2019 Annual Groundwater Monitoring and Corrective Action Report

CCR Landfill

R.M. Heskett Station
Mandan, North Dakota

Prepared for
Montana-Dakota Utilities Co.

January 2020

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Minneapolis, MN 55435
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R.M. Heskett Station
Mandan, North Dakota

January 31, 2020

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Acronyms

Acronym	Description
ASD	Alternative Source Demonstration
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
MDU	Montana Dakota Utilities Co.
SSI	Statistically Significant Increase
TDS	Total dissolved solids

1.0 Introduction

Montana-Dakota Utilities Co. (MDU) owns and operates R.M. Heskett Station, a coal-fired generating station and a gas fired turbine located in Mandan, North Dakota (Figure 1). One CCR landfill, as defined by 40 CFR 257.53, is located on the property. Wastes contained in the CCR landfill primarily consist of coal combustion by-products, asbestos wastes generated from construction activity associated with MDU-owned facilities, and ash derived from the burning of tire-derived fuel at the facility.

This 2019 Annual Groundwater Monitoring and Corrective Action Report (Annual Report) describes the monitoring program and results for the CCR landfill at MDU's R.M. Heskett Station (Site).

1.1 Purpose

As stated in Section §257.90 (e), the Annual Report must:

- Document the status of groundwater monitoring and any corrective action programs for the CCR unit,
- Summarize key actions completed,
- Describe any problems encountered,
- Discuss actions to resolve the problems, and
- Project key activities for the upcoming year.

1.2 CCR Rule Requirements

Additional requirements for the Annual Report, as outlined in §257.90 (e) of the CCR Rule and this Site's compliance with the CCR Rule, are summarized in Table 1.

Table 1 CCR Rule Requirements and Compliance

CCR Rule Reference	Content Required in Report	Location
§257.90(e)(1)	**Monitoring System Figure:** A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit;	Section 2.1 Groundwater Monitoring System; see Figure 1.
§257.90(e)(2)	**Monitoring System Adjustments**: Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken;	Section 2.1 Groundwater Monitoring System
§257.90(e)(3)	**Data and Collection Summary**: In addition to all the monitoring data obtained under §257.90 through §257.98, a summary including the number of groundwater samples that were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs;	Section 2.3 Monitoring and Analytical Results
§257.90(e)(4)	**Monitoring Program**: A narrative discussion of any transition between monitoring programs (e.g. the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels); and	Section 2.3 Monitoring and Analytical Results
§257.90(e)(5)	**Other Information**: Other information required, if applicable, to be included in the annual report as specified in §257.90 through §257.98. - Alternative Monitoring Frequency Demonstration (§257.94(d) and §257.95 (c)(3)) - Appendix III Alternative Source Demonstration Report (§257.94(e)(2)) - Assessment Monitoring Results and Discussion (§257.95(d)(3)) - Appendix IV Alternative Source Demonstration Report (§257.95(g)(3)(ii)) - Demonstration for Additional Time for Assessment or Corrective Measures (§257.96(a))	Section 2.3 Monitoring and Analytical Results

2.0 Groundwater Monitoring Program

This section documents the status of the groundwater monitoring and corrective action program for the CCR unit in 2019. The groundwater monitoring system is described in Section 2.1, key actions completed, and problems encountered are described in Section 2.2, the monitoring and analytical results are described in Section 2.3, and key activities planned for 2020 are described in Section 2.4.

2.1 Groundwater Monitoring System

The groundwater monitoring system is consistent with the Groundwater Monitoring System Certification (Barr, 2017a); no adjustments or changes were made to the groundwater monitoring system in 2019.

2.2 Actions Completed/Problems Encountered

The following actions were completed in 2019:

- **Detection Monitoring Sampling**: Groundwater samples were collected from each well in the groundwater monitoring system on April 1-2, 2019 and September 16-18, 2019; samples were analyzed for Appendix III constituents, per the detection monitoring program of the CCR Rule (257.94).
- **SSI Evaluation:** SSI evaluations were conducted in accordance with the Groundwater Statistical Method Selection Certification (Statistical Certification; Barr, 2017b) for the October 2018 and April 2019 detection monitoring events, both of which resulted in potential SSIs.
- **Verification Retesting:** Retesting was conducted, per the Statistical Certification (Barr, 2017b) on the potential SSIs for the April 2019 detection monitoring event (in August 2019). All SSIs were verified.
- **Alternative Source Demonstration (ASD):** ASDs were conducted on the SSIs for the October 2018 and April 2019 detection monitoring events. Both ASDs were able to demonstrate an alternative source, as allowed by the CCR rule (§257.94(e)(2)). More details are provided in Section 2.4.

2.3 Data and Collection Summary

2.3.1 October 2018 Detection Monitoring Event

As mentioned in the 2018 Annual Report, an SSI evaluation was to be conducted on the results of the October 2018 detection monitoring event. Four potential SSIs (fluoride at MW2-90, chloride at MW-105, and sulfate and TDS at MW-104) were identified. Field data sheets and analytical laboratory reports for detection monitoring sampling is included in Appendix A.

An Appendix III ASD was conducted on the verified SSIs and was able to successfully demonstrate that a natural variation in groundwater quality resulted in the SSIs, as allowed by §257.94(e)(4). The Alternative Source Demonstration: October 2018 Event Report is included in Appendix B.

2.3.2 April 2019 Detection Monitoring Event

Groundwater samples were collected from all 12 monitoring wells at the Site on April 1 and 2, 2019. Four potential SSIs (fluoride at MW2-90, chloride at MW-105, and sulfate and TDS at MW-104) were identified and subsequently verified through resampling on August 22, 2019. Field data sheets and analytical laboratory reports for detection monitoring sampling and verification resampling are included in Appendix A.

An Appendix III ASD was conducted on the verified SSIs and was able to successfully demonstrate that a natural variation in groundwater quality and/or "a source other than the CCR unit" resulted in the SSIs, as allowed by §257.94(e)(4). The Alternative Source Demonstration: April 2019 Event is included in Appendix B.

2.3.3 September 2019 Detection Monitoring Event

Groundwater samples were collected from all 12 monitoring wells at the Site on September 16, 17, and 18, 2019. Field data sheets and analytical laboratory reports for detection monitoring sampling are included in Appendix A.

2.4 Activities for Upcoming Year

The following key activities for analytical results and statistical evaluations are planned for 2020:

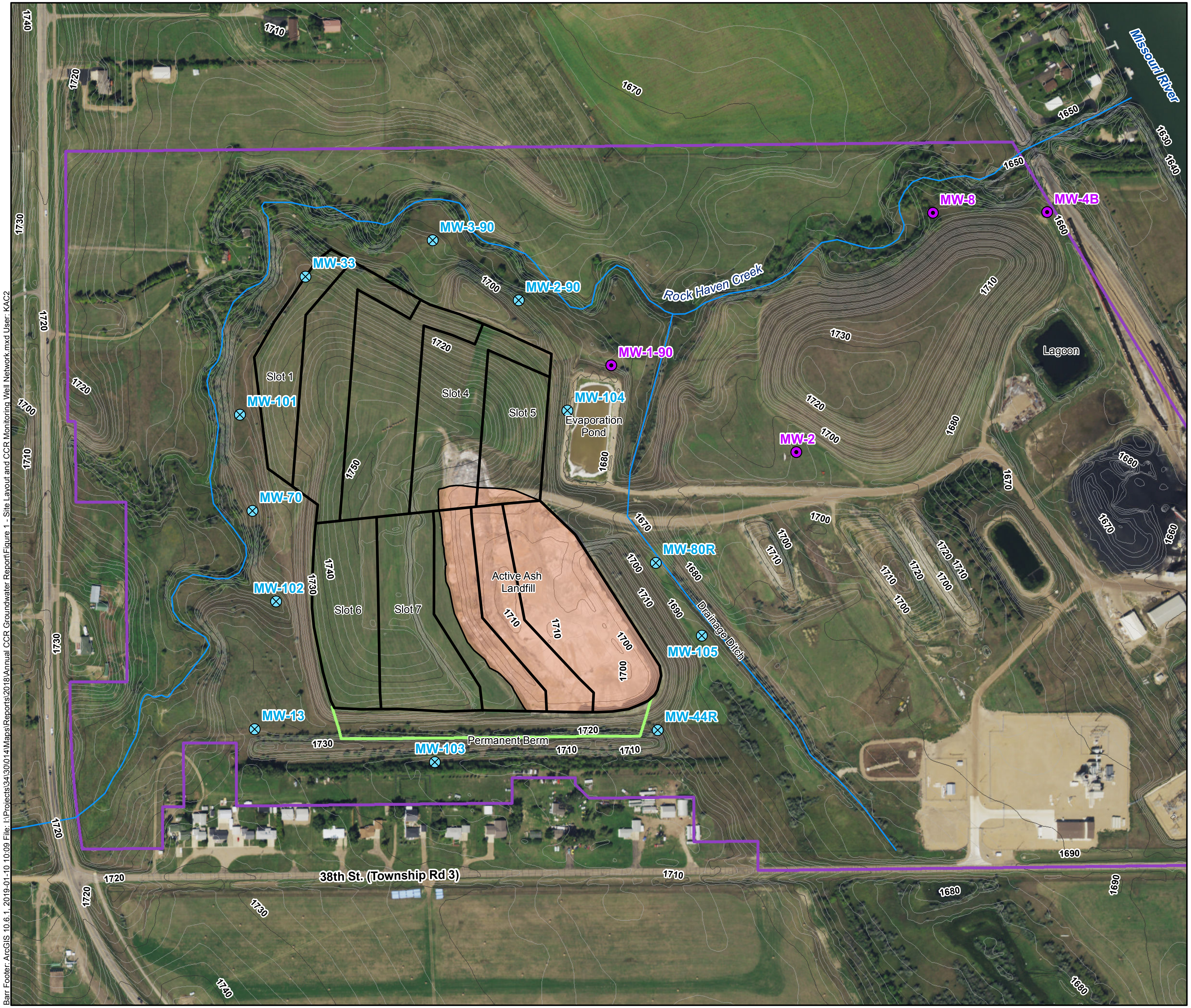
- Complete SSI evaluation for the September 2019 detection monitoring event in accordance with the Statistical Certification (Barr, 2017b).
- Evaluate analytical results from 2020 semi-annual detection monitoring events for SSIs according to the Statistical Certification (Barr, 2017b).

3.0 References

Barr Engineering Co. (Barr), 2017a, Groundwater Monitoring System Certification, October 2017.

Barr, 2017b, Statistical Method Selection Certification, October 2017.

Figure



Barr Footer: ArcGIS 10.6.1, 2019-01-10 10:09 File: I:\Projects\34\30\014\Maps\Reports\2018\Annual CCR Groundwater Report\Figure 1 - Site Layout and CCR Monitoring Well Network.mxd User: KAC2

Monitoring Well Location

Monitoring Well Location - Water Level Only

Existing Slot Boundaries

Streams

Property Line

Future Landfill Boundary

10ft Contours

2ft Contours

Active Portion of Landfill

Image Source: 2017 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg

Feet

350 0 350

BARR

Figure 1

SITE LAYOUT AND CCR MONITORING WELL NETWORK
R. M. Heskett Station
2019 CCR Groundwater Monitoring Report
Montana Dakota Utilities
Mandan, North Dakota

Appendix A

Laboratory Reports and Field Sheets

MVTL

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1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58502 ~ 800-279-6885 ~ Fax 701-258-9724
1201 Lincoln Highway ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

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Quality Control Report - CCR

Lab IDs: 19-W567 to 19-W574 **Project:** MDU Heskett **Work Order:** 201982-0624

Analyte	LCS Spike Amt	LCS Rec %	LCS % Rec Limits	Matrix Spike Amt	Matrix Spike ID	Matrix Spike Orig Result	Matrix Spike Result	Matrix Spike Rec %	Matrix Spike % Rec Limits	MSD/ Dup Orig Result	MSD/ Dup Result	MSD Rec %	MSD/ Dup RPD	MSD/ Dup RPD Limit (<)	Known Rec (%)	Known % Rec Limits	Method Blank
Boron - Total mg/l	0.40	95	80-120	0.400	19-D943	0.24	0.66	105	75-125	0.66	0.63	97	4.7	20	-	-	< 0.1
	0.40	100	80-120	2.00	19-W567	0.70	3.00	115	75-125	3.00	3.00	115	0.0	20	-	-	< 0.1
				2.00	19-W586	< 0.5	2.41	120	75-125	2.41	2.34	117	2.9	20	-	-	< 0.1
Calcium - Total mg/l	20.0	102	80-120	2000	19M537q	1950	4100	108	75-125	4100	4140	110	1.0	20	-	-	< 1
	20.0	107	80-120	1000	19M539q	1820	2830	101	75-125						-	-	< 1
				2000	19M541q	2060	4140	104	75-125						-	-	< 1
				500	19W571q	346	920	115	75-125	920	935	118	1.6	20	-	-	< 1
				500	19W587q	442	1040	120	75-125	1040	995	111	4.4	20	-	-	
Chloride mg/l	30.0	97	80-120	30.0	19-W593	< 1	28.4	95	80-120	28.4	29.6	99	4.1	20	-	-	< 1
	30.0	97	80-120												-	-	< 1
Fluoride mg/l	0.50	104	90-110	0.500	19-W568	0.98	1.45	94	80-120	1.45	1.46	96	0.7	20	-	-	< 0.1
				0.500	19-W583	< 0.1	0.52	104	80-120	0.52	0.52	104	0.0	20	-	-	< 0.1
pH units	-	-	-	-	-	-	-	-	-	7.1	7.1	-	0.0	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.6	7.6	-	0.0	20	-	-	-
Sulfate mg/l	100	96	80-120	1000	19-W583	370	1150	78	80-120	1150	1170	80	1.7	20	-	-	< 5
	100	100	80-120	100	19-W574	< 5	103	103	80-120	103	105	105	1.9	20	-	-	< 5
Total Dissolved Solids mg/l	-	-	-	-	-	-	-	-	-	31200	30800	-	1.3	20	-	-	< 10

Samples were received in good condition on 1 Apr 2019 at 1529.
Temperature upon receipt at the Bismarck laboratory was 2.8°C. Samples were received on ice and evidence of cooling had begun.
All samples were properly preserved unless noted here and/or flagged on the individual analytical laboratory report.
With the exception of pH, all holding times were met.
Approved methodology was followed for all sample analyses.
All acceptance criteria were met for calibration, method blanks, laboratory control samples, laboratory fortified matrix/duplicates unless noted here.

- For some analytes, the reported results were elevated due to additional dilutions required to minimize the effects of sample matrix.
- One sulfate matrix spike recovery was outside the acceptable limits. Recovery for the matrix spike duplicate was acceptable. RPD for the recoveries of the matrix spike duplicate and the matrix spike was within limits. No further action was taken.

Approved by: C. Cam[illegible]
6 May 19

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1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W567
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 11:48
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 13

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.78	units	NA	SM 4500 H+ B	1 Apr 19 11:48	DJN
pH	* 7.2	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	8.12	Degrees C	NA	SM 2550B	1 Apr 19 11:48	DJN
Conductivity - Field	10270	umhos/cm	1	EPA 120.1	1 Apr 19 11:48	DJN
Fluoride	0.98	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	6160	mg/l	5.00	ASTM D516-07	5 Apr 19 16:09	EMS
Chloride	64.6	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	10400	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	408	mg/l	1.0	6010D	4 Apr 19 11:36	SZ
Boron - Total	0.70	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

CC
Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W568
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: Dup1

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH	* 7.2	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Fluoride	0.98	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	6230	mg/l	5.00	ASTM D516-07	5 Apr 19 16:09	EMS
Chloride	63.6	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	10400	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	410	mg/l	1.0	6010D	4 Apr 19 11:36	SZ
Boron - Total	0.72	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W569
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 10:45
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 102

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.75	units	NA	SM 4500 H+ B	1 Apr 19 10:45	DJN
pH	* 7.1	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	7.32	Degrees C	NA	SM 2550B	1 Apr 19 10:45	DJN
Conductivity - Field	9026	umhos/cm	1	EPA 120.1	1 Apr 19 10:45	DJN
Fluoride	0.18	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	4810	mg/l	5.00	ASTM D516-07	5 Apr 19 16:09	EMS
Chloride	5.0	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	8190	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	449	mg/l	1.0	6010D	4 Apr 19 11:36	SZ
Boron - Total	1.62	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W570
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 11:52
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 70

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.91	units	NA	SM 4500 H+ B	1 Apr 19 11:52	DJN
pH	* 7.3	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	7.67	Degrees C	NA	SM 2550B	1 Apr 19 11:52	DJN
Conductivity - Field	3951	umhos/cm	1	EPA 120.1	1 Apr 19 11:52	DJN
Fluoride	0.32	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	1830	mg/l	5.00	ASTM D516-07	5 Apr 19 16:09	EMS
Chloride	45.6	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	3400	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	338	mg/l	1.0	6010D	4 Apr 19 11:36	SZ
Boron - Total	0.64	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll 6 May 19 CC

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W571
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 14:17
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 101

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.69	units	NA	SM 4500 H+ B	1 Apr 19 14:17	DJN
pH	* 7.1	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	7.74	Degrees C	NA	SM 2550B	1 Apr 19 14:17	DJN
Conductivity - Field	4785	umhos/cm	1	EPA 120.1	1 Apr 19 14:17	DJN
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	2850	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	16.0	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	4400	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	346	mg/l	1.0	6010D	4 Apr 19 11:36	SZ
Boron - Total	1.34	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W572
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 14:25
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 103

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.48	units	NA	SM 4500 H+ B	1 Apr 19 14:25	DJN
pH	* 7.1	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	7.95	Degrees C	NA	SM 2550B	1 Apr 19 14:25	DJN
Conductivity - Field	5198	umhos/cm	1	EPA 120.1	1 Apr 19 14:25	DJN
Fluoride	0.15	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	2930	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	142	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	4860	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	530	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W573
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19 13:12
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 44R

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH - Field	6.36	units	NA	SM 4500 H+ B	1 Apr 19 13:12	DJN
pH	* 6.9	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Temperature - Field	7.77	Degrees C	NA	SM 2550B	1 Apr 19 13:12	DJN
Conductivity - Field	9300	umhos/cm	1	EPA 120.1	1 Apr 19 13:12	DJN
Fluoride	0.67	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	6350	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	205	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	10100	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	436	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	0.82	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

CL

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
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MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 25 Apr 19
Lab Number: 19-W574
Work Order #: 82-0624
Account #: 002800
Date Sampled: 1 Apr 19
Date Received: 1 Apr 19 15:29
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: FB1

Temp at Receipt: 2.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	2 Apr 19	SVS
pH	* 6.2	units	0.1	SM4500 H+ B	2 Apr 19 17:00	SVS
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	2 Apr 19 17:00	SVS
Sulfate	< 5	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	< 1	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	< 10	mg/l	10	I1750-85	4 Apr 19 9:15	SVS
Calcium - Total	< 1	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	< 0.1	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

cc
Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

MVTL

2616 E. Broadway Ave, Bismarck, ND

Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	13
Sampling Personal:	Darren Niesvadog

Weather Conditions: Temp: 33 °F Wind: west @ 5 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:	—		
Casing Diameter:	2"		
Water Level Before Purge:	30.68 ft		
Depth to Top of Pump:	32.08 ft		
Water Level After Sample:	31.46 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder		
Sampling Method:	Bladder		
Dedicated Equip?:	Yes	No	
Duplicate Sample?:	Yes	No	
Duplicate Sample ID:	Dup-1		
Purge Date:	1APR19	Time Purging Began:	1003 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	1APR19	Time of Sampling:	1148 am/pm

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	—	

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric
	2	2	2	2

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1008	7.72	10452	7.12	4.12 ~~245.1~~	-245.1	11.4	31.13	100	500	clear
2	1023	7.48	10460	6.78	1.97	-253.0	2.71	31.32	100	1500	clear
3	1028	7.87	10448	6.79	2.01	-245.8	1.92	31.39	100	500	clear
4	1033	7.69	10402	6.83	2.20	-242.1	5.03	31.39	100	500	clear
5	1038	7.69	10316	6.88	2.39	-238.6	5.22	31.37	100	500	clear
6	1043	8.03	10239	6.90	2.42	-232.4	7.13	31.39	100	500	clear
7	1113	7.69	10248	6.87	2.48	-215.9	10.2	31.52	100	3000	clear
8	1138	8.20	10267	6.77	3.48	-215.8	5.10	31.46	100	2500	clear
9	1143	8.37	10269	6.77	3.50	-212.8	4.98	31.46	100	500	clear
10	1148	8.12	10270	6.78	3.47	-214.1	4.89	31.50	100	500	clear

Stabilized: Yes No

Total Volume Removed: 10,500 mL

Comments:

MVTL

2616 E. Broadway Ave, Bismarck, ND

Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	102
Sampling Personal:	[illegible]

Weather Conditions: Temp: 35 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	18.58 ft		
Depth to Top of Pump:	27.05 ft		
Water Level After Sample:	20.40 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	1 Apr 19	Time Purging Began:	1005 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	1 Apr 19	Time of Sampling:	1045 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1010	6.97	9746	6.91	2.95	-3.3	2.59	19.23	100.0	500.0	Clear
2	1020	7.00	9835	6.86	2.71	-36.3	0.93	19.50	100.0	1000.0	Clear
3	1030	7.19	9602	6.81	2.78	-36.6	0.78	19.82	100.0	1000.0	Clear
4	1035	7.05	9462	6.80	3.18	-33.5	0.57	19.89	100.0	500.0	Clear
5	1040	7.21	9291	6.78	3.42	-33.4	0.82	19.98	100.0	500.0	Clear
6	1045	7.32	9026	6.75	3.27	-27.3	0.61	20.02	100.0	500.0	Clear
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 4000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company: MDU Heskett
Event: Spring 2019
Sample ID: 70
Sampling Personal: Jerry [illegible]

Weather Conditions: Temp: 35 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	~~Yes~~	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	21.05 ft		
Depth to Top of Pump:	32.71 ft		
Water Level After Sample:	22.25 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:		

Purge Date:	1 Apr 19	Time Purging Began:	1117 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	1 Apr 19	Time of Sampling:	1152 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1122	6.77	3887	6.93	3.66	13.0	2.52	21.60	100.0	500.0	Clear
2	1132	6.79	3952	6.92	3.81	37.9	0.86	21.86	100.0	1000.0	Clear
3	1142	7.46	3948	6.92	4.34	60.4	0.66	22.23	100.0	1000.0	Clear
4	1147	7.39	3960	6.91	4.39	68.1	0.49	22.25	100.0	500.0	Clear
5	1152	7.67	3951	6.91	4.51	71.6	0.27	22.31	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 3500.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sampling ID:	101
Sampling Personal:	Jerry Mayer

Weather Conditions: Temp: 35 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	**Not Visible**
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	36.80 ft		
Depth to Top of Pump:	46.90 ft		
Water Level After Sample:	40.21 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	**Bladder**	
Sampling Method:	**Bladder**	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	40	

Purge Date:	1 Apr 19	Time Purging Began:	1227 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	1 Apr 19	Time of Sampling:	1417 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1232	7.68	4814	6.75	5.90	94.5	20.1	37.67	100.0	500.0	Clear
2	1242	7.87	4768	6.69	5.02	28.5	64.9	38.63	100.0	1000.0	Clear
3	1252	8.32	4761	6.69	5.22	21.1	30.5	39.25	100.0	1000.0	Clear
4	1302	8.02	4758	6.68	4.74	22.1	24.1	39.23	100.0	1000.0	Clear
5	1322	8.01	4768	6.68	4.88	33.9	14.9	39.40	100.0	2000.0	Clear
6	1342	7.81	4770	6.67	5.11	35.6	9.04	39.62	100.0	2000.0	Clear
7	1402	7.82	4777	6.69	5.39	32.3	7.06	39.80	100.0	2000.0	Clear
8	1407	7.75	4779	6.69	5.35	31.8	4.86	39.97	100.0	500.0	Clear
9	1412	7.83	4782	6.66	5.39	27.5	4.72	40.06	100.0	500.0	Clear
10	1417	7.74	4785	6.69	5.31	26.7	4.69	40.13	100.0	500.0	Clear

Stabilized: Yes No

Total Volume Removed: 11,000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	103
Sampling Personal:	Dallin Nitsukas

Weather Conditions: Temp: 34 °F Wind: West @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:	—		
Casing Diameter:	2"		
Water Level Before Purge:	32.44 ft		
Depth to Top of Pump:	40.85 ft		
Water Level After Sample:	34.33 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	—	

Purge Date:	1APR19	Time Purging Began:	1340 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	1APR19	Time of Sampling:	1425 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1345	7.62	5066	6.60	5.44	-211.9	6.25	33.01	100	500	cl
2	1405	8.02	5210	6.50	3.09	-208.4	3.25	33.56	100	2000	cl
3	1415	8.07	5203	6.50	3.10	-208.0	3.12	33.76	100	1000	cl
4	1420	7.98	5199	6.49	2.91	-208.9	3.00	33.84	100	500	cl
5	1425	7.95	5198	6.48	2.95	-201.7	2.96	33.90	100	500	cl
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 4500 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company: MDU Heskett
Event: Spring 2019
Sample ID: 44R
Sampling Personal: Darren Niesway

Weather Conditions: Temp: 33 °F Wind: West @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:	—		

Casing Diameter:	2"
Water Level Before Purge:	26.20 ft
Depth to Top of Pump:	35.16 ft
Water Level After Sample:	26.30 ft
Measurement Method:	Electric Water Level Indicator

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:		

Purge Date:	1APR19	Time Purging Began:	1237 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	1APR19	Time of Sampling:	1312 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1242	3.77	10528	6.41	3.90	-221.8	7.44	26.28	~~8,100~~ 100	500	- Cl
2	1257	7.92	9286	6.36	1.70	-253.1	4.97	26.30	100	1500	clear
3	1302	7.91	9294	6.36	1.47	-252.7	2.89	26.30	100	500	cl
4	1307	7.94	9294	6.36	1.38	-258.5	2.77	26.30	100	500	cl
5	1312	7.77	9300	6.36	1.42	-259.0	2.72	26.30	100	500	cl
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 3500 mL

Comments:

MVTL Laboratories, Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

Chain of Custody Record

Project Name: MDU Heskett	Event: Spring 2019	Work Order Number: 82- 0624
Report To: MDU Attn: Samantha Davies Address: 5181 Southgate Dr. Billings, MT 59102 phone: 406-896-4227 email:	Carbon Copy: Attn: Address:	Name of Sampler(s): Darren Nieswaag Jeremy Meyer

Lab Number	Sample ID	Date	Time	Sample Type		1 liter	500mL Nitric	500mL Nitric (filtered)	250 mL Sulfuric			Temp (°C)	Spec. Cond.	pH	Analysis Required
WS67	13	1APR19	1148	GW		X	X	X	X			8.12	10270	6.78	MDU List AA & MDU Appendix 3
WS68	Dup1	1APR19	–	GW		X	X	X	X			–	–	–	
WS69	102	1APR19	1045	GW		X	X	X	X			7.32	9026	6.75	
WS70	70	1APR19	1152	GW		X	X	X	X			7.67	3951	6.91	
WS71	101	1APR19	1417	GW		X	X	X	X			7.74	4785	6.69	
WS72	103	1APR19	1425	GW		X	X	X	X			7.95	5198	6.48	
WS73	44R	1APR19	1312	GW		X	X	X	X			7.77	9300	6.36	
WS74	FB1	1APR19	–	GW		X	X	X	X			–	–	–	

Comments:

	Relinquished By: Name:	Date/Time	Sample Condition: Location:	Temp (°C)	Received by: Name:	Date/Time
1	[signature]	1APR19 1529	~~Log In~~ Walk In #2	ROI 2.8 1 ~~TM562 / TM588~~ TM805	[signature]	1 Apr 2019 1529
2						

MVTL

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Quality Control Report - CCR

Lab IDs: 19-W586 to 19-W593 **Project:** MDU Heskett **Work Order:** 201982-0648

Analyte	LCS Spike Amt	LCS Rec %	LCS % Rec Limits	Matrix Spike Amt	Matrix Spike ID	Matrix Spike Orig Result	Matrix Spike Result	Matrix Spike Rec %	Matrix Spike % Rec Limits	MSD/ Dup Orig Result	MSD/ Dup Result	MSD Rec %	MSD/ Dup RPD	MSD/ Dup RPD Limit (<)	Known Rec (%)	Known % Rec Limits	Method Blank
Boron - Total mg/l	0.40	95	80-120	0.400	19-D943	0.24	0.66	105	75-125	0.66	0.63	97	4.7	20	-	-	< 0.1
	0.40	100	80-120	2.00	19-W567	0.70	3.00	115	75-125	3.00	3.00	115	0.0	20	-	-	< 0.1
	0.40	90	80-120	2.00	19-W586	< 0.5	2.41	120	75-125	2.41	2.34	117	2.9	20	-	-	< 0.1
	0.40	95	80-120	0.400	19-W593	< 0.1	0.37	92	75-125	0.37	0.37	92	0.0	20	-	-	< 0.1
															-	-	< 0.1
															-	-	< 0.1
Calcium - Total mg/l	20.0	107	80-120	500	19W587q	442	1040	120	75-125	1040	995	111	4.4	20	-	-	< 1
	20.0	104	80-120	500	19W592q	328	915	117	75-125	915	930	120	1.6	20	-	-	< 1
															-	-	< 1
															-	-	< 1
Chloride mg/l	30.0	97	80-120	30.0	19-W593	< 1	28.4	95	80-120	28.4	29.6	99	4.1	20	-	-	< 1
	30.0	97	80-120												-	-	< 1
Fluoride mg/l	0.50	104	90-110	0.500	19-W587	0.13	0.64	102	80-120	0.64	0.64	102	0.0	20	-	-	< 0.1
				0.500	19-W590	0.55	0.94	78	80-120	0.94	0.94	78	0.0	20	-	-	< 0.1
pH units	-	-	-	-	-	-	-	-	-	7.5	7.6	-	1.3	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.3	7.3	-	0.0	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.6	7.7	-	1.3	20	-	-	-
Sulfate mg/l	100	100	80-120	100	19-W574	< 5	103	103	80-120	103	105	105	1.9	20	-	-	< 5
	100	102	80-120	100	19-W593	< 5	100	100	80-120	100	102	102	2.0	20	-	-	< 5
Total Dissolved Solids mg/l	-	-	-	-	-	-	-	-	-	1120	1120	-	0.0	20	-	-	< 10

Samples were received in good condition on 3 Apr 2019 at 0800.
Temperature upon receipt at the Bismarck laboratory was 0.8°C. Samples were received on ice and evidence of cooling had begun.
All samples were properly preserved unless noted here and/or flagged on the individual analytical laboratory report.
With the exception of pH, all holding times were met.
Approved methodology was followed for all sample analyses.
All acceptance criteria were met for calibration, method blanks, laboratory control samples, laboratory fortified matrix/duplicates unless noted here.

- For some analytes, the reported results were elevated due to additional dilutions required to minimize the effects of sample matrix.
- The recoveries for one fluoride matrix spike/matrix spike duplicate were outside the acceptable limits. RPD for the recoveries was within limits. Poor recoveries were determined to be due to sample matrix. Data was accepted based on acceptable recovery of the LCS. No further action was taken.

Approved by: C. Cantl
7 May 19

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www.mvtl.com

MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W586
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 12:58
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 33

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	6.31	units	NA	SM 4500 H+ B	2 Apr 19 12:58	DJN
pH	* 7.0	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	8.92	Degrees C	NA	SM 2550B	2 Apr 19 12:58	DJN
Conductivity - Field	5125	umhos/cm	1	EPA 120.1	2 Apr 19 12:58	DJN
Fluoride	0.23	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	3340	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	10.8	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	5320	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	440	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	8 Apr 19 10:36	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix   # = Due to concentration of other analytes
! = Due to sample quantity   + = Due to internal standard response

CERTIFICATION: ND # ND-00016

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MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W587
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 13:45
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 3-90

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	6.61	units	NA	SM 4500 H+ B	2 Apr 19 13:45	DJN
pH	* 7.2	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	7.71	Degrees C	NA	SM 2550B	2 Apr 19 13:45	DJN
Conductivity - Field	4730	umhos/cm	1	EPA 120.1	2 Apr 19 13:45	DJN
Fluoride	0.13	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	2670	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	33.2	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	4430	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	442	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	0.19	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W588
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: Dup2

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH	* 7.3	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Fluoride	0.13	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	2690	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	33.3	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	4430	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	426	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	0.14	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W589
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 15:00
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 2-90

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	6.76	units	NA	SM 4500 H+ B	2 Apr 19 15:00	DJN
pH	* 7.5	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	7.37	Degrees C	NA	SM 2550B	2 Apr 19 15:00	DJN
Conductivity - Field	7068	umhos/cm	1	EPA 120.1	2 Apr 19 15:00	DJN
Fluoride	1.02	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	4940	mg/l	5.00	ASTM D516-07	11 Apr 19 8:30	EV
Chloride	67.7	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	7590	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	450	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	0.68	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W590
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 15:52
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 104

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	6.83	units	NA	SM 4500 H+ B	2 Apr 19 15:52	DJN
pH	* 7.5	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	7.90	Degrees C	NA	SM 2550B	2 Apr 19 15:52	DJN
Conductivity - Field	14209	umhos/cm	1	EPA 120.1	2 Apr 19 15:52	DJN
Fluoride	0.55	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	11100	mg/l	5.00	ASTM D516-07	11 Apr 19 8:48	EV
Chloride	87.6	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	17700	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	448	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	1.00	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W591
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 16:10
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 80R

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	7.01	units	NA	SM 4500 H+ B	2 Apr 19 16:10	DJN
pH	* 7.6	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	7.38	Degrees C	NA	SM 2550B	2 Apr 19 16:10	DJN
Conductivity - Field	5688	umhos/cm	1	EPA 120.1	2 Apr 19 16:10	DJN
Fluoride	0.27	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	3520	mg/l	5.00	ASTM D516-07	11 Apr 19 8:48	EV
Chloride	146	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	5820	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	313	mg/l	1.0	6010D	4 Apr 19 12:36	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

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@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W592
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19 12:45
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: 105

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH - Field	6.76	units	NA	SM 4500 H+ B	2 Apr 19 12:45	DJN
pH	* 7.4	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Temperature - Field	6.07	Degrees C	NA	SM 2550B	2 Apr 19 12:45	DJN
Conductivity - Field	6292	umhos/cm	1	EPA 120.1	2 Apr 19 12:45	DJN
Fluoride	0.27	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	4220	mg/l	5.00	ASTM D516-07	11 Apr 19 8:48	EV
Chloride	282	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	6880	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	328	mg/l	1.0	6010D	4 Apr 19 13:36	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
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CERTIFICATION: ND # ND-00016

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MEMBER ACIL

CERTIFICATE of ANALYSIS - CCR

Samantha Davies
Montana Dakota Utilities
5181 Southgate Dr
Billings MT 59102

Report Date: 24 Apr 19
Lab Number: 19-W593
Work Order #: 82-0648
Account #: 002800
Date Sampled: 2 Apr 19
Date Received: 3 Apr 19 8:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett
Sample Description: FB2

Temp at Receipt: 0.8C ROI

Event and Year: Spring 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Metal Digestion				EPA 200.2	3 Apr 19	SVS
pH	* 7.6	units	0.1	SM4500 H+ B	3 Apr 19 17:00	SVS
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	3 Apr 19 17:00	SVS
Sulfate	< 5	mg/l	5.00	ASTM D516-07	11 Apr 19 8:48	EV
Chloride	< 1	mg/l	1.0	SM4500-Cl-E	3 Apr 19 15:19	EMS
Total Dissolved Solids	< 10	mg/l	10	I1750-85	5 Apr 19 11:23	SVS
Calcium - Total	< 1	mg/l	1.0	6010D	4 Apr 19 13:36	SZ
Boron - Total	< 0.1	mg/l	0.10	6010D	8 Apr 19 11:36	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 6 May 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company: MDU Heskett
Event: Spring 2019
Sample ID: 33
Sampling Personal: Darren Niesmaas

Weather Conditions: Temp: 40 °F Wind: NW @ 22 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	41.58 ft		
Depth to Top of Pump:	ft		
Water Level After Sample:	41.90 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	—	

Purge Date:	2 APR 19	Time Purging Began:	1148 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	~~am/pm~~
Sample Date:	2 APR 19	Time of Sampling:	1258 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1153	8.37	5476	6.37	3.22	-43.4	251	41.82	100	500	Turbid
2	1213 ~~1158~~	8.46	5267	6.31	2.04	-111.1	38.0	41.80	100	2000	Clear
3	1233	8.42	5166	6.38	1.98	-124.0	10.2	41.84	100	2000	clear
4	1243	8.43	5131	6.36	2.04	-125.8	3.93	41.92	100	1000	clear
5	1248	8.65	5139	6.31	2.07	-127.3	3.45	41.92	100	500	clear
6	1253	8.59	5136	6.31	2.10	-128.1	3.23	41.87	100	500	clear
7	1258	8.92	5125	6.31	2.09	-127.3	3.20	41.89	100	500	clear
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 7000 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	3-90
Sampling Personal:	Darren Niesvaag

Weather Conditions: Temp: 40 °F Wind: NW @ 22 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	17.96 ft		
Depth to Top of Pump:	20.17 ft		
Water Level After Sample:	18.00 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder		
Sampling Method:	Bladder		
Dedicated Equip?:	Yes	No	
Duplicate Sample?:	Yes	No	
Duplicate Sample ID:	Dup-2		

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	-	

Purge Date:	2APR19	Time Purging Began:	1320 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	am/pm
Sample Date:	2APR19	Time of Sampling:	1345 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1325	7.70	4734	6.65	4.34	-111.7	8.05	18.00	100	500	clear
2	1330	7.74	4737	6.60	2.28	-153.8	2.49	18.00	100	500	clear
3	1335	7.51	4738	6.59	2.30	-156.7	2.61	18.00	100	500	clear
4	1340	7.77	4749	6.61	2.22	-165.1	2.05	18.00	100	500	clear
5	1345	7.71	4730	6.61	2.28	-168.2	2.18	18.00	100	500	clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company: MDU Heskett
Event: Spring 2019
Sample ID: 2-90
Sampling Personal: Darren Niesnaas

Weather Conditions: Temp: 40 °F Wind: NW @ 22 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	~~Not Visible~~
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	20.43 ft		
Depth to Top of Pump:	22.35 ft		
Water Level After Sample:	20.99 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	—	

Purge Date:	2 APR 19	Time Purging Began:	1435 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	2 APR 19	Time of Sampling:	1500 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1440	7.24	7152	6.76	5.43	-10.6	1.87	20.78	100	500	clear
2	1445	7.49	7045	6.73	3.90	-119.7	1.89	20.89	100	500	clear
3	1450	7.36	7100	6.75	3.75	-126.7	1.81	20.94	100	500	clear
4	1455	7.31	7033	6.76	3.70	-132.0	1.75	20.99	100	500	clear
5	1500	7.37	7068	6.76	3.62	-133.7	1.83	20.99	100	500	clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	104
Sampling Personal:	Darren Nichwray

Weather Conditions: Temp: 40 °F Wind: NW @ 22 Precip: **Sunny** / **Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:	—		
Casing Diameter:	2"		
Water Level Before Purge:	14.06 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	14.38 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings	
Purge:	5 sec.
Recover:	55 sec.
PSI:	—

Purge Date:	2APR19	Time Purging Began:	1527 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	2APR19	Time of Sampling:	1552 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1532	8.08	14296	6.88	3.68	-121.8	1.34	14.39	100	500	Clear
2	1537	8.04	14276	6.84	2.02	-139.6	0.92	14.33	100	500	cl
3	1542	8.00	14250	6.84	2.08	-140.9	0.88	14.33	100	500	cl
4	1547	7.87	14189	6.83	2.03	-148.3	0.84	14.33	100	500	cl
5	1552	7.90	14209	6.83	1.97	-156.3	0.79	14.33	100	500	cl
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL

2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	80R
Sampling Personal:	Jerry Mayer

Weather Conditions: Temp: 30 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	13.81 ft		
Depth to Top of Pump:	19.30 ft		
Water Level After Sample:	14.21 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	2-Apr-19	Time Purging Began:	1440 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	2-Apr-19	Time of Sampling:	1610 am/pm

Bottle List: 1L Raw, 500mL Nitric, 500mL Nitric (filtered), 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1445	7.27	5692	6.98	3.27	238.9	31.6	14.18	100.0	500.0	Clear
2	1505	7.48	5680	6.98	3.00	237.6	17.5	14.18	100.0	2000.0	Clear
3	1525	7.09	5690	6.98	2.77	234.7	11.4	14.18	100.0	2000.0	Clear
4	1535	7.12	5689	7.01	2.83	234.4	10.7	14.19	100.0	1000.0	Clear
5	1545	7.00	5687	7.01	3.00	237.9	7.91	14.20	100.0	1000.0	Clear
6	1555	7.22	5691	7.00	2.89	238.7	5.32	14.20	100.0	1000.0	Clear
7	1600	7.30	5696	7.01	2.91	235.9	4.87	14.20	100.0	500.0	Clear
8	1605	7.37	5689	7.01	3.07	235.2	4.79	14.21	100.0	500.0	Clear
9	1610	7.38	5688	7.01	3.15	235.4	4.75	14.21	100.0	500.0	Clear
10											

Stabilized: Yes No

Total Volume Removed: 9000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet
Groundwater Assessment

Company:	MDU Heskett
Event:	Spring 2019
Sample ID:	105
Sampling Personal:	[illegible]

Weather Conditions: Temp: 40 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	12.38 ft		
Depth to Top of Pump:	21.24 ft		
Water Level After Sample:	12.55 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	2 Apr-19	Time Purging Began:	1130 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	2 Apr-19	Time of Sampling:	1245 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1135	6.25	4669	6.82	2.43	300.4	10.9	12.62	100.0	500.0	Clear
2	1145	6.10	4466	6.84	3.13	291.4	4.65	12.48	100.0	1000.0	Clear
3	1155	6.60	4463	6.84	4.41	281.2	8.29	12.56	100.0	1000.0	Clear
4	1205	6.82	5217	6.79	2.77	269.2	3.58	12.55	100.0	1000.0	Clear
5	1215	6.64	5569	6.78	3.23	265.6	2.67	12.55	100.0	1000.0	Clear
6	1225	6.61	5927	6.77	3.49	264.8	2.98	12.55	100.0	1000.0	Clear
7	1235	6.78	6109	6.77	3.48	264.0	2.88	12.52	100.0	1000.0	Clear
8	1240	6.83	6204	6.76	3.57	265.1	3.04	12.56	100.0	500.0	Clear
9	1245	6.07	6292	6.76	3.65	265.9	2.94	12.55	100.0	500.0	Clear
10											

Stabilized: Yes No

Total Volume Removed: 7500.0 mL

Comments:

MVTL Laboratories, Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

Chain of Custody Record

Project Name: MDU Heskett	Event: Spring 2019	Work Order Number: 82- 0648
Report To: MDU Attn: Samantha Davies Address: 5181 Southgate Dr. Billings, MT 59102 phone: 406-896-4227 email:	Carbon Copy: Attn: Address:	Name of Sampler(s): Darren Nieswaag Jeremy Meyer

