Consumers Energy
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Date: October 17, 2017

To: Operating Record

From: Harold D. Register, Jr., P.E.

RE: Groundwater Monitoring System Certification, §257.91(f)
DE Karn Power Plant, DE Karn Bottom Ash Pond

Introduction

According to Title 40 Code of Federal Regulations (40 CFR) Part 257, Subpart D, §257.91(f); the owner or operator of a Coal Combustion Residual (CCR) management unit must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system at the CCR management unit has been designed and constructed to meet the requirements of §257.91. Additionally, §257.91(a) details a performance standard requiring the system monitor the uppermost aquifer and include a minimum of at least one upgradient and three downgradient monitoring wells, and that if the uppermost aquifer monitoring system includes the minimum number of wells, the basis supporting use of only the minimum.

Groundwater Monitoring System

A groundwater monitoring system has been established for the DE Karn Bottom Ash Pond, which established the following locations for determining background groundwater quality and detection monitoring.

Background:

MW-15002	MW-15008
MW-15016	MW-15019

Downgradient:

DEK-MW-15001	DEK-MW-15002	DEK-MW-15003
DEK-MW-15004	DEK-MW-15005	DEK-MW-15006

Provided herein, as required by §257.91(f), is certification from a qualified professional engineer that the groundwater monitoring system at Consumers Energy DE Karn Bottom Ash Pond meets the requirements of §257.91.

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.91]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations §257.91 (40 CFR Part 257.91), I attest that this Groundwater Monitoring System has been designed and constructed to meet the requirements of 40 CFR 257.91. The report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.91.

Harold D. Register Jr.

Signature

October 17, 2017

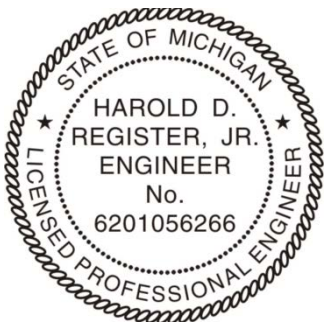
Date of Certification

Harold D. Register, Jr., P.E.

Name

6201056266

Professional Engineer Certification Number



10/17/2017

ENCLOSURES

ARCADIS (2016). "*Summary of Monitoring Well Design, Installation, and Development*"

ARCADIS Design & Consultancy for natural and built assets

Consumers Energy Company

SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT

D.E. Karn Electric Generation Facility – Essexville, Michigan

May 13, 2016

Gregory E. Zellmer, P.G.

Certified Project Manager/Senior Geologist

Mark Robert Klemmer, PE

Printed Name of Registered Professional Engineer

Signature of Registered Professional Engineer

Registration Number: 62010-49167 State: MI

Date: 5/13/16

Summary of Monitoring Well Design, Installation, and Development

D.E. Karn Electric Generation Facility – Essexville, MI

Prepared for:

Consumers Energy Company

Jackson, Michigan

Prepared by:

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi

Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

Our Ref.:

DE000722.0002.00006

Date:

May 13, 2016

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FIGURES

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1 INTRODUCTION

ARCADIS has prepared this Summary of Monitoring Well Design, Installation, and Development (Report) to summarize monitoring well installation activities for the D.E. Karn electric generation facility (DEK), located in Essexville, Michigan (Site). Monitoring wells were installed to achieve compliance under the recently published 40 CFR Part 257, Subpart D – Standards for the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities (specifically Section 257.91(e)(1)). This Report summarizes the groundwater monitoring well installation activities, including drilling procedures, well locations, well construction details, development activities, and hydraulic testing results. The methodology used in the field activities conforms to federal and state guidance and industry standards.

2 OBJECTIVES

The objectives of this report are to document the work completed at the Site, including:

- Advancement of soil borings
- Monitoring well installation
- Monitoring well development
- Hydraulic testing

The following section describes each of these elements in more detail.

3 FIELD ACTIVITIES

3.1 Soil Borings

Sixteen (16) soil borings were completed using rotosonic-drilling methods operated by Stock Drilling, Inc. of Ida, Michigan with oversight provided by an ARCADIS geologist. Rotosonic drilling uses powered equipment to collect subsurface-soil samples. The rotosonic drill rig advances a length of pipe into the ground through a combination of hydraulic force and high-frequency vibration. The high-frequency vibrations allow the pipe to advance through various types of soil producing a high-quality, continuous soil core within the pipe. Each length of pipe was extracted from the ground and emptied into a clear plastic liner for logging. This process was repeated until the total depth of the boring was reached.

Continuous soil cores were collected during drilling to provide detailed stratigraphic data. An on-site geologist inspected each core, classified the contents, and recorded the observations on an ARCADIS boring log field sheet (**Appendix A**). A photographic log showing the general soil types observed at the Site is included as **Appendix B**. Three soil borings were not completed as monitoring wells because they did not meet the minimum requirements of the CCR regulation for first usable aquifer due to the soils encountered at the boring locations; details of monitoring well installation are provided in the following section.

3.2 Monitoring Well Installation

Of the sixteen (16) soil borings that were completed, thirteen (13) of the soil boring locations were converted into permanent monitoring wells. The three (3) soil borings not converted to monitoring wells (Soil Borings SB-15004, SB-15005, and SB-15017) were backfilled with soil cuttings. Once the total depth of the soil boring was reached, a permanent monitoring well was installed in the uppermost aquifer unit for completion of monitoring wells. Monitoring wells were installed through the rotosonic drill rig piping allowing the driller to construct the monitoring well, while simultaneously removing the drill piping. Monitoring wells were constructed with 2-inch inside diameter Schedule 40, polyvinyl chloride (PVC) screens and PVC risers. The well screens have a slot size of 0.010 inch. The length of the monitoring well screens at the Site varied from 1 to 10 feet, and the length of the screen intervals was determined based on observations of each location during the soil boring activities. A medium-grained sand pack was placed around each well screen to a height 0.5 to 2.5 feet above the top of the well screen. Approximately 1 to 18.5 feet of bentonite pellets were placed on top of the sand pack. The remainder of the annular space was sealed with cement to a depth approximately 1.5 foot below ground surface, with exception to DEK MW-15004, MW-15001, MW-15008, MW-15015, and MW-15018. Monitoring well DEK MW-15004 was finished to ground surface with a bentonite grout, and the background monitoring wells MW-15001, MW-15008, MW-15015, and MW-15018 were finished to ground surface with soil cuttings and concrete.

The wells were finished at the surface using a 3-foot long, locking, stickup well cover set in a 24 inch by 24 inch concrete pad. Soil boring and well construction logs are included in **Appendix A**; well construction is summarized in **Table 1**; soil boring and well locations are shown on **Drawing SG-22355**. Wells were labeled according to Consumers Energy's site-specific nomenclature provided to ARCADIS. The CE construction manager supplied keyed-alike locks for each well that match the existing well keys.

3.3 Monitoring Well Development

Newly installed monitoring wells were allowed to set for a minimum of 48 hours, after which the wells were developed. Well development was completed by surging and evacuating water from the monitoring wells using a submersible pump. A "flow-thru cell" and a turbidity meter were utilized to monitor indicator parameters (turbidity, pH, temperature, oxidation-reduction potential (ORP), and conductivity) to determine if groundwater parameters had appropriately stabilized during the development activities at each monitoring well. The stabilization parameters are provided below in **Table 2**. Indicator parameters were recorded in field notes and the development process continued until development water was free of visible sediment, stabilization of the field parameters, and below 10 Nephelometric Turbidity Units (NTUs). The volume of groundwater removed during development and its appearance was recorded in the field logbook. If drilling fluids were utilized during well installation, the volume of fluids used was recorded in the field logbook. This volume was removed in addition to the volume required for standard development. Monitoring well development details are included in **Table 1**.

Table 2. Groundwater Parameter Stabilization Criteria

Groundwater Parameter	Stabilization Criteria
pH	3 readings within +/- 0.1 Standard Units
Specific Conductance (SpC)	3 readings within +/- 3% mS/cms
Temperature	3 readings within +/- 3%
Oxidation-Reduction Potential (ORP)	3 readings within +/- 10 mV
Turbidity	3 readings within +/- 10% or <1 when < 10 NTU
Dissolved Oxygen (DO)	3 readings within +/- 0.3 mg/L

3.4 Hydraulic Testing

On November 11, 2015, Arcadis conducted hydraulic tests (slug tests) at three (3) monitoring wells (DEK MW-15004, DEK MW-15005, and DEK MW-15006) at the Site. During the slug testing activities, three tests were completed at each of the three monitoring wells. Well construction logs are included in **Appendix A**; well construction details are summarized in **Table 1.**

The slug tests at the three wells were completed to estimate hydraulic conductivity (K) by introducing a water table displacement by removing a known volume of water or depressing the water level by compressed air and measuring the rate of recovery. The tests at DEK MW-15004 and DEK MW-15005 were completed using the pneumatic slug test method where a manifold and pump was used to depress the water level. The tests at DEK MW-15006 were completed using a disposable bailer to remove a known volume of water. The bailer used at this well was 1.5-inches in diameter and 36-inches long. All wells have casing and screen diameters of 2-inches and filter pack diameter of 8-inches. DEK MW-15004 is screened in very fine to medium fine sand that is confined by 27 feet of fly ash. DEK MW-15005 and DEK MW-15006 are screened in unconfined very fine to medium fine sand approximately 7.7 and 7.2 feet below the water table at the time of well development. At all the wells, a pressure transducer was set to record at 0.5 second intervals to measure pre-test static head, displacement and recovery data.

All tests at the three monitoring wells reached full recovery within approximately 80 to 500 seconds. Recovery data collected from the wells were analyzed using the applicable analytical solution with AQTESOLV® for Windows©. Based on diagnostic analyses, the solution utilized at the recovery data from the wells was the confined and unconfined KGS model (1994) that accounts for partial penetration effects. The recovery data of DEK MW-15004 was fit to the confined KGS model (1994) and the recovery data from wells: DEK MW-15005 and DEK MW-15006 were fit to the unconfined KGS model (1994). The results indicated an estimated hydraulic conductivity range from 9.5 to 31 feet per day (ft/d) with an average of 17 ft/d and a geometric mean of 15 ft/d. The results of this test seem to be a reasonable fit for the very fine to medium fine sand formation. The monitoring well locations where slug tests were conducted are shown on **Drawing SG-22355** and the results of the hydraulic conductivity tests are presented in **Table 3** and **Appendix C**.

