ATTACHMENT XIV.C5

SURFACE IMPOUNDMENTS

Surface Impoundments

The Tertiary Pond System is the only RCRA/Part 111 of Act 451 regulated Surface Impoundment included with this application.

Operations

This unit has been in operation since 1974. The unit is designed to receive influent wastewater from the secondary clarifiers of the Michigan Operations Wastewater Treatment Plant. Due to the mixture and derived-from rules currently in place in the regulations, the wastewater will carry all of the listed codes from the waste streams managed in the Incineration Complex and the main Wastewater Treatment Plant. Due to the large number of waste streams managed by these units, the Tertiary Pond System may have received, during its operating life, most of the acceptable waste codes for this unit with the exception of the F020-series of waste codes. Attachment XIV.A2 contains a list of acceptable waste types for this unit. The F020-series codes have not been treated in the Michigan Division due to the specialized equipment required to treat those wastes. Prior to accepting any F020-series waste into the Tertiary Pond System, a Dioxin Management Plan would be generated as required by 40 CFR 264.231. The Surface Impoundment Standards of Subpart CC are not applicable to the Tertiary Pond System as all hazardous waste placed in the unit meet the land disposal restrictions. (40 CFR 264.1082(c)(4))

The Pentagonal Pond is the first pond in the System and receives secondary treated water via force main from the pumping facility downstream of the secondary clarifiers at the wastewater treatment plant. Water flows from the Pentagonal Pond over a weir and through a submerged pipe to the Rectangular Pond. Both the Pentagonal Pond and Rectangular Pond are maintained at an approximate elevation of 614 feet USGS. Water exits the Rectangular Pond at the west end and flows over rock cascades into the Main Pond. The elevation of the Main Pond is typically ten feet below the elevation of the Rectangular Pond.

The Tertiary Pond System operates as a flow through pond with the normal operating level maintained between –30 - 85 percent full. With no outflow, the pond would fill at the rate of three to four percent per day. Because the pond level is continuously monitored, the chances of overfilling the pond for any reason are very remote.

When measured 100% full, the pond surface elevation is 614.2 feet USGS. At this level, a minimum of 2.5 feet of freeboard still remains to protect against wind and wave action.

In late 2000, Dow submitted a Treatability Variance Petition applicable to the T-Pond solids management program. The petition was subsequently approved. To satisfy the requirements of the Amended Final Order No. AFO-SW2000-01 (4/25/2000) and Waste Management Division Order No 111-31-02 (4/11/02), Dow remediated Tertiary Pond solids through removal, pressing/drying and landfilling in accordance with an approved Land Disposal Restriction Treatability variance. This work was fully completed by December 31, 2006 at which time the variance expired.

The T-Pond Solids Maintenance Plan dated September 22, 2006, as provided in this Attachment, was approved by the MDEQ with Amendment #5 of the Operating License. With the approval, this plan and any subsequent approved revisions became an enforceable part of the Operating License. The plan requires routine monitoring and maintenance cleaning of the Tertiary Pond System to address solids accumulation as specified in the plan. The routine maintenance of solids accumulation in the ponds will incorporate a method similar to the management of the solids removed from the WWTP clarification systems (dewatering, drying/pressing, incineration, ash disposal in the landfill). Treatment and disposal of the solids removed, as a result of long-term maintenance activities will meet either the Land Disposal Restrictions requirements or the requirements of an approved Land Disposal Restrictions variance as specified in 40 CFR 268 [R299.9311].

Influent Pump System and Piping

Secondary wastewater effluent discharges into the Pentagonal Pond from a 48-inch diameter force main, which runs from the secondary pumping station near the secondary clarifiers, across the Tittabawassee River on a support bridge and through the Main Pond to the Pentagonal Pond. Secondary effluent flow is measured using a flowmeter.

Discharge System

Level Indicator

A differential pressure level indicator is used to automatically measure pond level. The signal is received at the Environmental Operations control room in 34 Building where it is monitored and recorded. When the level indicator is inoperable, an operator determines the pond level visually from a staff gauge (located behind 1214 Building) at the unit. Under manual operation, this is performed and recorded on a daily basis.

De-aeration System

A floating de-aeration system to remove excess oxygen from the Main Pond effluent before it enters the enhanced solids removal process and sandfilter system may be deployed as required due south of the 1214 Building intake channel. This system consists of grids of diffusers supported from floating pontoons. Water is channeled over the diffusers as it flows into the intake. A floating system was chosen to avoid interaction with the pond bottom.

Overflow Weir

A small overflow weir designed to reduce sediment migration from the Pentagonal Pond is installed in front of the inlet of the pipeline between the Pentagonal Pond and the Rectangular Pond. The weir is made of reinforced ½-inch carbon steel plate coated with a sealant for corrosion protection.

Outflow Mechanism

Two 20-inch control valves are used in parallel to control the pond discharge flow. Both valves can be controlled by the flow controller in the Environmental Operations control room automatically or can be manually opened or closed in the field by the facility operator. The enhanced solids removal process and sandfilter system can be shutdown as a backup shut-off system if either of these valves fail, or the discharge needs to be shut off. (The enhanced solids removal process and sand filtration are the final polishing steps for treatment of the wastewater as required by the National Pollutant Discharge Elimination System (NPDES) Permit. Operation of the enhanced solids removal process and the sand filters is not covered in this reapplication.)

Discharge Flow Measurement

A 10-foot Cippoletti Weir and a differential pressure level indicator are used to automatically measure pond discharge flow. This flow rate signal is utilized by the discharge flow controller to adjust the position of the discharge valves. There are other flow meters used as backup for determining discharge flow. Manual measurement of flow over the weir is possible if both automatic systems are inoperable.

Prevention of Overtopping

The water level in this facility is continuously monitored as described previously. Overtopping of the Tertiary Pond System is prevented by manually shutting off the pond influent flow when an elevation of 614.2 feet is reached in the Main Pond or by obtaining special permission from the Michigan Department of Environmental Quality to discharge from NPDES outfall 001. This shutoff elevation allows for 2.5 feet of additional freeboard. Two feet remains to protect against wind and wave action plus an additional six inches to handle the run-on resulting from a 100 year, 24 hour storm.

100 Year, 24-Hour Storm

Drainage Basin = 220.7 acres (A)

Surface Area Main Pond = 174.2 acres (B)

Maximum 100-year, 24 hour rain = 4.5 inches (C)

Required Retention Height Main Pond = 5.7" or 6" (A x C / B)

Outflow Operating Procedure

Under normal operation, the discharge from the Tertiary Pond System is controlled by operations personnel from the Environmental Operations control room. A flow controller that monitors water quality parameters is used to set discharge flow out of the pond based on allowable NPDES discharge limits.

When the process controller is inoperable, the discharge flow rate is manually set by the facility operator based on the water quality parameters.

Design and Construction

The Tertiary Pond System was designed to provide thermal equalization and Total Dissolved Solids management of treated wastewater prior to discharging to the Tittabawassee River. It has a total capacity of approximately 800 million gallons. The unit is divided into three ponds as follows:

	Surface Area	Capacity
Pentagonal Pond	7.5 acres	33 million gallons
Rectangular Pond	13 acres	50 million gallons
Main Pond	182 acres	700 million gallons

Dike/Dam Structural Integrity

Perimeter and interior dikes are earthen in nature and were built in 1974 as part of this unit's construction. As required by 270.17(d), a structural integrity analysis was performed in 1987 on Main Pond dikes along Bullock Creek, the Tittabawassee River and the Pentagonal and Rectangular Ponds. The analysis was performed using the simplified Bishop Method.

A summary of the 1987 results of each dike analysis follows:

Bullock Creek Dike

An overall factor of safety of 1.5 was reported for this dike. A lower factor of 1.04 was determined for a localized area on the outside of the dike. This may result in localized sloughing, but would not significantly affect overall dike integrity. If localized sloughing were to occur, appropriate action would be taken to eliminate long term, negative impacts on the dike.

The dike stability study was performed prior to installation of the Tertiary Pond Revetment Groundwater Interception System (RGIS). This system has the effect of dewatering outside of the Bullock Creek dike, as well as partial dewatering of the dike along the southwest side of the pond. The dewatering will substantially increase dike stability by reducing the potential for internal erosion (i.e., piping).

Tittabawassee River Dike

Slope stability analyses on this dike revealed a factor of safety of 1.12. McDowell recommended that alternatives could be considered to improve the calculated safety factor for this dike section, such as additional soil placement along the exterior toe of the dike, sheet piling, pressure grouting or other similar techniques. Additional clay was placed along the toe of the dike in January 1996 to provide the additional safety factor desired during periods of high Tertiary Pond level. The computed factor of safety for the additional clay placed along the toe of the dike was 1.6. Detail regarding the dike stability reinforcement work is contained in Appendix A of Section VIII, Surface Impoundment, of the 1993 license application.

North Pentagonal and Rectangular Pond Dikes

A petition presenting information necessary to obtain a variance for the surface impoundment retrofitting requirements of 40 CFR 264.221 for the Tertiary Pond was prepared and submitted to the Environmental Protection Agency in March of 1987. Included in the information submitted were the results of a dike stability study, site hydrogeologic characteristics, and groundwater monitoring data all of which quantified the potential off-site impact on groundwater from the impoundment.

The information identified that the dike along the Pentagonal and Rectangular Ponds could be improved to greatly reduce leakage out of that section of the pond. Plans were made to construct a slurry wall along that portion of the dike.

Since the 1987 reapplication submission, the Tertiary Pond Dike Stability Project (Tertiary Pond Slurry Wall) has been completed.

Since the last reapplication submission, a portion of the Tertiary Pond System dikes have been classified as a “Dam” under Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. In 2011, as a result of completing Stage I Phase I of a two stage (with two phases per stage) stability evaluation of the Tertiary Pond System dikes/dam, an analysis was performed on the previously buttressed sections of the east dike/dam of the Main Pond. The results of that analysis can be found in Appendix C5-A. As a result of the analysis, a dike/dam stabilization project was completed in 2012 to increase the minimum factor of safety above that recommended by the United States Army Corps of Engineers. Dow is currently evaluating the course of action for the remaining portions (i.e., Stage I Phase II and Stage II Phases I & II) of the stability evaluation of the Tertiary Pond System dikes/dam. This stability evaluation of the Tertiary Pond System dikes/dam is above and beyond any regulatory requirements and was voluntarily initiated by Dow.

An additional project, Minor Hazardous Waste Management Facility Operating License Modification; Amendment 15, was completed in 2014 to fill a portion of the inboard embankment of the Main Pond dike/dam to increase the embankment width in order to accommodate new components for the Michigan Operations Waste Water Treatment Plant filtration process expansion. Certification of the Amendment 15 project work on the Main Pond dike/dam was submitted to the Department of

Environmental Quality, Office of Waste Management and Radiological Protection on October 17, 2014 and has been included as Appendix C5-B to this Attachment.

Removal from Service

The Dam Safety Act requires Dow to maintain an Emergency Action Plan (EAP) that addresses actions to be taken in the event the impoundment is removed from service because of actual or imminent dike/dam failure. The RCRA Contingency Plan for the Facility, as provided in Attachment XIV.A7, contains a current copy of the EAP. Refer to the EAP for specific procedures to be used for assessing or recertifying the structural integrity of any dike/dam removed from service.

In the event that external dike/dam failure occurred, triggering the requirements of 40 CFR 264.227(d)(1), the failed portion of the external dike/dam would be reconstructed. Reconstruction design would conform as nearly as possible to the previous dimensions and elevations of the dike/dam prior to failure.

Once reconstruction activities have been completed, soil borings of the reconstructed section would be obtained. These soil borings will include gathering adequate structural information on the reconstructed soils to allow for an evaluation by a qualified soils engineer. The soil borings and data will be analyzed to calculate a safety factor representative of the new section. This safety factor will be compared to the safety factors calculated for adjacent areas of the dike/dam. The safety factor for the new reconstructed section will be at least equal to or better than the safety factor calculated for existing dike/dam sections or the new dike/dam will be reconstructed until such can be demonstrated.

Determination Regarding Minimum Technology Requirements (Tertiary Pond Waiver)

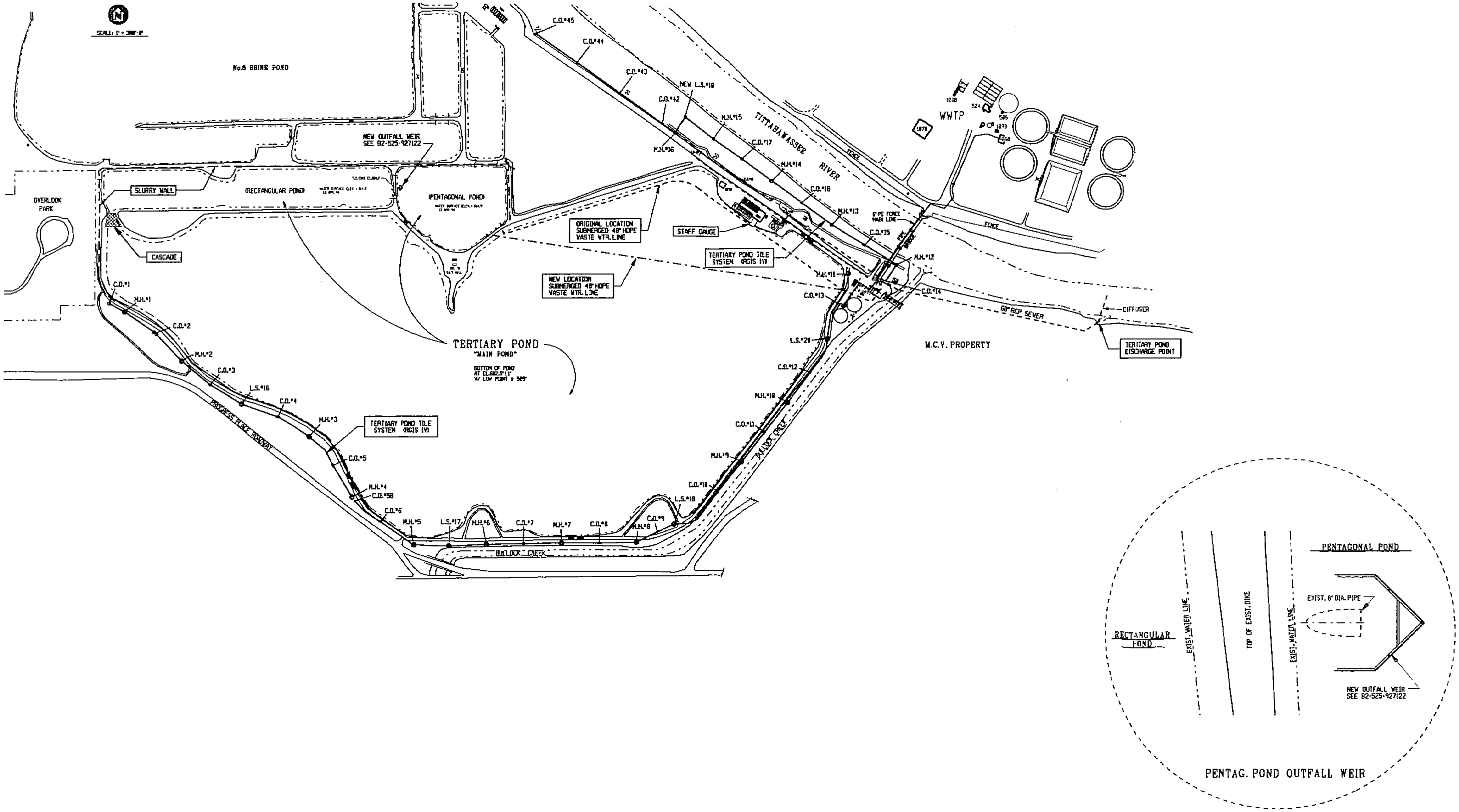
The Tertiary Pond System has received a waiver from the requirements pursuant to Section 3005(j)(3) and 40 CFR 264.221, as provided in Appendix C5-C.

Under the requirements of the waiver, Dow was required to institute corrective action if concentrations of specified constituents exceeded the Alternate Concentration Limits (ACLs) specified in the waiver. Exceedances of these ACLs occurred in 1989 which resulted in the establishment of a corrective action program for the Tertiary Pond System.

Tertiary Pond Corrective Action-Tertiary Pond Revetment Groundwater Intercept System

The Tertiary Pond Corrective Action Plan (CAP) was submitted and subsequently approved by the MDEQ. The CAP required the installation of a groundwater collection system (Tertiary Pond Revetment Groundwater Interception System, or RGIS) around the outside perimeter of the Tertiary Pond System dikes/dam along the Tittabawassee River, Bullock Creek, and the southwest side of the Main Pond. The purpose of the collection system is to capture all groundwater migrating away from the unit.

The construction of the RGIS collection tile was completed in December 1992. A copy of the RGIS as-built construction drawings are provided in Attachment XIV.B5, Environmental Monitoring Programs.



REV. MARK	REVISION	BY	CHK	APP	DATE	REV. MARK	REVISION	BY	CHK	APP	DATE
A	REVISED - ADDED NEW LOCATION OF SUBMERGED 48" HOPE WASTE WATER LINE	LEG	JJA	SL	9/9/03						
B	ADDED PENTAG POND OUTFALL WEIR	LEG		SL	10/28/06						

DRAWING ISSUE RECORD

ISSUE NO.	REV	MATERIAL OR JOB SPEC	BID	FAB	CONST	REF
				DATE ISSUED FOR		

DESIGNED	
DRAWN L.E. GIRARDIN	6/95
CHECKED J. BATAL	6/95
APPROVED J. BATAL	6/95
PROJ. ENGR.	
MFG. REP. T.S. KONECHNE	

STATUS
PLANT NO.
P.E. SEAL

THE DOW CHEMICAL COMPANY

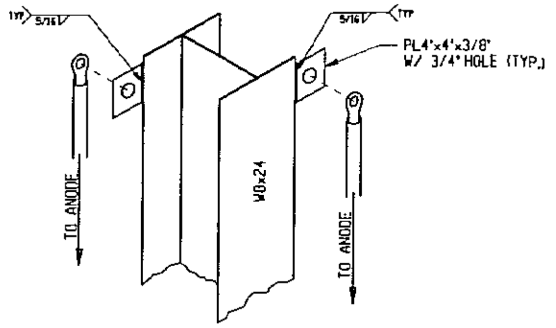
MICHIGAN DIVISION MIDLAND, MICHIGAN
T-POND PONDS

TERTIARY POND PLAN VIEW

PROJECT NUMBER	SCALE		REV.
927122	1" = 300'-0"	B2-509-927122	B

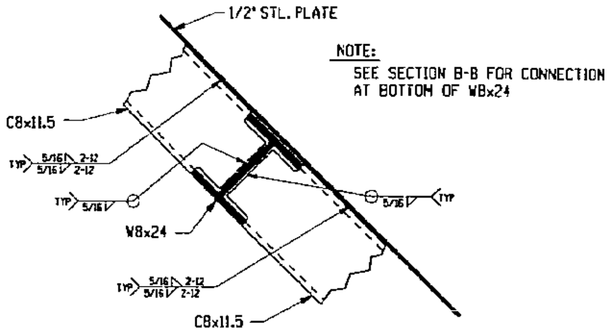
2

PRINTED
VER.



DETAIL FOR ANODE CONNECTION

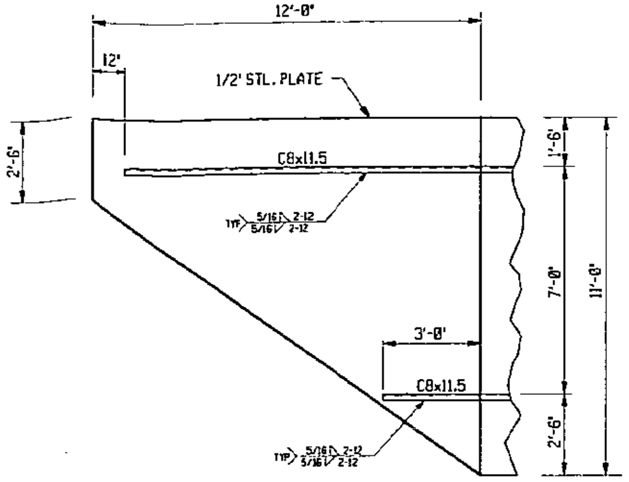
TYPICAL BOTH COLUMNS



DETAIL "A"

TYPICAL 2 PLACES

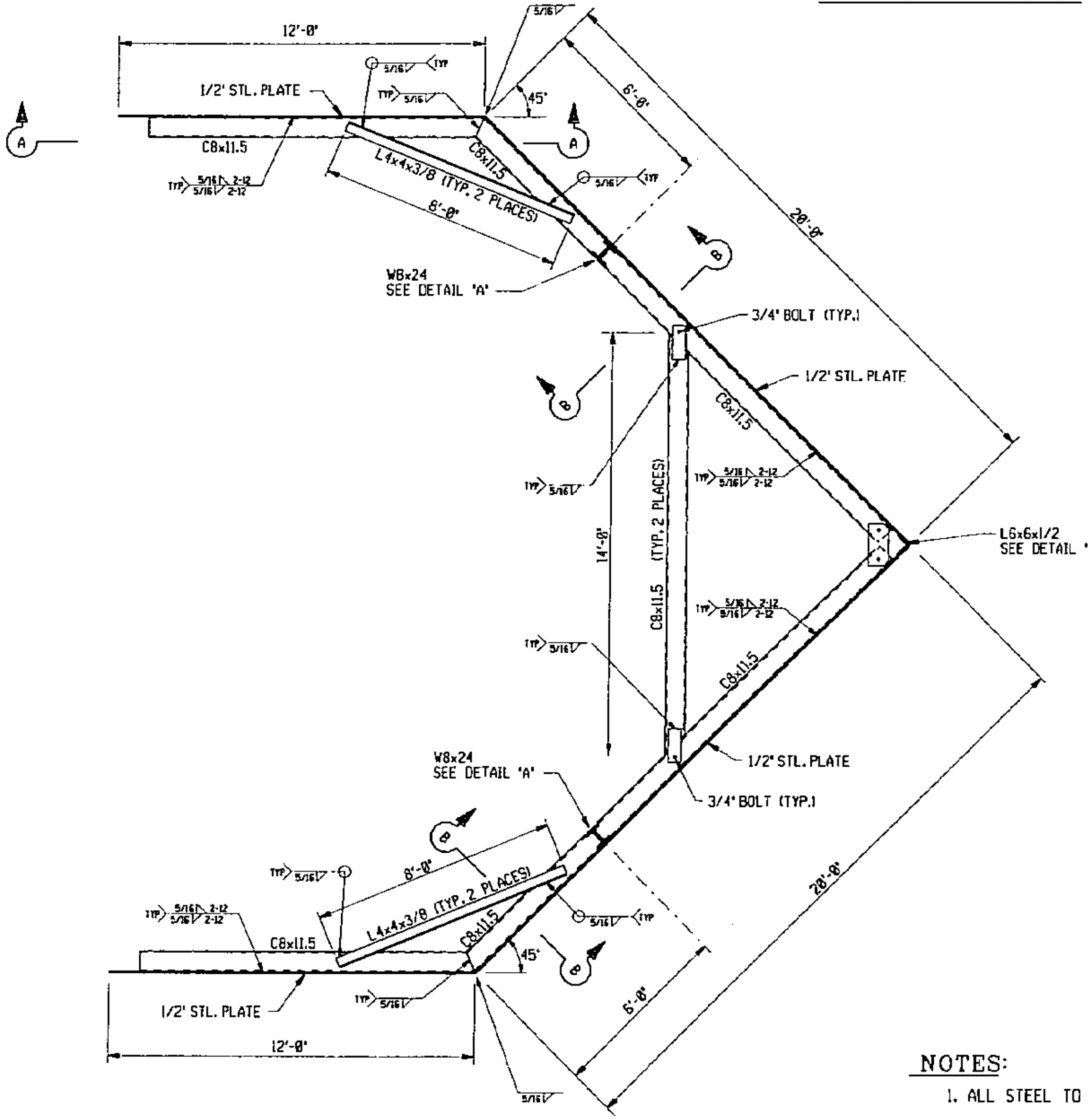
SCALE: 1 1/2" = 1'-0"



SECTION A-A

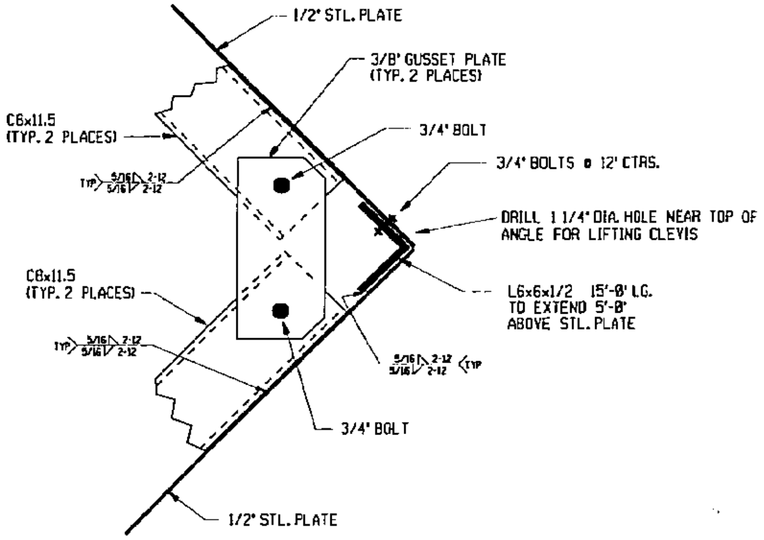
TYPICAL 2 PLACES

SCALE: 3/8" = 1'-0"



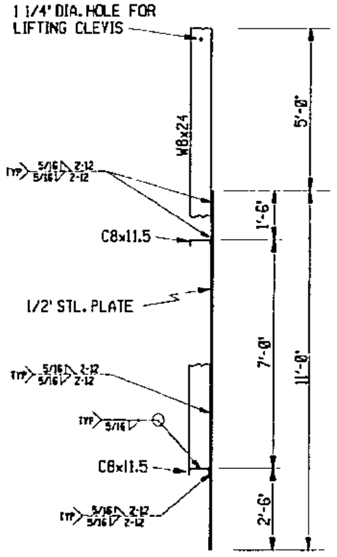
PLAN VIEW

SCALE: 3/8" = 1'-0"



DETAIL "B"

SCALE: 1 1/2" = 1'-0"



SECTION B-B

SCALE: 3/8" = 1'-0"

NOTES:

1. ALL STEEL TO BE COATED WITH DEVTAR 5A
2. BOLTS ETC TO BE COATED (TOUCH UP) PRIOR TO SETTING IN POND
3. ANODES:

REV. MARK	REVISION	BY	CHK	APP	DATE
A	CHANGED WEIR DEPTH FROM 10' TO 11'	LEG	TSK		10/26/06

DESIGNED	J.J. ALLEN	10/06
DRAWN	L.E. GIRARDIN	10/06
CHECKED	J.J.A.	10/06
APPROVED	J.J.A.	10/06
PROJ. ENGR.	J.J. ALLEN	10/06
MFG. REP.	T.S. KONECHNE	10/06

THE DOW CHEMICAL COMPANY

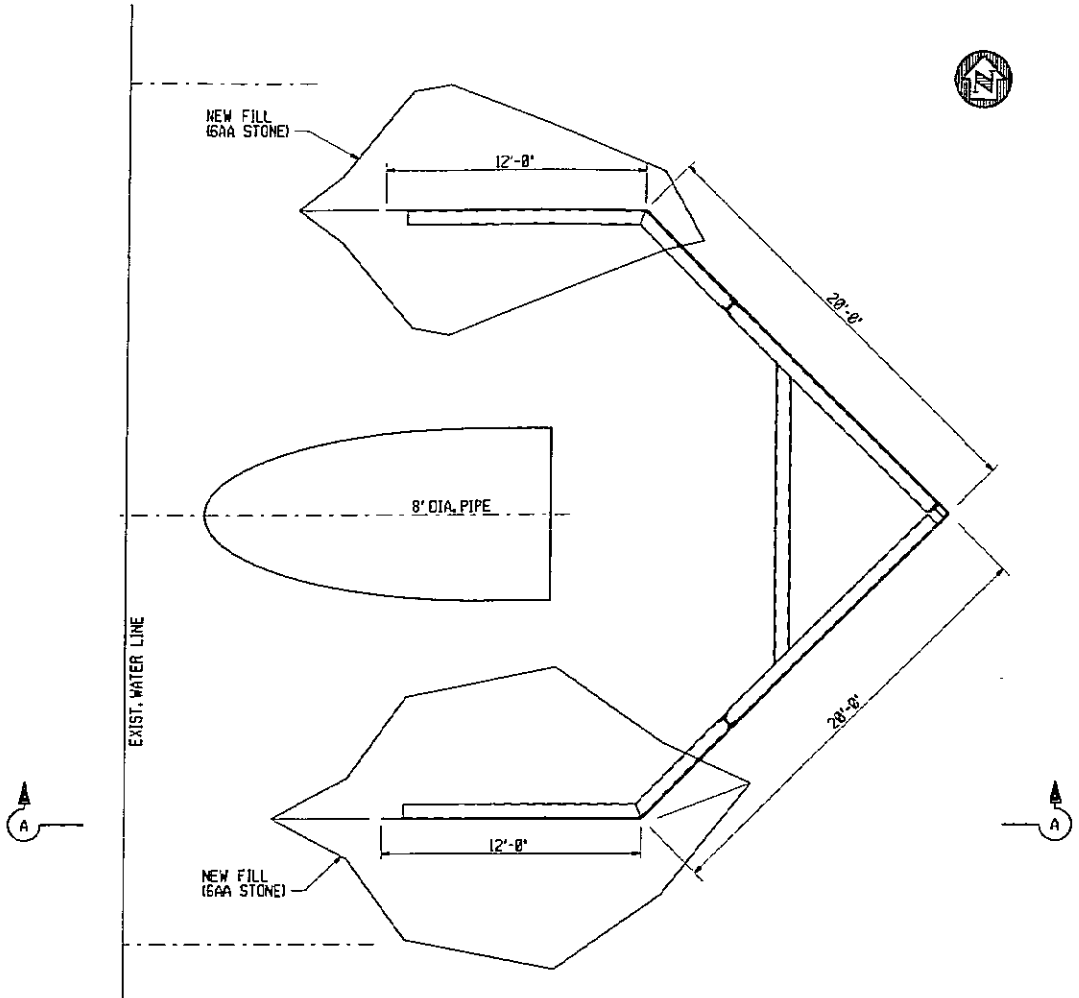
MICHIGAN DIVISION MIDLAND, MICHIGAN

EVO PONDS

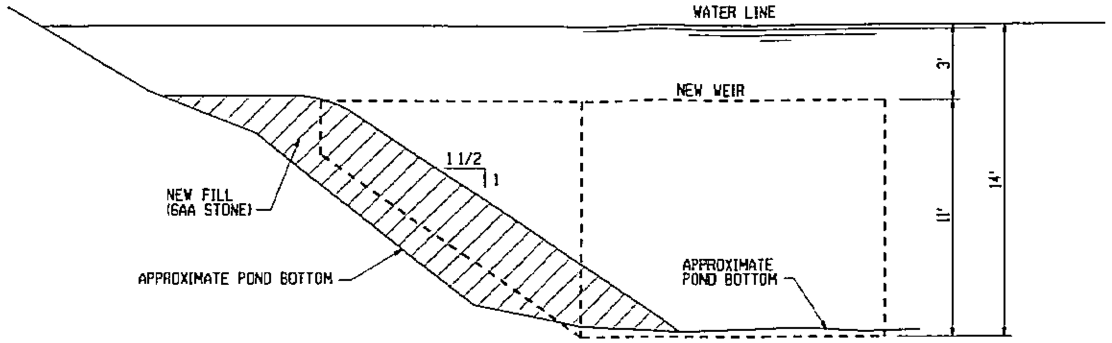
PENTAG POND OUTFALL WEIR
FRAMING PLAN & DETAILS

EJN NUMBER	SCALE		REV.
113411	3/8" = 1'-0"	B2-525-927122	A

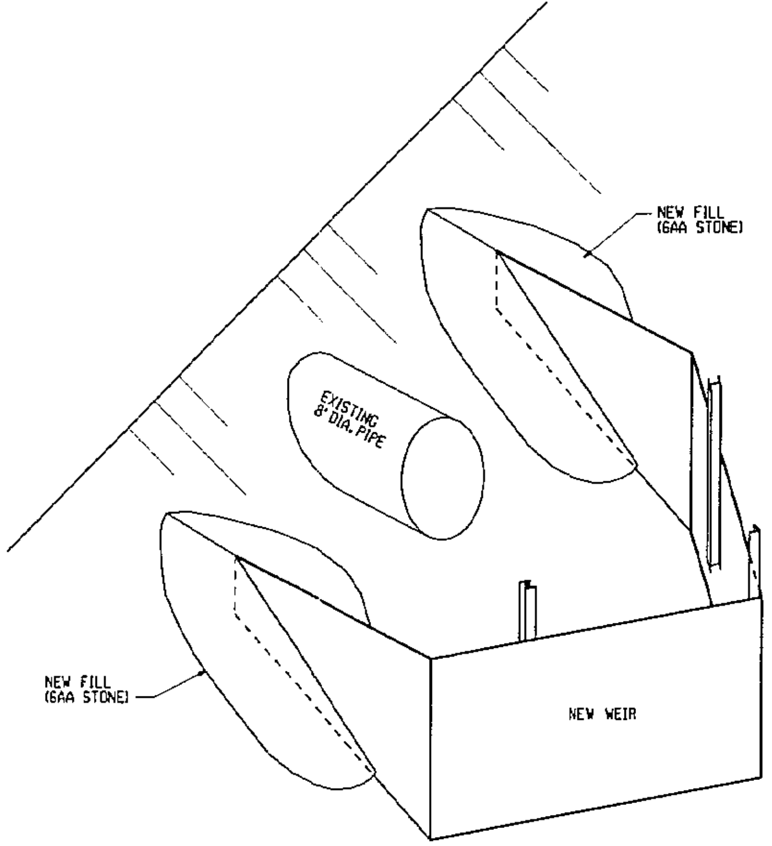
2 UND



PLAN VIEW



SECTION A-A



REV. MARK	REVISION	BY	CHK	APP	DATE	REV. MARK	REVISION	BY	CHK	APP	DATE
A	CHANGED WEIR DEPTH FROM 10' TO 11'	LEG	TK		10/25/06						

DRAWING ISSUE RECORD

ISSUE NO.	REV	MATERIAL OR JOB SPEC	BID	FAB	CONST	REF
			DATE ISSUED FOR			

DESIGNED	J.J. ALLEN	10/06
DRAWN	L.E. GIRARDIN	10/06
CHECKED	J.J.A.	10/06
APPROVED	J.J.A.	10/06
PROJ. ENGR.	J.J. ALLEN	10/06
MFG. REP.	T.S. KONECHNE	10/06