Sample Information / Bottle Type / Field Parameters / Analysis

Lab Number	Sample ID	Date	Time	Sample Type		1 liter	500mL Nitric	500mL Nitric (filtered)	250 mL Sulfuric			Temp (°C)	Spec. Cond.	pH	Analysis Required
WS86	33	2APR19	1258	GW		X	X	X	X			8.92	5125	6.31	MDU List AA & MDU Appendix 3
WS87	3-90	2APR19	1345	GW		X	X	X	X			7.71	4730	6.61	
WS88	Dup2	2APR19	—	GW		X	X	X	X			—	—	—	
WS89	2-90	2APR19	1500	GW		X	X	X	X			7.37	7068	6.76	
WS90	104	2APR19	1552	GW		X	X	X	X			7.90	14209	6.83	
WS91	80R	2APR19	1610	GW		X	X	X	X			7.38	5688	7.01	
WS92	105	2APR19	1245	GW		X	X	X	X			6.07	6292	6.76	
WS93	FB2	2APR19	—	GW		X	X	X	X			—	—	—	

Comments:

Relinquished By: Name:	Date/Time	Sample Condition: Location:	Temp (°C)
1 Darren Nieswaag	2APR19 1657	Log In Walk In #2	ROI 0.8 TM562 / TM588 TM805
2			

Received by: Name:	Date/Time
NBuchmann	3 Apr 19 0800

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2 North German St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 12 Sep 19
Lab Number: 19-W3191
Work Order #: 82-2271
Account #: 002800
Date Sampled: 22 Aug 19 13:30
Date Received: 22 Aug 19 15:30
Sampled By: MVTL Field Services

Todd Peterson
Montana-Dakota Utilities Co.
400 N 4th St
Bismarck ND 58501

Project Name: MDU Heskett
Sample Description: 104

Temp at Receipt: 3.3C ROI

Event and Year: August 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.86	units	NA	SM 4500 H+ B	22 Aug 19 13:30	JSM
Temperature - Field	13.9	Degrees C	NA	SM 2550B	22 Aug 19 13:30	JSM
Conductivity - Field	14152	umhos/cm	1	EPA 120.1	22 Aug 19 13:30	JSM
Sulfate	11000	mg/l	5.00	ASTM D516-07	28 Aug 19 11:22	EV
Total Dissolved Solids	17300	mg/l	10	I1750-85	27 Aug 19 10:44	SVS

CC
13Sep19

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2 North German St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 12 Sep 19
Lab Number: 19-W3192
Work Order #: 82-2271
Account #: 002800
Date Sampled: 22 Aug 19 12:52
Date Received: 22 Aug 19 15:30
Sampled By: MVTL Field Services

Todd Peterson
Montana-Dakota Utilities Co.
400 N 4th St
Bismarck ND 58501

Project Name: MDU Heskett
Sample Description: 105

Temp at Receipt: 3.3C ROI

Event and Year: August 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.70	units	NA	SM 4500 H+ B	22 Aug 19 12:52	JSM
Temperature - Field	16.9	Degrees C	NA	SM 2550B	22 Aug 19 12:52	JSM
Conductivity - Field	5897	umhos/cm	1	EPA 120.1	22 Aug 19 12:52	JSM
Chloride	279	mg/l	1.0	SM4500-Cl-E	27 Aug 19 11:03	EMS

Approved by: Claudette K. Carroll CC 13 Sep 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2 North German St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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1201 Lincoln Hwy. ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 12 Sep 19
Lab Number: 19-W3193
Work Order #: 82-2271
Account #: 002800
Date Sampled: 22 Aug 19 14:10
Date Received: 22 Aug 19 15:30
Sampled By: MVTL Field Services

Todd Peterson
Montana-Dakota Utilities Co.
400 N 4th St
Bismarck ND 58501

Project Name: MDU Heskett
Sample Description: 2-90

Event and Year: August 2019

Temp at Receipt: 3.3C ROI

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.93	units	NA	SM 4500 H+ B	22 Aug 19 14:10	JSM
Temperature - Field	11.9	Degrees C	NA	SM 2550B	22 Aug 19 14:10	JSM
Conductivity - Field	7098	umhos/cm	1	EPA 120.1	22 Aug 19 14:10	JSM
Fluoride	1.00	mg/l	0.10	SM4500-F-C	30 Aug 19 17:00	SVS

Approved by: Claudette K. Carroll CC 13 Sep 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	August 2019
Sample ID:	104
Sampling Personal:	Jerry Meyer

Weather Conditions: Temp: 75 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	14.04 ft		
Depth to Top of Pump:	22.20 ft		
Water Level After Sample:	14.35 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	10	

Purge Date:	22 Aug 19	Time Purging Began:	1305 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	22 Aug 19	Time of Sampling:	1330 am/pm

Bottle List:	
	1L Raw

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1310	14.47	14170	6.93	10.63	199.6	3.52	14.24	100.0	500.0	Clear
2	1315	13.78	14264	6.88	10.98	200.5	2.24	14.35	100.0	500.0	Clear
3	1320	14.27	14135	6.87	11.27	200.8	2.06	14.29	100.0	500.0	Clear
4	1325	13.61	14246	6.87	11.62	202.1	1.98	14.32	100.0	500.0	Clear
5	1330	13.89	14152	6.86	11.51	202.6	1.91	14.33	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500.0 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company: MDU Heskett
Event: August 2019
Sample ID: 105
Sampling Personal: Jeremy Menger

Weather Conditions: Temp: 75 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	12.96 ft		
Depth to Top of Pump:	21.24 ft		
Water Level After Sample:	13.19 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	10	

Purge Date:	22Aug19	Time Purging Began:	1132 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	22Aug19	Time of Sampling:	1252 am/pm

Bottle List: 1L Raw

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1137	12.18	4042	6.77	4.59	246.1	8.72	13.31	100.0	500.0	Clear
2	1207	15.06	4928	6.74	6.35	206.7	3.72	13.15	100.0	3000.0	Clear
3	1217	16.74	5316	6.72	6.99	202.3	2.88	13.18	100.0	1000.0	Clear
4	1227	18.51	5566	6.71	8.49	197.3	2.71	13.18	100.0	1000.0	Clear
5	1237	21.00	5714	6.70	10.08	189.4	2.21	13.16	100.0	1000.0	Clear
6	1242	17.72	5822	6.70	8.94	189.7	2.66	13.17	100.0	500.0	Clear
7	1247	17.03	5830	6.70	8.77	188.6	2.57	13.17	100.0	500.0	Clear
8	1252	16.89	5897	6.70	8.82	189.0	2.55	13.18	100.0	500.0	Clear
9											
10											

Stabilized: Yes No

Total Volume Removed: 8000.0 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	August 2019
Sample ID:	290
Sampling Personal:	Jeremy [illegible]

Weather Conditions: Temp: 75 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	21.55 ft		
Depth to Top of Pump:	22.32 ft		
Water Level After Sample:	22.00 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	22 Aug 19	Time Purging Began:	1345 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	22 Aug 19	Time of Sampling:	1410 am/pm

Bottle List: 1L Raw

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1350	12.21	7193	6.92	12.37	209.2	0.50	21.95	100.0	500.0	Clear
2	1355	12.30	7112	6.89	13.07	204.8	1.59	21.98	100.0	500.0	Clear
3	1400	11.72	7132	6.91	13.03	199.7	1.55	22.01	100.0	500.0	Clear
4	1405	12.47	7093	6.92	13.08	180.0	1.43	21.98	100.0	500.0	Clear
5	1410	11.90	7098	6.93	13.18	175.3	1.39	21.98	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500.0 mL

Comments:

MVTL Laboratories, Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

Chain of Custody Record

Project Name: MDU Heskett	Event: August 2019	Work Order Number: 82- 2271
Report To: MDU Attn: Samantha Davies Address: 5181 Southgate Dr. Billings, MT 59102 phone: 406-896-4227 email:	Carbon Copy: Attn: Address:	Name of Sampler(s):

Sample Information / Bottle Type / Field Parameters / Analysis

Lab Number	Sample ID	Date	Time	Sample Type		1 liter	500mL Nitric	500mL Nitric (filtered)	250 mL Sulfuric				Temp (°C)	Spec. Cond.	pH	Analysis Required
W3191	104	22Aug19	1330	GW		X							13.89	14152	6.86	sulfate+TDS
W3192	105	22Aug19	1252	GW		X							16.89	5897	6.70	chloride
W3193	2-90	22Aug19	1410	GW		X							11.90	7098	6.93	fluoride

Comments:

Relinquished By: Name	Date/Time	Sample Condition: Location:	Temp (°C)
1	22Aug19 1530	Log In Walk In #2	ROI 3.3 TM562 / TM588
2			

Received by: Name:	Date/Time
NBuchmann	22Aug19 @ 1530

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www.mvtl.com

October 4, 2019

Montana Dakota Utilities
Attn: Abbie Krebsbach
400 N. 4th St.
Bismarck, ND 58501

RE: Groundwater Sampling Event - MDU Heskett Ash Site

Dear Ms. Krebsbach:

From September 16-18, 2019, MVTL Laboratories' Field Services division collected groundwater samples at the MDU Heskett site near Mandan, ND for the Heskett Coal Combustion Rule.

All wells were located and were found to be in generally good condition. The wells for CCR were purged and sampled using a dedicated bladder pump and BARR's SOP for low flow purging and sampling. Sampling was also collected for the NDDH list of analysis. The samples collected were, placed on ice and transported back to the MVTL laboratory in Bismarck, ND for analysis. The field data report for the sampling event accompanies this letter.

Thank you for your trust and support of our services. If you have any questions, please call me at (701)391-4900.

Sincerely,

Jeremy Meyer
MVTL Field Services

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MEMBER ACIL

Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3728
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19 9:45
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 175103

Sample Description: 13

Temp at Receipt: 3.2C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.95	units	NA	SM 4500 H+ B	16 Sep 19 9:45	JSM
pH	* 7.8	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	10.9	Degrees C	NA	SM 2550B	16 Sep 19 9:45	JSM
Conductivity - Field	10184	umhos/cm	1	EPA 120.1	16 Sep 19 9:45	JSM
Fluoride	1.01	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	6380	mg/l	5.00	ASTM D516-07	25 Sep 19 8:53	EV
Chloride	65.3	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	10200	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	431	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	0.54	mg/l	0.10	6010D	24 Sep 19 10:54	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 11NOV19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
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= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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MEMBER ACIL

Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3729
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: Dup1

Event and Year: Fall 2019

PO #: 175103

Temp at Receipt: 3.2C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH	* 7.8	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Fluoride	1.01	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	6400	mg/l	5.00	ASTM D516-07	25 Sep 19 8:53	EV
Chloride	64.7	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	10200	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	404	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	0.54	mg/l	0.10	6010D	24 Sep 19 10:54	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 11 NOV 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

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= Due to concentration of other analytes
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CERTIFICATION: ND # ND-00016

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www.mvtl.com

MEMBER ACIL

Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3730
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19 11:30
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 102

Event and Year: Fall 2019

PO #: 175103

Temp at Receipt: 3.2C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.74	units	NA	SM 4500 H+ B	16 Sep 19 11:30	JSM
pH	* 7.6	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	13.6	Degrees C	NA	SM 2550B	16 Sep 19 11:30	JSM
Conductivity - Field	8680	umhos/cm	1	EPA 120.1	16 Sep 19 11:30	JSM
Fluoride	0.17	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	5390	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	4.2	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	7930	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	471	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	1.16	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carrell 11NOV19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

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= Due to concentration of other analytes
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CERTIFICATION: ND # ND-00016

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MEMBER ACIL

Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3731
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19 12:54
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 70

Event and Year: Fall 2019

PO #: 175103

Temp at Receipt: 3.2C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.96	units	NA	SM 4500 H+ B	16 Sep 19 12:54	JSM
pH	* 7.8	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	14.7	Degrees C	NA	SM 2550B	16 Sep 19 12:54	JSM
Conductivity - Field	4317	umhos/cm	1	EPA 120.1	16 Sep 19 12:54	JSM
Fluoride	0.34	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	2390	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	44.4	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	3770	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	406	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	0.45	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 11Nov19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3732
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19 14:44
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 175103

Sample Description: 101

Temp at Receipt: 3.2C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.66	units	NA	SM 4500 H+ B	16 Sep 19 14:44	JSM
pH	* 7.8	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	13.5	Degrees C	NA	SM 2550B	16 Sep 19 14:44	JSM
Conductivity - Field	4855	umhos/cm	1	EPA 120.1	16 Sep 19 14:44	JSM
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	2870	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	14.8	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	4360	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	383	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	0.97	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 11Nov19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3733
Work Order #: 82-2611
Account #: 002800
Date Sampled: 16 Sep 19 15:55
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 103

Event and Year: Fall 2019

PO #: 175103

Temp at Receipt: 3.2C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.62	units	NA	SM 4500 H+ B	16 Sep 19 15:55	JSM
pH	* 7.6	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	12.0	Degrees C	NA	SM 2550B	16 Sep 19 15:55	JSM
Conductivity - Field	5185	umhos/cm	1	EPA 120.1	16 Sep 19 15:55	JSM
Fluoride	0.13	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	2960	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	140	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	4820	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	560	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 11Nov19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3734
Work Order #: 82-2611
Account #: 002800
Date Sampled: 17 Sep 19 9:17
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

PO #: 175103

Temp at Receipt: 3.2C

Project Name: MDU Heskett

Sample Description: 44R

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.52	units	NA	SM 4500 H+ B	17 Sep 19 9:17	JSM
pH	* 7.4	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Temperature - Field	17.3	Degrees C	NA	SM 2550B	17 Sep 19 9:17	JSM
Conductivity - Field	9196	umhos/cm	1	EPA 120.1	17 Sep 19 9:17	JSM
Fluoride	0.68	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	5920	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	217	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	10100	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	464	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

CC

Approved by: Claudette K. Carroll 11 NOV 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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Amended PO# 5Nov2019 - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 9 Oct 19
Lab Number: 19-W3735
Work Order #: 82-2611
Account #: 002800
Date Sampled: 17 Sep 19
Date Received: 17 Sep 19 16:00
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 175103

Sample Description: FB1

Temp at Receipt: 3.2C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH	* 6.2	units	0.1	SM4500 H+ B	25 Sep 19 7:40	CC
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	25 Sep 19 7:40	CC
Sulfate	< 5	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	< 1	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	< 10	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	< 1	mg/l	1.0	6010D	20 Sep 19 16:21	SZ
Boron - Total	< 0.1	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 11NOV19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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= Due to concentration of other analytes
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CERTIFICATION: ND # ND-00016

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Quality Control Report – Amended 7 Nov 19

Lab IDs: 19-W3728 to 19-W3735 **Project:** MDU Heskett **Work Order:** 201982-2611

Analyte	LCS Spike Amt	LCS Rec %	LCS % Rec Limits	Matrix Spike Amt	Matrix Spike ID	Matrix Spike Orig Result	Matrix Spike Result	Matrix Spike Rec %	Matrix Spike % Rec Limits	MSD/ Dup Orig Result	MSD/ Dup Result	MSD Rec %	MSD/ Dup RPD	MSD/ Dup RPD Limit (<)	Known Rec (%)	Known % Rec Limits	Method Blank
Boron - Total mg/l	0.40 0.40	95 98	80-120 80-120	2.00 2.00	19-W3728 19-W3743	0.54 < 0.5	2.30 2.22	88 111	75-125 75-125	2.30 2.22	2.29 2.24	88 112	0.4 0.9	20 20	- - - -	- - - -	< 0.1 < 0.1 < 0.1 < 0.1
Calcium - Total mg/l	20.0	116	80-120	500	19W3732q	383	955	114	75-125	955	950	113	0.5	20	- -	- -	< 1 < 1
Chloride mg/l	30.0 30.0	90 91	80-120 80-120	30.0	19-W3735	< 1	25.3	84	80-120	25.3	25.3	84	0.0	20	- -	- -	< 1 < 1
Fluoride mg/l	0.50	108	90-110	0.500	19-W3727Q	0.68	1.23	110	80-120	1.23	1.24	112	0.7	20	- -	- -	< 0.1 < 0.1
pH units	-	-	-	-	-	-	-	-	-	7.8	7.8	-	0.0	20	-	-	-
Sulfate mg/l	100 100	100 101	80-120 80-120	100 100	19-W3725 19-W3735	< 5 < 5	96.9 106	97 106	80-120 80-120	96.9 106	101 106	101 106	4.1 0.0	20 20	- -	- -	< 5 < 5
Total Dissolved Solids mg/l	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	4360 7150 < 10	4480 7200 < 10	- - -	2.7 0.7 0.0	20 20 *	- - -	- - -	< 10 < 10

Samples were received in good condition on 17 Sep 2019 at 1600.
Temperature upon receipt at the Bismarck laboratory was 3.2°C.
Samples were received on ice and evidence of cooling had begun.
All samples were properly preserved unless noted here and/or flagged on the individual analytical laboratory report.
With the exception of pH, all holding times were met.
Approved methodology was followed for all sample analyses.
All acceptance criteria were met for calibration, method blanks, laboratory control samples, laboratory fortified matrix/duplicates unless noted here.

- For some analytes, the reported results were elevated due to additional dilutions required to minimize the effects of sample matrix.

Reporting

- Per email from Todd Peterson, MDU, sample data package was amended to revise Purchase Order number on reports.
- Per email from Barr, field summary report was amended to correct date sampled for MW44R.
- Per email from Terri Olson, Barr, dated 6 Nov 2019, the CCR data package was split into Appendix III and Appendix IV parameters.

Approved by: C. Cantrell
11Nov19

Claudette Carroll

From: Terri A. Olson <TOlson@barr.com>
Sent: Wednesday, November 6, 2019 12:41 PM
To: Claudette Carroll
Cc: Stephanie A. Theriault
Subject: RE: Re: MDU Heskett reports

Hi Claudette,

Regarding the 3rd bullet, we don't receive a CCR report for this one so you can take it off your list of things to do; however, we do need the other two reports split into Appendix III and Appendix IV parameters. For fluoride that is in both lists, please report with Appendix III.

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

From: Terri A. Olson
Sent: Friday, November 1, 2019 10:08 AM
To: 'ccarroll@mvtl.com' <ccarroll@mvtl.com>
Subject: Re: MDU Heskett reports

Hi Claudette,

Reviewed MDU Heskett reports and had the following questions/comments

- 201982-2611
  - MW44R in the Field Data Report has a sample date of 09/16/19 but raw field data and COC list 09/17/19 – please revise,
- 201982-2625
  - There is a QC page (page 9 of the report) that isn't applicable for CCR (includes dissolved parameters).
  - Case narrative for report has nitrate + nitrite as N comment but isn't applicable to CCR work.
- 201982-2626
  - This report is the state versions for MW1-90. Haven't see a CCR report yet?

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

resourceful. naturally. BARR

Claudette Carroll

From:	Peterson, Todd <Todd.Peterson@mdu.com>
Sent:	Friday, November 1, 2019 10:32 AM
To:	Claudette Carroll
Cc:	Dihle, Mark
Subject:	RE: Lab invoice and report
Attachments:	201982-2626 MDU ND.pdf; 201982-2611 MDU CCR.pdf

Claudette,

These lab analyses should both have the PO 175103 listed on them. I have the paper copies and can revise them on my end, but can you change the PO number on your copies and resend the corrected PDF analyses.

Thank you!

Todd.

From: Claudette Carroll <ccarroll@mvtl.com>
Sent: Thursday, October 31, 2019 1:29 PM
To: Dihle, Mark <Mark.Dihle@mdu.com>
Cc: Peterson, Todd <Todd.Peterson@mdu.com>
Subject: RE: Lab invoice and report

** WARNING: EXTERNAL SENDER. NEVER click links or open attachments without positive sender verification of purpose. DO NOT provide your user ID or password on sites or forms linked from this email. **

Hi Mark,

Looks like the work was done at MDU Heskett. Attached are the data packages. Let me know if we need to rebill/re-invoice with the correct PO.

Happy Halloween to you as well!
Claudette

MVTL
Minnesota Valley Testing Laboratories, Inc.
Providing Analytical Excellence Since 1951
ccarroll@mvtl.com
701-258-9720
2616 E. Broadway Ave/Bismarck, ND 58501

From: Dihle, Mark <Mark.Dihle@mdu.com>
Sent: Thursday, October 31, 2019 8:46 AM
To: Claudette Carroll <ccarroll@mvtl.com>
Cc: Peterson, Todd <Todd.Peterson@mdu.com>
Subject: Lab invoice and report

Good Morning!

Todd and I are trying to figure out this invoice, it appears to have the wrong PO attached to it. Please send along the analysis that the invoice is associated with and have a Happy Halloween!

Thanks!

Mark Dihle
Sr. Environmental Scientist
Montana Dakota Utilities
400 North Fourth Street
Bismarck, ND 58501-4092
Bus: 701.222.7865
Fax: 701.222.7845

Claudette Carroll

From: Terri A. Olson <TOlson@barr.com>
Sent: Friday, November 1, 2019 10:08 AM
To: Claudette Carroll
Subject: Re: MDU Heskett reports

Hi Claudette,

Reviewed MDU Heskett reports and had the following questions/comments

- 201982-2611
  - MW44R in the Field Data Report has a sample date of 09/16/19 but raw field data and COC list 09/17/19 – please revise,
- 201982-2625
  - There is a QC page (page 9 of the report) that isn't applicable for CCR (includes dissolved parameters).
  - Case narrative for report has nitrate + nitrite as N comment but isn't applicable to CCR work.
- 201982-2626
  - This report is the state versions for MW1-90. Haven't see a CCR report yet?

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

MVTL Laboratories Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

MDU - Heskett

Groundwater Sampling

MDU
400 N. 4th St.
Bismarck, ND 58501

WO#
82-2626 82-2611 82-2625

FIELD DATA REPORT - AMENDED 7 NOV 19

SAMPLE ID	PURGE DATE	START PURGE TIME	SAMPLE DATE	TIME OF SAMPLE	WATER LEVEL START (FT)	WATER LEVEL END (FT)	VOLUME REMOVED (mL)	SAMPLE METHOD	FIELD READINGS				SAMPLE APPEARANCE OR COMMENT
									TEMP (°C)	EC	pH	Turb. NTU	
2-90	18-Sep-19	9:31	18-Sep-19	9:56	21.30	21.73	2500.0	Bladder	12.49	7006	6.99	0.98	clear
3-90	18-Sep-19	8:25	18-Sep-19	8:55	18.46	18.60	3000.0	Bladder	9.43	4473	6.92	1.78	clear
13	16-Sep-19	8:30	16-Sep-19	9:45	30.11	30.72	7500.0	Bladder	10.93	10184	6.95	3.19	clear
33	17-Sep-19	13:18	17-Sep-19	15:13	41.59	42.15	11500.0	Bladder	13.01	5128	6.51	4.38	clear
70	16-Sep-19	12:04	16-Sep-19	12:54	20.80	22.40	5000.0	Bladder	14.68	4317	6.96	0.47	clear
80R	17-Sep-19	11:45	17-Sep-19	12:35	14.35	14.62	5000.0	Bladder	13.09	5723	7.00	1.09	clear
44R	17-Sep-19	8:27	17-Sep-19	9:17	26.34	26.40	5000.0	Bladder	17.32	9196	6.52	0.98	clear
101	16-Sep-19	13:24	16-Sep-19	14:44	36.57	40.70	8000.0	Bladder	13.49	4855	6.66	3.93	clear
102	16-Sep-19	10:40	16-Sep-19	11:30	17.42	19.70	5000.0	Bladder	13.63	8680	6.74	1.19	clear
103	16-Sep-19	15:15	16-Sep-19	15:55	31.65	33.21	4000.0	Bladder	11.98	5185	6.62	0.59	clear
104	18-Sep-19	11:16	18-Sep-19	11:46	13.78	14.06	3000.0	Bladder	13.77	14025	6.97	0.89	clear
105	17-Sep-19	10:01	17-Sep-19	11:21	12.62	12.94	8000.0	Bladder	12.47	6913	6.70	2.32	clear
1-90	18-Sep-19	10:25	18-Sep-19	10:50	11.22	11.42	2500.0	Bladder	12.54	9739	6.87	0.50	clear
	na = Not Applicable NR = Not Recorded												

MVTL Laboratories Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

MDU - Heskett

Groundwater Sampling
MDU
400 N. 4th St.
Bismarck, ND 58501

WO#
82-2626 82-2611 82-2625

FIELD DATA REPORT

SAMPLE ID	PURGE DATE	START PURGE TIME	SAMPLE DATE	TIME OF SAMPLE	WATER LEVEL START (FT)	WATER LEVEL END (FT)	VOLUME REMOVED (mL)	SAMPLE METHOD	FIELD READINGS				SAMPLE APPEARANCE OR COMMENT
									TEMP (°C)	EC	pH	Turb. NTU	
2-90	18-Sep-19	9:31	18-Sep-19	9:56	21.30	21.73	2500.0	Bladder	12.49	7006	6.99	0.98	clear
3-90	18-Sep-19	8:25	18-Sep-19	8:55	18.46	18.60	3000.0	Bladder	9.43	4473	6.92	1.78	clear
13	16-Sep-19	8:30	16-Sep-19	9:45	30.11	30.72	7500.0	Bladder	10.93	10184	6.95	3.19	clear
33	17-Sep-19	13:18	17-Sep-19	15:13	41.59	42.15	11500.0	Bladder	13.01	5128	6.51	4.38	clear
70	16-Sep-19	12:04	16-Sep-19	12:54	20.80	22.40	5000.0	Bladder	14.68	4317	6.96	0.47	clear
80R	17-Sep-19	11:45	17-Sep-19	12:35	14.35	14.62	5000.0	Bladder	13.09	5723	7.00	1.09	clear
44R	16-Sep-19	8:27	16-Sep-19	9:17	26.34	26.40	5000.0	Bladder	17.32	9196	6.52	0.98	clear
101	16-Sep-19	13:24	16-Sep-19	14:44	36.57	40.70	8000.0	Bladder	13.49	4855	6.66	3.93	clear
102	16-Sep-19	10:40	16-Sep-19	11:30	17.42	19.70	5000.0	Bladder	13.63	8680	6.74	1.19	clear
103	16-Sep-19	15:15	16-Sep-19	15:55	31.65	33.21	4000.0	Bladder	11.98	5185	6.62	0.59	clear
104	18-Sep-19	11:16	18-Sep-19	11:46	13.78	14.06	3000.0	Bladder	13.77	14025	6.97	0.89	clear
105	17-Sep-19	10:01	17-Sep-19	11:21	12.62	12.94	8000.0	Bladder	12.47	6913	6.70	2.32	clear
1-90	18-Sep-19	10:25	18-Sep-19	10:50	11.22	11.42	2500.0	Bladder	12.54	9739	6.87	0.50	clear
	na = Not Applicable NR = Not Recorded												

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	13
Sampling Personal:	[illegible signature]

Weather Conditions: Temp: 65 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	**Not Visible**
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	30.11 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	30.72 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	**Bladder**	
Sampling Method:	**Bladder**	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	Dup 1	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	30	

Purge Date:	16 Sept 19	Time Purging Began:	0830 am/pm
Well Purged Dry?	Yes / No	Time Purged Dry:	— am/pm
Sample Date:	16 Sept 19	Time of Sampling:	0945 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	0835	10.56	10282	6.55	9.92	198.7	3.47	30.41	100.0	500.0	Clear
2	0905	10.32	10146	6.94	7.79	169.6	5.12	30.70	100.0	3000.0	Clear
3	0925	10.85	10156	6.94	8.11	166.2	3.74	30.68	100.0	2000.0	Clear
4	0935	10.96	10159	6.95	9.35	167.9	3.39	30.65	100.0	1000.0	Clear
5	0940	11.14	10142	6.96	9.26	163.5	3.26	30.67	100.0	500.0	Clear
6	0945	10.93	10184	6.95	9.41	160.3	3.19	30.71	100.0	500.0	Clear
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 7500.0 mL

Comments:

MVTL

2616 E. Broadway Ave, Bismarck, ND

Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	102
Sampling Personal:	Jerry [illegible]

Weather Conditions: Temp: 70 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	17.42 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	19.70 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	16 Sept 19	Time Purging Began:	1040 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	16 Sept 19	Time of Sampling:	1130 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1045	12.61	8781	6.91	6.75	-74.3	1.13	18.07	100.0	500.0	Clear
2	1015	12.34	9059	6.78	4.94	-82.1	0.66	19.13	100.0	3000.0	Clear
3	1120	12.55	8866	6.75	5.95	-73.2	1.03	19.45	100.0	500.0	Clear
4	1125	13.54	8728	6.74	6.07	-67.9	0.95	19.46	100.0	500.0	Clear
5	1130	13.63	8680	6.74	6.12	-65.6	1.19	19.51	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 5000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	70
Sampling Personal:	Jerry Meyer

Weather Conditions: Temp: 75°F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	20.80 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	22.40 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	16 Sept 19	Time Purging Began:	1204 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	16 Sept 19	Time of Sampling:	1254 am/pm

Bottle List: 1L Raw, 500mL Nitric, 500mL Nitric (filtered), 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1209	14.17	4311	6.93	6.48	52.8	0.34	21.48	100.0	500.0	Clear
2	1239	13.83	4335	6.96	4.48	51.3	1.17	22.24	100.0	3000.0	Clear
3	1244	14.45	4347	6.96	4.89	52.0	0.36	22.30	100.0	500.0	Clear
4	1249	13.78	4303	6.96	4.98	53.3	0.42	22.32	100.0	500.0	Clear
5	1254	14.68	4317	6.96	5.06	54.5	0.47	22.40	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 5000.0 mL

Comments:

MVTL

2616 E. Broadway Ave, Bismarck, ND

Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	101
Sampling Personal:	Jerry Gloyn

Weather Conditions: Temp: 75°F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	36.57 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	40.70 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	35	

Purge Date:	16 Sept 19	Time Purging Began:	1324 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	16 Sept 19	Time of Sampling:	1444 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1329	14.37	4874	6.80	11.96	15.2	9.70	37.48	100.0	500.0	Clear
2	1359	13.34	4832	6.67	3.84	-16.6	9.05	39.49	100.0	3000.0	Clear
3	1429	13.64	4841	6.68	4.65	-4.7	4.20	40.13	100.0	3000.0	Clear
4	1434	13.37	4845	6.66	4.77	-10.6	4.06	40.26	100.0	500.0	Clear
5	1439	13.91	4840	6.66	4.91	-11.1	3.89	40.37	100.0	500.0	Clear
6	1444	13.49	4855	6.66	5.11	-12.7	3.93	40.41	100.0	500.0	Clear
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 8000.0 mL

Comments:

MVTL

2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	103
Sampling Personal:	Jerry Myer

Weather Conditions: Temp: 80 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			

Casing Diameter:	2"	
Water Level Before Purge:	31.65	ft
Depth to Top of Pump:	—	ft
Water Level After Sample:	33.21	ft
Measurement Method:	Electric Water Level Indicator	

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	30	

Purge Date:	16 Sept 19		Time Purging Began:	1515 am/pm
Well Purged Dry?	Yes	No	Time Purged Dry:	— am/pm
Sample Date:	16 Sept 19		Time of Sampling:	1555 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1520	13.61	5112	6.65	5.87	107.5	1.06	32.22	100.0	500.0	Clear
2	1540	11.79	5184	6.66	3.68	110.4	0.41	32.80	100.0	2000.0	Clear
3	1545	12.09	5179	6.63	3.75	116.9	0.40	32.93	100.0	500.0	Clear
4	1550	12.54	5164	6.62	3.87	119.8	0.56	32.94	100.0	500.0	Clear
5	1555	11.98	5185	6.62	3.92	120.4	0.59	33.02	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 4000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet
Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	44R
Sampling Personal:	[signature]

Weather Conditions: Temp: 65 °F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy**

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	26.34 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	26.40 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings

Purge:	5	sec.
Recover:	55	sec.
PSI:	30	

Purge Date:	17Sep19	Time Purging Began:	0827 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	17Sep19	Time of Sampling:	0917 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	0832	13.37	9155	6.49	8.67	198.9	1.26	26.42	100.0	500.0	Clear
2	0902	17.89	9176	6.51	7.85	172.7	1.66	26.38	100.0	3000.0	Clear
3	0907	17.87	9147	6.52	7.92	170.6	0.93	26.39	100.0	500.0	Clear
4	0912	17.16	9172	6.52	8.04	169.1	0.89	26.40	100.0	500.0	Clear
5	0917	17.32	9196	6.52	8.17	169.2	0.98	26.38	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 5000.0 mL

Comments:

MVTL Laboratories, Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

Chain of Custody Record

Project Name: MDU Heskett	Event: Fall 2019	Work Order Number: 82-26611
Report To: MDU Attn: Abbie Krebsbach Address: 400 N. 4th St. Bismarck, ND 58501 phone: 701-222-7844 email:	Carbon Copy: Attn: Address:	Name of Sampler(s): Jeremy Meyer

Lab Number	Sample ID	Date	Time	Sample Type		1 liter	500mL Nitric	500mL Nitric (filtered)	250 mL Sulfuric			Temp (°C)	Spec. Cond.	pH	Analysis Required	
W3728	13	16 Sept 19	0945	GW		X	X	X	X			10.93	10184	6.95	MDU List AA & List C	MDU
W3729	Dup1	16 Sept 19	—	GW		X	X	X	X			—	—	—		
W3730	102	16 Sept 19	1130	GW		X	X	X	X			13.63	8680	6.74		
W3731	70	16 Sept 19	1254	GW		X	X	X	X			14.68	4317	6.96		
W3732	101	16 Sept 19	1444	GW		X	X	X	X			13.49	4855	6.66		
W3733	103	16 Sept 19	1555	GW		X	X	X	X			11.98	5185	6.62		
W3734	44R	17 Sept 19	0917	GW		X	X	X	X			17.32	9196	6.52		
W3735	FB1	17 Sept 19	—	GW		X	X	X	X			—	—	—		

Comments:

Relinquished By: Name:	Date/Time	Sample Condition: Location:	Temp (°C)
1 [signature]	17 Sept 19 1600	~~Log In~~ Walk In #2	~~Bot~~ 3.2 ~~TM562~~ / TM588
2			

Received by: Name:	Date/Time
[signature]	17 Sept 2019 1600

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3743
Work Order #: 82-2625
Account #: 002800
Date Sampled: 17 Sep 19 15:13
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 33

Event and Year: Fall 2019

PO #: 174855 OP

Temp at Receipt: 5.5C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.51	units	NA	SM 4500 H+ B	17 Sep 19 15:13	JSM
pH	* 7.2	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Temperature - Field	13.0	Degrees C	NA	SM 2550B	17 Sep 19 15:13	JSM
Conductivity - Field	5128	umhos/cm	1	EPA 120.1	17 Sep 19 15:13	JSM
Fluoride	0.24	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	3340	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	10.2	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	5100	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	476	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

CC
11 NOV 19

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
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\+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3744
Work Order #: 82-2625
Account #: 002800
Date Sampled: 18 Sep 19 8:55
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 3-90

Event and Year: Fall 2019

PO #: 174855 OP

Temp at Receipt: 5.5C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.92	units	NA	SM 4500 H+ B	18 Sep 19 8:55	JSM
pH	* 7.5	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Temperature - Field	9.43	Degrees C	NA	SM 2550B	18 Sep 19 8:55	JSM
Conductivity - Field	4473	umhos/cm	1	EPA 120.1	18 Sep 19 8:55	JSM
Fluoride	0.12	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	2410	mg/l	5.00	ASTM D516-07	25 Sep 19 9:10	EV
Chloride	31.2	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	4000	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	464	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	0.12	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

CC
11 NOV 19

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3745
Work Order #: 82-2625
Account #: 002800
Date Sampled: 18 Sep 19
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

PO #: 174855 OP

Temp at Receipt: 5.5C

Project Name: MDU Heskett

Sample Description: Dup2

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH	* 7.5	units	0.1	SM4500 H+ B	27 Sep 19 17:00	CC
Fluoride	0.14	mg/l	0.10	SM4500-F-C	27 Sep 19 17:00	CC
Sulfate	2500	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	30.9	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	3970	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	446	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	0.11	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll KC 11 Nov 19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3746
Work Order #: 82-2625
Account #: 002800
Date Sampled: 18 Sep 19 9:56
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 2-90

Event and Year: Fall 2019

PO #: 174855 OP

Temp at Receipt: 5.5C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.99	units	NA	SM 4500 H+ B	18 Sep 19 9:56	JSM
pH	* 7.5	units	0.1	SM4500 H+ B	27 Sep 19 17:00	CC
Temperature - Field	12.5	Degrees C	NA	SM 2550B	18 Sep 19 9:56	JSM
Conductivity - Field	7006	umhos/cm	1	EPA 120.1	18 Sep 19 9:56	JSM
Fluoride	1.03	mg/l	0.10	SM4500-F-C	27 Sep 19 17:00	CC
Sulfate	4770	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	68.7	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	7400	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	494	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 11:54	SZ

* Holding time exceeded

KC
11NOV19

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3747
Work Order #: 82-2625
Account #: 002800
Date Sampled: 18 Sep 19 11:46
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 174855 OP

Sample Description: 104

Temp at Receipt: 5.5C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.97	units	NA	SM 4500 H+ B	18 Sep 19 11:46	JSM
pH	* 7.6	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Temperature - Field	13.8	Degrees C	NA	SM 2550B	18 Sep 19 11:46	JSM
Conductivity - Field	14025	umhos/cm	1	EPA 120.1	18 Sep 19 11:46	JSM
Fluoride	0.54	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	11300	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	84.9	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	17200	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	466	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	0.82	mg/l	0.10	6010D	24 Sep 19 12:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll 11NOV19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
! = Due to sample quantity
= Due to concentration of other analytes
+ = Due to internal standard response

CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3748
Work Order #: 82-2625
Account #: 002800
Date Sampled: 17 Sep 19 12:35
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

Sample Description: 80R

Event and Year: Fall 2019

PO #: 174855 OP

Temp at Receipt: 5.5C

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	7.00	units	NA	SM 4500 H+ B	17 Sep 19 12:35	JSM
pH	* 7.7	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Temperature - Field	13.1	Degrees C	NA	SM 2550B	17 Sep 19 12:35	JSM
Conductivity - Field	5723	umhos/cm	1	EPA 120.1	17 Sep 19 12:35	JSM
Fluoride	0.26	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	3350	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	146	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	5480	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	350	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 12:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll CC 11Nov19

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

RL = Method Reporting Limit

The reporting limit was elevated for any analyte requiring a dilution as coded below:
@ = Due to sample matrix
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CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3749
Work Order #: 82-2625
Account #: 002800
Date Sampled: 17 Sep 19 11:21
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 174855 OP

Sample Description: 105

Temp at Receipt: 5.5C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH - Field	6.70	units	NA	SM 4500 H+ B	17 Sep 19 11:21	JSM
pH	* 7.5	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Temperature - Field	12.5	Degrees C	NA	SM 2550B	17 Sep 19 11:21	JSM
Conductivity - Field	6913	umhos/cm	1	EPA 120.1	17 Sep 19 11:21	JSM
Fluoride	0.26	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	4600	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	290	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	7150	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	400	mg/l	1.0	6010D	27 Sep 19 12:02	SZ
Boron - Total	< 0.5 @	mg/l	0.10	6010D	24 Sep 19 12:54	SZ

* Holding time exceeded

Approved by: Claudette K. Carroll 11 NN19 KC

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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CERTIFICATION: ND # ND-00016

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Amended 22Oct19 (Cation/Anion Sum) - CCR

Abbie Krebsbach
Montana Dakota Utilities
400 N 4th
Bismarck ND 58501

Report Date: 15 Oct 19
Lab Number: 19-W3750
Work Order #: 82-2625
Account #: 002800
Date Sampled: 18 Sep 19
Date Received: 18 Sep 19 12:50
Sampled By: MVTL Field Services

Project Name: MDU Heskett

PO #: 174855 OP

Sample Description: FB2

Temp at Receipt: 5.5C

Event and Year: Fall 2019

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
pH	* 6.3	units	0.1	SM4500 H+ B	26 Sep 19 6:45	CC
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	26 Sep 19 6:45	CC
Sulfate	< 5	mg/l	5.00	ASTM D516-07	25 Sep 19 9:28	EV
Chloride	< 1	mg/l	1.0	SM4500-Cl-E	19 Sep 19 11:19	EV
Total Dissolved Solids	< 10	mg/l	10	I1750-85	20 Sep 19 16:19	CC
Calcium - Total	< 1	mg/l	1.0	6010D	27 Sep 19 13:02	SZ
Boron - Total	< 0.1	mg/l	0.10	6010D	24 Sep 19 12:54	SZ

* Holding time exceeded

CC
11 NOV 19

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

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CERTIFICATION: ND # ND-00016

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Quality Control Report – Amended 7 Nov 19

Lab IDs: 19-W3743 to 19-W3750 **Project:** MDU Heskett **Work Order:** 201982-2625

Analyte	LCS Spike Amt	LCS Rec %	LCS % Rec Limits	Matrix Spike Amt	Matrix Spike ID	Matrix Spike Orig Result	Matrix Spike Result	Matrix Spike Rec %	Matrix Spike % Rec Limits	MSD/ Dup Orig Result	MSD/ Dup Result	MSD Rec %	MSD/ Dup RPD	MSD/ Dup RPD Limit (<)	Known Rec (%)	Known % Rec Limits	Method Blank
Boron - Total mg/l	0.40	98	80-120	2.00	19-W3743	< 0.5	2.22	111	75-125	2.22	2.24	112	0.9	20	-	-	< 0.1
	0.40	100	80-120	0.400	19-W3750	< 0.1	0.35	88	75-125	0.35	0.35	88	0.0	20	-	-	< 0.1
															-	-	< 0.1
															-	-	< 0.1
Calcium - Total mg/l	20.0	113	80-120	500	19W3744q	464	1030	113	75-125	1030	1000	107	3.0	20	-	-	< 1
	20.0	110	80-120	100	19W3816q	130	229	99	75-125	229	229	99	0.0	20	-	-	< 1
	20.0	114	80-120												-	-	< 1
															-	-	< 1
															-	-	< 1
Chloride mg/l	30.0	90	80-120	30.0	19-W3735	< 1	25.3	84	80-120	25.3	25.3	84	0.0	20	-	-	< 1
	30.0	91	80-120												-	-	< 1
Fluoride mg/l	0.50	102	90-110	0.500	19-W3744	0.12	0.63	102	80-120	0.63	0.63	102	0.0	20	-	-	< 0.1
	0.50	110	90-110	0.500	19-W3746	1.03	1.45	84	80-120	1.45	1.47	88	1.4	20	-	-	< 0.1
															-	-	< 0.1
															-	-	< 0.1
pH units	-	-	-	-	-	-	-	-	-	7.5	7.5	-	0.0	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.5	7.5	-	0.0	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.6	7.4	-	2.7	20	-	-	-
	-	-	-	-	-	-	-	-	-	7.5	7.5	-	0.0	20	-	-	-
Sulfate mg/l	100	101	80-120	100	19-W3735	< 5	106	106	80-120	106	106	106	0.0	20	-	-	< 5
	100	100	80-120	100	19-W3750	< 5	107	107	80-120	107	108	108	0.9	20	-	-	< 5
Total Dissolved Solids mg/l	-	-	-	-	-	-	-	-	-	4360	4480	-	2.7	20	-	-	< 10
	-	-	-	-	-	-	-	-	-	7150	7200	-	0.7	20	-	-	< 10
	-	-	-	-	-	-	-	-	-	< 10	< 10	-	0.0	*	-	-	

Samples were received in good condition on 18 Sep 2019 at 1250. Temperature upon receipt at the Bismarck laboratory was 5.5°C. Samples were received on ice and evidence of cooling had begun.
All samples were properly preserved unless noted here and/or flagged on the individual analytical laboratory report. With the exception of pH, all holding times were met
Approved methodology was followed for all sample analyses.
All acceptance criteria were met for calibration, method blanks, laboratory control samples, laboratory fortified matrix/duplicates unless noted here.