TABLES

Table 1
Monitoring Well Construction and Development Summary
Consumers Energy Co.
D.E. Karn Generating Facility
Essexville, Michigan

MW ID	Former MW ID	Site Coordinates				Date Installed	Geologic Unit of Screen Interval	Well Construction	Well Screen Length (ft)	Screen Interval (ft bgs)	Development Details				
		Northing	Easting	Ground Surface Elevation (ft above msl)	TOC Elevation (ft above msl)						Static DTW (ft below TOC)	Total Depth	Pumping DTW (ft below TOC)	Gallons Removed	Final Turbity (NTU)
Background Monitoring Well															
MW-15002	--	777616.50	13263683.70	584.90	587.71	9/17/2015	Sand	2" PVC, 10 slot	10	4 - 14	7.8	16.9	NR	150	15.7
MW-15008	--	778850.30	13262994.10	582.70	585.36	9/24/2015	Sand	2" PVC, 10 slot	10	4 - 14	4.78	17.46	5.76	110	2.94
MW-15016	--	777566.20	13263941.70	583.70	586.49	9/30/2015	Sand	2" PVC, 10 slot	3	2.5-5.5	4.33	8.03	8.00	51	5.1
MW-15018	--	777822.40	13263663.80	583.60	586.42	10/1/2015	Sand	2" PVC, 10 slot	4	3 - 7	6.26	10.03	10.00	68	2.07
MW-15019	--	778024.10	13263504.90	583.50	586.17	10/1/2015	Sand/Clay Sand	2" PVC, 10 slot	10	4 - 14	6.02	16.00	10.17	280	0.84
MW-15020	--	778708.40	13263077.40	582.50	585.95	10/1/2015	Sand	2" PVC, 10 slot	10	4 - 14	5.41	17.03	5.95	135	6.1
MW-15024	--	778249.10	13263347.90	583.70	586.56	10/8/2015	Sand	2" PVC, 10 slot	10	4 - 14	6.40	17.11	11.37	200	2.6
MW-15027	MW-116A	778601.30	13263139.30	583.20	586.25	4/26/2005	Sand	NR	10	5 - 15	5.73	18.29	6.45	110	1.51
Downgradient MW															
DEK MW-15001	--	782854.00	13263363.70	592.10	594.64	10/9/2015	Sand	2" PVC, 10 slot	1	16 - 17	8.78	20.22	12.18	112.5	6.00
DEK MW-15002	--	782690.60	13262816.80	588.30	590.87	10/9/2015	Sand	2" PVC, 10 slot	3	10 - 13	4.79	15.68	12.96	175	9.81
DEK MW-15003	--	783112.80	13263202.10	599.90	602.79	10/12/2015	Sand	2" PVC, 10 slot	4	21 - 25	NR	23.52	22.46	200	8.57
DEK MW-15004	--	783407.40	13262642.00	604.90	607.40	10/12/2015	Sand	2" PVC, 10 slot	5	30 - 35	17.99	38.10	22.85	275	0.98
DEK MW-15005	--	783163.00	13262105.30	586.80	589.72	10/13/2015	Sand	2" PVC, 10 slot	5	14.5 - 19.5	7.79	22.01	11.40	225	0.52
DEK MW-15006	--	782812.90	13262180.20	586.50	589.24	10/13/2015	Sand	2" PVC, 10 slot	5	13.5 - 18.5	NR	NR	11.97	190	0.87

Notes:
ft = feet
bgs = below ground surface
TOC = top of casing
NR = Not recorded
NA = Not applicable
msl = mean sea level

Table 3
Estimated Hydraulic Conductivity (K) Values
Consumers Energy Co.
D.E. Karn Generating Facility
Essexville, Michigan

Well ID	Test	H^0 (ft)	H^* (ft)	K (ft/d)	K (cm/sec)	Slug Test Solution
DEK MW-15004	3	2.106	2.31	9.5	3.4E-03	KGS Model (Hyder et. al, 1994)
DEK MW-15005	1	0.937	1.15	17	6.0E-03	KGS Model (Hyder et. al, 1994)
	3	1.917	2.31	11	3.9E-03	KGS Model (Hyder et. al, 1994)
	Average			*14*	*4.9E-03*	
DEK MW-15006	3	1.613	1.69	31	1.1E-02	KGS Model (Hyder et. al, 1994)
Overall Average				***17***	***6.0E-03***	
Overall Geometric mean				***15***	***5.4E-03***	
Minimum				***9.5***	***3.4E-03***	
Maximum				***31***	***1.1E-02***	

Notes:
H^0 = initial displacement
H^* = expected (calculated) displacement
cm/sec = centimeters per second
ft = feet
ft/d = feet per day

References

Butler, J.J., Jr., 1998. The Design, Performance, and Analysis of Slug Tests, Lewis Publishers, Boca Raton, 252p.

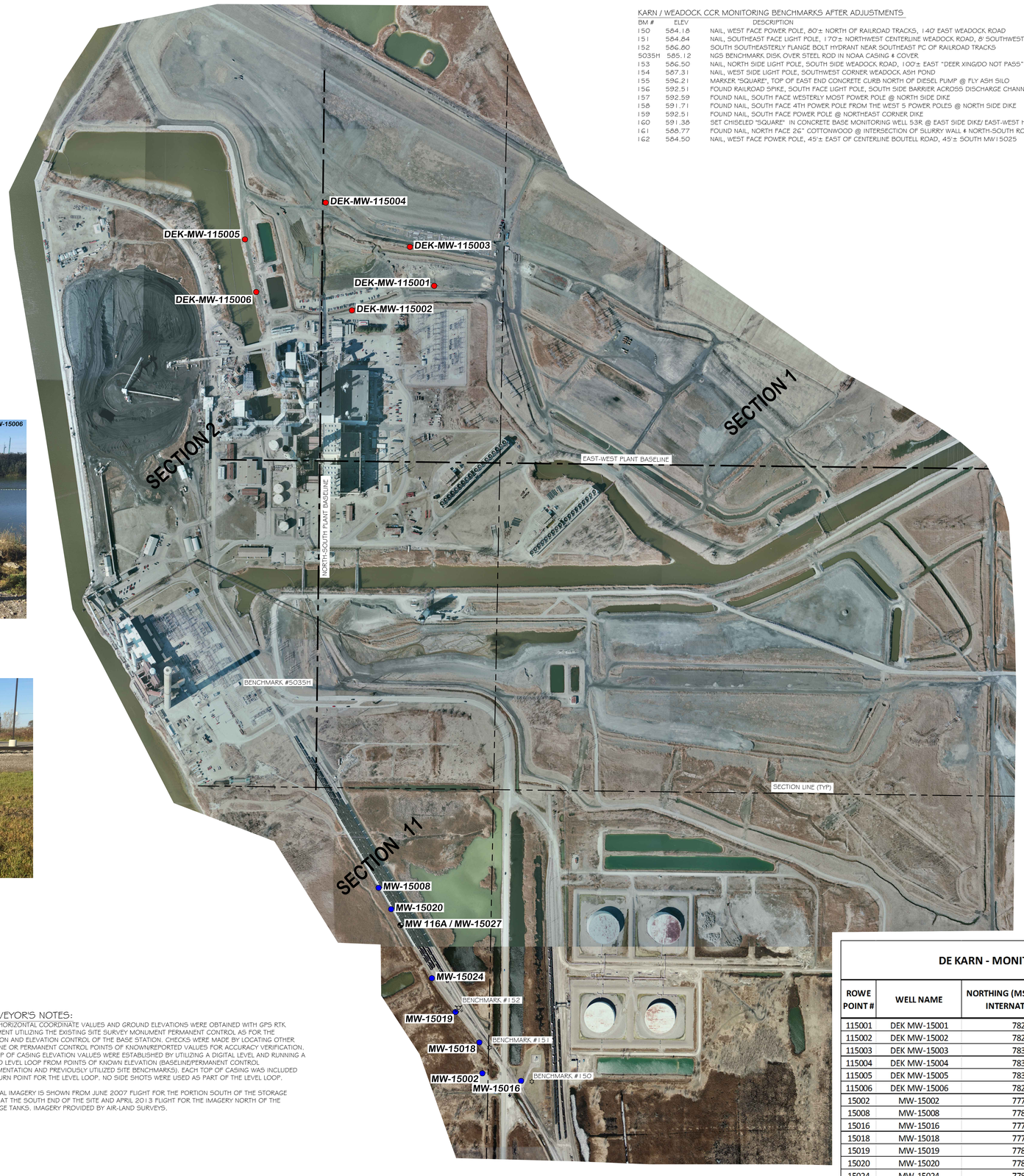
Hyder, Z, J.J. Butler, Jr., C.D. McElwee and W. Liu, 1994. Slug tests in partially penetrating wells, Water Resources Research, vol. 30, no. 11, pp. 2945-2957

FIGURES

N

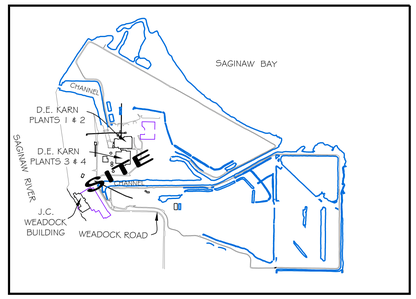
0 300 600

1 inch = 300 ft.