STATUS
PLANT NO.
P.E. SEAL

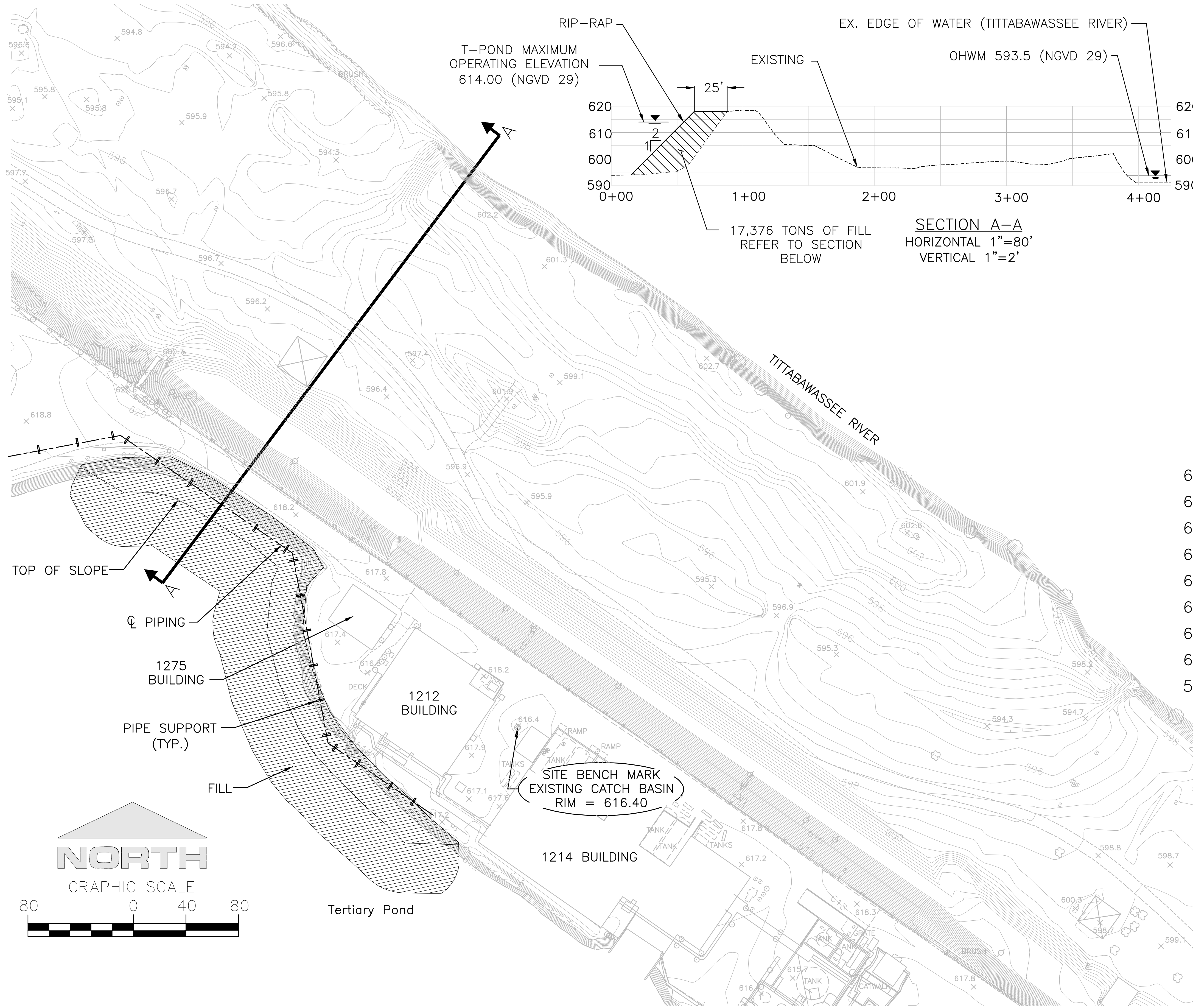
THE DOW CHEMICAL COMPANY
MICHIGAN OPERATIONS MIDLAND, MICHIGAN
EVO PONDS

PENTAG POND OUTFALL WEIR PLACEMENT
PLACEMENT PLAN

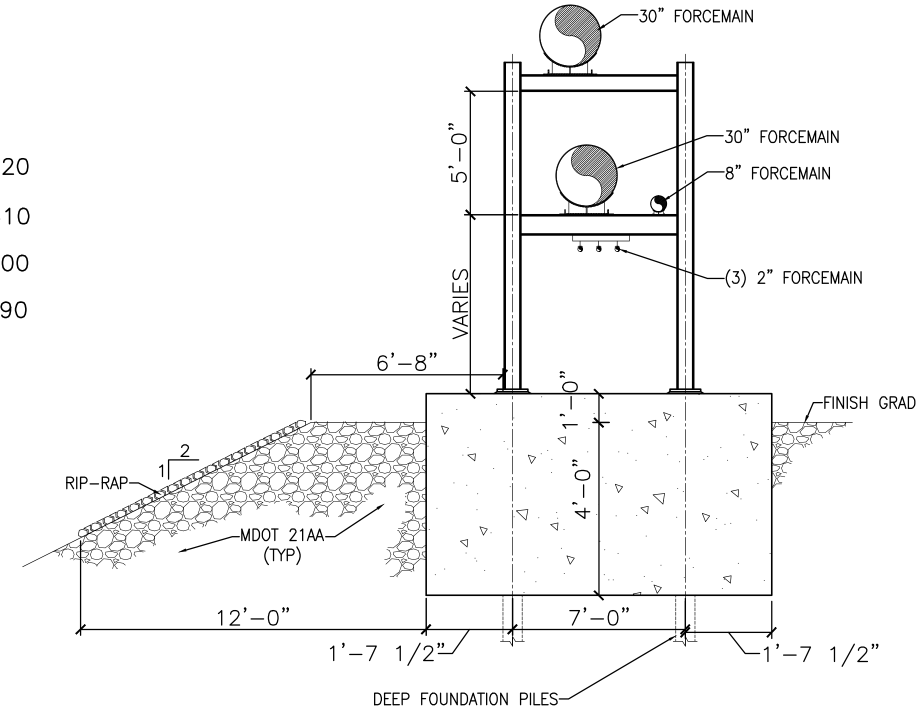
C/N NUMBER	SCALE		REV.
11341:	1/4" = 1'-0"	B2-526-927122	A

2 UND

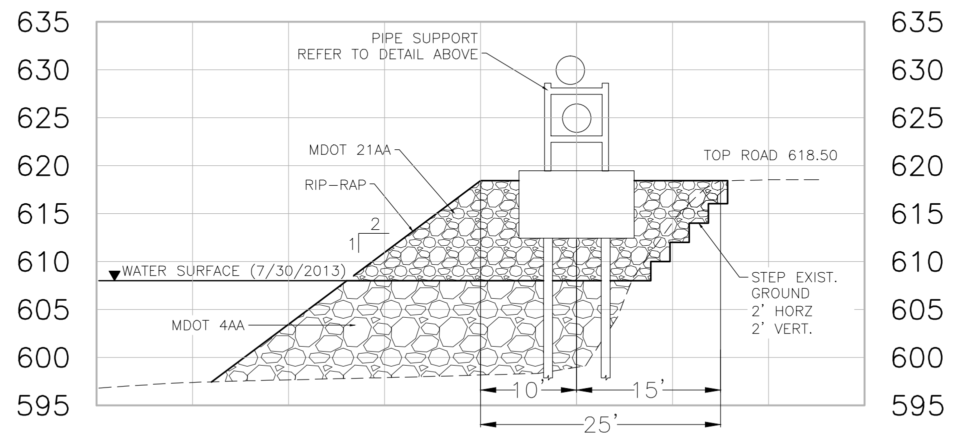
PRINTED
VER.
INSTRUCTIONS



SECTION A-A
HORIZONTAL 1"=80'
VERTICAL 1"=2'



TYPICAL PIPE SUPPORT FRAME
NOT TO SCALE



TYPICAL SECTION THROUGH PIPE SUPPORT
HORIZONTAL 1"=20'
VERTICAL 1"=20'

PROPOSED: T-POND DAM INBOARD FILL
APPLICANT: THE DOW CHEMICAL COMPANY
WATERWAY: TITTABAWASSEE RIVER
CITY: MIDLAND
COUNTY: MIDLAND
SECTION 28, T14N, RO2E
DATUM: NGVD 29
DATE: 08/02/2013

REV. MARK	REVISION	BY	CHK	APP	DATE

CONSULTANT

URS

URS CORPORATION
MIDLAND, MI.,
25 BUILDING

URS PROJECT NUMBER: 41569523

DRAWING ISSUE RECORD

ISSUE NO.	REV	MATERIAL OR JOB SPEC	BID	FAB	CONST	REF
	1	AS-BUILT				09/25/14
	0	FOR PERMIT				08/02/13
			DATE ISSUED FOR			

DESIGNED	T. ROBERTS	08/02/13
DRAWN	T. ROBERTS	08/02/13
CHECKED	D. WEHNER	08/02/13
APPROVED	D. WEHNER	08/02/13
PROJ. ENGR.	K. DETRICH	08/02/13
MFG. REP.	S. BENNETT	08/02/13

STATUS
PLANT NO.
P.E. SEAL

MAP
SITE

T-POND DAM INBOARD FILL
AS-BUILT EMBANKMENT, FILL CONDITIONS, PIPE SUPPORTS, AND PIPELINE

PROJECT NUMBER	SCALE		REV.
	AS SHOWN ON PLAN	FIGURE 1	1

INSTRUCTIONS

T-Pond Solids Maintenance Plan

Condition of

Site Specific Treatability Variance MID 000 724 724, Approved June 18, 2002

And

WMD Order No. 111-31-02

The Dow Chemical Company

Michigan Operations

Midland, Michigan

MID 000 724 724

December 2002
Revised September 22, 2006

1.0 Introduction

On June 18, 2002, Dow received approval from the United States Environmental Protection Agency (US EPA) Region 5 for a Site-Specific Treatability Variance (Variance) applicable to waste generated during the remediation of the Tertiary Pond Treatment System (T-Pond). Condition 4 of this Variance requires that "*By December 31, 2002, Dow shall submit a T-Pond solids Maintenance Plan to the MDEQ for review and approval,* …". Submission of a T-Pond Solids Maintenance Plan is also required by Paragraph 5.3.4 of WMD Order No. 111-31-02. According to Condition 4 of the Variance, the purpose of the Maintenance Plan is "*to prevent the excess accumulation of solids in the T-Pond following the removal of the existing T-Pond solids accumulation. Upon approval of the T-Pond Solids Maintenance Plan, Dow shall request and obtain approval of a Midland Plant License modification which incorporates the approved plan*". This plan has been prepared to fulfill these requirements.

The T-Pond consists of the Pentagonal, Rectangular and Main hazardous waste surface impoundments connected in series. These surface impoundments are licensed to store up to 783,000,000 gallons of secondary wastewater treatment plant effluent from Michigan Operations by the State of Michigan Hazardous Waste Facility Operating License issued June 12, 2003. The treatment and discharge from the surface impoundment of up to 35,000,000 gallons/day is permitted by NPDES Permit No. MI0000868. The Pentagonal Pond capacity is 33,000,000 gallons, the Rectangular Pond capacity is 50,000,000 gallons and the Main Pond capacity is 700,000,000 gallons. Secondary wastewater treatment plant effluent enters into the T-Pond in the Pentagonal Pond, flows into the Rectangular Pond, and finally enters the Main Pond prior to final discharge to the river.

Secondary wastewater treatment plant effluent contains low levels of suspended solids. These solids will tend to settle out of the effluent and slowly accumulate in the T-Pond system. The natural tendency is for solids to accumulate in the Pentagonal Pond first. As residence time in the Pentagonal Pond is reduced by the accumulation of solids, suspended solids will begin to carry over into the Rectangular Pond and settle. Over long periods of time this process can continue until suspended solids carry over into the Main Pond before settling. Historical experience indicates that solids accumulation in the Main Pond will primarily occur near the inlet at the west end of the Pond. In order to minimize the rate of accumulation of solids in the T-Pond system MDEQ and Dow have entered into ACO-FTO-SW05-002 issued August 29, 2005 specifying enforceable limits for total suspended solids (TSS) from the secondary clarifiers into the T-Pond. Compliance with ACO- FTO-SW05-002 issued August 29, 2005 and any subsequent revisions to the order are considered to be a condition of this maintenance plan.

The main objective of the T-Pond Solids Maintenance Plan is to monitor and manage the accumulation of solids in the Pentagonal and Rectangular Ponds in order to prevent solids carryover into the Main Pond. It is anticipated that this effort will result in periodic routine solids removal activities in the Pentagonal and Rectangular Ponds. The T-Pond solids Maintenance Plan also addresses solids accumulation in the Main Pond should that occur. The details of the Plan are described in subsequent sections.

2.0 Containment of Solids to Pentagonal Pond

Installation of a weir to the Pentagonal Pond will be proposed in order to help reduce solids carry over into the Rectangular Pond. A design is being developed and will be submitted to the MDEQ for review and approval as a License Modification. A schedule for completion of the Modifications to the Pentagonal Pond will be submitted with the design and License Modification request.

3.0 Measurement of Solids Accumulation

Each calendar year beginning in 2007 the top of solids elevation in the Pentagonal and Rectangular ponds and the west end of the Main Pond (see Figure 1) will be surveyed. The top of solids elevation in the entire Main Pond will be surveyed at 5 year intervals (years ending with 0 or 5). These surveys will measure the height of the solids from the bottom of the pond at a minimum of 20 points distributed across the full width and length of both the Pentagonal and Rectangular ponds. The Main Pond (west end annually, full pond 5 year intervals) will be surveyed to measure the height of the solids from the bottom of the pond at points located approximately 200 feet apart as currently conducted for the T-Pond solids removal project surveys. Precise spatial locations (x and y coordinates) will be measured using a surveyor global positioning system. These solids level measurements will be used to create contour maps to indicate the solids thickness and top of solids in each pond. To the extent reasonably possible, the same measurement location will be used each year to complete the survey.

This survey will usually be completed during September of each year, although the actual date of survey may vary anywhere from August to November depending on the status of current T-Pond maintenance activities, the availability of necessary resources, and weather/wind conditions. MDEQ will be notified of the planned survey schedule approximately two weeks prior to the scheduled survey date. The timing of the survey is selected to provide the data necessary to allow for appropriate planning and budgeting to start maintenance activities as soon as weather allows in April of the following calendar year. Beginning in 2007 the contour maps and solids elevation and location data from the annual surveys, along with the plan for T-Pond maintenance for the up coming season shall be submitted to the MDEQ for review by December 31st of each calendar year. If needed, Dow or MDEQ may request a meeting to further review and evaluate the contents of the annual report. In the future, if solids carry over and accumulation in the Main Pond is de minimis, a License Modification request may be submitted to the MDEQ to reduce the survey and contour mapping frequencies of the Main Pond.

4.0 Execution of Maintenance Activity

The level of solids in the Pentagonal, Rectangular, and Main Ponds obtained from the annual survey will be compared to a defined action level for each pond. If the level in the Pentagonal, Rectangular, or Main Pond at the time of the survey exceeds the defined action level for that pond, then maintenance activities for the affected pond will be planned and scheduled as soon as weather allows during the next T-Pond maintenance season. Dow will provide notification to MDEQ in the annual report referenced in Section 3.0 when maintenance activities are planned for the following maintenance season.

The action level for the Pentagonal Pond and Rectangular Ponds are initially established at 5 feet thickness above the pond bottom. The action level for each of these ponds was established at a level where significant carry over of solids into the Main Pond is believed to be unlikely and an appropriate thickness for adequate dredging operation. The action level in the Main Pond is 3 feet thickness in a contiguous area of at least 10 acres. It is anticipated that appropriate monitoring and maintenance activities in the Pentagonal and Rectangular Ponds will greatly minimize any carryover into the Main Pond. The review of the annual survey results with the MDEQ should provide adequate means for both the MDEQ and Dow to understand the long term impact of this program on the Main T-Pond and establish appropriate actions if necessary.

The actions levels for initiating the T-Pond Solids maintenance activities have been established such that when solid levels reach the action level, there is not an immediate environmental concern. Rather, the action levels are established at a decision point that is appropriate to begin preparation for maintenance activities during the following maintenance season. Over time the annual surveys of the ponds will provide valuable information as to the expected long term rate of increase in solids in each of these ponds helping to fine tune the planning process.

If it is determined at a future date that the action levels should be changed (increase or decrease), to prevent carry over into the Main Pond Dow will re-evaluate and propose a change through the Operating License Modification process.

The maintenance season for the T-Pond occurs from approximately April 1st to November 15th. This timeframe can vary due to actual weather conditions. Maintenance activities in the T-Pond cannot take place during freezing weather conditions due to safety considerations.

At the beginning of a maintenance season solids removal activities will begin in the most up stream (relative to water flow) pond above the action level and proceed to any down stream ponds that are above action levels after the upstream pond is complete. Dow may choose to complete solids removal activities in ponds that are not above action levels at its discretion if time permits.

Maintenance activities will continue until solids have been removed to within approximately one foot of the pond bottom, or weather conditions do not permit activities to continue. At the conclusion of a T-Pond maintenance season if the solids level in the Pentagonal, Rectangular Ponds, and Main Ponds are below their respective action levels and the pond(s) scheduled for maintenance during the current maintenance season have been completed to within approximately one foot of the bottom Dow will evaluate if additional maintenance activities will be scheduled for the next maintenance season. If the pond(s) scheduled for maintenance during the season have not been completed or if any pond's average solids level is above its action level at the conclusion of a maintenance season, then maintenance will continue the following maintenance season.

During a T-Pond maintenance season, activities may need to be temporarily suspended in order to properly address equipment malfunctions, safety concerns, unusual conditions that have the potential to adversely impact NPDES permitted effluent quality or other unusual events or weather related circumstances. If T-Pond maintenance activities are suspended, Dow will reasonably attempt to resume maintenance activities as soon as possible after the unusual event has been properly addressed. MDEQ will be advised of any disruption or suspension of the maintenance activities that last longer than 5 days.

The objective for a T-Pond maintenance season shall be to remove solids from all ponds above the action level during the previous survey to within approximately one foot of the bottom. In the event this objective is not achieved during a maintenance season Dow shall provide in writing to MDEQ a report explaining the cause(s) for not meeting the objective and any additional steps that shall be taken to achieve the objective during the next maintenance season. This report is due by December 31st of the calendar year. The solids in any individual pond shall be removed to within approximately one foot of the bottom by the conclusion of the second year after the survey identified the pond to be above its action level. The MDEQ may grant an extension to Dow for the completion of a pond beyond two years after receiving a written request. This written request shall be submitted at least 60 days prior to the two year deadline. The written request shall include:

a) A detailed description of what will prevent Dow from achieving the deadline.
b) A description of the measures Dow has taken to meet the deadline.
c) A description of the measures Dow intends to take to remove solids from all of the ponds currently above their action level to within one foot of the bottom
d) The length of the extension request and the anticipated date on which the obligations will be met.

5.0 Method Used to Remove and Treat Solids

At this time, Dow's intent is to remove solids from the Pentagonal, Rectangular and Main ponds utilizing either a floating sludge pump or hydraulic dredge. The floating sludge pump has been used successfully to remove solids from the pentagonal pond during the 2006 maintenance season. The hydraulic dredge has been successfully used during the T-Pond Solids Removal Project. The solids slurry will be pumped back to the wastewater treatment plant (WWTP). The solids will be mixed with other solids in the WWTP and processed through the WWTP dewatering, drying, and storage process. All solids will then be transported to a properly permitted hazardous waste incinerator for additional treatment prior to being transported to the landfill.

The T-Pond maintenance operation will be consistent with the T-Pond Maintenance Process Description submitted to MDEQ-Water Bureau on September 22, 2006 and any subsequent approved revisions. This will include appropriate characterization of T-Pond solids prior to starting maintenance removal activities in a pond. Additionally, during periods when dredged T-Pond solids are sent to the on site WWTP clarifiers and aeration basin Dow shall monitor and record appropriate WWTP process information to assure that the T-Pond solids are not interfering with the proper operation of the plant.

During periods when dredged T-Pond solids are sent to the on site WWTP dewatering, drying, and storage process Dow shall conduct sampling and analysis of the sludge consistent with the requirements of PTI 129-06 approved September 07, 2006 and any subsequent revisions. Results of the analysis of the sludge shall be provided to MDEQ Waste and Hazardous Materials Division within 60 days of the end of the quarter that the sample was taken.

Capacity of the wastewater treatment plant solids dewatering, drying, and storage process is anticipated to be adequate to process both normal solids generated within the water plant and solids recovered from maintenance of the Pentagonal, Rectangular, and Main Ponds. Until this can be verified by operating experience, the dewatering, storage, and truck loading facilities used by the T-Pond Solids Removal Project will remain available for use. If necessary, this equipment will be utilized to provide additional solids dewatering capacity to support maintenance of the ponds. If this equipment is used, dewatered solids would be transported to the incinerator for additional treatment prior to landfill. If operating experience demonstrates that this equipment is no longer necessary, it may be eliminated or converted to other uses.

Over time and as circumstances may dictate, Dow may evaluate other legal options for solids removal and treatment. Changes may be implemented if they prove to be technically practical and cost effective and can achieve the objectives stated in this Plan. Any changes considered will be addressed to meet applicable regulations and pertinent approvals will be obtained prior to implementation.

6.0 Changes to the Plan

The T-Pond Maintenance Plan is subject to change based on the ability to best manage the long-term operation while insuring compliance with permits and rules is maintained, and the controls are able to achieve the stated purpose of the Plan which is to prevent the excess accumulation of solids in the T-Pond system. Proposed changes will be submitted to MDEQ for approval prior to implementation as an Operating License Modification.

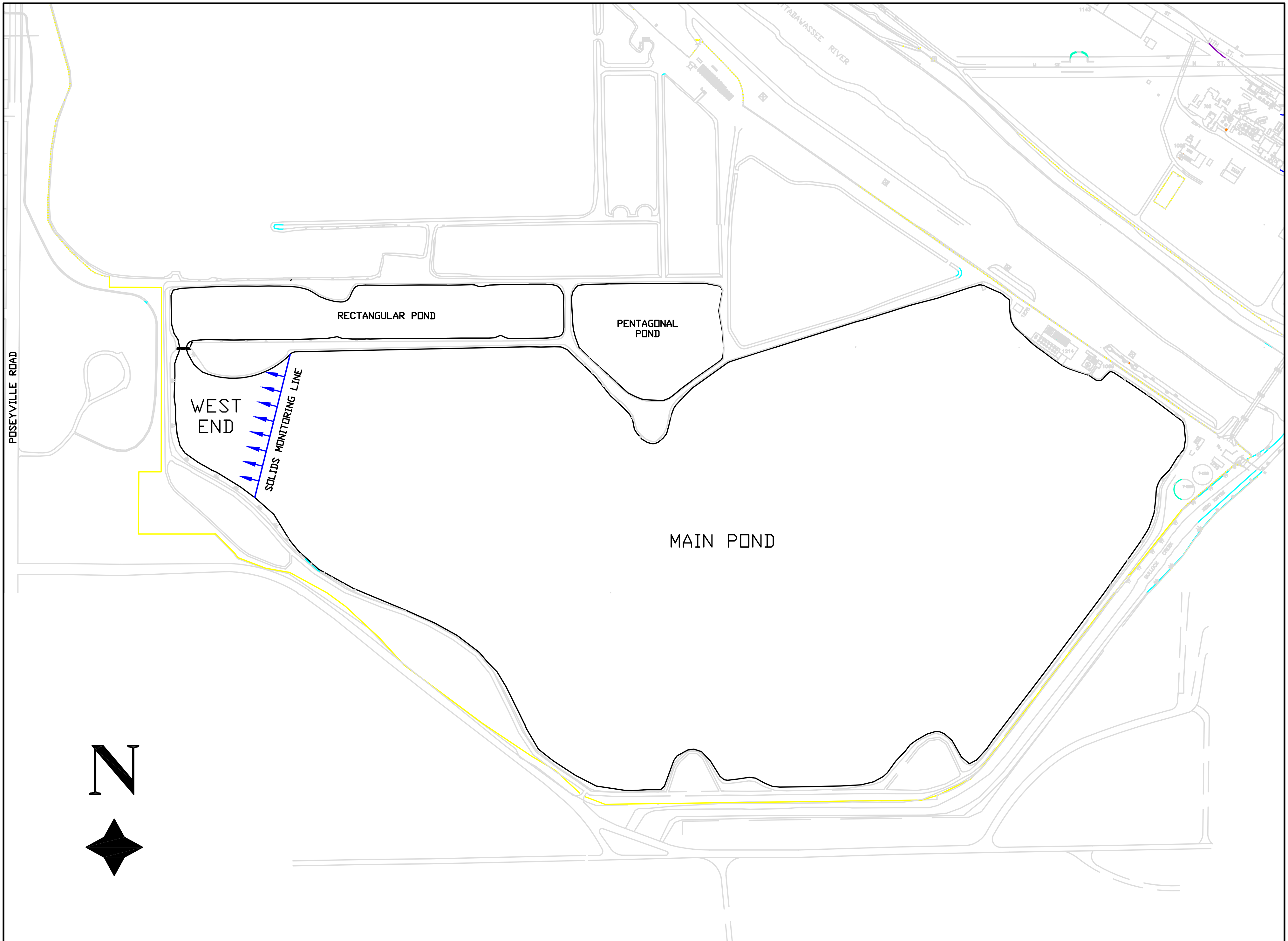


FIGURE 1: MEASUREMENT OF SOLIDS ACCUMULATION

ATTACHMENT XIV.C5

APPENDIX C5-A

TERTIARY POND DIKE/DAM STABILITY ANALYSIS

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Architectural & Engineering Services

GEOTECHNICAL ENGINEERING MEMORANDUM

TO:	Kip Cosan and Shane Bennett	**DATE:**	January 10,2012 Rev.1 February 1, 2012
FROM:	Vik Gautam, PE Doug Wehner	**PROJECT:**	Dow Chemical Company T-Pond Dike Stability Analysis
COPIES:	File	**JOB NO.:**	41569029
ATTACHMENTS:	Figures 1 and 2; Appendix A (Boring Logs); Appendix B (Laboratory Test Data); Appendix C (Results of Slope Stability Analysis)	**RE:**	*Evaluation and Recommendations For Slope Distress at T-Pond East Dike*

1.1 EXECUTIVE SUMMARY

During a site walkover performed in June 2011, URS Corporation (URS) geotechnical engineers observed slope distress along a limited section of the east dike of the Tertiary Pond (T-Pond). The distressed area is located near the existing Sand Filters and building, is approximately 150 ft in length (along the dike alignment), and involves the eastern crest of the dike. The slope distress is located between two areas of the T-Pond dike that were buttressed in the past, due to previous concerns over slope stability.

The observed distress included a failing guardrail and cracked asphalt pavement at the crest of the dike. Maintenance of the crest within the distressed area has been ongoing and includes placement of rock fill to retain the roadway. These repairs have largely covered the section of slope that experienced movement, so direct observation of any scarps or slope movements is not possible. Later observations made by URS personnel after tall grass on the slope face had been mowed indicated some creep movements of the surface of the dike slope, but signs of a deep seated failure involving a large section of the dike were not observed. The visual observations thus suggest that the distress is a shallow translational movement limited to the crest and upper third of the slope and is likely the result of the steep configuration of the dike slope.

In the memorandum entitled “Preliminary Results of Cone Penetrometer Testing Program Stage I, Phase I - Interpretation and Stage I Phase I - T-Pond Dike Stability Analysis”, submitted to Dow Chemical Company (Dow) in July 2011, URS recommended that a specific exploration of the distressed section of the slope be performed and a repair scheme be designed in short order. Subsequently, Dow retained URS to perform the recommended exploration and to provide repair recommendations. The exploration was performed in the Fall of 2011.

This memorandum presents the results of our subsurface exploration and summarizes our repair recommendations. The recommended repair for the distressed slope includes regrading of the upper part of the slope to a shallower angle and providing a soil buttress to provide additional support at the toe. The repair limits encompass the distressed area, but also include the entire segment of the dike between the ends of the historically constructed buttresses (approximately 425 ft of dike length). The recommended repair is schematically illustrated on Figure 2. The repair scheme has been evaluated and designed in general accordance with US Army Corps of Engineers (USACE) protocols for dam embankments.

1.2 INVESTIGATIONAL FINDINGS

Reconnaissance and a subsurface exploration were performed at the site area, in order to evaluate the potential cause of the slope distress and to obtain information required for evaluation of feasible repair options. Findings from these activities are summarized in the following sections.

1.2.1 Reconnaissance

URS geotechnical engineers initially observed the distressed area on June 21, 2011. The observed distress included a failing guardrail and fence, and cracked asphalt pavement at the crest of the dike. The guardrail “sags outward” several feet (on the order of 5 ft) relative to the guardrail alignment outside of the distressed area, which provides some indication of the size and extent of the mass of soil that has displaced. Marked linear cracks (anticipated to be tension cracks due to ground movement) in the asphalt pavement were apparent across most of the distressed area. The cracking was generally set back a few feet west of the existing edge of pavement. Some cracks appeared to be relatively new (they were not filled with silt), which indicated that movement was likely ongoing. URS recognizes that some cracking may have been exacerbated by snow plowing practices. Aggregate materials have been placed at the crest of the slope, to retain the failing fence/guardrail, and concrete jersey barriers have been placed at the crest of the slope, to limit access and proximity of vehicles to the distressed area.

During the initial walkover, the dike slope was not clearly visible due to the presence of tall grass on the surface. The grass was subsequently mowed, and a URS engineer returned to perform additional observations, photo-documentation, and topographic survey of the dike surface in the distressed area (notes and photos are retained in the project file). Some signs of “mudflow” type movements near the midslope and toe of the dike were observed (specifically, accumulations of soil behind existing electric posts that exist on the lower slope), suggesting that some slope creep may be taking place. Bulging at the lower slope and in the toe area was not observed, and this is interpreted as a sign that deep-seated movements of the dike slope are not being mobilized. Furthermore, a prominent head scarp or other cracking/sloughing of the dike surface at or near the crest of the slope was not visually apparent. This is due to the fact that the slope crest has been maintained by placement of rock fill to retain the fence/guardrail. The head scarp has likely been covered by this fill. Finally, no groundwater seepage was observed on the dike slope.

In addition to the visual inspection, a desktop study was conducted by analyzing the topographic survey of the distressed area obtained during the site reconnaissance and the existing 2008 plant-wide aerial survey that is available. Specifically, it was attempted to determine the extent of the slope distress by identifying significant differences in surface elevations along the dike crest and sideslope between these two surveys. In general, more prominent differences in topographic elevations between the two surveys (on the order of 0.5 to 1 ft) exist only at the crest and upper third of the slope – the current survey elevations being lower than 2008 aerial elevation, suggesting downward movement of slope soils in these areas.

The extent of the distressed area estimated from the limits of the failing guardrail and from the comparison of the current and 2008 topography is approximately 150 ft along the alignment of the dike and is shown on Figure 2.

Conclusions:

Based on the results of the site reconnaissance, it is concluded that the slope distress is the result of a shallow movement that is limited to the crest and upper slope. The angle of the dike sideslope is greater than 1.5H:1V, which represents an oversteepened condition for the loose/medium stiff soils of which the dike is constructed. This condition, in conjunction with saturation of surficial soils during periods of wet weather are anticipated to be the trigger for the shallow instabilities observed.

Signs of larger, deep-seated instabilities or seepage problems are not apparent based on the visual observations.

1.2.2 Subsurface Exploration

A subsurface exploration within the distressed area was performed, in order to obtain subsurface information necessary to perform slope stability analyses of both the existing conditions and to establish repair schemes. The subsurface exploration consisted of three (3) soil borings drilled within the limits of the distressed area, SB-8508 and SB-8509 drilled at the dike crest and SB-8511 drilled at the toe of the dike. The boring locations are shown on Figure 1.

Clearance of underground utilities was verified before drilling began. Vacuum excavation was performed by GeoServ, Inc. of New Hudson, Michigan to clear for utilities at each boring location to a depth of 6 to 7 ft. Borings were then drilled adjacent to the vacuum excavations. McDowell and Associates, Inc. of Midland, Michigan, used a CME-55 track drill rig to drill the borings between September 26 and September 29, 2011. The borings were advanced using 3¼-inch inner-diameter, hollow stem, continuous flight augers. Borings were advanced to depths ranging between 20 and 30 ft below existing ground surface (bgs) and were terminated in the hard till deposit that underlies this area of the plant.

To provide detailed information on the stratigraphy and material variations within the dike at each boring location, continuous split spoon sampling was performed in accordance with the Standard Penetration Test (SPT), ASTM D 1586. A URS geologist was present to oversee all drilling and sampling operations and to log soil samples. Representative soil samples were collected from the borings for classification and/or testing during drilling. Soil samples were visually classified in the field in general accordance with ASTM D 2487 and 2488. Undisturbed soil samples using Shelby Tubes, collected in general accordance with ASTM D 1587, were obtained in some soft fine-grained soils. These samples were collected from separate augured holes, which were offset from the corresponding boring. All three soil borings were finished as groundwater piezometers.

Detailed soil boring logs are presented in Appendix A.

1.2.3 Laboratory Testing Program

Selected soil samples and Shelby tube samples were shipped to McDowell and Associates, Inc. of Midland, Michigan for laboratory testing to determine the classification and engineering properties of the soils. The laboratory-testing program consisted of the following tests:

Table 1: Laboratory Testing Program

TEST SPECIFICATION	REFERENCE STANDARD	NUMBER OF TESTS
Natural Moisture Content	ASTM D-2216	18
Atterberg Limits (Plasticity Index, Liquid Limit)	ASTM D-4318	13
Total Unit Weight	ASTM D-2937	5
Particle Size Analysis (Sieve)	ASTM D-422	10
Unconfined Compression Test (UC)	ASTM D-2850	5
Direct Shear Test (CIU)	ASTM D-4767	4 samples, 12 points total

Results of these tests are presented in Appendix B.

1.2.4 Subsurface Conditions

Subsurface conditions encountered at the borings can be generally summarized as follows (from highest to lowest elevation): Surficial materials consisting of asphalt pavement and pavement base material; Dike embankment fill materials; Lacustrine deposits; Glacial till. The subsurface conditions encountered are described in detail below. Note that all elevations given in this memo correspond to the NGVD29 datum.

Surficial Materials

Borings 8508 and 8509 (drilled at the dike crest near El. 618) encountered approximately 6 inches of asphalt pavement at the surface, followed by approximately 6 to 12 inches of medium dense, gray gravel with sand as base course material.

