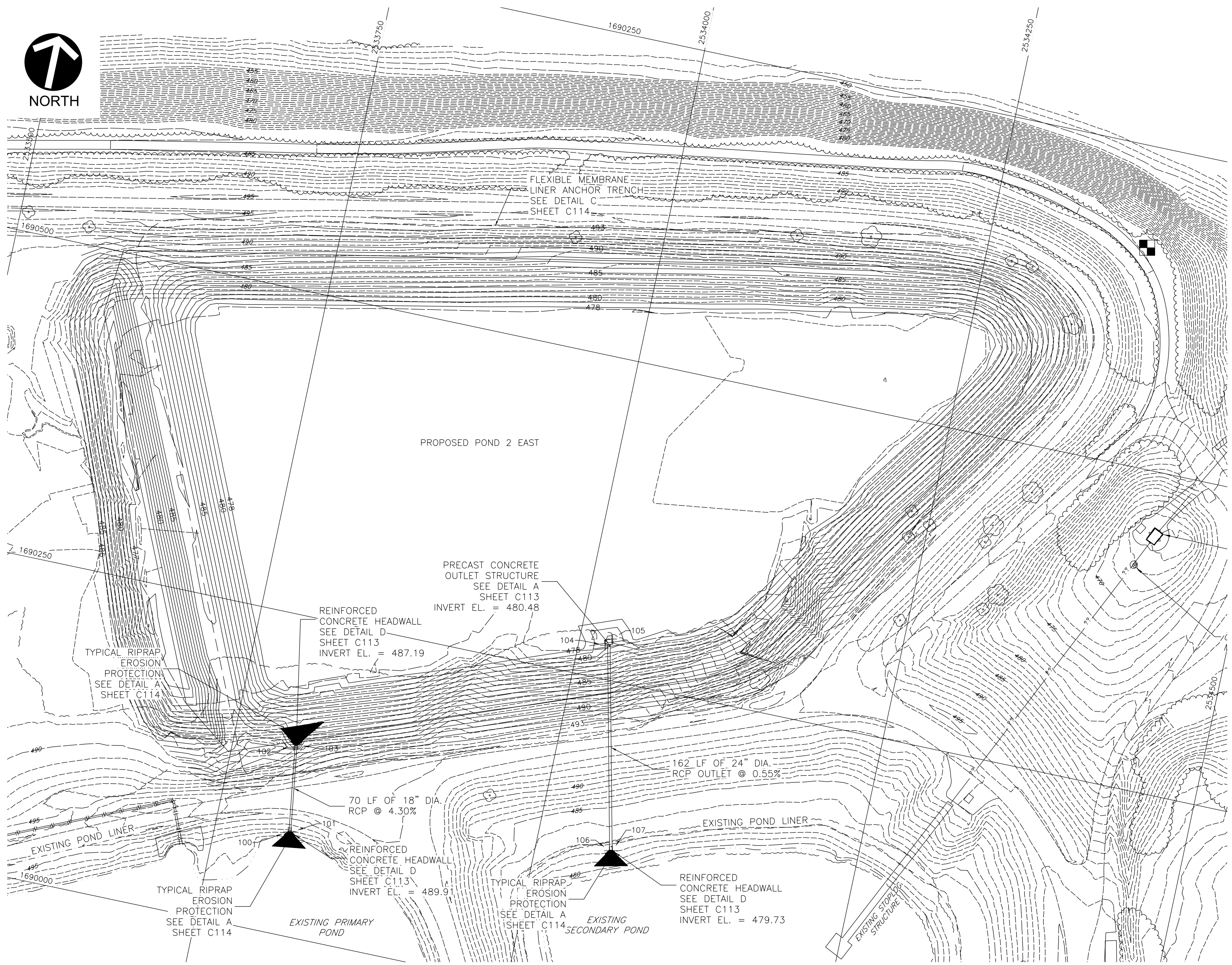
0

ILLINOIS POWER COMPANY
DECATUR

CONTOUR AND GRADING PLAN
UNIT #2 ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-11-89
OK	CKD	SCALE 1"=100"
APP	PLOTTED 03-08-90	CE-HEN1-B461
APP		

OVO.1.2.3.4.5



SCALE IN FEET

0 40 80

DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

REFERENCE

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON OCTOBER 26, 2008.

STRUCTURE TABLE		
Point #	Northing	Easting
100	1690080.864	2533807.450
101	1690081.207	2533809.928
102	1690149.246	2533797.977
103	1690149.589	2533800.456
104	1690276.331	2534020.790
105	1690282.205	2534024.973
106	1690118.909	2534057.560
107	1690119.451	2534060.003

NOTE

THE LOCATION OF THE ABOVE AND BELOW GRADE STRUCTURES SHOWN ON THESE DRAWINGS ARE APPROXIMATE. PRIOR TO PERFORMING EXCAVATIONS, THE CONTRACTOR SHALL FIELD LOCATE STRUCTURES THAT MAY BE WITHIN THE LIMITS OF WORK AND PROTECT THEM ACCORDINGLY.