KARN / WEADOCK CCR MONITORING BENCHMARKS AFTER ADJUSTMENTS

BM #	ELEV	DESCRIPTION
150	584.18	NAIL, WEST FACE POWER POLE, 80± NORTH OF RAILROAD TRACKS, 140' EAST WEADOCK ROAD
151	584.84	NAIL, SOUTHEAST FACE LIGHT POLE, 170± NORTHWEST CENTERLINE WEADOCK ROAD, 5' SOUTHWEST RAILROAD TRACKS
152	586.80	SOUTH SOUTHEASTERLY FLANGE BOLT HYDRANT NEAR SOUTHEAST PC OF RAILROAD TRACKS
5035H	585.12	NGS BENCHMARK DISK OVER STEEL ROD IN NOAA CASING & COVER
153	586.50	NAIL, NORTH SIDE LIGHT POLE, SOUTH SIDE WEADOCK ROAD, 100± EAST "DEER XING/DO NOT PASS" SIGN
154	587.31	NAIL, WEST SIDE LIGHT POLE, SOUTHWEST CORNER WEADOCK ASH POND
155	596.21	MARKER "SQUARE", TOP OF EAST END CONCRETE CURB NORTH OF DIESEL PUMP @ FLY ASH SILO
156	592.51	FOUND RAILROAD SPIKE, SOUTH FACE LIGHT POLE, SOUTH SIDE BARRIER ACROSS DISCHARGE CHANNEL
157	592.59	FOUND NAIL, SOUTH FACE WESTERLY MOST POWER POLE @ NORTH SIDE DIKE
158	591.71	FOUND NAIL, SOUTH FACE 4TH POWER POLE FROM THE WEST 5 POWER POLES @ NORTH SIDE DIKE
159	592.51	FOUND NAIL, SOUTH FACE POWER POLE @ NORTHEAST CORNER DIKE
160	591.38	SET CHISELED "SQUARE" IN CONCRETE BASE MONITORING WELL 53R @ EAST SIDE DIKE/ EAST-WEST HAUL ROAD INTERSECTION
161	588.77	FOUND NAIL, NORTH FACE 26" COTTONWOOD @ INTERSECTION OF SLURRY WALL & NORTH-SOUTH ROAD
162	584.50	NAIL, WEST FACE POWER POLE, 45± EAST OF CENTERLINE BOUTELL ROAD, 45± SOUTH MW15025



LOCATION MAP

NOT TO SCALE

SECTION 1, 2, 11 & 12 HAMPTON TOWNSHIP — T14N-R5E BAY COUNTY

BASIS OF BEARING

MICHIGAN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE NAD83 (1994). COMBINED SCALE FACTOR = 0.99996843

BASIS OF ELEVATION

NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88)

*NAVD88 = NORTH AMERICAN VERTICAL DATUM OF 1988
*NGVD29 = NATIONAL GEODETIC VERTICAL DATUM OF 1929
*USLS = UNITED STATE LAKE SURVEY 1935
*IGLD55 = INTERNATIONAL GREAT LAKES DATUM 1955 ADJUSTMENT
*IGLD85 = INTERNATIONAL GREAT LAKES DATUM 1985 ADJUSTMENT
* REPORTED IN UNITS OF FEET.

CONVERSIONS

NAVD88 TO USLS = +0.92'
NAVD88 TO IGLD85 = -0.11'
USLS TO IGLD55 = -1.754'
USLS TO NGVD29 = -0.237'
IGLD55 TO IGLD85 = +0.72'

NOTE: THE CONVERSIONS TO USLS AND TO IGLD DATUMS ONLY APPLY TO THE IMMEDIATE AREA AT THE KARN PLANT AND SHOULD NOT BE USED ELSEWHERE.


DEK-MW-15006


MW-15016


MW-15019

LEGEND

DEK MW-406 ● DE KARN BOTTOM ASH POND WELL
MW-408 ● BACKGROUND MONITORING WELL
MW-409 ● EXISTING MONITORING WELL

SURVEYOR'S NOTES:

1) THE HORIZONTAL COORDINATE VALUES AND GROUND ELEVATIONS WERE OBTAINED WITH GPS RTK EQUIPMENT UTILIZING THE EXISTING SITE SURVEY MONUMENT PERMANENT CONTROL AS FOR THE LOCATION AND ELEVATION CONTROL OF THE BASE STATION. CHECKS WERE MADE BY LOCATING OTHER BASELINE OR PERMANENT CONTROL POINTS OF KNOWN/REPORTED VALUES FOR ACCURACY VERIFICATION. THE TOP OF CASING ELEVATION VALUES WERE ESTABLISHED BY UTILIZING A DIGITAL LEVEL AND RUNNING A CLOSED LEVEL LOOP FROM POINTS OF KNOWN ELEVATION (BASELINE/PERMANENT CONTROL MONUMENTATION AND PREVIOUSLY UTILIZED SITE BENCHMARKS). EACH TOP OF CASING WAS INCLUDED AS A TURN POINT FOR THE LEVEL LOOP. NO SIDE SHOTS WERE USED AS PART OF THE LEVEL LOOP.

2) AERIAL IMAGERY IS SHOWN FROM JUNE 2007 FLIGHT FOR THE PORTION SOUTH OF THE STORAGE TANKS AT THE SOUTH END OF THE SITE AND APRIL 2013 FLIGHT FOR THE IMAGERY NORTH OF THE STORAGE TANKS. IMAGERY PROVIDED BY AIR-LAND SURVEYS.

DE KARN - MONITORING WELLS; WO#25477881; ROWE #15L0110; OCTOBER 2015

ROWE POINT #	WELL NAME	NORTHING (MSPC NAD 83(1994) INTERNATIONAL FEET)	EASTING (MSPC NAD 83(1994) INTERNATIONAL FEET)	GROUND ELEV. (NAVD88)	T/CASING ELEV. (NAVD88)	LATITUDE (DECIMAL DEGREES)	LONGITUDE (DECIMAL DEGREES)
115001	DEK MW-15001	782854.0	13263363.7	592.1	594.64	43.6468779	-83.8377431
115002	DEK MW-15002	782690.6	13262816.8	588.3	590.87	43.6464391	-83.8398133
115003	DEK MW-15003	783112.8	13263202.1	599.9	602.79	43.6475906	-83.8383476
115004	DEK MW-15004	783407.4	13262642.0	604.9	607.40	43.6484083	-83.8404567
115005	DEK MW-15005	783163.0	13262105.3	586.8	589.72	43.6477471	-83.8424899
115006	DEK MW-15006	782812.9	13262180.2	586.5	589.24	43.6467853	-83.8422153
15002	MW-15002	777616.5	13263683.7	584.9	587.71	43.6325042	-83.8366589
15008	MW-15008	778850.3	13262994.1	582.7	585.36	43.6359007	-83.8392343
15016	MW-15016	777566.2	13263941.7	583.7	586.49	43.6323619	-83.8356858
15018	MW-15018	777822.4	13263663.8	583.6	586.42	43.6330693	-83.8367291
15019	MW-15019	778024.1	13263504.9	583.5	586.17	43.6336254	-83.8373244
15020	MW-15020	778708.4	13263077.4	582.5	585.95	43.6355101	-83.8389231
15024	MW-15024	778249.1	13263347.9	583.7	586.56	43.6342456	-83.8379121
15027	MW 116A/MW-15027	778601.3	13263139.3	583.2	586.25	43.6352151	-83.8386919

DRAWING NO.	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.
FIG 1, REV2	ARCADIS RCRA CCR GROUNDWATER MONITORING PROGRAM	A	11/30/15	EDIT TABLE AND LEGEND	EMB	

DR. J. PLUMMER 11/05/15
FIELD BOOK # 1989 FLD. BC/DM 11/4/15
CHKD. H. HORTON 11/06/15
APP.

Consumers Energy
ROWE PROFESSIONAL SERVICES COMPANY

DE KARN MONITORING WELLS CCR MONITORING

SECTION 1,2,11 & 12 HAMPTON TOWNSHIP — T14N-R5E BAY COUNTY — SAP 25477881

SCALE: 1"=300' | DRAWING NO. SG-22355 | SHEET 1 | REV. A

FILE NAME: 22355BASE.DWG
ROWE # 15L0110

APPENDIX A

Soil Boring and Monitoring Well Construction Logs

Date Start: 10/09/15
Date Finish: 10/09/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 11.0
Water Level Finish (ft. btoc.): 8.78

Northing: 782854
Easting: 13263363.7
Casing Elevation: 594.64

Borehole Depth (ft. bgs.): 19.0
Surface Elevation: 592.1

Descriptions By: L. Rogers

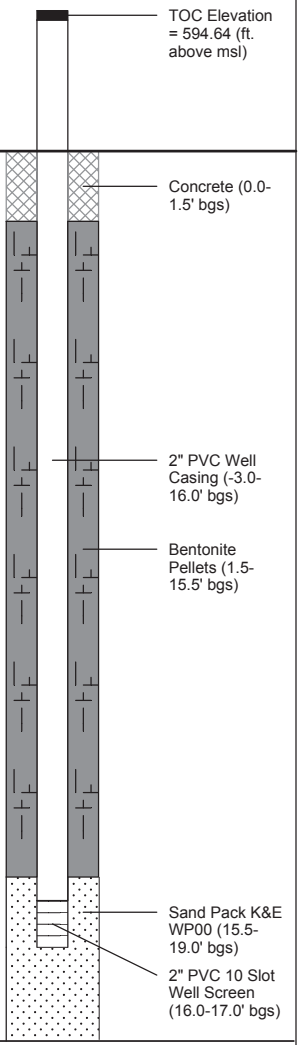
Well/Boring ID: **DEK MW-15001**

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 57 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
595 / 0								
590 / 5	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
585 / 10	2	6.0-9.0'	3.0	NA			(6.0 - 9.0') ASH; wet; black (10YR 2/1). NOTE: Fill material.	
							(9.0 - 11.0') CLAY, medium plasticity; little fine sand to very large pebbles, subrounded to subangular; moist to wet; soft; brown (10YR 5/3).	
580							(11.0 - 12.5') ASH; wet; soft; black (10YR 2/1).	
15	3	9.0-19.0'	9.6	NA			(12.5 - 17.0') SAND, very fine to fine; little medium sand; trace ash; well sorted; wet; very dark grayish brown (10YR 3/2). NOTE: Trace shell fragments at 15.0' bgs. NOTE: Lose trace ash at 15.5' bgs.	
575							(17.0 - 19.0') CLAY, medium to low plasticity; trace silt; trace fine to medium sand; trace granule to large pebbles, subrounded to subangular; dry; stiff to very stiff; dark grayish brown (10YR 4/2).	
20							End of boring 19.0' bgs.	