Fill Materials

Embankment fill materials corresponding to the original dike construction were encountered in borings 8508 and 8509 to approximate El. 600. The fill consisted of clay material in the upper slope, overlying sand material in the lower slope. The clay fill consisted of moist brown lean clay (CL) to silty clay (CL-ML) with varying amounts of sand and trace amounts of cinders. Thickness of the clay layer was roughly 4 to 6 ft and its consistency could be described as medium stiff to hard as indicated by SPT N-values ranging between 7 and 17 blows per foot (bpf), (average of 12 bpf) and pocket penetrometer readings generally greater than 4.5 tsf. The sand fill generally consisted of moist light to dark brown poorly graded sand (SP). The apparent density of the sandy fill materials was loose as indicated by SPT N-values ranging between 1 and 6 bpf (average of 4 bpf). The SPT results in the sand were generally observed to decrease with depth.

Lacustrine Deposits

Lacustrine deposits were encountered between El. 600 and 588 and generally consisted of moist to wet, light brown to gray, interbedded sand, silt and clay soils. Fine grained layers consisted of gray and brown lean clay (CL) and silt (ML), with varying amounts of sand. Sand layers consisted of brown and gray, fine sand (SP) and silty sand (SM). SPT N-values in these deposits ranged between 1 and 10, with an average value of 5 bpf, which indicates a very soft to medium stiff consistency in the fine-grained materials and very loose to loose relative density in the sand materials.

Glacial Till

Glacial till deposits were first encountered near El. 588 underlying the lacustrine deposits in all borings, which was as anticipated based on historical information. The till deposits predominantly consisted of lean clay (CL) with varying amounts of sand and gravel. SPT N-values in the till varied between 21 and over 50, and pocket penetrometer values were generally greater than 4.5 tsf. These results are indicative of a very stiff to hard consistency.

Groundwater

Groundwater readings were taken in the piezometers on October 19, 2011. The measured groundwater levels are provided in the table below (the piezometers at SB-8508 and 8509 were dry).

Piezometer Water Level Data

Boring ID	Boring El. (NGVD29)	10/19/11	
		ft bgs	Water El. (NGVD29)
SB-8508	617.63	>18	<599.6
SB-8509	617.78	>20	<597.8
SB-8511	598.60	2.25	596.35

The groundwater table was generally encountered below El. 596, corresponding to a few feet below the base of the dike (which is at approximately El. 599) and within the lacustrine soils. The groundwater table as indicated in the piezometers lies well below the operating pool of the T-Pond (which is approximately El. 613). The downstream slope of the dike at the project site is located on the order of 150 ft from the water line (due to the existing sand filter and building construction at the site). It is anticipated that the phreatic surface generated by the static water level in the pond descends to the static groundwater elevation west of the sideslope.

1.3 SLOPE STABILITY ANALYSES – EXISTING CONDITIONS

The following slope stability analyses were performed using the existing configuration of the dike:

1. Case 1, Forensic Analysis: This analysis focused on identifying potential shallow failure surfaces involving the upper dike and crest. The results of this analysis were compared to the observed slope distress.
2. Case 2, Global Stability Analysis: The factor of safety against global (deep-seated) slope stability under normal operating conditions was evaluated, for the existing configuration of the dike. The results of this analysis were compared to U.S. Army Corps of Engineers guidelines.

Both Case 1 and Case 2 analyses were based on an average cross-section within the distressed area, established using the topographic data obtained during the site reconnaissance. Analyses were performed using Spencer's Method, which is a limit equilibrium slope stability analysis procedure The computer program SLOPE/W 2007 by Geo-Slope International was utilized. The program analyzes a large number of potential slip surface geometries and identifies the geometry that results in a critical (i.e. lowest) factor of safety (FS). Additional information on the program is available at http://www.geo-slope.com/.

Stratigraphy used in the slope stability analyses was established based on the profiles indicated by the soil borings. Material properties (soil unit weight and shear strength parameters) were selected based on the results of the laboratory testing program, engineering judgment and past experience with similar soils at the Dow site. Specific stratigraphic deposits and corresponding material properties used in the slope stability analyses are summarized in the table below:

Material Properties for Slope Stability Analysis

Stratum	Elevation (NGVD29)	γ (pcf)	ϕ (deg)	c (psf)
Stiff Lean Clay – Embankment Fill Layer	617 – 612	115	32	25
Loose Sand – Embankment Fill Layer	612 – 600	110	28	0
Soft Clay – Lacustrine Deposit	600 – 594	128	30	0
V Loose Sand – Lacustrine Deposit	594 – 588	110	28	0
Hard Till	588	135	38	250

1.3.1 Results of Existing Conditions Stability Analysis

Pertinent results of the existing conditions analyses are presented on figures C-1 (Case 1) and C-2 (Case 2), given in Appendix C. The figures show the critical failure surfaces and corresponding factors of safety computed by the models.

The following commentary is provided based on the results of slope stability analyses:

- The results of the Case 1 analysis indicate that shallow failure surface geometries involving the crest and upper portion of the slope are expected to have low factors of safety (the critical surface shown in Figure C-1 has FS of 0.95). This indicates that the slope in its existing configuration had marginal stability with respect to the type of movement that has been observed in the distressed area, and manifestation of a shallow instability would be likely or expected. The result thus supports the observations made in the field and the conclusions provided in Section 1.2.1.
- Per guidelines given in U.S. Army Corps of Engineers Engineer Manual EM-1110-2-1902 "Slope Stability", the recommended factor of safety for long term, steady state conditions of a dam embankment is 1.50. The results of the Case 2 analysis indicate a critical (lowest) factor of safety for a deep-seated or global failure geometry of approximately 1.30. Thus, the dike in its current configuration is not in imminent danger of a deep-seated failure that could compromise the integrity of the pond (i.e., because the factor of safety is well above 1.0), but does not meet widely accepted guidance for slope stability.
- The critical failure surface for a deep-seated failure does not encroach on the sand filters and other structures nor the water surface of the T-Pond, which are all located a substantial distance west of the sideslope. Therefore, it is anticipated that a failure of the sideslope will not immediately impact the integrity of the structures, nor create an immediate risk of loss of the T-Pond reservoir.

Conclusions:

The existing configuration of the dike features an over-steepened downstream slope, which is prone to shallow movements such as what has already occurred in the distressed area, and which has factors of safety against larger instabilities that do not meet industry-accepted guidelines. It is recommended that the configuration of the downstream slope be modified, both to repair and stabilize the upper slope and to bring the overall slope stability up to standards.

Given that the downstream slope is readily accessible from a construction standpoint, simple earthwork, consisting of regrading and buttressing of the slope, is the recommended repair/reconfiguration solution by inspection. It is noted that repair/reconfiguration in this area will require floodplain permitting. Detailed recommendations and supporting analyses for the repair/reconfiguration are provided in the next section.

1.4 SLOPE REPAIR SCHEME

The recommended slope reconfiguration is illustrated on Figure 2. The reconfiguration involves reducing the angle of the dike slope to 2H:1V and constructing a soil buttress at the lower slope. The slope angle reduction is designed to stabilize the slope face against shallow instabilities, and the buttress is designed to increase the factor of safety against deep-seated failures to meet industry guidelines.

Though the analyses summarized above in Section 1.3 were performed using cross-sections and subsurface information collected locally within the distressed area, it is anticipated that the conclusions will apply to the entire section of dike that lies between the two previously constructed buttresses. Therefore, the reconfiguration is recommended to be performed for this entire section of dike (as indicated on Figure 2), which corresponds to roughly 425 lineal feet of dike length. Reconfiguration expanded as such is anticipated to bring this entire section of dike to compliance with industry- accepted factors of safety. Furthermore, although not addressed herein, the existing buttressed sections of the dike should also be reanalyzed using modern software, to verify that those sections of dike meet current industry-accepted factors of safety. If these sections are found to be deficient, they may also be upgraded as an addition to the repair scheme recommended herein. The analysis of the currently buttressed sections will be addressed at a later Phase/Stage of the overall T-Pond dike evaluation, which is currently in progress.

Pertinent dimensions and geometric requirements of the various components of the slope reconfiguration are shown on Figure 2. Additional specific recommendations related to the reconfiguration are as follows:

- ***Slope Excavation:*** A shallow slip plane has likely developed within the soils of the upper slope within the limits of the distressed area. Displacement along the slip plane is anticipated to have mobilized residual strength conditions within these soils, which is anticipated to be less than the peak strength. Thus, the soils of the upper slope are prone to further movements, even if new fill is placed over top of them to reduce the slope angle. To mitigate this condition, it is recommended that the soils of the upper slope be removed and replaced. This should be accomplished by excavating a bench into the upper third of the slope and replacing the excavated soils with compacted fill, as shown on Figure 2. The excavation will start from the crest, at least 8 ft from the edge of the crest and will extend to minimum 10 ft depth at an angle of 1H: 1V. The excavation will further require removal of the existing fence and guardrail at the crest of the slope, and will partially encroach onto the paved roadway at the crest. Replacement of these features and maintenance of traffic during construction will be required.

  In addition to the planned benching, all surfaces of the dike that will receive new fill should be stripped of existing vegetation and topsoil, and the exposed subgrade should be bladed and roughened, to promote bonding of the new fill to the existing subgrade.

- ***Embankment Fill:*** Engineered fill materials should be selected, placed, and compacted in accordance with Michigan Department of Transportation (MDOT) "Standard Specifications For Construction", Section 205. Specifically, fine-grained soils (classified as silty clay (CL-ML, or lean clay (CL) per the Unified classification system) should be utilized and placement and compaction should be per the "Controlled Density Method", Section 205.03(4)(a). Existing soils removed as part of bench excavations may be reused, to the extent that they meet the MDOT requirements and the material types listed above.

- ***Additional Points:*** The recommended slope reconfiguration will involve temporary staging of construction materials and equipment and the placement of permanent fills (net overall increase) within the floodplain of the Tittabawasee River. Appropriate permits will need to be obtained prior to construction.

  A number of existing utilities are located along and perpendicular to the dike crest. The locations of these utilities is an important consideration when designing and implementing the proposed slope excavations. It may be necessary to temporarily protect, re-route or shut down and reconstruct some utilities during construction.

  Existing topsoil should be stockpiled and reused to the extent possible at the surface of the reconfigured slope. Some import of topsoil may be required, depending on thickness of the existing material and on how much of the existing material can be salvaged for reuse. The entire surface of the reconstructed slope should be revegetated at the close of filling activities.

  An electric line runs through the project limits, and a number of electric poles currently exist within on the lower slope. The line will have to be temporarily re-routed or shut down during construction, and poles removed will have to be replaced.

  The existing gravel access road that is located beyond the toe of the dike will be covered by the proposed soil buttress, and will need to be reconstructed/rerouted.

1.4.1 Slope Stability Analysis With Recommended Improvements

Slope stability analyses of the reconfigured slope were performed to establish the geometry of the improvements recommended above. The stability analyses were performed in general accordance with procedures outlined in the U.S. Army Corps of Engineers Circular EM-1110-2-1902 “Slope Stability” in the design of the repair for the slope. In these analyses, the buttress crest width was taken as 20 ft. Specifically, the following cases were analyzed:

Case 1: Steady State Seepage (Normal Operating Conditions)

Case 2: 500-year Flood Conditions

Case 3: Earthquake Loading

Case 1 for steady state seepage represents the dike in its normal operating condition.

Case 2 models conditions in relation to a 500-year flood of the Tittabawasee River. Based on previous analytical work performed for the T-Pond and No. 6 Brine Pond, the 500-year flood is expected to inundate the area of the T-Pond dikes with the water at El. 615. In the Case 2 analysis, it is assumed that the flood event saturates the downstream dike up to the flood level of El. 615, and then quickly recedes, leaving an elevated groundwater condition in the dike and resulting in a rapid drawdown condition.

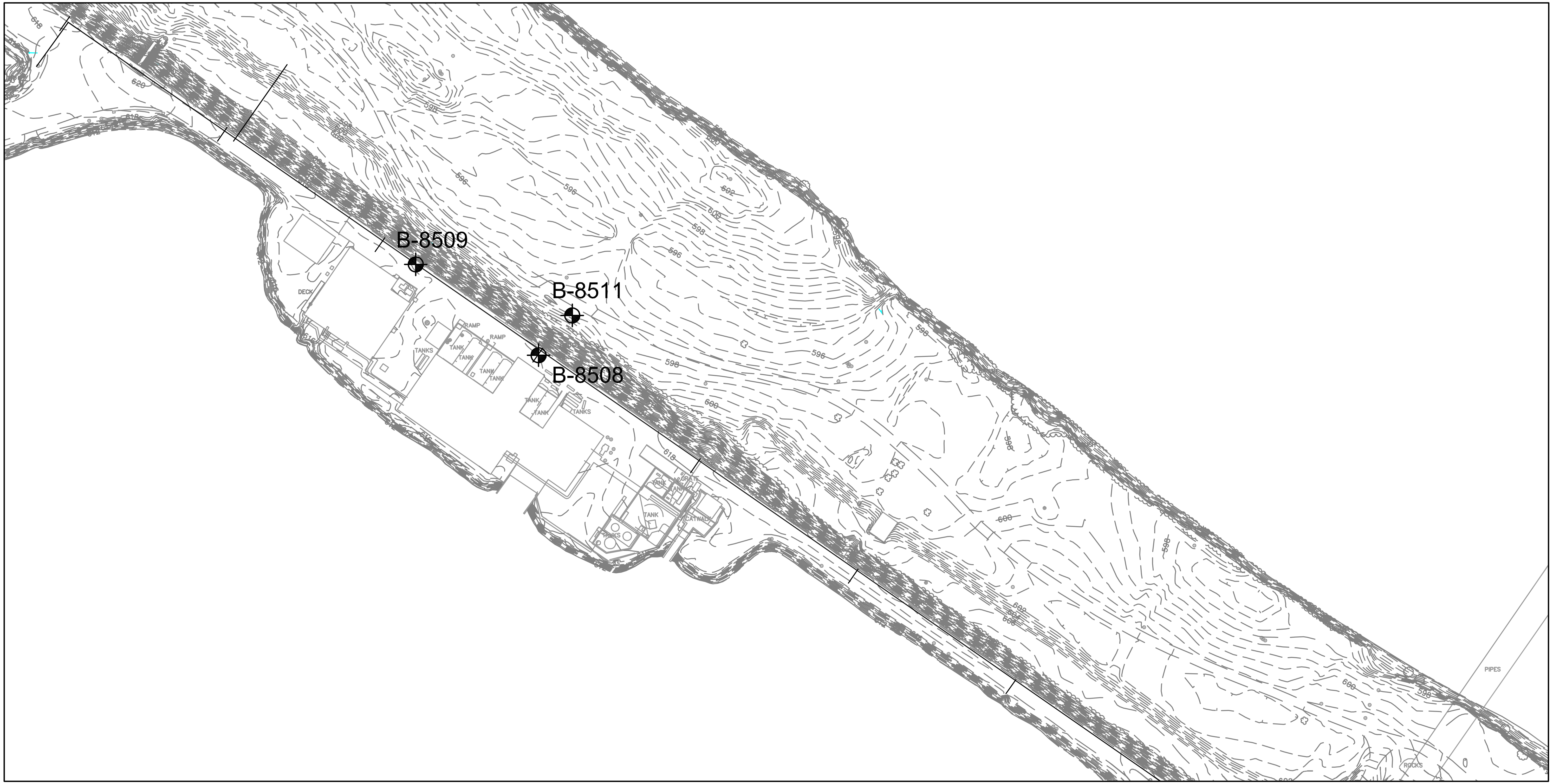
For Case 3, earthquake loading was evaluated using a pseudo-static analysis. The general model of Case 1 was used, but a seismic coefficient of 0.0332 g added. The seismic coefficient was based on information obtained from the United States Geological Survey (USGS) Earthquake Hazard Maps, and corresponds to a peak ground acceleration with a 2% probability of exceedence in 50 years (corresponding to an earthquake event with recurrence interval of approximately 2500 years).

The results of the analyses (critical factors of safety) are presented in the table below, along with recommended factors of safety corresponding to each case, as presented in USACE EM-1110-2-1902. Figures portraying the critical failure surfaces are given in Appendix C. The results indicate that the recommended reconfigured slope will meet the USACE recommendations for slope stability.

Results of Slope Stability Analysis With Recommended Improvements

Stability Case	Computed Critical Factor of Safety	USACE Recommended Factor of Safety
Case 1 : Steady State Seepage (Normal Operating Conditions) (See Figure C4)	1.75	1.5
Case 2: 500 Year Flood (See Figure C5)	1.53	1.1 to 1.3
Case 3: Earthquake Loading (See Figure C6)	1.65	1.1 to 1.3

FIGURES



LEGEND

⌖ BORING LOCATION

BORING LOCATIONS		
BORING ID	NORTHING	EASTING
B–8508	–3684.0400	–1250.1100
B–8509	–3593.0400	–1373.0700
B–8511	–3644.1400	–1216.3500

0 50 100

SCALE: 1"=100'

N

URS

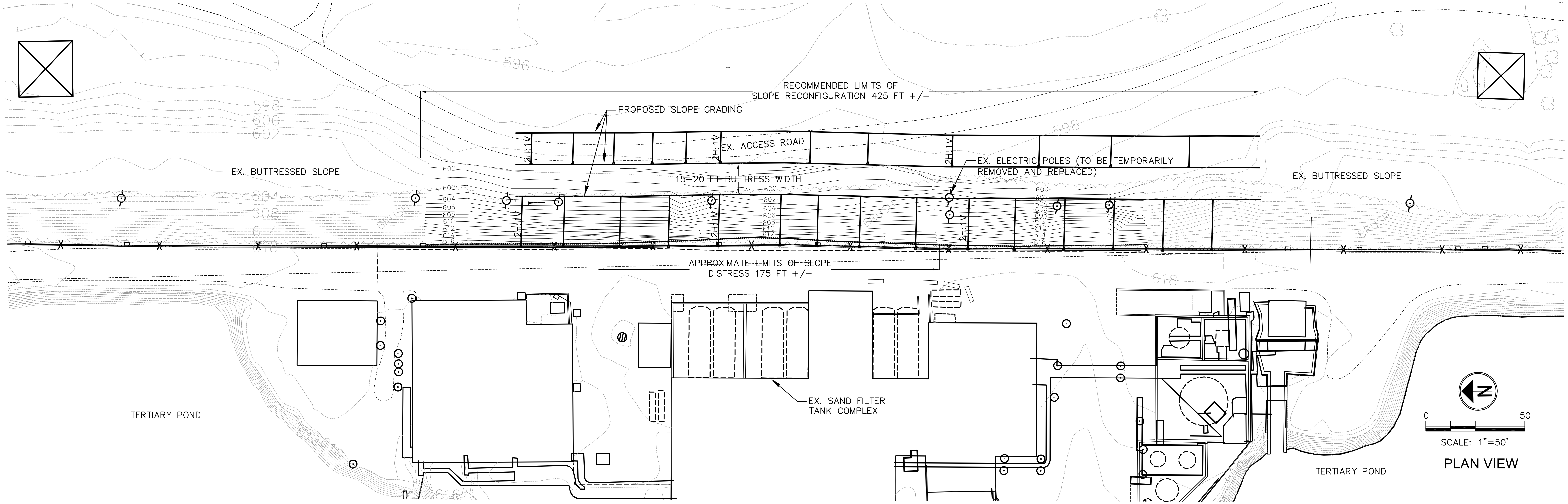
DOW T-POND SLOPE EVALUATION

MIDLAND, MICHIGAN

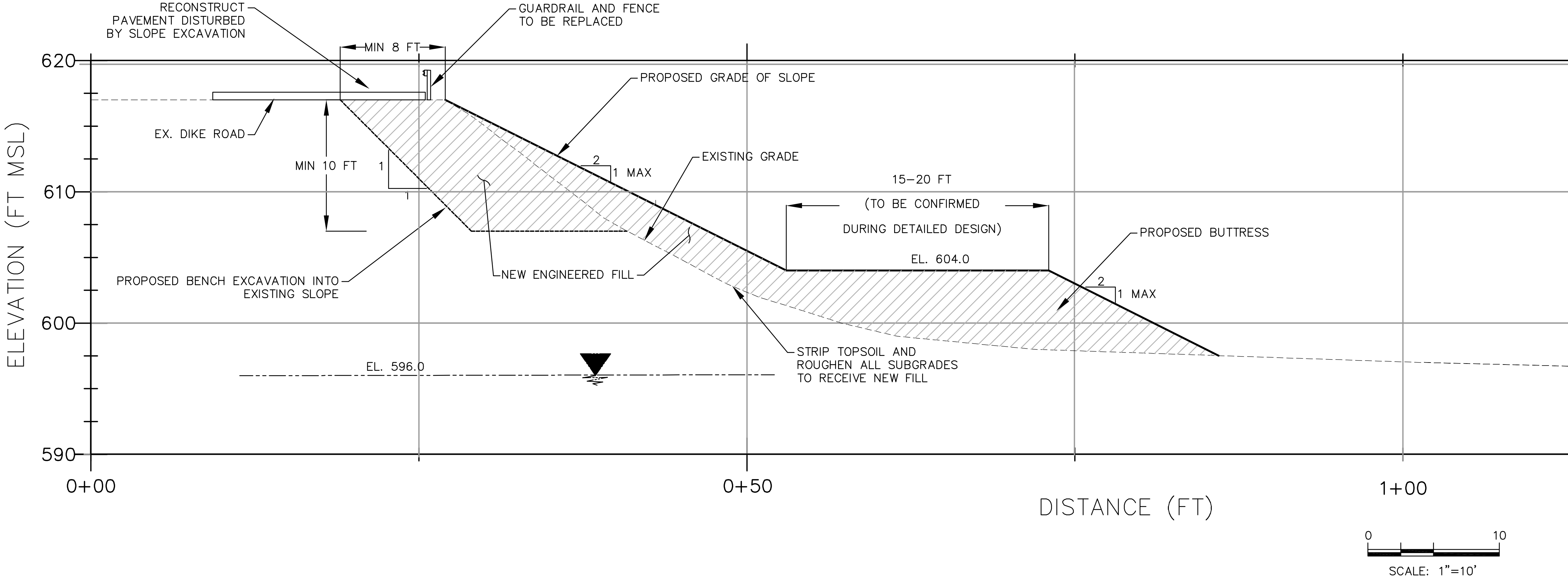
BORING LOCATION MAP

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
KNF	VKG	41569029	11/15/11	1

K:\Projects\D\Dow\41569029\DWGs\C\Geotech\Fig3-Slope Repair-Dow.dwg User: vik_gautam Feb 01, 2012 - 7:14pm



PLAN VIEW



PROFILE VIEW

URS

DOW T-POND SLOPE EVALUATION
MIDLAND, MICHIGAN

RECOMMENDED SLOPE RECONFIGURATION

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
KNF	VKG	41569029	11/15/11	2

APPENDIX A

Boring Logs

Project: Annual T-Pond Dike Inspection
Project Location: Midland, Michigan
Project Number: 41569029

Key to Log of Boring

Sheet

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance Blows/6"	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
1	2	3	4	5	6	7	8	9	10	11

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to mean sea level (MSL) or site datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Sampling Resistance:** Number of blows required to advance driven sampler each 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop.

6 **Recovery:** Percentage of driven sample length actually recovered.

7 **Pocket Penetrometer:** Pocket penetrometer field consistency measurement in tons per square foot (tsf).

8 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

9 **Material Description:** Description of material encountered; may include color, moisture, grain size, and density/consistency.

10 **Water Content:** Water content of soil sample measured in laboratory, expressed as percent of dry weight of sample.

11 **Remarks and Other Details:** Comments and observations regarding drilling or sampling made by driller or field personnel.

TYPICAL MATERIAL GRAPHIC SYMBOLS

- ░ POORLY-GRADED SAND
- ▨ LEAN CLAY
- ░ SILTY SAND
- ▨ FILL
- ● GRAVEL
- ▥ SILT
- ▥ SILTY CLAY
- ● SLAG
- ■ ASPHALT
- ▥ ELASTIC SILT

OTHER GRAPHIC SYMBOLS

▽ Water level in boring ATD

▼ Water level in boring at time indicated after drilling

↓ Minor change in material properties within a lithologic stratum

– – – – Inferred or gradational lithologic contact

ATD	At Time of Drilling
NR	Not Recorded
NA	Not Applicable
bgs	Below Ground Surface

TYPICAL SAMPLER GRAPHIC SYMBOLS

◪ Split spoon

▥ Shelby Tube

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

MINOR SOIL TYPE(s)

"trace"	When the soil type's percentage is estimated, using visual/manual procedures, to be between 1 and 15 percent of the total sample.
"with"	When the soil type's percentage is estimated, using visual/manual procedures, to be greater than 15 percent and less than 30 percent of the total sample.
"y"	When the soil type's percentage is estimated, using visual/manual procedures, to be greater than 30 percent of the total sample.

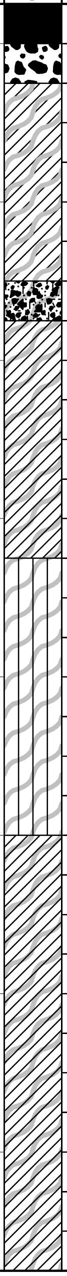
Project: Annual T-Pond Dike Inspection
Project Location: Midland, Michigan
Project Number: 41569029

Log of Boring 8508

Sheet 1 of 2

Date(s) Drilled	**9/27/11 and 9/28/11**	Logged By	**V. Wetzel**	Checked By	**V. Gautam**
Drilling Method	**Hollow Stem Auger**	Drill Bit Size/Type	**3-1/4" ID/ 6" OD**	Total Depth of Borehole	**30.5´ bgs**
Drill Rig Type	**CME-55**	Drilling Contractor	**McDowell & Assoc.**	Ground Surface Elevation	**617.6 ft NGVD29**
Borehole Completion	**Soil Cuttings**	Sampling Method(s)	**Split Spoon**	Hammer Data	**140#/ 30" Auto**
Coordinate Location	**N -3,684.0 E -1,250.1**	Groundwater Level(s)	**< El. 599.6 ft. Piezometer dry on 10/19/2011**		

Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
0							6" ASPHALT		
1 2		1	14 6 8 11	67	4.5+		Dense, dry, gray GRAVEL (GW) road base, with coarse sand Hard, moist, brown lean CLAY (CL), trace coarse sand and cinders [FILL]	12.0	*LL=20.6 PL=12.4 PI=8.2*
3 4		2	14 9 8 11	75	4.5+		Medium dense, moist, brown and black CINDERS and SLAG, with medium sand [FILL] Hard, moist, brown and light orange lean CLAY (CL), with fine sand [FILL]		
5 6		3	4 4 3 4	71			Medium stiff, moist, light orange, lean CLAY (CL), with sand [FILL]		*Shelby tube samples were taken @ 5' bgs WC=31.6 LL=49.1 PL=26.4 Unit Dry Weight=90.6 pcf*
7 8		4	3 2 3 3	71			Soft, moist, dark brown clayey SILT (ML), with fine sand [FILL]		*Shelby tube samples were taken @ 7' bgs WC=29.8 LL=19.3 PL=14.2 Unit Dry Weight=86.6 pcf*
9 10		5	2 1 2 1	75			seam of moist, light yellow fine SAND (SP)		
11 12		6	2 1 2 4	79			Soft, moist, light brown with dark brown mottling, sandy CLAY (CL) [FILL]		
13 14		7	2 1 2 2	100					
15 16		8	1	79			seam of wet, light brown medium SAND	15.8	



URS

Project: Annual T-Pond Dike Inspection
Project Location: Midland, Michigan
Project Number: 41569029

Log of Boring 8508

Sheet 2 of 2

Depth, feet	SAMPLES Type	 Number	 Sampling Resist. Blows/6" OR CORE% RQD	 Recovery, %	 Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
16		8	2	79		▨		15.8	
			3			▨			*End of drilling on 9/27/11*
17			3			▨			*Commenced drilling on 9/28/11*
		9	2	92		▨			
18			2			▨			*18-ft Monitoring Well with 5 ft of screen was intalled*
			2			▨			
19			2			▨	Soft, wet, light brown CLAY (CL), with fine sand		
		10	1	100		▨	becomes with black spotting and light orange mottling, with medium sand, trace shells and fine gravel	20.3	*LL=24.8 PL=16.5 PI=8.3*
20			1			▨	▼		
			2			▨			
21			2			▨			
		11	1	79		▨			
22			1			▨			
			2			▨	Medium stiff, moist, gray brown CLAY (CL)		
23			2		3.0	▨			
		12	2	83		▨			
24			3		1.0	▨	becomes medium stiff to soft, trace organics		
			4			▨			
25			4			▨			
		13	2	100	0.75	▨		31.5	*LL=37.3 PL=21.6 PI=16.1*
26			2			▨			
			3			▥	Soft, wet, brown and black SILT (ML), with fine sand		
27			4			▥			
		14	1	100		▥			
28			2			░	Loose, wet, gray and black SAND (SP), trace silt		
			2			░			
29			3			░			
		15	5	100		▨	Very stiff, moist, brown lean CLAY (CL), with silt lamina		
30			10			▨			
			11				End of Boring at 30.5´ bgs		
			14						

URS

Project: Annual T-Pond Dike Inspection
Project Location: Midland, Michigan
Project Number: 41569029

Log of Boring 8509

Sheet 1 of 2

Date(s) Drilled	9/26/11	Logged By	V. Wetzel	Checked By	V. Gautam
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID/ 6" OD	Total Depth of Borehole	30.5´ bgs
Drill Rig Type	CME-55	Drilling Contractor	McDowell & Assoc.	Ground Surface Elevation	617.8 ft NGVD29
Borehole Completion	Soil Cuttings	Sampling Method(s)	Split Spoon	Hammer Data	140#/ 30" Auto
Coordinate Location	N -3,593.0 E -1,373.1	Groundwater Level(s)	< El. 597.8 ft. Piezometer dry on 10/19/2011		

Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
0							6" ASPHALT		
1 2		1	4 4 5 4	83	4.5+		Loose, moist, brown sandy fine GRAVEL (GW) [FILL] Hard, moist, brown CLAY (CL), trace sand and fine gravel [FILL]		
3 4		2	4 5 8 11	96	3.0		becomes very stiff Medium dense, moist, dark brown with light brown mottling fine SAND (SP), with cinders and bricks, trace silt and slag [FILL]		
5 6		3	6 5 6 7	96					*@ 5.7' hit line and moved boring 2' west*
7 8		4	2 1 1 2	83			becomes without cinders, bricks, silt, and slag		
9 10		5	2 2 2 3	83			becomes with silt and clay		
11 12		6	2 3 3 4	83			Loose, light brown clayey SAND (SC)	14.0	
13 14		7	2 2 2 3	79			becomes with trace brick fragments Loose, moist, light brown silty SAND (SM) [FILL]		
15 16		8	2	96					

Project: Annual T-Pond Dike Inspection

Project Location: Midland, Michigan

Project Number: 41569029

Log of Boring 8509

Sheet 2 of 2

Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
16		8	2	96			Soft, moist, light brown sandy lean CLAY (CL), with trace gravel [FILL]		
17		9	2 2 2 2	92				19.9	*LL=25.3 PL=15.9 PI=9.4* *Shelby tube samples were taken @ 17' bgs WC=21.4 LL=37.3 PL=20.8 Unit Dry Weight=106.3 pcf*
19		10	2 2 1 1	100			Very soft, moist, light brown lean CLAY (CL), with sand [FILL] ▼		*Shelby tube samples were taken @ 19.5' bgs WC=21.0 LL=31.6 PL=16.1 Unit Dry Weight=107.1 pcf* *20-ft Monitoring Well with 5 ft of screen was intalled*
21		11	1 2 2 3	96					
22							Very stiff, moist, gray CLAY (CL), with silt		*Top of natural deposit*
23		12	3 4 4 5	75					
25		13	3 3 7 13	100			Soft, moist, gray CLAY (CL) with silt		
26							Very dense, wet, black fine SAND (SP)		
27		14	35 7 15 21	100	4.5		Hard, moist, brown CLAY (CL), with fine sand and silt, trace coarse gravel		
28							Very dense, wet, black fine SAND (SP)		
29		15	15 25 26 40	100					
30							End of Boring at 30.5´ bgs		

Project: Annual T-Pond Dike Inspection
Project Location: Midland, Michigan
Project Number: 41569029

Log of Boring 8511

Sheet 1 of 2

Date(s) Drilled	9/28/11 and 9/29/11	Logged By	V. Wetzel	Checked By	V. Gautam
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	3-1/4" ID/ 6" OD	Total Depth of Borehole	20.0´ bgs
Drill Rig Type	CME-55	Drilling Contractor	McDowell & Assoc.	Ground Surface Elevation	598.6 ft NGVD29
Borehole Completion	Soil Cuttings	Sampling Method(s)	Split Spoon	Hammer Data	140#/ 30" Auto
Coordinate Location	N -3,644.1 E -1,216.4	Groundwater Level(s)	2.25 ft bgs in piezometer on 10/19/2011		

Depth, feet	SAMPLES					Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
	Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Penetrometer, tsf				
0 1		1	4 2 3 4	83			Medium stiff, moist, light brown sandy CLAY (CL) [FILL]		
2 3		2	2 3 3 3	67			Very loose, wet, PEA GRAVEL [FILL] ▼ Soft, moist, light brown sandy CLAY (CL) [FILL]		*Shelby tube samples were taken @ 3' bgs WC=16.4 LL=29.6 PL=16.2 Unit Dry Weight=116.3 pcf*
4 5		3	1 1 1 1	33			Very soft, wet, dark brown silty CLAY (CL-ML), trace organics Very loose, wet, dark brown fine SAND (SP), trace silt		*Top of natural deposit* *Shelby tube samples were taken @ 5' bgs WC=21.0 LL=29.6 PL=13.4 Unit Dry Weight=103.9 pcf*
6 7		4	2 1 1 2	63			Soft, wet, gray and light brown silty CLAY (CL-ML), trace gravel Very loose, wet, light brown, coarse to fine SAND (SP)		
8 9		5	1 1 1 1	71				22.7	
10 11		6	4 5 7 9	75			Stiff, moist, brown, lean CLAY (CL), with silt laminate [LACUSTRINE] } seam of wet silt		*11-ft Monitoring Well with 5 ft of screen was intalled*
12 13		7	5 7 12 17	58	4.5+			19.0	*LL=38.4 PL=18.5 PI=19.9*
14 15		8	5 8 12 17	75	4.5+				
16									

Project: Annual T-Pond Dike Inspection

Project Location: Midland, Michigan

Project Number: 41569029

Log of Boring 8511

Sheet 2 of 2

Depth, feet	SAMPLES Type	Number	Sampling Resist. Blows/6" OR CORE% RQD	Recovery, %	Pocket Pene-trometer, tsf	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	REMARKS AND OTHER DETAILS
16		9	6 9 12 17	100	4.5+	▨			
18		10	7 10 14 16	100	4.5+	▨			
20							End of Boring at 20´ bgs		

APPENDIX B

Laboratory Results

McDowell & Associates
Geotechnical, Environmental & Hydrogeological Services • Materials Testing & Inspection
3730 James Savage Road • Midland, MI 48642
Phone (989) 496-3610 • Fax (989) 496-3190

January 3, 2012

URS Corporation
c/o Dow Chemical Company
25 Building
Midland, Michigan 48667

Job No. 11-63260

Attention: Mr. Doug Wehner

Subject: T-Pond Dike Inspection
Job No. 4156029.100000
Soils Testing
Michigan Operations

Dear Mr. Wehner,

In accordance with your request, we have performed the soil tests on the samples collected while drilling for the above mentioned project. Testing was done in general accordance with: Moisture (ASTM D2216), Liquid Limit/Plastic Limit/Plasticity Index (ASTM D4318), Particle Size (ASTM D422), Unit Weight (ASTM D4254), Unconfined Compressive Strength (ASTM D2166) and Direct Shear (ASTM D3080).