- For some analytes, the reported results were elevated due to additional dilutions required to minimize the effects of sample matrix.

Reporting

- Per email from Barr, data package was rescanned to remove extraneous/not applicable QC page. In addition, QC report was modified to remove flag/comment for nitrate+nitrite since it was not part of the CCR data package.
- Per email from Terri Olson, Barr, dated 6 Nov 2019, the CCR data package was split into Appendix III and Appendix IV parameters.

Approved by: C. Carroll
11 NOV19

Claudette Carroll

From: Terri A. Olson <TOlson@barr.com>
Sent: Wednesday, November 6, 2019 12:41 PM
To: Claudette Carroll
Cc: Stephanie A. Theriault
Subject: RE: Re: MDU Heskett reports

Hi Claudette,

Regarding the 3rd bullet, we don't receive a CCR report for this one so you can take it off your list of things to do; however, we do need the other two reports split into Appendix III and Appendix IV parameters. For fluoride that is in both lists, please report with Appendix III.

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

From: Terri A. Olson
Sent: Friday, November 1, 2019 10:08 AM
To: 'ccarroll@mvtl.com' <ccarroll@mvtl.com>
Subject: Re: MDU Heskett reports

Hi Claudette,

Reviewed MDU Heskett reports and had the following questions/comments

- 201982-2611
  - MW44R in the Field Data Report has a sample date of 09/16/19 but raw field data and COC list 09/17/19 – please revise,
- 201982-2625
  - There is a QC page (page 9 of the report) that isn't applicable for CCR (includes dissolved parameters).
  - Case narrative for report has nitrate + nitrite as N comment but isn't applicable to CCR work.
- 201982-2626
  - This report is the state versions for MW1-90. Haven't see a CCR report yet?

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

resourceful. naturally. BARR

Claudette Carroll

From:	Terri A. Olson <TOlson@barr.com>
Sent:	Friday, November 1, 2019 10:08 AM
To:	Claudette Carroll
Subject:	Re: MDU Heskett reports

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  - This report is the state versions for MW1-90. Haven't see a CCR report yet?

Thank-you,

Terri A. Olson
Senior Data Quality Specialist
Minneapolis, MN office: 952.842.3578
TOlson@barr.com
www.barr.com

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	33
Sampling Personal:	Jerry Meyer

Weather Conditions: Temp: 80 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	41.59 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	42.15 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings	
Purge:	5 sec.
Recover:	55 sec.
PSI:	40

Purge Date:	17 Sept 19	Time Purging Began:	1318 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	17 Sept 19	Time of Sampling:	1513 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1323	13.71	5542	6.66	7.82	-44.0	159.0	41.96	100.0	500.0	~~Clear~~ Slightly Turbid
2	1423	12.47	5135	6.50	7.00	2.9	7.01	41.95	100.0	6000.0	Clear
3	1443	12.62	5120	6.53	7.33	4.3	5.06	42.15	100.0	2000.0	Clear
4	1503	12.54	5147	6.52	7.34	11.7	4.59	42.21	100.0	2000.0	Clear
5	1508	12.59	5131	6.51	7.46	12.1	4.42	41.92	100.0	500.0	Clear
6	1513	13.01	5128	6.51	7.57	13.5	4.38	42.05	100.0	500.0	Clear
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 11,500.0 mL

Comments:
17Sept17 1315 pump was not operating when attempted to initiate purge. removed pump & freed up check balls. Pump is opperational

MVTL

2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company: MDU Heskett
Event: Fall 2019
Sample ID: 3-90
Sampling Personal: Jerry Meyer

Weather Conditions: Temp: 60 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	18.46	ft	
Depth to Top of Pump:	—	ft	
Water Level After Sample:	18.60	ft	
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	Dup 2	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	18 Sept 19	Time Purging Began:	0825 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	18 Sept 19	Time of Sampling:	0855 am/pm

Bottle List: 1L Raw | 500mL Nitric | 500mL Nitric (filtered) | 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
			±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
SEQ #	Time										
1	0830	9.85	4548	6.87	5.34	-20.1	3.70	18.68	100.0	500.0	Clear
2	0840	9.38	4494	6.91	5.69	-28.1	1.44	18.61	100.0	1000.0	Clear
3	0845	9.57	4481	6.92	7.39	-18.7	1.81	18.58	100.0	500.0	Clear
4	0850	9.47	4478	6.92	6.98	-11.8	1.76	18.65	100.0	500.0	Clear
5	0855	9.43	4473	6.92	6.77	-4.9	1.78	18.61	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 3000.0 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	2-90
Sampling Personal:	Jerry Meyer

Weather Conditions: Temp: 70 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	21.30 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	21.73 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	18 Sept 19	Time Purging Began:	0931 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	18 Sept 19	Time of Sampling:	0956 am/pm

Bottle List: 1L Raw, 500mL Nitric, 500mL Nitric (filtered), 250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	0936	12.34	7044	7.05	10.10	80.0	0.83	21.60	100.0	500.0	Clear
2	0941	11.47	7094	6.98	7.63	101.7	0.90	21.72	100.0	500.0	Clear
3	0946	12.42	7036	6.99	7.35	108.7	1.10	21.64	100.0	500.0	Clear
4	0951	11.74	7064	6.98	7.05	115.2	1.04	21.70	100.0	500.0	Clear
5	0956	12.49	7006	6.99	6.96	120.0	0.98	21.64	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 2500.0 mL

Comments:

Field Datasheet

Groundwater Assessment

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	104
Sampling Personal:	[signature]

Weather Conditions: Temp: 70°F Wind: N @ 5-10 Precip: **Sunny / Partly Cloudy / Cloudy** (Partly Cloudy circled)

Well Information

Well Locked?	Yes	No (circled)	
Well Labeled?	Yes (circled)	No	
Casing Straight?	Yes (circled)	No	
Grout Seal Intact?	Yes (circled)	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	13.78 ft		
Depth to Top of Pump:	— ft		
Water Level After Sample:	14.06 ft		
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes (circled)	No
Duplicate Sample?:	Yes	No (circled)
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	18 Sept 19	Time Purging Began:	1116 am/pm (am circled)
Well Purged Dry?	Yes / No (No circled)	Time Purged Dry:	— am/pm
Sample Date:	18 Sept 19	Time of Sampling:	1146 am/pm (am circled)

Bottle List: 1L Raw, 500mL Nitric, 500mL Nitric (filtered), 250mL Sulfuric

Field Measurements

SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. (Clear, Slightly Turbid, Turbid)
1	1121	15.06	13977	7.02	6.29	133.7	2.55	14.08	100.0	500.0	Clear
2	1126	13.71	14027	6.96	5.64	141.7	2.19	14.15	100.0	500.0	Clear
3	1131	14.14	14043	6.95	5.08	144.6	1.63	14.05	100.0	500.0	Clear
4	1136	13.67	14021	6.95	4.70	148.3	0.77	14.06	100.0	500.0	Clear
5	1141	14.35	14044	6.94	4.98	151.8	0.85	14.04	100.0	500.0	Clear
6	1146	13.77	14025	6.97	5.05	153.1	0.89	14.05	100.0	500.0	Clear
7											
8											
9											
10											

Stabilized: Yes (circled) No

Total Volume Removed: 3000.0 mL

Comments:

MVTL

2616 E. Broadway Ave, Bismarck, ND

Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	BOR
Sampling Personal:	Jerry Hagen

Weather Conditions: Temp: 75°F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	14.35	ft	
Depth to Top of Pump:	—	ft	
Water Level After Sample:	14.62	ft	
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	17 Sept 19	Time Purging Began:	1145 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	17 Sept 19	Time of Sampling:	1235 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive)		Temp (°C)	Spec. Cond.	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Water Level (ft)	Pumping Rate	mL Removed	Description: Clarity, Color, Odor, Ect.
SEQ #	Time		±5%	±0.1	±10%	±20 mV	±10%	0.25 ft	ml/min		Clear, Slightly Turbid, Turbid
1	1150	13.58	5760	7.04	6.01	161.0	2.27	14.51	100.0	500.0	Clear
2	1220	13.41	5704	6.97	6.59	154.4	1.11	14.63	100.0	3000.0	Clear
3	1225	13.25	5724	7.00	6.72	153.7	1.17	14.65	100.0	500.0	Clear
4	1230	13.69	5714	7.00	6.88	153.2	1.25	14.61	100.0	500.0	Clear
5	1235	13.09	5723	7.00	6.97	153.1	1.09	14.61	100.0	500.0	Clear
6											
7											
8											
9											
10											

Stabilized: Yes No

Total Volume Removed: 5000.0 mL

Comments:

MVTL
2616 E. Broadway Ave, Bismarck, ND
Phone: (701) 258-9720

Field Datasheet

Groundwater Assessment

Company:	MDU Heskett
Event:	Fall 2019
Sample ID:	105
Sampling Personal:	Jerry [signature]

Weather Conditions: Temp: 70 °F Wind: N @ 5-10 Precip: Sunny / Partly Cloudy / Cloudy

Well Information

Well Locked?	Yes	No	
Well Labeled?	Yes	No	
Casing Straight?	Yes	No	
Grout Seal Intact?	Yes	No	Not Visible
Repairs Necessary:			
Casing Diameter:	2"		
Water Level Before Purge:	12.62	ft	
Depth to Top of Pump:	—	ft	
Water Level After Sample:	12.94	ft	
Measurement Method:	Electric Water Level Indicator		

Sampling Information

Purging Method:	Bladder	
Sampling Method:	Bladder	
Dedicated Equip?:	Yes	No
Duplicate Sample?:	Yes	No
Duplicate Sample ID:	—	

Control Settings		
Purge:	5	sec.
Recover:	55	sec.
PSI:	20	

Purge Date:	17Sept19	Time Purging Began:	1001 am/pm
Well Purged Dry?	Yes No	Time Purged Dry:	— am/pm
Sample Date:	17Sept19	Time of Sampling:	1121 am/pm

Bottle List:	1L Raw	500mL Nitric	500mL Nitric (filtered)	250mL Sulfuric

Field Measurements

Stabilization (3 consecutive) SEQ #	Time	Temp (°C)	Spec. Cond. ±5%	pH ±0.1	DO (mg/L) ±10%	ORP (mV) ±20 mV	Turbidity (NTU) ±10%	Water Level (ft) 0.25 ft	Pumping Rate ml/min	mL Removed	Description: Clarity, Color, Odor, Ect. Clear, Slightly Turbid, Turbid
1	1006	12.82	3834	6.85	7.79	144.3	5.07	12.82	100.0	500.0	Clear
2	1036	11.87	5612	6.77	4.85	130.2	2.24	12.90	100.0	3000.0	Clear
3	1046	11.88	6131	6.75	4.99	133.7	2.63	13.00	100.0	1000.0	Clear
4	1056	12.40	6399	6.72	5.84	133.4	2.57	12.82	100.0	1000.0	Clear
5	1106	12.22	6659	6.72	5.98	136.3	2.55	12.91	100.0	1000.0	Clear
6	1111	12.42	6820	6.71	6.17	137.8	2.36	12.84	100.0	500.0	Clear
7	1116	12.12	6865	6.71	6.54	138.1	2.49	12.92	100.0	500.0	Clear
8	1121	12.47	6913	6.70	6.32	138.1	2.32	12.90	100.0	500.0	Clear
9											
10											

Stabilized: Yes No

Total Volume Removed: 8000.0 mL

Comments:

MVTL Laboratories, Inc.
2616 E. Broadway
Bismarck, ND 58501
Phone (701) 258-9720

Chain of Custody Record

Project Name: MDU Heskett	Event: Fall 2019	Work Order Number: 82- 2625
Report To: MDU Attn: Abbie Krebsbach Address: 400 N. 4th St. Bismarck, ND 58501 phone: 701-222-7844 email:	Carbon Copy: Attn: Address:	Name of Sampler(s): Jeremy Moyer

Sample Information — **Bottle Type** — **Field Parameters** — **Analysis**

Lab Number	Sample ID	Date	Time	Sample Type		1 liter	500mL Nitric	500mL Nitric (filtered)	250 mL Sulfuric				Temp (°C)	Spec. Cond.	pH	Analysis Required
W3743	33	17Sept19	1513	GW		X	X	X	X				13.01	5128	6.51	MDU List AA & List C MDU
W3744	3-90	18 Sept19	0855	GW		X	X	X	X				9.43	4473	6.92	
W3745	Dup2	18 Sept19	—	GW		X	X	X	X				—	—	—	
W3746	2-90	18 Sept19	0956	GW		X	X	X	X				12.49	7006	6.99	
W3747	104	18Sept19	1146	GW		X	X	X	X				13.77	14025	6.97	
W3748	80R	17Sept19	1235	GW		X	X	X	X				13.09	5723	7.00	
W3749	105	17Sept19	1121	GW		X	X	X	X				12.47	6913	6.70	
W3750	FB2	18 Sept19	—	GW		X	X	X	X				—	—	—	

Comments:

JB 18Sept19

Relinquished By: Name:	Date/Time	Sample Condition: Location:	Temp (°C)
1 [signature]	18Sept19 1250	~~Log In~~ Walk In #2	~~Rot~~ 5.5 TM562 / TM588
2			

Received by: Name:	Date/Time
[signature]	18 Sept 2019 1250

Appendix B

Alternative Source Demonstration Reports

Alternative Source Demonstration: October 2018 Event

R.M. Heskett Station

Prepared for
Montana-Dakota Utilities Co.

April 2019

Alternative Source Demonstration: October 2018 Event

R.M. Heskett Station

Prepared for
Montana-Dakota Utilities Co.

April 2019

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Alternative Source Demonstration
October 2018 Event

April 2019

Contents

List of Tables

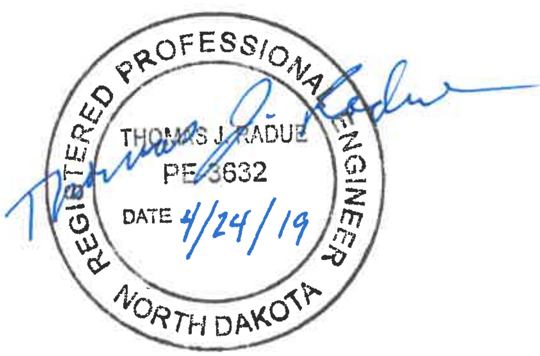
List of Figures

List of Appendices

Certifications

I hereby certify that I, or my agent, have examined this written demonstration and attest that this Coal Combustion Residuals Facility Alternative Source Demonstration (ASD) is accurate and has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and the requirements of 40 CFR §257.94. I further certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of North Dakota.

Revision	Date	Summary of Revisions
0	April 24, 2019	Initial Alternative Source Demonstration



Thomas J. Radue, P.E.
Barr Engineering Co.
ND Registration Number PE – 3632

1.0 Introduction

Montana-Dakota Utilities Co. (MDU) owns and operates R.M. Heskett Station (Site), a coal-fired generating station and a gas-fired turbine located in Mandan, North Dakota (Figure 1). One CCR (coal combustion residual) unit, as defined by 40 CFR 257.53, is located on the property. The CCR unit contains coal combustion by-products, asbestos wastes generated from construction activity associated with MDU-owned facilities, and ash derived from burning of tire-derived fuel (TDF) at the facility.

The CCR Rule (US EPA, 2015) §257.94(e)(2) allows for an alternative source demonstration (ASD) in the event of an identified statistically significant increase (SSI) in a water quality parameter in a downgradient monitoring well over background levels:

The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report.

The purpose of this work is to evaluate the data collected as part of the October 2018 monitoring event, along with historical data, to demonstrate if the proposed SSIs are the results of a “source other than the CCR unit” or due to natural variation in groundwater quality, an error in sampling, analysis, or statistical evaluation.

2.0 October 2018 SSIs

Sampling for the second detection monitoring event in 2018 was conducted on October 1-4, 2018. Four potential SSIs over background were identified: chloride at MW-105, sulfate and total dissolved solids (TDS) at MW-104, and fluoride at MW-2-90.

Several characteristics of the CCR unit site geology, groundwater monitoring well locations, and historic groundwater quality data prompted consideration of potential alternative sources for the potential SSIs, including:

- Elevated water quality parameters in pre-landfill groundwater monitoring data; and
- Site-specific geologic conditions.

Three methods of evaluation were subsequently undertaken in an effort to review potential alternative sources for the SSIs. These include the following evaluations:

- Comparison with leaching tests of on-site CCR materials;
- Comparison with groundwater quality collected at the site prior to construction of the CCR unit; and
- Comparison with regional (background) groundwater quality data.

A successful alternative source demonstration is discussed in Section 3.0.

3.0 Alternative Source Demonstration

Methods used to evaluate potential alternative sources as the basis for water quality parameter concentrations over background from the October 2018 detection monitoring event are discussed below. Concentrations for potential SSIs observed in October 2018 are similar to those observed in prior detection monitoring events (Table 1).

Table 1. Detection Monitoring Results for Potential SSI Well-Parameter Pairs

Well	Parameter	Interwell Prediction Limit (mg/L)	Detection Monitoring Results		
			October 2017 (mg/L)	April 2018 (mg/L)	October 2018 (mg/L)
MW-105	Chloride	271	**346**	**333**	**384**
MW-104	Sulfate	6,770	**10,200**	**10,700**	**11,000**
MW-104	Total Dissolved Solids	9,970	**15,400**	**17,400**	**18,000**
MW-2-90	Fluoride	0.93	0.93	**1.03**	**1.00**

Bolded values indicate concentrations exceed the associated interwell predication limits.

Successful demonstrations of alternative sources have previously been documented for the four potential SSIs. The associated ASD Reports (Barr, 2018a and Barr, 2018b) documented that each of the SSIs could be explained by natural groundwater quality variability based on concentrations that were either present at the Site before the landfill was constructed and/or consistent with regional groundwater quality data. The purpose of this ASD Report is to validate the results of prior findings with the October 2018 data. For each potential SSI, two hypotheses regarding the potential source of the SSI are assessed: 1) a release of leachate from the CCR unit is the source of one or more of the potential SSIs or 2) natural variations of pre-landfill or regional groundwater quality is the source of one or more of the potential SSIs.

3.1 Source Hypothesis #1: CCR Unit Release

To accept the hypothesis that a release of leachate from the CCR unit is the source of one or more of the potential SSIs, it would be assumed that groundwater chemistry at one or more of the potentially impacted wells (MW-2-90, MW-104, and MW-105) would be geochemically similar to that of impacted water from the CCR unit. However, if they are geochemically dissimilar, this indicates that a source “other than the CCR unit” is responsible for the potential SSI. Therefore, major ion chemistry from the CCR monitoring locations (upgradient and downgradient) were compared to CCR ash Synthetic Precipitation Leaching Procedure (SPLP method; EPA Method 1312) data collected July 2011 (Appendix A).

In order to test this hypothesis, Piper diagrams were used to visually compare the CCR SPLP results (Appendix A) and the measured groundwater quality at the Site (Figure 2). Piper diagrams are plots of major ion chemistry of water samples (calcium, magnesium, potassium, sodium, chloride, sulfate, and alkalinity) that are used to differentiate between water types and to identify potential mixing of water types. This method is a means to identify or “fingerprint” water samples by their common characteristics (major ions) to assess which types of water are similar or dissimilar to potential source water types (Hensel and Hirsch, 2002).

Downgradient water quality (including the potential SSI parameter-well pairs) is characterized as a Ca/Mg-SO_4 type water, whereas the ash SPLP results are Na-SO_4 type water. The major difference observed between the downgradient water quality and the SPLP results is the dominant cation concentration (calcium and magnesium vs. sodium). Because water quality data from SSI well-parameter pairs are clustered within the upgradient wells rather than near the SPLP results, it indicates that the water chemistry at those locations are more similar to upgradient groundwater than a potential release from the CCR unit. **Therefore, we reject the hypothesis that the CCR unit is the source of the fluoride observed at MW-2-90, sulfate and TDS observed at MW-104, and chloride at MW-105.**

3.2 Source Hypothesis #2: Natural Variations of Pre-Landfill or Regional Groundwater Quality

Since Source Hypothesis #1 (CCR Unit Release) was rejected as a potential source of the SSIs, natural variations of pre-landfill conditions and/or regional groundwater quality were evaluated for each of the potential SSIs.

The second hypothesis evaluated is that concentrations of fluoride at MW-2-90, sulfate and TDS at MW-104, and chloride at MW-105 are consistent with historical (pre-landfill) or regional (background) groundwater data. To test this hypothesis, results of October 2018 Detection Monitoring were compared to pre-landfill data and/or regional groundwater quality data from the Cannonball Formation and associated units to determine if natural variation is a potential alternative source for the SSIs.

3.2.1 Chloride at MW-105

Groundwater samples collected in 1986 (prior to construction of the CCR unit; an aerial photograph from March 30, 1988 shows the area of the CCR unit, which appears to be undisturbed (Appendix B)) were included in the 1989 Special Use Disposal Site Permit Application (Permit Application; MDU, 1989; Appendix C). Pre-landfill chloride concentrations collected from groundwater at the Site were measured as high as 558 mg/L (Well 44, 1986), indicating that high chloride concentrations pre-date construction of the CCR unit. Additionally, the North Dakota State Water Commission conducted a groundwater study in Morton County (Ackerman, 1980); 45 wells screened in the Cannonball and Ludlow Formations were sampled for various parameters including chloride. Chloride concentrations ranged from 0 to 500 mg/L (37% of which had concentrations greater than 250 mg/L).

Historic data shows that concentrations of chloride in groundwater at the site measured prior to the construction of the CCR unit (558 mg/L) as well as regional groundwater quality data (0-500 mg/L) are consistent with and/or higher than chloride measured at MW-105 in October 2018 (384 mg/L). This supports the hypothesis that the SSI for chloride at MW-105 is due to a "source other than the CCR unit." **Therefore, we accept the hypothesis that chloride concentrations observed at MW-105 are consistent with regional (background) groundwater data.**

3.2.2 Sulfate and TDS at MW-104

Analyses of groundwater samples collected prior to construction of the CCR unit included in the Permit Application (Appendix C) notes that high sulfate and TDS was observed at the Site. Maximum sulfate and

TDS concentrations reported in 1986 were 11,632 mg/L and 14,917 mg/L, respectively, in Well 60 (approximately 700 feet southwest of MW-104), with similar concentrations observed two years later. Sulfate and TDS concentrations reported in October 2018 (11,000 mg/L and 18,000 mg/L, respectively,) at MW-104 are within range of historically observed concentrations. A trend analysis was conducted on sulfate and TDS concentrations at MW-104 (Figures 3 and 4, respectively) and no statistically significant increasing trend was observed. Figures 5 and 6 show the range of sulfate and TDS concentrations, respectively, across the Site, including recent and historical monitoring well data.

The mineralogy of the underlying geology may yield an explanation for the elevated sulfate concentrations (which leads to elevated TDS concentrations). The dominant lithology observed at the Site is unconsolidated silt in a clay matrix with interspersed fine to medium-grained sand (10% to 30%). Small gypsum crystals are documented discontinuously throughout the upper 30 feet of the surface materials, which have been presumed to be the result of diagenetic processes which occur above the water table during alternating wetting and drying cycles (Groenewold et al, 1983). Gypsum is a hydrated calcium sulfate mineral that can be a source of high sulfate concentrations in groundwater. Dissolution of gypsum will occur until equilibrium concentrations are attained in the groundwater or until all the minerals are consumed.

The boring log for MW-104 (Appendix C) notes gypsum present throughout the upper layer of the screened interval. Boring logs for other CCR wells and pre-landfill wells note gypsum occurrences across the Site (Appendix C (Exhibit 5-E) and Appendix D). The water level and screened interval in MW-104 are within the gypsum-bearing unit. In other wells with lower sulfate and TDS concentrations, the water levels and/or screened units are below the documented gypsum occurrences. As groundwater fluctuates and surface water infiltration occurs, periodic dissolution of gypsum into the water column may occur, resulting in elevated sulfate concentrations (and therefore elevated TDS, too).

Based on presence of gypsum in native subsurface deposits and documentation of elevated sulfate and TDS in pre-landfill groundwater, the hypothesis that the SSI for sulfate and TDS at MW-104 is due to a "source other than the CCR unit." is supported. **Therefore, we accept the hypothesis that for SSIs of sulfate and TDS at MW-104 are consistent with regional (background) groundwater data.**

3.2.3 Fluoride at MW2-90

This hypothesis was tested by comparing fluoride concentrations collected as part of several regional groundwater quality studies on the Cannonball Formation and associated units. A summary of the range of fluoride concentrations in the Cannonball Formation and associated units are included in the table below.

Table 2. Fluoride Concentrations in Morton County, North Dakota

Reference	Fluoride Conc. Range	Formation/Units	Data Source Location
Ackerman, D.J., 1980. Ground-Water Resources of Morton County, North Dakota. North Dakota Geological Survey Bulletin 72, Part III. 51 p.	0.0 to 4.0 mg/L	Cannonball and Ludlow formations, undifferentiated	Morton County
Crosby, O.A. and Klausing, R.L., 1984. Hydrology of Area 47, Northern Great Plains and Rocky Mountain Coal Provinces, North Dakota, South Dakota, and Montana. USGS Water-Resources Investigations Open-File Report 83-221, 93 p.	0.1 to 6.3 mg/L	Entire Fort Union Formation (includes Cannonball Formation)	Morton County

The Ackerman study provides summary statistics for the fluoride concentrations observed in Morton County. Forty-six samples were analyzed for fluoride; of those, 20 (or 43%) had concentrations greater than 1.3 mg/L (Ackerman, 1980). The fluoride concentrations observed at MW-2-90 are within the range of values consistent with naturally-occurring concentrations of fluoride associated with the Cannonball Formation in Morton County. **Therefore, we accept the hypothesis that fluoride concentrations observed at MW-2-90 are consistent with regional (background) groundwater data.**

4.0 Conclusions

Four SSIs were identified from the October 2018 detection monitoring event. This report demonstrates that a “source other than the CCR unit” caused the potential SSIs (natural variation in regional and/or pre-landfill groundwater quality), as allowed by §257.94(e)(2). The results of this alternative source demonstration are summarized in the table below.

Table 3. Summary of SSIs and Alternative Sources

Well	Parameter	Report Section	Evidence for Alternative Source
MW-105	Chloride	3.2.1	Natural variability (pre-landfill values and geologic background)
MW-104	Sulfate	3.2.2	Natural variability (pre-landfill values and geologic background)
MW-104	Total Dissolved Solids	3.2.2	Natural variability (pre-landfill values and geologic background)
MW-2-90	Fluoride	3.2.3	Natural variability (pre-landfill values and geologic background)

Based on the foregoing, the alternative source demonstration presented herein meets the requirements of CCR Rule §257.94(e)(2).

5.0 References

Ackerman, D.J., 1980. Ground-Water Resources of Morton County, North Dakota. North Dakota Geological Survey Bulletin 72, Part III. 51 p.

Barr Engineering Co., 2018a. Alternative Source Demonstration: October 2017 Event. R.M. Heskett Station. Prepared for Montana-Dakota Utilities Co. April 2018.

Barr Engineering Co., 2018b. Alternative Source Demonstration: April 2018 Event. R.M. Heskett Station. Prepared for Montana-Dakota Utilities Co. December 2018.

Crosby, O.A. and Klausing, R.L., 1984. Hydrology of Area 47, Northern Great Plains and Rocky Mountain Coal Provinces, North Dakota, South Dakota, and Montana. USGS Water-Resources Investigations Open-File Report 83-221, 93 p.

Groenewold, G.H., Koob, G.J., McCarthy, B.W., and Peterson, W.M., 1983, Geologic and Geochemical Controls on the Chemical Evolution of Subsurface Water in Undisturbed and Surface-Mined Landscapes on Western North Dakota, North Dakota Geological Survey Report of Investigation 79, 151 p.

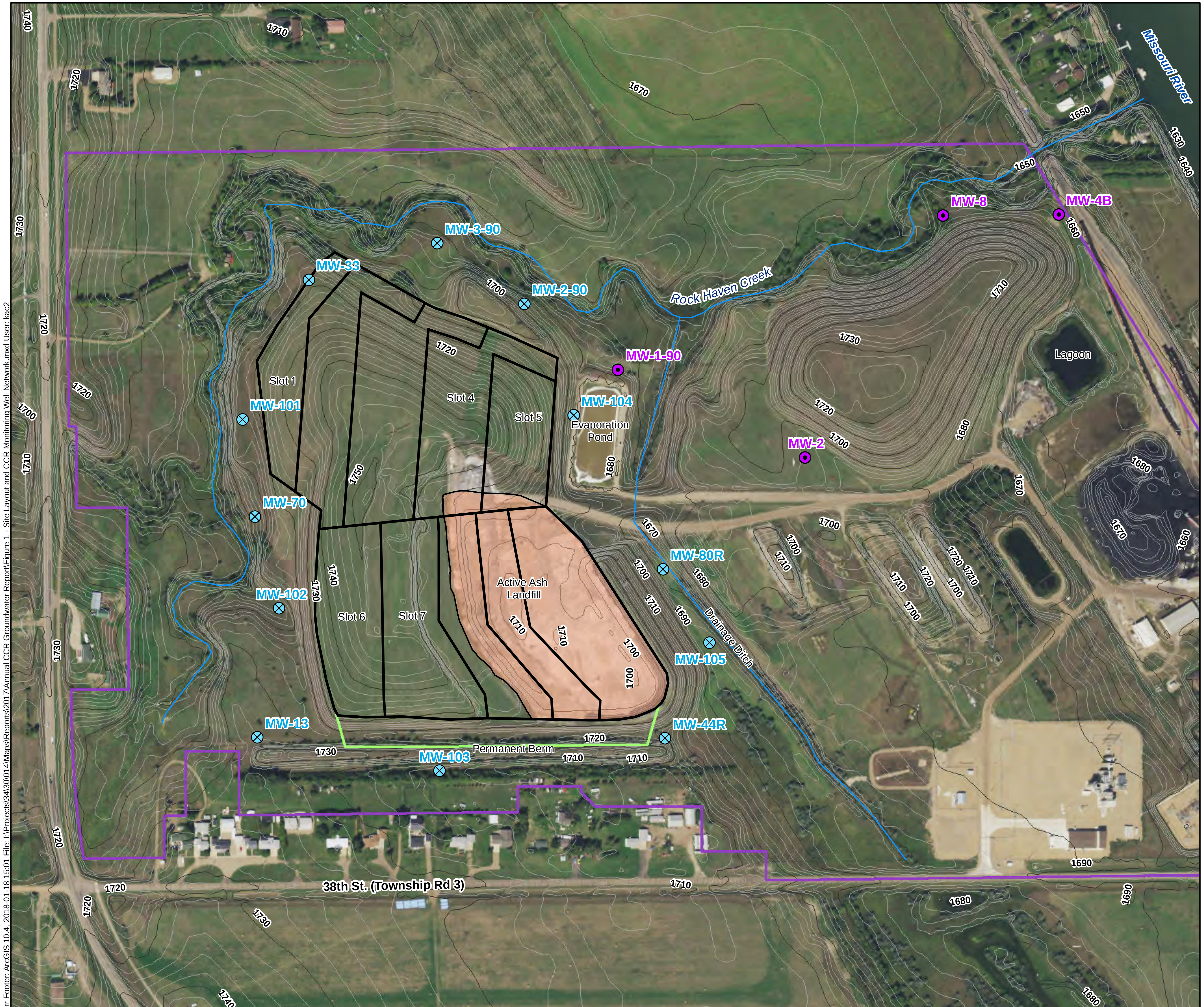
Hensel, D.R. and R. M. Hirsch, 2002. Statistical Methods in Water Resources Techniques of Water Resources Investigations, Book 4, chapter A3. U.S. Geological Survey. 522 pages.

Lindholm, R., 1983. Bivalve Associations of Cannonball Formation (Paleocene, Danian) of North Dakota. AAPG Bulletin, Volume 67, Issue 8, P1347. Meeting abstract available at: http://archives.datapages.com/data/bulletns/1982-83/data/pg/0067/0008/1300/1347a.htm

Montana-Dakota Utilities Co. (MDU), 1989, R.M. Heskett Station Special Use Disposal Site Permit Application. Submitted to North Dakota State Department of Health, March 1, 1989.

US EPA, 2015, Hazardous and Solid Waste Management Systems; Management of Coal Combustion Residuals From Electric Utility, CFR Parts 257 and 261 , Federal Register, Vol. 80, No. 74, April 17, 2015.

Figures



Monitoring Well Location

Monitoring Well Location - Water Level Only

Existing Slot Boundaries

Streams

Property Line

Future Landfill Boundary

10ft Contours

2ft Contours

Active Portion of Landfill

Image Source: 2017 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg

N

Feet

350 0 350

BARR

Figure 1

SITE LAYOUT AND CCR MONITORING WELL NETWORK
R. M. Heskett Station

Montana Dakota Utilities
Mandan, North Dakota

Piper Diagram

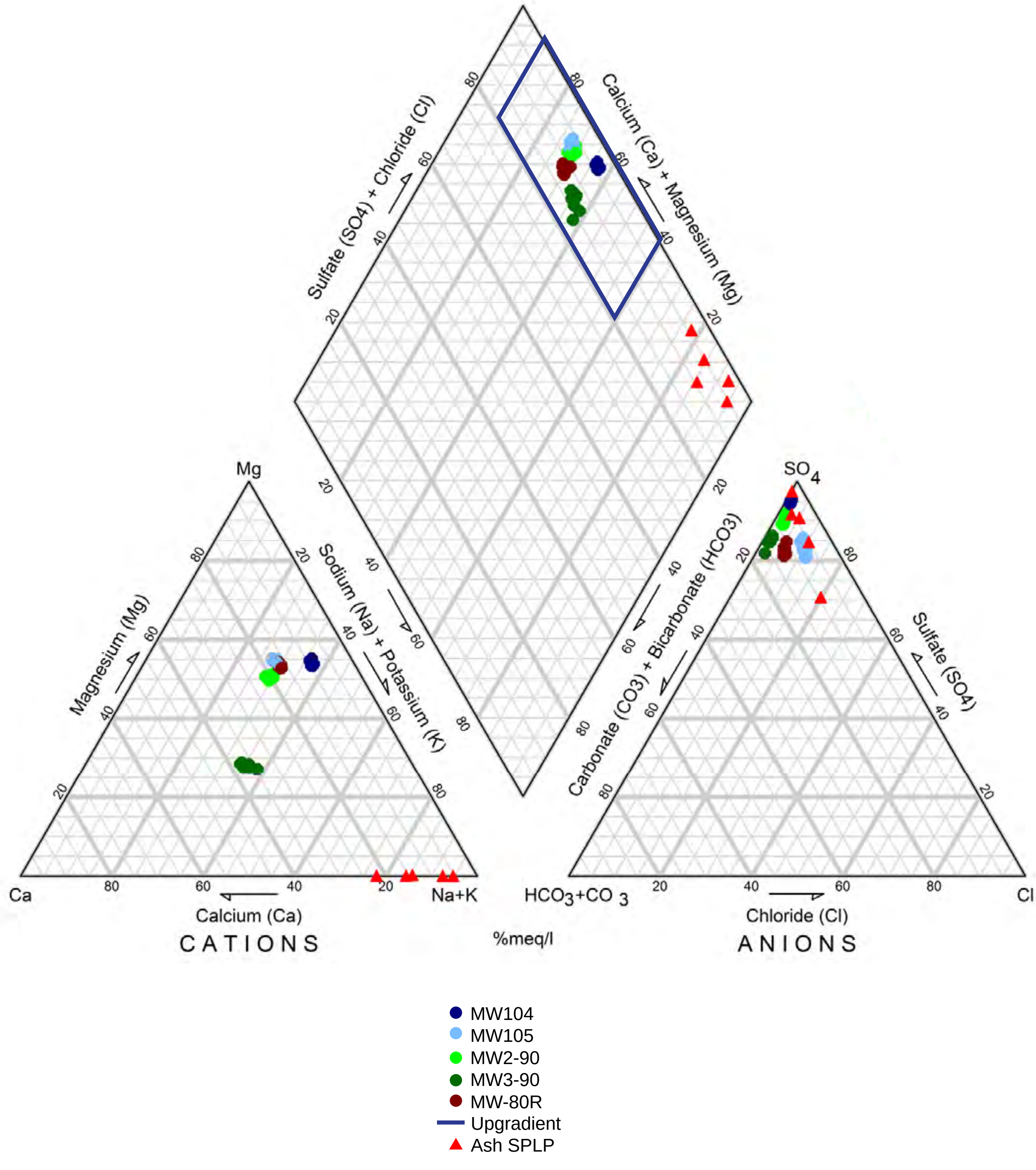
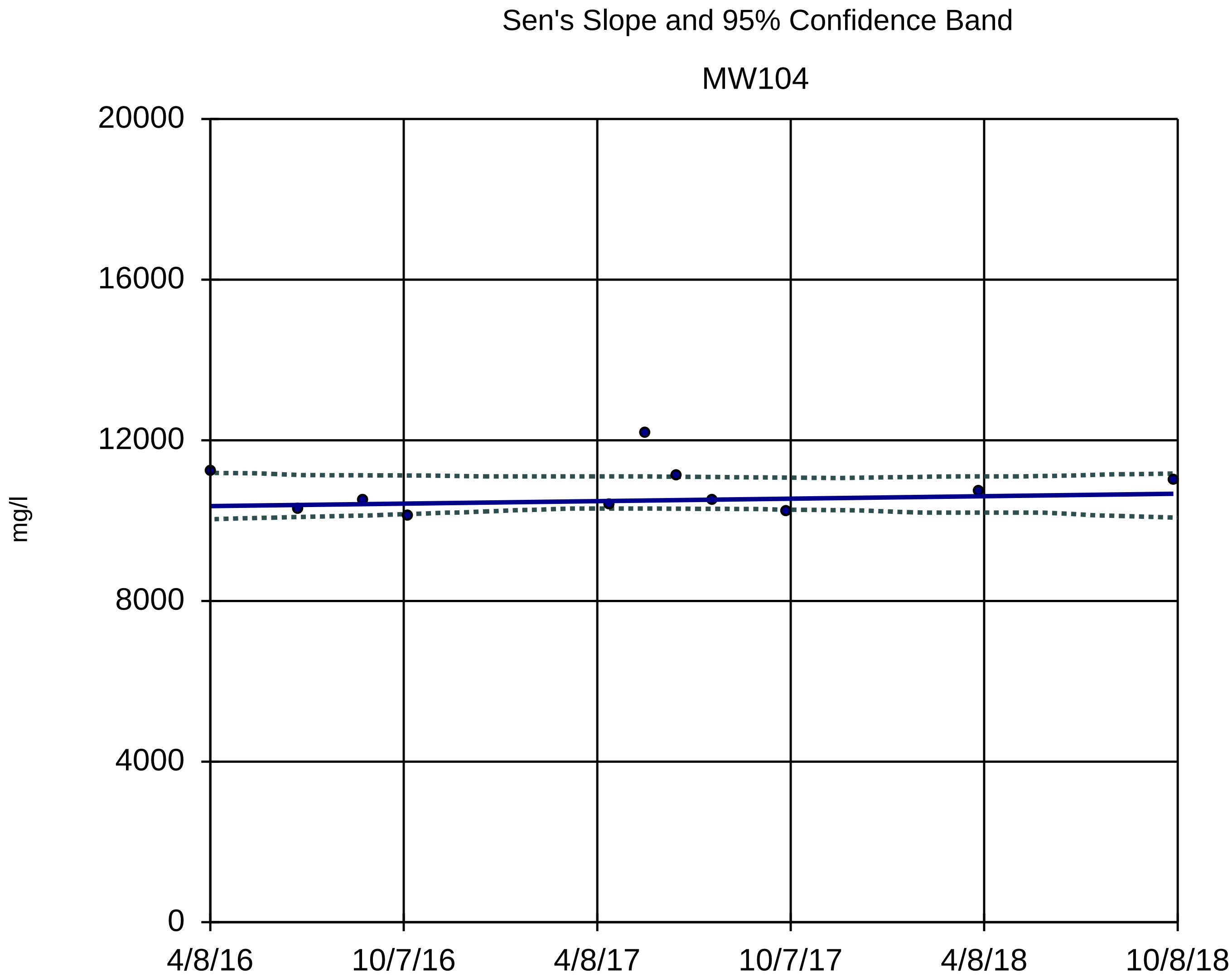


Figure 2

PIPER PLOT
R.M. Heskett Station
Alternative Source Demonstration
October 2018 Event
Montana Dakota Utilities
Mandan, North Dakota

Sanitas™ v.9.6.12 Sanitas software licensed to Montana-Dakota Utilities Co. UG



n = 11

Slope = 123.7
units per year.