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 11.0' bgs during drilling.
Water level at development was 8.78' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 585.97 feet above mean sea level.

Date Start: 10/09/15
Date Finish: 10/09/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 10.0
Water Level Finish (ft. btoc.): 4.79

Northing: 782690.6
Easting: 13262816.8
Casing Elevation: 590.87

Borehole Depth (ft. bgs.): 19.0
Surface Elevation: 588.3

Descriptions By: L. Rogers

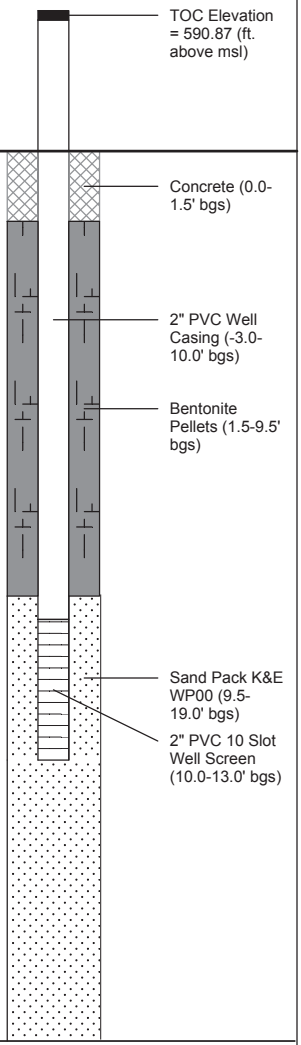
Well/Boring ID: DEK MW-15002

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 64 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
590								
0							(0.0 - 6.0') Hydrovac; no lithology recorded.	
585	1	0.0-6.0'	0.0	NA				
5						×	(6.0 - 6.8') Bottom ASH.	
580	2	6.0-9.0'	3.0	NA			(6.8 - 9.0') SAND, very fine to fine; little medium sand; trace coarse sand; well sorted; moist; dark grayish brown (10YR 4/2).	
10							(9.0 - 10.0') SILT, medium to low plasticity, high dilatancy; some clay; little very fine to fine sand; moist to wet; dark olive gray (5Y 3/2).	
							(10.0 - 13.0') SAND, very fine to fine; little medium sand; trace coarse sand to granule, subrounded to subangular; well sorted; moist to wet; dark grayish brown (10YR 4/2).	
575	3	9.0-19.0'	10.0	NA			(13.0 - 19.0') CLAY, medium to low plasticity; trace silt; trace fine to medium sand; trace granule to large pebbles, subrounded to subangular; dry; stiff to very stiff; dark grayish brown (10YR 4/2). NOTE: Till.	
15								
570								
20							End of boring 19.0' bgs.	



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Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 10.0' bgs during drilling.
Water level at development was 4.79' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 586.02 feet above mean sea level.

Date Start: 10/12/15
Date Finish: 10/12/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 7.0
Water Level Finish (ft. btoc.): 12.08

Northing: 783112.8
Easting: 13263202.1
Casing Elevation: 602.79

Borehole Depth (ft. bgs.): 29.0
Surface Elevation: 599.9

Descriptions By: L. Rogers

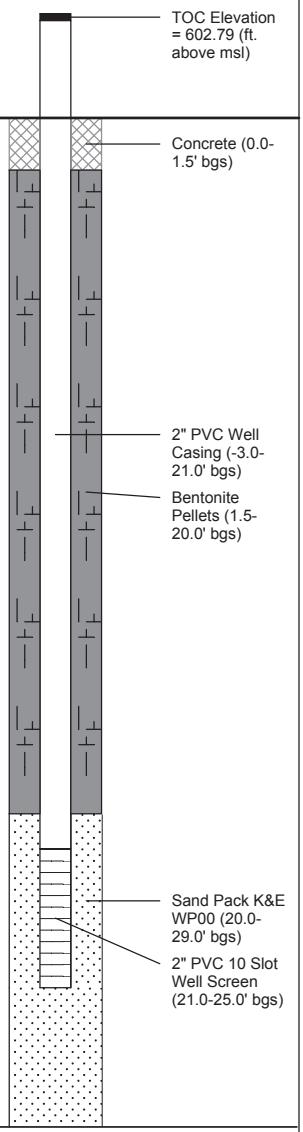
Well/Boring ID: DEK MW-15003

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 60 F Windy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0 / 600								
	1	0.0-7.0'	0.0	NA			(0.0 - 7.0') Hydrovac; no lithology recorded.	
5 / 595								
	2	7.0-9.0'	2.0	NA			(7.0 - 8.0') Fly ASH; wet; black (10YR 2/1). NOTE: Fill material. (8.0 - 9.5') PEAT and ASH; little roots; little organics; wet; black (10YR 2/1).	
10 / 590							(9.5 - 19.5') ASH, mix of bottom and fly; wet; black (10YR 2/1). NOTE: Fill material.	
	3	9.0-19.0'	7.5	NA			NOTE: Trace clay from 16.0' to 19.5' bgs.	
15 / 585								
20 / 580							(19.5 - 21.0') SAND, very fine to fine; little silt and clay; trace medium sand; well sorted; moist to wet; dark olive gray (5Y 3/2).	
							(21.0 - 25.0') SAND, very fine to medium; trace coarse sand; trace silt; well sorted; moist to wet; dark gray (10YR 4/1).	
25 / 575	4	19.0-29.0'	10.3	NA			(25.0 - 29.0') CLAY, medium to low plasticity; little granule to large cobbles, subrounded to subangular; trace silt; dry; stiff to very stiff; brown (10YR 4/7). NOTE: Till.	
30 / 570							End of boring 29.0' bgs.	



Well/Boring Construction

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Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 7.0' bgs.
Groundwater encountered at 7.0' bgs during drilling.
Water level at development was 12.08' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 588.82 feet above mean sea level.

Date Start: 10/12/15
Date Finish: 10/12/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 13.0
Water Level Finish (ft. btoc.): 17.99

Northing: 783407.4
Easting: 13262642
Casing Elevation: 607.4

Borehole Depth (ft. bgs.): 39.0
Surface Elevation: 604.9

Descriptions By: L. Rogers

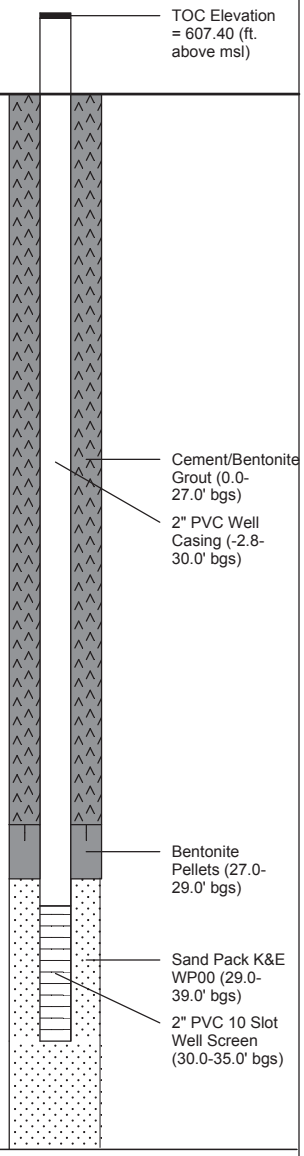
Well/Boring ID: DEK MW-15004

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 65 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	605								
		1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5	600								
		2	6.0-9.0'	4.7	NA			(6.0 - 15.0') Fly ASH; dry to moist; black (10YR 2/1). NOTE: Fill material. NOTE: Moist from 7-8.5' bgs. NOTE: Add little very fine to fine sand at 8.5' bgs.	
10	595								
		3	9.0-19.0'	8.2	NA			NOTE: Wet at 13.0' bgs.	
15	590							(15.0 - 26.0') Bottom ASH; wet; black (10YR 2/1). NOTE: Fill material.	
20	585								
		4	19.0-29.0'	9.6	NA			(26.0 - 27.0') Fly ASH; wet; black (10YR 2/1). NOTE: Fill material.	
25	580							(27.0 - 27.5') PEAT; little organics.	
30	575							(27.5 - 38.5') SAND, very fine to medium; trace coarse sand; well sorted; moist; gray (10YR 5/1).	
35	570	5	29.0-39.0'	7.6	NA			(38.5 - 39.0') SILT, no plasticity, slow dilatancy; little very fine sand; dry; soft; very dark grayish brown (10YR 3/2).	
40	565							End of boring 39.0' bgs.	



Well/Boring Construction

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Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 13.0' bgs during drilling.
Water level at development was 17.99' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 588.86 feet above mean sea level.

Date Start: 10/13/15
Date Finish: 10/13/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 15.0
Water Level Finish (ft. btoc.): 11.40

Northing: 783163
Easting: 13262105.3
Casing Elevation: 589.72

Borehole Depth (ft. bgs.): 19.5
Surface Elevation: 586.8

Descriptions By: L. Rogers

Well/Boring ID: **DEK MW-15005**

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 52 F Cloudy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
590 / 0									TOC Elevation = 589.72 (ft. above msl)
585 / 5	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.		Concrete (0.0-1.5' bgs)
580 / 10	2	6.0-9.5'	5.0	NA			(6.0 - 6.5') Bottom ASH and TOPSOIL; trace roots. NOTE: Fill material. (6.5 - 19.5') SAND, very fine to medium; trace coarse sand; well sorted; dry to moist; dark grayish brown (10YR 4/2). NOTE: Moist to wet at 8.5' bgs. NOTE: Color change to dark gray (10YR 4/1) at 10.0' bgs.		2" PVC Well Casing (-3.0-14.5' bgs) Bentonite Pellets (1.5-12.0' bgs)
575 / 15	3	9.5-19.5'	10.6	NA			NOTE: Wet at 15.0' bgs. NOTE: Trace very coarse sand and trace shell fragments at 16.0' bgs.		Sand Pack K&E WP00 (12.0-19.5' bgs) 2" PVC 10 Slot Well Screen (14.5-19.5' bgs)
570 / 20							End of boring 19.5' bgs.		
565									

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 15.0' bgs during drilling.
Water level at development was 11.40' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 579.72 feet above mean sea level.