LEGEND

495 PROPOSED INDEX CONTOURS
495 PROPOSED INTERMEDIATE CONTOURS
495 EXISTING INDEX CONTOURS
495 EXISTING INTERMEDIATE CONTOURS
?? EXISTING STORM WATER DRAINS
EXISTING ACCESS ROAD

Civil & Environmental Consultants, Inc.
5910 Haper Road, Suite 106 - Solon, OH 44139
Ph: 330.310.6800 · 866.507.2324
www.cecinc.com

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED
0	7/20/10	RECORD REVISION - 082-255	DFB	SFP

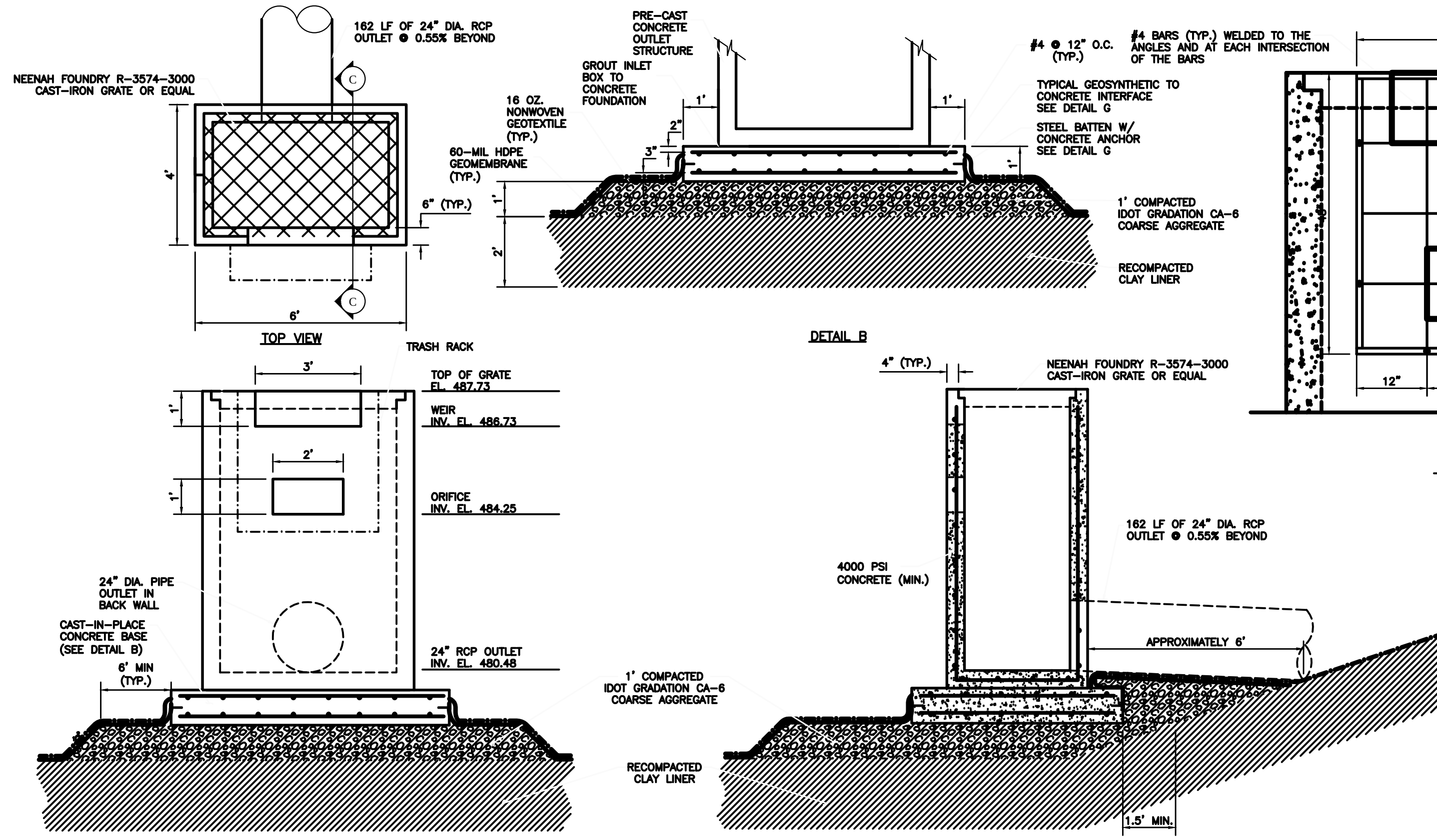
SCALE: AS_NOTED
DWN. DFB DATE 07/05/2010
CHK. RTM DATE 07/12/2010
APPV. SFP DATE 07/12/2010