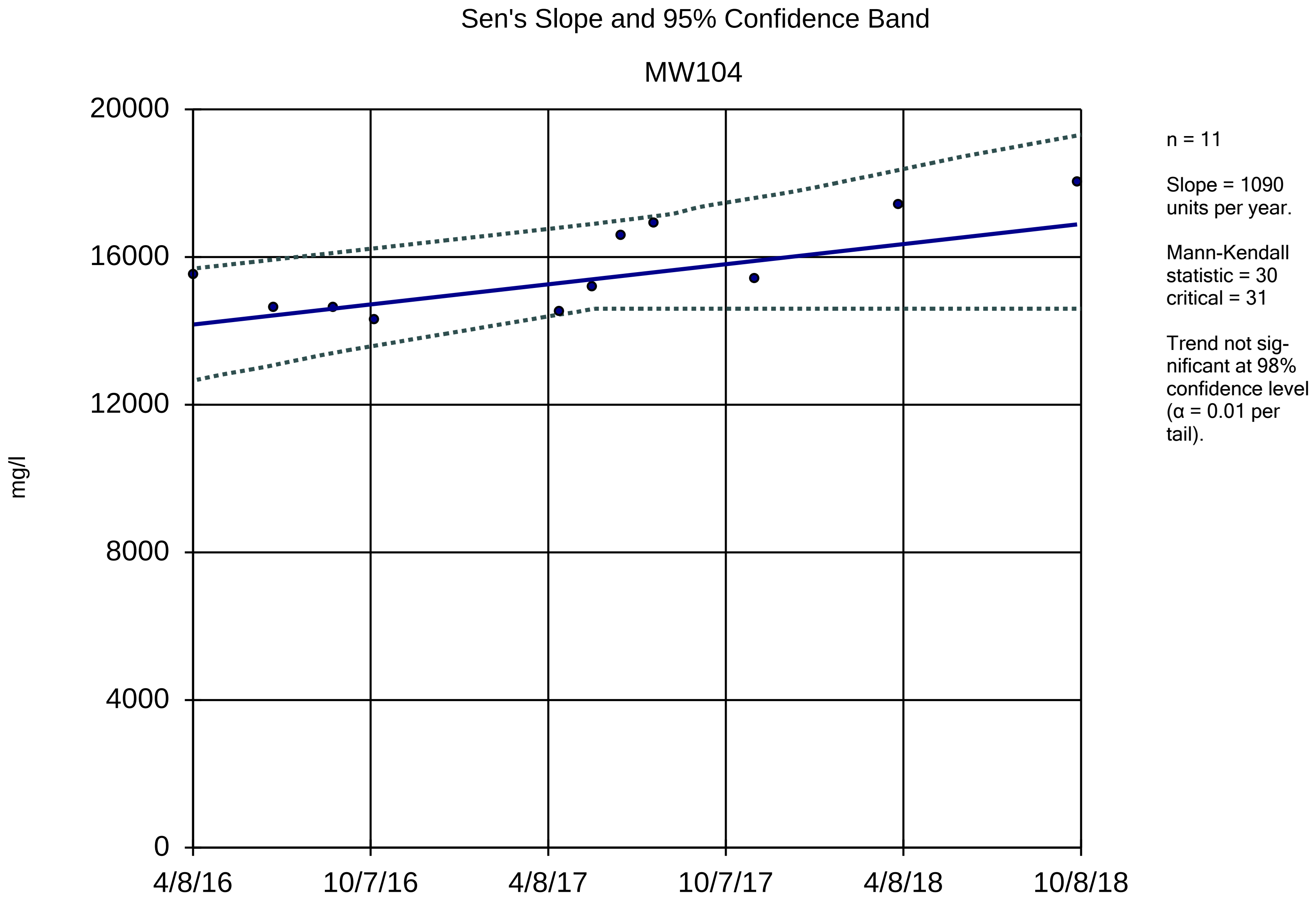
Mann-Kendall
statistic = 4
critical = 31

Trend not sig-
nificant at 98%
confidence level
(α = 0.01 per
tail).

Constituent: Sulfate, as SO4 Analysis Run 4/15/2019 2:25 PM

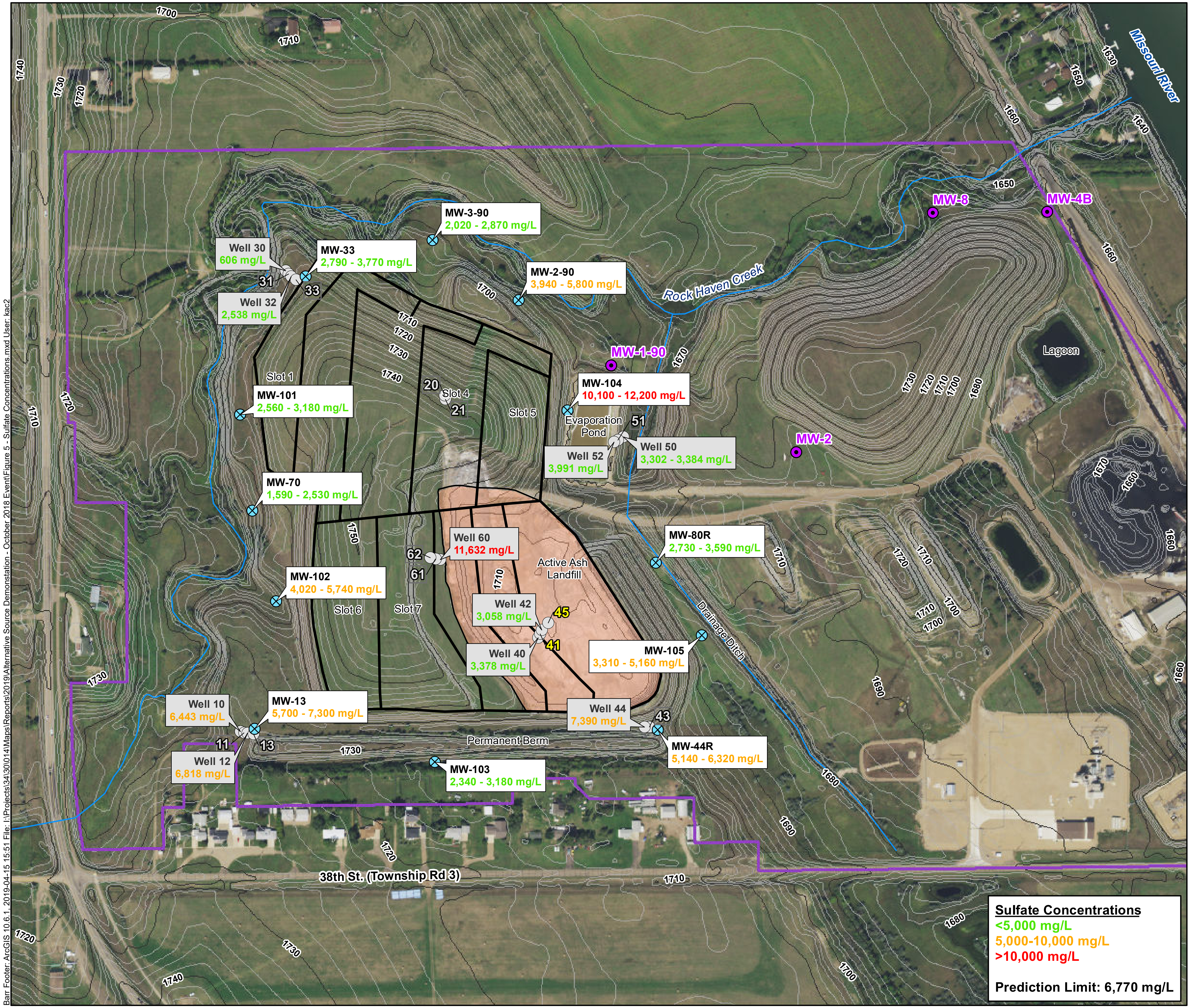
Heskett Station Client: Barr Engineering Company Data: Heskett_SanitasAppIII_Oct2018

Sanitas™ v.9.6.12 Sanitas software licensed to Montana-Dakota Utilities Co. UG



Constituent: Solids, total dissolved Analysis Run 4/15/2019 2:25 PM

Heskett Station Client: Barr Engineering Company Data: Heskett_SanitasAppIII_Oct2018



- Monitoring Well Location
- Monitoring Well Location - Water Level Only
- Pre-Landfill Wells (Approximate)
- Existing Slot Boundaries
- Streams
- Property Line
- 10ft Contours
- 2ft Contours
- Active Portion of Landfill

Image Source: 2017 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg
Pre-Landfill well concentrations are from 9/11/1986, 11/21/1986 (MDU, 1989), and CCR Rule monitoring well concentrations are from 2016-2018.

N

Feet
350 0 350

BARR

Figure 5

SULFATE CONCENTRATIONS
R. M. Heskett Station
Alternative Source Demonstration:
October 2018 Event
Montana Dakota Utilities
Mandan, North Dakota

Barr Footer: ArcGIS 10.6.1, 2019-04-15 15:51 File: I:\Projects\34\30\014\Maps\Reports\2019\Alternative Source Demonstration - October 2018 Event\Figure 5 - Sulfate Concentrations.mxd User: kac2

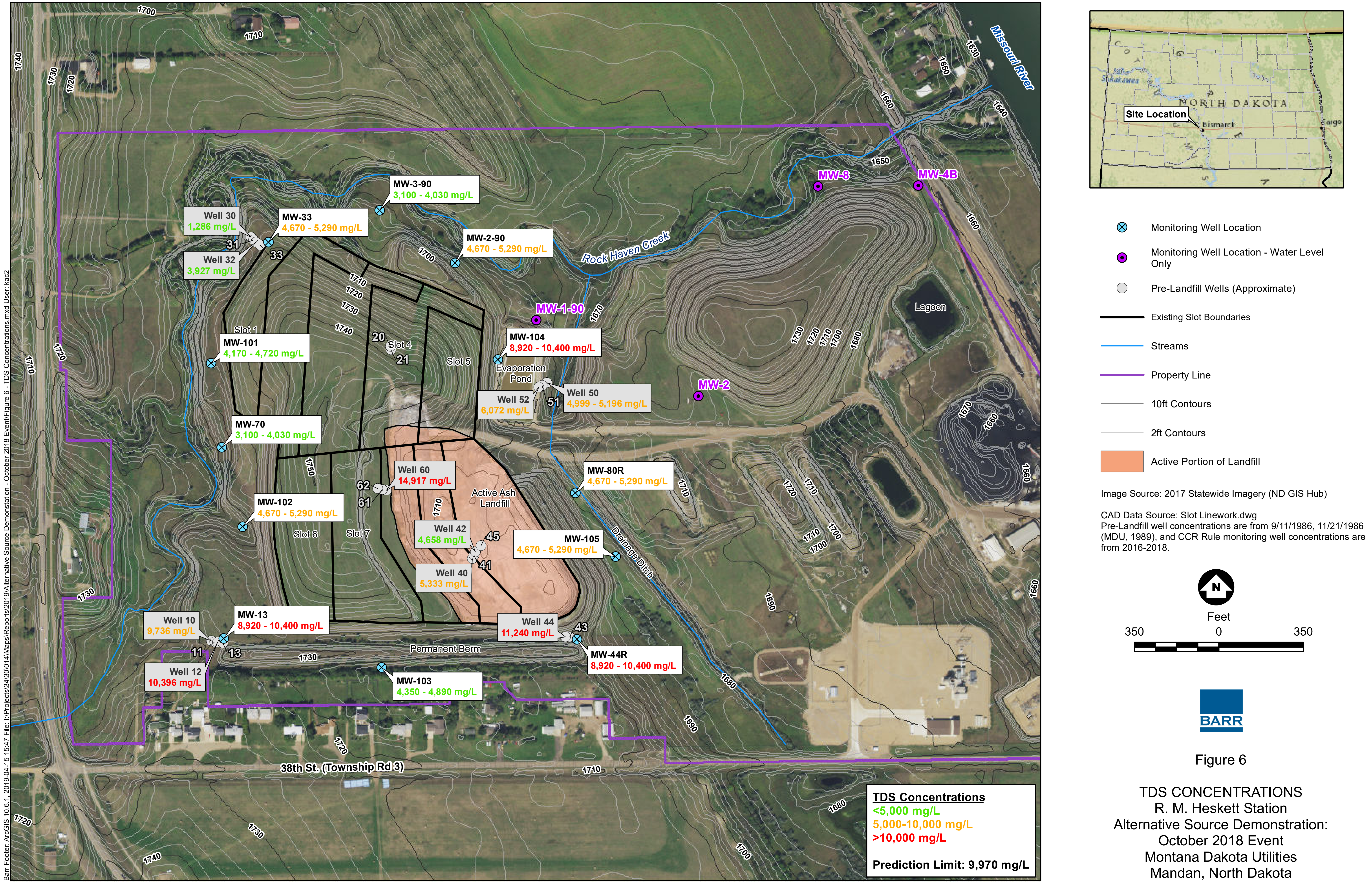


Figure 6

TDS CONCENTRATIONS
R. M. Heskett Station
Alternative Source Demonstration:
October 2018 Event
Montana Dakota Utilities
Mandan, North Dakota

Appendix A

Ash SPLP Laboratory Report (2011)

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

Report Date: 8 Sep 11
Lab Number: 11-M2450
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Bottom Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.2	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	8778	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	3	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	1120	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	1090	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	60	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	1060	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	4860	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	524	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	30.7	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	74.3	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	74.6	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	-0.24	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	27.1		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	0.7	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	2440	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	50.5	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.21	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	0.32	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	< 5	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	210	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 2.5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	1440	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	44.8	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	28.2	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	< 0.5	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2450
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Bottom Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.0044	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.1135	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00164	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0065	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.0213	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0027	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.6860	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0074	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.0133	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.0189	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.0151	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Zander

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity

\# = Due to sample concentration
\+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2451
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Sand Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	11.1	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	20110	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	21	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	203	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	171	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	64	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	139	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	22500	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1200	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	70.2	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	318	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	314	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	0.65	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	80.9		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	See Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	< 0.5	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	14900	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	2.0	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	< 0.1	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	0.10	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	< 5	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	481	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	6500	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	459	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	1.09	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 1	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	66.0	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 1	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	5.96	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2451
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Sand Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.0822	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.0930	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00182	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0244	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.1108	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0052	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.1000	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0136	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.0937	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.3026	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.0327	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Zander

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
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MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2452
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.9	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	50660	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	30	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	7020	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Phenolphthalein Alk	6900	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Carbonate	240	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Hydroxide	6780	mg/l CaCO3	0	SM2320-B	25 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	42200	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1750	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	102	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	663	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	613	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	3.99	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	143		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	1.5	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	5.60	mg/l	0.10	SM4500-F-C	10 Aug 11 17:00	CLB
Sulfate	22600	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	53.8	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.68	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	7.22	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	22.4	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	700	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 25	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	14100	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	580	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	59.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	1.89	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix; ! = Due to sample quantity; # = Due to sample concentration; + = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2452
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.1128	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.0906	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00244	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0270	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.2934	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	0.0161	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0102	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.9246	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0175	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.1959	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.0158	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.3984	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Lorda

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
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\# = Due to sample concentration
\+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2453
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.8	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	27240	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	13	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	4570	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	4520	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	100	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	4470	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	16000	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1960	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	115	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	252	meq/L	NA	SM1030-F	9 Aug 11 9:09	Calculated
Anion Summation	247	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	1.00	%	NA	SM1030-F	9 Aug 11 9:09	Calculated
Sodium Adsorption Ratio	46.1		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	1.6	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	3.60	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	7400	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	66.0	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.38	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	15.0	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	9.4	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	785	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	4720	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	275	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Iron - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Strontium - Total	85.0	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Titanium - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Boron - Total	< 1	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

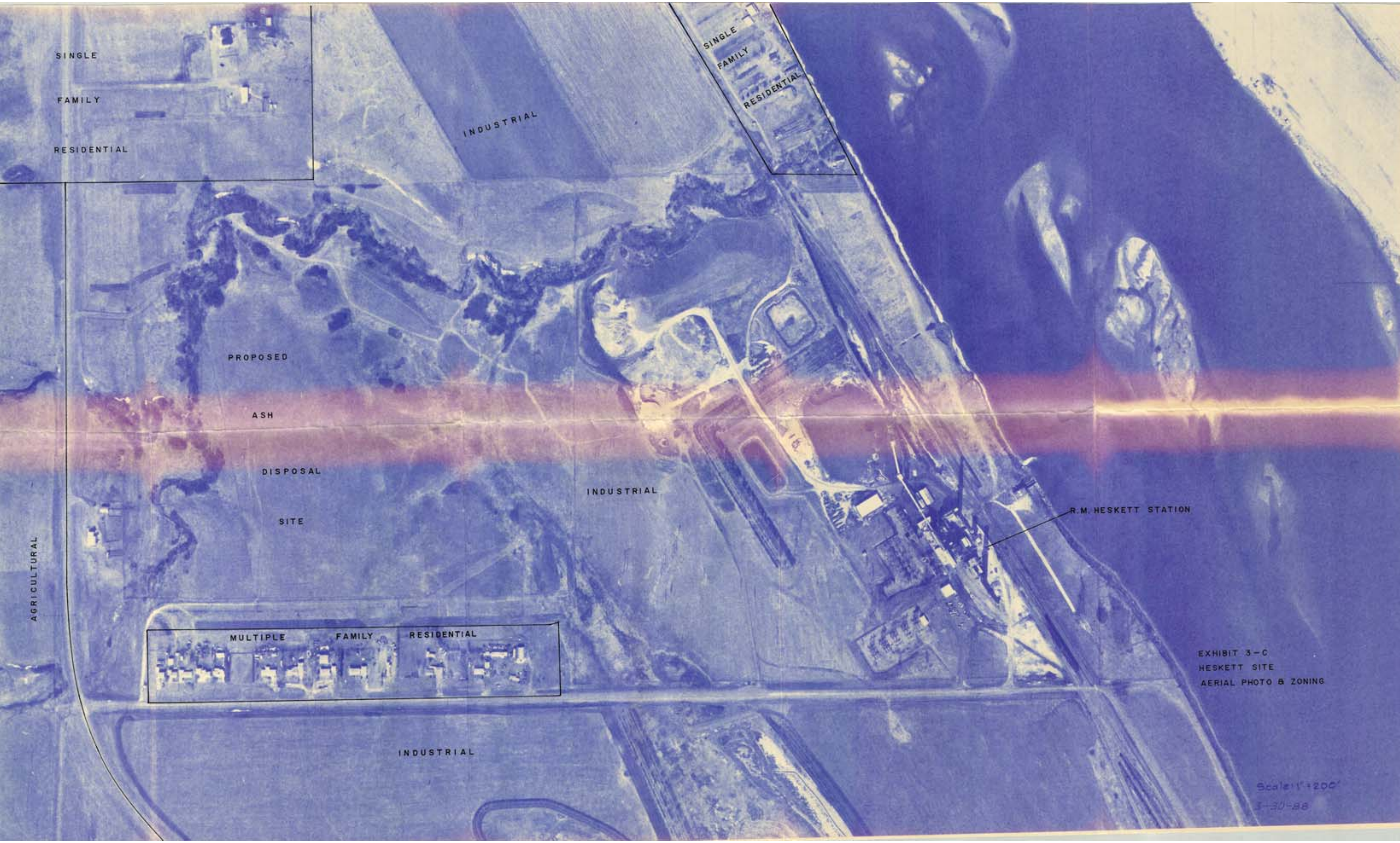
RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

Appendix B

Aerial Photo (March 30, 1988)


SINGLE
FAMILY
RESIDENTIAL
INDUSTRIAL
SINGLE
FAMILY
RESIDENTIAL
PROPOSED
ASH
DISPOSAL
SITE
INDUSTRIAL
R.M. HESKETT STATION
AGRICULTURAL
MULTIPLE FAMILY RESIDENTIAL
INDUSTRIAL
EXHIBIT 3-C
HESKETT SITE
AERIAL PHOTO & ZONING
Scale: 1" = 200'
3-30-88

Appendix C

Heskett Station Permit Application (March 1989)

R. M. HESKETT STATION

SPECIAL USE DISPOSAL SITE

PERMIT APPLICATION

Montana-Dakota Utilities Co.
400 North 4th Street
Bismarck, ND 58501

March 1, 1989

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LIST OF TABLES

LIST OF EXHIBITS

1.0 INTRODUCTION

This application describes hydrogeologic, constructional, and operational details relevant to the procurement of a Solid Waste Disposal Permit from the State of North Dakota. The characterization data and design specifications contained within this application are based upon results obtained from a 1986 investigation which focused upon selecting a waste disposal site that would be suitable for long-term disposal of coal combustion ash generated at the R.M. Heskett Station. The specific objective was to locate a site that would require minimal engineering design and allow the use of in-situ materials for leachate containment and chemical attenuation. Several localities were considered with one site being selected for a highly detailed geohydrologic evaluation. The proposed ash disposal site is located approximately one-quarter mile west of Heskett Station and 2 miles north of Mandan, ND.

A total of 27 monitoring wells were installed in and around the site. The monitoring of well water levels over a two year period has indicated the presence of a static water table (generally 30-40 feet below the ground surface) which flows in a north-northeasterly direction. Potentiometric levels indicated a substantial downward component of groundwater flow over the entire proposed disposal site.

During the operational phase of ash disposal primary objectives will include the minimization of fugitive dust production and preservation of the area landscape by continual reclamation of ash-filled "trenches". Frequent coverage of the trenches with low permeability earthen materials, in conjunction with in-pit water collection devices and an evaporative liquids treatment system, is expected to reduce highly mineralized leachate generation and its degradation potential to the poor-quality groundwater resource beneath the facility. The suitability of the disposal setting is further assured by the placement of waste above the historic water table and the construction of a surface water drainage system adjacent to the site. Contingencies have also been identified which would hinder unanticipated increases in water table elevation.

2.0 WASTE INFORMATION

2.1 Sources of Waste

Montana-Dakota Utilities Co. currently operates two lignite-fired electrical generation units at its R. M. Heskett Station. Unit #1, operational since 1954, utilizes a spreader stoker-type steam generator in the production of up to 20,000 Kw/hr of electrical energy. Unit #2 became functional in 1963 with a boiler similar in design to Unit #1. In early 1987, Unit #2 was converted to an atmospheric fluidized bed combustor capable of supporting a turbine capacity of 73,000 Kw/hr. Units #1 and #2 have an anticipated remaining operational life of 20 years and 30 years, respectively. Both units produce fly ash and bottom ash as the mineral residue of lignite combustion.

2.2 Amounts of Waste Produced

Annual ash generation rates from Heskett Station are estimated in Table 2.1. The proposed disposal facility is designed to accomodate the combustion wastes that will be generated throughout the remaining operational life of Unit #1 (175,000 tons or 1.5×10^5 cy) and Unit #2 (1,569,000 tons or 1.4×10^6 cy).

TABLE 2-1

Annual Ash Generation from Units 1 and 2
at R. M. Heskett Station

	FLY ASH		BOTTOM ASH		SAND [1]	
	Tons	Cubic Yards	Tons	Cubic Yards	Tons	Cubic Yards
Unit 1	4035	4000	4737	3500	-----	-----
Unit 2	25877	25500	10569	7800	15854	11800
Total	29912	29500	15306	11300	15854	11800
Percent (by weight)	49	-----	25	-----	26	-----

Estimated total weight of ash (with sand) 61,070 tons
Estimated total volume of ash (with sand) 52,600 cubic yards

1 Sand is only used within the fluidized bed of Unit #2.

2.3 Description of Waste

All lignite combustion waste produced at Heskett Station will be deposited within the disposal facility in a nonsegregated manner. The combined ash-types differ in color from a light brown to gray-black. Waste texture can vary from a fine, flour-like powder to a distinctly granular consistency. The fluidized bed combustor for Unit #2 utilizes significant amounts of inert sand as a bed matrix. During combustion this sand becomes coated and interspersed with bottom ash slag. Bed sand will be disposed of with the fly ash/bottom ash mixture. The fluidized bed material is visually obvious in the ash mixture due to its uniform granular appearance.

An analysis was performed on the leachate of representative samples of each type of ash waste intended for disposal at the proposed facility. Fly ash and bottom ash samples were collected from Unit #1 ash hoppers during normal operations. Unit #2 fly ash and bottom ash samples were obtained during a "test burn" of Beulah lignite in a scale model fluidized bed steam generation system.

Leachate was extracted from each ash sample using EPA Extraction Procedure Method 1310 (EP Toxicity Test) without pH adjustments (no acetic acid additions). Exhibit 2-A present results of the analytical analysis for both fly ash and bottom ash types. (Because Unit #2 fly ash and bottom ash were collected from a test burn, an EP Toxicity Test was later performed to characterize operational ash samples - these results also appear in Exhibit 2-A.)

The pH of all ash leachates appeared quite alkaline in nature. Fly ashes from Units #1 and #2 contained more alkali than their respective bottom ashes. Leachate pH was considered an important factor in judging site suitability in that it controls the release of trace elements which are locked in the lattice structures of various mineral phases of lignite combustion residue (Groenewold et al., 1980). Sulfate and sodium concentrations were also higher in the fly ashes when compared to those of the bottom ashes.

Leachate from all ash samples, except Unit #1 bottom ash, contained detectable levels of arsenic, cadmium and lead. Selenium was detected only in the fly ash of both units. Fluoride, iron, magnesium, chloride and boron occurred in both the fly and bottom ash leachate at very low concentrations. Nitrates and other analyzed trace elements were near or below laboratory detection limits.

EXHIBIT 2-A

WASTE LEACHATE EXTRACTION ANALYSES

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, *Inc.*

PHONE (507) 354-8517 P.O. BOX 249, CENTER & GERMAN STREETS, NEW ULM, MINNESOTA 56073-0249

Report To: Montana Dakota Utilities
400 North 4th Street
Bismarck, ND 58501

Attn: John Verwey

Date: November 11, 1986

Work Order # CS-2251

Date Received: 9-25-86

Sample Identification: Coarse Ash Hopper, Precipitation Hopper Comp.

Analyses	Coarse Ash Hopper (Unit #1 Bottom Ash)	Precipitation Hopper Comp. (Unit #1 Fly Ash)
Total Alkalinity as CaCO3..mg/l..	414	1,472
Bicarbonate as CaCO3...mg/l......	161	150
Calcium.......mg/l................	77.5	95.0
Carbonate as CaCO3 ...mg/l.......	253	1,323
Chloride......mg/l................	19.0	23.0
Fluoride......mg/l................	0.11	0.22
Hardness as CaCO3...mg/l.........	194	238
Iron..........mg/l................	0.2	0.2
Manganese.....mg/l................	< 0.01	0.01
Magnesium.....mg/l................	0.1	0.1
Nitrate.......mg/l................	< 1.0	< 1.0
pH................................	11.5	12.6
Potassium.....mg/l................	15.0	100
Sodium........mg/l................	380	2,200
Specific Conductance micromhos/cm	2,544	15,001
Sulfate.......mg/l................	900	6,550
Total Dissolved Solids...mg/l....	1,357	10,389
Boron.........mg/l................	0.91	1.[illegible]8

EP Tox Extraction
no acid added.

BY Jerome [illegible]

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

PHONE (507) 354-8517

P.O. BOX 249, CENTER & GERMAN STREETS, NEW ULM, MINNESOTA 56073-0249

Report To: Montana Dakota Utilities
400 North 4th Street
Bismarck, ND 58501

Attn: John Verwey

Date: November 11, 1986

Work Order # CS-2251

Date Received: 9-25-86

Sample Identification: Coarse Ash Hopper, Precipitation Hopper Comp.

Analyses	Unit #1 Bottom Ash Coarse Ash Hopper	Unit #1 Fly Ash Precipitation Hopper Comp.
Arsenic.......mg/l............	< 0.002	0.070
Barium........mg/l............	< 0.5	< 0.5
Cadmium.......mg/l............	< 0.01	0.02
Chromium......mg/l............	< 0.05	< 0.05
Lead..........mg/l............	< 0.10	0.40
Mercury.......mg/l............	< 0.002	< 0.002
Selenium......mg/l............	< 0.003	0.003
Silver........mg/l............	< 0.05	< 0.05
Molybdenum....mg/l............	< 0.50	< 0.50

EP-TOX Extraction
no acid added

BY Jerome Kotelecky

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

PHONE (507) 354-8517

P.O. BOX 249, CENTER & GERMAN STREETS, NEW ULM, MINNESOTA 56073-0249

Report To: Montana Dakota Utilities
400 North 4th Street
Bismarck, ND 58501

Attn: John Verwey

Date: November 11, 1986

Work Order # CS-2251

Date Received: 9-25-86

Sample Identification: Bed Ash, Bag House

Analyses	Unit #2 Bottom Ash Bed Ash	Unit #2 Fly Ash Bag House
Total Alkalinity as CaCO3..mg/l..	173	598
Bicarbonate as CaCO3...mg/l......	69.0	80.5
Calcium.......mg/l................	570	105
Carbonate as CaCO3 ...mg/l.......	103.5	517.5
Chloride......mg/l................	5.0	21.0
Fluoride......mg/l................	< 0.10	0.27
Hardness as CaCO3...mg/l.........	1,429	263
Iron..........mg/l................	0.2	0.1
Manganese.....mg/l................	< 0.01	< 0.01
Magnesium.....mg/l................	1.4	0.1
Nitrate.......mg/l................	< 1.0	< 1.0
pH................................	10.7	11.9
Potassium.....mg/l................	40.0	100
Sodium........mg/l................	1,200	2,350
Specific Conductance micromhos/cm	7,066	10,870
Sulfate.......mg/l................	4,300	6,160
Total Dissolved Solids...mg/l....	5,774	8,324
Boron.........mg/l................	1.20	1.7

EP Tox Extraction
no acid added

BY Jerome Kotelecky

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

PHONE (507) 354-8517

P.O. BOX 249, CENTER & GERMAN STREETS, NEW ULM, MINNESOTA 56073-0249

Report To: Montana Dakota Utilities
400 North 4th Street
Bismarck, ND 58501

Attn: John Verwey

Date: November 11, 1986

Work Order # CS-2251

Date Received: 9-25-86

Sample Identification: Bed Ash, Bag House

Analyses	Bed Ash (Unit #2 Bottom Ash)	Bag House (Unit #2 Fly Ash)
Arsenic........mg/l............	0.155	0.045
Barium.........mg/l............	< 0.5	< 0.5
Cadmium........mg/l............	0.02	0.03
Chromium.......mg/l............	< 0.05	< 0.05
Lead...........mg/l............	0.35	0.25
Mercury........mg/l............	< 0.002	< 0.002
Selenium.......mg/l............	< 0.003	0.004
Silver.........mg/l............	< 0.05	< 0.05
Molybdenum.....mg/l............	< 0.50	< 0.50

EP Tox Extraction
no acid added

BY Jerome Kotetecky

Generic
ash - Utilization

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

PHONE (507) 354-8517

P.O. BOX 249, CENTER & GERMAN STREETS, NEW ULM, MINNESOTA 56073-0249

Report To: Montana Dakato Utilities Co.
Attn: Gene Brown
P.O. Box 40
Mandan, ND 58554

Date: November 18, 1987

Work Order # 12-2237

Date Received: 9-29-87

Sample Identification: EPA Toxicity

Unit #2 bottom ash

Analysis	4638
Arsenic........mg/L.............	0.004
Barium........mg/L.............	< 0.1
Cadmium........mg/L.............	< 0.05
Chromium........mg/L.............	0.14
Lead...........mg/L.............	< 0.100
Mercury........mg/L.............	0.0003
Selenium.......mg/L.............	< 0.003
Silver.........mg/L.............	0.04

A FULL SERVICE LABORATORY

BY David H. Diamond

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325

LABORATORY REPORT

To: Mineral Specialities (1) Lab No.: 87-7859
Address: P.O. Box 1563 Date: 7/24/87 pjf
Billings, Montana 59103
ATTN: Jerry Vollmer

EP TOXICITY ANALYSIS - Fly Ash - Unit 2

Heskett Plant, North Dakota
Submitted 6/26/87

Extraction and analysis performed according to SW-846, Test Methods for Evaluating Solid Waste.

CONSTITUENT	mg/l in extract
Arsenic	<0.5
Barium	<10
Cadmium	<0.1
Chromium	<0.5
Lead	<0.5
Mercury	<0.02
Selenium	0.2
Silver	<0.5

Post-it® Fax Note 7671	Date 4/3 # of pages ▶ 1
To Alan Welte	From Andrea
Co./Dept.	Co.
Phone #	Phone #
Fax #	Fax #

3.0 PROPOSED SPECIAL USE DISPOSAL SITE

3.1 Site Location

The R. M. Heskett Station is located in Morton County approximately two miles north of Mandan, ND. Disposal facility siting began by reviewing existing published geologic and hydrologic data to preliminarily identify potential sites within a 20 mile radius of Heskett Station. Five candidate sites were chosen and field evaluated. Two sites were determined as meriting further characterization and were comparatively examined in detail (Exhibit 3-A). Hydrologic, lithologic, aesthetic, economic, land use, and safety considerations indicated that the Heskett Site would prove best suited for the proposed disposal facility.

The Heskett Site is located east of Highway No. 1806 and approximately one-half mile west of Heskett Station. The site covers 47 acres of the SW1/4 of Section 10, Range 81 West, Township 139 North and is bound on the west and north by Rock Haven Creek, east by Heskett Station and the existing ash storage pile, and on the south by 43rd Street Northeast. Industrial property belonging to the Amoco Oil Refinery lies directly to the south of 43rd Street Northeast. Scattered residential housing lies adjacent to the north, west, and south of Heskett Site.

3.2 Land Use and Zoning

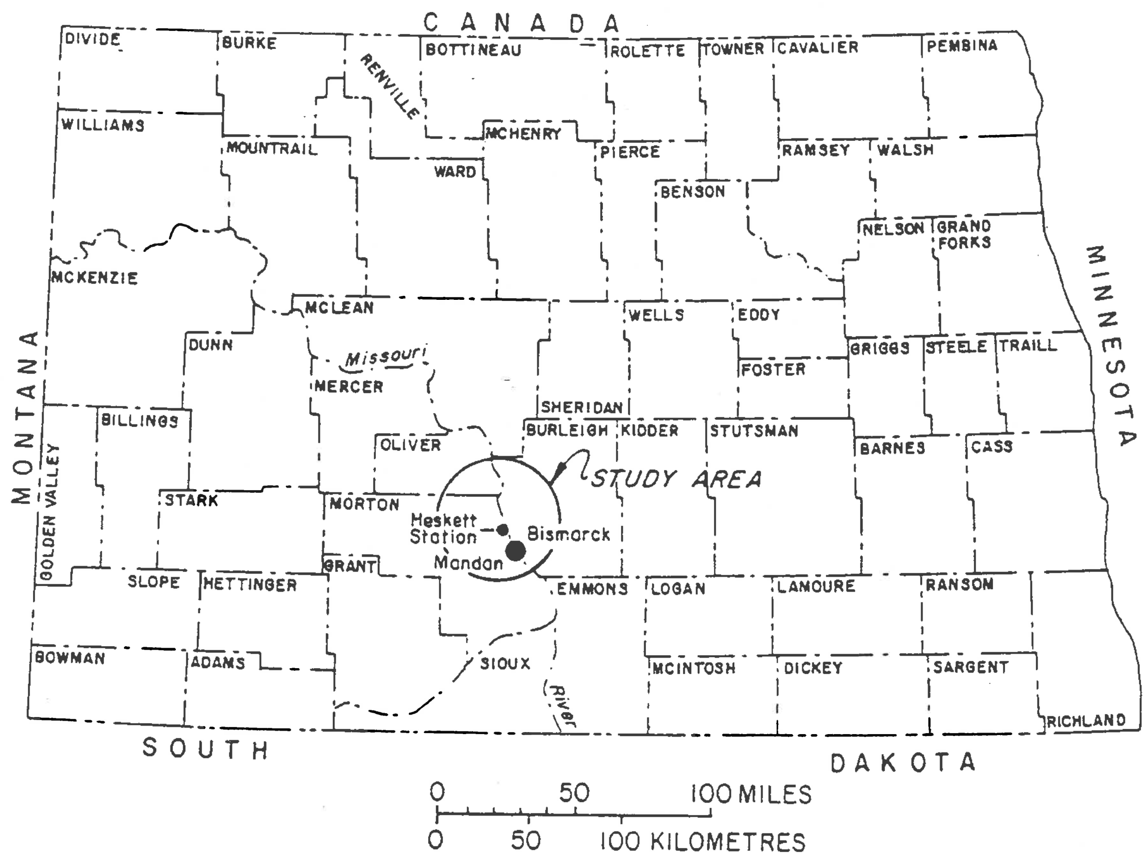
Heskett Site is currently owned by Montana-Dakota Utilities Co. and holds an industrial zoning designation. A plat of the site appears in Exhibit 3-B along with monitoring well location/elevation information. An examination of Exhibits 3-B and 3-C indicates area land use to be primarily of an industrial and agricultural nature. The site itself is native grassland previously used for grazing livestock. Flat farmlands extend to the north while hilly pasture predominates to the west of Highway No. 1806. Level cropland and wildlife sanctuary exists on Amoco Refinery property south of 43rd Street Northeast.

Several family dwellings exist to the south and west of the Heskett Site. Other dwellings are scattered singly and in groups throughout the surrounding area. Because of the close proximity of some residences to the proposed facility, certain features will be incorporated into the design which will preserve the landscape by presenting line-of-site obstructions from the south and, if needed, west and north.

EXHIBIT 3-A

STUDY REVIEW AREA AND FINAL SITES

Study Review Area



Study Area - Final Sites

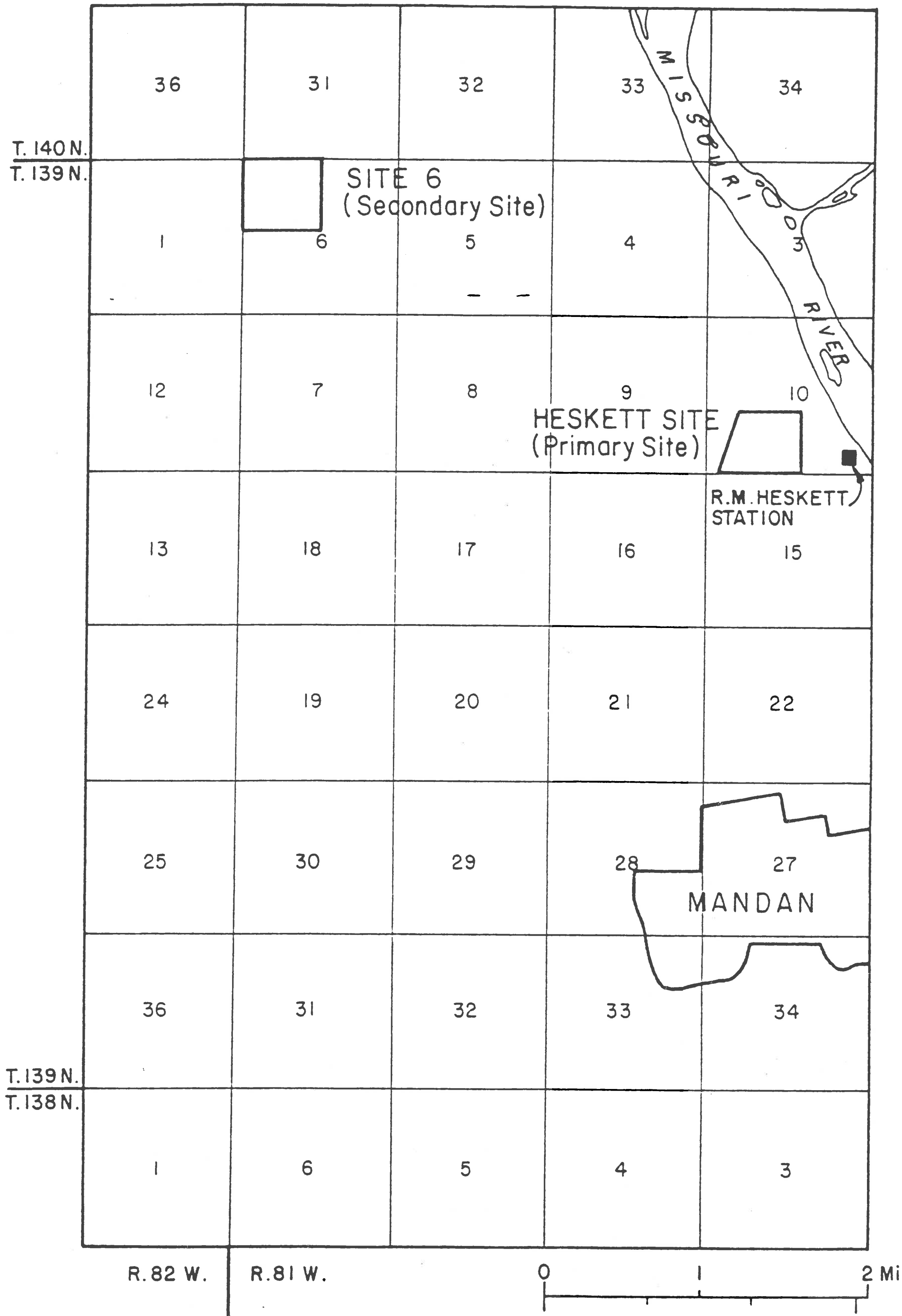


EXHIBIT 3-B

SITE PLAT/WELL SITINGS

EXHIBIT 3-C

AERIAL PHOTO AND ZONING

4.0 AREA DESCRIPTION

4.1 Geographical Setting

The disposal area is located entirely within the Missouri Plateau of the Great Plains Physiographic Province. Characterized by plains and gently sloping hills, the landscape is interrupted by isolated tablelands and river valleys entrenched 200 to 400 feet (Ackerman, 1980). Surface altitudes generally increase towards the west.

The Heskett site is a relatively flat area bounded on the west and north by an ephemeral stream (Rock Haven Creek) which supports a small shrub/woodlands community. Rock Haven Creek drains a small hilly area of approximately 2.4 square miles to the west of the site. Discharge is made directly into the Missouri River. No surface water flow gauging has ever been done at Rock Haven Creek. The North Dakota State Water Commission estimated annual flow of at least 50 acre-feet for every 80 years out of 100. One hundred acre feet of flow can be expected for 50 years out of 100.

4.2 Regional Geology

The Tertiary Cannonball Formation underlies the entire Heskett site and lies stratigraphically under several other regional formations (Exhibit 4-A). The Cannonball Formation crops out over a large portion of eastern Morton County. The bluffs along the Missouri River north of Mandan near Heskett Station are resultant from these outcrops.

The Cannonball Formation is characterized by deposits of sand, silt and clay. The beds within this formation are generally unconsolidated and tend to weather rapidly. Some of the sand units are partially cemented and are resistant to erosion. The resistant units often form benches along eroded drainages (Carlson, 1983). Cvancara (1976) points out another characteristic of the Cannonball Formation; lack of persistent lithostratigraphic units or beds. The units are often truncated because most bedding within this formation is lenticular.

The Cretaceous and Tertiary rocks in this portion of North Dakota generally dip toward the center of the Williston Basin. Reported dips of the Cannonball Formation in the Bismarck-Mandan area are generally less than 1° and trend toward the northwest. Local irregularities in dip direction and magnitude are common in the Cannonball Formation. These minor variations are caused by small synclines and anticlines which are superimposed on the larger structure of the basin (Kume and Hansen, 1965). These small anomalies may often be responsible for local irregularities in groundwater flow direction and magnitude.

4.3 Regional Groundwater

The Cannonball Formation interfingers with its continental equivalent, the Ludlow Formation. The two formations are contemporary with deposition of the Cannonball occurring in a marine environment and deposition of the Ludlow occurring in a fresh water environment.

Aquifers within these formations are generally found in fine grained sandstones. Such units range from 5 to 129 feet thick and contain from 5 to 40 percent silt and clay. Lateral extensiveness is typically lacking. Core samples from these aquifers possess hydraulic conductivities ranging 2.9 X 10^{-3} cm sec^{-1} to 1.5 X 10^{-5} cm sec^{-1} (Ackerman, 1980). General groundwater movement is to the east or northeast with major discharge areas occurring in the valleys of the Missouri River, Heart River, and Big Muddy Creek.