The samples tested were the samples that you indicated on the "Laboratory Testing Assignment and Data Summary" sheet (dated 11/2/11). A summary table of the test results is attached, as well as the results of Particle Size and Direct Shear.

If you have any questions, or if we can be of further service, please feel free to call.

Respectfully submitted,

McDOWELL & ASSOCIATES

Erik L. Johnson
Midland Operations Manager

Michael S. Keenan, P.E.
Project Engineer

Southeast Michigan Office
21355 Hatcher Avenue • Ferndale, MI 48220
Phone: (248) 399-2066 • Fax: (248) 399-2157

T-Pond Dike Inspection
URS Project No. 4156029.100000

Laboratory Testing Summary Table (Split Spoon and Bag Samples)

Boring and Sample No.	Depth (ft)	Requests	Natural Water Content (%)	Atterberg Limits		Unconfined Compressive Strength		Unit Dry Weight (pcf)
				Liquid Limit	Plasticity Index	Stress (tsf)	Strain (%)	
8505 (S2)	2-4		6.6	19.8%	6.6%			
8505 (S7)	12-14		24.9	31.9%	13.0%			
8505 (S12)	22-24		32.0	34.1%	11.2%			
8506 (S7)	12-14		16.7					
8506 (S9)	16-18		20.3	23.8%	5.8%			
8506 (S14)	26-28		29.6					
8508 (S1)	0.5-2.5		12.0	20.6%	8.2%			
8508 (S8)	14.5-16.5		15.8					
8508 (S10)	18.5-20.5		20.3	24.8%	8.3%			
8508 (S13)	24.5-26.5		31.5	37.3%	16.1%			
8509 (6)	10.5-12.5		14.0					
8509 (S9)	16.5-18.5	LOI 1.86%	19.9	25.3%	9.4%			
8511 (5)	8-10		22.7					
8511 (7)	12-14		19.0	38.4%	19.9%			

T-Pond Dike Inspection
URS Project No. 4156029.100000

Laboratory Testing Summary Table (Shelby Tube Samples)

Boring and Sample No.	**Depth (ft)**	**Requests**	**Natural Water Content (%)**	**Atterberg Limits**		**Unconfined Compressive Strength**		**Unit Dry Weight (pcf)**
				Liquid Limit	**Plasticity Index**	**Stress (tsf)**	**Strain (%)**	
8508	5-7	Shelby Tube #1	31.6*	49.1%	22.7%	--	--	90.6*
8508	7-9	Shelby Tube #2	29.8	19.3%	5.1%	1.18	4.8	86.6
8509	17-19.5	Shelby Tube #1	21.4*	37.3%	16.5%	--	--	106.3*
8509	19.5-22.5	Shelby Tube #2	21.0*	31.6%	15.5%	0.82	9.0	107.1*
8511	3-5	Shelby Tube #1	16.4*	29.6%	16.2%	--	--	116.3*
8511	5-7	Shelby Tube #2	21.0	41.8%	13.4%	0.30	6.8	103.9

* - Denotes the average moisture content or unit dry weight of the sample as tested for direct shear.

McDowell & Associates

SIEVE ANALYSIS

ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8506 S-7 12'-14'

Sample Date: --

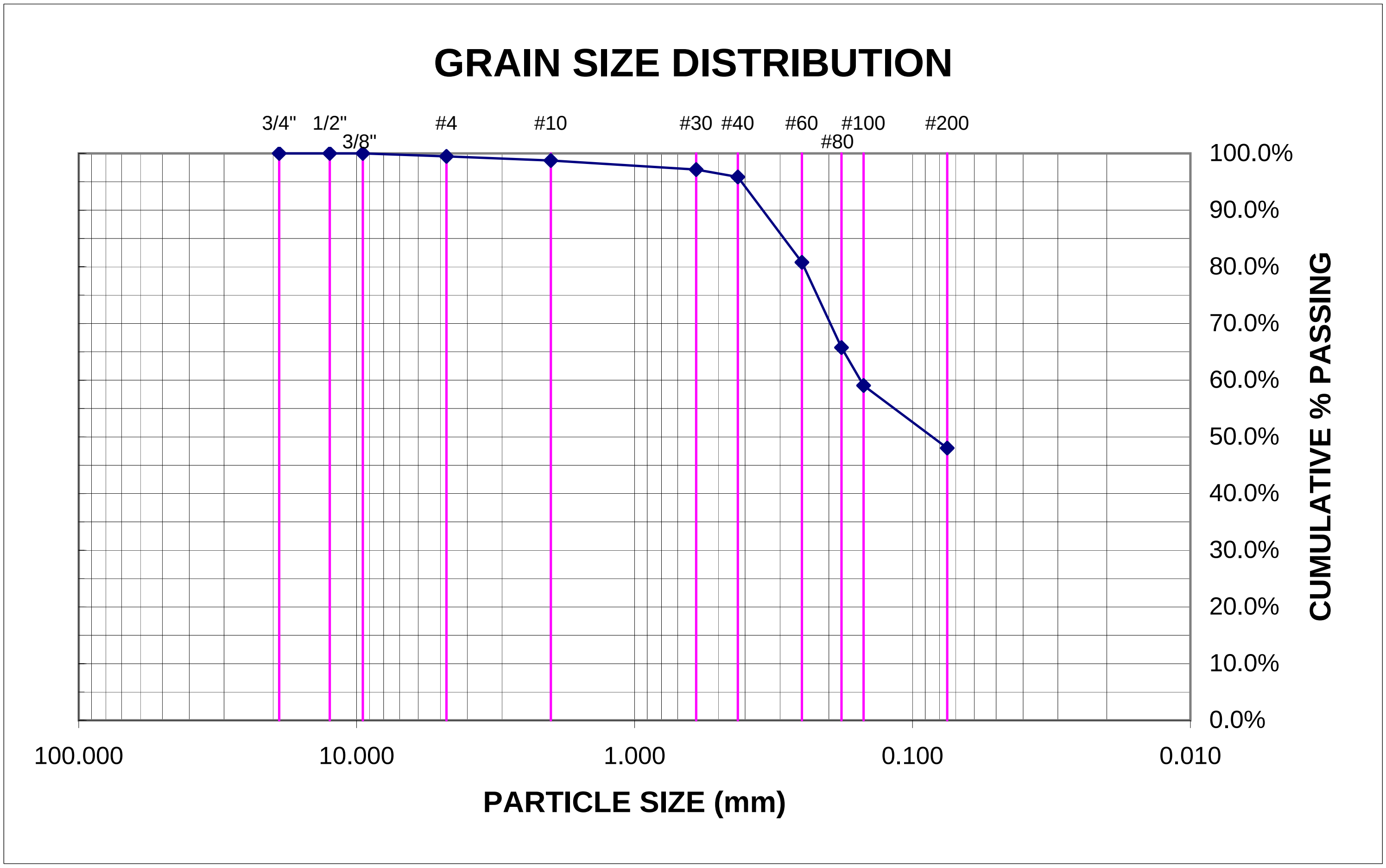
Sampled By: Client

Tested Date: January 4, 2012

Performed By: David Fath

Source: 8506 S-7 12'-14'

Material Description: Brown clayey fine SAND



D$_{80}$: 0.25 mm

D$_{60}$: 0.15 mm

D$_{30}$: --

D$_{10}$: --

% Passing 1/2" Sieve: 100.0%

% Passing 3/8" Sieve: 100.0%

% Passing #4 Sieve: 99.5%

% Passing #10 Sieve: 98.7%

% Passing #30 Sieve: 97.1%

% Passing #40 Sieve: 95.8%

% Passing #60 Sieve: 80.8%

% Passing #80 Sieve: 65.8%

% Passing #100 Sieve: 59.0%

% Passing #200 Sieve: 48.0%

Remarks:

McDowell & Associates

SIEVE ANALYSIS
ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8506 S-14 26'-28'

Sample Date: --

Sampled By: Client

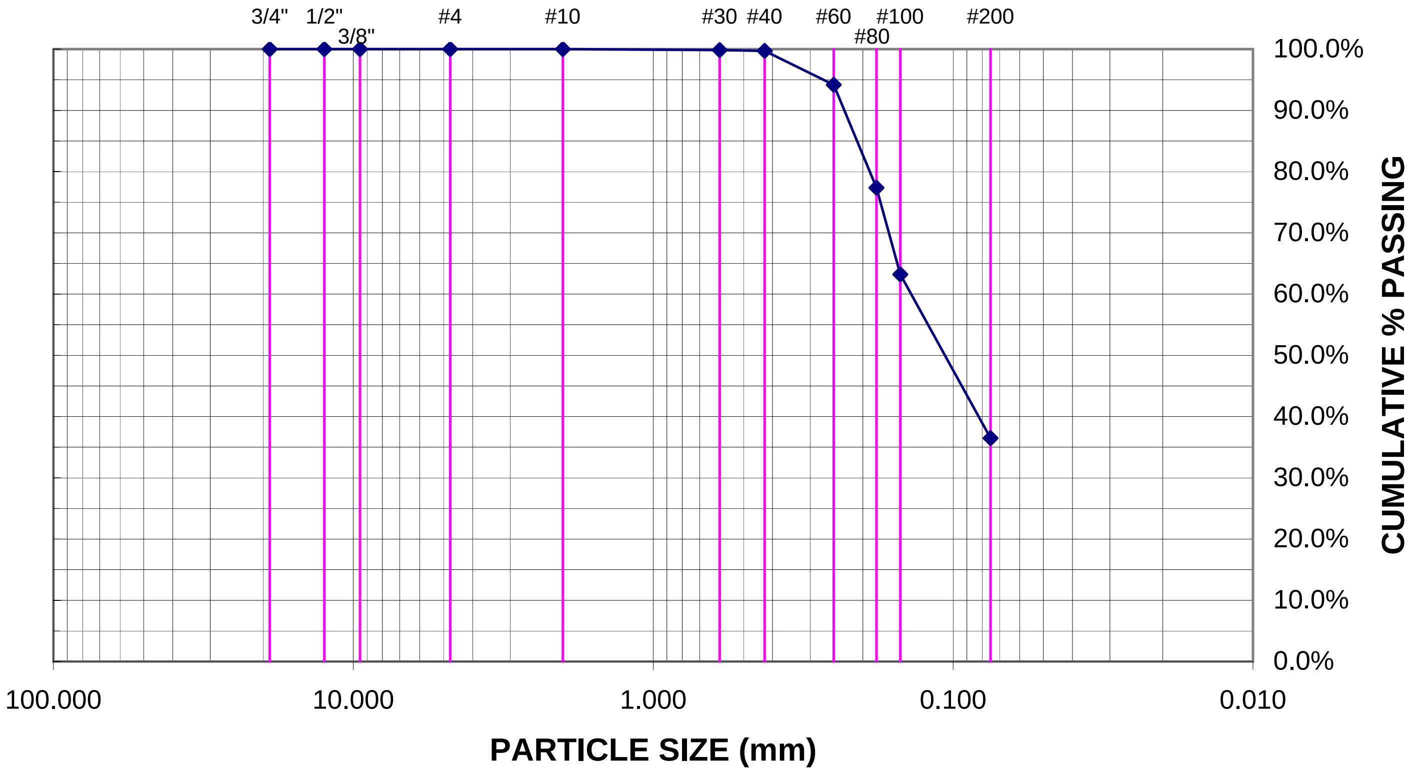
Tested Date: January 4, 2012

Performed By: David Fath

Source: 8506 S-14 26'-28'

Material Description: Dark brown clayey fine SAND

GRAIN SIZE DISTRIBUTION



D_{80}: 0.19 mm

% Passing 1/2" Sieve: 100.0%

% Passing #40 Sieve: 99.7%

D_{60}: 0.14 mm

% Passing 3/8" Sieve: 100.0%

% Passing #60 Sieve: 94.2%

D_{30}: --

% Passing #4 Sieve: 100.0%

% Passing #80 Sieve: 77.4%

D_{10}: --

% Passing #10 Sieve: 100.0%

% Passing #100 Sieve: 63.2%

% Passing #30 Sieve: 99.8%

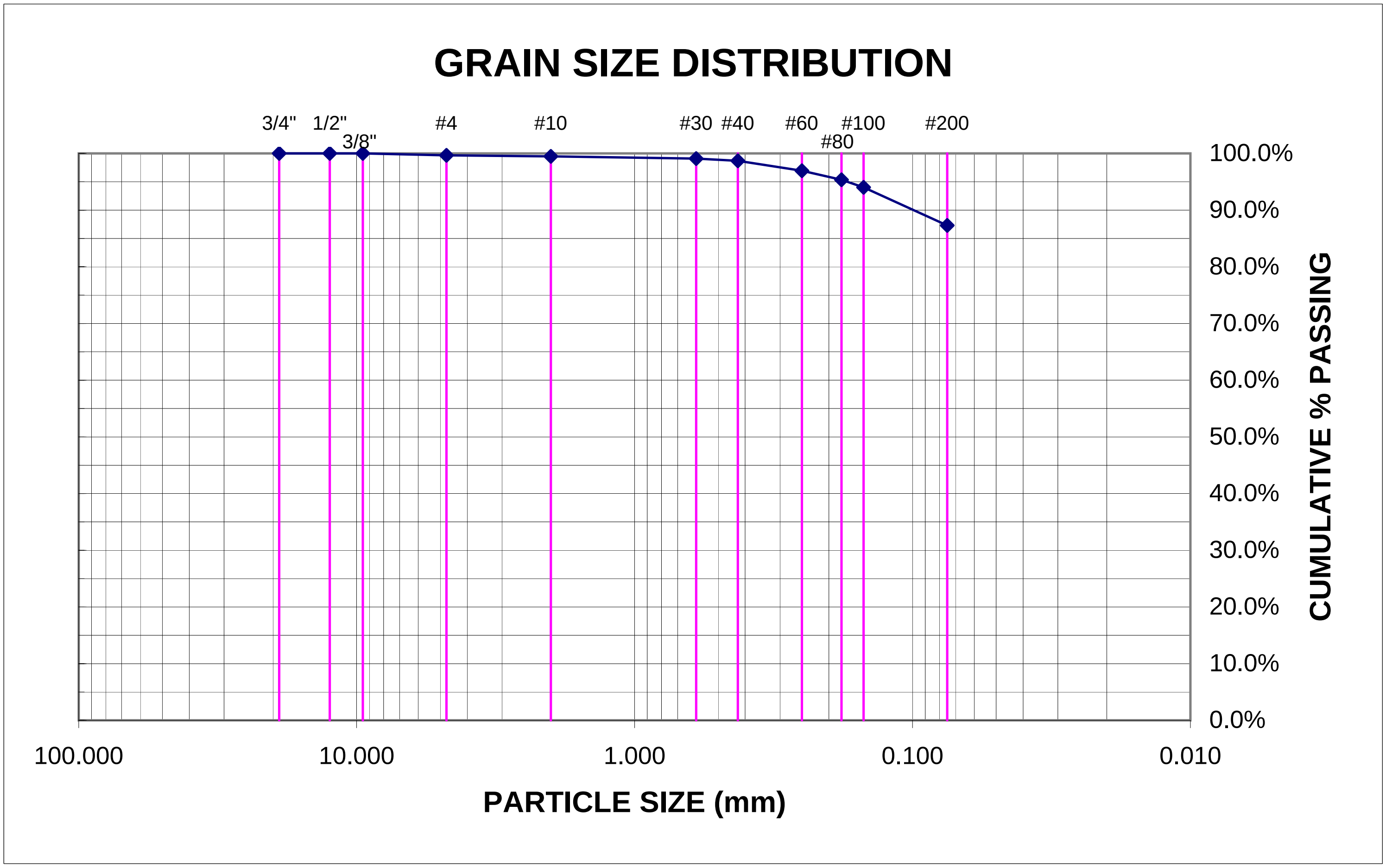
% Passing #200 Sieve: 36.5%

Remarks:

McDowell & Associates

SIEVE ANALYSIS
ASTM D422

Project Name: T-Pond Dike Inspection
Project No.: 11-63260
Client: URS
Sample No.: 8508 ST 7'-9'
Sample Date: --
Sampled By: Client
Tested Date: November 18, 2011
Performed By: David Fath
Source: 8508 ST 7'-9'
Material Description: Brown CLAY with sand



D_{80}: --
% Passing 1/2" Sieve: 100.0%
% Passing #40 Sieve: 98.7%
D_{60}: --
% Passing 3/8" Sieve: 100.0%
% Passing #60 Sieve: 97.0%
D_{30}: --
% Passing #4 Sieve: 99.7%
% Passing #80 Sieve: 95.4%
D_{10}: --
% Passing #10 Sieve: 99.5%
% Passing #100 Sieve: 94.0%
% Passing #30 Sieve: 99.1%
% Passing #200 Sieve: 87.3%

Remarks:

McDowell & Associates

SIEVE ANALYSIS
ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8508 S-8 14.5'-16.5'

Sample Date: --

Sampled By: Client

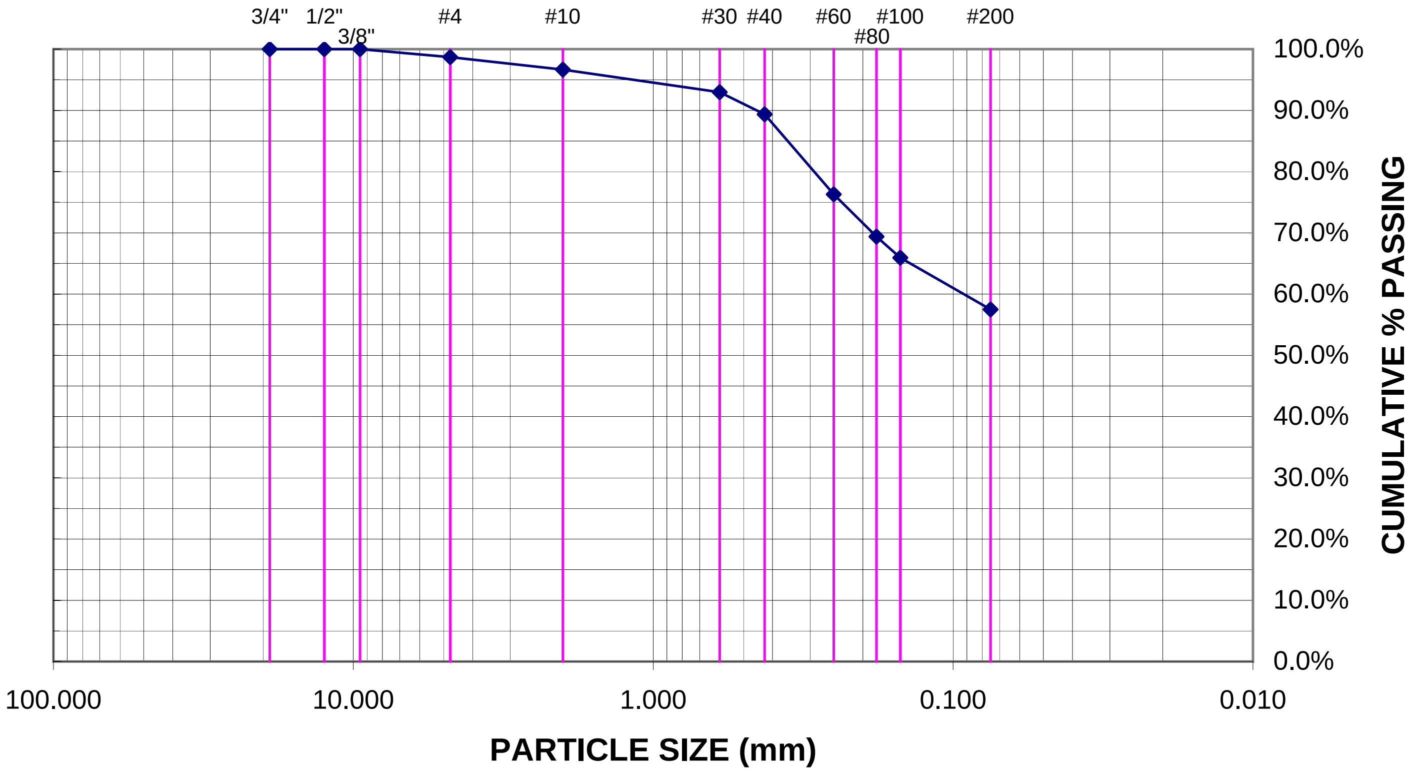
Tested Date: January 5, 2012

Performed By: David Fath

Source: 8508 S-8 14.5'-16.5'

Material Description: Brown sandy CLAY

GRAIN SIZE DISTRIBUTION



D_{80}:	0.29 mm	**% Passing 1/2" Sieve:**	100.0%	**% Passing #40 Sieve:**	89.4%
D_{60}:	0.09 mm	**% Passing 3/8" Sieve:**	100.0%	**% Passing #60 Sieve:**	76.3%
D_{30}:	--	**% Passing #4 Sieve:**	98.7%	**% Passing #80 Sieve:**	69.4%
D_{10}:	--	**% Passing #10 Sieve:**	96.6%	**% Passing #100 Sieve:**	65.9%
		% Passing #30 Sieve:	93.0%	**% Passing #200 Sieve:**	57.5%

Remarks:

McDowell & Associates

SIEVE ANALYSIS

ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8509 (6)

Sample Date: --

Sampled By: Client

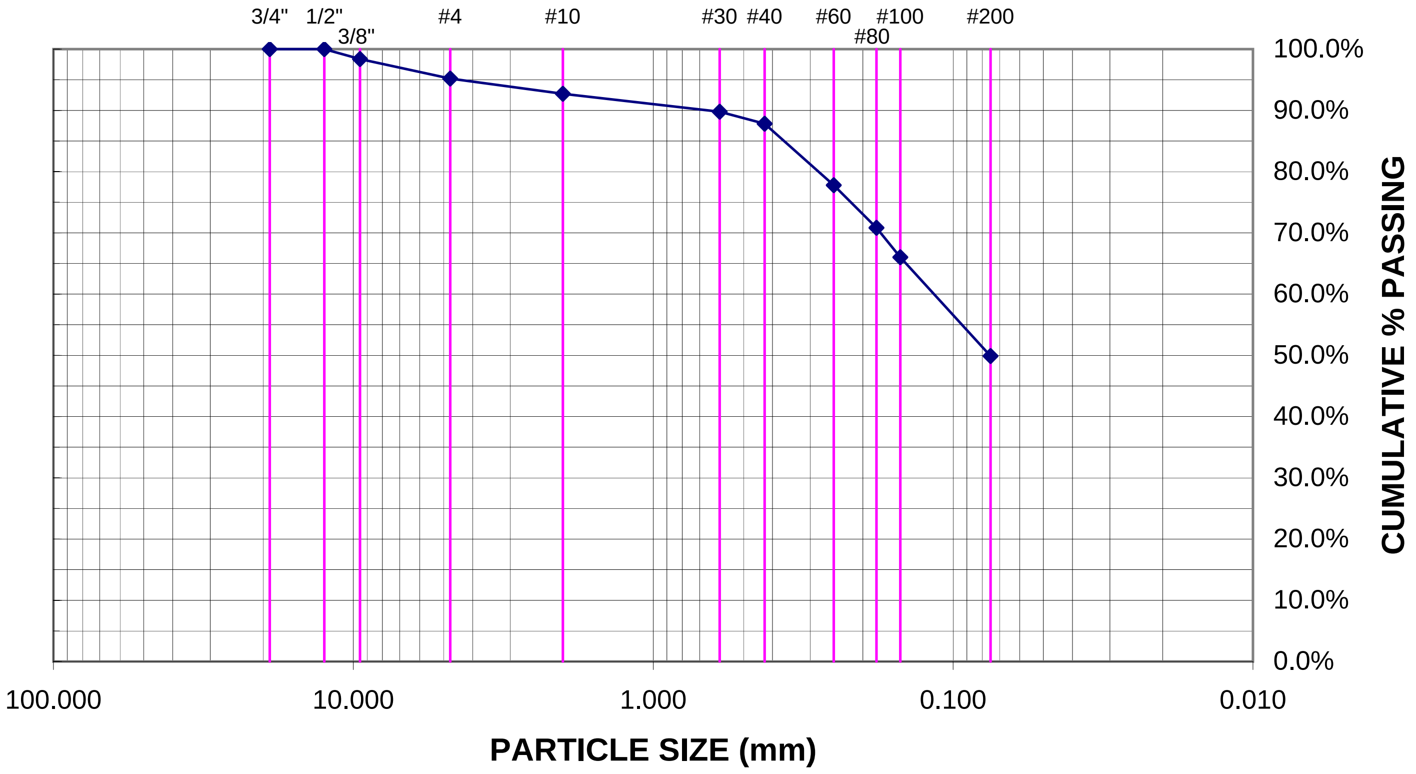
Tested Date: November 18, 2011

Performed By: David Fath

Source: 8509 (6) 10.5-12.5 Feet

Material Description: Light brown clayey SAND

GRAIN SIZE DISTRIBUTION



D$_{80}$: 0.28 mm

D$_{60}$: 0.12 mm

D$_{30}$: --

D$_{10}$: --

% Passing 1/2" Sieve: 100.0%

% Passing 3/8" Sieve: 98.4%

% Passing #4 Sieve: 95.2%

% Passing #10 Sieve: 92.7%

% Passing #30 Sieve: 89.8%

% Passing #40 Sieve: 87.8%

% Passing #60 Sieve: 77.8%

% Passing #80 Sieve: 70.8%

% Passing #100 Sieve: 66.0%

% Passing #200 Sieve: 49.9%

Remarks:

McDowell & Associates

SIEVE ANALYSIS

ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8509 S-9 16.5'-18.5'

Sample Date: --

Sampled By: Client

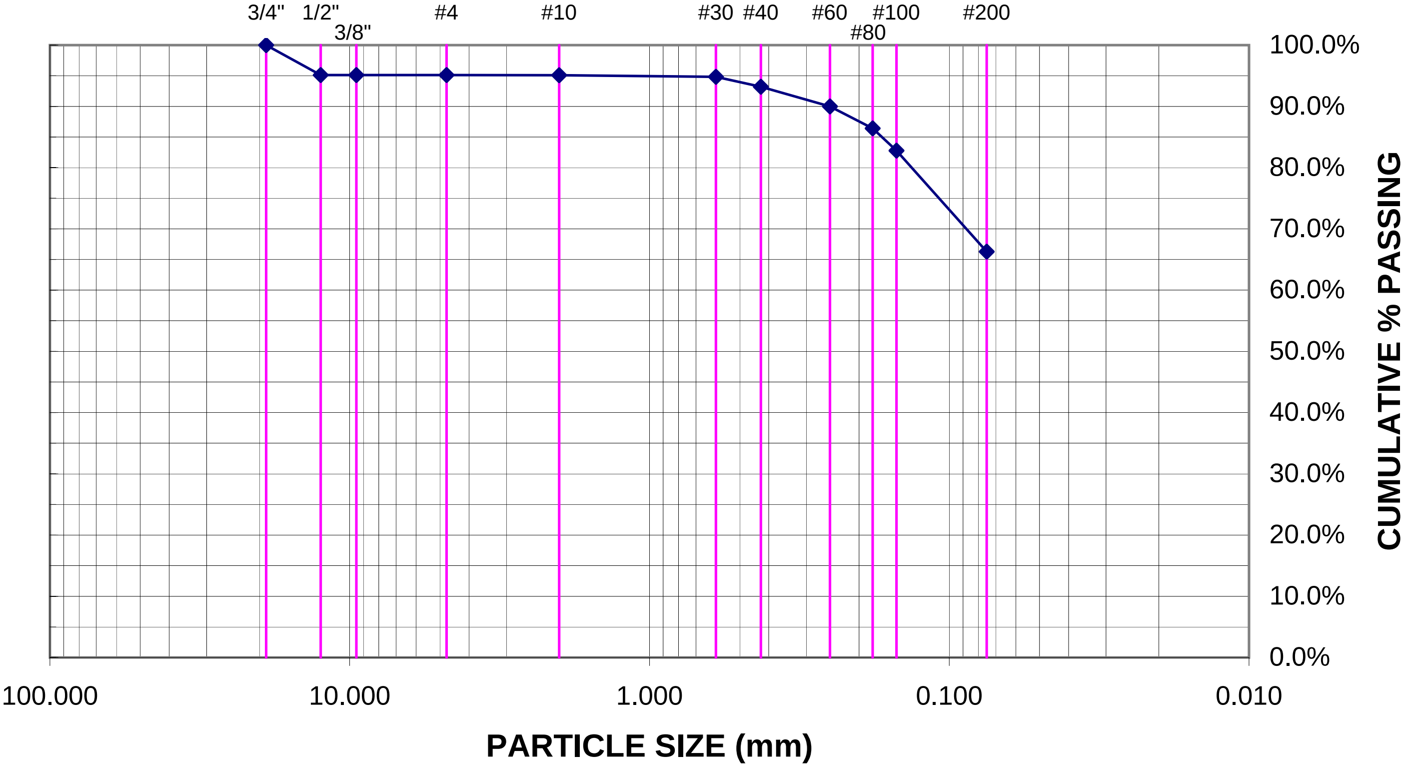
Tested Date: January 6, 2012

Performed By: David Fath

Source: 8509 S-9 16.5'-18.5'

Material Description: Brown sandy CLAY

GRAIN SIZE DISTRIBUTION

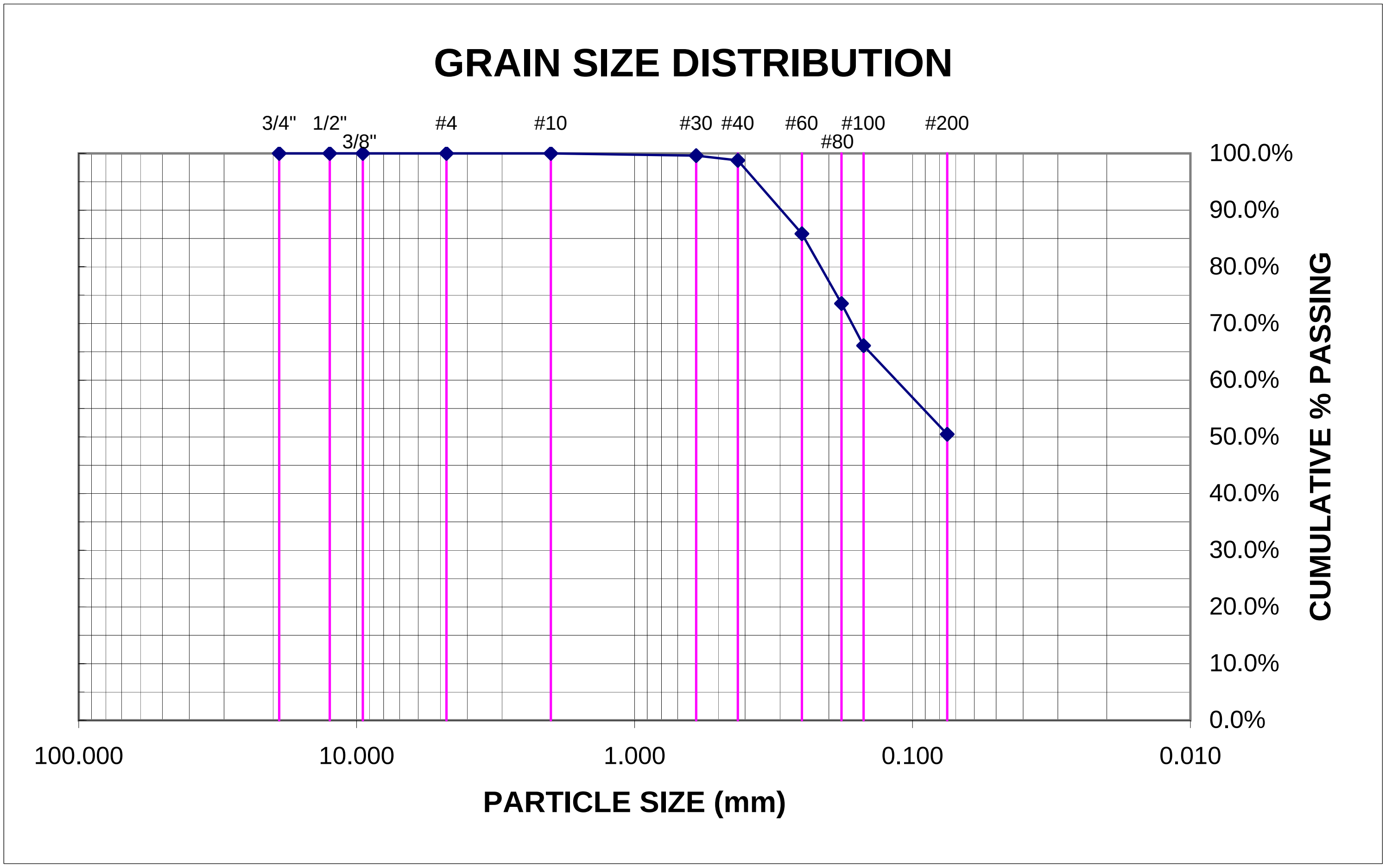


D_{80}:	0.13 mm	**% Passing 1/2" Sieve:**	95.1%	**% Passing #40 Sieve:**	93.2%
D_{60}:	--	**% Passing 3/8" Sieve:**	95.1%	**% Passing #60 Sieve:**	90.0%
D_{30}:	--	**% Passing #4 Sieve:**	95.1%	**% Passing #80 Sieve:**	86.4%
D_{10}:	--	**% Passing #10 Sieve:**	95.1%	**% Passing #100 Sieve:**	82.8%
		% Passing #30 Sieve:	94.8%	**% Passing #200 Sieve:**	66.3%

Remarks:

SIEVE ANALYSIS
ASTM D422

Project Name: T-Pond Dike Inspection
Project No.: 11-63260
Client: URS
Sample No.: 8511 ST 5'-7'
Sample Date: --
Sampled By: Client
Tested Date: November 18, 2011
Performed By: David Fath
Source: 8511 ST 5'-7'
Material Description: Gray sandy CLAY



D_{80}: 0.21 mm
% Passing 1/2" Sieve: 100.0%
% Passing #40 Sieve: 98.8%
D_{60}: 0.11 mm
% Passing 3/8" Sieve: 100.0%
% Passing #60 Sieve: 85.8%
D_{30}: --
% Passing #4 Sieve: 100.0%
% Passing #80 Sieve: 73.5%
D_{10}: --
% Passing #10 Sieve: 100.0%
% Passing #100 Sieve: 66.1%
% Passing #30 Sieve: 99.6%
% Passing #200 Sieve: 50.5%

Remarks:

SIEVE ANALYSIS
ASTM D422

Project Name: T-Pond Dike Inspection

Project No.: 11-63260

Client: URS

Sample No.: 8511 (5)

Sample Date: --

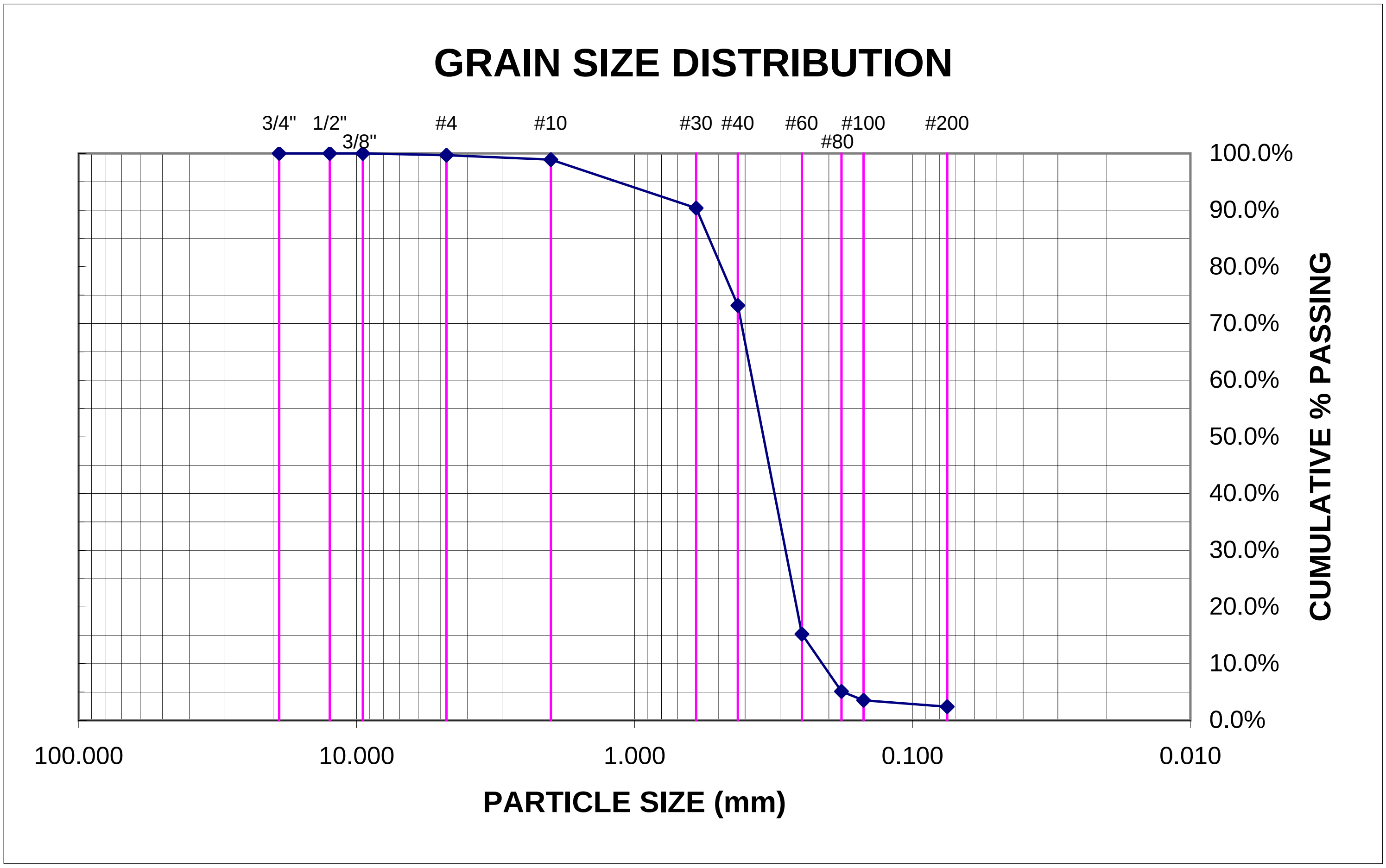
Sampled By: Client

Tested Date: November 18, 2011

Performed By: David Fath

Source: 8511 (5) 8-10 Feet

Material Description: Yellow-orange SAND



D_{80}:	0.49 mm	**% Passing 1/2" Sieve:**	100.0%	**% Passing #40 Sieve:**	73.2%
D_{60}:	0.38 mm	**% Passing 3/8" Sieve:**	100.0%	**% Passing #60 Sieve:**	15.2%
D_{30}:	0.29 mm	**% Passing #4 Sieve:**	99.7%	**% Passing #80 Sieve:**	5.1%
D_{10}:	0.21 mm	**% Passing #10 Sieve:**	98.9%	**% Passing #100 Sieve:**	3.5%
		% Passing #30 Sieve:	90.3%	**% Passing #200 Sieve:**	2.4%

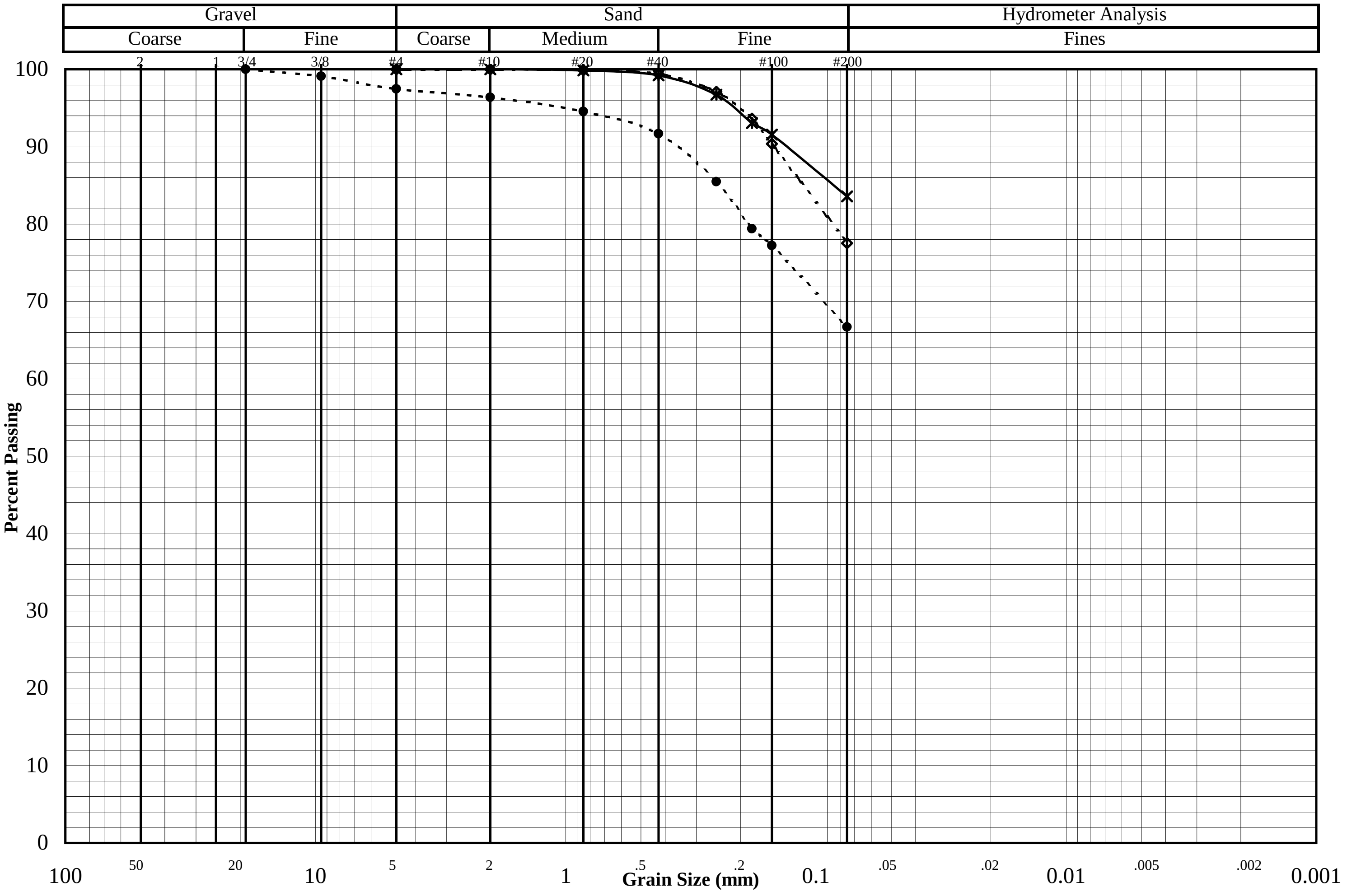
Remarks:

Grain Size Distribution ASTM D422

Job No. : **8227**

Project:	#11-63260	Test Date:	12/15/11
Reported To:	McDowell & Associates	Report Date:	12/22/11

	Location / Boring No.	Sample No.	Depth	Sample Type	Soil Classification
∗	8508		5'5"-5'11"	3T	Lean Clay w/sand (CL)
●	8509		18'-18'6"	3T	Sandy Lean Clay w/a trace of gravel (CL)
◇	8509		21'1"-21'7"	3T	Lean Clay w/sand (CL)



Other Tests

	∗	●	◇
Liquid Limit	49.1	37.3	31.6
Plastic Limit	26.4	20.8	16.1
Plasticity Index	22.7	16.5	15.5
Water Content			
Dry Density (pcf)			
Specific Gravity			
Porosity			
Organic Content			
pH			
Shrinkage Limit			
Penetrometer			
Qu (psf)			

(* = assumed)

Percent Passing

	∗	●	◇
Mass (g)	134.7	162.4	131.7
1"			
3/4"		100.0	
3/8"		99.1	
#4	100.0	97.5	100.0
#10	100.0	96.4	100.0
#20	99.9	94.6	99.9
#40	99.2	91.7	99.4
#60	96.7	85.5	97.1
#80	93.0	79.4	93.6
#100	91.6	77.2	90.4
#200	83.6	66.7	77.5

	∗	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

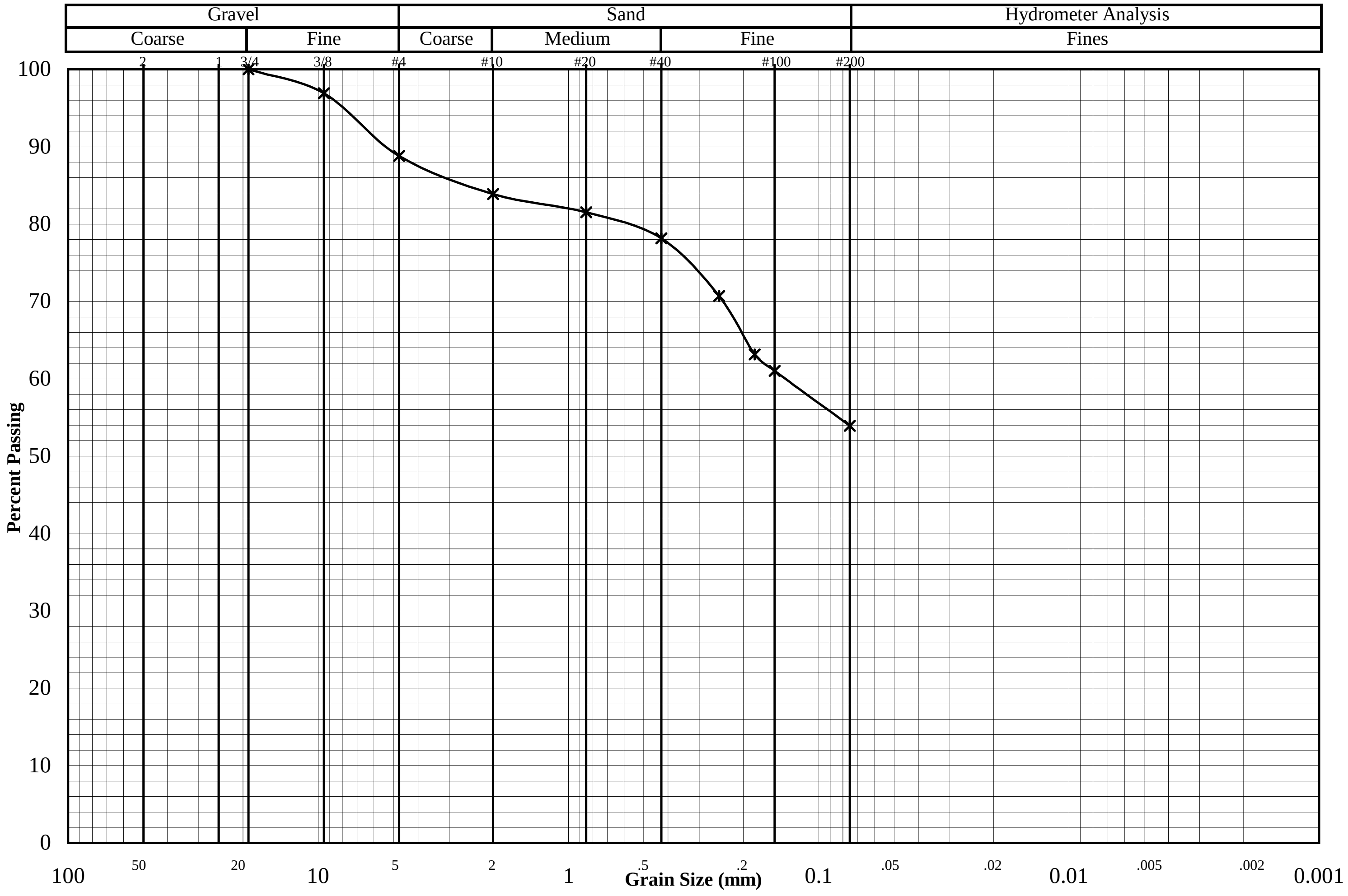
Remarks:

Grain Size Distribution ASTM D422

Job No. : **8227**

Project:	#11-63260	Test Date:	12/15/11
Reported To:	McDowell & Associates	Report Date:	12/22/11

	Location / Boring No.	Sample No.	Depth	Sample Type	Soil Classification
⁎	8511		3'7"-4'1"	3T	Sandy Lean Clay w/a little gravel (CL)
●					
◇					



Other Tests

	⁎	●	◇
Liquid Limit	29.6		
Plastic Limit	13.4		
Plasticity Index	16.2		
Water Content			
Dry Density (pcf)			
Specific Gravity			
Porosity			
Organic Content			
pH			
Shrinkage Limit			
Penetrometer			
Qu (psf)			

(* = assumed)

Percent Passing

	⁎	●	◇
Mass (g)	139.0		
1"			
3/4"	100.0		
3/8"	96.9		
#4	88.8		
#10	83.9		
#20	81.5		
#40	78.2		
#60	70.7		
#80	63.2		
#100	61.0		
#200	53.9		

	⁎	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

Direct Shear Test

ASTM: D3080

Job No.: **8227**

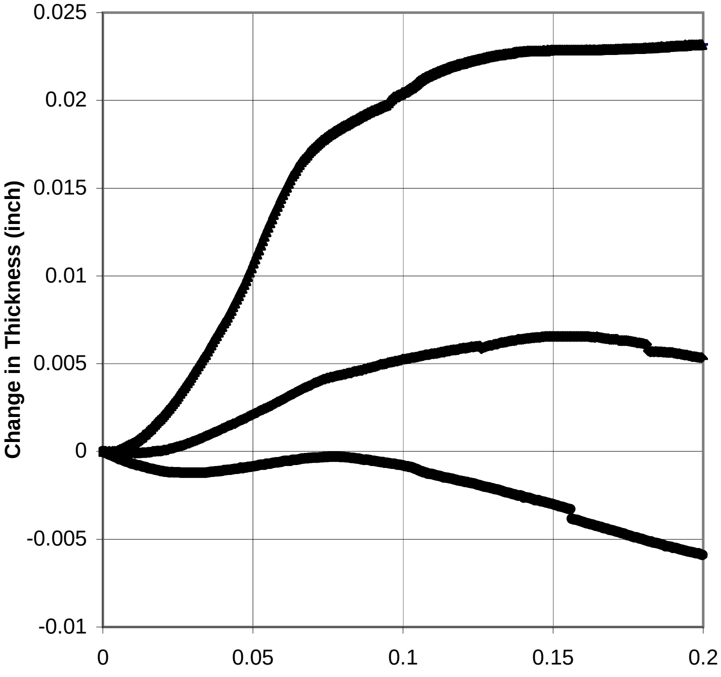
Project: **#11-63260**
Boring No.: **8508** Sample No. Depth: **5'5"-5'11"**
Location: Sample Type: **TWT**
Soil Type: **Lean Clay with Sand (CL)**

Test Date:	**12/15/2011**
Date Reported:	**12/22/2011**
Shear Rate	
0.0006 (in/min)	

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load. Consolidated and sheared to given displacements at constant rate of 0.0006 inches/minute.

(*) = Assumed Specific Gravity

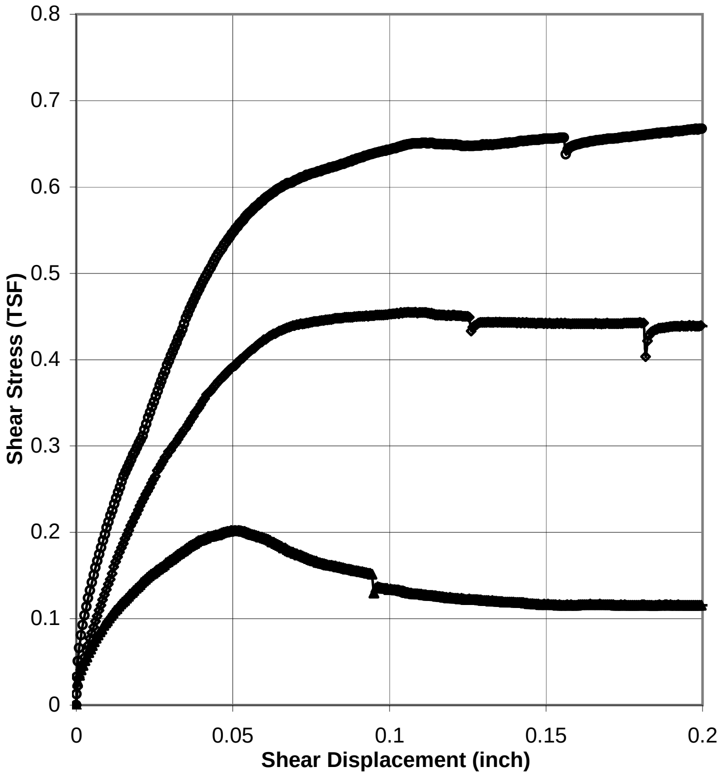
Liquid Limit:	**49.1**
Plastic Limit:	**26.4**
Plasticity Index:	**22.7**
Specific Gravity (*):	**2.68**

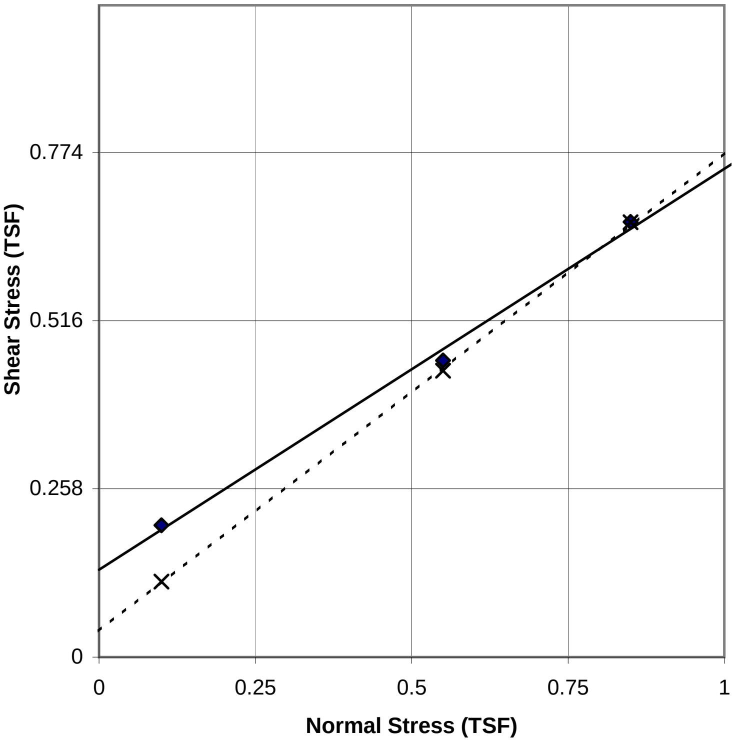


Failure Criterion:				
Max Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.51	2.51	2.51	
Thickness (In.)	0.75	0.75	0.75	
Water Content (%)	22.2	22.2	22.2	
Dry Density (pcf)	91.3	87.5	86.0	
Before Shear				
Thickness (In.)	0.74	0.73	0.72	
Water Content (%)	30.5	31.9	32.4	
Dry Density (pcf)	92.1	90.2	89.5	
Normal Stress	0.10	0.55	0.85	
Shear Stress	0.20	0.46	0.67	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions			At Given Shear Disp. Of:		0.2
Friction Angle:	$\phi=$ **31.6**	**deg.**	Friction Angle:	$\phi=$ **36.2**	**deg.**
Apparent Cohesion	**0.134**	**TSF**	Apparent Cohesion	**0.040**	**TSF**





Direct Shear Test

ASTM: D3080

Job No.: 8227

Project: **#11-63260**
Boring No.: **8509** Sample No. Depth: **18'- 18'6"**
Location: Sample Type: **TWT**
Soil Type: **Sandy Lean Clay with a trace of gravel (CL)**

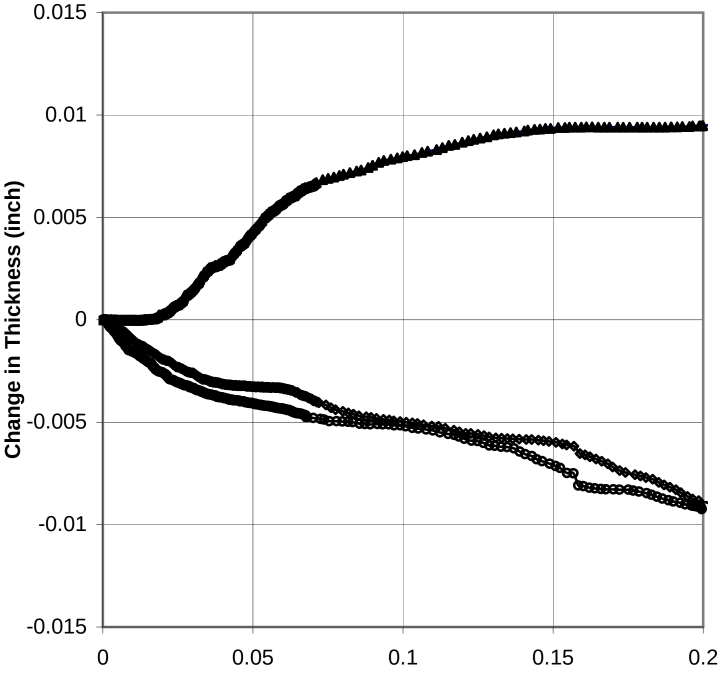
Test Date:	**12/15/2011**
Date Reported:	**12/22/2011**

Shear Rate
0.0006 (in/min)

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load. Consolidated and sheared to given displacements at constant rate of 0.0006 inches/minute.

(*) = Assumed Specific Gravity

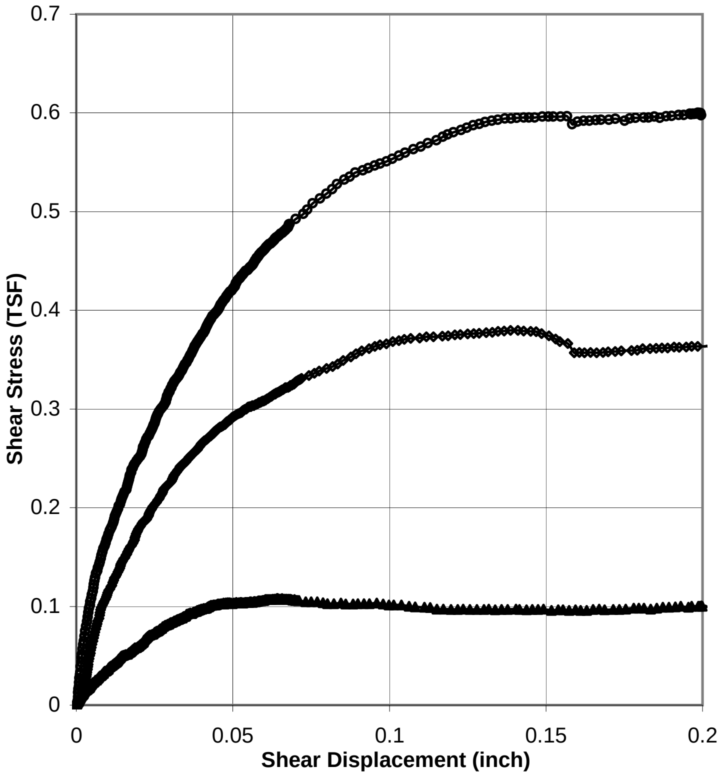
Liquid Limit:	**37.3**
Plastic Limit:	**20.8**
Plasticity Index:	**16.5**
Specific Gravity (*):	**2.68**

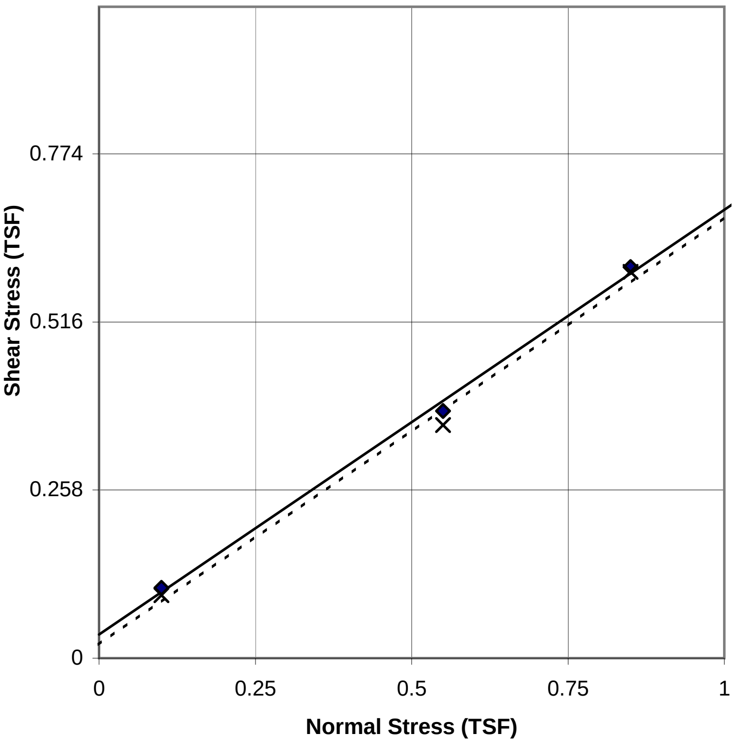


Failure Criterion:				
Max Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.51	2.51	2.51	
Thickness (In.)	0.99	0.99	0.99	
Water Content (%)	21.2	21.2	21.2	
Dry Density (pcf)	104.9	100.6	103.0	
Before Shear				
Thickness (In.)	0.97	0.96	0.95	
Water Content (%)	21.1	22.7	20.5	
Dry Density (pcf)	106.8	104.0	108.1	
Normal Stress	0.10	0.55	0.85	
Shear Stress	0.11	0.38	0.60	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions			At Given Shear Disp. Of:		0.17
Friction Angle:	ϕ= **33.1**	**deg.**	Friction Angle:	ϕ= **33.2**	**deg.**
Apparent Cohesion	**0.036**	**TSF**	Apparent Cohesion	**0.021**	**TSF**





Direct Shear Test

ASTM: D3080

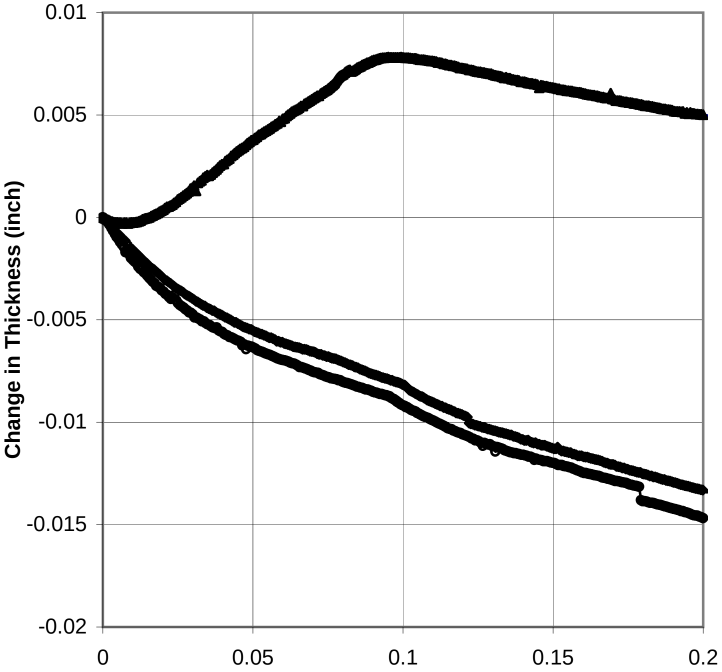
Job No.: 8227

Project:	**#11-63260**				
Boring No.:	**8509**	Sample No.	Depth: **21'1"-21'7"**	Test Date:	**12/15/2011**
Location:			Sample Type: **TWT**	Date Reported:	**12/22/2011**
Soil Type:	**Lean Clay with Sand (CL) - Specimen "A" contained more sand than Specimens "B" & "C**			Shear Rate	
				0.0006 (in/min)	

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load. Consolidated and sheared to given displacements at constant rate of 0.0006 inches/minute.

(*) = Assumed Specific Gravity

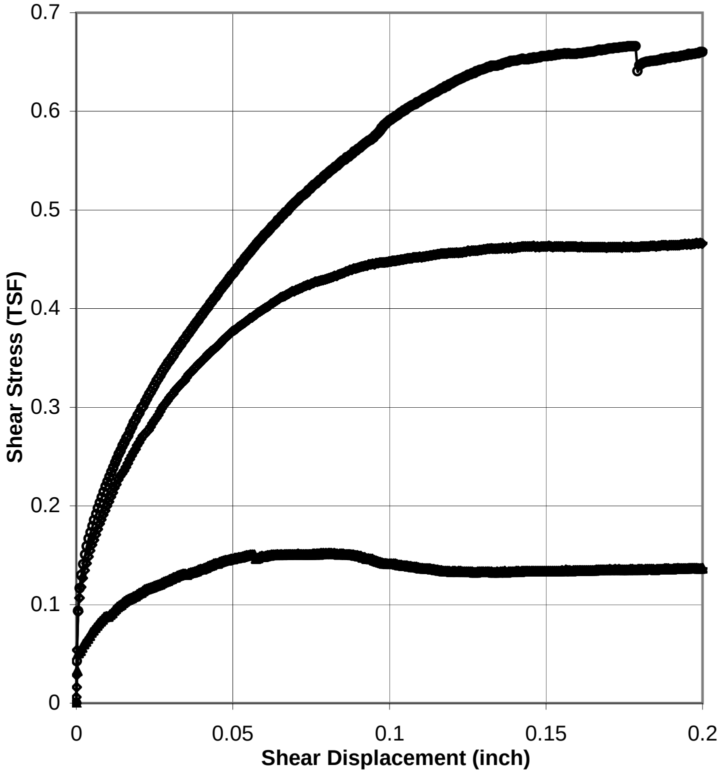
Liquid Limit:	**31.6**
Plastic Limit:	**16.1**
Plasticity Index:	**15.5**
Specific Gravity (*):	**2.68**

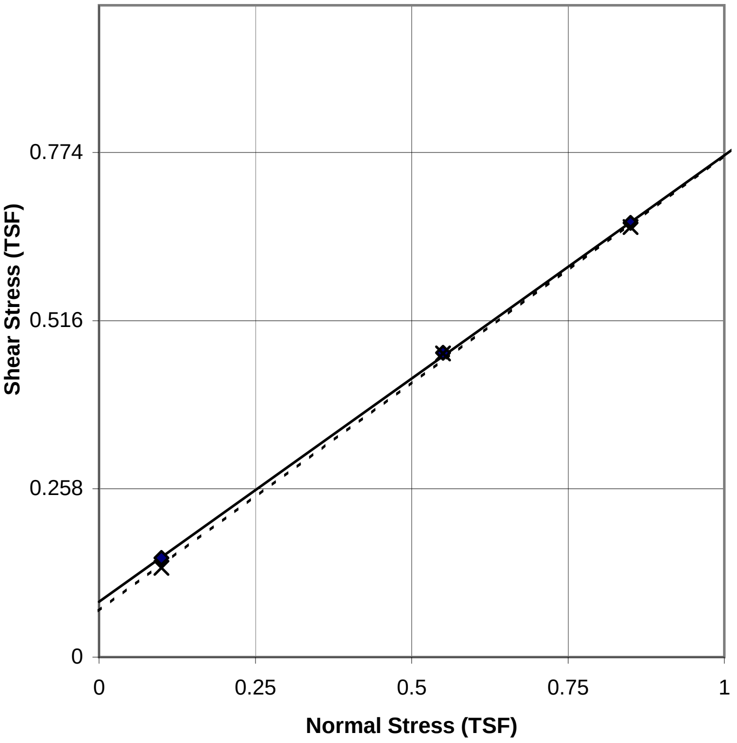


Failure Criterion:				
Max Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.51	2.51	2.51	
Thickness (In.)	1.00	1.00	1.00	
Water Content (%)	21.8	23.1	22.0	
Dry Density (pcf)	104.7	101.5	102.6	
Before Shear				
Thickness (In.)	0.97	0.96	0.95	
Water Content (%)	20.8	21.8	20.3	
Dry Density (pcf)	107.4	105.6	108.3	
Normal Stress	0.10	0.55	0.85	
Shear Stress	0.15	0.47	0.67	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions		At Given Shear Disp. Of:	0.2
Friction Angle:	φ= **34.4 deg.**	Friction Angle:	φ= **34.9 deg.**
Apparent Cohesion	**0.085 TSF**	Apparent Cohesion	**0.071 TSF**





Direct Shear Test

ASTM: D3080

Job No.: **8227**

Project: **#11-63260**
Boring No.: **8511** Sample No. Depth: **3'7"-4'1"**
Location: Sample Type: **TWT**
Soil Type: **Sandy Lean Clay with a little gravel (CL)**

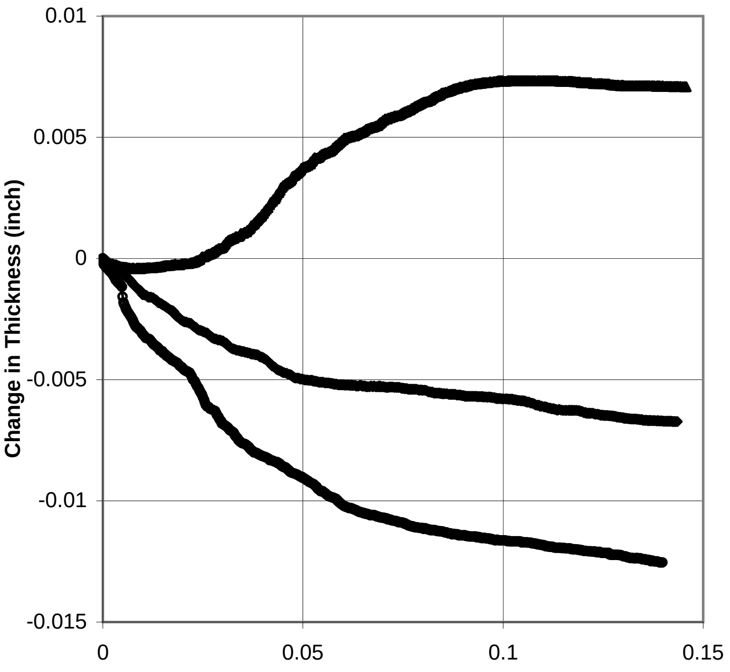
Test Date:	**12/15/2011**
Date Reported:	**12/22/2011**

Shear Rate
0.0006 (in/min)

Remarks: Specimens trimmed to given sizes; Inundated after applying normal load. Consolidated and sheared to given displacements at constant rate of 0.0006 inches/minute.