DYNEGY

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
POND 2 EAST
FLEXIBLE MEMBRANE LINER AND STRUCTURES

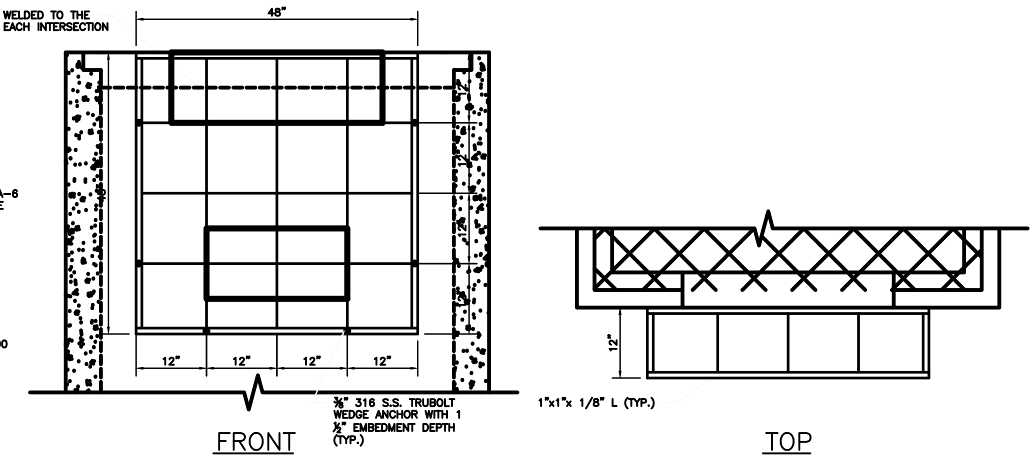
PROJECT NO.: 082-255
CLIENT: DYNEGY
DWG. NO.: HEN1-C109
REV. 0

HENNEPIN HEN1-C109 DFB 07/05/2010

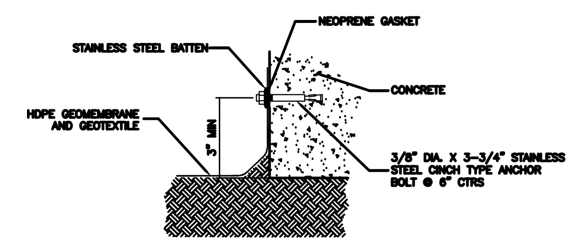


DETAIL A
PRECAST CONCRETE OUTLET STRUCTURE
N.T.S.

NOTES
1. REFER TO ILLINOIS DEPARTMENT OF TRANSPORTATION (IDOT) STANDARD FOR OUTLET REINFORCING.

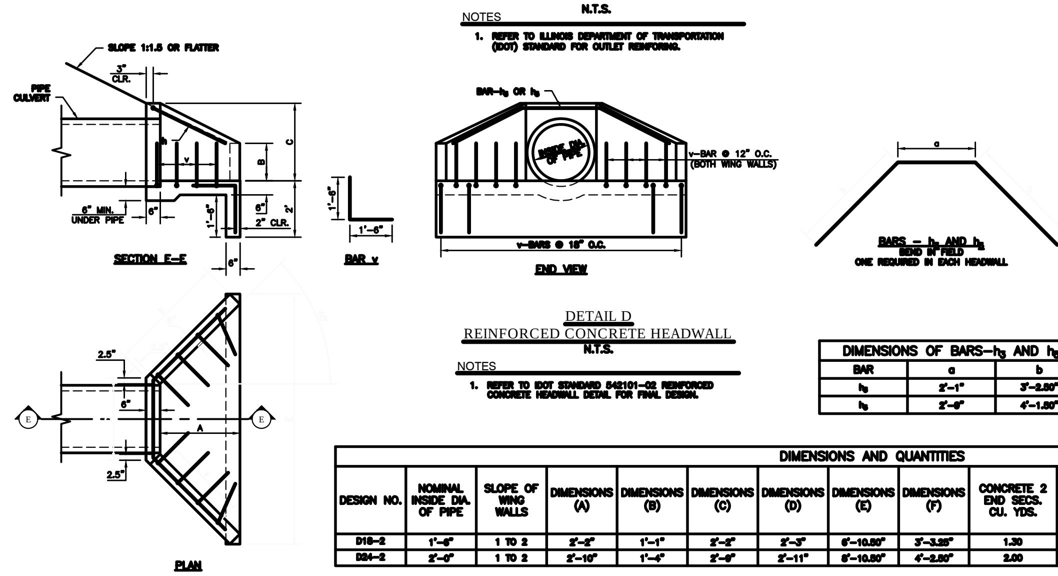


DETAIL F
TRASH RACK
N.T.S.



DETAIL G
TYPICAL GEOSYNTHETIC TO CONCRETE INTERFACE
N.T.S.

NOTES
1. EARTH ADJACENT TO CONCRETE TO BE WELL COMPACTED TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT.
2. ALL CONCRETE COLLARS TO BE CHAMFERED A MINIMUM OF 1" (TYP.) @ ALL CORNERS IN CONTACT WITH LINER



DETAIL D
REINFORCED CONCRETE HEADWALL
N.T.S.

NOTES
1. REFER TO IDOT STANDARD 542101-02 REINFORCED CONCRETE HEADWALL DETAIL FOR FINAL DESIGN.