Date Start: 10/13/15
Date Finish: 10/13/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 14.0
Water Level Finish (ft. btoc.): 9.33

Northing: 782812.9
Easting: 13262180.2
Casing Elevation: 589.24

Borehole Depth (ft. bgs.): 19.5
Surface Elevation: 586.5

Descriptions By: L. Rogers

Well/Boring ID: DEK MW-15006

Client: Consumers Energy

Location: DE Karn Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 57 F Windy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
590									TOC Elevation = 589.24 (ft. above msl)
0									
585	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.		Concrete (0.0-1.5' bgs)
5									2" PVC Well Casing (-3.0-13.5' bgs)
580	2	6.0-9.5'	3.0	NA	X		(6.0 - 6.5') SAND, very fine to coarse; trace granule to large pebbles, subrounded to subangular; poorly sorted; dry; brown (10YR 4/3).		Bentonite Pellets (1.5-11.5' bgs)
							(6.5 - 19.5') SAND, very fine to fine; little medium sand; trace coarse sand; well sorted; dry; dark yellowish brown (10YR 3/6).		
10							NOTE: Moist; change to very dark gray (10YR 3/1) at 9.0' bgs.		
575					X				
15	3	9.5-19.5'	10.3	NA			NOTE: Wet at 14.0' bgs.		Sand Pack K&E WP00 (11.5-19.5' bgs)
570					X				2" PVC 10 Slot Well Screen (13.5-18.5' bgs)
20							End of boring 19.5' bgs.		
565									

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 14.0' bgs during drilling.
Water level at development was 9.33' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 579.65 feet above mean sea level.

Date Start: 09/17/15
Date Finish: 09/17/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): 7.8

Northing: 777616.5
Easting: 13263683.7
Casing Elevation: 587.71

Borehole Depth (ft. bgs.): 15.0
Surface Elevation: 584.9

Descriptions By: L. Rogers

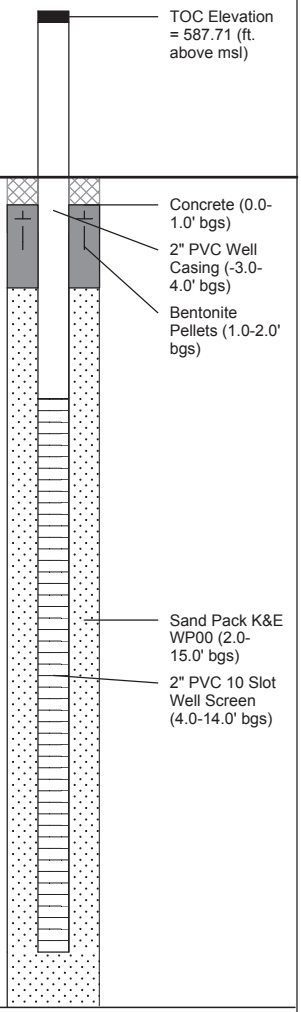
Well/Boring ID: **MW-15002**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 72 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0 / 585	1	0.0-6.0'	6.0	NA			(0.0 - 6.0') Hydrovac no lithology recorded.	
5 / 580	2	6.0-10.0'	2.5	NA			(6.0 - 8.0') SAND, very fine to medium; little organics; trace silt; trace clay; trace granule, subrounded to subangular; moist to wet; very dark brown (10YR 2/2).	
							(8.0 - 14.0') SAND, fine to coarse; little very coarse; trace granule to medium pebbles, subrounded to subangular; poorly sorted; moist; very dark grayish brown (10YR 3/2).	
10 / 575	3	10.0-15.0'	4.7	NA			NOTE: trace small pebbles to small cobbles, subrounded to subangular from 12.0 to 14.0' bgs.	
15 / 570							(14.0 - 15.0') CLAY, low to medium plasticity; little silt; little granule to small cobbles, subrounded to subangular; dry; stiff; dark grayish brown (10YR 4/2).	
							End of boring 15.0' bgs.	



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 7.8' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.49 feet above mean sea level.

Date Start: 09/23/15
Date Finish: 09/24/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 2.0
Water Level Finish (ft. btoc.): 4.78

Northing: 778850.3
Easting: 13262994.1
Casing Elevation: 585.36

Borehole Depth (ft. bgs.): 39.0
Surface Elevation: 582.7

Descriptions By: L. Rogers

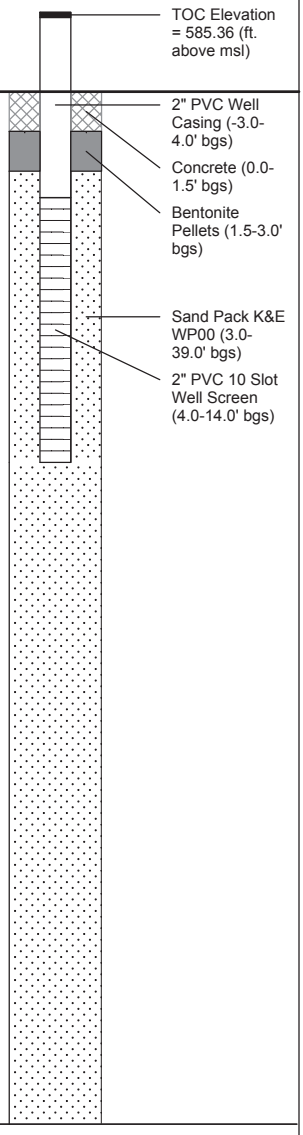
Well/Boring ID: **MW-15008**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 71 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
585 / 0								
580 / 5	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac no lithology recorded.	
575 / 10	2	6.0-9.0'	3.2	NA			(6.0 - 8.0') SAND, very fine to fine; trace medium to coarse sand; well sorted; wet; trace organics; very dark gray (10YR 3/1). NOTE: Sluff.	
							(8.0 - 8.5') CLAY, low plasticity; trace granule to small pebbles, subrounded to subangular; dry; stiff; dark yellowish brown (10YR 4/4).	
570 / 15	3	9.0-19.0'	9.4	NA			(8.5 - 19.0') SAND, very fine to medium; trace coarse to very coarse sand; trace granule, subrounded to subangular; well sorted; wet; very dark gray (10YR 3/1). NOTE: little medium to very coarse sand; trace granule, subrounded to subangular; color change to dark grayish brown (10YR 4/2) at 16.5' bgs.	
565 / 20								
560 / 25	4	19.0-29.0'	10.0	NA			(19.0 - 33.0') SAND, very fine to fine; trace medium to coarse sand; trace clay; well sorted; moist; dark grayish brown (10YR 4/2).	
555 / 30								
550 / 35	5	29.0-39.0'	8.7	NA			(33.0 - 39.0') SILT and CLAY, medium to high plasticity, slow dilatancy; trace organics; moist; soft; olive brown (2.5Y 4/3).	
545 / 40							End of boring 39.0' bgs.	



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 2.0' bgs during drilling.
Water level at development was 4.78' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.68 feet above mean sea level.

Date Start: 09/28/15
Date Finish: 09/30/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 2.5
Water Level Finish (ft. btoc.): 4.33

Northing: 777566.2
Easting: 13263941.7
Casing Elevation: 586.49

Borehole Depth (ft. bgs.): 9.0
Surface Elevation: 583.7

Descriptions By: L. Rogers

Well/Boring ID: **MW-15016**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 55 F Cloudy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
585									TOC Elevation = 586.49 (ft. above msl)
0							(0.0 - 0.1') GRASS and TOPSOIL.		Concrete (0.0-1.0' bgs)
							(0.1 - 4.0') SAND, very fine to coarse; little granule; trace small pebbles, subrounded to subangular; poorly sorted; dry; gray (10YR 4/1).		2" PVC Well Casing (-3.0-2.5' bgs)
							NOTE: Trace clay at 2.0' bgs.		Bentonite Pellets (1.0-2.0' bgs)
							NOTE: Wet at 2.5' bgs.		
	1	0.0-6.0'	6.0	NA			NOTE: Trace organics, roots from 3.0 to 4.0' bgs.		
580									Sand Pack K&E WP00 (2.0-9.0' bgs)
5							(4.0 - 5.5') SAND, very fine to fine; trace medium sand; trace organics, shell fragments; well sorted; wet; very dark gray (10YR 3/1).		2" PVC 10 Slot Well Screen (2.5-5.5' bgs)
							(5.5 - 9.0') CLAY, trace silt, medium plasticity; trace very fine to medium sand; trace organics, roots; moist to dry; medium stiff to stiff; gray (10YR 5/1).		
	2	6.0-9.0'	6.0	NA			NOTE: Lose trace organics at 6.0' bgs; little granule to small cobbles, subrounded to subangular from 6.0' to 9.0' bgs.		
575									
10							End of boring 9.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hand Auger to 6.0' bgs.
Groundwater encountered at 2.5' bgs during drilling.
Water level at development was 4.33' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 582.73 feet above mean sea level.

Date Start: 09/28/15
Date Finish: 10/01/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 3.0
Water Level Finish (ft. btoc.): 6.26

Northing: 777822.4
Easting: 13263663.8
Casing Elevation: 586.42

Borehole Depth (ft. bgs.): 9.0
Surface Elevation: 583.6

Descriptions By: L. Rogers

Well/Boring ID: **MW-15018**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 54 F

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
585									TOC Elevation = 586.42 (ft. above msl)
0							(0.0 - 0.2') GRASS and TOPSOIL.		Concrete (0.0-0.5' bgs)
							(0.2 - 7.0') SAND, very fine to medium; trace coarse sand to granule, subrounded to subangular; dry; well sorted; dark yellowish brown (10YR 3/4).		Bentonite Pellets (0.5-2.0' bgs)
							NOTE: Moist at 2.0' bgs.		2" PVC Well Casing (-3.0-3.0' bgs)
	1	0.0-6.0'	6.0	NA			NOTE: Wet at 3.0' bgs.	▼	
580									
5							NOTE: Little peat and organics at 5.5' to 6.0' bgs.		Sand Pack K&E WP00 (2.0-9.0' bgs)
							NOTE: Lose peat at 6.0' bgs.		2" PVC 10 Slot Well Screen (3.0-7.0' bgs)
	2	6.0-9.0'	3.2	NA			(7.0 - 9.0') CLAY, medium plasticity; little granule to small pebbles, subrounded to subangular; trace silt; dry stiff; dark gray (10YR 4/1).		
575									
10							End of boring 9.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hand Auger to 6.0' bgs.
Groundwater encountered at 3.0' bgs during drilling.
Water level at development was 6.26' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.5 feet above mean sea level.