Ackerman (1980) further states that the Cannonball and Ludlow Formation aquifers maybe in hydraulic connection with adjacent glacial drift aquifers. Area groundwater is generally of a sodium bicarbonate or sodium bicarbonate-sulfate type. Such waters are usually of poor quality for domestic usage because of high sulfate concentrations and excessive levels of total dissolved solids.

4.4 Climate

The climate of the Heskett site is semiarid with widely ranging seasonal temperatures. Summer temperatures may exceed 100°F (38°C) while winter temperatures may drop below -40°F (-40°C). The mean average annual temperature at Mandan, ND is 41.4°F (5.2°C) with average annual precipitation being 16.8 inches (42.6 cm). Approximately 60 percent of the annual precipitation (10 inches) occurs as rain during a four month period beginning in April and extending through July (U.S. Department of Commerce, 1973).

There are on the average about 125 frost-free days in this region of North Dakota. The mean depth of frost penetration is 4.5 feet (1.4 m). Extremely cold winters may occasionally allow frost to penetrate up to a depth of 7.0 feet (2.1 m) (Jensen, 1984).

The prevailing wind in the Bismarck-Mandan area is from the west-northwest with a mean velocity of 10 mph (16.1 km/hr). Winds are generally stronger in the spring and early summer as opposed to the fall and winter (Jensen, 1984).

4.5 Regional Soils

Regional near-surface materials are soils which have developed from climatic and biotic interactions with poorly consolidated sand, silt, and clay of the Upper Cretaceous and Tertiary Formations. Glacial till appears preserved on some upland surfaces and lowland alluviums (Carlson, 1983).

Area hills have moderately steep slopes and typically have well entrenched dendritic drainageways. Patterson, et al. (1968) stated that the Bainville and Morton soil series dominate the smoothly rounded hills west of the proposed site. These soils appear on slopes of 2 to 30 percent and are well to excessively drained. Both soils, being derived from weathered medium-textured beds of the Tertiary period, tend to be loamy with high water holding capacities and somewhat limited permeabilities. Morton soils comprise 35 to 50 percent of the immediate area and are often used for cropland. Bainville soils cover 40 to 55 percent of area acreage and, being susceptible to water erosion hazards, are commonly used for pasturage.

Adjacent to the Heskett site lies the floodplain of the Missouri River. Alluvial Havre soils overlay medium-textured sediments and dominate 60 to 85 percent of the nearly level floodplain. Havre soils, with their moderate permeability and high water-holding capacities, are extensively utilized for croplands and pasturage. Well-drained Banks and Lohmiller soils each comprise 5 to 15 percent of the slightly elevated ridges and flats associated with the Missouri River floodplain (Patterson, et al., 1968).

4.6 Vegetation

The principle natural vegetative community in the study area is the mixed-grass prairie dominated by short grasses. Edwards and Ableiter (1936) stated that the smooth heavy soils of the uplands support substantial growths of western wheatgrass (<u>Agropyron smithii</u>) and needlegrass (<u>Stipa comata</u>). Little bluestem (<u>Andropogon scoparius</u>) commonly grows on exposed knobs and steep slopes. Sedges, weeds, and cattails are typical of the poorly drained areas.

Natural forests are confined to bottomlands and along large streams and drainageways. Steep-sided gullies, especially those with northern exposures, contain ash (_Fraxinus lanceolata_), elm (_Ulmus americana_), aspen (_Populus tremuloides_), and oak (_Quercus macrocarpa_). The Missouri River floodplain contains significant natural stands of cottonwood trees (_Populus deltoides_). Also present are occasional occurrences of thicket-type woody vegetative communities dominated by buffaloberry (_Shepherdia argentea_). Such thickets are common in or near "woody draws" and bottomlands but seldom cover large surface expanses.

EXHIBIT 4-A

REGIONAL GEOLOGIC FORMATIONS

Regional Geologic Formations

ERA	SYSTEM	FORMATION OR GROUP		THICKNESS (FEET)	LITHOLOGY
CENOZOIC	QUATERNARY	ALLUVIUM		0-30	SILT, SAND AND GRAVEL
		COLEHARBOR		0-300	TILL, GRAVEL AND SAND
	TERTIARY	FORT UNION GROUP	GOLDEN VALLEY	0-60	SILT, CLAY AND SANDSTONE
			SENTINEL BUTTE	0-700	SILT, CLAY, SAND AND LIGNITE
			BULLION CREEK	0-500	SILT, CLAY, SAND AND LIGNITE
			SLOPE	0-60	SILT, CLAY, SAND AND LIGNITE
			CANNONBALL	0-300	SILT, CLAY AND SAND
			LUDLOW	0-200	SILT, CLAY, SAND AND LIGNITE

5.0 SITE SPECIFIC CHARACTERISTICS

5.1 Site Investigation Methods

5.1.1 Site Selection Criteria

A primary concern involved the location and development of a site which would have near-surface (upper 30 feet) in-situ materials possessing characteristics similar to those of clay liner material. Relatively level near-surface sediments characterized by high clay and silt content were considered desirable. Because such materials typically transmit groundwater at slow rates, the migration of leachate into usable subsurface water supplies would be severely hindered. Another consideration was the chemical attenuation capabilities of the subsurface geologic materials. Clay and silt have been reported to generally have higher chemical attenuation capabilities than do other sediments, thereby making their presence desirable for many waste disposal settings. (Drever, 1982).

Selection of potential site areas larger than 1 square mile were based solely upon existing available data. A database was constructed which included published information from county geologic and groundwater investigative reports, soil survey reports, and water well drilling reports submitted to the North Dakota State Water Commission (NDSWC) by private contractors. Topographic maps and county zoning maps were also reviewed.

Five candidate sites were selected based upon geologic, geomorphic, and hydrologic data evaluations. Limited surficial investigations (including soil borings) were then conducted at each of the five sites. The position of the water table was very important in defining an acceptable site. Only those sites with water tables more than 25 feet below a relatively level ground surface were considered.

Selection of two final sites were based on lithology, transport distance, road limitations, topography, and apparent depth to groundwater. Boreholes were drilled at each of the sites (maximum drilled depth was 120 feet) and lithologic/hydrologic/geophysical information recorded. Review of this information indicated that the final candidate sites had very similar geologic and hydrologic characteristics. Economics of site development, local zoning conditions, land use, transportation safety, facility access, and operational monitoring factors strongly suggested that the Heskett site was the most suitable disposal facility location.

5.1.2 Subsurface Borings

Boreholes were drilled by either a Portadrill 524 or a Denver-Gardner Heavy Duty 1000. All borings were air drilled (without the addition of drilling fluids) to reduce contaminations to groundwater. Drilling conditions for each bore hole are presented in Exhibit 5-C. Samples were collected at 5-foot intervals or at occurrences of lithologic change.

A total of 27 observation wells were installed at the Heskett site with twelve of the boreholes developed into water table monitoring wells and 15 developed as piezometers. The location of the various observation wells are shown in Exhibit 5-A. Additional information on area hydrogeochemistry was obtained from 9 wells (identified in this report as monitoring wells WS1, WS1A, WS1B, WS2, WS3, WS3A, WS4, WS4A, and WS4B) that were installed during a previous groundwater investigation which was conducted around the ash waste pile immediately east of the proposed facility (Armstrong and Schmid, 1986).

The observation wells were installed in nests of 2 to 4 single wells screened at differing elevations. Nine separate piezometer nests were installed over the Heskett study area. The deepest well in each nest was geophysically and lithologically logged (Exhibits 5-D and 5-E, respectively). A typical nest contained one water table monitoring well and two piezometers screened at different elevations.

5.1.3 Monitoring Well Construction

Monitoring wells were constructed of two-inch schedule 40 PVC pipe with screened lengths of either 4 or 20 feet. The 20-foot screened sections were installed to monitor the elevation of the water table and for water quality sampling. The 4-foot screened sections were primarily installed to monitor hydraulic head. A factory slotted size of 1 X .020 inches was used for all well screens.

A filter sand pack was placed around the screened portion of each well after the pipe was lowered into the bore hole. Washed quartz sand was packed with the use of packing poles to a height of two feet above the top of the screened interval. Before sampling was conducted each well was developed twice by backwash and mechanical surge methods.

After the sand pack was complete, sealing grout was slurried down the annulus between the bore hole and the PVC pipe. The grout seal was continued to the land surface where a two-foot diameter grout pad was constructed around each monitoring well. The monitoring wells were capped with threaded male PVC cap adapters and assigned unique well numbers.

The water level measuring reference point for the wells was the top of the PVC well pipe. Well locations and elevations can be seen on Exhibits 3-B and 5-A. Well construction data are presented in Exhibit 5-C.

5.1.4 Groundwater Monitoring

Water levels were monitored periodically during and after the course of the formal characterization study. Water level information, as determined with an electric-contact gauge tape, appears in Exhibit 5-G.

Each well was purged prior to sampling by removing at least 3 well volumes of standing water or until dry, which ever occurred first. The wells were purged with either a stainless steel and teflon mechanical two-inch submersible pump or a 1.25 inch hand bailer. All well groundwater samples were collected with a hand bailer in accordance with the Environmental Protection Agency's publication 600/4-82-029, "Handbook for Sampling and Sample Preservation of Water and Waste Water" (US EPA, 1982). Immediately after the samples were collected field pH, specific conductance and temperature were measured and recorded.

Samples were collected and preserved for major ion analysis and for trace element determinations. Other samples were collected from select wells for oil, grease, and phenol analyses. Site characterization study samples (collected in 1986) were transported to the University of North Dakota's Mining and Mineral Resources Research Institute's Fuels Analysis Laboratory for chemical analysis. Additional follow-up sampling and chemical analysis was performed in 1988 by Minnesota Valley Testing Labs of Bismarck, ND.

5.2 Site Investigation Results

5.2.1 Geology

Lithologic and geophysical logs of the wells drilled at this site indicated that at least the upper most 100 feet of subsurface material lies within the Cannonball Formation. Consequently, the proposed Heskett waste disposal facility would be constructed completely within the Cannonball Formation. The Ludlow Formation may appear subsurface of the Heskett site study area below an elevation of 1605 feet above mean sea level (MSL). However, only the deepest bore holes penetrated to this elevation and geophysical logs from these wells do not provide any indication of contact between the two formations.

An existing topographic reference map (with well locations and cross-section locations) is provided in Exhibit 5-A. A series of eight geohydrologic cross-sections of the proposed Heskett disposal site are provided in Exhibit 5-B. Each cross-section includes topography (exaggerated 10 times), dominant lithologies, observation well locations, potentiometric levels and water table position as of October, 1986.

The Heskett Site consists of unconsolidated silt and clay with lesser amounts of very fine to medium-grained sand (lithologic log, Exhibit 5-E). The sand is generally found interspersed in a matrix of silt and clay; however, it sometimes occurs as distinct lenses which range in depth from 0.5 inches to 1 foot. The thin sand lenses are not horizontally persistent. Small gypsum crystals occur throughout the upper 30 feet of the site. These gypsum crystals are presumed to be the result of diagenetic processes which occur above the water table during alternate wetting and drying cycles (Groenewold et al., 1983).

The dominant lithology of the site is silt which commonly occurs in a clay-rich matrix. Above an elevation of 1695 feet MSL the clayey-silt is generally brownish-tan in color with grain coatings and mottling of iron-oxides. Below this elevation the color changes to steel-gray with the iron compounds existing in the reduced state. The reduced/oxidized boundary is well defined over the site by the color change described above and corresponds with the elevation of the water table.

The uppermost indurated unit encounter beneath the proposed disposal area is a siltstone bed occurring between the elevations of 1625 feet and 1635 feet MSL. This is the most laterally continuous and persistent unit found at the Heskett site.

A thin veneer of till is present in small patches throughout the Heskett study area. This till, along with all glacial material in North Dakota, has been grouped within the Coleharbor Formation (Bluemle, 1971). The till of the Heskett study area is less than 2 feet thick and is of a pebble-loam nature. Other evidence of glaciation includes the presence of several large boulders, less than 3 feet in diameter, which were derived from the Canadian Shield.

The glacial sediments indicate that glacial ice covered the study area during the Pleistocene Epoch. Horizontal sheet fracturing may have developed within the surficial bedrock formations, including the Cannonball Formation, as this glacial ice ablated. The fracturing of these sediments might promote secondary porosity and be responsible for the relatively large groundwater flow volumes encountered within the silts and clays beneath the Heskett site study area.

The soils across the proposed Heskett ash disposal area (Exhibit 5-F) are generally well developed. Edwards and Ableiter (1936) classified upland soils of the site as Hall series silt-loam. The soil is very silty with abundant clay and minor amounts of fine-grained sand. Internal drainage is generally good and surface drainage is sufficient. Most site soils are approximately 1 foot thick with the upper 6 to 8 inches appearing very dark due to abundant organic matter. The soil becomes lighter in color 8 inches below the soil surface. All soils at the Heskett site are calcareous and freely effervesces with dilute hydrochloric acid.

5.2.2 Geohydrology

Exhibit 5-H illustrates the water table elevation contour of the Heskett site as of October 16, 1986. Because periodic well measurements over two years indicated relatively static potentiometric levels, the described elevation of the water table is considered representative. Water levels of all of the Heskett Site wells are given in Exhibit 5-G. Hydrographs of select piezometer nests appear in Exhibit 5-I.

The shallow groundwater beneath the proposed facility is flowing generally towards the northeast. Local variations do exist and can be attributed to the heterogeneous nature of the lithologies of the Cannonball Formation along with the undulating surface topography of the site. Surface topography appears to exert the most profound effect on groundwater flow with water table elevation mimicking the surface topography. As the groundwater approaches Rock Haven Creek it begins to take a more easterly path following the down-cut gradient of this creek into the Missouri River.

The groundwater flow beneath the base of a small draw, which extends to the north and slightly west from the south-central border of Section 10 to its intersection with the Rock Haven Creek, is nearly directly north. This groundater flow is strongly influenced by the surficial topography which also dips toward the north. Industrial surface water holding ponds located on Amoco refinery property south of the proposed site occasionally provides surface discharge into this draw. Running and ponded water resultant from these discharges as well as area ground surface runoff are frequently evident on MDU property just north of 43rd Street Northeast.

Morton County often experiences a drop in the elevation of the water table during the winter months due to a lack of recharge (Groenewold, et at., 1979 and 1983). Hydrographs (Exhibit 5-I) developed from two years of accumulated site potentiometric data indicate little apparent seasonal effect. An overall potentiometric level drop can be noted during the drought year of 1988. The data also indicated that the groundwater is flowing strongly downward. Thus, it can be expected that water will not be entering the proposed disposal pit from beneath the site.

Six subsurface lithologic intervals were sampled from in and near the proposed ash disposal site and laboratory tested to determine certain physical/ chemical properties. Table 5-1 summarizes the results of cation exchange capacity and hydraulic conductivity testing for these samples (See Exhibit 5-K for greater detail). Data obtained from such lab permeability testing should be considered representative only of the point of sampling. Samples are often modified, in terms of hydraulic conductivity, during well drilling and sample collection. Minor subsurface fracturing might not be preserved in the laboratory. However, these data are useful in estimating flow rates through interstices in the subsurface geologic media and in situations where in-situ sediments will be modified by compaction to reduce secondary permeability.

Single-well response tests performed on select Heskett site wells (wells 11, 20, 31, 41 and 43) show greater in-situ permeabilities than the falling-head lab permeabilities of wells screened in the same sediments.

TABLE 5-1

Hydraulic Conductivities and Cation Exchange Capacities

Well Number	60	WS2	WS2
Sample Depth (ft)	20-40	29-30	61-62
Type of Sample	Bag	Core	Core
Permeability			
K @ 20°C (cm/sec)	2.0×10^{-7}	2.7×10^{-9}	3.6×10^{-8}
K @ 20°C (ft/min)	4.0×10^{-7}	5.4×10^{-9}	7.1×10^{-8}
Cation Exchange Cap. (meq/100 grams)	-------	92.2	12.0

Well Number	WS1	WS1	WS1
Sample Depth (ft)	20-21	25-26	30-31
Type of Sample	Core	Core	Core
Permeability			
K @ 20°C (cm/sec)	2.6×10^{-8}	1.5×10^{-8}	1.7×10^{-8}
K @ 20°C (ft/min)	5.2×10^{-8}	2.9×10^{-8}	3.4×10^{-8}
Cation Exchange Cap. (meq/100 grams)	71.8	12.3	74.2

WS - Refers to wells installed and sampled during a previous groundwater investigation around the coal ash waste pile at Heskett Station. This study was conducted by Water Supply, Incorporated.

These slug tests provide estimates of permeability over the screened 4-foot interval. Results, which appear in Table 5-2, show that wells 11 and 31 have the lowest permeabilities of the wells tested with values on the order of $K = 10^{-5}$ cm sec^{-1}. Higher conductivities were encountered in wells 20, 41 and 43 with values approximating $K = 10^{-4}$ cm sec^{-1}.

TABLE 5-2

Single Well Response Tests

Well	Permeability	Screen Depth (MSL)
11	3.78×10^{-5} cm sec^{-1}	1642.81 - 1646.81
20	6.57×10^{-4} cm sec^{-1}	1627.48 - 1631.48
31	2.84×10^{-5} cm sec^{-1}	1635.58 - 1639.58
41	4.12×10^{-4} cm sec^{-1}	1626.77 - 1630.77
43	5.07×10^{-4} cm sec^{-1}	1650.14 - 1654.14

Reference: Freeze, R. A., and Cherry, J. A., 1979., Groundwater: Chapter 8.5, pgs. 339-342, Prentice-Hall Inc., Englewood Cliffs, NJ.

5.2.3 Hydrogeochemistry

Results of the site groundwater characterizations are shown in Exhibit 5-J. Analysis of samples collected in 1986 from wells 10-70 were conducted by the Mining and Mineral Resources Research Institute's Fuels Analysis Laboratory at the University of North Dakota. Supplemental sampling was conducted in 1988 by Minnesota Valley Testing Labs of Bismarck, ND. All samples were analyzed in accordance with EPA publication 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes" (U.S. EPA, 1979).

The quality of the shallow (less than 120 feet below the land surface) groundwater at the proposed Heskett disposal site was found to be quite poor. Similar groundwater quality has been reported in other shallow wells within the Cannonball Formation (Ackerman, 1977 and 1980). Large quantities of salts and soluble mineral phases were deposited along with the sediments of the Cannonball. These materials dissociate as undersaturated interstitial groundwater flows through the formation. The ultimate quality of the water depends on the solubility of the geologic media and saturation condition of the groundwater which flows through it. Soluble constituents of the shallow groundwater at the Heskett site, as is characteristic of other Cannonball Formation wells, are high or very high relative to water in other aquifers in the area. Without pretreatment such groundwater is generally considered to be unfit for consumption by humans and livestock. Most of the local domestic wells tap either the underlying Hell Creek or the Fox Hills aquifers which possess waters with qualities far superior to that of the Cannonball.

An examination of the 1986 data appearing in Exhibit 5-J shows that the specific conductance and pH of wells sampled at the Heskett site are within the range of what has been reported as characteristic of the Cannonball Formation. Well 70 is located upgradient from known industrial influences and can be considered representative of background groundwater quality at the site. Chemical analyses indicate that water within wells 60 and 70 have the highest specific conductance of all monitored wells.

Total dissolved solids (TDS) concentrations show the shallow groundwater at the Heskett site to be highly mineralized, ranging from 1,286 mg/L in well 30 to 14,917 mg/L in well 60. Wells screened within the Cannonball Formation commonly have TDS concentrations ranging from 1,000 to 3,000 mg/L (Ackerman, 1980).

Wells finished within the Cannonball Formation typically have sodium concentrations ranging from 500 mg/L to 1000 mg/L (Ackerman, 1977 and 1980). Sodium levels of wells 10, 12, 55 and 70 were well above these levels. Sulfate concentrations were highest in wells 44, 55, 60 and 70 with observed maximum occurring in well 60 (11,632 mg/L). Sodium, TDS and sulfate concentrations indicated that extremely saline pockets of groundwater exist at the southwestern (near wells 70, 10-13, and 60-62) and east-central (near wells 55 and 56) borders of the Heskett study area.

Both magnesium and calcium concentrations were relatively high and variable over the Heskett site study area. Well 44 contained the highest levels of these two constituents with 648 mg/L of calcium and 1,322 mg/L of magnesium. Heskett site water would be considered quite hard with actual values (expressed as $CaCO_3$) ranging from 222 mg/L in well 30 to 7,040 mg/L in well 60.

Chloride, potassium, iron, and fluoride concentrations were generally within the expected range of concentrations for wells finished within the Cannonball Formation. However, potassium was slightly elevated in wells 44 and 60 where it reached concentrations of 51 mg/L and 41 mg/L, respectively.

Nitrate concentrations were found to be erratic over the Heskett site. Wells 55 and 60 contain the highest nitrate levels with 154 mg/L and 170 mg/L, respectively. The drinking water standard (provided in Exhibit 5-J for reference purposes) for nitrate (NO_3^-) is currently set at 45 mg/L. The elevated nitrate concentrations in wells 50, 52, 55 and 60 would tend to indicate contamination from biological sources. Domestic sewage drainfields are known to exist near the center of the south border of the proposed disposal site in the vicinity of wells 43 and 44. It is believed that these sources contribute at least a portion of the observed elevated nitrate concentrations.

Selenium is a common naturally-occurring element in sediments, especially in shale and clay (Freeze and Cherry, 1979). Wells 55 and 60 had the highest concentrations with 0.368 mg/L and 0.195 mg/L, respectively. The levels observed in these two wells are above levels common to groundwater systems which contain shale and dissolved selenium. Indeed, these levels approach 100 times the concentration observed in groundwater taken elsewhere from the Cannonball Formation (Ackerman, 1977).

Molybdenum was detected at reduced concentrations in wells 10, 32, 54 and 70. Water Supply Incorporated (WS), in their previous groundwater investigation concerning the currently operational Heskett ash pile, noted concentrations of molybdenum in well WS4 similar to those observed in this study in wells 10, 54 and 70. Well WS4 was at the time noted for increasing molybdenum levels with the greatest concentration reaching 0.11 mg/L on September 11, 1985 (Armstrong and Schmid, 1986). Further groundwater monitoring has shown that after this finding molybdenum levels then dropped below analytical detection limits. Minimum detection levels have only occasionally been exceeded in the ensuing years. With this study's addition of background monitoring wells upgradient from the current ash pile it can be determined that concentrations of molybdenum in well WS4 were within the background range of groundwater at the Heskett site. The elevated molybdenum concentrations as noted by W.S. are therefore not believed caused by the migration of leachate from the existing ash pile.

The 1988 groundwater data characterized only the uppermost zone of saturation near the proposed site. Its review indicated that the same general relationship between water quality and heavy metal parameters still exists after two years. A general diminishing of nitrate concentrations can be noted. Boron, an untested analyte in 1986, appeared in concentrations ranging from 1.0 ppm to 2.8 ppm (wells 45 and 70, respectively). Molybdenum was not detected. Wells 60 and 70 continued to exhibit extremely poor overall quality.

5.2.4 Chemical Attenuation of Leachate in Soil

A major concern in developing a waste disposal landfill is the potential generation and migration of toxic leachate. If highly mineralized subsurface leachate moves beyond the disposal site degradation of valuable groundwater supplies might occur. The leachate from the fly ash and bottom ash samples were generally comparable, in terms of overall quality, to the chemical composition of naturally-occurring groundwater at the Heskett site. An examination of Exhibits 2-A and 5-J shows that several of the major ions actually occurred at lower concentrations in the leachate than in the groundwater. Unit 1 bottom ash leachate appeared to be of much better quality than any groundwater sampled. Fly ash samples produced more highly mineralized (higher TDS) leachate than did bottom ash samples.

The overall quality of the existing groundwater at the proposed Heskett ash disposal site is brackish to saline with an average TDS concentration of 8,000 mg/L. The ash leachate produced using the modified EP toxicity test had an average TDS concentration of 6,500 mg/L. Consequently it may be expected that Heskett ash leachate will not significantly affect the TDS content of contaminated underlying groundwater even if soil buffer and attenuation mechanisms would be discounted.

The heavy metal analytes of primary concern in the leachate appear to be arsenic, cadmium, and lead. Sorptive, precipitation and co-precipitation processes are the major attenuation mechanisms that effect the concentration of these dissolved elements. Hassett and Groenewold (1986) studied trace element attenuation capabilities of coal-bearing Tertiary overburden deposits of central and western North Dakota. They found that the pH of a given leachate and the alkaline buffering capacity of the geologic media were the most critical variables in trace element attenuation. Western fly ash leachates are typically very alkaline with pH values approaching 13. In order to buffer such a solution either protons (H^+) must be added or hydroxyls (OH^-) must be removed. Oxides tend to loose protons in strongly alkaline solutions. This H^+ source, along with other acid producing reactions such as pyrite oxidation and organic decomposition, are the main alkaline buffering reactions. The protons that are liberated during these reactions will tend to neutralize the hydroxyl ions, thereby lowering the pH of the solution. The pH of the leachate will be buffered until it reaches equilibrium with the groundwater. In central and western North Dakota this equilibrium is generally attained at a pH value of between 7 and 9 (Groenewold et al., 1983; Koob and Groenewold, 1984).

Direct precipitation of cadmium and lead occur at pH values above 6.5. The solubility product of lead carbonate ($PbCO_3$) at 18°C is 3.3 X 10^{-14}. In groundwater systems which contain abundant carbonate lead will be precipitated as lead carbonate, thereby maintaining dissolved lead at low concentrations (Beaver, 1986 and 1987). The same type of reaction maintains cadmium at very low concentrations. Hassett and Groenewold (1986) found that cadmium was removed in excess of 99 percent during laboratory experiments with reduced and oxidized silts. Beaver (1986) confirmed the attenuation capabilities of similar geologic media during a coal ash field monitoring program near Center, North Dakota. He noted that several ions, including arsenic, cadmium and lead, were highly mobile under alkaline conditions within the ash itself. However, the alkaline leachate was buffered as soon as it came into contact with the surrounding clay and silt deposits. As the pH became lower the concentrations of cadmium and lead were greatly reduced (Beaver, 1986).

Arsenic attenuation is also controlled by solution pH. Laboratory experiments performed by Hassett and Groenewold (1986) have shown that arsenic, as As^{5+}, is significantly attenuated by the Tertiary sediments of western North Dakota. Arsenic appears to be most strongly attenuated in the pH range of 7-9. The mobility of selenium is similar to that of arsenic and the same attenuation processes control its concentration in groundwater systems. Sorptive processes appear responsible for arsenic attenuation in geologic media but the mechanisms of attenuation have not yet been well defined (Hassett and Groenewold, 1986). It does appear that cation and anion adsorption on clay particles and hydroxide coatings are important mechanisms in attenuating arsenic and other trace elements.

Hassett and Groenewold (1986) have shown that the clay, silt and sand sediments of central and western North Dakota have a strong capacity to buffer highly alkaline leachates and attenuate trace elements such as arsenic and selenium. The ash pile at Heskett station has been subjected to continuous leaching for the past 30 years. When the quality of the shallow groundwater in the vicinity of the ash pile (data currently on file with the Health Department) was compared to the proposed disposal site it was apparent that upgradient groundwater quality was similar to or of poorer quality than the water near the ash pile. Consequently, groundwater sampling data around the existing ash pile may support the Hassett and Groenewold conclusions if buffered and attenuated leachate from the ash pile is infiltrating underlying groundwater.

EXHIBIT 5-A

TOPOGRAPHY AND BOREHOLE/CROSS-SECTION LOCATIONS

EXHIBIT 5-B

GEOHYDROLOGIC CROSS-SECTIONS

(PLATES A THROUGH H)

EXHIBIT 5-C

WELL COMPLETION REPORTS

Well Number: 10

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CCD

Elevation: Ground; 1722.06 ft. Casing top; 1725.01 ft.
Well Bottom; 1604.01 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 120 ft.
Encountered water (below surface); 65 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.90-115.30 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 115.30-119.30 ft.
Elevation of interval; 1604.01-1608.01 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 114-120 ft.

Grout Seal: Depths (from ground); 0-114 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 51.97 ft. below top of casing
Elevation; 1673.04 ft.

Chemistry: Date; 8-21-86
pH; 7.75 Sp. cond; 11050 micromhos/cm
Temp; 8.9 oC

Well Number: 11

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CCD

Elevation: Ground; 1722.10 ft. Casing top; 1725.01 ft.
Well Bottom; 1642.81 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 80 ft.
Encountered water (below surface); 65 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.90-78.20 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 78.20-82.20 ft.
Elevation of interval; 1642.81-1646.81 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 77-79 ft.

Grout Seal: Depths (from ground); 0-77 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 43.83 ft. below top of casing
Elevation; 1681.18 ft.

Chemistry: Date; 8-21-86
pH; 7.75 Sp. cond; 9840 micromhos/cm
Temp; 8.6 oC

Well Number: 12

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CCD

Elevation: Ground; 1721.88 ft. Casing top; 1724.90 ft.
Well Bottom; 1643.51 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 80 ft.
Encountered water (below surface); 65 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.02-58.37 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 58.37-78.37 ft.
Elevation of interval; 1643.51-1663.51 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 57-79 ft.

Grout Seal: Depths (from ground); 0-57 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 43.60 ft. below top of casing
Elevation; 1681.30 ft.

Chemistry: Date; 8-21-86
pH; 7.60 Sp. cond; 11440 micromhos/cm
Temp; 8.5 oC

Well Number: 13

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CCD

Elevation: Ground; 1721.88 ft. Casing top; 1724.90 ft.
Well Bottom; 1681.88 ft.

Completion: Date drilled; 11-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 40 ft.
Encountered water (below surface); ? ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.02-20.37 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC Depths (from ground); 20.37-40.37 ft.
Elevation of interval; 1681.51-1701.51 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 19-41 ft.

Grout Seal: Depths (from ground); 0-19 ft.
Date sealed; 1-27-87

Additional Data:
Static Water Level: Date; 12-15-86
Depth; 30.09 ft. below top of casing
Elevation; 1694.81 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA
Temp; NA

Well Number: 20

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CAC

Elevation: Ground; 1707.04 ft. Casing top; 1709.48 ft.
Well Bottom; 1627.48 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 80 ft.
Encountered water (below surface); 45 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.44-75.56 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 75.56-79.56 ft.
Elevation of interval; 1627.48-1631.48 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 74-80 ft.

Grout Seal: Depths (from ground); 0-74 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 37.96 ft. below top of casing
Elevation; 1671.52 ft.

Chemistry: Date; 8-21-86
pH; 7.98 Sp. cond; 4970 micromhos/cm
Temp; 8.7 oC

Well Number: 21

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CAC

Elevation: Ground; 1707.22 ft. Casing top; 1709.40 ft.
Well Bottom; 1661.90 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;

Boring: Diameter; 5 5/8 in. Depth drilled; 50 ft.
Encountered water (below surface); 45 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.66-21.32 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 21.32-45.32 ft.
Elevation of interval; 1661.90-1685.90 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 20-46 ft.

Grout Seal: Depths (from ground); 0-20 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 29.33 ft. below top of casing
Elevation; 1680.07 ft.

Chemistry: Date; 8-21-86
pH; 6.95 Sp. cond; 13920 micromhos/cm
Temp; 8.5 oC

Well Number: 30

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CBA

Elevation: Ground; 1715.55 ft. Casing top; 1717.64 ft.
Well Bottom; 1595.64 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 120 ft.
Encountered water (below surface); 60 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.90-115.91 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 115.91-119.91 ft.
Elevation of interval; 1595.64-1599.64 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 114-120 ft.

Grout Seal: Depths (from ground); 0-114 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 49.41 ft. below top of casing
Elevation; 1668.23 ft.

Chemistry: Date; 8-21-86
pH; 7.95 Sp. cond; 1993 micromhos/cm
Temp; 8.6 oC

Well Number: 31

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CBA

Elevation: Ground; 1715.24 ft. Casing top; 1717.58 ft.
Well Bottom; 1635.58 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 80 ft.
Encountered water (below surface); 60 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.34-75.66 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 75.66-79.66 ft.
Elevation of interval; 1635.58-1639.58 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 74-80 ft.

Grout Seal: Depths (from ground); 0-74 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 43.54 ft. below top of casing
Elevation; 1674.04 ft.

Chemistry: Date; 8-21-86
pH; 7.96 Sp. cond; 1993 micromhos/cm
Temp; 7.8 oC

Well Number: 32

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CBA

Elevation: Ground; 1715.34 ft. Casing top; 1717.79 ft.
Well Bottom; 1641.69 ft.

Completion: Date drilled; 8-12-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 80 ft.
Encountered water (below surface); 60 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.45-53.65 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 53.65-73.65 ft.
Elevation of interval; 1641.69-1661.69 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 52-75 ft.

Grout Seal: Depths (from ground); 0-52 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 42.03 ft. below top of casing
Elevation; 1675.76 ft.

Chemistry: Date; 8-21-86
pH; 7.22 Sp. cond; 3000 micromhos/cm
Temp; 8.0 oC

Well Number: 33

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CBA

Elevation: Ground; 1715.34 ft. Casing top; 1717.79 ft.
Well Bottom; 1672.79 ft.

Completion: Date drilled; 11-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 45 ft.
Encountered water (below surface); ? ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.45-25.65 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 25.65-45.65 ft.
Elevation of interval; 1669.69-1689.69 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 24-45 ft.

Grout Seal: Depths (from ground); 0-24 ft.
Date sealed; 1-27-87

Additional Data:
Static Water Level: Date; 12-15-86
Depth; 40.68 ft. below top of casing
Elevation; 1677.11 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA
Temp; NA

Well Number: 40

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDB

Elevation: Ground; 1708.02 ft. Casing top; 1710.15 ft.
Well Bottom; 1592.25 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry; some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 120 ft.
Encountered water (below surface); 50 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.13-111.77 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 111.77-115.77 ft.
Elevation of interval; 1592.25-1596.25 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 110-117 ft.

Grout Seal: Depths (from ground); 0-117 ft.
Date sealed; 8-13-86

Additional Data:

Static Water Level: Date; 8-21-86
Depth; 63.72 ft. below top of casing
Elevation; 1646.43 ft.

Chemistry: Date; 8-21-86
pH; 7.58 Sp. cond; 6260 micromhos/cm
Temp; 8.2 oC

Well Number: 41

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDB

Elevation: Ground; 1708.03 ft. Casing top; 1710.07 ft.
Well Bottom; 1626.77 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 82 ft.
Encountered water (below surface); 50 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.04-77.26 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 77.26-81.26 ft.
Elevation of interval; 1626.77-1630.77 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 76-82 ft.

Grout Seal: Depths (from ground); 0-76 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 36.58 ft. below top of casing
Elevation; 1673.49 ft.

Chemistry: Date; 8-21-86
pH; 7.57 Sp. cond; 5480 micromhos/cm
Temp; 8.4 oC

Well Number: 42

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDB

Elevation: Ground; 1708.12 ft. Casing top; 1710.31 ft.
Well Bottom; 1652.61 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 60 ft.
Encountered water (below surface); 50 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.19-35.51 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 35.51-55.51 ft.
Elevation of interval; 1652.61-1672.61 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 34-56 ft.

Grout Seal: Depths (from ground); 0-34 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 32.88 ft. below top of casing
Elevation; 1677.43 ft.

Chemistry: Date; 8-21-86
pH; 7.22 Sp. cond; 5060 micromhos/cm
Temp; 8.6 oC

Well Number: 43

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDD

Elevation: Ground; 1708.92 ft. Casing top; 1711.03 ft.
Well Bottom; 1650.14 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 60 ft.
Encountered water (below surface); 25 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.11-54.78 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 54.78-58.78 ft.
Elevation of interval; 1650.14-1654.14 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 53-59 ft.

Grout Seal: Depths (from ground); 0-53 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 25.85 ft. below top of casing
Elevation; 1685.18 ft.

Chemistry: Date; 10-4-86
pH; 6.70 Sp. cond; 6950 micromhos/cm
Temp; 8.5 oC

Well Number: 44

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDD

Elevation: Ground; 1709.09 ft. Casing top; 1711.40 ft.
Well Bottom; 1685.88 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 25 ft.
Encountered water (below surface); 25 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.31-3.21 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 3.21-23.54 ft.
Elevation of interval; 1685.88-1705.88 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 2.5-24.0 ft.

Grout Seal: Depths (from ground); 0-2.5 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 21.92 ft. below top of casing
Elevation; 1689.48 ft.

Chemistry: Date; 10-4-86
pH; 6.72 Sp. cond; 10270 micromhos/cm
Temp; 9.1 oC

Well Number: 45

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDB

Elevation: Ground; 1708.12 ft. Casing top; 1710.31 ft.
Well Bottom; 1668.12 ft.

Completion: Date drilled; 11-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;

Boring: Diameter; 5 5/8 in. Depth drilled; 40 ft.
Encountered water (below surface); ? ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.19-20.51 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 20.51-40.51 ft.
Elevation of interval; 1667.61-1687.61 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 19-41 ft.

Grout Seal: Depths (from ground); 0-19 ft.
Date sealed; 1-27-86

Additional Data:
Static Water Level: Date; 12-15-86
Depth; 28,71 ft. below top of casing
Elevation; 1681.60 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA
Temp; NA

Well Number: 50

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CAD

Elevation: Ground; 1674.58 ft. Casing top; 1677.01 ft.
Well Bottom; 1647.51 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry; some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 30 ft.
Encountered water (below surface); 17 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.43-7.07 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 7.07-27.07 ft.
Elevation of interval; 1647.51-1667.51 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 6-29 ft.

Grout Seal: Depths (from ground); 0-6 ft.
Date sealed; 8-13-86

Additional Data:

Static Water Level: Date; 8-21-86
Depth; 5.45 ft. below top of casing
Elevation; 1671.56 ft.

Chemistry: Date; 8-21-86
pH; 7.56 Sp. cond; 6480 micromhos/cm
Temp; 10.8 oC

Well Number: 51

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CAD

Elevation: Ground; 1674.47 ft. Casing top; 1676.70 ft.
Well Bottom; 1637.33 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 40 ft.
Encountered water (below surface); 18 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.23-32.14 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 32.14-37.14 ft.
Elevation of interval; 1637.33-1642.33 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 31-38 ft.

Grout Seal: Depths (from ground); 0-31 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 5.77 ft. below top of casing
Elevation; 1670.93 ft.

Chemistry: Date; 10-4-86
pH; 7.46 Sp. cond; 3700 micromhos/cm
Temp; 8.2 oC

Well Number: 52

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CAD

Elevation: Ground; 1674.45 ft. Casing top; 1676.71 ft.
Well Bottom; 1658.01 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 20 ft.
Encountered water (below surface); 18 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.26-6.44 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 6.44-16.44 ft.
Elevation of interval; 1658.01-1668.01 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 5-18 ft.

Grout Seal: Depths (from ground); 0-5 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 4.13 ft. below top of casing
Elevation; 1672.58 ft.

Chemistry: Date; 10-4-86
pH; 7.29 Sp. cond; 6300 micromhos/cm
Temp; 9.4 oC

Well Number: 53

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DCC

Elevation: Ground; 1685.71 ft. Casing top; 1688.17 ft.
Well Bottom; 1665.70 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 21 ft.
Encountered water (below surface); 15 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.46-5.01 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 5.01-20.01 ft.
Elevation of interval; 1665.70-1680.70 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 4-21 ft.

Grout Seal: Depths (from ground); 0-4 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 6.30 ft. below top of casing
Elevation; 1681.87 ft.

Chemistry: Date; 10-4-86
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: 54

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DCC

Elevation: Ground; 1685.71 ft. Casing top; 1688.10 ft.
Well Bottom; 1633.11 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 60 ft.
Encountered water (below surface); 15 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.39-47.60 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 47.60-52.60 ft.
Elevation of interval; 1633.11-1638.11 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 46-54 ft.

Grout Seal: Depths (from ground); 0-46 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 15.16 ft. below top of casing
Elevation; 1672.94 ft.

Chemistry: Date; 10-4-86
pH; 9.55 Sp. cond; 1100 micromhos/cm
Temp; 9.8 oC

Well Number: 55

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DCA

Elevation: Ground; 1693.86 ft. Casing top; 1696.10 ft.
Well Bottom; 1636.95 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 60 ft.
Encountered water (below surface); 45 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.24-31.91 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 31.91-56.91 ft.
Elevation of interval; 1636.95-1661.95 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 30-58 ft.

Grout Seal: Depths (from ground); 0-30 ft.
Date sealed; 9-18-86

Additional Data:

Static Water Level: Date; 10-4-86
Depth; 29.46 ft. below top of casing
Elevation; 1666.64 ft.

Chemistry: Date; 10-4-86
pH; 6.81 Sp. cond; 10840 micromhos/cm
Temp; 8.5 oC

Well Number: 56

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-80-10DCA

Elevation: Ground; 1693.86 ft. Casing top; 1696.42 ft.
Well Bottom; 1597.99 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 100 ft.
Encountered water (below surface); 45 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.56-91.87 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 91.87-96.87 ft.
Elevation of interval; 1597.99-1601.99 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 90-98 ft.

Grout Seal: Depths (from ground); 0-90 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 42.03 ft. below top of casing
Elevation; 1654.39 ft.

Chemistry: Date; 10-4-86
pH; 8.44 Sp. cond; 4160 micromhos/cm
Temp; 8.3 oC

Well Number: 60

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-18-10CDB

Elevation: Ground; 1714.23 ft. Casing top; 1716.42 ft.
Well Bottom; 1662.02 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 60 ft.
Encountered water (below surface); 45 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.19-22.21 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 22.21-52.21 ft.
Elevation of interval; 1662.02-1692.02 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 21-54 ft.

Grout Seal: Depths (from ground); 0-21 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 31.01 ft. below top of casing
Elevation; 1685.41 ft.

Chemistry: Date; 8-21-86
pH; 6.94 Sp. cond; 15760 micromhos/cm
Temp; 8.5 oC

Well Number: 61

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDA

Elevation: Ground; 1714.23 ft. Casing top; 1716.53 ft.
Well Bottom; 1670.89 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 46 ft.
Encountered water (below surface); 37 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.30-13.34 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 13.34-43.34 ft.
Elevation of interval; 1670.89-1700.89 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 12-45 ft.

Grout Seal: Depths (from ground); 0-12 ft.
Date sealed; 9-18-86

Additional Data:

Static Water Level: Date; 10-4-86
Depth; 32.58 ft. below top of casing
Elevation; 1683.95 ft.

Chemistry: Date; 10-4-86
pH; 6.83 Sp. cond; 12750 micromhos/cm
Temp; 8.4 oC

Well Number: 62

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10CDB

Elevation: Ground; 1714.32 ft. Casing top; 1716.67 ft.
Well Bottom; 1681.40 ft.

Completion: Date drilled; 9-18-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry

Boring: Diameter; 5 5/8 in. Depth drilled; 35 ft.
Encountered water (below surface); 35 ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.35-12.92 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 12.92-32.91 ft.
Elevation of interval; 1681.40-1701.40 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 11-34 ft.

Grout Seal: Depths (from ground); 0-11 ft.
Date sealed; 9-18-86

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 32.74 ft. below top of casing
Elevation; 1683.93 ft.