DIMENSIONS OF BARS-h_3 AND h_5		
BAR	a	b
h_3	2'-1"	3'-2.50"
h_5	2'-9"	4'-1.50"

DIMENSIONS AND QUANTITIES

DESIGN NO.	NOMINAL INSIDE DIA. OF PIPE	SLOPE OF WING WALLS	DIMENSIONS (A)	DIMENSIONS (B)	DIMENSIONS (C)	DIMENSIONS (D)	DIMENSIONS (E)	DIMENSIONS (F)	CONCRETE 2 END SECS. CU. YDS.	NO.4 REBAR h-BARS (BAR)	NO.4 REBAR h-BARS (LENGTH)	NO.4 REBAR v-BARS NO.	NO.4 REBAR TOTAL WT. 2 END SECS. LBS.
D18-2	1'-6"	1 TO 2	2'-2"	1'-1"	2'-2"	2'-3"	6'-10.50"	3'-3.25"	1.30	h_3	8'-6"	22	60
D24-2	2'-0"	1 TO 2	2'-10"	1'-4"	2'-9"	2'-11"	8'-10.50"	4'-2.50"	2.00	h_5	11'-0"	28	70

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED
0	7/28/10	RECORD REVISION - 082-255	DFB	SFP

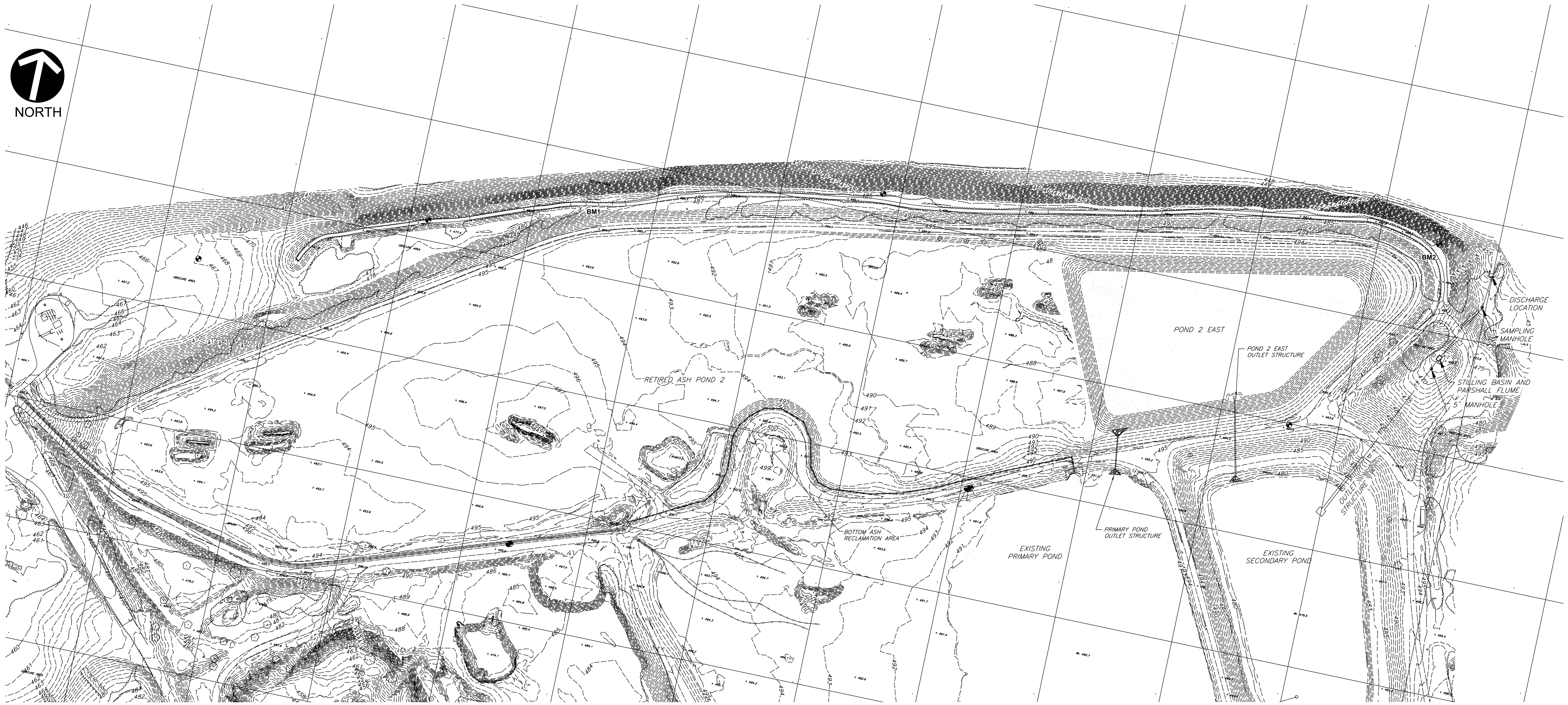
SCALE: AS_NOTED
DWN. DFB DATE 07/05/2010
CHK. RTM DATE 07/12/2010
APPV. SFP DATE 07/12/2010

Civil & Environmental Consultants, Inc.
5910 Haper Road, Suite 106 - Solon, OH 44139
Ph: 330.310.6800 · 866.507.2324
www.cecinc.com

DYNEGY

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
POND 2 EAST
DETAILS

PROJECT NO.: 082-255
CLIENT: DYNEGY
DWG. NO.: HEN1-C113
REV. 0



BENCHMARK LOCATIONS			
NUMBER	NORTHING	EASTING	ELEVATION
1	1690395.43	2532618.60	482.19
2	1690670.86	2534372.87	484.00
3*	1689478.87	2534643.99	506.80
4*	1688458.82	2533256.76	499.45
5*	1688781.84	2531352.15	468.27
6*	1689875.08	2531310.12	463.75

* BENCHMARKS BEYOND DRAWING BOUNDARY.