Date Start: 10/01/15
Date Finish: 10/01/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 3.0
Water Level Finish (ft. btoc.): 6.02

Northing: 778024.1
Easting: 13263504.9
Casing Elevation: 586.17

Borehole Depth (ft. bgs.): 19.0
Surface Elevation: 583.5

Descriptions By: L. Rogers

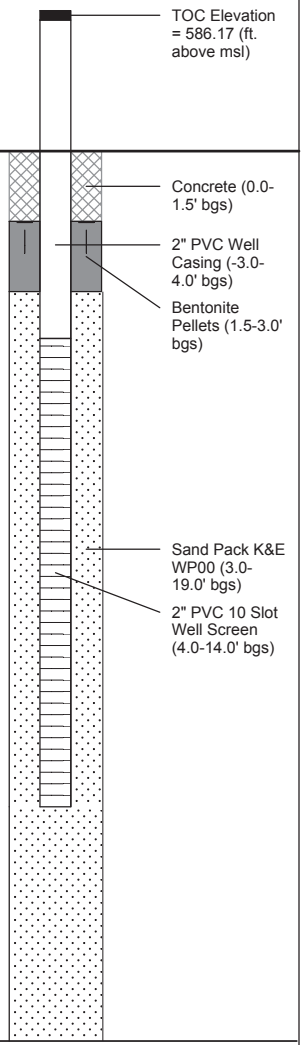
Well/Boring ID: **MW-15019**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 55 F Windy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
585 / 0								
580 / 5	1	0.0-6.0'	6.0	NA			(0.0 - 0.2') GRASS and TOPSOIL. (0.2 - 2.0') SAND, fine to medium; little coarse to very coarse sand; trace granule to small pebbles, subrounded to subangular; dry; well sorted; dark brown (10YR 3/3). (2.0 - 7.5') SAND, very fine to medium; trace coarse sand; moist; well sorted; very dark brown (10YR 2/2). NOTE: Wet at 3.0' bgs. NOTE: Little coarse sand to granule, subrounded to subangular starting at 4.0' bgs.	
	2	6.0-9.0'	NA	NA			(7.5 - 14.5') SAND and CLAY, very fine to fine, high plasticity; trace medium sand; trace silt; moist to wet; well sorted; dark gray (10YR 4/1).	
575 / 10	3	9.0-19.0'	9.5	NA			(14.5 - 16.5') SAND, fine to coarse; little very coarse sand to granule; trace small pebbles, subrounded to subangular; well sorted; wet; dark gray (10YR 4/1). (16.5 - 19.0') SAND, very fine to fine; some clay; trace medium sand; well sorted; wet; dark gray (10YR 4/1).	
570 / 15								
565 / 20							End of boring 19.0' bgs.	



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Remarks: bgs = below ground surface btoc = below top of casing

Hand Auger to 6.0' bgs.
Groundwater encountered at 3.0' bgs during drilling.
Water level at development was 6.02' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.39 feet above mean sea level.

Date Start: 09/28/15
Date Finish: 10/01/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 5.0
Water Level Finish (ft. btoc.): 5.41

Northing: 778708.4
Easting: 13263077.4
Casing Elevation: 585.95

Borehole Depth (ft. bgs.): 19.0
Surface Elevation: 582.5

Descriptions By: L. Rogers

Well/Boring ID: **MW-15020**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 54 F Windy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
585									TOC Elevation = 585.95 (ft. above msl)
0							(0.0 - 0.2') GRASS, TOPSOIL. and FRAGMITES.		Concrete (0.0-1.5' bgs)
							(0.2 - 1.0') SAND, very fine to medium; trace coarse sand to granule, subrounded to subangular; trace roots; poorly sorted; moist; dark grayish brown (10YR 4/2).		2" PVC Well Casing (-3.0-4.0' bgs)
580	1	0.0-6.0'	6.0	NA			(1.0 - 19.0') SAND, very fine to fine; trace medium sand; well sorted; moist; dark yellowish brown (10YR 4/4).		Bentonite Pellets (1.5-3.0' bgs)
5							NOTE: Color change to gray (10YR 5/1) at 2.0' bgs.		
							NOTE: Trace coarse sand; color change to very dark brown (10YR 2/2) at 4.0' bgs.		
							NOTE: Trace organics, shells; wet at 5.0' bgs.		
575	2	6.0-9.0'	3.5	NA			NOTE: Lose trace shells; color change to dark gray (10YR 4/1) at 6.0' bgs.		Sand Pack K&E WP00 (3.0-19.0' bgs)
10									2" PVC 10 Slot Well Screen (4.0-14.0' bgs)
570	3	9.0-19.0'	9.6	NA					
15									
565									
20							End of boring 19.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hand Auger to 6.0' bgs.
Groundwater encountered at 5.0' bgs during drilling.
Water level at development was 5.41' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.61 feet above mean sea level.

Date Start: 10/08/15
Date Finish: 10/08/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 5.0
Water Level Finish (ft. btoc.): 6.4

Northing: 778249.1
Easting: 13263347.9
Casing Elevation: 586.56

Borehole Depth (ft. bgs.): 19.5
Surface Elevation: 583.7

Descriptions By: L. Rogers

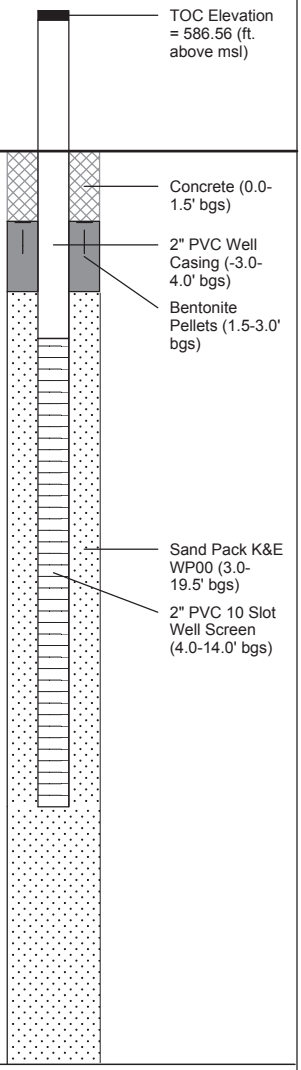
Well/Boring ID: **MW-15024**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 61 F Cloudy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
585								
0							(0.0 - 0.2') GRASS and TOPSOIL.	
							(0.2 - 1.0') CLAY, medium plasticity; trace fine to medium sand; trace granule to small cobbles, subrounded to subangular; dry; stiff; dark yellowish brown (10YR 4/6).	
580	1	0.0-6.0'	6.0	NA			(1.0 - 13.0') SAND, very fine to medium; trace coarse sand to small pebbles, subrounded to subangular; well sorted; mosit; very dark gray brown (10YR 3/2).	
5							NOTE: Lose trace small pebbles; change to trace coarse sand to granule; color change to black (10YR 2/1) at 3.0' bgs.	
							NOTE: Change to little coarse to very coarse sand with trace organics, shells; color change to very dark gray (10YR 3/1) at 4.0' bgs.	
							NOTE: Little shell fragments; wet at 5.0' bgs.	
575	2	6.0-9.5'	3.0	NA				
10							NOTE: Little coarse sand to small cobbles, subrounded from 10.0-13.0' bgs.	
570							(13.0 - 19.5') SAND, medium to very coarse; some granule to large cobbles, subrounded to subangular; poorly sorted; wet; dark gray (10YR 4/1).	
15	3	9.5-19.5'	10.0	NA				
565								
20							End of boring 19.5' bgs.	



Remarks: bgs = below ground surface btoc = below top of casing

Hand Auger to 6.0' bgs.
Groundwater encountered at 5.0' bgs during drilling.
Water level at development was 6.4' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 580.27 feet above mean sea level.

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Date Start: 04/26/2005
Date Finish: 04/26/2005
Drilling Company: Rau Drilling
Driller's Name: Greg Compeau
Drilling Method: Hollow Stem Auger
Sampling Method: Continuous
Rig Type: Auger
Water Level Start (ft. bgs.): 2.0
Water Level Finish (ft. btoc.): NA

Northing: 778601
Easting: 13263139
Casing Elevation:

Borehole Depth (ft. bgs.): 15.5
Surface Elevation: 584.1

Descriptions By: B Hennings (NRT, Inc.)

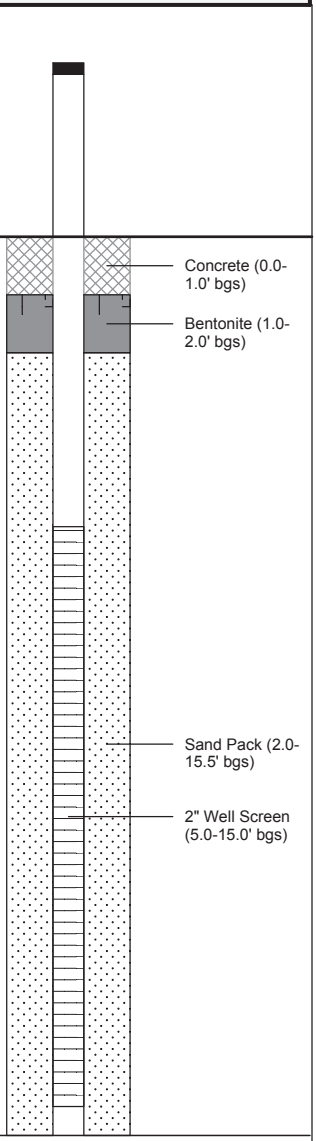
Well/Boring ID: **MW-15027**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: NA

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
585 / 0								
	1	0.0-2.0'	1	NA	X		(0.0 - 1.0') CLAY, tan low plasticity lean clay, trace gravel and organics.	
							(1.0 - 2.0') SAND, brown medium grained sand, trace fine gravel.	
	2	2.0-4.0'	2	NA	X		(2.0 - 15.5') SAND, well graded, tan, wet, fine to coarse grained, sub-rounded sand composed of 90% quartz and 10% other lithic grains, trace shell fragments, mottled red-orange. NOTE: Sand becomes gray, no mottling.	
580 / 5	3	4.0-6.0'	1.6	NA	X		NOTE: Sand becomes medium grained, well graded with trace coarse sand.	
	4	6.0-8.0'	1.5	NA	X		NOTE: Sand becomes brown (10YR 5/3), 5% shell fragments, trace roots.	
575 / 10	5	8.0-10.0'	1.5	NA	X			
	6	10.0-12.0'	1.7	NA	X			
570 / 15	7	12.0-14.0'	1.7	NA	X		NOTE: Sand becomes well-graded medium to coarse grained, 5% shell fragments, no roots.	
	8	14.0-15.5'	1.7	NA	X			
							End of boring 15.5' bgs.	