(*) = Assumed Specific Gravity

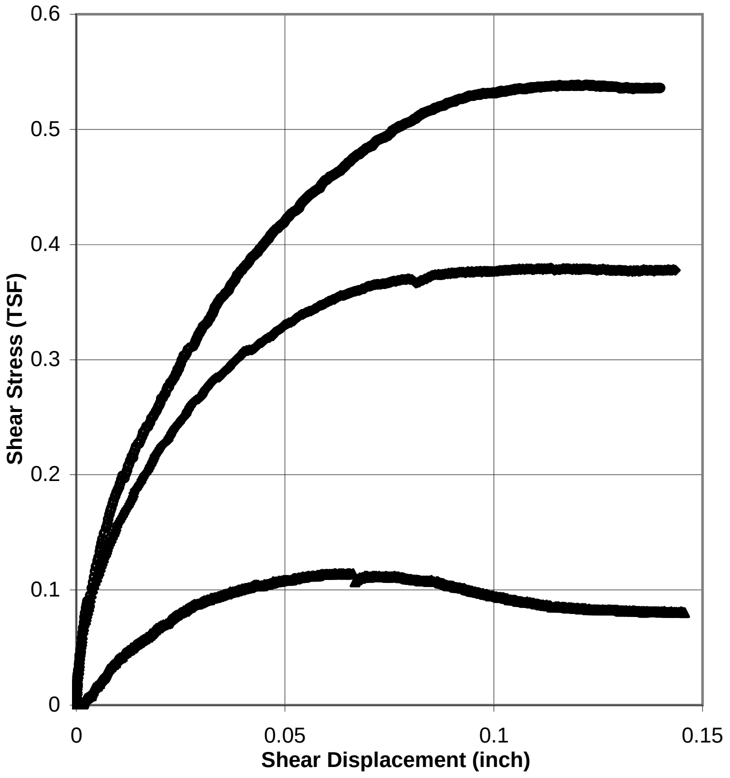
Liquid Limit:	**29.6**
Plastic Limit:	**13.4**
Plasticity Index:	**16.2**
Specific Gravity (*):	**2.68**

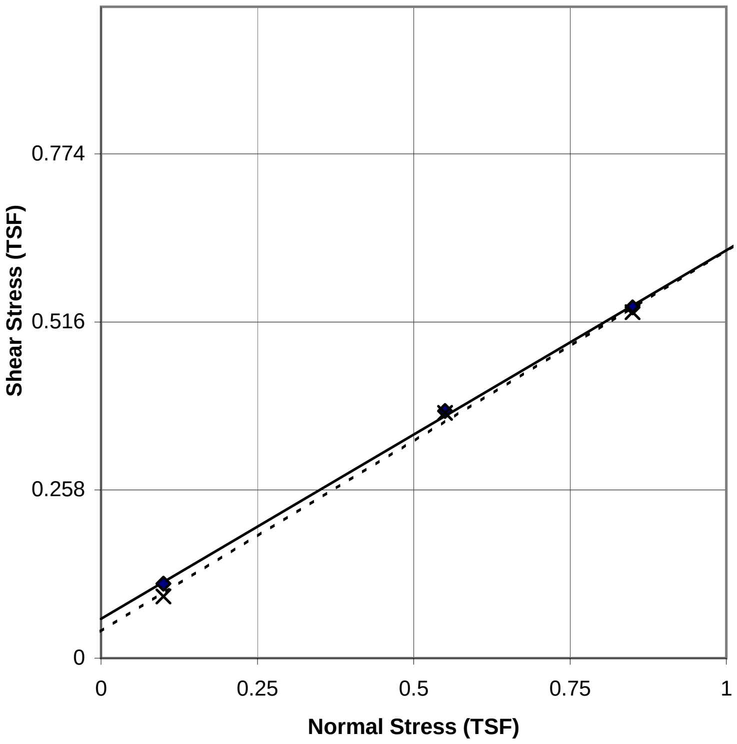


Failure Criterion:				
Max Stress	A	B	C	D
Initial	▲	◇	○	X
Diameter (In.)	2.51	2.51	2.51	
Thickness (In.)	1.00	1.00	1.00	
Water Content (%)	18.6	17.7	17.9	
Dry Density (pcf)	112.7	113.2	114.0	
Before Shear				
Thickness (In.)	0.99	0.97	0.95	
Water Content (%)	17.7	16.5	15.0	
Dry Density (pcf)	113.4	116.1	119.4	
Normal Stress	0.10	0.55	0.85	
Shear Stress	0.11	0.38	0.54	

"These tests are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design."

Peak Conditions			At Given Shear Disp. Of:		0.1
Friction Angle:	$\phi=$ **29.5**	**deg.**	Friction Angle:	$\phi=$ **30.3**	**deg.**
Apparent Cohesion	**0.060**	**TSF**	Apparent Cohesion	**0.041**	**TSF**





APPENDIX C

SLOPE/W Results

SLOPE FAILURE ANALYSIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

FORENSIC ANALYSIS
STABILITY OF SLOPE WITH EXISTING CONDITIONS

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °

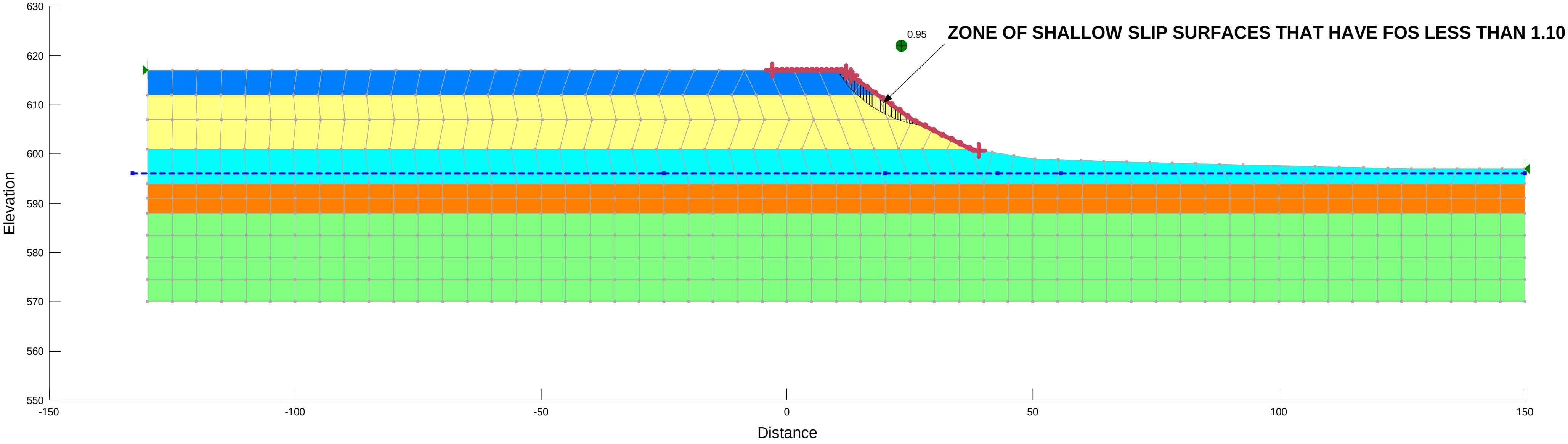


FIGURE - C1

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ STABILITY ANALYSIS -FORENSIC.GSZ

SLOPE FAILURE ANALYSIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

GLOBAL STABILITY OF SLOPE WITH EXISTING CONDITIONS

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °

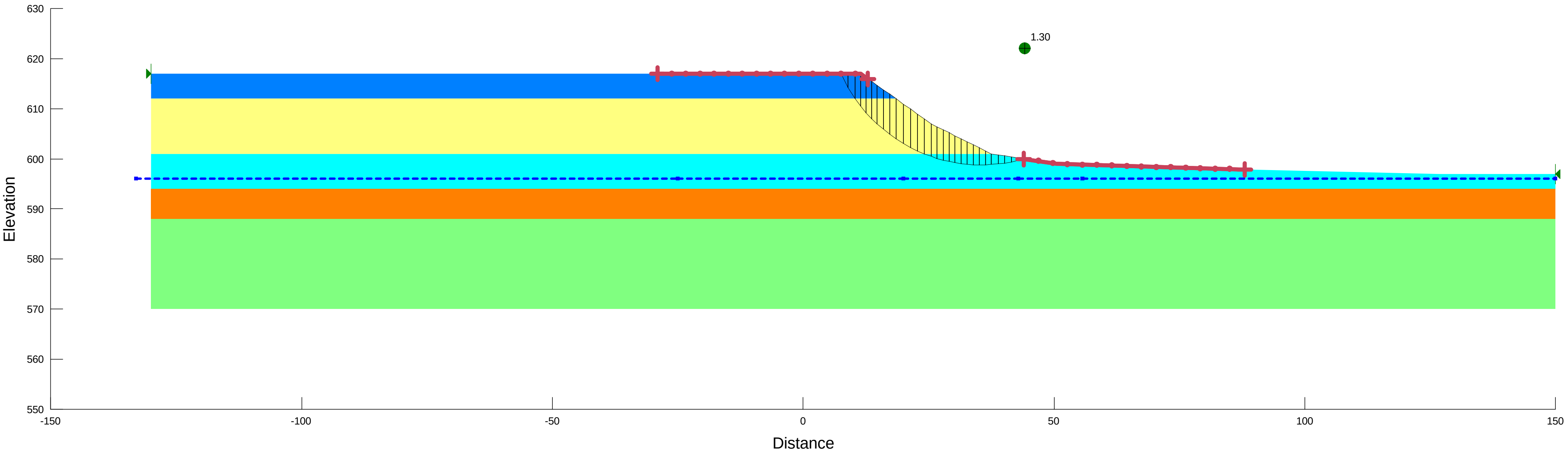


FIGURE - C2

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ STABILITY ANALYSIS -FORENSIC - GLOBAL FOS.GSZ

SLOPE FAILURE ANALYIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

SLOPE STABILITY ANALYSIS - SLOPE REPAIR
MITIGATED SHALLOW SLOPE FAILURE

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 132 pcf Cohesion: 300 psf Phi: 28 °

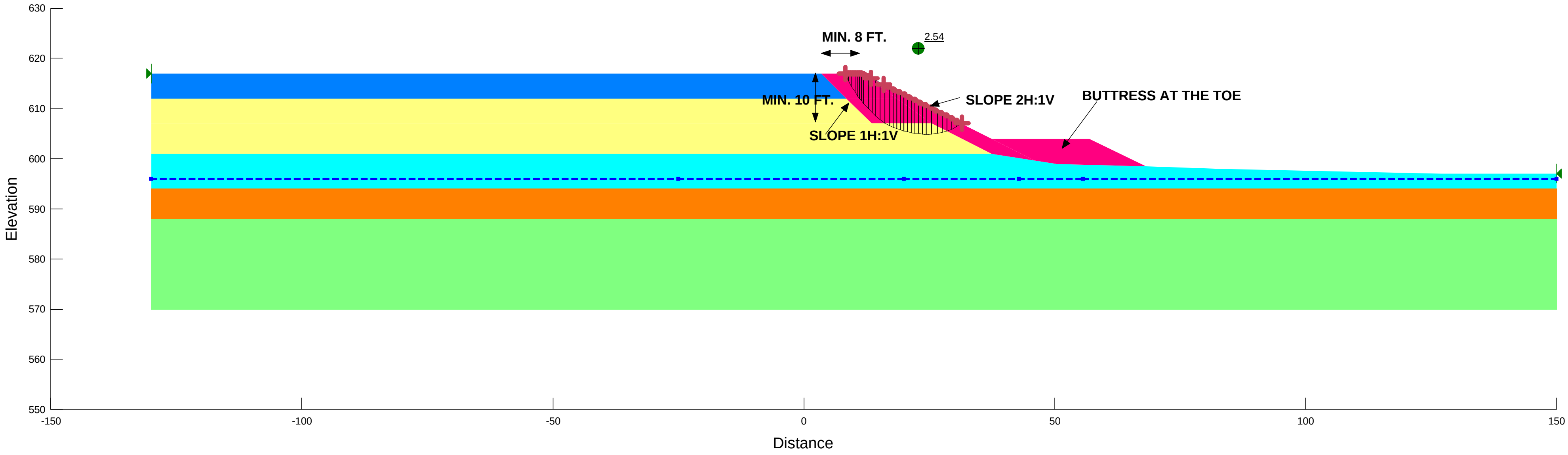


FIGURE - C3

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ SLOPE SECTION - IMPROVEMENT OPTION 1 - STEADY STATE-1.GSZ

SLOPE FAILURE ANALYIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

SLOPE STABILITY ANALYSIS - SLOPE REPAIR
STEADY STATE SEEPAGE CASE

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 132 pcf Cohesion: 300 psf Phi: 28 °

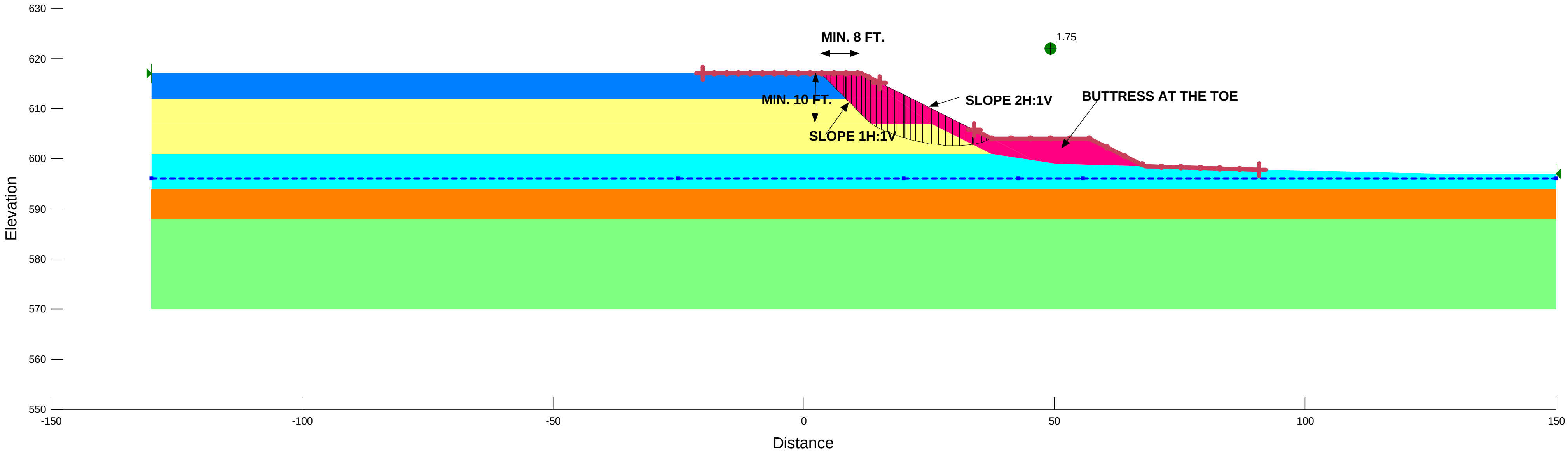


FIGURE - C4

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ SLOPE SECTION - IMPROVEMENT OPTION 1 - STEADY STATE.GSZ

SLOPE FAILURE ANALYIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

SLOPE STABILITY ANALYSIS - SLOPE REPAIR
SUDDEN DRAWDOWN CASE

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 132 pcf Cohesion: 300 psf Phi: 28 °

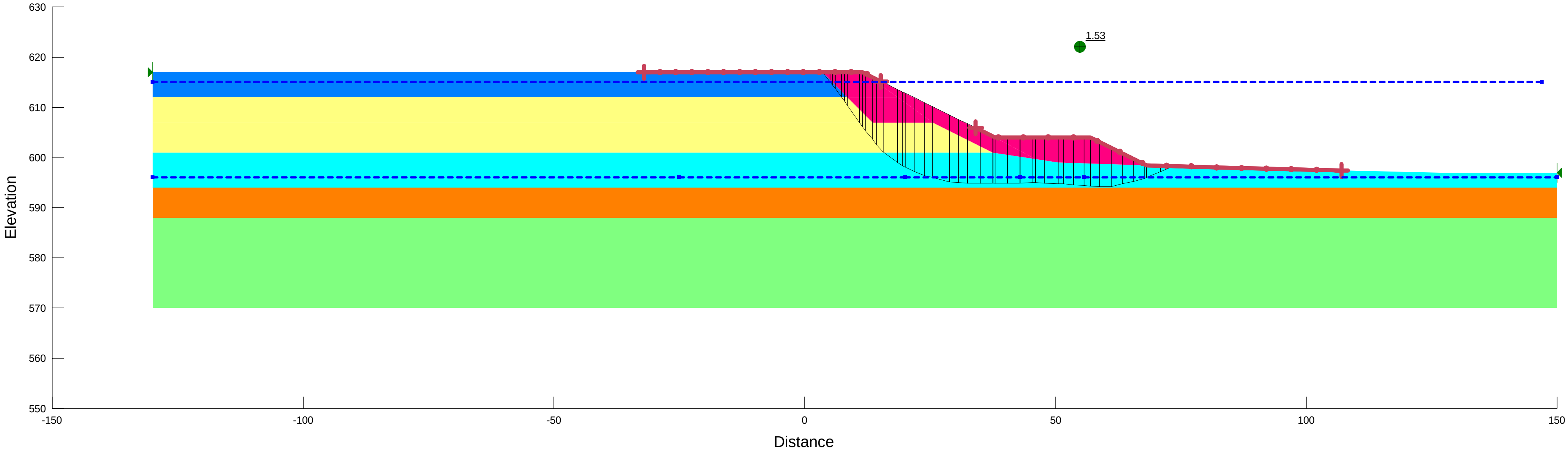


FIGURE - C5

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ SLOPE SECTION - IMPROVEMENT OPTION 1 - SUDDEN DD.GSZ

SLOPE FAILURE ANALYIS - T-POND
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

SLOPE STABILITY ANALYSIS - SLOPE REPAIR
EARTHQUAKE LOADING CASE

CALCULATED BY: NS
CHECKED BY: VKG

DATE: 1/5/2012

Name: Sand Fill Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Clay Fill Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 25 psf Phi: 32 °
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion: 250 psf Phi: 38 °
Name: Lacustrine Sand Model: Mohr-Coulomb Unit Weight: 110 pcf Cohesion: 0 psf Phi: 28 °
Name: Lacustrine Clay Model: Mohr-Coulomb Unit Weight: 128 pcf Cohesion: 0 psf Phi: 30 °
Name: Compacted Fill Model: Mohr-Coulomb Unit Weight: 132 pcf Cohesion: 300 psf Phi: 28 °

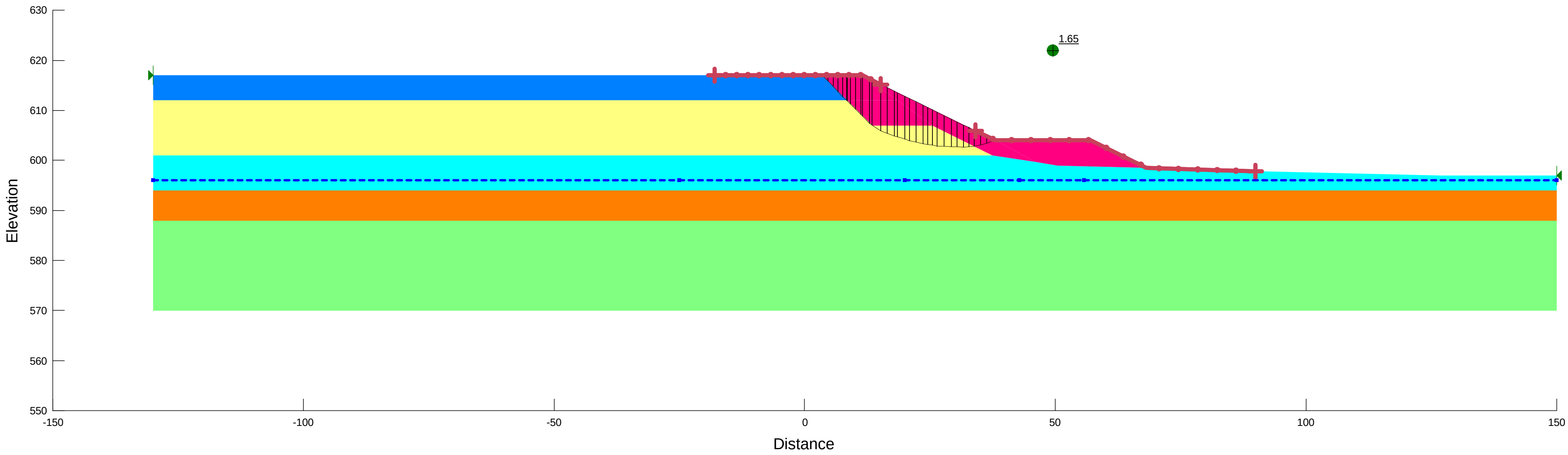


FIGURE - C6

DIRECTORY: K:\PROJECTS\D\DOW\41569029\DOCS\ANALYSES\SLOPE STABILITY\ SLOPE SECTION - IMPROVEMENT OPTION 1 - EARTHQUAKE.GSZ

ATTACHMENT XIV.C5

APPENDIX C5-B

TERTIARY POND DIKE/DAM EMBANKMENT INBOARD FILL SUMMARY REPORT

The Dow Chemical Company
Midland, Michigan 48667
USA

October 17, 2014

CERTIFIED MAIL
7014 0150 0000 7880 2526

Bryce Feighner, Chief
Office of Waste Management and Radiological Protection
Michigan Department of Environmental Quality
P.O. Box 30241
Lansing, MI 48909

cc: Cheryl Howe, MDEQ-OWMRP, P.O. Box 30241, Lansing, MI 48909
Trisha Confer, MDEQ-OWMRP, 401 Ketchum St, Suite B, Bay City, MI 48708
James T. Pawloski, MDEQ-WRD, 2100 West M-32, Gaylord, MI

Subject: THE DOW CHEMICAL COMPANY – MID 000 724 724 MINOR MODIFICATION 15
PART 315 DAM SAFETY PERMIT NO. 13-56-0026-P
TERTIARY POND DAM EMBANKMENT INBOARD FILL SUMMARY REPORT

Attached please find the Summary Report for the Tertiary Pond Dam Embankment Inboard Fill performed under the above referenced License Modification and Part 315 Dam Safety Permit. This Summary Report describes the work conducted and completed per the requirements of the modification and permit.

If you have any questions regarding this report, please contact Brent Gaudreau at (989) 636-6503.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Shari Kennett
Responsible Care Leader
Environment, Health and Safety
1790 Building, Washington Street
Midland, MI 48674

btg
Attachments

The Dow Chemical Company
MID 000 724 724
Minor Modification 15
and
Part 315 Dam Safety Permit No.13-56-0026-P
Tertiary Pond Dam Embankment Inboard Fill
Summary Report

October 17, 2014
Prepared by URS Corporation

Table of Contents

Figure

Attachments

1.0 Introduction

The purpose of this report is to summarize construction activities related to the Minor Hazardous Waste Management Facility Operating License (License) Modification; Amendment 15 - Approval of Tertiary Pond Dam Embankment Inboard Fill; The Dow Chemical Company (Dow), Michigan Operations, Midland, Michigan; MID 000 724 724 (Minor Modification 15) issued August 27, 2013, and Part 315 Dam Safety Program Permit 13-56-0026-P (Permit 13-56-0026-P) issued August 29, 2013, Tertiary Pond Dam Embankment Inboard Fill (Inboard Fill Project).

Dow submitted the Minor Modification 15 Request on July 3, 2013, and provided a response to Michigan Department of Environmental Quality's (MDEQ's) Dr. Xuede (Dan) Qian's July 24, 2013 technical comments on August 6, 2013. The Permit 13-56-0026-P Application was submitted on July 1, 2013.

The approved construction activities included placing fill and rip rap to widen the embankment, and construct a new pipeline rack system on the inboard slope of the Tertiary Pond Dam embankment in accordance with the plans and specifications supplied in each request package. This summary report will provide documentation of completed construction activities, actual quantities used in construction, and as-built conditions.

2.0 Pre-Construction Submittals

A pre-condition in the Minor Modification 15 approval was that prior to the start of construction, laboratory testing to establish the internal friction angle of the proposed aggregate materials to be used in construction be performed. This was conducted to confirm the assumptions of URS Corporation's (URS') Technical Memorandum dated June 28, 2013, titled "Dike Stability Analysis Supporting T-Pond Filtration Project" slope stability analysis included in the Minor Modification 15 request and the Permit 13-56-0026-P application submittals.

A minor deviation from the original construction plans in the License and Permit submittals was the construction contractor's substitution of a more coarse MDOT 4AA aggregate, in lieu of MDOT 6AA. Geotechnical laboratory shear testing was performed on the two aggregate components, MDOT 21AA (as designed) and the MDOT 4AA. These results were submitted via electronic message to MDEQ on November 21, 2013. On December 2, 2013 a conference call was held with Dow, MDEQ, and URS attendees to discuss the results. These results were incorporated into Attachment A of this Summary Report, titled Dike Stability Analysis Supporting T-Pond Filtration Project – Revised Analysis, dated December 3, 2013. Resultant factors of safety were in line with the previously submitted stability analysis in the June 28, 2013 URS Technical Memorandum License Modification and Permit Application requests. On December 3, 2013 MDEQ provided Dow with an electronic message granting approval of the MDOT 4AA aggregate for the embankment fill construction.

3.0 Construction Activities

The following construction activities were performed during the Inboard Fill Project:

- Site preparation;
- Import and placement of fill materials; and
- Wood pile, Pipe support pile caps pipe installation.

A photo log of construction activities can be found in Attachment B.

3.1 Site Preparation

Embankment fill construction activities commenced on November 18, 2013. A turbidity curtain was installed in the pond around the embankment area to be filled, to minimize pond sediment mobilization. Prior to importing fill material, existing rip rap was removed from the pond's inboard slope and staged for reuse.

3.2 Import and Placement of Fill Materials

Fill activities were performed between December 1 through December 12, 2013. Work began at the northwest corner of the embankment fill area by placing the 4AA with an excavator down the existing bank. Once sufficient material was placed to form a ramp, dump trucks were backed down the ramp to deposit additional stone. A rubber tired loader conveyed the aggregate to a placement stockpile. The 4AA material was placed with an excavator below the water line. Once above the water line, smaller 21AA material was then pushed into 12-inch lifts with a bulldozer. A vibratory compactor was used to compact and proof roll each lift up to the design elevation. Various underground building drains and process overflow piping were extended through the embankment fill as they were encountered at existing elevations in the original embankment face. The salvaged and imported rip rap was then placed with an excavator along the embankment interface with the pond.

The total imported aggregate placed consisted of 9,471 tons of MDOT 4AA, 7,905 tons of MDOT 21AA, and 50 tons of rip rap. Figure 1 is the as-built drawing reflecting the final inboard berm fill prior to pipe support and pipeline construction.

3.3 Installation of Piling, Pipe Support Foundations, and Pipelines

In May of 2014 piling, pipe support pile caps, and pipe supports were constructed in the embankment fill along an alignment from the 1212/1214 Buildings to the new 1209 Building. Two wood piles per each pile cap were driven through the embankment fill into the underlying clay till to an approximate average tip elevation of 589 ft. Pile driving logs were maintained and pile capacities verified using pile driving formulas as required by the specifications. The embankment fill was then excavated to an approximate depth of 24 inches to facilitate forming of concrete pile caps for the pipe support steel as per the detail on Figure 1. The caps were then poured to design plans and specifications.

Once the concrete footings were allowed to cure, the steel pipe support frames were erected. The following pipelines were then installed on the pipe supports:

- Two 30-inch steel pipes;
- One 8-inch steel pipe; and
- Three 2-inch steel pipes.

Construction activities were substantially completed within the embankment fill area on August 31, 2014. Figure 1 shows the as-built pipe support and pipeline conditions.

4.0 Certification

In my professional opinion, the Tertiary Pond Dam Embankment Inboard Fill improvements under RCRA License MID 000 724 724 Minor Modification 15 and Part 315 Dam Safety Program Permit 13-56-0026-P were completed in general compliance with the design parameters, and should reasonably reflect the estimated factors of safety as described in the Dike Stability Analysis Supporting T-Pond Filtration Project – Revised Analysis, dated December 3, 2013. These factors of safety were estimated in accordance with standard engineering practice and US Army Corps of Engineers Manual EM-1110-2-1902 recommendations, and this area of improvement to the dikes:

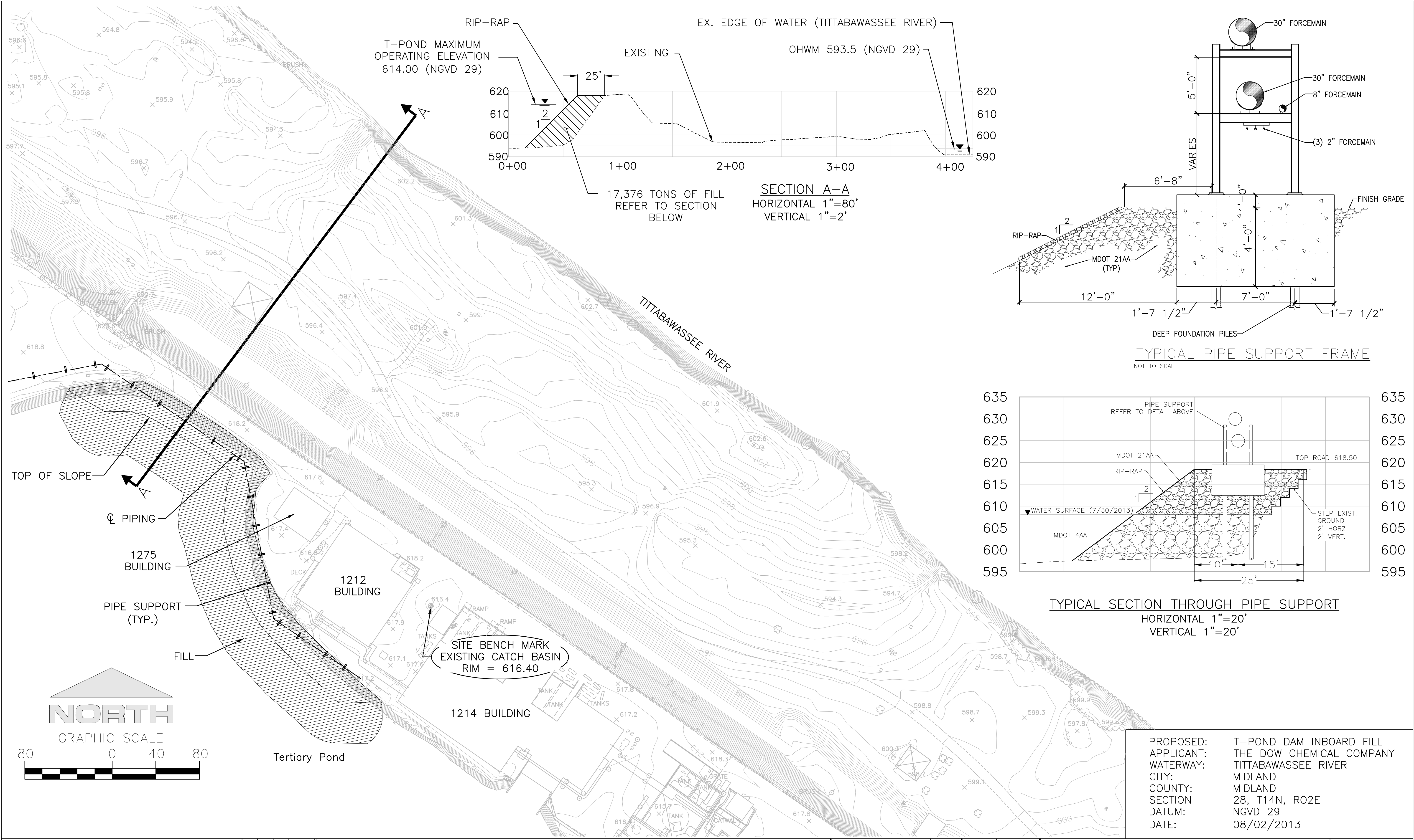
(1) Meets accepted engineering standards for withstanding the stress of the pressure exerted by the types and amounts of wastes to be placed in the Tertiary Pond; and

(2) Has not provided evidence of failure due to scouring or piping, and has no known dependence on any liner system included in the surface impoundment construction.