SCALE IN FEET

0 100 200

DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.

   DUE TO CONSTRUCTION ACTIVITIES, ACTUAL FIELD TOPOGRAPHY MAY VARY.

2. POND 2 EAST CONTOURS FROM CONSTRUCTION DRAWINGS SUBMITTED AUGUST 2009.

LEGEND

- MISCELLANEOUS FLOW PIPING
- EXISTING STORMWATER DRAINS
- EXISTING TREELINE
- EXISTING PIPING
- EXISTING ACCESS ROAD
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING BENCHMARK
- -500- EXISTING INDEX CONTOUR
- -499- EXISTING INTERMEDIATE CONTOUR
- EXISTING ROCK CHANNEL PROTECTION
- EXISTING MONITORING WELL

Civil & Environmental Consultants, Inc.
5910 Haper Road, Suite 106 - Solon, OH 44139
Ph: 330.310.6800 · 866.507.2324
www.cecinc.com

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED
0	11/28/10	RECORD REVISION - 082-255	DFB	SFP

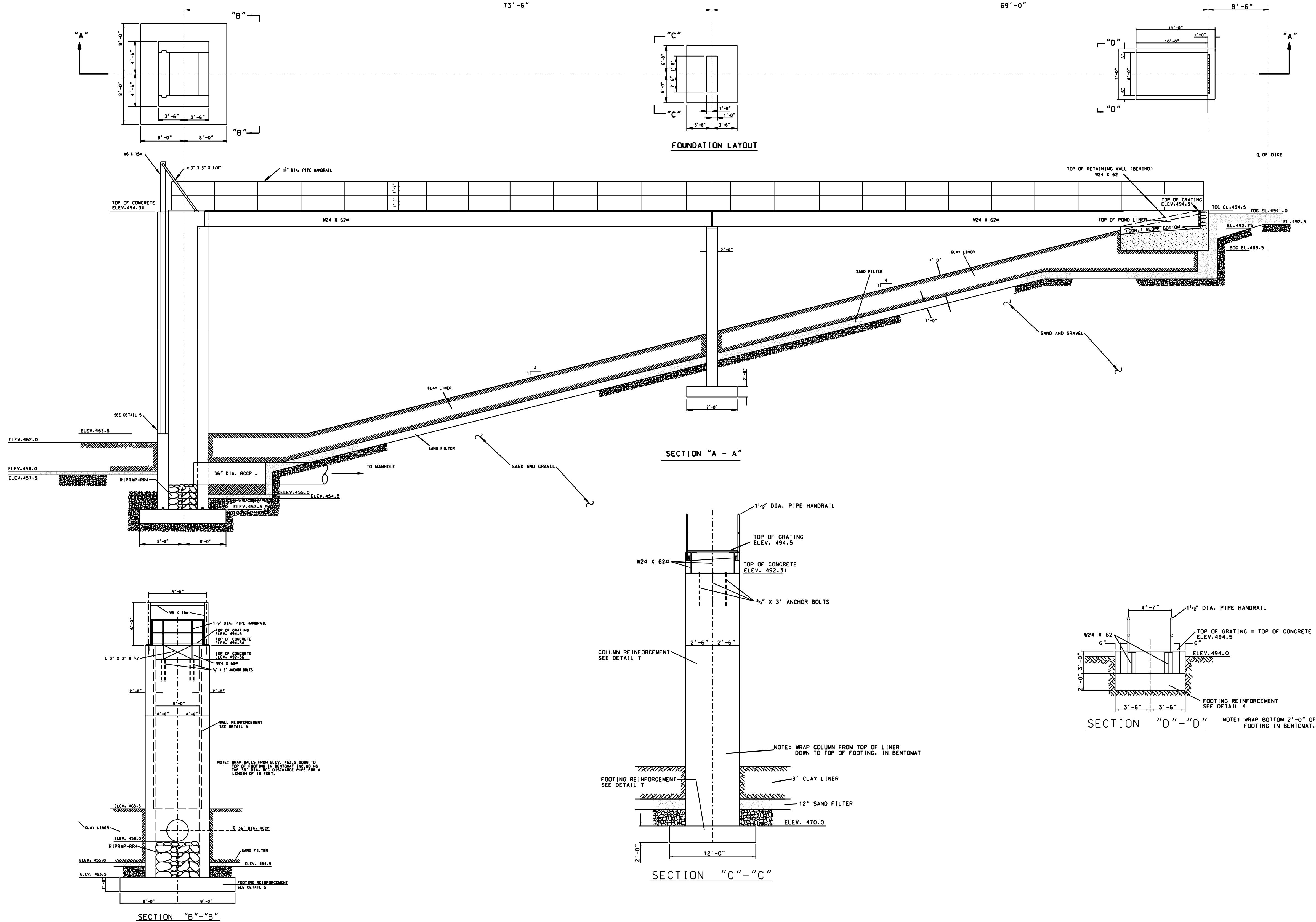
SCALE: AS_NOTED	
DWN. DFB	DATE 11/05/2010
CHK. RTM	DATE 11/12/2010
APPV. SFP	DATE 11/12/2010
EAPP_BY	EABD
FEAPP_BY	FEABD