Well/Boring Construction

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Groundwater encountered at 2.0' bgs during drilling.
No odor or staining observed.

Date Start: 09/21/15
Date Finish: 09/21/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: NA

Descriptions By: L. Rogers

Well/Boring ID: **SB-15004**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 74 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0 / 0							(0.0 - 0.6') Hydrovac; no lithology recorded.		
	1	0.0-6.0'	0.0	NA					
5 / -5							(6.0 - 6.5') Bottom ASH. NOTE: Fill material.		
	2	6.0-10.0'	7.5	NA			(6.5 - 20.0') CLAY, medium plasticity, no dilatancy; trace very fine to fine sand; trace granule to small cobble, subrounded to subangular; dry; stiff to very stiff; dark yellowish brown (10YR 4/6).		Borehole backfilled with soil cuttings.
10 / -10									
	3	10.0-15.0'	7.5	NA			NOTE: color change to dark gray (10YR 4/1) at 13.5' bgs.		
15 / -15									
	4	15.0-20.0'	9.0	NA					
20 / -20							End of boring 20.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater not encountered during drilling.
No odor or staining observed.

Date Start: 09/21/15
Date Finish: 09/21/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hydrovac/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: NA

Descriptions By: L. Rogers

Well/Boring ID: **SB-15005**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 70 F Sunny

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0 / 0	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.		
5 / -5	2	6.0-10.0'	5.0	NA			(6.0 - 20.0') CLAY, medium plasticity, no dilatancy; trace very fine to fine sand; trace granule to small cobble, subrounded to subangular; dry; stiff to very stiff; dark yellowish brown (10YR 4/6).		
10 / -10	3	10.0-15.0'	7.0	NA			NOTE: color change to dark gray (10YR 4/1) at 13.0' bgs.		Borehole backfilled with soil cuttings.
15 / -15	4	15.0-20.0'	7.0	NA					
20 / -20							End of boring 20.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater not encountered during drilling.
No odor or staining observed.

Date Start: 10/01/15
Date Finish: 10/01/15
Drilling Company: Stock Drilling
Driller's Name: Austin Goldsmith
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 3.0
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth (ft. bgs.): 9.0
Surface Elevation: NA

Descriptions By: L. Rogers

Well/Boring ID: **SB-15017**

Client: Consumers Energy

Location: JC Weadock Facility
2742 Weadock Highway
Essexville, MI 48732

Weather Conditions: 51 F Cloudy, windy

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0 / 0							(0.0 - 0.1') TOPSOIL, GRASS and road GRAVEL.		
							(0.1 - 1.0') SAND and ASH, very fine to medium pebbles, subrounded to subangular; poorly sorted; dry; dark brown (10YR 3/3). NOTE: Fill.		
							(1.0 - 5.0') CLAY, medium plasticity; little very fine to medium sand; trace coarse sand to small pebbles, subrounded to subangular; trace silt; trace ash; dry; medium stiff; brown (10YR 4/3).		
	1	0.0-6.0'	6.0	NA			NOTE: Lose trace ash, clay becomes stiff; wet; dark grayish brown (10YR 4/2) at 3.0' bgs.		
5 / -5							(5.0 - 6.0') PEAT; black (10YR 2/1).		Borehole backfilled with soil cuttings.
	2	6.0-9.0'	3.0	NA			(6.0 - 9.0') CLAY, medium to low plasticity; little granule to small pebbles, subrounded to subangular; dry; stiff; dark grayish brown (10YR 4/2).		
10 / -10							End of boring 9.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encounteredat 3.0' bgs during drilling.
No odor or staining observed.

SOIL DESCRIPTION

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Description	Criteria
Nonplastic	A $^1/_8$ inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

APPENDIX B

Photographic Log

Photograph #1

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Site Location:
Consumers Energy Co.
D.E. Karn Generating Facility
Essexville, Michigan

Photograph Taken By:
Lance Rogers

Date of Photograph:
September 21, 2015

Photograph #2

Description of Photograph:
View of the various soil types encountered during the monitoring well installation activities at the Site.

Consumers Energy Co.
D.E. Karn Generating Facility
Essexville, Michigan

Photograph Taken By:
Lance Rogers

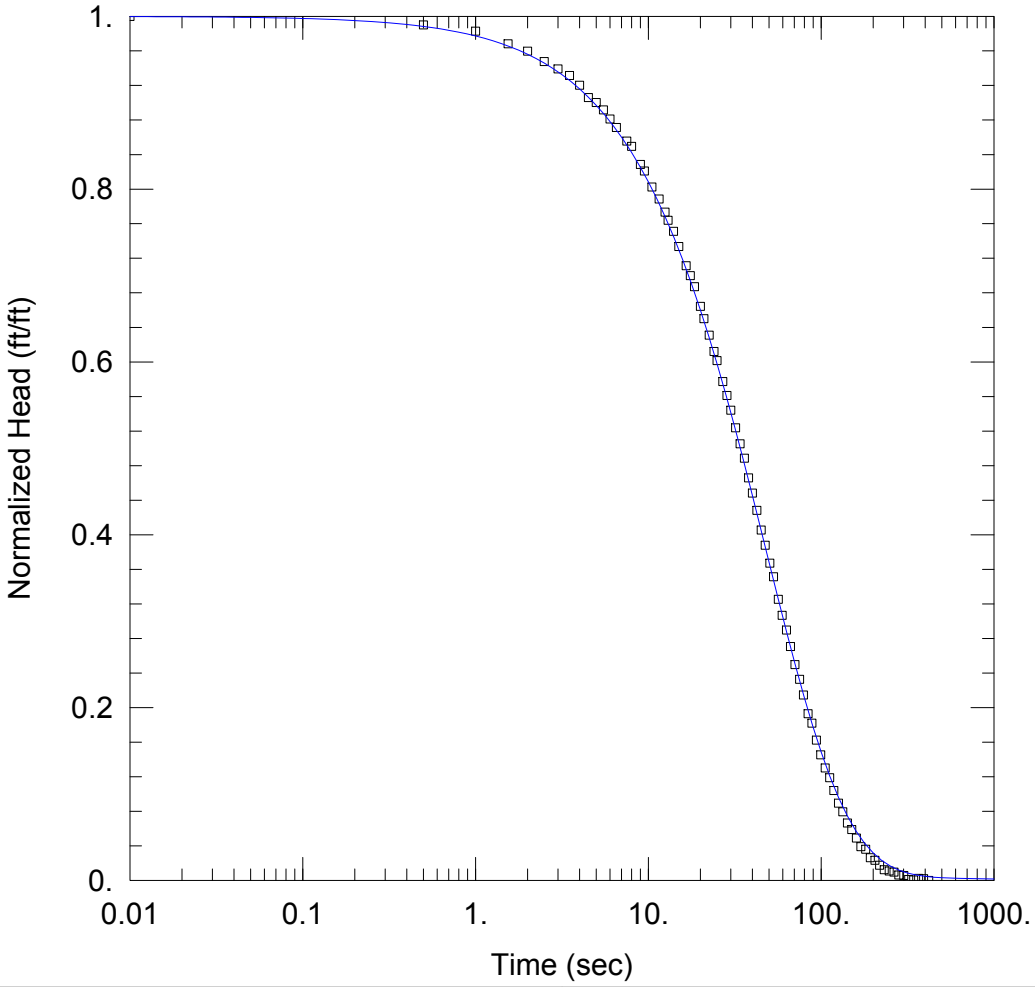
Date of Photograph:
October 8, 2015

APPENDIX C

Hydraulic Test Logs

Slug Test Analysis Results for DEK MW-15004 -Test 3

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: Essexville, MI



SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 9.5 ft/day Ss = 5.6E-12 ft^{-1}
Kz/Kr = 0.001