The foregoing is a statement of professional opinion only, based on limited field observations and information provided by others, the accuracy of which has not been independently verified. URS does not warrant or guarantee the condition or performance of the dikes, or assume responsibility for hidden or unobserved conditions. The opinions expressed herein are based on data, site conditions and other information that is generally applicable as of October 15, 2014, and are therefore applicable and valid only for that time frame.

Thomas Roberts, PS/PE

10-17-14



PROPOSED: T-POND DAM INBOARD FILL
APPLICANT: THE DOW CHEMICAL COMPANY
WATERWAY: TITTABAWASSEE RIVER
CITY: MIDLAND
COUNTY: MIDLAND
SECTION 28, T14N, RO2E
DATUM: NGVD 29
DATE: 08/02/2013

REV. MARK	REVISION	BY	CHK	APP	DATE

CONSULTANT

URS

URS CORPORATION
MIDLAND, MI.,
25 BUILDING

URS PROJECT NUMBER: 41569523

DRAWING ISSUE RECORD

ISSUE NO.	REV	MATERIAL OR JOB SPEC	BID	FAB	CONST	REF
	1	AS-BUILT				09/25/14
	0	FOR PERMIT				08/02/13

DATE ISSUED FOR

DESIGNED	T. ROBERTS	08/02/13
DRAWN	T. ROBERTS	08/02/13
CHECKED	D. WEHNER	08/02/13
APPROVED	D. WEHNER	08/02/13
PROJ. ENGR.	K. DETRICH	08/02/13
MFG. REP.	S. BENNETT	08/02/13

STATUS
PLANT NO.
P.E. SEAL

MAP
SITE

T-POND DAM INBOARD FILL
AS-BUILT EMBANKMENT, FILL CONDITIONS, PIPE SUPPORTS, AND PIPELINE

PROJECT NUMBER
SCALE AS SHOWN ON PLAN
FIGURE 1
REV. 1

INSTRUCTIONS

URS Corporation
1375 Euclid Avenue, Suite 600
Cleveland, Ohio 44115
Phone: (216) 622-2400
Fax: (216) 622-2428
Architectural & Engineering Services

GEOTECHNICAL ENGINEERING MEMORANDUM

TO: Mr. Shane Bennett, PE

DATE: December 3, 2013

FROM: Vik Gautam, PE
Doug Wehner

PROJECT: Dow Chemical Company
T-Pond Filtration Project

COPIES: File

JOB NO.: 41569363

ATTACHMENTS: Attachment A (Results of Slope Stability Analysis)

RE: *Dike Stability Analysis Supporting T-Pond Filtration Project – Revised Analysis*

The Dow Chemical Company (Dow) proposes to construct a new filtration plant at the Triangle Pond site, located just to the northeast of the Tertiary Pond (T-Pond). As part of the improvements for the filtration plant, a pipe rack carrying two 42 in and several smaller diameter force mains will be constructed from the new plant toward the 1212 Building complex, which is located southeast of the Triangle Pond. The pipe rack alignment will follow along the inboard side of the existing T-Pond dike throughout the majority of its alignment. In order to construct the pipe rack and piping, additional fill embankment is proposed at the dike. In order to widen the dike crest to provide access and facilitate the ability to construct the pipe rack on level grade, the crest will be constructed to roughly match the elevation of the current dike crest at the proposed elevation (EL.) of 618.5 ft National Geodetic Vertical Datum of 1929 (NGVD29). The new fill will be placed over the existing inboard dike slope and will extend below the T-Pond water line and to the existing pond bottom. The fill will consist of clean, crushed aggregate material. MDOT-specification 21AA material will be utilized above the normal pool level of the pond (approximate El. 608 ft NGVD29), while MDOT-specification 4AA material will be used below normal pool in the water.

On August 5, 2013 URS submitted a memorandum summarizing the results of slope stability analysis of the inboard dike slope in the proposed configuration with aggregate fill in place. Those calculations made an assumption on the shear strength properties of the proposed aggregate fill – namely, a 40 degree angle of internal friction was utilized to model the aggregate (both types of aggregate were modeled with the same properties). Since the original calculations were performed, direct shear testing of actual samples of the proposed aggregate materials was performed at the request of the Michigan Department of Environmental Quality (MDEQ). The two proposed aggregate materials (MDOT 21AA and MDOT 4AA) were each individually tested using a 12-inch by 12-inch shear box and in general accordance with ASTM D 3080. 3-

point direct shear tests were performed, with normal stresses selected to cover the range of vertical stresses anticipated in-situ within the finished construction.

Test results were as follows, when a linear regression line is fit to the data:

MDOT 21AA: friction angle = 37 degrees, cohesion intercept = 34 psf

MDOT 4AA: friction angle = 40 degrees, cohesion intercept = 272 psf

Lab data sheets documenting the above results are provided in Attachment B.

If the regression line is forced through the origin to remove the cohesion intercept, the following equivalent friction angles are obtained:

MDOT 21AA: 37.5 degrees

MDOT 4AA: 44.4 degrees

At the request of MDEQ, the original slope stability calculations were revised to account for the laboratory testing results. Specifically:

- The aggregate material represented in the stability analysis was divided into 21AA and 4AA zones, as proposed to be constructed.
- Friction angles for each of the aggregate zones were assigned as given above with the cohesion intercept removed (i.e., 37 degrees for 21AA and 44 degrees for 4AA).
- All other aspects of the original analyses were kept the same.

Attachment A below provides outputs from the revised SLOPE/W analysis, depicting the calculated critical failure surfaces and corresponding factors of safety for the various cases considered. Factors of safety are further summarized in Table 1 below. Table 1 also provides factors of safety that were computed in the original analyses. Comparison of the results indicates that there is little change between the revised and original analyses, and the revised analysis results still meet or exceed USACE recommended minimum values.

Table 1 - Results of Revised Slope Stability Analysis and Comparison With Original Analysis

Stability Case	Computed Critical Factor of Safety – Revised Analyses	Computed Critical Factor of Safety – Original Analyses	USACE Recommended Factor of Safety
Case 1 : Steady State Seepage Failure Surface Within New Fill (See Figure A-1)	1.58	1.59	1.5
Case 1 : Steady State Seepage Failure Surface Within Existing Dike Fill (See Figure A-2)	1.79	1.78	1.5
Case 1 : Steady State Seepage Translational Failure Surface At New Fill/Existing Interface (See Figure A-3)	1.68	1.68	1.5
Case 2: Temporary Construction Conditions With Crane Loading (See Figure A-4)	1.53	1.54	1.3
Case 3: Rapid Drawdown (See Figure A-5)	1.15	1.16	1.1 to 1.3
Case 4: Earthquake Loading (See Figure A-6)	1.40	1.41	1.1 to 1.3

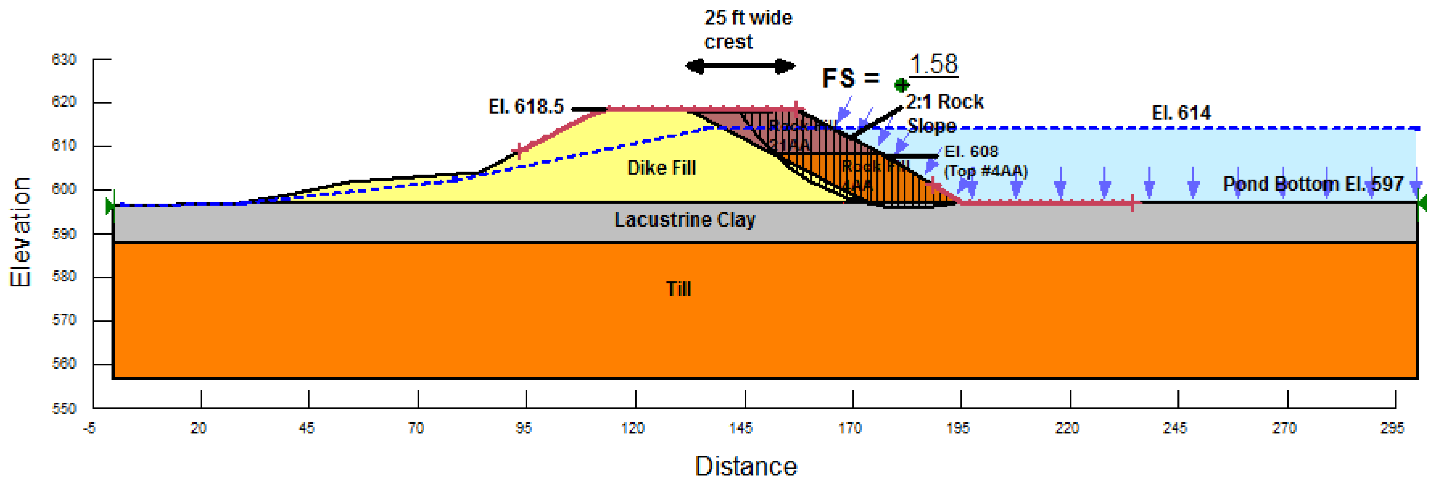
Based on these results and the assumptions contained in the analyses, it is concluded that all computed factors of safety meet or exceed USACE recommended values. Instability of the dike as a result of the proposed project is thus not anticipated.

ATTACHMENT A

RESULTS OF REVISED SLOPE STABILITY ANALYSIS

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 1a: Steady State Seepage - Failure Surface Within New Fill
Figure A-1



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °

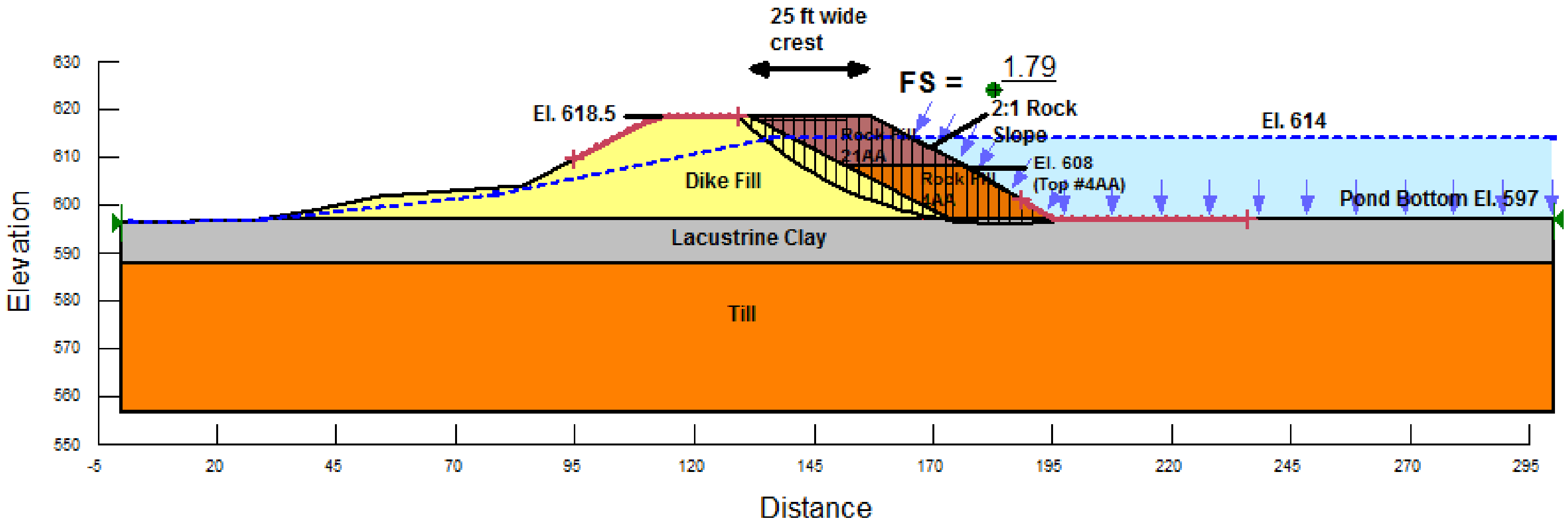
Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °

Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 1b: Steady State Seepage - Failure Surface Within Existing Dike Fill
Figure A-2



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °

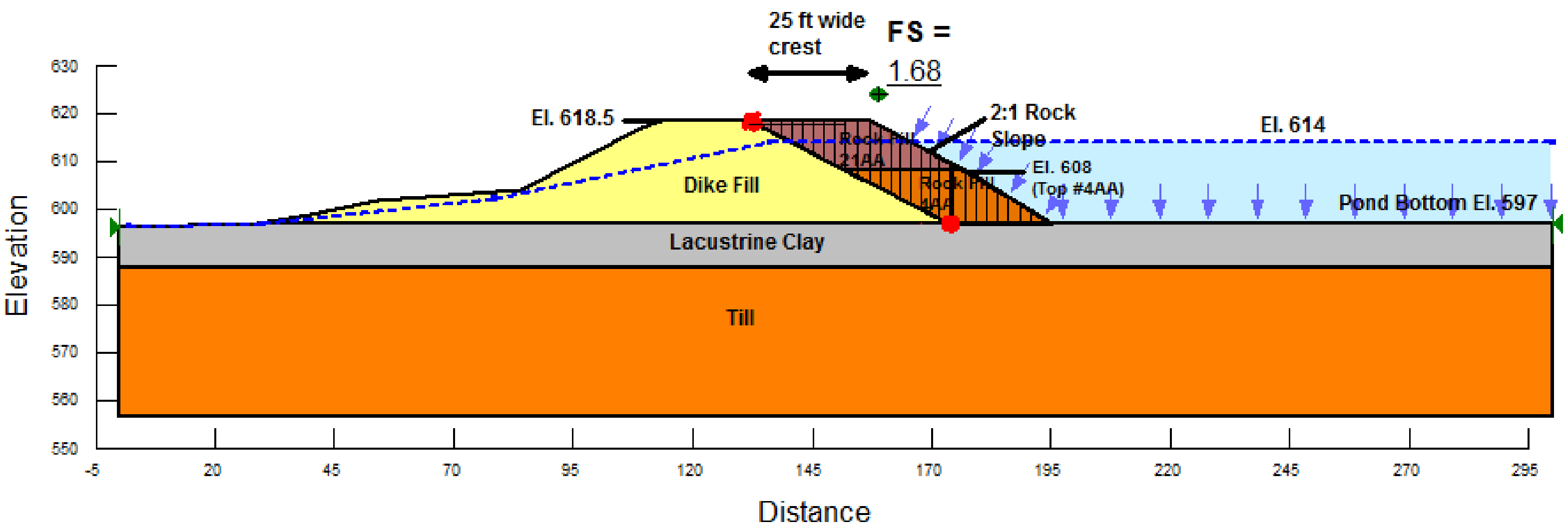
Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °

Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 1a: Steady State Seepage - Translational Failure At Interface of New Fill/Dike
Figure A-3



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °

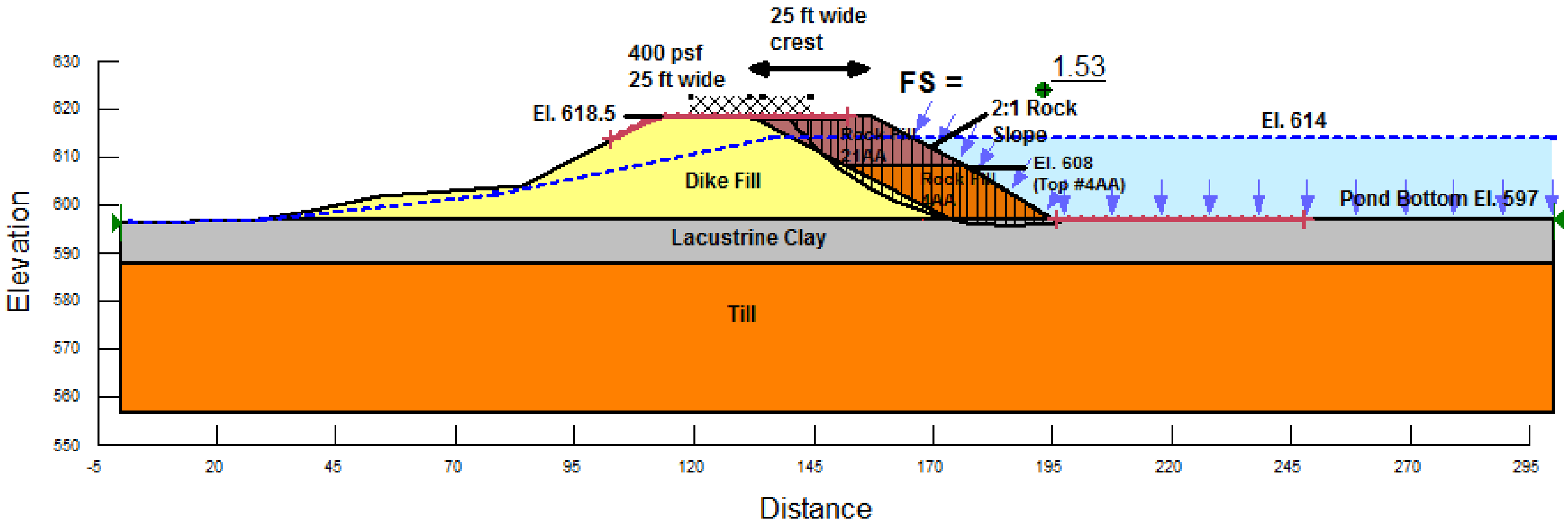
Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 2: Temporary Construction Conditions with Crane Loading
Figure A-4

Temporary Crane Loading = 400 psf



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °

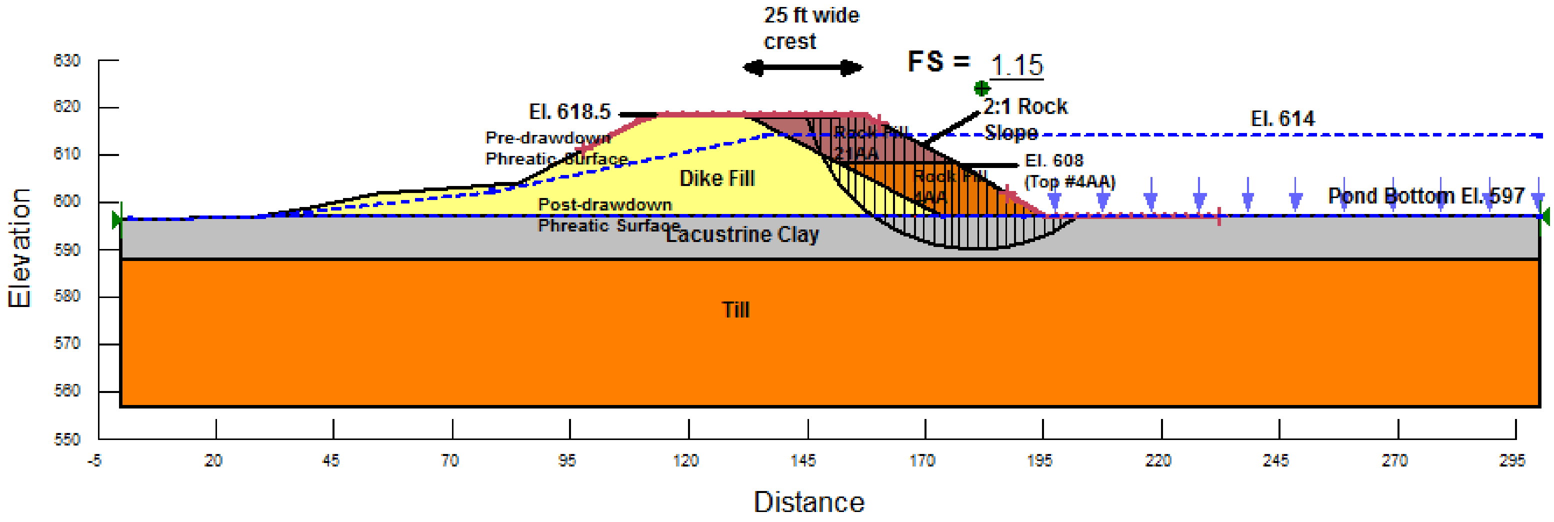
Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °

Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 3: Rapid Drawdown
Figure A-5



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °
Drawdown Total Cohesion: 1250 psf
Drawdown Total Phi: 0 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °
Drawdown Total Cohesion: 500 psf
Drawdown Total Phi: 0 °

Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °
Drawdown Total Cohesion: 5000 psf
Drawdown Total Phi: 0 °

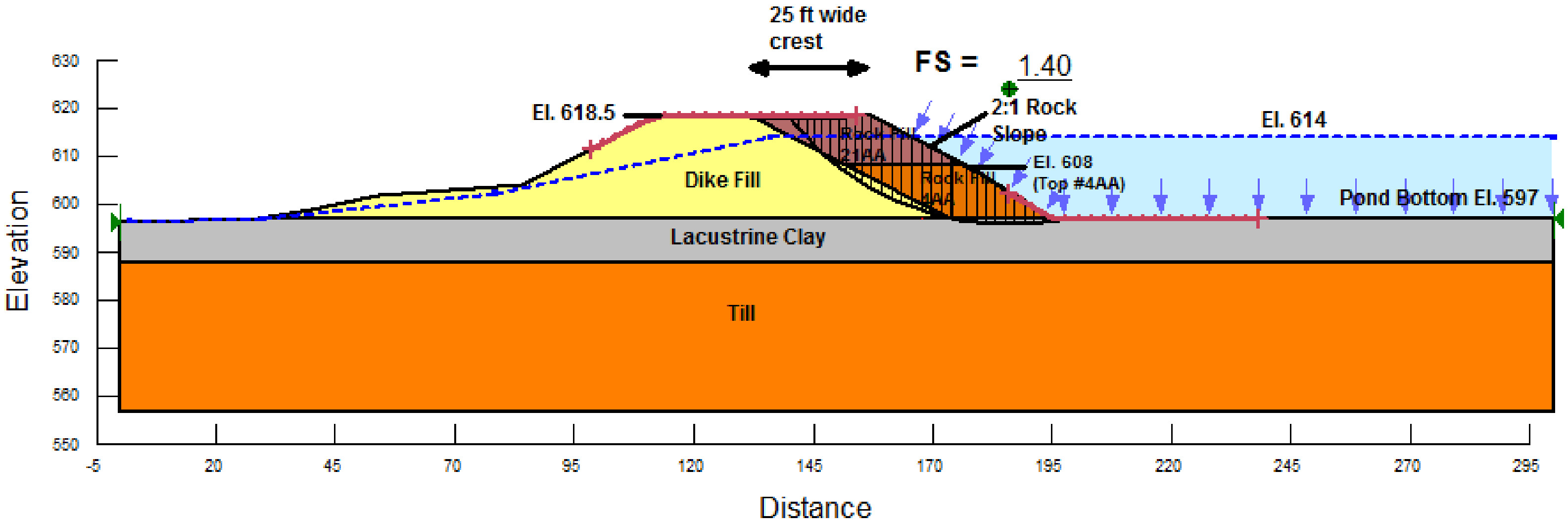
Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °
Drawdown Total Cohesion: 0 psf
Drawdown Total Phi: 44 °

Dow T-Pond Filtration Project
Stability Analysis of Inboard Dike Slope With Rock Fill

Cross-Section A-A
Case 4: Earthquake Loading
Figure A-6

Horizontal Seismic Coefficient = 0.0332 g



Assumed Material Properties

Name: Dike Fill
Unit Weight: 115 pcf
Cohesion: 0 psf
Phi: 28 °

Name: Lacustrine Clay
Unit Weight: 120 pcf
Cohesion: 100 psf
Phi: 28 °

Name: Till
Unit Weight: 135 pcf
Cohesion: 250 psf
Phi: 38 °

Name: Rock Fill - 21AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 37 °

Name: Rock Fill -4AA
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 44 °

ATTACHMENT B

DIRECT SHEAR TEST RESULTS

DIRECT SHEAR TEST RESULTS

ASTM D 3080 *Modified

geotechnics
INTEGRITY IN TESTING

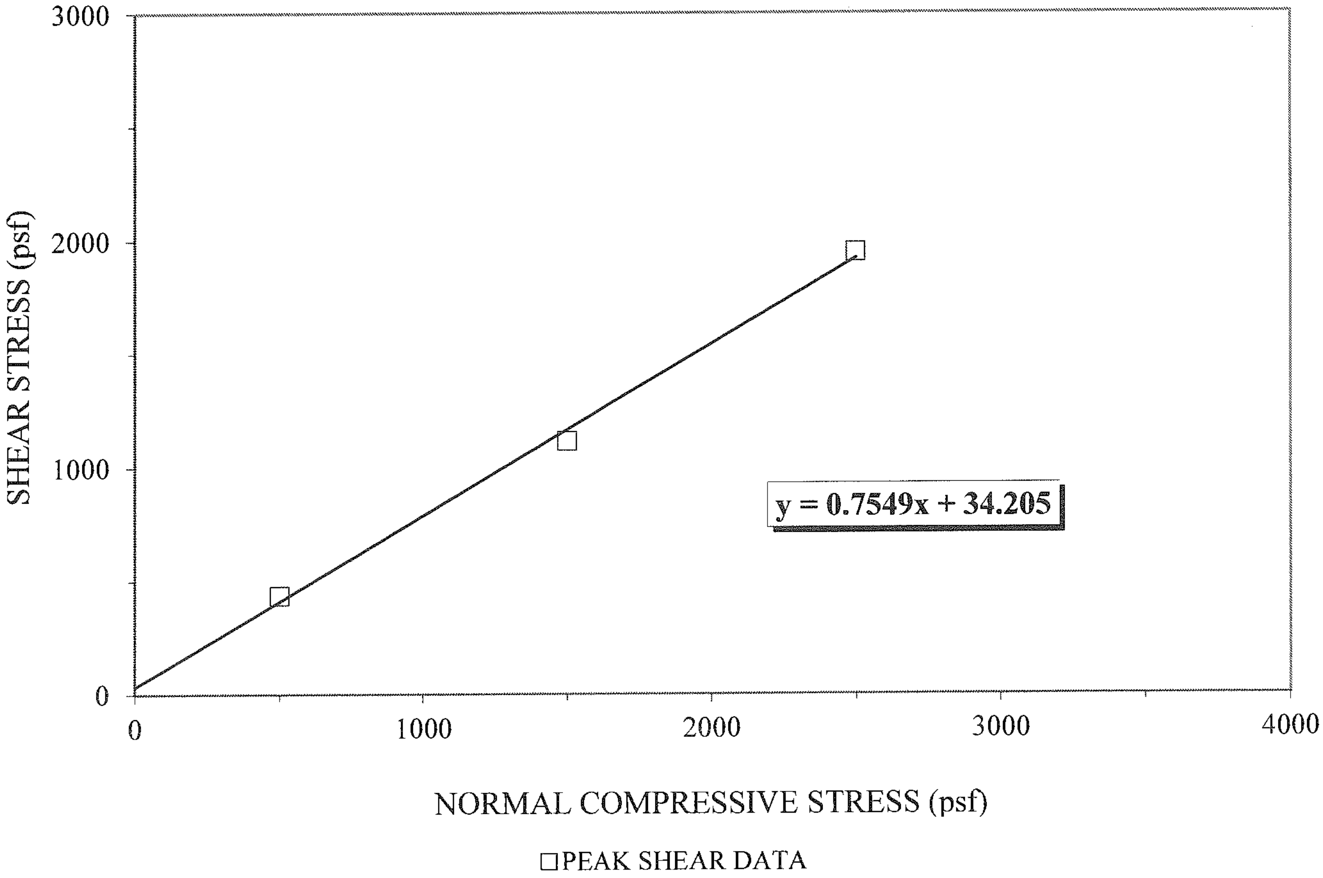
CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 91.7 pcf & 5.7 % M.C.

PEAK SHEAR

FRICTION ANGLE (deg) : Φ = **37.0**
COEFFICIENT OF FRICTION : = **0.755**
COHESION [Calculated] (psf): c = **34**

NOTES:
1.) Specimen was composed of soil sample passing 1 inch sieve and placed in the shear box to a thickness of 5 inches.
2.) The specimen was dumped into shear box and leveled without any additional compaction effort.
3.) The specimen was placed under load, inundated with water & seated for 1 hour prior to shearing.
4.) The specimen was sheared at a displacement rate of 0.04 ipm as directed by client.
5.) The peak friction angle was calculated using linear regression of the data points.



APPROVED BY :

DATE : 11-18-13

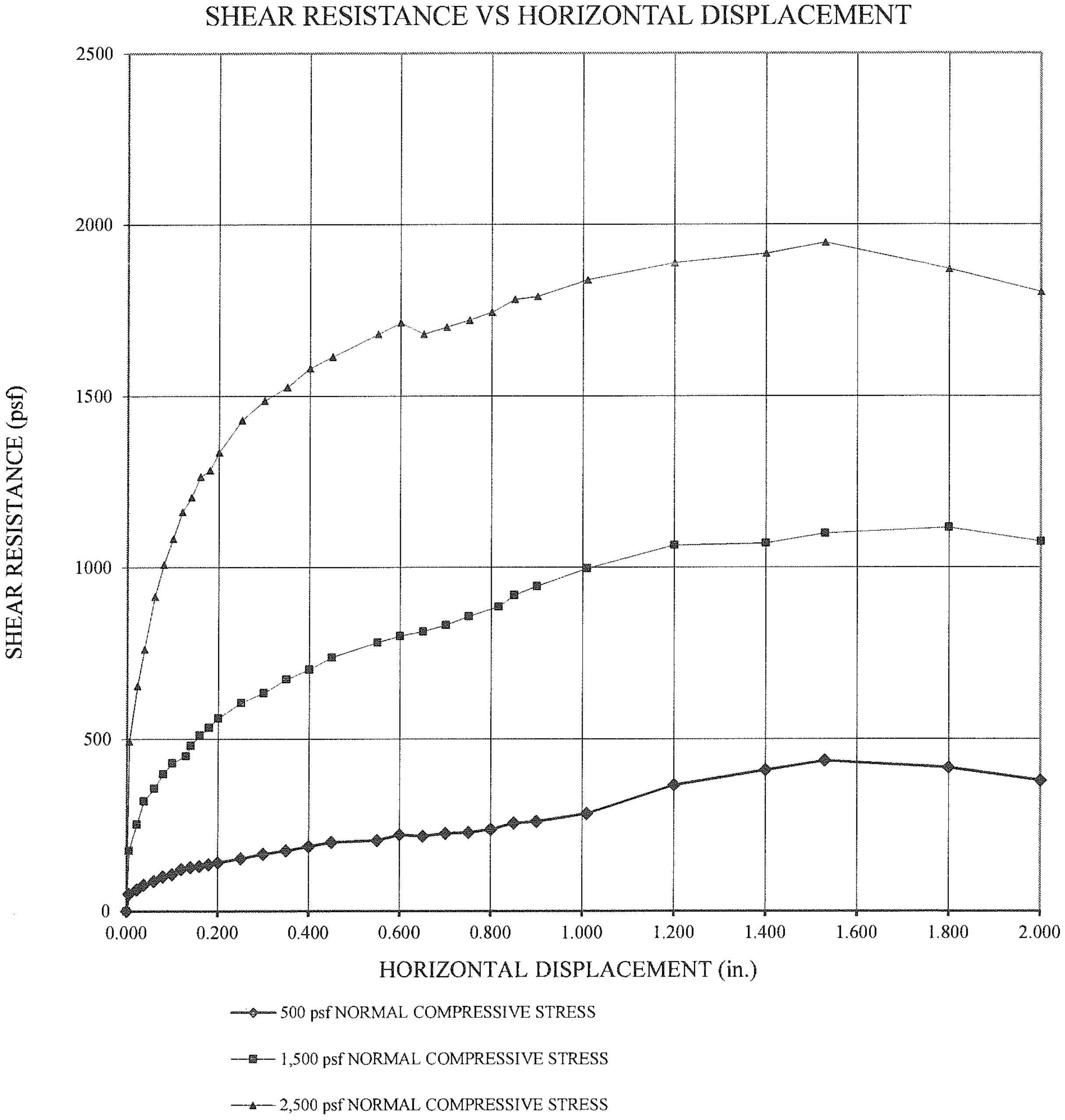
DIRECT SHEAR TEST RESULTS

ASTM D 3080 *Modified

geotechnics
INTEGRITY IN TESTING

CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 91.7 pcf & 5.7 % M.C.



PAGE 2 OF 3

APPROVED BY :

DATE : 11-18-13

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L13137-01

11/18/2013

DIRECT SHEAR TEST RESULTS
ASTM D 3080 *Modified

geotechnics
INTEGRITY IN TESTING

CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 91.7 pcf & 5.7 % M.C.