DYNEGY

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
LANDFILL PHASE 1 CONSTRUCTION
EXISTING CONDITIONS

PROJECT NO.: 082-255
CLIENT: DYNEGY
DWG. NO.: HEN1-C117
REV. 0

HENNEPIN HEN1-C117 DFB 07/05/2010



NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

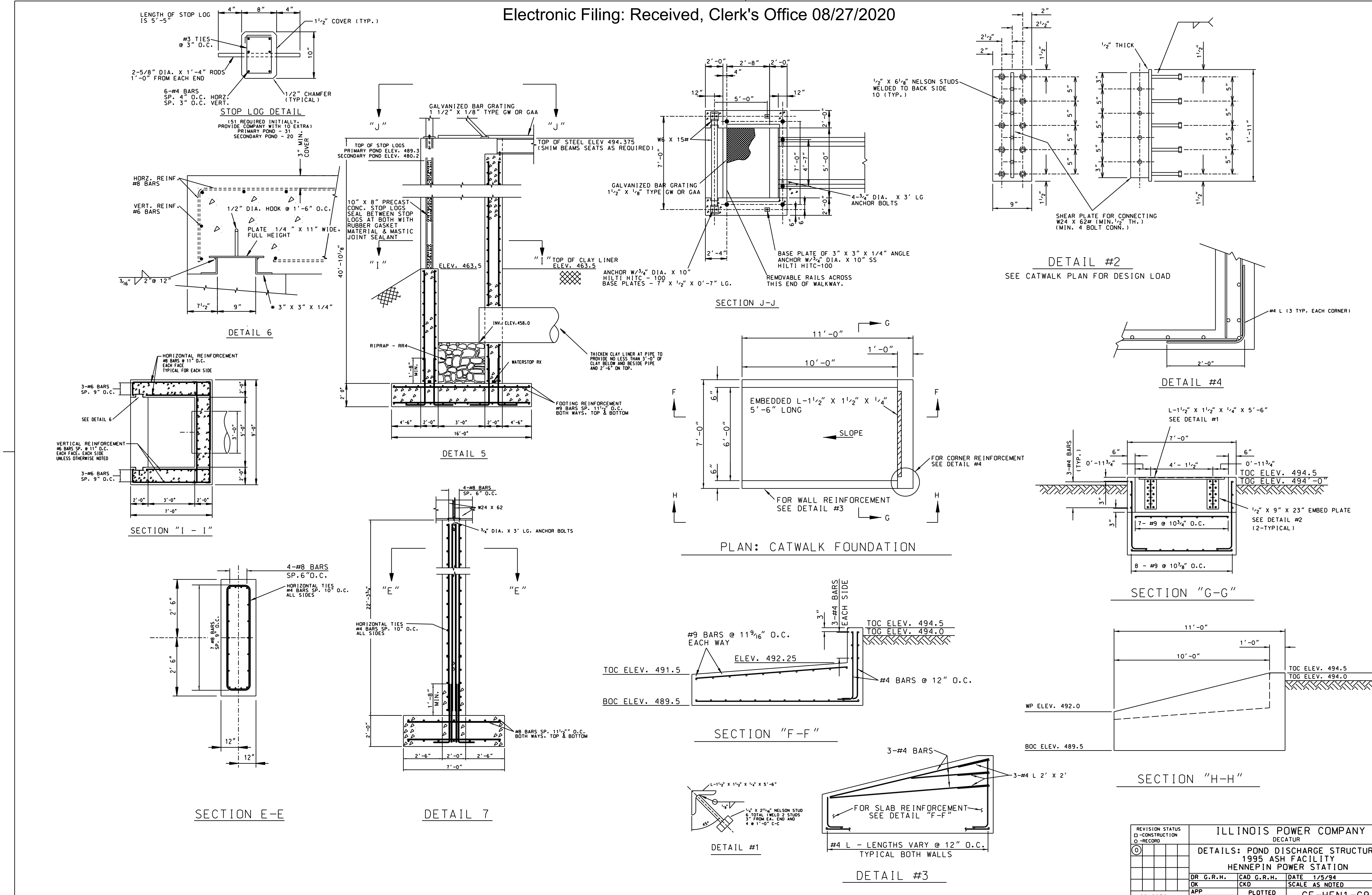
REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