Chemistry: Date; 10-4-86
pH; 6.71 Sp. cond; 13170 micromhos/cm
Temp; 9.3 oC

Well Number: 70

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-16ABA

Elevation: Ground; 1733.18 ft. Casing top; 1735.67 ft.
Well Bottom; 1634.57 ft.

Completion: Date drilled; 8-13-86
Driller; Mohl Drilling, Beulah, ND
Method of drilling; Air rotary, dry;
some air-mist

Boring: Diameter; 5 5/8 in. Depth drilled; 102 ft.
Encountered water (below surface); 45 ft.
Geophysical log recorded

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.49-94.61 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 94.61-98.61 ft.
Elevation of interval; 1634.57-1638.57 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 93-99 ft.

Grout Seal: Depths (from ground); 0-93 ft.
Date sealed; 8-13-86

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 54.20 ft. below top of casing
Elevation; 1681.47 ft.

Chemistry: Date; 8-21-86
pH; 7.85 Sp. cond; 13000 micromhos/cm
Temp; 10.1 oC

Well Number: (WS1)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-DBB

Elevation: Ground; 1679.61 ft. Casing top; 1681.71 ft.
Well Bottom; 1606.73 ft.
Repaired casing top (1-13-86); 1683.67 ft.

Completion: Date drilled; 9-22-81
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 73 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +2.7-40, 45-73 ft.
(as of 1-13-87); +4.7-40, 45-73 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 40-45 ft.
Elevation of interval; 1634.61-1639.61 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 37-47 ft.

Grout Seal: Depths (from ground); 0-37 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 24.61 ft. below top of casing
Elevation; 1657.10 ft.

Chemistry: Date; 8-21-86
pH; 7.47 Sp. cond; 1899 micromhos/cm
Temp 7.0 oC

Well Number: (WS1A)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-DBB

Elevation: Ground; 1679.10 ft. Casing top; 1682.23 ft.
Well Bottom; 1657.10 ft.

Completion: Date drilled; 8-5-85
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 23 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.2-17 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 17-22 ft.
Elevation of interval; 1657.10-1662.10 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 15-23 ft.

Grout Seal: Depths (from ground); 0-15 ft.
Date sealed; NA

Additional Data:

Static Water Level: Date; 8-21-86
Depth; DRY ft. below top of casing
Elevation; ft.

Chemistry: Date: 8-21-86
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: (WS1B)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBB

Elevation: Ground; 1678.80 ft. Casing top; 1682.07 ft.
Well Bottom; 1648.80 ft.

Completion: Date drilled; 8-6-85
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 30 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.3-25 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 25-30 ft.
Elevation of interval; 1648.80-1653.80 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 23-30 ft.

Grout Seal: Depths (from ground); 0-22 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 8-21-86
Depth; 24.48 ft. below top of casing
Elevation; 1657.59 ft.

Chemistry: Date; 8-21-86
pH; 7.07 Sp. cond; 3940 micromhos/cm
Temp; 8.5 oC

Well Number: (WS2)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DCC

Elevation: Ground; 1696.00 ft. Casing top; 1698.64 ft.
Well Bottom; 1607.00 ft.

Completion: Date drilled; 9-23-81
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 90 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3-56, 61-89 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 56-61 ft.
Elevation of interval; 1635.00-1640.00 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 53-62 ft.

Grout Seal: Depths (from ground); 0-52 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 33.86 ft. below top of casing
Elevation; 1664.78 ft.

Chemistry: Date; 8-21-86
pH; 7.04 Sp. cond; 3760 micromhos/cm
Temp; 8.6 oC

Well Number: (WS3)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBA

Elevation: Ground; 1658.00 ft. Casing top; 1661.00 ft.
Well Bottom; 1608.00 ft.

Completion: Date drilled; 9-21-81
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 50 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3-25, 30-50 ft.

Screen: Diameter; 2 in. Slot size; 20

Material; Factory slotted PVC
Depths (from ground); 25-30 ft.
Elevation of interval; 1628.00-1633.00 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 24-32 ft.

Grout Seal: Depths (from ground); 0-23 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 9-4-86
Depth; 14.67 ft. below top of casing
Elevation; 1646.33 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: (WS3A)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBA

Elevation: Ground; 1657.70 ft. Casing top; 1660.81 ft.
Well Bottom; 1645.31 ft.

Completion: Date drilled; 8-5-85
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 13 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.1-7.5 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 7.5-12.5 ft.
Elevation of interval; 1645.31-1650.31 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 6-13 ft.

Grout Seal: Depths (from ground); 0-6 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 10-4-86
Depth; 8.37 ft. below top of casing
Elevation; 1652.44 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: (WS4)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBA

Elevation: Ground; 1659.61 ft. Casing top; 1662.61 ft.
Well Bottom; 1607.60 ft.

Completion: Date drilled; 9-24-81
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 52 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3-30, 35-52 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 30-35 ft.
Elevation of interval; 1624.60-1629.60 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 27-36 ft.

Grout Seal: Depths (from ground); 0-26 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 9-4-86
Depth; 19.62 ft. below top of casing
Elevation; 1642.99 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: (WS4A)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBA

Elevation: Ground; 1659.49 ft. Casing top; 1662.49 ft.
Well Bottom; 1641.50 ft.

Completion: Date drilled; 9-24-81
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 18 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3-13 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 13-18 ft.
Elevation of interval; 1641.50-1646.50 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 11-18 ft.

Grout Seal: Depths (from ground); 0-11 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 9-4-86
Depth; 17.29 ft. below top of casing
Elevation; 1645.20 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

Well Number: (WS4B)

Project: MDU Ash Disposal Program

Construction Data:

Location: 139-81-10DBA

Elevation: Ground; 1659.75 ft. Casing top; 1662.75 ft.
Well Bottom; 1635.80 ft.

Completion: Date drilled; 8-5-85
Driller; Water Supply, Inc.
Method of drilling; NA

Boring: Diameter; NA in. Depth drilled; 25 ft.
Encountered water (below surface); NA ft.

Casing: Diameter; 2 in. Material; Sch. 40 PVC
Depths (from ground); +3.1-19.0 ft.

Screen: Diameter; 2 in. Slot size; 20
Material; Factory slotted PVC
Depths (from ground); 19-24 ft.
Elevation of interval; 1635.80-1640.80 ft.

Sand Pack: Type of sand; Washed sand
Depths (from ground); 18-25 ft.

Grout Seal: Depths (from ground); 0-18 ft.
Date sealed; NA

Additional Data:
Static Water Level: Date; 9-4-86
Depth; 17.39 ft. below top of casing
Elevation; 1645.36 ft.

Chemistry: Date; NA
pH; NA Sp. cond; NA micromhos/cm
Temp; NA oC

EXHIBIT 5-D

GEOPHYSICAL LOGS

EXHIBIT 5-E

LITHOLOGIC LOGS

Wells 10, 11, 12 and 13

0-1	Top soil, silty, clayey, sandy, brown, calcareous; with some limestone pebbles.
1-11	Silt, clayey, brownish-tan, slightly indurated, very dry, calcareous; with thin coarse-grained, clean silt lenses and a few small (less than .5 in.) iron oxide concretions. Abundant small gypsum crystals (less than .13 in. long). Some small, black flakes of organic plant material. Cannonball-Ludlow Formations.
11-14	Silt, as above, with some (less than 20%) very fine- to fine-grained sand interspersed.
14-30	Silt, as above, clayey, less sand than above interval, oxidized; with very fine-grained silty sand lenses and very few gypsum crystals.
30-41	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with fewer small gypsum crystals than above intervals.
41-59	Silt, as above, very clayey, with some (less than 20%) fine- to medium-grained sand interspersed in a silt and clay matrix.
59-65	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
65-81	Silt, clayey, steel-gray to bluish, moderately indurated; with thin coarse-grained silt to very fine-grained sand lenses in an otherwise fine silt to clay matrix.
81-84	Clay, silty, steel-gray to bluish, moderately indurated, dense.
84-91	Siltstone, sandy, clayey, steel-gray to bluish, slightly indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.
91-110	Silt, clayey, bluish-gray, moderately indurated; with thin (less than 1 foot) mudstone lenses.
110-120	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

Wells 20 and 21

0-1	Top soil, silty, sandy, clayey, dark-brown, calcareous; with some limestone and granite pebbles.
1-21	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.
21-26	Silt, as above, steel-gray (color change).
26-49	Silt, clayey, with some (less than 20%) very fine- to medium-grained sand interspersed, steel-gray to bluish, slightly indurated; with very few small gypsum crystals and some thin (less than 1 foot) siltstone lenses.
49-53	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
53-63	Silt, as above, clayey, less sand, with thin (less than 1 foot) siltstone to mudstone lenses.
63-80	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

Wells 30, 31, 32 and 33

0-1	Top soil, silty, sandy, brownish, calcareous; with some granite and limestone pebbles.
1-2	Pebble-loam (glacial till), silty, sandy, clayey, yellowish-brown, dry, calcareous.
2-31	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions. Some small, black flakes organic plant material. Cannonball-Ludlow Formations.
31-44	Silt, clayey, steel-gray (color change), slightly indurated, calcareous; with small iron oxide concretions, thin coarse silt lenses, small gypsum crystals and gray to reddish-brown mottling.

44-61	Silt, as above, with some (less than 20%) fine- to medium-grained sand interspersed.
61-65	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed, dense.
65-76	Silt, as above, clayey, less sand, some thin (less than 1 foot) lenses of siltstone to mudstone.
76-80	Siltstone, sandy, clayey, steel-gray to bluish, slightly indurated; with small fine-grained sand lenses and abundant (more than 20%) fine-grained sand interspersed in the matrix.
80-92	Silt, clayey, steel-gray to bluish, moderately indurated, with some (less than 20%) very fine- to fine grained sand interspersed.
92-120	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

<u>Well 40</u>

0-1	Top soil, sandy, silty, brownish-tan, calcareous; with some granite and limestone pebbles.
1-5	Pebble-loam (glacial till), sandy, silty, with detrital lignite and organic matter, yellowish-brown, very dry, calcareous.
5-22	Sand, very fine- to medium-grained, unconsolidated, with thin lenses of clay and detrital lignite, brownish-yellow, calcareous.
22-40	Silt, clayey, with minor amounts (less than 10%) very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions and small gypsum crystals; Cannonball-Ludlow Formations.
40-51	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with some reddish-brown mottling and some very thin (less than 6 inches) mudstone lenses.
51-58	Silt, as above, with abundant (more than 20%) fine-grained sand and thin silty-clay lenses.

58-62 Siltstone, sandy, clayey, steel-gray to bluish, moderately indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.

62-70 Silt, clayey, with some (less than 20%) fine- to medium-grained sand interspersed, steel-gray to bluish, moderately indurated; with thin (less than 2 feet) sandy lenses.

70-80 Silt, as above, very clayey, some (less than 10%) fine-grained sand interspersed; less sand than above interval.

80-120 Silt, as above, dark-steel-gray. Cannonball-Ludlow Formations.

Wells 41, 42 and 43

0-1 Top soil, sandy, silty, dark-brown, calcareous; with some granite and limestone pebbles.

1-4 Pebble-loam (glacial till), sandy, silty, clayey, yellowish-brown, very dry, calcareous.

4-40 Silt, clayey, with some (less than 20%) very fine-grained sand interspersed, brownish-tan, unconsolidated, noncompacted, calcareous to 25 feet, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.

40-51 Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with some reddish-brown mottling and some very thin (less than 6 inches) mudstone lenses.

51-58 Silt, as above, with abundant (more than 20%) fine-grained sand and thin silty-clay lenses.

58-62 Siltstone, sandy, clayey, steel-gray to bluish, moderately indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.

62-70 Silt, clayey, with some (less than 20%) fine- to medium-grained sand interspersed, steel-gray to bluish, moderately indurated; with thin (less than 2 feet) sandy lenses.

30-40	Silt, as above, very clayey, less sand than above interval, dark-steel-gray. Cannonball-Ludlow Formations.

<u>Wells 53 and 54</u>

0-4	Top soil, clayey, silty, very dark-brown, wet, sticky.
4-15	Clay, silty, with some (less than 20%) fine- to medium-grained sand interspersed, brownish-tan, slightly indurated, dry, calcareous; with small iron oxide concretions, small gypsum crystals and occasional reddish-brown mottling; Cannonball-Ludlow Formations.
15-20	Sand, very fine-grained to medium-grained, silty, clayey, unconsolidated, yellowish-brown, oxidized.
20-30	Silt, clayey, with some (less than 20%) fine-grained sand interspersed, steel-gray (color change), slightly indurated; with clay and sand lenses, some small concretions and some small gypsum crystals.
30-45	Silt, as above, very clayey.
45-60	Silt, as above, clayey, brownish-gray, moderately indurated, some reddish-brown mottling. Cannonball-Ludlow Formations.

<u>Wells 55 and 56</u>

0-5	Sandy-loam (glacial), with fine- to medium-grained sand, silty, calcareous; with small granite and limestone pebbles.
5-26	Clay, silty, with minor amounts (less than 10%) of very fine-grained sand, dark-brownish-tan, moderately indurated, brittle, very dry, calcareous; with small iron oxide concretions, small gypsum crystals and occasional thin sandstone laminae. Some small, black flakes of organic plant material. Cannonball-Ludlow Formations.
26-35	Clay, as above, very silty, sandy, brownish-tan, oxidized.

35-40	Silt, clayey, with some (less than 20%) very fine- to fine-grained sand interspersed, steel-gray (color change) moderately indurated; with small gypsum crystals and occasional clay lenses.
40-60	Silt, as above, with minor amounts (less than 10%) of fine-grained sand interspersed.
60-85	Silt, as above, clayey, less sand than above interval.
85-100	Silt, as above, very clayey, with minor amounts (less than 10%) of sand interspersed, light-gray. Cannonball-Ludlow Formations.

Wells 60, 61 and 62

0-2	Top soil, silty, clayey, dark-brown to tanish-brown, calcareous.
2-25	Silt, very clayey, with some minor amounts (less than 10%) of very fine- to fine-grained sand interspersed, brownish-tan, slightly indurated, dry, calcareous; with abundant small gypsum crystals and thin silt and sand lenses; Cannonball-Ludlow Formations.
25-29	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
29-36	Silt, as above, clayey, less sand than above interval, dark-brownish-tan, oxidized.
36-60	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with thin (less than 1 foot) sandy-silt lenses. Cannonball-Ludlow Formations.

Well 70 0-2 Pebble-loam (glacial till), clayey, sandy, yellowish-brown, unconsolidated, damp, calcareous.

2-21	Silty, clayey, with some (less than 20%) fine-grained sand interspersed, brownish-tan, moderately indurated, very dry, calcareous, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.

21-24	Shale, silty, steel- to dark-gray (color change), indurated, fissile, very dry; with occasional thin silt and sand lenses.
24-31	Silt, clayey, with abundant (more than 30%) sand, steel-gray, moderately indurated.
31-62	Silt, clayey, with some (less than 20%) very fine- to fine- grained sand interspersed, steel-gray, moderately indurated; with some small gypsum crystals and small iron oxide concretions.
62-76	Silt, as above, with some (less than 20%) fine-grained sand interspersed.
76-82	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand.
82-100	Silt, as above, clayey, with some (less than 20%) fine-grained sand interspersed, dark-gray. Cannonball-Ludlow Formations.

EXHIBIT 5-F

SITE SOILS CLASSIFICATION MAP

EXHIBIT 5-G

WATER LEVEL DATA

HESKETT SWL INFORMATION

WELL DATA

WELL NO.	TOP OF CASE	GROUND SURFACE	SCREENED		INTERVAL	CASING HEIGHT
10	1725.01	1722.06	1604.01	to	1608.01	2.95
11	1725.01	1722.10	1642.81	to	1646.81	2.91
12	1724.90	1721.88	1643.51	to	1663.51	3.02
13	1724.98	1721.80	1681.51	to	1701.51	3.18
20	1709.48	1707.04	1627.48	to	1631.48	2.44
21	1709.40	1707.22	1661.90	to	1685.90	2.18
30	1717.64	1715.55	1595.64	to	1599.64	2.09
31	1717.58	1715.24	1635.58	to	1639.58	2.34
32	1717.79	1715.34	1641.69	to	1661.69	2.45
33	1717.91	1715.48	1669.69	to	1689.69	2.43
40	1710.15	1708.02	1592.25	to	1596.25	2.13
41	1710.07	1708.03	1626.77	to	1630.77	2.04
42	1710.31	1708.12	1652.61	to	1672.61	2.19
43	1711.03	1708.92	1650.14	to	1654.14	2.11
44	1711.40	1709.09	1685.88	to	1705.88	2.31
45	1710.17	1708.34	1667.61	to	1687.61	1.83
50	1677.01	1674.58	1647.51	to	1667.51	2.43
51	1676.70	1674.47	1637.33	to	1642.33	2.23
52	1676.71	1674.45	1658.01	to	1668.01	2.26
53	1688.17	1685.71	1665.70	to	1680.70	2.46
54	1688.10	1685.71	1633.11	to	1638.11	2.39
55	1696.10	1693.86	1636.95	to	1661.95	2.24
56	1696.42	1693.86	1597.99	to	1601.99	2.56
60	1716.42	1714.23	1662.02	to	1692.02	2.19
61	1716.53	1714.23	1670.89	to	1700.89	2.30
62	1716.67	1714.32	1681.40	to	1701.40	2.35
70	1735.67	1733.18	1634.57	to	1638.57	2.49
WS2	1698.64	1696.00	1635.00	to	1640.00	2.64
WS1	1681.71	1679.61	1634.61	to	1639.61	2.10
WS1	1683.67 as of 1-3-87					4.06
WS1A	1682.23	1679.10	1657.10	to	1662.10	3.13
WS1B	1682.07	1678.80	1648.80	to	1653.80	3.27
WS4	1662.61	1659.61	1624.60	to	1629.60	3.00
WS4A	1662.49	1659.49	1641.50	to	1646.50	3.00
WS4B	1662.75	1659.75	1635.80	to	1640.80	3.00
WS3	1661.00	1658.00	1628.00	to	1633.00	3.00
WS3A	1660.81	1657.70	1645.31	to	1650.31	3.11

CASING ON WELL WS1 WAS REPAIRED IN JANUARY,1987

ALL VALUES ARE IN FEET ABOVE MEAN SEA LEVEL

SWL-TOP = STATIC WATER LEVEL (in feet) FROM TOP OF CASING
SWL-MSL = STATIC WATER LEVEL (in feet) AT MEAN SEA LEVEL
SWL-BLS = STATIC WATER LEVEL (in feet) BELOW LAND SURFACE

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
10	9-11-86	51.64	1673.37	48.69
	10-16-86	53.32	1671.69	50.37
	11-21-86	53.58	1671.43	50.63
	1-13-87	53.71	1671.30	50.76
	3-6-87	53.61	1671.40	50.66
	4-21-87	53.45	1671.56	50.50
	6-3-87	53.48	1671.53	50.53
	5-11-88	54.79	1670.22	51.84
	9-12-88	55.05	1669.96	52.10
	1-4-89	56.33	1668.68	53.38
11	9-11-86	42.42	1682.59	39.51
	10-16-86	41.47	1683.54	38.56
	11-21-86	40.88	1684.13	37.97
	1-13-87	40.72	1684.29	37.81
	3-6-87	40.59	1684.42	37.68
	4-21-87	40.72	1684.29	37.81
	6-3-87	40.65	1684.36	37.74
	5-11-88	42.62	1682.39	39.71
	9-12-88	43.67	1681.34	40.76
	1-4-89	44.10	1680.91	41.19
12	9-11-86	42.42	1682.48	39.40
	10-16-86	40.55	1684.35	37.53
	11-21-86	40.00	1684.90	36.98
	1-13-87	39.86	1685.04	36.84
	3-6-87	39.77	1685.13	36.75
	4-21-87	39.83	1685.07	36.81
	6-3-87	39.90	1685.00	36.88
	5-11-88	41.90	1683.00	38.88
	9-12-88	43.21	1681.69	40.19
	1-4-89	43.37	1681.53	40.35
13	12-15-86	30.09	1694.89	26.91
	1-13-87	29.99	1694.99	26.81
	3-6-87	30.15	1694.83	26.97
	4-21-87	29.92	1695.06	26.74
	6-3-87	29.86	1695.12	26.68
	5-11-88	31.27	1693.71	28.09
	9-12-88	31.53	1693.45	28.35
	1-4-89	31.69	1693.29	28.51

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
20	9-11-86	37.17	1672.31	34.73
	10-16-86	36.85	1672.63	34.41
	11-21-86	36.75	1672.73	34.31
	1-13-87	36.68	1672.80	34.24
	3-6-87	35.09	1674.39	32.65
	4-21-87	35.73	1673.75	33.29
	6-3-87	35.93	1673.55	33.49
	5-11-88	37.93	1671.55	35.49
	9-12-88	39.80	1669.68	37.36
	1-4-89	40.16	1669.32	37.72
21	9-11-86	29.17	1680.23	26.99
	10-16-86	28.94	1680.46	26.76
	11-21-86	28.61	1680.79	26.43
	1-13-87	28.51	1680.89	26.33
	3-6-87	28.41	1680.99	26.23
	4-21-87	27.95	1681.45	25.77
	6-3-87	28.12	1681.28	25.94
	5-11-88	30.77	1678.63	28.59
	9-12-88	32.22	1677.18	30.04
	1-4-89	33.07	1676.33	30.89

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
30	9-11-86	49.38	1668.26	47.29
	10-16-86	49.35	1668.29	47.26
	11-21-86	49.28	1668.36	47.19
	1-13-87	49.15	1668.49	47.06
	3-6-87	48.53	1669.11	46.44
	4-21-87	48.10	1669.54	46.01
	6-3-87	48.36	1669.28	46.27
	5-11-88	50.36	1667.28	48.27
	9-12-88	51.97	1665.67	49.88
	1-4-89	52.40	1665.24	50.31
31	9-11-86	43.21	1674.37	40.87
	10-16-86	43.74	1673.84	41.40
	11-21-86	43.74	1673.84	41.40
	1-13-87	43.41	1674.17	41.07
	3-6-87	42.59	1674.99	40.25
	4-21-87	42.26	1675.32	39.92
	6-3-87	42.59	1674.99	40.25
	5-11-88	45.01	1672.57	42.67
	9-12-88	46.88	1670.70	44.54
	1-4-89	47.31	1670.27	44.97
32	9-11-86	42.52	1675.27	40.07
	10-16-86	42.03	1675.76	39.58
	11-21-86	41.87	1675.92	39.42
	1-13-87	41.18	1676.61	38.73
	3-6-87	40.29	1677.50	37.84
	4-21-87	40.00	1677.79	37.55
	6-3-87	40.39	1677.40	37.94
	5-11-88	43.18	1674.61	40.73
	9-12-88	45.18	1672.61	42.73
	1-4-89	45.65	1672.14	43.20
33	12-15-86	40.68	1677.23	38.25
	1-13-87	40.72	1677.19	38.29
	3-6-87	39.73	1678.18	37.30
	4-21-87	39.01	1678.90	36.58
	6-3-87	39.54	1678.37	37.11
	5-11-88	42.06	1675.85	39.63
	9-12-88	43.57	1674.34	41.14
	1-4-89	44.03	1673.88	41.60

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
40	9-11-86	63.82	1646.33	61.69
	10-16-86	63.68	1646.47	61.55
	11-21-86	63.29	1646.86	61.16
	1-13-87	63.39	1646.76	61.26
	3-6-87	63.06	1647.09	60.93
	4-21-87	63.16	1646.99	61.03
	6-3-87	63.26	1646.89	61.13
	5-11-88	63.36	1646.79	61.23
	9-12-88	63.72	1646.43	61.59
	1-4-89	63.89	1646.26	61.76
41	9-11-86	36.29	1673.78	34.25
	10-16-86	36.09	1673.98	34.05
	11-21-86	35.93	1674.14	33.89
	1-13-87	36.16	1673.91	34.12
	3-6-87	35.83	1674.24	33.79
	4-21-87	35.43	1674.64	33.39
	6-3-87	35.63	1674.44	33.59
	5-11-88	37.40	1672.67	35.36
	9-12-88	39.21	1670.86	37.17
	1-4-89	39.70	1670.37	37.66
42	9-11-86	33.30	1677.01	31.11
	10-16-86	32.74	1677.57	30.55
	11-21-86	31.43	1678.88	29.24
	1-13-87	31.46	1678.85	29.27
	3-6-87	31.27	1679.04	29.08
	4-21-87	31.20	1679.11	29.01
	6-3-87	31.30	1679.01	29.11
	5-11-88	32.61	1677.70	30.42
	9-12-88	33.96	1676.35	31.77
	1-4-89	34.12	1676.19	31.93
45	12-15-86	28.71	1681.46	26.88
	1-13-87	28.58	1681.59	26.75
	3-6-87	28.48	1681.69	26.65
	4-21-87	28.58	1681.59	26.75
	6-3-87	28.71	1681.46	26.88
	5-11-88	29.89	1680.28	28.06
	9-12-88	30.84	1679.33	29.01
	1-4-89	30.97	1679.20	29.14

HESKETT SWL INFORMATION

WELL NO	DATE	SWL-TOP	SWL-MSL	SWL-BLS
43	10-16-86	26.02	1685.01	23.91
	11-21-86	25.82	1685.21	23.71
	1-13-87	26.08	1684.95	23.97
	3-6-87	25.89	1685.14	23.78
	4-21-87	26.12	1684.91	24.01
	6-3-87	26.58	1684.45	24.47
	5-11-88	27.56	1683.47	25.45
	9-12-88	29.92	1681.11	27.81
	1-4-89	29.20	1681.83	27.09
44				
	10-16-86	21.98	1689.42	19.67
	11-21-86	21.85	1689.55	19.54
	1-13-87	22.15	1689.25	19.84
	3-6-87	22.05	1689.35	19.74
	4-21-87	21.72	1689.68	19.41
	6-3-87	22.21	1689.19	19.90
	5-11-88	23.46	1687.94	21.15
	9-12-88	dry		
	1-4-89	24.87	1686.53	22.56

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
50	9-11-86	5.45	1671.56	3.02
	10-16-86	4.53	1672.48	2.10
	11-21-86	4.17	1672.84	1.74
	1-13-87	4.76	1672.25	2.33
	3-6-87	not taken		
	4-21-87	3.74	1673.27	1.31
	6-3-87	4.33	1672.68	1.90
	5-11-88	5.41	1671.60	2.98
	9-12-88	7.87	1669.14	5.44
	1-4-89	7.97	1669.04	5.54
51	10-16-86	6.43	1670.27	4.20
	11-21-86	6.07	1670.63	3.84
	1-13-87	6.30	1670.40	4.07
	3-6-87	5.94	1670.76	3.71
	4-21-87	5.45	1671.25	3.22
	6-3-87	5.74	1670.96	3.51
	5-11-88	7.35	1669.35	5.12
	9-12-88	9.61	1667.09	7.38
	1-4-89	9.81	1666.89	7.58
52	10-16-86	4.43	1672.28	2.17
	11-21-86	4.07	1672.64	1.81
	1-13-87	4.56	1672.15	2.30
	3-6-87	3.81	1672.90	1.55
	4-21-87	3.61	1673.10	1.35
	6-3-87	4.20	1672.51	1.94
	5-11-88	4.99	1671.72	2.73
	9-12-88	7.81	1668.90	5.55
	1-4-89	7.89	1668.82	5.63

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
53	10-16-86	6.66	1681.51	4.20
	11-21-86	6.46	1681.71	4.00
	1-13-87	6.92	1681.25	4.46
	3-6-87	7.55	1680.62	5.09
	4-21-87	6.17	1682.00	3.71
	6-3-87	7.32	1680.85	4.86
	5-11-88	7.51	1680.66	5.05
	9-12-88	11.25	1676.92	8.79
	1-4-89	10.93	1677.24	8.47
54	10-16-86	21.36	1666.74	18.97
	11-21-86	20.97	1667.13	18.58
	1-13-87	20.87	1667.23	18.48
	3-6-87	21.00	1667.10	18.61
	4-21-87	20.70	1667.40	18.31
	6-3-87	20.54	1667.56	18.15
	5-11-88	22.28	1665.82	19.89
	9-12-88	23.13	1664.97	20.74
	1-4-89	23.62	1664.48	21.23
55	10-16-86	29.46	1666.64	27.22
	11-21-86	29.50	1666.60	27.26
	1-13-87	29.56	1666.54	27.32
	3-6-87	29.30	1666.80	27.06
	4-21-87	29.30	1666.80	27.06
	6-3-87	29.13	1666.97	26.89
	5-11-88	29.86	1666.24	27.62
	9-12-88	30.35	1665.75	28.11
	1-4-89	29.66	1666.44	27.42
56	10-16-86	42.52	1653.90	39.96
	11-21-86	39.93	1656.49	37.37
	1-13-87	39.96	1656.46	37.40
	3-6-87	39.83	1656.59	37.27
	4-21-87	39.40	1657.02	36.84
	6-3-87	39.54	1656.88	36.98
	5-11-88	41.08	1655.34	38.52
	9-12-88	42.06	1654.36	39.50
	1-4-89	42.88	1653.54	40.32

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
60	9-11-86	32.58	1683.84	30.39
	10-16-86	32.51	1683.91	30.32
	11-21-86	32.35	1684.07	30.16
	1-13-87	32.35	1684.07	30.16
	3-6-87	32.51	1683.91	30.32
	4-21-87	32.29	1684.13	30.10
	6-3-87	32.25	1684.17	30.06
	5-11-88	34.61	1681.81	32.42
	9-12-88	35.47	1680.95	33.28
	1-4-89	35.92	1680.50	33.73
61	10-16-86	32.55	1683.98	30.25
	11-21-86	32.38	1684.15	30.08
	1-13-87	32.38	1684.15	30.08
	3-6-87	32.55	1683.98	30.25
	4-21-87	32.32	1684.21	30.02
	6-3-87	32.32	1684.21	30.02
	5-11-88	34.65	1681.88	32.35
	9-12-88	35.47	1681.06	33.17
	1-4-89	35.96	1680.57	33.66
62	10-16-86	32.74	1683.93	30.39
	11-21-86	32.55	1684.12	30.20
	1-13-87	32.51	1684.16	30.16
	3-6-87	32.71	1683.96	30.36
	4-21-87	32.48	1684.19	30.13
	6-3-87	32.48	1684.19	30.13
	5-11-88	34.81	1681.86	32.46
	9-12-88	dry		
	1-4-89	dry		
70	9-11-86	55.02	1680.65	52.53
	10-16-86	54.99	1680.68	52.50
	11-21-86	54.56	1681.11	52.07
	1-13-87	54.46	1681.21	51.97
	3-6-87	54.40	1681.27	51.91
	4-21-87	54.53	1681.14	52.04
	6-3-87	54.43	1681.24	51.94
	5-11-88	54.56	1681.11	52.07
	9-12-88	54.82	1680.85	52.33
	1-4-89	54.92	1680.75	52.43

HESKETT SWL INFORMATION

WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
WS1	9-4-86	25.00	1656.71	22.90
	10-16-86	25.13	1656.58	23.03
	11-21-86	25.56	1656.15	23.46
	1-13-87*	28.15	1655.52	24.09
	3-6-87	26.77	1656.90	22.71
	4-21-87	24.97	1658.70	20.91
	6-3-87	25.36	1658.31	21.30
	5-11-88	29.00	1654.67	24.94
	9-12-88	30.32	1653.35	26.26
	1-4-89	29.86	1653.81	25.80
	* = WELL CASING REPAIRED			
WS1A	9-4-86	dry		
	10-16-86	dry		
	11-21-86	dry		
	1-13-87	dry		
	3-6-87	24.31	1657.92	21.18
	4-21-87	22.18	1660.05	19.05
	6-3-87	22.38	1659.85	19.25
	5-11-88	dry		
	9-12-88	dry		
	1-4-89	dry		
WS1B	9-4-86	25.33	1656.74	22.06
	10-16-86	25.53	1656.54	22.26
	11-21-86	26.08	1655.99	22.81
	1-13-87	27.07	1655.00	23.80
	3-6-87	24.35	1657.72	21.08
	4-21-87	21.82	1660.25	18.55
	6-3-87	22.77	1659.30	19.50
	5-11-88	28.22	1653.85	24.95
	9-12-88	30.18	1651.89	26.91
	1-4-89	29.92	1652.15	26.65
WS2	9-4-86	33.96	1664.68	31.32
	10-16-86	33.66	1664.98	31.02
	11-21-86	33.47	1665.17	30.83
	1-13-87	33.79	1664.85	31.15
	3-6-87	33.73	1664.91	31.09
	4-21-87	32.91	1665.73	30.27
	6-3-87	33.04	1665.60	30.40
	5-11-88	35.33	1663.31	32.69
	9-12-88	36.68	1661.96	34.04
	1-4-89	37.17	1661.47	34.53

HESKETT SWL INFORMATION

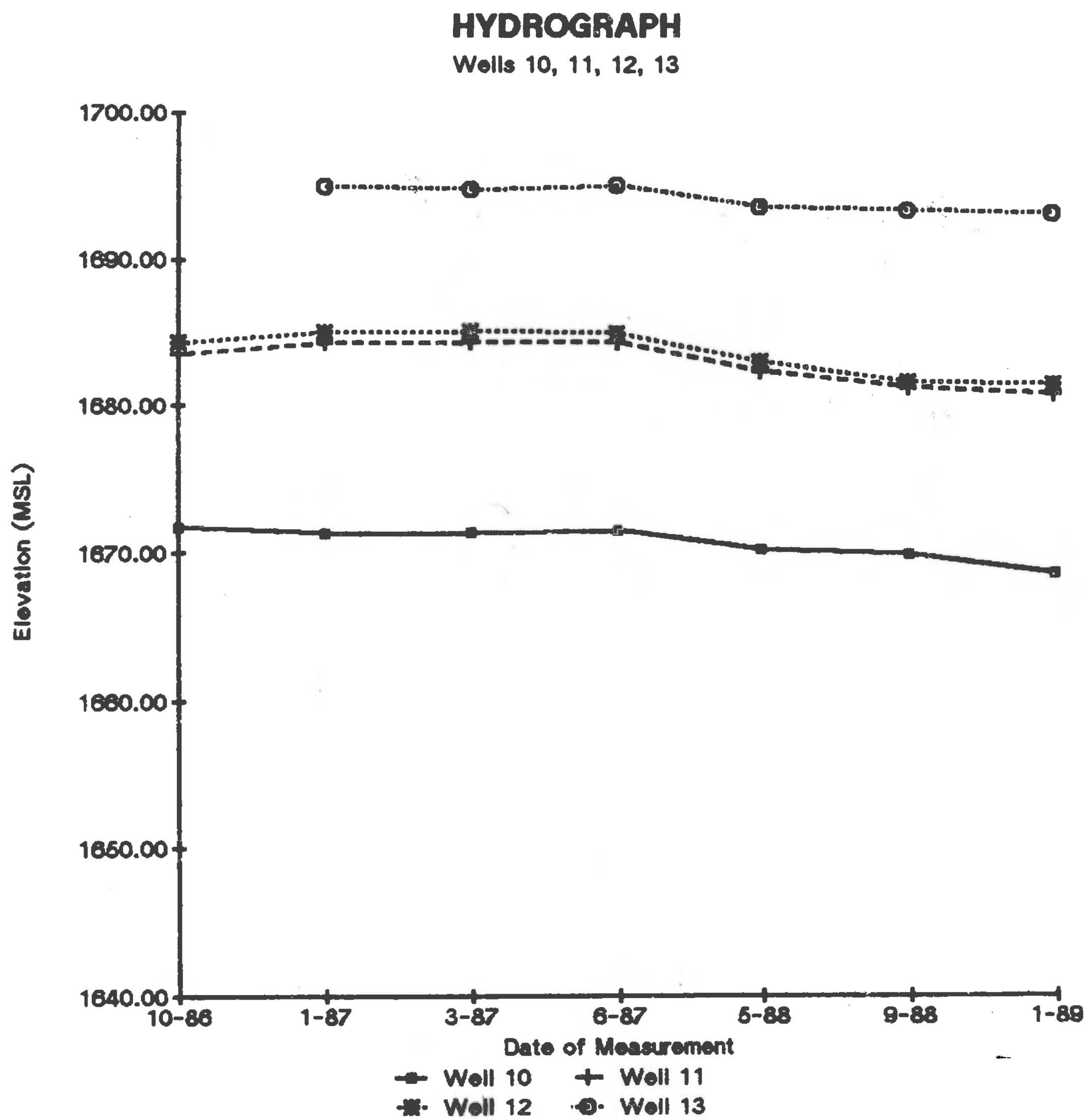
WELL NO.	DATE	SWL-TOP	SWL-MSL	SWL-BLS
WS3	9-4-86	14.67	1646.33	11.67
	10-16-86	14.44	1646.56	11.44
	11-21-86	14.40	1646.60	11.40
	1-13-87	13.98	1647.02	10.98
	3-6-87	14.80	1646.20	11.80
	4-21-87	13.94	1647.06	10.94
	6-3-87	14.60	1646.40	11.60
	5-11-88	17.52	1643.48	14.52
	9-12-88	17.88	1643.12	14.88
	1-4-89	17.68	1643.32	14.68
WS3A	10-16-86	8.30	1652.51	5.19
	11-21-86	8.43	1652.38	5.32
	1-13-87	9.55	1651.26	6.44
	3-6-87	10.17	1650.64	7.06
	4-21-87	6.82	1653.99	3.71
	6-3-87	8.73	1652.08	5.62
	5-11-88	13.71	1647.10	10.60
	9-12-88	13.81	1647.00	10.70
	1-4-89	14.73	1646.08	11.62
WS4	9-4-86	19.62	1642.99	16.62
	10-16-86	19.52	1643.09	16.52
	11-21-86	19.42	1643.19	16.42
	1-13-87	18.83	1643.78	15.83
	3-6-87	19.16	1643.45	16.16
	4-21-87	19.00	1643.61	16.00
	6-3-87	19.39	1643.22	16.39
	5-11-88	21.46	1641.15	18.46
	9-12-88	21.95	1640.66	18.95
	1-4-89	21.23	1641.38	18.23
WS4A	9-4-86	17.29	1645.20	14.29
	10-16-86	17.16	1645.33	14.16
	11-21-86	17.13	1645.36	14.13
	1-13-87	17.39	1645.10	14.39
	3-6-87	17.62	1644.87	14.62
	4-21-87	15.81	1646.68	12.81
	6-3-87	16.93	1645.56	13.93
	5-11-88	19.36	1643.13	16.36
	9-12-88	20.11	1642.38	17.11
	1-4-89	19.75	1642.74	16.75
WS4B	9-4-86	17.39	1645.36	14.39
	10-16-86	17.23	1645.52	14.23
	11-21-86	17.16	1645.59	14.16
	1-13-87	17.42	1645.33	14.42
	3-6-87	17.65	1645.10	14.65
	4-21-87	15.81	1646.94	12.81
	6-3-87	17.06	1645.69	14.06
	5-11-88	19.55	1643.20	16.55
	9-12-88	20.28	1642.47	17.28
	1-4-89	19.92	1642.83	16.92