STRAIN RATE (in / min) : 0.04
PLACEMENT CONDITION: Inundated

DIRECT SHEAR UNIT: Geo Test 2
NORMAL LOAD: Hydraulic Cylinders

NORMAL LOAD (psf)		500	NORMAL LOAD (psf)		1500	NORMAL LOAD (psf)		2500
PEAK SHEAR STRESS (psf)		437	PEAK SHEAR STRESS (psf)		1116	PEAK SHEAR STRESS (psf)		1947
HORIZONTAL			HORIZONTAL			HORIZONTAL		
DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)	DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)	DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)
0.000	0	0	0.000	0	0	0.000	0	0
0.005	50	50	0.005	176	176	0.005	493	493
0.023	63	63	0.023	252	252	0.023	655	655
0.038	76	76	0.038	319	319	0.038	761	761
0.060	87	87	0.060	357	357	0.060	915	915
0.080	100	100	0.080	398	398	0.080	1008	1008
0.100	107	107	0.100	430	430	0.100	1083	1083
0.120	121	121	0.130	451	451	0.120	1161	1161
0.140	128	128	0.140	481	481	0.140	1204	1204
0.160	131	131	0.160	511	511	0.160	1264	1264
0.180	136	136	0.180	534	534	0.180	1283	1283
0.200	141	141	0.200	561	561	0.200	1335	1335
0.250	153	153	0.250	605	605	0.250	1430	1430
0.300	166	166	0.300	635	635	0.300	1487	1487
0.350	176	176	0.350	673	673	0.350	1526	1526
0.400	188	188	0.400	703	703	0.400	1581	1581
0.450	201	201	0.450	737	737	0.450	1615	1615
0.550	205	205	0.550	781	781	0.550	1680	1680
0.600	222	222	0.600	800	800	0.600	1714	1714
0.650	218	218	0.650	813	813	0.650	1680	1680
0.700	226	226	0.700	832	832	0.700	1701	1701
0.750	228	228	0.750	857	857	0.750	1721	1721
0.800	237	237	0.816	886	886	0.800	1744	1744
0.850	255	255	0.850	919	919	0.850	1782	1782
0.900	260	260	0.900	945	945	0.900	1790	1790
1.010	283	283	1.010	997	997	1.010	1838	1838
1.200	366	366	1.200	1064	1064	1.200	1887	1887
1.400	410	410	1.400	1070	1070	1.400	1915	1915
1.530	437	437	1.530	1099	1099	1.530	1947	1947
1.800	417	417	1.800	1116	1116	1.800	1870	1870
2.000	379	379	2.000	1075	1075	2.000	1803	1803

APPROVED BY :
L13137-01

DATE : 11-18-13
11/18/2013

DIRECT SHEAR TEST RESULTS
ASTM D 3080 *Modified

geotechnics
INTEGRITY IN TESTING

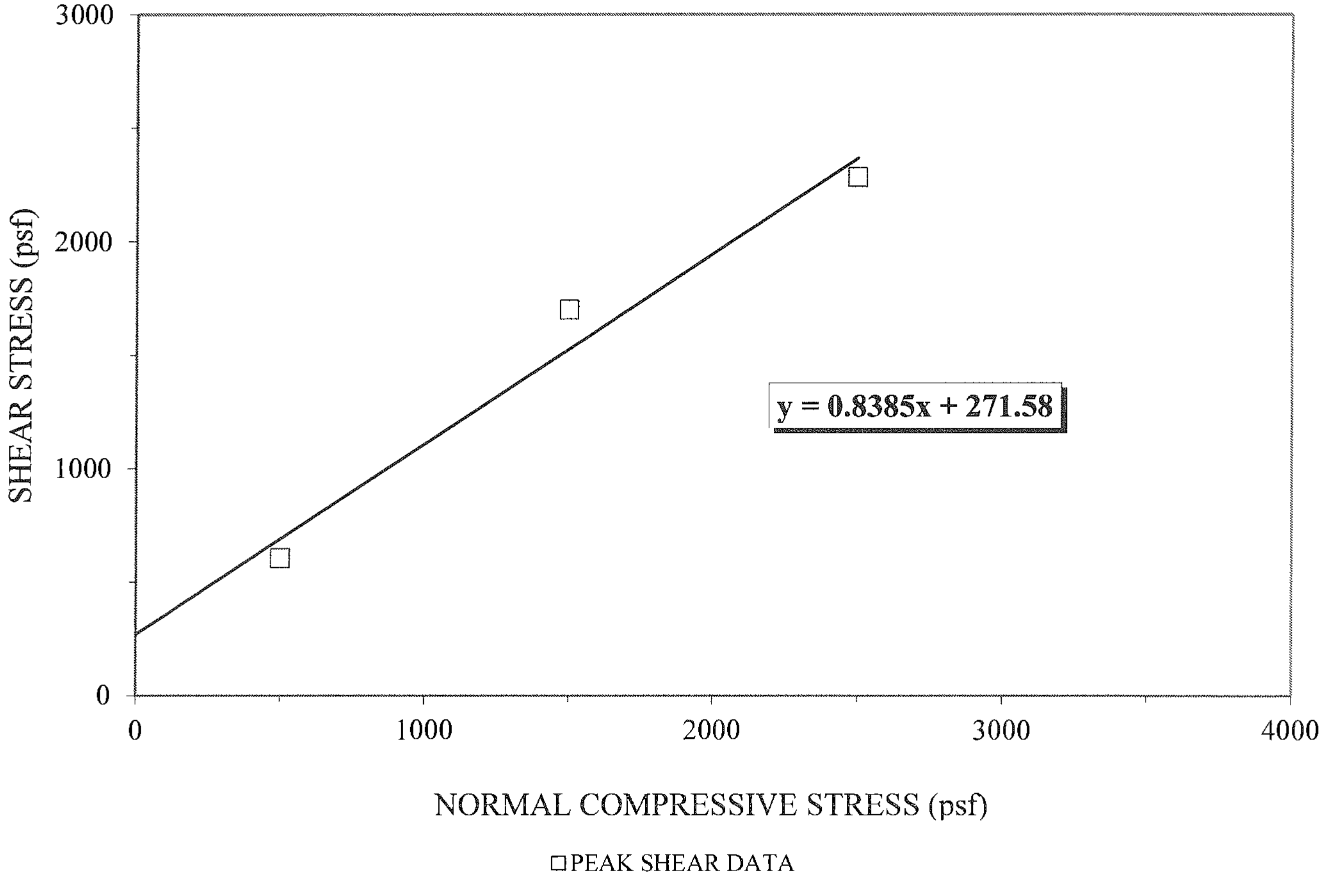
CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 4A Aggregate (2013-522-001-002) with + 0.75 inch 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 90.4 pcf & 1.1 % M.C.

PEAK SHEAR

FRICTION ANGLE (deg) :	Φ =	**40.0**
COEFFICIENT OF FRICTION :	=	0.839
COHESION [Calculated] (psf):	c =	272

NOTES:
1.) Specimen was composed of 0.75 - 1.0 inch nominal diameter material placed in the shear box to a thickness of 6 inches.
2.) The specimen was dumped into shear box and leveled without any additional compaction effort.
3.) The specimen was placed under load, inundated with water & seated for 1 hour prior to shearing.
4.) The specimen was sheared at a displacement rate of 0.04 ipm as directed by client.
5.) The peak friction angle was calculated using linear regression of the data points.
6.) Due to the amount of material available, specimen was sheared at 500 psf, reconditioned and re-sheared at 2500 psf and then 1500psf normal load.



APPROVED BY :

DATE : 11-21-13

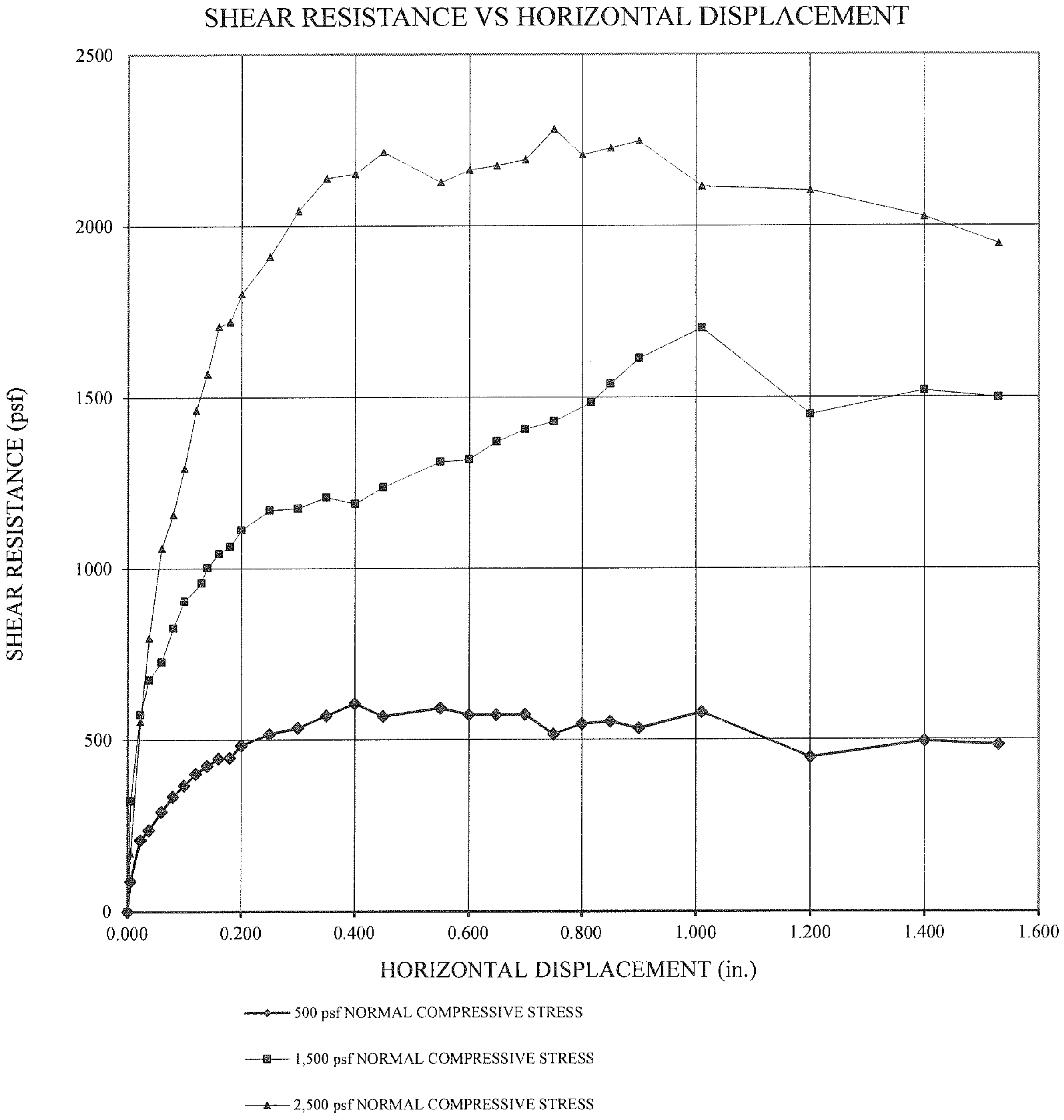
DIRECT SHEAR TEST RESULTS

ASTM D 3080 *Modified

geotechnics
INTEGRITY IN TESTING

CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 4A Aggregate (2013-522-001-002) with + 0.75 inch 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 90.4 pcf & 1.1 % M.C.



PAGE 2 OF 3

APPROVED BY : TPK

DATE : 11-21-13

\\geoserver\Data Drive\Ryan\Finished Reports\L13\137\01\[L13137-01 INT 2.xls]3 Points

L13137-01

11/21/2013

DIRECT SHEAR TEST RESULTS
ASTM D 3080 *Modified

CLIENT : URS Corporation
CLIENT PROJECT : Dow Chemical
PROJECT NO. : L13137-01
LAB I. D. NO.: 4A Aggregate (2013-522-001-002) with + 0.75 inch 21AA Aggregate (2013-522-001-001)

INTERFACE : **12" Direct Shear of Aggregate**
@ 90.4 pcf & 1.1 % M.C.

STRAIN RATE (in / min) : 0.04
DIRECT SHEAR UNIT: Geo Test 2
PLACEMENT CONDITION: Inundated
NORMAL LOAD: Hydraulic Cylinders

NORMAL LOAD (psf)		500	NORMAL LOAD (psf)		1500	NORMAL LOAD (psf)		2500
PEAK SHEAR STRESS (psf)		605	PEAK SHEAR STRESS (psf)		1701	PEAK SHEAR STRESS (psf)		2282
HORIZONTAL			HORIZONTAL			HORIZONTAL		
DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)	DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)	DISPLACE. (in.)	SHEAR FORCE (lbs)	STRESS (psf)
0.000	0	0	0.000	0	0	0.000	0	0
0.005	90	90	0.005	323	323	0.005	170	170
0.023	209	209	0.023	574	574	0.023	554	554
0.038	238	238	0.038	675	675	0.038	798	798
0.060	292	292	0.060	728	728	0.060	1060	1060
0.080	336	336	0.080	826	826	0.080	1159	1159
0.100	367	367	0.100	904	904	0.100	1293	1293
0.120	401	401	0.130	958	958	0.120	1463	1463
0.140	425	425	0.140	1004	1004	0.140	1568	1568
0.160	445	445	0.160	1044	1044	0.160	1707	1707
0.180	448	448	0.180	1064	1064	0.180	1720	1720
0.200	484	484	0.200	1113	1113	0.200	1801	1801
0.250	517	517	0.250	1170	1170	0.250	1911	1911
0.300	534	534	0.300	1176	1176	0.300	2044	2044
0.350	570	570	0.350	1208	1208	0.350	2140	2140
0.400	605	605	0.400	1189	1189	0.400	2152	2152
0.450	568	568	0.450	1237	1237	0.450	2216	2216
0.550	592	592	0.550	1311	1311	0.550	2128	2128
0.600	572	572	0.600	1319	1319	0.600	2164	2164
0.650	572	572	0.650	1371	1371	0.650	2176	2176
0.700	573	573	0.700	1406	1406	0.700	2194	2194
0.750	516	516	0.750	1430	1430	0.750	2282	2282
0.800	546	546	0.816	1484	1484	0.800	2206	2206
0.850	552	552	0.850	1538	1538	0.850	2227	2227
0.900	532	532	0.900	1613	1613	0.900	2247	2247
1.010	579	579	1.010	1701	1701	1.010	2115	2115
1.200	449	449	1.200	1449	1449	1.200	2102	2102
1.400	495	495	1.400	1518	1518	1.400	2025	2025
1.530	484	484	1.530	1498	1498	1.530	1947	1947

APPROVED BY :
L13137-01

DATE : 11-21-13
11/21/2013

Photo No. **1**

Date: 12/1/13

Direction Photo Taken:

Southeast

Description:

Below water level berm construction placing 4AA aggregate progressing near northeast corner of Tertiary Pond.

Photo No. **2**

Date: 12/4/13

Direction Photo Taken:

Southeast

Description:

Above water level berm construction placing 21AA aggregate over 4AA aggregate progressing Northeast corner of Tertiary Pond.

Photo No. **3**

Date: 12/5/13

Direction Photo Taken:

Northwest.

Description:

Above water level berm construction placing 21AA aggregate progressing near corner of 1275 Building.

Photo No. **4**

Date: 12/11/13

Direction Photo Taken:

Northwest

Description:

Substantially complete Inboard Berm Fill Area.

Client Name: The Dow Chemical Company T-Pond Filtration Expansion Project	**Site Location:** Tertiary Pond Embankment inboard Fill Midland Plant WWTP Midland, MI 48667	**Project No.** 41569523

Photo No. 5

Date: 12/11/13

Direction Photo Taken:

Southeast

Description:

Substantially complete Inboard Berm Fill Area.

Photo No. 6

Date: 5/30/14

Direction Photo Taken:

South

Description:

Installed piling for pipe supports (two per).

URS

PHOTOGRAPHIC LOG

Client Name:	**Site Location:**	**Project No.**
The Dow Chemical Company T-Pond Filtration Expansion Project	Tertiary Pond Embankment inboard Fill Midland Plant WWTP Midland, MI 48667	41569523

Photo No. 7

Date: 6/25/14

Direction Photo Taken:

Southwest

Description:

Trimmed piling for pipe support (typical) foundation.

Photo No. 8

Date: 6/25/14

Direction Photo Taken:

Southeast

Description:

Pipe support foundation.

PHOTOGRAPHIC LOG

Client Name:	Site Location:	Project No.
The Dow Chemical Company T-Pond Filtration Expansion Project	Tertiary Pond Embankment inboard Fill Midland Plant WWTP Midland, MI 48667	41569523

Photo No. 9

Date: 7/10/14

Direction Photo Taken:

Northwest

Description:

Steel pipe support erection.

Photo No. 10

Date: 8/15/14

Direction Photo Taken:

Southeast

Description:

Substantially complete pipe supports, pipeline, and embankment fill.

ATTACHMENT XIV.C5

APPENDIX C5-C

TERTIARY POND WAIVER

§ 30005(j)(3)

COPY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

OCT 06 1987

REPLY TO THE ATTENTION OF:
5RA-14

Certified Mail P 250 760 439
Return Receipt Requested

Mr. J. M. Rio
Manager, Environmental Services
Dow Chemical U.S.A.
628 Building
D and 14th Streets
Midland, Michigan 48640

RE: Final Determination
Dow Chemical U.S.A. - Michigan Division
Midland, Michigan
MID 000 724 724

Dear Mr. Rio:

The purpose of this letter is to inform you that the United States Environmental Protection Agency (U.S. EPA) has made a final determination, pursuant to Section 3005 (j)(5) of the Resource Conservation and Recovery Act (RCRA) 42 U.S.C. §6901 et seq., that the minimum technological requirements of Section 3004 (o)(1) do not apply to the Tertiary Pond (pentagonal, rectangular, and main pond series) of the Dow Chemical U.S.A. facility (Dow) in Midland, Michigan, for the reasons provided in Section 3005 (j)(3). This final determination is conditional upon the compliance requirements set forth in the attached document.

Enclosed is a copy of the final determination regarding double liner requirements, pursuant to RCRA Section 3005 (j)(3), for the above-referenced facility. The final determination shall be incorporated into the Federal Hazardous and Solid Waste Amendments (HSWA) permit.

If you have any questions regarding this matter, please contact Karl E. Bremer of my staff, at (312) 353-4783, for assistance.

Sincerely yours,

Valdas V. Adamkus

Valdas V. Adamkus
Regional Administrator

Enclosures

COPY

DETERMINATION REGARDING MINIMUM TECHNOLOGY REQUIREMENTS
PURSUANT TO SECTION 3005 (j)(3)

DOW CHEMICAL U.S.A. - MICHIGAN DIVISION
TERTIARY POND SYSTEM
MIDLAND, MICHIGAN
MID 000 724 724

DETERMINATION REGARDING MINIMUM TECHNOLOGY REQUIREMENTS PURSUANT TO SECTION 3005 (j)(3)

DOW CHEMICAL U.S.A. - MICHIGAN DIVISION
TERTIARY POND SYSTEM
MIDLAND, MICHIGAN
MID 000 724 724

Section 3005 (j)(1) of the Resource Conservation and Recovery Act (RCRA) 42 U.S.C. §6901 et seq., requires that each surface impoundment in existence on November 8, 1984, and qualifying to operate under interim status shall not receive, store, or treat hazardous waste after November 8, 1988, unless such surface impoundment is in compliance with the technological requirements of Section 3004 (o)(1)(A) (codified at 40 CFR §265.221), which would apply if it were new. Section 3004 (o)(1) requires that the owner or operator of a surface impoundment install two or more liners and a leachate collection system between such liners for each unit. These requirements apply to Dow Chemical U.S.A. - Michigan Division (Dow), Tertiary Pond (pentagonal, rectangular, and main pond series), Midland, Michigan.

Section 3005 (j)(3) of RCRA provides that the above minimum technological requirements do not apply to any surface impoundment which the Regional Administrator finds; "(A) contains treated waste water during the secondary or subsequent phases of an aggressive biological treatment facility subject to a permit issued under section 402 of the Clean Water Act (or which holds such treated waste water after treatment and prior to discharge); (B) is in compliance with generally applicable ground water monitoring requirements for facilities with permits under subsection (c) of section 3005; and (C)(i) is part of a facility in compliance with section 301 (b)(2) of the Clean Water Act, or (ii) in the case of a facility for which no effluent quidelines required under section 304 (b)(2) of the Clean Water Act are in effect and no permit under section 402 (a)(1) of such Act implementing section 301 (b)(2) of such Act has been issued, is part of a facility in compliance with a permit under section 402 of such Act, which is achieving significant degradation of toxic pollutants and hazardous constituents contained in the untreated waste stream and which has identified those toxic pollutants and hazardous constituents to the appropriate permitting authority."

The Regional Administrator for Region V determines that, pursuant to Section 3005 (j)(3) of RCRA, the minimum technological requirements of Section 3004 (o)(1) do not apply to the Tertiary Pond (which includes the pentagonal, rectangular, and main ponds) and that the concentration limits in this determination set for hazardous constituents, leaking from the unit, are protective of human health and the environment as set out in Section 3005 (j)(7)(B) of RCRA, to the extent specified below, upon the specific condition that Dow incorporates the dike stability program and observes the Efficiency Monitoring of that system, and complies with the conditions in the determination described below.

The design of Dow's Tertiary Pond deviates from the requirements of Section 3004 (o)(1) of RCRA by the failure to have a double liner and a leachate collection system between the liners for all the surface impoundments. This requirement is compensated for, as documented by the Dow Surface Impoundment Retrofitting Variance Petition: RCRA Section 3005 (j)(3), dated October 5, 1986, revised March 19, 1987, and sections E and D-4b, and volume 17 of the Resource Conservation and Recovery Act (RCRA), Michigan Act 64 operating license reapplication dated October 3, 1983, and all revisions thereafter, by meeting the requirements of Section 3005 (j)(3) of RCRA.

COMPLIANCE REQUIREMENTS:

To continue to qualify for this determination, Dow must meet the following compliance conditions:

1. State Requirements. Obtain a Michigan Act 245 ground water discharge exemption or a Michigan Act 245 ground water discharge permit by November 8, 1988. Obtain a Michigan Act 64 operating license with an adequate ground water monitoring system by November 8, 1988.

2. Concentration Limits. Meet the Michigan Act 64 ground water monitoring requirements. Establish background data pursuant to the Michigan Act 64 operating license. Dow may not exceed the concentration limits specified below or as modified from background data upon the effective date of the RCRA and HSWA permits, at the point of compliance wells identified in Attachment I. Dow must establish Method Detection Limits for the permit that are capable of detecting the concentration limits set forth below.

Constituent	Concentration	Test Method
Benzene	28.0 ppb*	SW-846 8020, 8240
Chlorobenzene	220.0 ppb*	SW-846 8020, 8240, 8010
1,2-Dichloroethane	5.0 ppb	SW-846 8010, 8240
1,4-Dioxane	110.0 ppb*	SW-846 8240
Methyl Isobutyl Ketone	24.0 ppb	SW-846 8240**
Acetone	880.0 ppb*	SW-846 8240
Methyl Ethyl Ketone	80.0 ppb	SW-846 3015, 8240
Benzoic Acid	130.0 ppb*	SW-846 3510, 8270
2,4-D	100.0 ppb	SW-846 8270
Silvex	10.0 ppb	SW-846 8270
2,4,5-T	18.8 ppb	SW-846 8270
Phenol	108.0 ppb	SW-846 8040, 8270
2-Chlorophenol	3.6 ppb	SW-846 8040, 8270
2,4-Dichlorophenol	15.2 ppb	SW-846 8040, 8270
Bis-2-Ethylhexyl Phthalate	700.0 ppb	SW-846 8270

Constituent	Concentration	Test Method
2,4,5-Trichlorophenol	11.0 ppb*	SW-846 8040, 8270
Pentachlorophenol	10.4 ppb	SW-846 8040, 8270
Barium†	7600.0 ppb*	SW-846 6010
Barium††	1000.0 ppb	SW-846 6010
Nickel	820.0 ppb*	SW-846 6010
Zinc	620.0 ppb*	SW-846 6010
Arsenic	50.0 ppb	SW-846 7060
Copper	344.0 ppb	SW-846 6010

* If no statistically significant increase above background is found in the surface water bodies (i.e., the Tittabawassee River and Bullock Creek), according to sampling procedures approved in the Federal HSWA permit, and/or the Michigan Act 64 permit.

** SW-846 Method 8240 modified by Dow by use of heated purge and trap.

† This concentration shall be met at the point of compliance wells along the dike next to the Tittabawassee River.

†† This concentration shall be met at the point of compliance wells along the dike next to Bullock Creek.

a. ppb means parts per billion.

b. SW-846 means EPA Report SW-846 "Test Methods for Evaluating Solid Waste", third edition, November 1986.

3. Dike Stability Program. Install, operate, maintain, and monitor the dike stability program as described in the Michigan Act 64 operating license section D-4.

Although the conceptual program has been proposed for dike stability, the system must be in place and operational before a Michigan Act 245 ground water discharge permit or exemption can be obtained, and when the permit becomes effective. Therefore, plans, construction, and monitoring must be established before the HSWA permit is issued. Dow must comply with the following:

a. Draft Construction and Monitoring Plan

Dow, within 90 days of the date of the final determination, must submit a Draft Construction and Monitoring Plan for the dike stability system to the Regional Administrator and the State for review.

b. Final Construction and Monitoring Plan

Within 45 days of receipt of the Draft Construction and Monitoring Plan, the State will provide comments to Dow as to the corrections or modifications, if any, which must be made to the Construction and Monitoring Plan. Within 45 days of receipt of such comments, Dow must submit an approvable Final Construction and Monitoring Plan to the Regional Administrator and the State. No construction may begin until the facility has an approved plan.

c. Initiation of Construction and Monitoring Plan

Within 60 days of the State's approval of the Final Construction and Monitoring Plan, Dow shall initiate the approved Final Construction and Monitoring Plan, pursuant to the terms and schedule set forth in the Plan.

d. Construction Completion

The dike stability system must be completed in accordance with the approved Final Construction and Monitoring Plan by November 8, 1988.

e. Construction Quality Assurance Documentation Report

Dow shall submit the Final Construction Quality Assurance Documentation Report, including as-built drawings, to the Regional Administrator and the State within 60 days of completion of the system.

f. Removal of Ground Water

Dow shall treat all ground water removed by the dike stability system before the liquid may be returned to the Tertiary Pond. Dow shall not directly discharge any collected ground water into the Tertiary Pond. Ground water containing residues from the Tertiary Pond shall be handled as a hazardous waste.

g. Efficiency Monitoring

Dow shall monitor the entire dike stability system at each dike in accordance with the Final Construction and Monitoring Plan.

h. Notification and Reporting of Failure of the Dike Stability Program

(1) Dow shall notify the Regional Administrator and the State in writing within 15 days of failure in any portion of the dike stability program. This notice shall include:

(a) Name of Facility,

(b) EPA Identification Number,

(c) Identification of the portion of the dike stability program found to have failed,

(d) Date of failure detection.

(2) Dow shall report to the Regional Administrator and the State in writing every 30 days after detection of failure in the dike stability program. This report shall include:

(a) Name of Facility,

(b) EPA Identification Number,

(c) Identification of the portion of the dike stability program found to have failed,

(d) Steps taken to repair the failure,

(e) Daily static water level readings, and an evaluation of water level changes due to the failure.

Dow will discontinue or alter the frequency of such reports upon written direction from the State.

i. Repair of the Dike Stability System

Dow shall define the rate and extent, and clean up any contamination caused by a failure of the system, and notify the Regional Administrator and the State of all activities.

4. Land Ban Requirements. The surface impoundments are prohibited from receiving restricted wastes for treatment under Section 3005 (j)(11)(B).

5. Dioxin Requirements. Hazardous wastes F020, F021, F022, F023, F026, and F027 must not be placed into the surface impoundments unless Dow operates the surface impoundments in accordance with a management plan for these wastes that is approved by the Regional Administrator pursuant to the standards in 40 CFR §264.231. The dioxin management plan must be incorporated in the draft HSWA permit.

6. Section 3005 (j)(3) Eligibility. Continue to meet the criteria set forth in Section 3005 (j)(3) of RCRA, including, but not limited to remaining in compliance with all relevant permits issued under the Federal Water Pollution Control Act (FWPCA).

7. Well Restriction. Not install, operate, or maintain any ground water drinking or supply wells in the area between the Point of Compliance (POC) and the Tittabawassee River and Bullock Creek.

8. Waste Water Treatment Plant. The surface impoundments shall only contain treated waste water during the secondary or subsequent phases of an aggressive biological treatment facility subject to a permit issued under Section 402 of the Clean Water Act, or only hold such treated waste water after such treatment and prior to discharge.

9. Submittal of Reports or Other Information. All reports or other information required to be submitted by the terms of this determination shall be sent to:

RCRA Activities
U.S. EPA, Region V
P.O. Box A3587
Chicago, Illinois 60690-3587

10. Signatory Requirement. All reports or other information requested by the Regional Administrator shall be signed and certified as required by 40 CFR §270.11.

11. Confidential Information. In accordance with 40 CFR §270.12 and 40 CFR Part 2, Subpart B, any information submitted to EPA pursuant to this determination may be claimed as confidential by the submitter. Any such claim must be asserted at the time of submission in the manner prescribed on the application form or instructions, or, in the case of other submissions, by stamping the words "confidential business information" on each page containing such information. If no claim is made at the time of submission, EPA may make the information available to the public without further notice. If a claim is asserted, the information will be treated in accordance with the procedures in 40 CFR Part 2.

12. Modification of the Final Determination. The following modification requirements apply to the final determination:

   a. When Dow complies with item 1 on page 3, Dow shall submit a copy of the exemption or permit to be incorporated into the determination.

   b. Upon establishment of all background concentrations, this determination may be modified to include those background concentrations or be limited to the concentrations established in item 2 on pages 3 and 4.

c. Pursuant to Section 3005 (j)(3)(B), whenever hazardous constituents from the Tertiary Pond exceed concentration limits in item 2, on pages 3 and 4, in ground water between the compliance point, identified in Attachment I, and the downgradient facility property boundary, Dow must institute a corrective action program under 40 CFR §264.100.

d. Whenever hazardous constituents under the surface water body monitoring program are found to be statistically significant above background in either surface water bodies (i.e., the Tittabawassee River or Bullock Creek), Dow must institute a corrective action program under 40 CFR §264.100.

e. If Dow finds Appendix VIII constituents in the ground water that are not identified in the permit as hazardous constituents, Dow must report the concentrations of these additional constituents to the Regional Administrator within seven days after completion of the analysis.

f. (1) If Dow determines that a concentration limit set in item 2, pages 3 and 4, is being exceeded at any monitoring well at the point of compliance, or in any surface water body, Dow must:

  (a) Notify the Regional Administrator of this finding in writing within seven days. The notification must indicate what concentration limits have been exceeded.

  (b) Submit to the Regional Administrator an application for a modification of the permit and final determination pursuant to Section 3005 (j)(3), to establish a corrective action program meeting the requirements of 40 CFR §264.100 within 180 days. The application must at a minimum include the following information:

    (i) A detailed description of corrective actions that will achieve compliance with the ground water protection standard specified in item 2, pages 3 and 4; and

    (ii) A plan for a ground water monitoring program that will demonstrate the effectiveness of the corrective action. Such a ground water monitoring program may be based on a compliance monitoring program developed to meet the requirements of the Michigan Act 64 permit; and/or

(2) Dow may demonstrate that a source other than a regulated unit caused the increase or that the increase resulted from error in sampling, analysis, or evaluation. Dow must:

  (a) Notify the Regional Administrator in writing within seven days that Dow intends to make a demonstration.

(b) Within 90 days, submit a report to the Regional Administrator which demonstrates that a source other than a regulated unit caused the standard to be exceeded or that the apparent noncompliance with the standards resulted from error in sampling, analysis, or evaluation; and

(c) Continue to monitor in accord with the compliance monitoring program established under the Michigan Act 64 permit.

Failure to comply with the compliance requirements of items 1, 2, 3, 4, 5, 6, 7 and/or 8, on pages 3 - 7, may result in a decision by the Regional Administrator to revoke the final determination. The Regional Administrator could also revoke the determination if;

1. A change in the waste water system results in a means of degradation other than mechanical aeration.
2. Section 3005 (j)(12)(B)(i) or (ii) or (iii) is no longer true.
3. The purpose of the impoundment changes (i.e., the impoundment receives sludges as opposed to treated liquids.

DATE: OCT 0 6 1987

Valdas V. Adamkus

Regional Administrator
U.S. EPA Region V

ATTACHMENT I

LOCATION MAP OF POINT OF COMPLIANCE
DOW CHEMICAL U.S.A. - MICHIGAN DIVISION
MIDLAND, MICHIGAN
MID 000 724 724

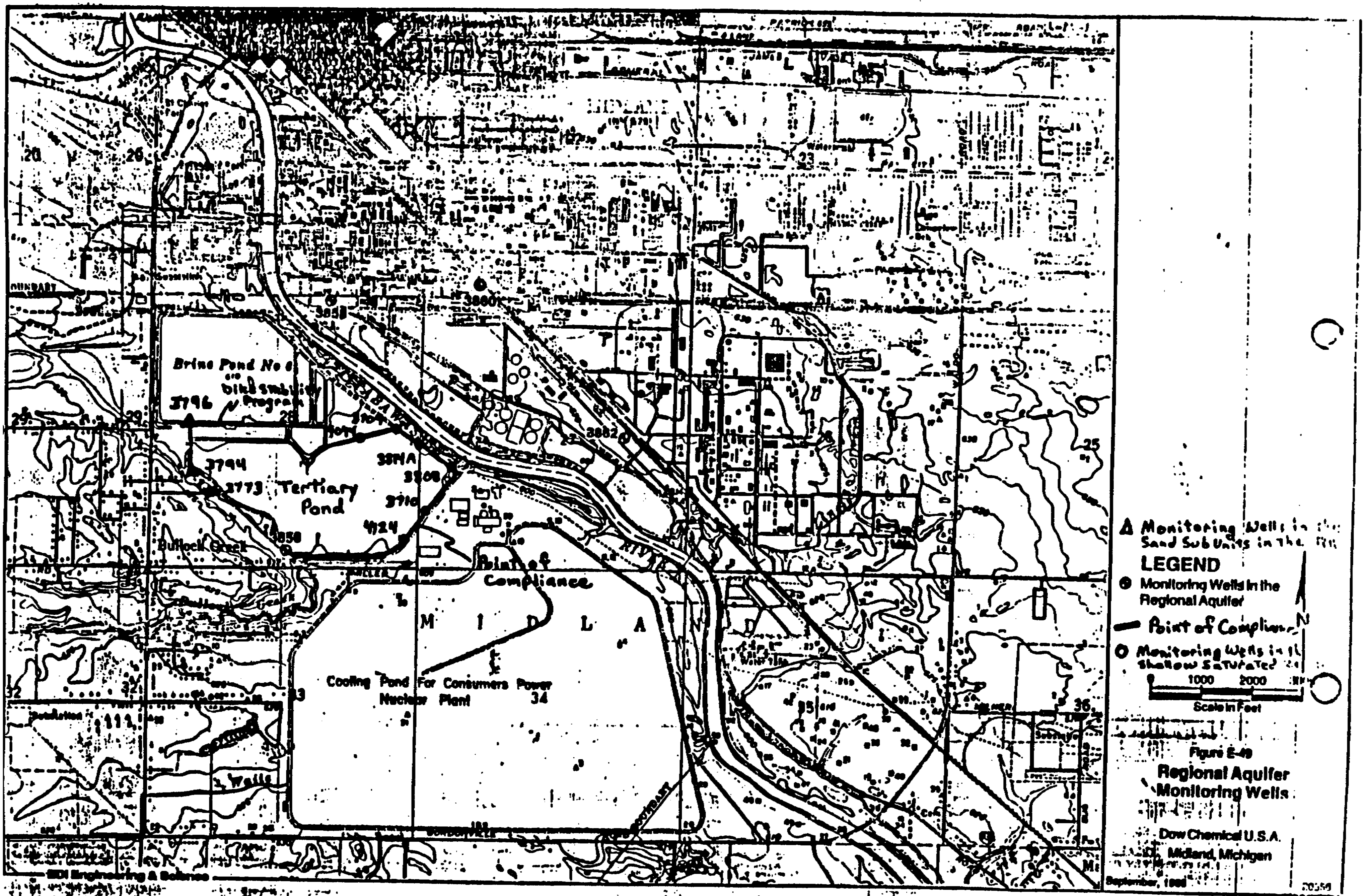


Figure E-49

Regional Aquifer Monitoring Wells

Dow Chemical U.S.A.
Midland, Michigan

September, 1986

Modified by the U.S. EPA
September, 1987