ILLINOIS POWER COMPANY
DECATUR

LAYOUT-POND DISCHARGE STRUCTURES
1995 ASH FACILITY
HENNEPIN POWER STATION

DR G.R.H.	CAD G.R.H.	DATE 1/5/94
CK	CKD	SCALE NO SCALE
APP	PLOTTED 9/17/96	CE-HEN1-C8

p0019275.dgn

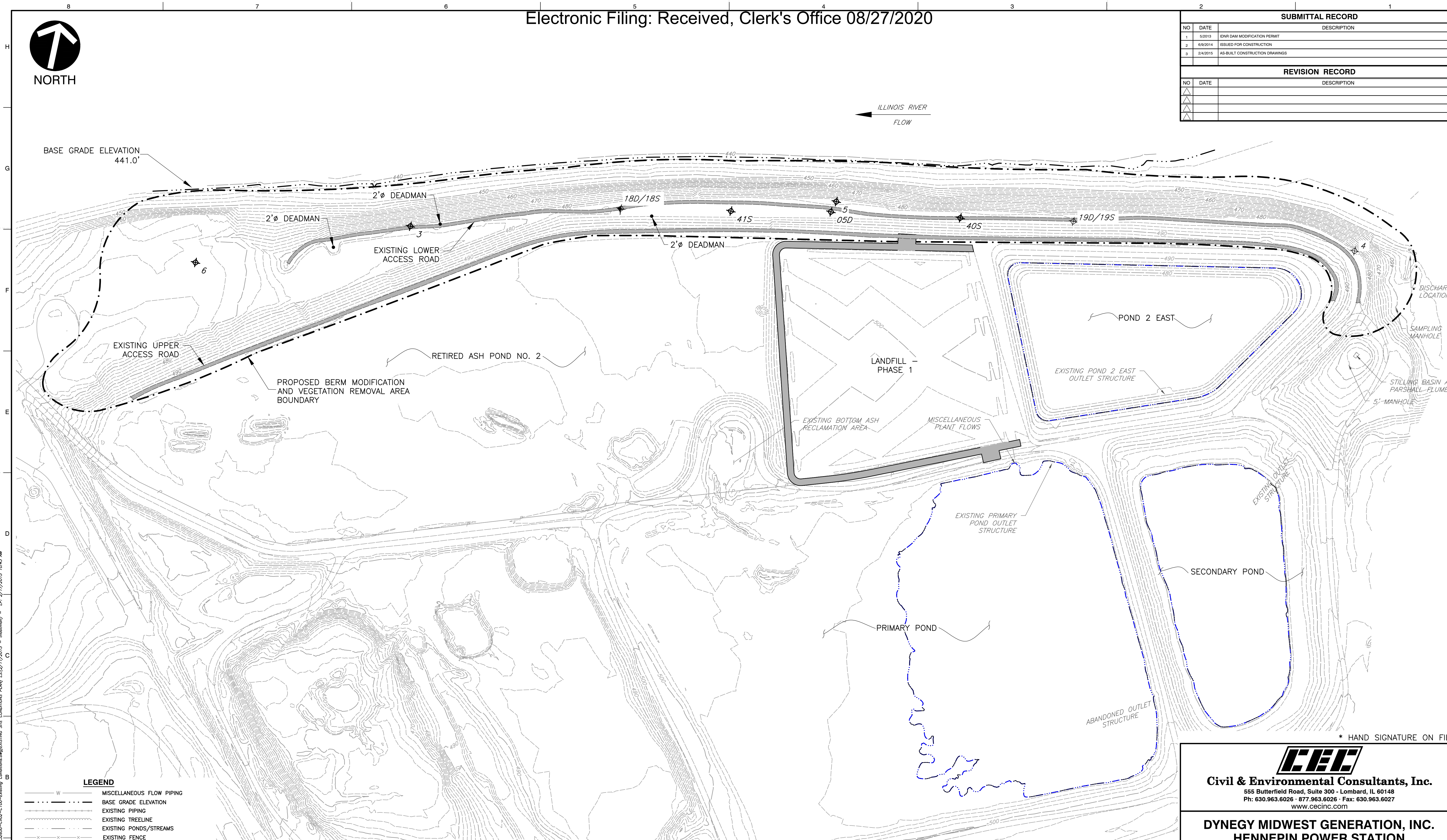

STOP LOG DETAIL
(51 REQUIRED INITIALLY, PROVIDE COMPANY WITH 10 EXTRA) PRIMARY POND - 31 SECONDARY POND - 20
LENGTH OF STOP LOG IS 5'-5"
#3 TIES @ 3" O.C.
2-5/8" DIA. X 1'-4" RODS 1'-0" FROM EACH END
6-#4 BARS SP. 4" O.C. HORZ. SP. 3" O.C. VERT.
1/2" CHAMFER (TYPICAL)
DETAIL 6
HORZ. REINF. #8 BARS
VERT. REINF. #6 BARS
1/2" DIA. HOOK @ 1'-6" O.C.
PLATE 1/4" X 11" WIDE, FULL HEIGHT
3" X 3" X 1/4"
SECTION "I - I"
HORIZONTAL REINFORCEMENT #8 BARS @ 11" O.C. EACH FACE TYPICAL FOR EACH SIDE
3-#6 BARS SP. 9" O.C.
SEE DETAIL 6
VERTICAL REINFORCEMENT #6 BARS SP. @ 11" O.C. EACH FACE, EACH SIDE UNLESS OTHERWISE NOTED
DETAIL 5
GALVANIZED BAR GRATING 1 1/2" X 1/8" TYPE GW OR GAA
TOP OF STEEL ELEV 494.375 (SHIM BEAMS SEATS AS REQUIRED)
TOP OF STOP LOGS PRIMARY POND ELEV. 489.3 SECONDARY POND ELEV. 480.2
10" X 8" PRECAST CONC. STOP LOGS SEAL BETWEEN STOP LOGS AT BOTH WITH RUBBER GASKET MATERIAL & MASTIC JOINT SEALANT
ELEV. 463.5
TOP OF CLAY LINER ELEV. 463.5
INV. ELEV. 458.0
THICKEN CLAY LINER AT PIPE TO PROVIDE NO LESS THAN 3'-0" OF CLAY BELOW AND BESIDE PIPE AND 2'-6" ON TOP.
RIPRAP - RR4
WATERSTOP RX
FOOTING REINFORCEMENT #9 BARS SP. 11 1/2" O.C. BOTH WAYS, TOP & BOTTOM
SECTION J-J
W6 X 15#
GALVANIZED BAR GRATING 1 1/2" X 1/8" TYPE GW OR GAA
4-3/4" DIA. X 3' LG ANCHOR BOLTS
BASE PLATE OF 3" X 3" X 1/4" ANGLE ANCHOR W/3/4" DIA. X 10" SS HILTI HITC-100
ANCHOR W/3/4" DIA. X 10" HILTI HITC - 100 BASE PLATES - 7" X 1/2" X 0'-7" LG.
REMOVABLE RAILS ACROSS THIS END OF WALKWAY.
DETAIL #2
SEE CATWALK PLAN FOR DESIGN LOAD
1/2" X 6 1/8" NELSON STUDS WELDED TO BACK SIDE 10 (TYP.)
1/2" THICK
SHEAR PLATE FOR CONNECTING W24 X 62# (MIN. 1/2" TH.) (MIN. 4 BOLT CONN.)
DETAIL #4
#4 L (3 TYP. EACH CORNER)
PLAN: CATWALK FOUNDATION
EMBEDDED L-1 1/2" X 1 1/2" X 1/4" 5'-6" LONG
SLOPE
FOR CORNER REINFORCEMENT SEE DETAIL #4
FOR WALL REINFORCEMENT SEE DETAIL #3
SECTION "G-G"
L-1 1/2" X 1 1/2" X 1/4" X 5'-6" SEE DETAIL #1