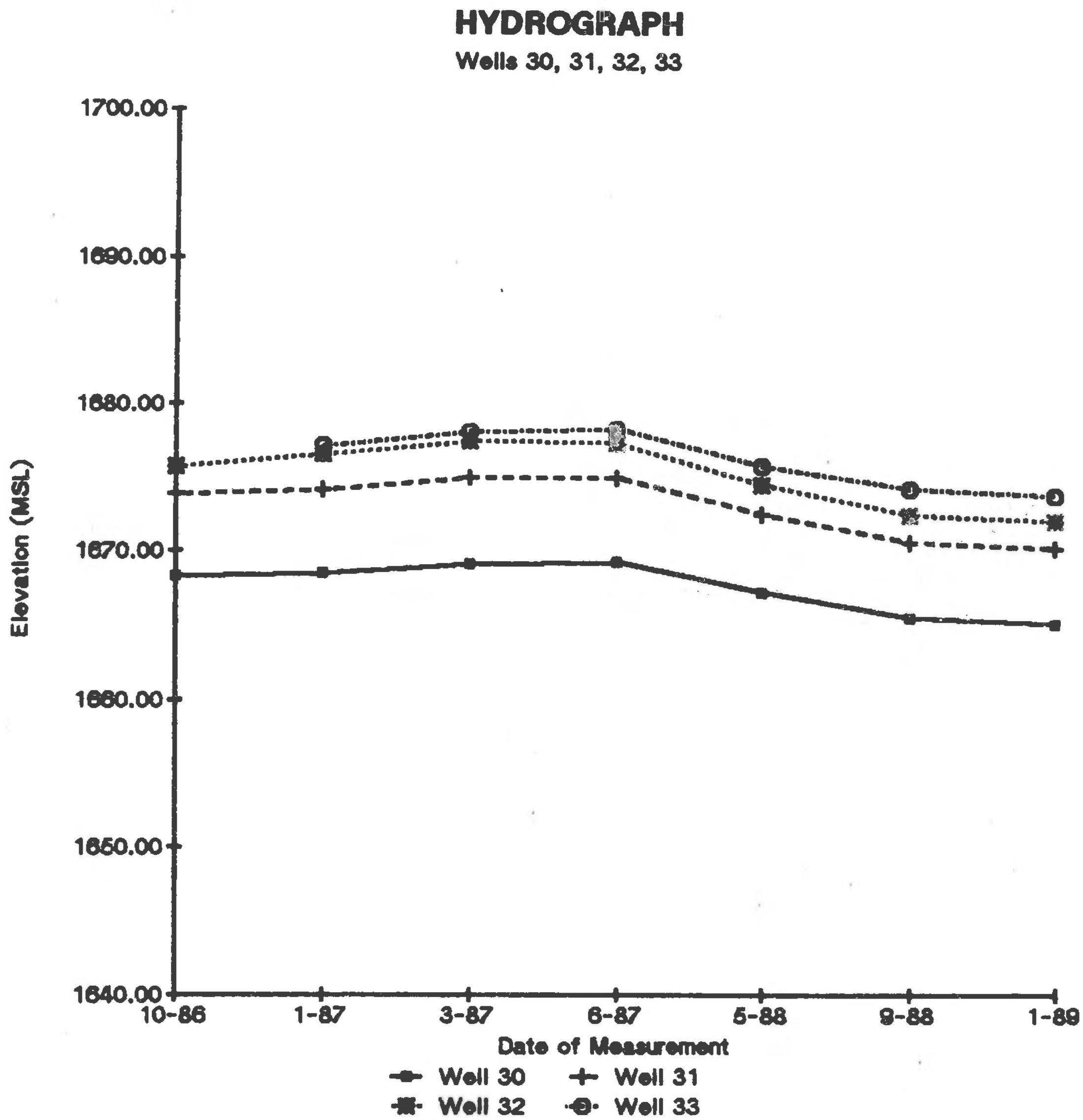
EXHIBIT 5-H

WATER TABLE ELEVATION CONTOUR MAP

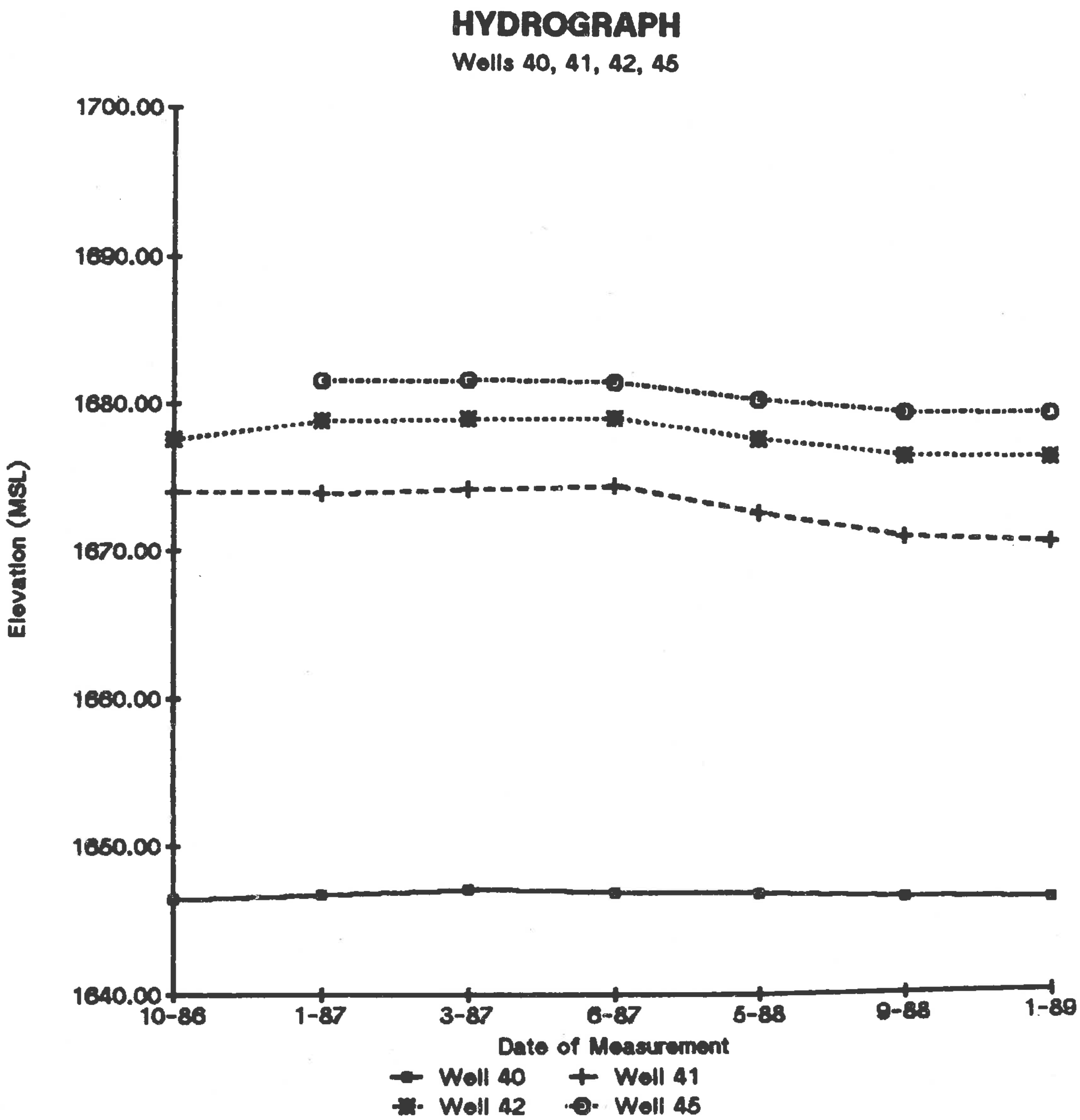
EXHIBIT 5-I

SITE HYDROGRAPHS


HYDROGRAPH
Wells 10, 11, 12, 13
1700.00
1690.00
1680.00
1670.00
1660.00
1650.00
1640.00
Elevation (MSL)
10-86
1-87
3-87
6-87
5-88
9-88
1-89
Date of Measurement
Well 10
Well 11
Well 12
Well 13



HYDROGRAPH
Wells 30, 31, 32, 33
1700.00
1690.00
1680.00
1670.00
1660.00
1650.00
1640.00
Elevation (MSL)
10-86
1-87
3-87
6-87
5-88
9-88
1-89
Date of Measurement
Well 30
Well 31
Well 32
Well 33



HYDROGRAPH
Wells 40, 41, 42, 45
1700.00
1690.00
1680.00
1670.00
1660.00
1650.00
1640.00
Elevation (MSL)
10-86
1-87
3-87
6-87
5-88
9-88
1-89
Date of Measurement
Well 40
Well 41
Well 42
Well 45

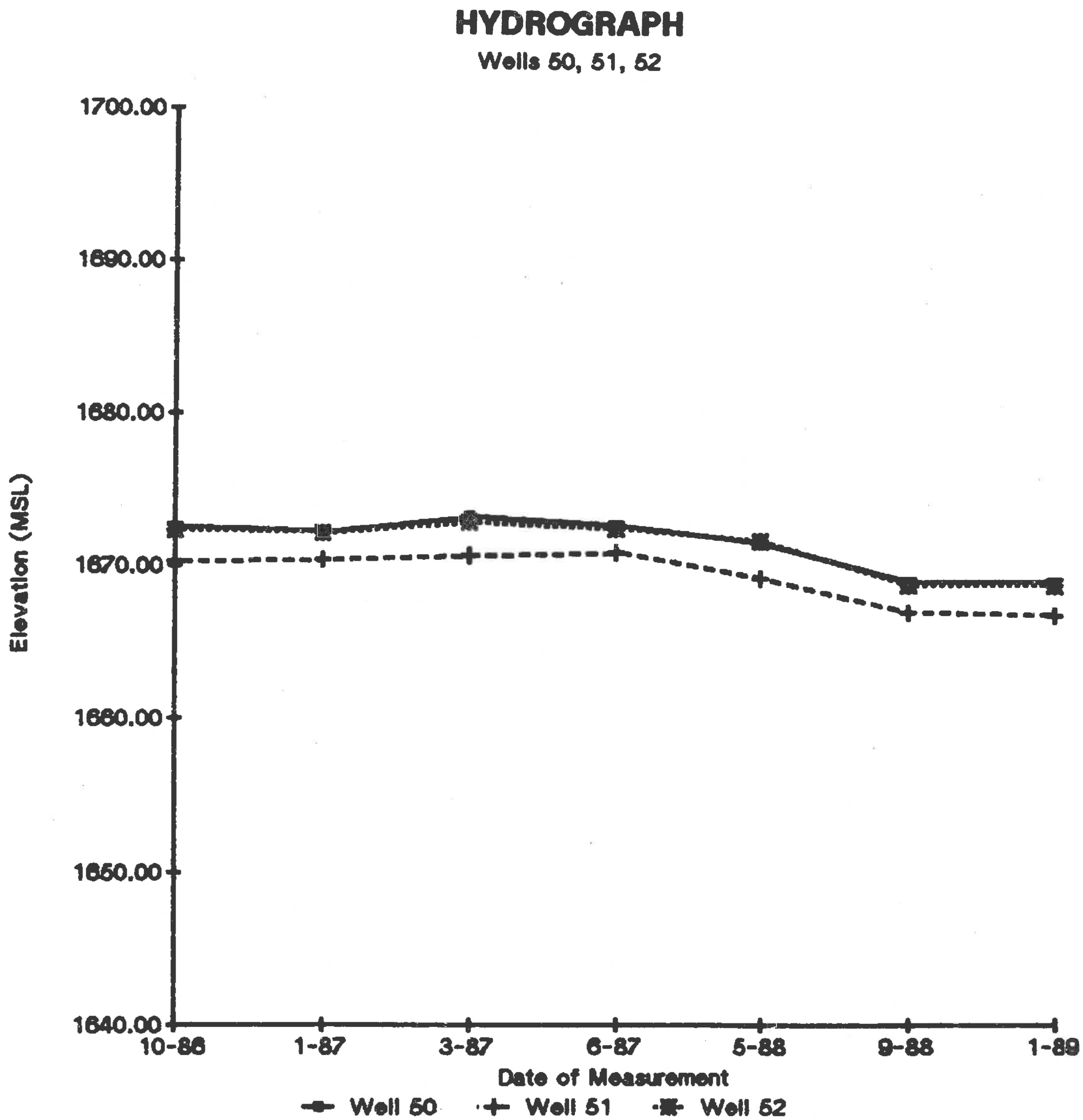

HYDROGRAPH
Wells 50, 51, 52
1700.00
1690.00
1680.00
1670.00
1660.00
1650.00
1640.00
Elevation (MSL)
10-86
1-87
3-87
6-87
5-88
9-88
1-89
Date of Measurement
Well 50
Well 51
Well 52

EXHIBIT 5-J

GROUNDWATER CHEMICAL ANALYSIS

Drinking Water Standards

Constituent		Recommended Concentration Limit[1]
Total Dissolved Solids	(mg/L)	500
Sulfate (SO_2)	(mg/L)	250
Chloride (Cl)	(mg/L)	250
Nitrate (NO_3)	(mg/L)	45
Iron (Fe)	(mg/L)	0.3
Manganese (Mn)	(mg/L)	0.05
Copper (Cu)	(mg/L)	1.0
Zinc (Zn)	(mg/L)	5.0
Boron (B)	(mg/L)	1.0
Hydrogen Sulfide (H_2S)	(mg/L)	0.05
		Maximum Permissible Concentration[2]
Arsenic (As)	(mg/L)	0.05
Antimony (Sb)	(mg/L)	0.01
Barium (Ba)	(mg/L)	1.0
Cadmium (Cd)	(mg/L)	0.01
Chromium (Cr)	(mg/L)	0.05
Lead (Pb)	(mg/L)	0.050
Mercury (Hg)	(mg/L)	0.002
Selenium (Se)	(mg/L)	0.01
Silver (Ag)	(mg/L)	0.050
Fluoride (F)	(mg/L)	1.4-2.41[3]
Organics:		
Cyanide	(mg/L)	0.05
Phenol	(mg/L)	0.001
Synthetic Detergents	(mg/L)	0.5

[1]Recommended concentration limits for these constituents are mainly to provide esthetic and taste characteristics.

[2]Maximum permissible limits are set according to health criteria.

[3]Limit depends on average air temperature of the region; fluoride is toxic at about 5-10 mg/L if water is consumed over a long period of time.

Chemical Analyses of Selected Wells

Parameter		Well 10	Well 12	Well 30
Sample Collection Date		9-11-86	9-11-86	9-11-86
Water Level[1]	(ft)	51.6	42.4	49.4
Elevation; Screen Center	(ft)	1606.0	1653.5	1597.6
Field Water Temp	(^{o}C)	8.0	8.4	8.0
Field pH	(standard units)	7.6	7.2	8.1
Field Sp.Cond.	(umhos/cm)	7370.0	8070.0	1350.0
Total Dissolved Solids[2]	(mg/L)	9736.0	10396.0	1286.0
Total Alkalinity as $CaCO_3$	(mg/L)	674.0	645.0	425.0
Bicarbonate (HCO_3)	(mg/L)	825.0	789.0	520.0
Boron (B)	(mg/L)			
Calcium (Ca)	(mg/L)	339.0	422.0	33.0
Chloride (Cl)	(mg/L)	20.8	20.7	2.1
Fluoride (F)	(mg/L)	0.3	<.2	0.4
Iron (Fe)	(mg/L)	<.2	0.6	<.2
Potassium (K)	(mg/L)	16.0	13.0	5.8
Magnesium (Mg)	(mg/L)	302.0	318.0	34.0
Nitrate (NO_3)	(mg/L)	<1	<1	<1
Sodium (Na)	(mg/L)	2232.0	2438.0	352.0
Sulfate (SO_4)	(mg/L)	6443.0	6818.0	606.0
TRACE ELEMENTS:				
Arsenic (Ar)	(mg/L)	<.002	.0025	<.002
Barium (Ba)	(mg/L)	0.090	0.157	0.030
Cadmium (Cd)	(mg/L)	0.0020	0.0012	<.001
Chromium (Cr)	(mg/L)	<.002	<.002	<.002
Lead (Pb)	(mg/L)	<.002	<.002	<.002
Manganese (Mn)	(mg/L)	0.986	2.130	0.124
Mercury (Hg)	(mg/L)	<.0003	<.0003	<.0003
Molybdenum (Mo)	(mg/L)	0.018	<.010	<.010
Selenium (Se)	(mg/L)	<.002	<.002	<.002
Silver (Ag)	(mg/L)	<.001	<.001	<.001

[1] From top of PCV casing.
[2] TDS is calculated.

Chemical Analyses of Selected Wells

Parameter		Well 32	Well 40	Well 42
Sample Collection Date		9-11-86	9-11-86	9-11-86
Water Level[1]	(ft)	42.5	63.8	33.3
Elevation; Screen Center	(ft)	1651.7	1594.3	1662.6
Field Water Temp	(^{o}C)	8.3	8.6	8.5
Field pH	(standard units)	6.9	7.5	7.0
Field Sp.Cond.	(umhos/cm)	3150.0	4290.0	3700.0
Total Dissolved Solids[2]	(mg/L)	3927.0	5333.0	4658.0
Total Alkalinity as $CaCO_3$	(mg/L)	467.0	565.0	424.0
Bicarbonate (HCO_3)	(mg/L)	571.0	691.0	519.0
Boron (B)	(mg/L)			
Calcium (Ca)	(mg/L)	313.0	422.0	432.0
Chloride (Cl)	(mg/L)	10.0	15.2	46.8
Fluoride (F)	(mg/L)	0.3	0.2	0.3
Iron (Fe)	(mg/L)	<.2	<.2	0.3
Potassium (K)	(mg/L)	14.0	12.0	15.0
Magnesium (Mg)	(mg/L)	318.0	136.0	250.0
Nitrate (NO_3)	(mg/L)	<1	<1	4.3
Sodium (Na)	(mg/L)	464.0	1047.0	648.0
Sulfate (SO_4)	(mg/L)	2538.0	3378.0	3058.0
TRACE ELEMENTS:				
Arsenic (Ar)	(mg/L)	<.002	<.002	<.002
Barium (Ba)	(mg/L)	0.093	0.083	0.198
Cadmium (Cd)	(mg/L)	<.001	<.001	<.001
Chromium (Cr)	(mg/L)	<.002	<.002	<.002
Lead (Pb)	(mg/L)	<.002	<.002	<.002
Manganese (Mn)	(mg/L)	0.462	0.037	0.670
Mercury (Hg)	(mg/L)	<.0003	<.0003	<.0003
Molybdenum (Mo)	(mg/L)	0.014	<.010	<.010
Selenium (Se)	(mg/L)	<.002	0.005	0.032
Silver (Ag)	(mg/L)	<.001	<.001	<.001

[1] From top of PCV casing.
[2] TDS is calculated.

Chemical Analyses of Selected Wells

Parameter		Well 44	Well 50	Well 50
Sample Collection Date		11-21-86	9-11-86	11-21-86
Water Level[1]	(ft)	21.85	5.5	4.17
Elevation; Screen Center	(ft)	1687.9	1657.5	1657.5
Field Water Temp	(^{o}C)	6.5	9.7	8.5
Field pH	(standard units)	6.76	7.5	7.37
Field Sp.Cond.	(μmhos/cm)	7580.0	4310.0	3620.0
Total Dissolved Solids[2]	(mg/L)	11240.0	4999.0	5196.0
Total Alkalinity as $CaCO_3$	(mg/L)	401.0	418.0	416.0
Bicarbonate (HCO_3)	(mg/L)	491.0	511.0	509.2
Boron (B)	(mg/L)			
Calcium (Ca)	(mg/L)	648.0	313.0	391.0
Chloride (Cl)	(mg/L)	558.0	34.8	33.0
Fluoride (F)	(mg/L)	0.5	0.3	<0.2
Iron (Fe)	(mg/L)	<0.2	<.2	<0.2
Potassium (K)	(mg/L)	51.0	12.0	13.0
Magnesium (Mg)	(mg/L)	1322.0	250.0	257.0
Nitrate (NO_3)	(mg/L)	30.0	23.5	112.0
Sodium (Na)	(mg/L)	1589.0	871.0	902.0
Sulfate (SO_4)	(mg/L)	7390.0	3302.0	3384.0
TRACE ELEMENTS:				
Arsenic (Ar)	(mg/L)	<.002	<.002	<.002
Barium (Ba)	(mg/L)	0.156	0.084	0.128
Cadmium (Cd)	(mg/L)	<.001	<.001	<.001
Chromium (Cr)	(mg/L)	<0.001	<.002	0.003
Lead (Pb)	(mg/L)	<.005	<.002	<.005
Manganese (Mn)	(mg/L)	0.218	0.010	0.005
Mercury (Hg)	(mg/L)	<.0003	<.0003	<.0003
Molybdenum (Mo)	(mg/L)	<.010	<.010	<.010
Selenium (Se)	(mg/L)	0.086	0.055	0.076
Silver (Ag)	(mg/L)	<.002	<.001	<.002
Phenol	(mg/L)	<1.0	<1.0	<1.0
Oil & Grease	(mg/L)	<3.0	<3.0	<3.0

[1]From top of PCV casing.
[2]TDS is calculated.

Chemical Analyses of Selected Wells

Parameter		Well 52	Well 54	Well 55
Sample Collection Date		11-21-86	11-21-86	11-21-86
Water Level[1]	(ft)	4.07	20.97	29.50
Elevation; Screen Center	(ft)	1663.0	1635.1	1648.9
Field Water Temp	(oC)	8.7	6.9	7.5
Field pH	(standard units)	7.38	8.03	6.81
Field Sp.Cond.	(umhos/cm)	4650.0	4570.0	9007.0
Total Dissolved Solids[2]	(mg/L)	6072.0	7223.0	13081.0
Total Alkalinity as $CaCO_3$	(mg/L)	424.0	616.0	528.0
Bicarbonate (HCO_3)	(mg/L)	519.0	754.0	646.3
Boron (B)	(mg/L)			
Calcium (Ca)	(mg/L)	392.0	295.0	445.0
Chloride (Cl)	(mg/L)	45.0	92.0	81.0
Fluoride (F)	(mg/L)	<0.2	0.3	0.7
Iron (Fe)	(mg/L)	<0.2	<0.2	<0.2
Potassium (K)	(mg/L)	15.0	13.0	28.0
Magnesium (Mg)	(mg/L)	305.0	439.0	862.0
Nitrate (NO_3)	(mg/L)	148.0	6.0	154.0
Sodium (Na)	(mg/L)	1115.0	1490.0	2423.0
Sulfate (SO_4)	(mg/L)	3991.0	4617.0	9007.0
TRACE ELEMENTS:				
Arsenic (Ar)	(mg/L)	<.002	<.002	<.002
Barium (Ba)	(mg/L)	0.125	0.105	0.133
Cadmium (Cd)	(mg/L)	<.001	<.001	<.001
Chromium (Cr)	(mg/L)	0.003	0.003	0.003
Lead (Pb)	(mg/L)	<.005	<.005	<.005
Manganese (Mn)	(mg/L)	0.004	1.080	0.045
Mercury (Hg)	(mg/L)	<.0003	<.0003	<.0003
Molybdenum (Mo)	(mg/L)	<.010	0.041	<.010
Selenium (Se)	(mg/L)	0.088	0.025	0.386
Silver (Ag)	(mg/L)	<.002	<.002	<.002
Phenol	(mg/L)		<1.0	
Oil & Grease	(mg/L)		<3.0	

[1]From top of PCV casing.
[2]TDS is calculated.

Chemical Analyses of Selected Wells

Parameter		Well 60	Well 70
Sample Collection Date		11-21-86	9-11-86
Water Level[1]	(ft)	32.35	55.0
Elevation; Screen Center	(ft)	1677.0	1636.4
Field Water Temp	(^{o}C)	7.6	8.6
Field pH	(standard units)	6.83	8.3
Field Sp.Cond.	(umhos/cm)	10440.0	10370.0
Total Dissolved Solids[2]	(mg/L)	14917.0	13129.0
Total Alkalinity as $CaCO_3$	(mg/L)	540.0	491.0
Bicarbonate (HCO_3)	(mg/L)	661.0	600.0
Boron (B)	(mg/L)		
Calcium (Ca)	(mg/L)	417.0	192.0
Chloride (Cl)	(mg/L)	208.0	10.9
Fluoride (F)	(mg/L)	0.5	0.3
Iron (Fe)	(mg/L)	<0.2	<.2
Potassium (K)	(mg/L)	41.0	22.0
Magnesium (Mg)	(mg/L)	1355.0	121.0
Nitrate (NO_3)	(mg/L)	170.0	<1
Sodium (Na)	(mg/L)	1148.0	3682.0
Sulfate (SO_4)	(mg/L)	11632.0	8818.0
TRACE ELEMENTS:			
Arsenic (Ar)	(mg/L)	<.002	.0032
Barium (Ba)	(mg/L)	0.151	0.080
Cadmium (Cd)	(mg/L)	<.001	0.0010
Chromium (Cr)	(mg/L)	0.004	<.002
Lead (Pb)	(mg/L)	<.005	<.002
Manganese (Mn)	(mg/L)	0.033	0.110
Mercury (Hg)	(mg/L)	<.0003	<.0003
Molybdenum (Mo)	(mg/L)	<.010	0.017
Selenium (Se)	(mg/L)	0.195	<.002
Silver (Ag)	(mg/L)	<.002	<.001
Phenol	(mg/L)	<1.0	
Oil & Grease	(mg/L)	<3.0	

[1] From top of PCV casing.
[2] TDS is calculated.

PROJECT LOCATION/SITE: ____MDU Hesket Plant - FIELD INVESTIGATOR J.Solberg

GENERAL INFORMATION						
Sample Location/I.D.	45	52	60	33	13	70
Casing Diameter	2" PVC	2" PVC	2" PVC	2" PVC	2" PVC	2" PVC
Total Well Depth	40' ?	17' ?	48' ?	38' ?	40' ?	100' ?
Past Static Water Level	30.6'	7.7'	35.8'	36.8'	31.9'	54.85'
Approximate Volume of Water	1.5 gal	1.5 gal	2 gal	.25 gal	1.5 gal	7.5 gal
STATIC LEVEL MEASUREMENT						
Date	12/19/88	12/19/88	12/19/88	12/19/88	12/19/88	12/19/88
Time	14:20	14:45	15:00	15:25	16:00	16:35
Datum	PVC Top	PVC Top	PVC Top	PVC Top	PVC Top	PVC Top
Measurement Equipment	SteelTape	SteelTape	SteelTape	SteelTape	SteelTape	SteelTape
Static Water Level	30.60	7.65	35.80	36.80	31.92	54.85
PRE-SAMPLING PREPARATION						
Pre-Sample Technique/Equip.	PVCbailer	PVCbailer	PVCbailer	PVCbailer	PVCbailer	PVCbailer
Volume Removed	1.5 gal (dirty)	1 gal	2 gal	.5 gal (dirty)	1.5 gal	6 gal
SAMPLING						
Date	12/20/88	12/20/88	12/20/88	12/20/88	12/21/88	12/21/88
Time	10:15	10:45	11:25	12:00	15:50	16:22
Measurement Equipment	SteelTape	SteelTape	SteelTape	SteelTape	SteelTape	SteelTape
Static Water Level	31.05	7.95	35.86	36.92	31.85	54.90
Sampling Technique/Equip.	PVCbailer	PVCbailer	PVCbailer	PVCbailer	PVCbailer	PVCbailer
Field Temperature (C)	6	5	5	4	7	6
Field pH	5.60	5.80	5.50	5.60	5.90	6.40
Field Conductivity	3800	7200	1400	5900	1190	1380
Samples Collected						
Raw-Unfiltered	2 liters	2 liters	2 liters	*	2 liters	2 liters
Unfiltered/Sulferic Acid	2 125ml	2 125ml	2 125ml		2 125ml	2 125ml
Filtered/Nitric Acid	1 125ml	1 125ml	1 125ml		1 125ml	1 125ml
Other (unfilter/untreat)	1 125ml	1 125ml	1 125ml		1 125ml	1 125ml

DELIVERY

Date	12/20/88 - 12/22/88
Time	4:30 - 10:30
Delivered To	Minnesota Valley Testing Laboratories, Inc.
Via	Hand Delivered
Delivery Container	Cooler with Ice

COMMENTS

* Well 33 had insufficient water for any samples - field parameters taken
Well 45 - samples were dirty

MVTL

PHONE (701) 258-9720

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

1411 SOUTH 12TH STREET • P.O. BOX 1873
BISMARCK, NORTH DAKOTA 58502-1873

WATER ANALYSIS REPORT

Montana-Dakota Utilities
400 North Fourth
Bismarck, ND 58501

Date: January 27, 1989

W.O. #: 82-045

Attention: John Verwey

Lab. #: M- 156

Sample Identification: MDU - Heskett #13 15:50 CST 12/20/88

P.O. #: M04548

Date Received: 12/22/88

PHYSICAL PARAMETERS:

Parameter	Units	Value
Color	units of apparent color	
Conductivity	micromhos/cm @ 25°C	12078
pH		7.2
Solids (Total)	mg/l	
Solids (Total Dissolved)	mg/l	11967
Solids (Total Suspended)	mg/l	
Solids (Total Volatile)	mg/l	
Turbidity — NTU		

COMMON IONS:

Parameter	Units	Value
Calcium	mg/l	366.0
Magnesium	mg/l	642.0
Sodium	mg/l	1965.0
Potassium	mg/l	27.0
Acidity as $CaCO_3$	mg/l	
Alkalinity (Total) as $CaCO_3$	mg/l	600
Bicarbonate as $CaCO_3$	mg/l	600
Bicarbonate as HCO_3	mg/l	
Carbonate as $CaCO_3$	mg/l	0
P-Alkalinity as $CaCO_3$	mg/l	
Sulfate	mg/l	6774.9
Chloride	mg/l	327.6
Total Hardness as $CaCO_3$	mg/l	3556
Sodium Adsorption Ratio		14.37
Cations		157.9
Anions		164.2
% Error		2.0

NUTRIENTS:

Parameter	Units	Value
Ammonia-Nitrogen	mg/l	
Nitrite-Nitrogen as N	mg/l	
Nitrate-Nitrogen as N	mg/l	25.8
Organic-Nitrogen	mg/l	
Total - Kjeldahl Nitrogen	mg/l	
Ortho-phosphate as P	mg/l	
Phosphorus (Total) as P	mg/l	
Phosphorus (Dissolved) as P	mg/l	

METALS:

Parameter	Units	Value
Copper (Total)	mg/l	
Iron (Total)	mg/l	
Manganese (Total)	mg/l	

MISCELLANEOUS:

Parameter	Units	Value
ADA	g/l	
Biochemical Oxygen Demand	mg/l	
Chemical Oxygen Demand	mg/l	
Cyanide	mg/l	
Fecal Coliform Count — Millipore filter/100 ml		
Fluoride	mg/l	0.62
Iron Bacteria		
Oil & Grease	mg/l	
Phenols	mg/l	
Total Organic Carbon	mg/l	
Total Plate Count per 100ml		

TRACE ELEMENTS:

Element	Units	Value	Element	Units	Value	Element	Units	Value
Aluminum	mg/l		Cobalt	mg/l		Silver	mg/l	0.034
Antimony	mg/l		Copper	mg/l		Strontium	mg/l	
Arsenic	mg/l	0.007	Iron	mg/l	0.11	Thallium	mg/l	
Barium	mg/l	<0.100	Lead	mg/l	<0.001	Thorium	mg/l	
Beryllium	mg/l		Manganese	mg/l	<0.05	Tin	mg/l	
Boron	mg/l	1.500	Mercury	mg/l	0.0011	Titanium	mg/l	
Bromide	mg/l		Molybdenum	mg/l	<0.100	Vanadium	mg/l	
Cadmium	mg/l	<0.001	Nickel	mg/l		Zinc	mg/l	
Chromium	mg/l	<0.050	Selenium	mg/l	<0.002			

******** *Metals are reported as dissolved, unless otherwise indicated.* ********

FIELD DATA:

Flow	-	**T° C**	7.0°C
E. C.	1190	**pH**	5.90
Static Water Level	31.85		

Catherine Anne Phelps

Catherine A. Phelps, Chemist

MVTL

PHONE (701) 258-9720

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

1411 SOUTH 12TH STREET • P.O. BOX 1873
BISMARCK, NORTH DAKOTA 58502-1873

WATER ANALYSIS REPORT

Montana-Dakota Utilities
400 North Fourth
Bismarck, ND 58501

Date: January 24, 1989

W.O. #: 82-041

Attention: John Verwey

Lab. #: M- 145

Sample Identification: MDU - Heskett #45 10:15 CST 12-20-88

P.O. #: M04548

Date Received: 12-21-88

PHYSICAL PARAMETERS:

Color	units of apparent color	
Conductivity	micromhos/cm @ 25°C	3937
pH		7.5
Solids (Total)	mg/l	
Solids (Total Dissolved)	mg/l	3611
Solids (Total Suspended)	mg/l	
Solids (Total Volatile)	mg/l	
Turbidity — NTU		

COMMON IONS:

Calcium	mg/l	465.0
Magnesium	mg/l	171.0
Sodium	mg/l	247.0
Potassium	mg/l	11.7
Acidity as $CaCO_3$	mg/l	
Alkalinity (Total) as $CaCO_3$	mg/l	340
Bicarbonate as $CaCO_3$	mg/l	340
Bicarbonate as HCO_3	mg/l	
Carbonate as $CaCO_3$	mg/l	0
P-Alkalinity as $CaCO_3$	mg/l	
Sulfate	mg/l	1840.0
Chloride	mg/l	124.1
Total Hardness as $CaCO_3$	mg/l	1865
Sodium Adsorption Ratio		2.50
Cations		48.5
Anions		49.0
% Error		0.5

NUTRIENTS:

Ammonia-Nitrogen	mg/l	
Nitrite-Nitrogen as N	mg/l	
Nitrate-Nitrogen as N	mg/l	4.6
Organic-Nitrogen	mg/l	
Total - Kjeldahl Nitrogen	mg/l	
Ortho-phosphate as P	mg/l	
Phosphorus (Total) as P	mg/l	
Phosphorus (Dissolved) as P	mg/l	

METALS:

Copper (Total)	mg/l	
Iron (Total)	mg/l	
Manganese (Total)	mg/l	

MISCELLANEOUS:

ADA	g/l	
Biochemical Oxygen Demand	mg/l	
Chemical Oxygen Demand	mg/l	
Cyanide	mg/l	
Fecal Coliform Count — Millipore filter/100 ml		
Fluoride	mg/l	0.20
Iron Bacteria		
Oil & Grease	mg/l	
Phenols	mg/l	
Total Organic Carbon	mg/l	
Total Plate Count per 100ml		

TRACE ELEMENTS:

Aluminum	mg/l		Cobalt	mg/l		Silver	mg/l	0.019
Antimony	mg/l		Copper	mg/l		Strontium	mg/l	
Arsenic	mg/l	0.005	Iron	mg/l	<0.10	Thallium	mg/l	
Barium	mg/l	<0.10	Lead	mg/l	<0.001	Thorium	mg/l	
Beryllium	mg/l		Manganese	mg/l	<0.05	Tin	mg/l	
Boron	mg/l	1.000	Mercury	mg/l	0.0008	Titanium	mg/l	
Bromide	mg/l		Molybdenum	mg/l	<0.10	Vanadium	mg/l	
Cadmium	mg/l	<0.001*	Nickel	mg/l		Zinc	mg/l	
Chromium	mg/l	<0.05	Selenium	mg/l	<0.002			

******** *Metals are reported as dissolved, unless otherwise indicated.* ******** *CEP

FIELD DATA:

Flow - **T°C** 6.0° C
E. C. 3800 **pH** 5.6
Static Water Level 31.05

*Analysis completed by Controls for Environmental Pollution; Santa Fe, New Mexico

Catherine Anne Phelps

Catherine A. Phelps, Chemist

MVTL

PHONE (701) 258-9720

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

1411 SOUTH 12TH STREET • P.O. BOX 1873
BISMARCK, NORTH DAKOTA 58502-1873

WATER ANALYSIS REPORT

Montana-Dakota Utilities
400 North Fourth
Bismarck, ND 58501

Date: January 24, 1989

W.O. #: 82-041

Attention: John Verwey

Lab. #: M-146

Sample Identification: MDU - Heskett #52 10:45 CST 12-20-88

P.O. #: M04548

Date Received: 12-21-88

PHYSICAL PARAMETERS:

Parameter	Units	Value
Color	units of apparent color	
Conductivity	micromhos/cm @ 25°C	7300
pH		7.6
Solids (Total)	mg/l	
Solids (Total Dissolved)	mg/l	6724
Solids (Total Suspended)	mg/l	
Solids (Total Volatile)	mg/l	
Turbidity — NTU		

COMMON IONS:

Parameter	Units	Value
Calcium	mg/l	421.0
Magnesium	mg/l	285.0
Sodium	mg/l	1060.0
Potassium	mg/l	14.3
Acidity as $CaCO_3$	mg/l	
Alkalinity (Total) as $CaCO_3$	mg/l	438
Bicarbonate as $CaCO_3$	mg/l	438
Bicarbonate as HCO_3	mg/l	
Carbonate as $CaCO_3$	mg/l	0
P-Alkalinity as $CaCO_3$	mg/l	
Sulfate	mg/l	3535.6
Chloride	mg/l	99.3
Total Hardness as $CaCO_3$	mg/l	2224
Sodium Adsorption Ratio		9.80
Cations		91.3
Anions		87.2
% Error		2.3

NUTRIENTS:

Parameter	Units	Value
Ammonia-Nitrogen	mg/l	
Nitrite-Nitrogen as N	mg/l	
Nitrate-Nitrogen as N	mg/l	27.8
Organic-Nitrogen	mg/l	
Total - Kjeldahl Nitrogen	mg/l	
Ortho-phosphate as P	mg/l	
Phosphorus (Total) as P	mg/l	
Phosphorus (Dissolved) as P	mg/l	

METALS:

Parameter	Units	Value
Copper (Total)	mg/l	
Iron (Total)	mg/l	
Manganese (Total)	mg/l	

MISCELLANEOUS:

Parameter	Units	Value
ADA	g/l	
Biochemical Oxygen Demand	mg/l	
Chemical Oxygen Demand	mg/l	
Cyanide	mg/l	
Fecal Coliform Count — Millipore filter/100 ml		
Fluoride	mg/l	0.29
Iron Bacteria		
Oil & Grease	mg/l	
Phenols	mg/l	
Total Organic Carbon	mg/l	
Total Plate Count per 100ml		

TRACE ELEMENTS:

Element	Units	Value	Element	Units	Value	Element	Units	Value
Aluminum	mg/l		Cobalt	mg/l		Silver	mg/l	0.02
Antimony	mg/l		Copper	mg/l		Strontium	mg/l	
Arsenic	mg/l	0.004	Iron	mg/l	<0.10	Thallium	mg/l	
Barium	mg/l	<0.10	Lead	mg/l	<0.001	Thorium	mg/l	
Beryllium	mg/l		Manganese	mg/l	0.06	Tin	mg/l	
Boron	mg/l	1.200	Mercury	mg/l	0.001	Titanium	mg/l	
Bromide	mg/l		Molybdenum	mg/l	<0.10	Vanadium	mg/l	
Cadmium	mg/l	<0.001*	Nickel	mg/l		Zinc	mg/l	
Chromium	mg/l	<0.05	Selenium	mg/l	0.005	*CEP		

******** *Metals are reported as dissolved, unless otherwise indicated.* ********

FIELD DATA:

Flow	-	**T° C**	5.0° C
E. C.	7200	**pH**	5.8
Static Water Level	7.95		

*Analysis completed by Controls for Environmental Pollution; Santa Fe, New Mexico

Catherine A. Phelps, Chemist

MVTL

PHONE (701) 258-9720

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

1411 SOUTH 12TH STREET • P.O. BOX 1873
BISMARCK, NORTH DAKOTA 58502-1873

WATER ANALYSIS REPORT

Montana-Dakota Utilities
400 North Fourth
Bismarck, ND 58501

Date: January 24, 1989

W.O. #: 82-041

Attention: John Verwey

Lab. #: M- 147

Sample Identification: MDU - Heskett 60 11:25 CST 12-20-88

P.O. #: M04548

Date Received: 12-21-88

PHYSICAL PARAMETERS:

Color	units of apparent color	
Conductivity	micromhos/cm @ 25°C	15,166
pH		7.0
Solids (Total)	mg/l	
Solids (Total Dissolved)	mg/l	17,634**
Solids (Total Suspended)	mg/l	
Solids (Total Volatile)	mg/l	
Turbidity — NTU		

COMMON IONS:

Calcium	mg/l	415.0
Magnesium	mg/l	1,340.0
Sodium	mg/l	2,245.0
Potassium	mg/l	33.8
Acidity as $CaCO_3$	mg/l	
Alkalinity (Total) as $CaCO_3$	mg/l	524
Bicarbonate as $CaCO_3$	mg/l	524
Bicarbonate as HCO_3	mg/l	
Carbonate as $CaCO_3$	mg/l	0
P-Alkalinity as $CaCO_3$	mg/l	
Sulfate	mg/l	10,779.8
Chloride	mg/l	273.0
Total Hardness as $CaCO_3$	mg/l	6,552
Sodium Adsorption Ratio		12.09
Cations		230.4
Anions		244.2
% Error		2.9

NUTRIENTS:

Ammonia-Nitrogen	mg/l	
Nitrite-Nitrogen as N	mg/l	
Nitrate-Nitrogen as N	mg/l	19.4
Organic-Nitrogen	mg/l	
Total - Kjeldahl Nitrogen	mg/l	
Ortho-phosphate as P	mg/l	
Phosphorus (Total) as P	mg/l	
Phosphorus (Dissolved) as P	mg/l	

METALS:

Copper (Total)	mg/l	
Iron (Total)	mg/l	
Manganese (Total)	mg/l	

MISCELLANEOUS:

ADA	g/l	
Biochemical Oxygen Demand	mg/l	
Chemical Oxygen Demand	mg/l	
Cyanide	mg/l	
Fecal Coliform Count — Millipore filter/100 ml		
Fluoride	mg/l	0.64
Iron Bacteria		
Oil & Grease	mg/l	
Phenols	mg/l	
Total Organic Carbon	mg/l	
Total Plate Count per 100ml		

**High TDS due to hygroscopic nature of cations and anions.

TRACE ELEMENTS:

Aluminum	mg/l		Cobalt	mg/l		Silver	mg/l	0.04
Antimony	mg/l		Copper	mg/l		Strontium	mg/l	
Arsenic	mg/l	<0.002	Iron	mg/l	0.20	Thallium	mg/l	
Barium	mg/l	<0.10	Lead	mg/l	<0.001	Thorium	mg/l	
Beryllium	mg/l		Manganese	mg/l	0.08	Tin	mg/l	
Boron	mg/l	1.800	Mercury	mg/l	0.001	Titanium	mg/l	
Bromide	mg/l		Molybdenum	mg/l	<0.10	Vanadium	mg/l	
Cadmium	mg/l	<0.001*	Nickel	mg/l		Zinc	mg/l	
Chromium	mg/l	<0.05	Selenium	mg/l	<0.002			

******** *Metals are reported as dissolved, unless otherwise indicated.* ********

FIELD DATA:

Flow	-	T° C	5.0° C
E. C.	1400	pH	5.5
Static Water Level	35.86		

*Analysis completed by Controls for Environmental Pollution; Santa Fe, New Mexico

Catherine Anne Phelps

Catherine A. Phelps, Chemist

MVTL

PHONE (701) 258-9720

MINNESOTA VALLEY TESTING LABORATORIES, Inc.

1411 SOUTH 12TH STREET • P.O. BOX 1873
BISMARCK, NORTH DAKOTA 58502-1873

WATER ANALYSIS REPORT

Montana-Dakota Utilities
400 North Fourth
Bismarck, ND 58501

Date: January 27, 1989

W.O. #: 82-045

Attention: John Verwey

Lab. #: M- 157

Sample Identification: MDU - Heskett #70 16:22 CST 12/20/88

P.O. #: M04548

Date Received: 12/22/88

PHYSICAL PARAMETERS:		
Color	units of apparent color	
Conductivity	micromhos/cm @ 25°C	14841
pH		8.0
Solids (Total)	mg/l	
Solids (Total Dissolved)	mg/l	13393
Solids (Total Suspended)	mg/l	
Solids (Total Volatile)	mg/l	
Turbidity — NTU		
COMMON IONS:		
Calcium	mg/l	212.5
Magnesium	mg/l	117.0
Sodium	mg/l	3880.0
Potassium	mg/l	26.5
Acidity as $CaCO_3$	mg/l	
Alkalinity (Total) as $CaCO_3$	mg/l	510
Bicarbonate as $CaCO_3$	mg/l	510
Bicarbonate as HCO_3	mg/l	
Carbonate as $CaCO_3$	mg/l	0
P-Alkalinity as $CaCO_3$	mg/l	
Sulfate	mg/l	8334.9
Chloride	mg/l	19.9
Total Hardness as $CaCO_3$	mg/l	1012
Sodium Adsorption Ratio		53.19
Cations		190.4
Anions		184.4
% Error		1.6

NUTRIENTS:		
Ammonia-Nitrogen	mg/l	
Nitrite-Nitrogen as N	mg/l	
Nitrate-Nitrogen as N	mg/l	<1.0
Organic-Nitrogen	mg/l	
Total - Kjeldahl Nitrogen	mg/l	
Ortho-phosphate as P	mg/l	
Phosphorus (Total) as P	mg/l	
Phosphorus (Dissolved) as P	mg/l	
METALS:		
Copper (Total)	mg/l	
Iron (Total)	mg/l	
Manganese (Total)	mg/l	
MISCELLANEOUS:		
ADA	g/l	
Biochemical Oxygen Demand	mg/l	
Chemical Oxygen Demand	mg/l	
Cyanide	mg/l	
Fecal Coliform Count — Millipore filter/100 ml		
Fluoride	mg/l	0.27
Iron Bacteria		
Oil & Grease	mg/l	
Phenols	mg/l	
Total Organic Carbon	mg/l	
Total Plate Count per 100ml		

TRACE ELEMENTS:

Element	Unit	Value	Element	Unit	Value	Element	Unit	Value
Aluminum	mg/l		Cobalt	mg/l		Silver	mg/l	0.030
Antimony	mg/l		Copper	mg/l		Strontium	mg/l	
Arsenic	mg/l	0.002	Iron	mg/l	0.14	Thallium	mg/l	
Barium	mg/l	<0.100	Lead	mg/l	<0.001	Thorium	mg/l	
Beryllium	mg/l		Manganese	mg/l	0.28	Tin	mg/l	
Boron	mg/l	2.800	Mercury	mg/l	0.0010	Titanium	mg/l	
Bromide	mg/l		Molybdenum	mg/l	<0.100	Vanadium	mg/l	
Cadmium	mg/l	<0.001	Nickel	mg/l		Zinc	mg/l	
Chromium	mg/l	<0.050	Selenium	mg/l	<0.002			

******** *Metals are reported as dissolved, unless otherwise indicated.* ********

FIELD DATA:

Flow	-	**T° C**	6.0°C
E. C.	1380	**pH**	6.40
Static Water Level	54.90		

Catherine Anne Phelps

Catherine A. Phelps, Chemist

EXHIBIT 5-K

HYDRAULIC CONDUCTIVITIES, CATION EXCHANGE CAPACITIES,

AND PARTICLE SIZE ANALYSES

(WELLS 60, WS1, WS2, WS3, AND WS4)

twin city testing corporation
3100 EAST BROADWAY
P.O. BOX 1114
BISMARCK, ND 58502
PHONE 701/223-6149

LABORATORY TEST RESULTS

PROJECT: PROPOSED ASH PIT HESKETT STATION
MANDAN, NORTH DAKOTA

REPORTED TO: Montana-Dakota Utilities
Attn: John Verwey
400 North 4th Street
Bismarck, ND 58501

DATE: September 18, 1986

FURNISHED BY:

COPIES TO:

LABORATORY No. 5200-86-454

INTRODUCTION

A sample of fat clay was submitted to Twin City Testing Corporation on August 14, 1986. We were authorized by you to perform an Atterberg limit test, standard proctor test and permeability test. We are transmitting two (2) copies of this report.