AQUIFER DATA

Saturated Thickness: 11. ft

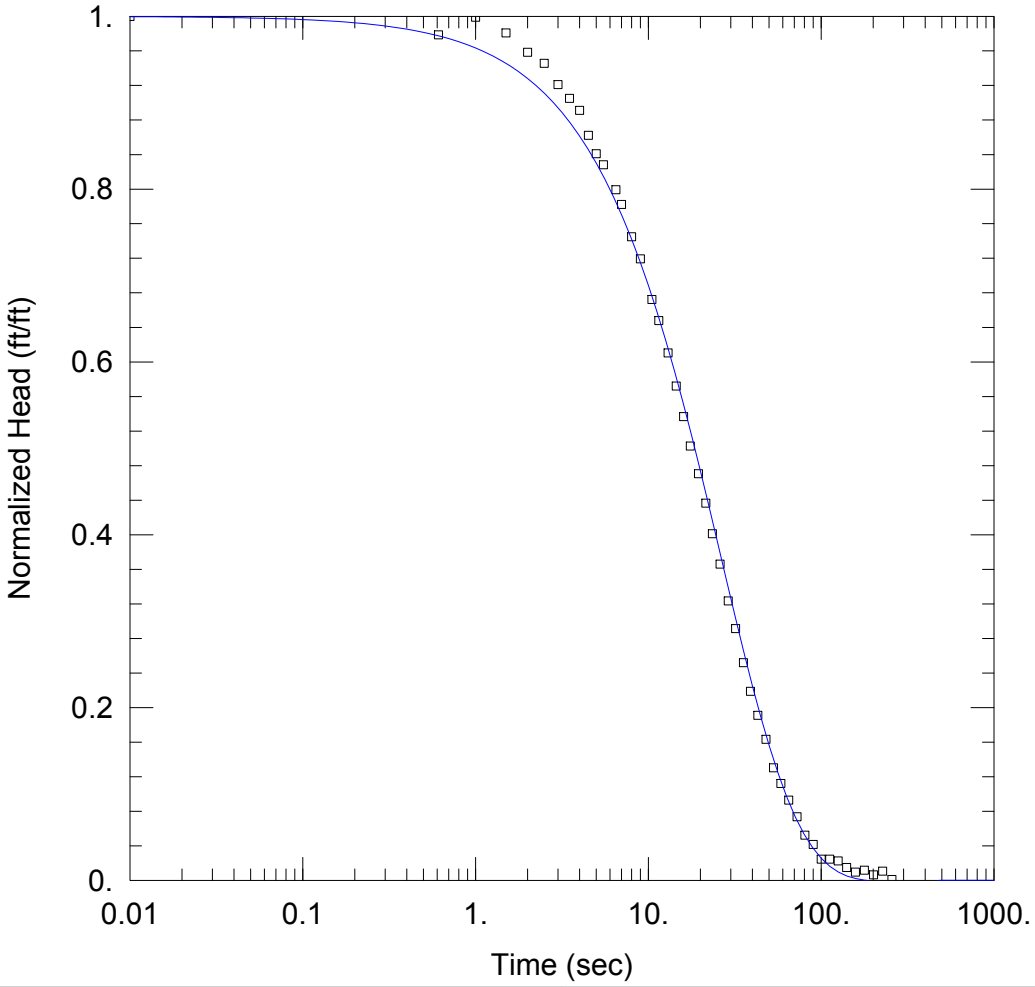
WELL DATA (DEK-MW-15004)

Initial Displacement: 2.106 ft
Static Water Column Height: 20.09 ft
Total Well Penetration Depth: 7.5 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Results for DEK MW-15005 -Test 1

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: Essexville, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 17. ft/day Ss = 1.0E-12 ft^{-1}
Kz/Kr = 0.001062

AQUIFER DATA

Saturated Thickness: 12.66 ft

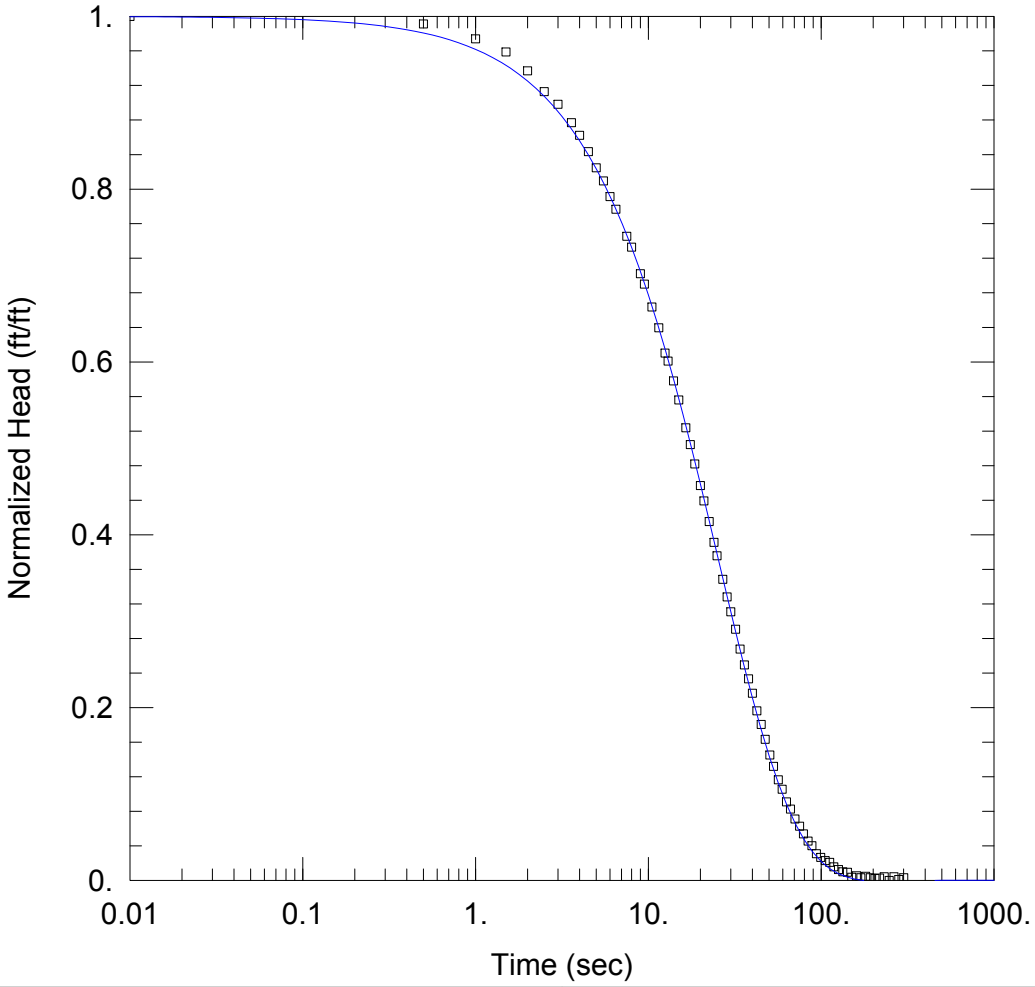
WELL DATA (DEK-MW-15005)

Initial Displacement: 0.937 ft
Static Water Column Height: 12.66 ft
Total Well Penetration Depth: 12.66 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Results for DEK MW-15005 -Test 3

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: Essexville, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 11. ft/day Ss = 5.6E-12 ft^{-1}
Kz/Kr = 0.111

AQUIFER DATA

Saturated Thickness: 12.66 ft

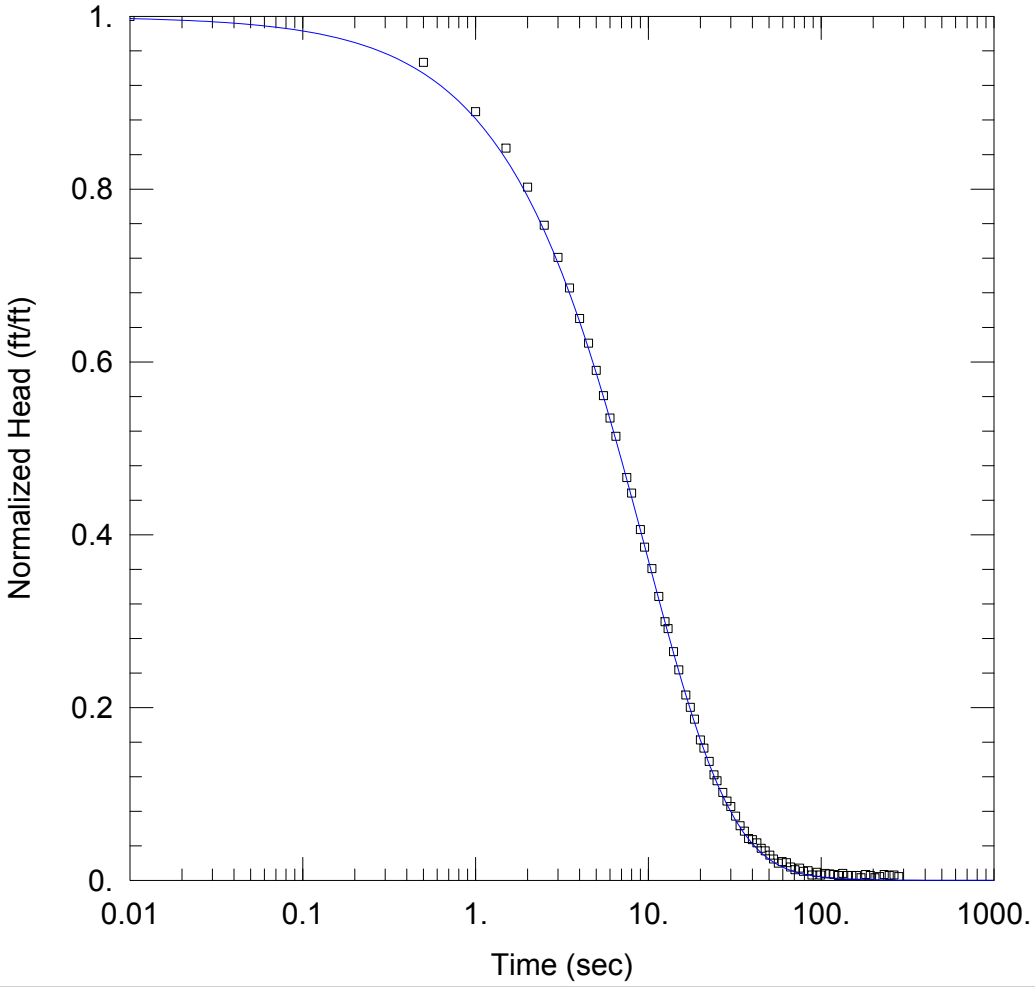
WELL DATA (DEK-MW-15005)

Initial Displacement: 1.917 ft
Static Water Column Height: 12.66 ft
Total Well Penetration Depth: 12.66 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Results for DEK MW-15006 -Test 3

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: Essexville, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 31. ft/day Ss = 6.3E-7 ft^{-1}
Kz/Kr = 0.001

AQUIFER DATA

Saturated Thickness: 13.21 ft

WELL DATA (DEK-MW-15006)

Initial Displacement: 1.613 ft
Static Water Column Height: 12.21 ft
Total Well Penetration Depth: 12.21 ft
Screen Length: 5. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi, Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

www.arcadis.com