3-#4 BARS (TYP.)
TOC ELEV. 494.5
TOG ELEV. 494'-0"
1/2" X 9" X 23" EMBED PLATE SEE DETAIL #2 (2-TYPICAL)
7- #9 @ 10 3/4" O.C.
8 - #9 @ 10 7/8" O.C.
SECTION E-E
4-#8 BARS SP.6" O.C.
HORIZONTAL TIES #4 BARS SP. 10" O.C. ALL SIDES
7 #8 BARS SP. 9" O.C.
DETAIL 7
4-#8 BARS SP. 6" O.C.
W24 X 62
3/4" DIA. X 3' LG. ANCHOR BOLTS
HORIZONTAL TIES #4 BARS SP. 10" O.C. ALL SIDES
#8 BARS SP. 11 1/2" O.C. BOTH WAYS, TOP & BOTTOM
SECTION "F-F"
#9 BARS @ 11 9/16" O.C. EACH WAY
3-#4 BARS EACH SIDE
TOC ELEV. 494.5
TOG ELEV. 494.0
ELEV. 492.25
TOC ELEV. 491.5
BOC ELEV. 489.5
#4 BARS @ 12" O.C.
SECTION "H-H"
TOC ELEV. 494.5
TOG ELEV. 494.0
WP ELEV. 492.0
BOC ELEV. 489.5
DETAIL #1
L-1 1/2" X 1 1/2" X 1/4" X 5'-6"
1/4" X 2 11/16" NELSON STUD 6 TOTAL (WELD 2 STUDS 3" FROM EA. END AND 4 @ 1'-0" C-C
DETAIL #3
3-#4 BARS
3-#4 L 2' X 2'
FOR SLAB REINFORCEMENT SEE DETAIL "F-F"
#4 L - LENGTHS VARY @ 12" O.C. TYPICAL BOTH WALLS
REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
ILLINOIS POWER COMPANY
DECATUR
DETAILS: POND DISCHARGE STRUCTURE
1995 ASH FACILITY
HENNEPIN POWER STATION
DR G.R.H.
CAD G.R.H.
DATE 1/5/94
CK
CKD
SCALE AS NOTED
APP
APP
PLOTTED 9/17/96
CE-HEN1-C9
p0019276.dgn

SUBMITTAL RECORD

NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD

NO	DATE	DESCRIPTION
△		
△		
△		
△		



* HAND SIGNATURE ON FILE

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www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

LEGEND

- MISCELLANEOUS FLOW PIPING
- BASE GRADE ELEVATION
- EXISTING PIPING
- EXISTING TREELINE
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING ACCESS ROAD
- EXISTING STORM WATER PIPING
- EXISTING UNDERGROUND PLANT FLOW PIPING
- EXISTING PLANT FLOW PIPING
- 495 EXISTING INDEX CONTOURS
- EXISTING INTERMEDIATE CONTOURS
- 18D EXISTING MONITORING WELL LOCATIONS
- EXISTING ACCESS ROAD
- PROPOSED EAST BERM MODIFICATIONS AREA BOUNDARY

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

AS-BUILT CONSTRUCTION PLANS

SCALE IN FEET
0 100 200

DRAWN BY: DFB	CHECKED BY: MDJ	APPROVED BY: *MDJ
DATE: FEBRUARY 2015	DWG SCALE: AS NOTED	PROJECT NO: 132-650

EXISTING SITE CONDITIONS PLAN

DRAWING NO.: **3**

SHEET 3 OF 9