RESULTS

The test results can be found on the attached drafts. The permeability test was performed with the falling head method on a sample remolded to 94.5% of the maximum dry density at a moisture content of 32.4%, or 0.1% above the optimum moisture content. The maximum dry density and optimum moisture content were determined in accordance with ASTM:D698.

The test results indicate that the coeficient of permeability is 2.0×10^{-7} centimeters per second on the remolded sample.

CLOSURE

If you desire to test the coeficient of permeability at a higher remolded compaction level and/or higher moisture content, please contact us. Also contact us if you have any questions in regards to this report or if we can be of further service to you.

Twin City Testing Corporation

By Joel Zeltinger

*Revised Copy 9/17/86

twin city testing
and engineering laboratory, inc.
3100 EAST BROADWAY, P.O. BOX 1114
BISMARCK, ND 58502
PHONE: 701/223-6149

MOISTURE - DENSITY CURVE

SAMPLE NO. 1 - Hole 60, 20'-40

PROJECT: PROPOSED ASH PIT HESKETT STATION
MANDAN, NORTH DAKOTA

DATE: August 21, 1986

REPORTED TO: Montana-Dakota Utilities Company
Attn: John Verwey

COPIES TO:

LABORATORY NO. 5200-86-454

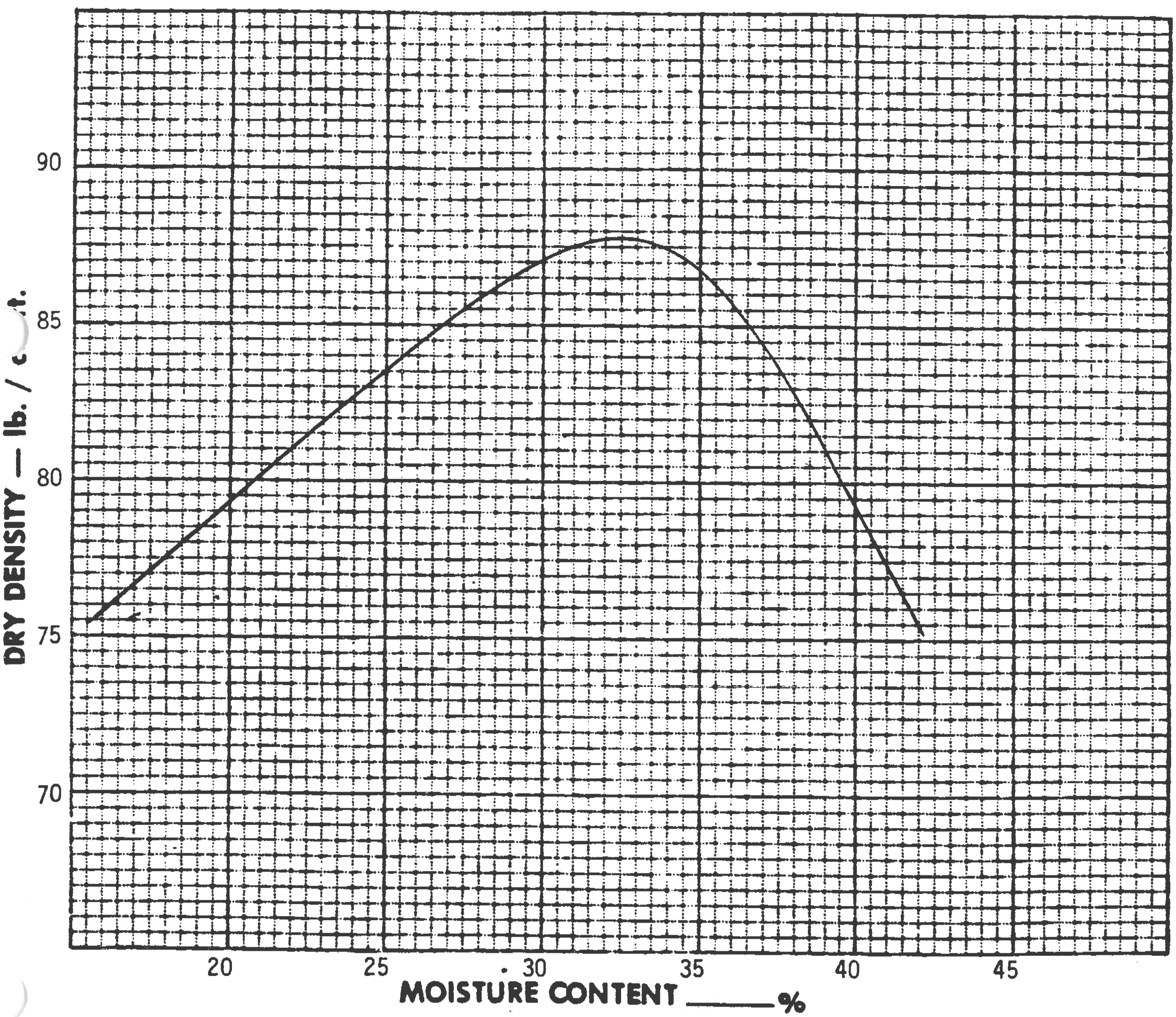
*LIQUID LIMIT: 59.4
*PLASTIC LIMIT: 23.9

METHOD OF TEST: ASTM:D698-78, Method "A"

TYPE OF MATERIAL: Fat Clay, brown (CH)

MAXIMUM DENSITY: 87.8 lb./cu. ft.

OPTIMUM MOISTURE 32.3 %



Twin City Testing and Engineering Laboratory, Inc.

By

G-232(2/84)

LABORATORY TEST DATA

PROJECT: PROPOSED ASH PIT-HESKETT STATION-MANDAN, NORTH DAKOTA

REPORTED TO: Montana-Dakota Utilities Company
Attn: John Verwey

JOB NO.: 5200-86-454

Boring No.				
Sample No. Sample Designation	Hole 60			
Depth (ft)	20-40			
Type of Sample	Bag			
Soil Classification (ASTM:D2487)	Fat Clay (CH)			
In-Place Moisture Content (%)	-			
Moisture-Density Relation of Soil (ASTM:D698)				
Max. Dry Density (PCF)	87.8			
Optimum Moisture Content (%)	32.3			
Permeability Test				
Trial No.	6.8			
Type of Test	Falling Head			
Type of Specimen	Compacted			
Specimen Height (inches)	3.00			
Specimen Diameter (inches)	2.82			
Dry Density (PCF)	82.9			
Percent of Max. Density	94.5			
Moisture Content (%)	32.4			
Max. Head Differential (ft)	5.0			
Confining Pressure (effective - PSI)	2.0			
Water Temperature (^{o}C)	21			
Coefficient of Permeability K @ 20°C (cm/sec)	2×10^{-7}			
K @ 20°C (ft/min)	4×10^{-7}			
Atterberg Limits				
Liquid Limit (%)	59.4			
Plastic Limit (%)	23.9			
Plasticity Index	35.5			

December 14, 1981

Water Supply, Inc
PO Box 1191
Bismarck, ND 58502

Attn: Roger Schmid

Gentlemen

Subj: Soil Testing for MDU Heskett Power Plant
Mandan, North Dakota
Invoice #52-0688

Attached herewith, please find our laboratory test results for permeability tests, cation exchange capacity, particle size distribution curves and U.S.D.A. textural classification charts.

If you have any questions or need any additional information, please contact us at the Bismarck office.

Very truly yours,

Gary L Ayman, P.E.
Operations Manager
Western North Dakota

GLA:djs

Encs

LABORATORY TEST DATA

PROJECT: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, ND

DATE: December 14, 1981

REPORTED TO: Water Supply, Inc

JOB NO.: 52-0688

Boring No.	MDU Heskett 1	MDU Heskett 1	MDU Heskett 1	MDU Heskett 2
Sample No. Sample Designation				
Depth (ft)	20-21	25-26	30-31	29-30
Type of Sample	Core	Core	Core	Core
Soil Classification (ASTM:D2487)	SILTY CLAY & FAT CLAY (CL & CH)	SILTY CLAY & FAT CLAY (CL & CH)	SILTY CLAY & FAT CLAY (CL & CH)	SHALE, (Textural Classification: Fat Clay) (CH)
In-Place Moisture Content (%)				
Moisture-Density Relation of Soil (ASTM:D698)				
Max. Dry Density (PCF)				
Optimum Moisture Content (%)				
Permeability Test				
Trial No.	1	1	1	1
Type of Test	Falling Head	Falling Head	Falling Head	Falling Head
Type of Specimen	Natural	Natural	Natural	Natural
Specimen Height (inches)	4.36	3.49	3.76	2.08
Specimen Diameter (inches)	4.00	2.86	4.00	1.98
Dry Density (PCF)				
Percent of Max. Density				
Moisture Content (%)				
Max. Head Differential (ft)	5.0	5.0	5.0	5.0
Confining Pressure (effective - PSI)	2.0	2.0	2.0	2.0
Water Temperature (°C)	21	21	20	21
Coefficient of Permeability K @ 20°C (cm/sec)	2.6×10^{-8}	1.5×10^{-8}	1.7×10^{-8}	2.7×10^{-9}
K @ 20°C (ft/min)	5.2×10^{-8}	2.9×10^{-8}	3.4×10^{-8}	5.4×10^{-9}
Atterberg Limits				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index				

TWIN CITY TESTING LAB

SL-26(77-8)

LABORATORY TEST DATA

PROJECT: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, ND DATE: December 14, 1981

REPORTED TO: Water Supply, Inc JOB NO.: 52-0688

Boring No.	MDU Heskett 2	MDU Heskett 2	MDU Heskett 3	MDU Heskett 3
Sample No. Sample Designation				
Depth (ft)	61-62	73-74	15-16	19-20
Type of Sample	Core	Core	Core	Core
Soil Classification (ASTM:D2487)	SHALE, (Textural Classification: Fat Clay) (CH)	SHALE, (Textural Classification: Fat Clay) (CH)	SILTY CLAY (CL-ML)	FAT CLAY & SILTY CLAY (CH & CL)
In-Place Moisture Content (%)				
Moisture-Density Relation of Soil (ASTM:D698)				
Max. Dry Density (PCF)				
Optimum Moisture Content (%)				
Permeability Test				
Trial No.	1	1	1	1
Type of Test	Falling Head	Falling Head	Falling Head	Falling Head
Type of Specimen	Natural	Natural	Natural	Natural
Specimen Height (inches)	1.96	0.80	2.93	3.29
Specimen Diameter (inches)	1.99	1.98	4.00	4.00
Dry Density (PCF)				
Percent of Max. Density				
Moisture Content (%)				
Max. Head Differential (ft)	5.0	5.0	5.0	50.0
Confining Pressure (effective - PSI)	2.0	2.0	2.0	2.0
Water Temperature (^{o}C)	21	19	22	22
Coefficient of Permeability K @ 20°C (cm/sec)	3.6×10^{-8}	1.8×10^{-8}	8.5×10^{-8}	1.8×10^{-9}
K @ 20°C (ft/min)	7.1×10^{-8}	3.6×10^{-8}	1.7×10^{-7}	3.5×10^{-9}
Atterberg Limits				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index				

TWIN CITY TESTING LAB

SL-26(77-B)

LABORATORY TEST DATA

PROJECT: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, ND   DATE: December 14, 1981

REPORTED TO: Water Supply, Inc   JOB NO.: 52-0688

Boring No.	MDU Heskett 3	MDU Heskett 4	MDU Heskett 4	MDU Heskett 4
Sample No. Sample Designation				
Depth (ft)	31-32	9-10	41-42	51-52
Type of Sample	Core	Core	Core	Core
Soil Classification (ASTM:D2487)	SILTY CLAY & FAT CLAY (CL & CH)	FAT CLAY & SILTY CLAY (CH & CL)	SHALE, (Textural Classification: Organic Fat Clay (CH-OH))	SHALE, (Textural Classification: Silty Clay (CL))
In-Place Moisture Content (%)				
Moisture-Density Relation of Soil (ASTM:D698)				
Max. Dry Density (PCF)				
Optimum Moisture Content (%)				
Permeability Test				
Trial No.	1	1	1	1
Type of Test	Falling Head	Falling Head	Falling Head	Falling Head
Type of Specimen	Natural	Natural	Natural	Natural
Specimen Height (inches)	2.20	3.63	2.31	2.31
Specimen Diameter (inches)	4.00	4.00	1.98	1.45
Dry Density (PCF)				
Percent of Max. Density				
Moisture Content (%)				
Max. Head Differential (ft)	30.0	50.0	5.0	5.0
Confining Pressure (effective - PSI)	2.0	2.0	2.0	2.0
Water Temperature (^{o}C)	21	22	20	21
Coefficient of Permeability K @ 20^{o}C (cm/sec)	9.1×10^{-9}	7.2×10^{-9}	7.6×10^{-9}	1.9×10^{-7}
K @ 20^{o}C (ft/min)	1.8×10^{-8}	1.4×10^{-8}	1.5×10^{-8}	3.7×10^{-7}
Atterberg Limits				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index				

TWIN CITY TESTING LAB

SL-26(77-8)

twin city testing
and engineering laboratory, inc.
3100 E. Broadway
Box 1114
Bismarck, ND 5850
Phone 701/223-6149

REPORT OF: CATION EXCHANGE CAPACITY

PROJECT: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

DATE: December 14, 1981

REPORTED TO: Water Supply, Inc
PO Box 1191
Bismarck, ND 58502
Attn: Roger Schmid

LABORATORY No. 52-0688

SAMPLE NUMBER	DEPTHS	CATION EXCHANGE CAPACITY (meq/100g) (milliequivalents/100 gr)
MDU Heskett #1	20'-21	71.8
#1	25'-26'	12.3
#1	30'-31'	74.2
#1	40'-41'	27.4
MDU Heskett #2	29'-30'	92.2
#2	56'-57'	69.7
#2	61'-62'	12.0
#2	73'-74'	48.4
MDU Heskett #3	15'-16'	70.1
#3	19'-20'	58.1
#3	31'-32'	35.6
MDU Heskett #4	9'-10'	40.4
#4	15'-16'	60.9
#4	31'-32'	26.1
#4	41'-42'	51.3
#4	51'-52'	56.4

Job No. 52-0688

Sample No. MDU Heskett #1 Depth: 20'-21'

Classification (ASTM:D2487) CL & CH

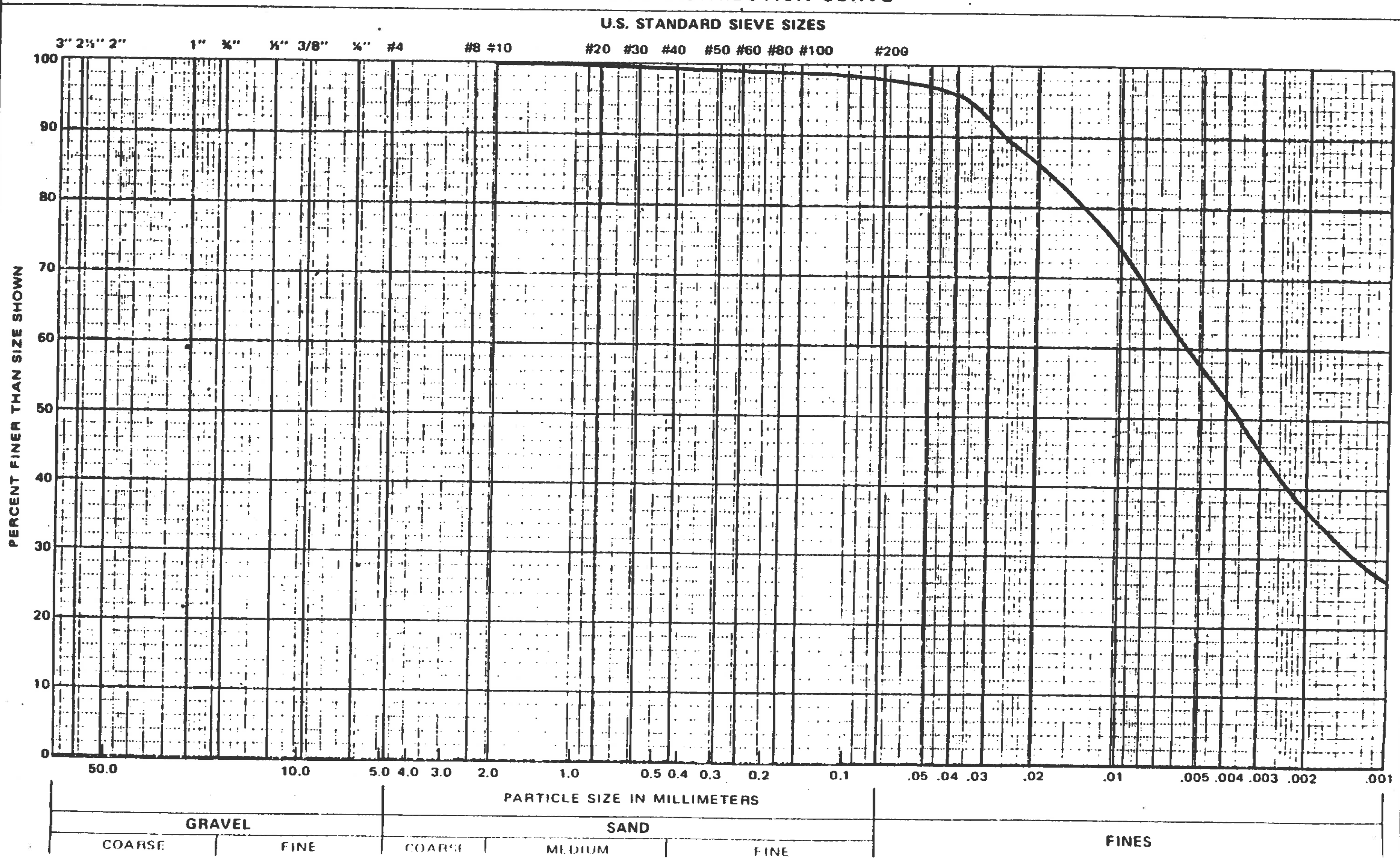
Description SILTY CLAY & FAT CLAY

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612-645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

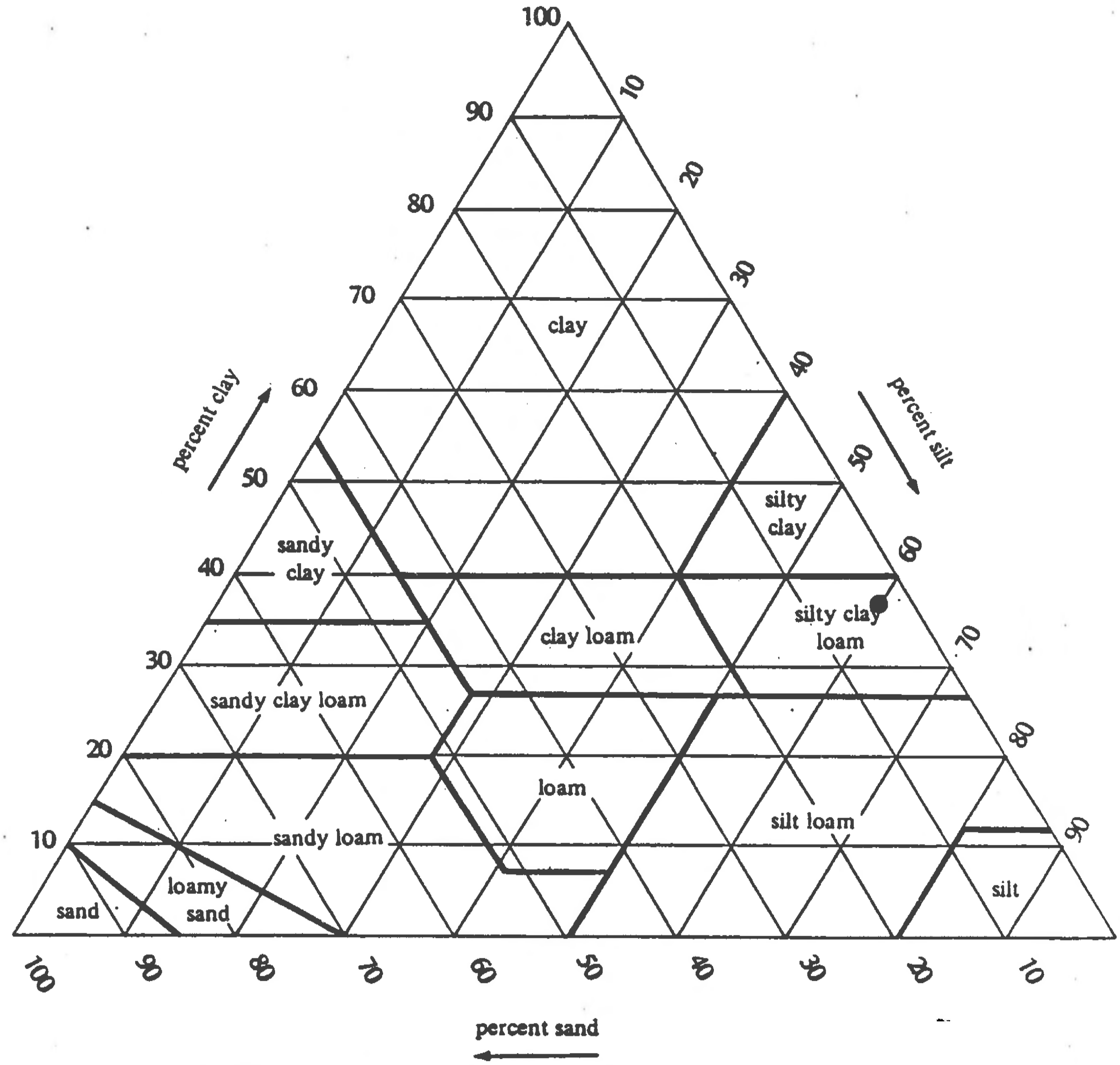
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #1, 20'-21'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 | 2 | 1 | 0.5 | 0.25 | 0.1 | 0.05 | 0.02 | 0.005 | 0.002 | 0.0002 | 0.00008

GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Me-dium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10 | 18 | 35 | 60 | 140 | 300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #1 Depth: 25'-26'

Classification (ASTM:D2487) CL & CH

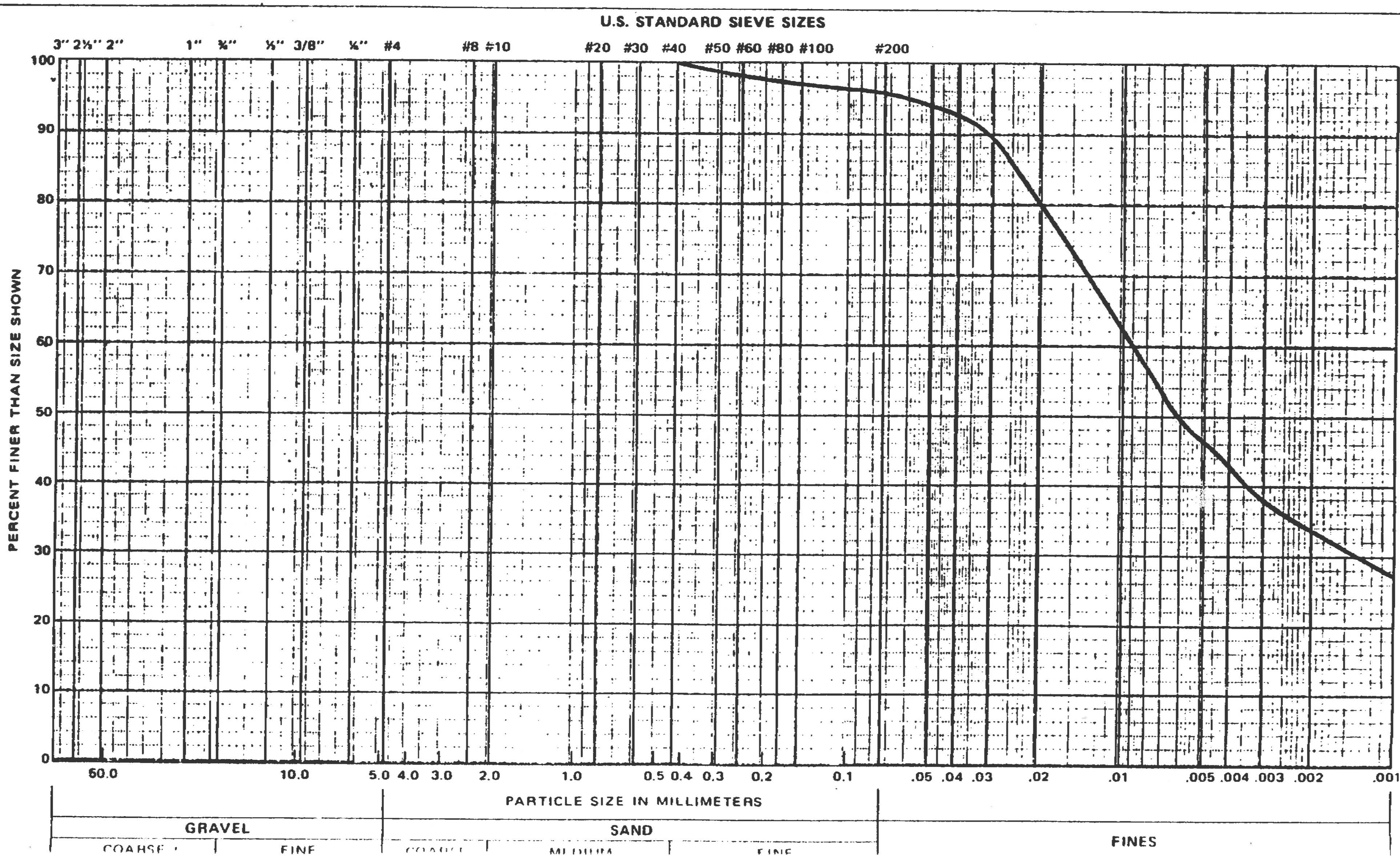
Description SILTY CLAY & FAT CLAY

twin city testing
and engineering laboratory, inc.
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

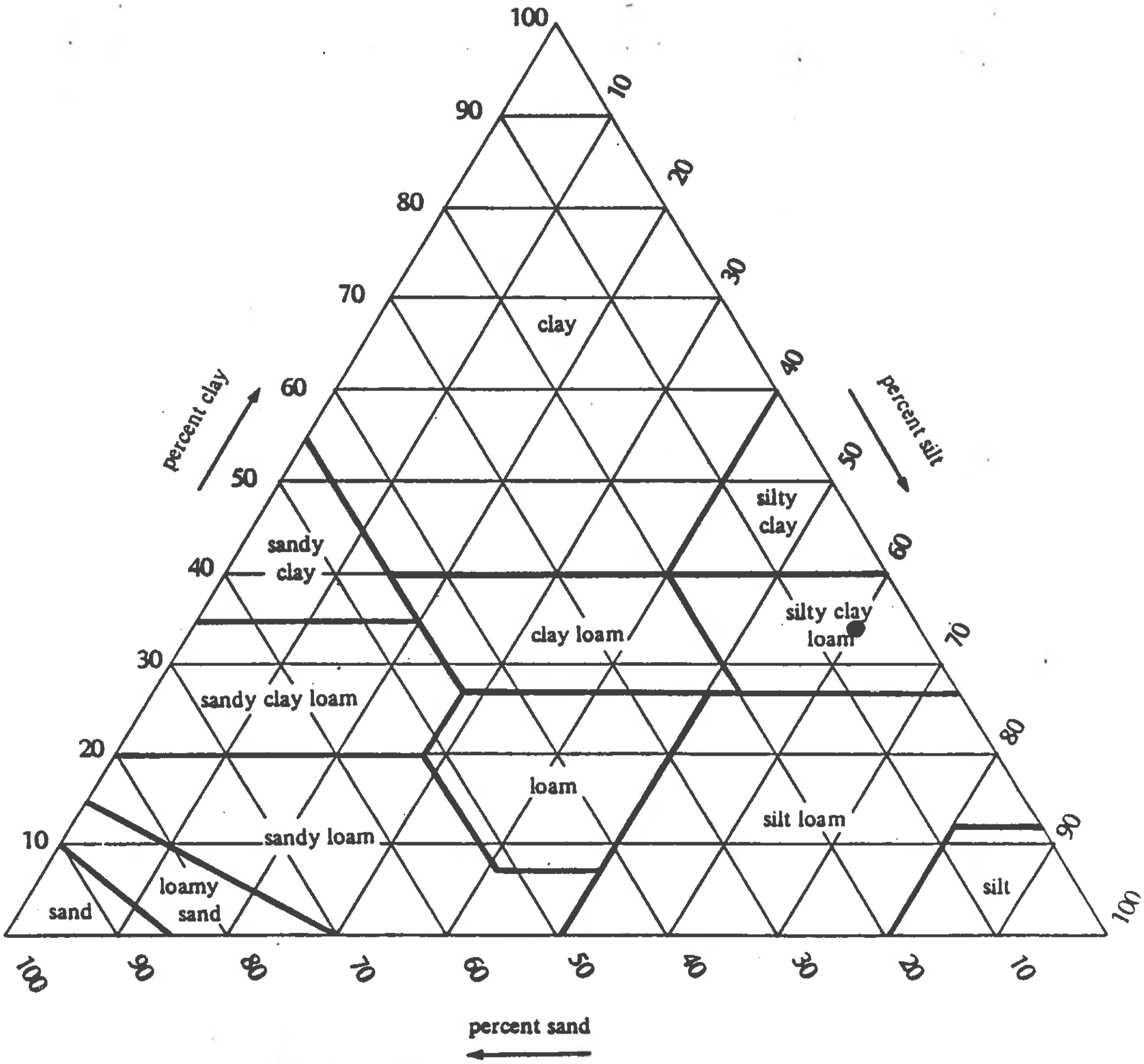
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #1, 25'-26'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
	10	18	35	60	140	300					

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #1 Depth: 30'-31'

Classification (ASTM:D2487) CL & CH

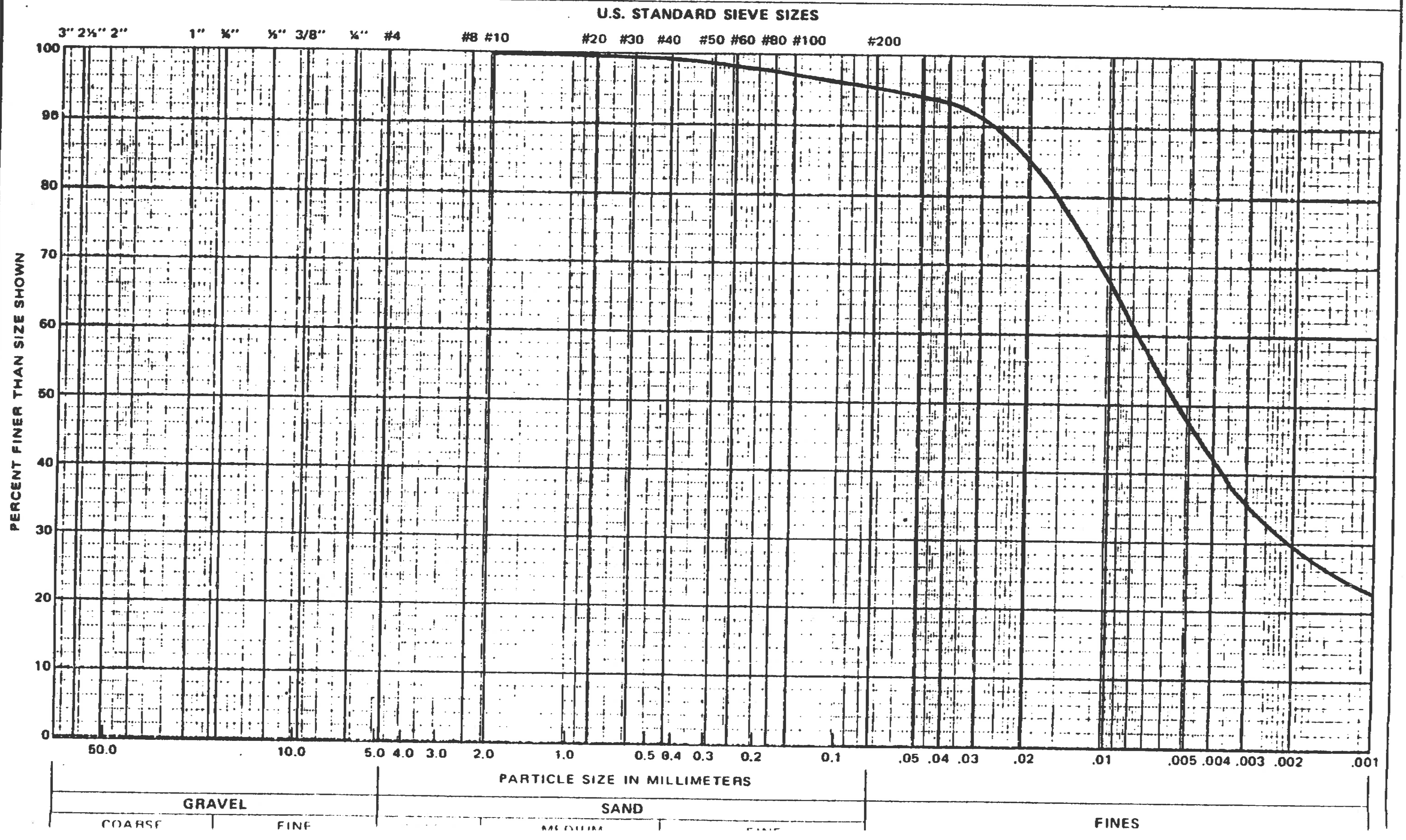
Description SILTY CLAY & FAT CLAY

twin city testing
and engineering laboratory, inc.
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT
POWER PLANT - MANDAN, NORTH DAKOTA

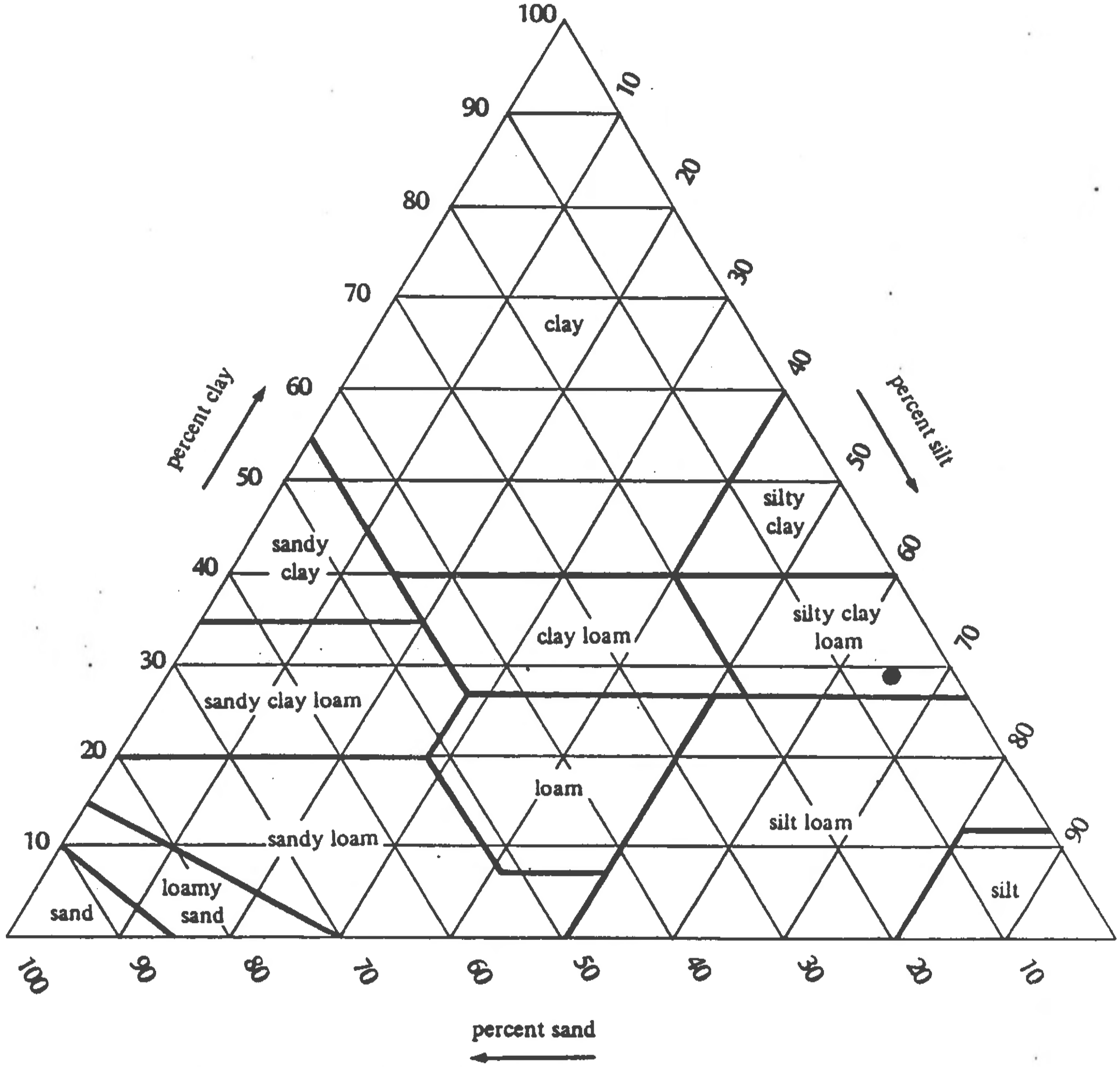
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #1, 30'-31'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 | 2 | 1 | 0.5 | 0.25 | 0.1 | 0.05 | 0.02 | 0.005 | 0.002 | 0.0002 | 0.00008

GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10 | 18 | 35 | 60 | 140 | 300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #2 Depth: 29'-30'

Classification (ASTM:D2487) CH

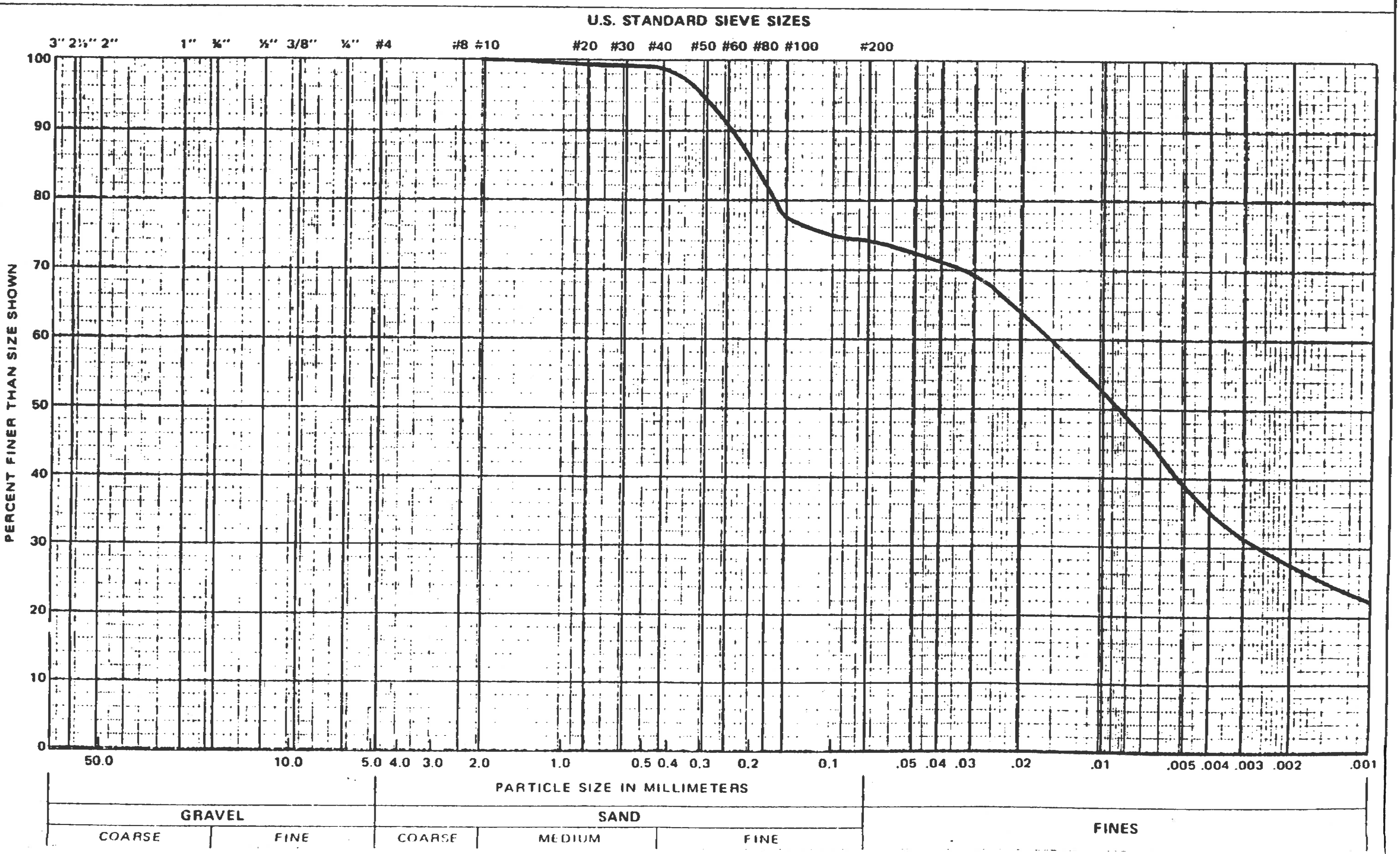
Description SHALE, (Textural Classification: Fat Clay)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612-645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

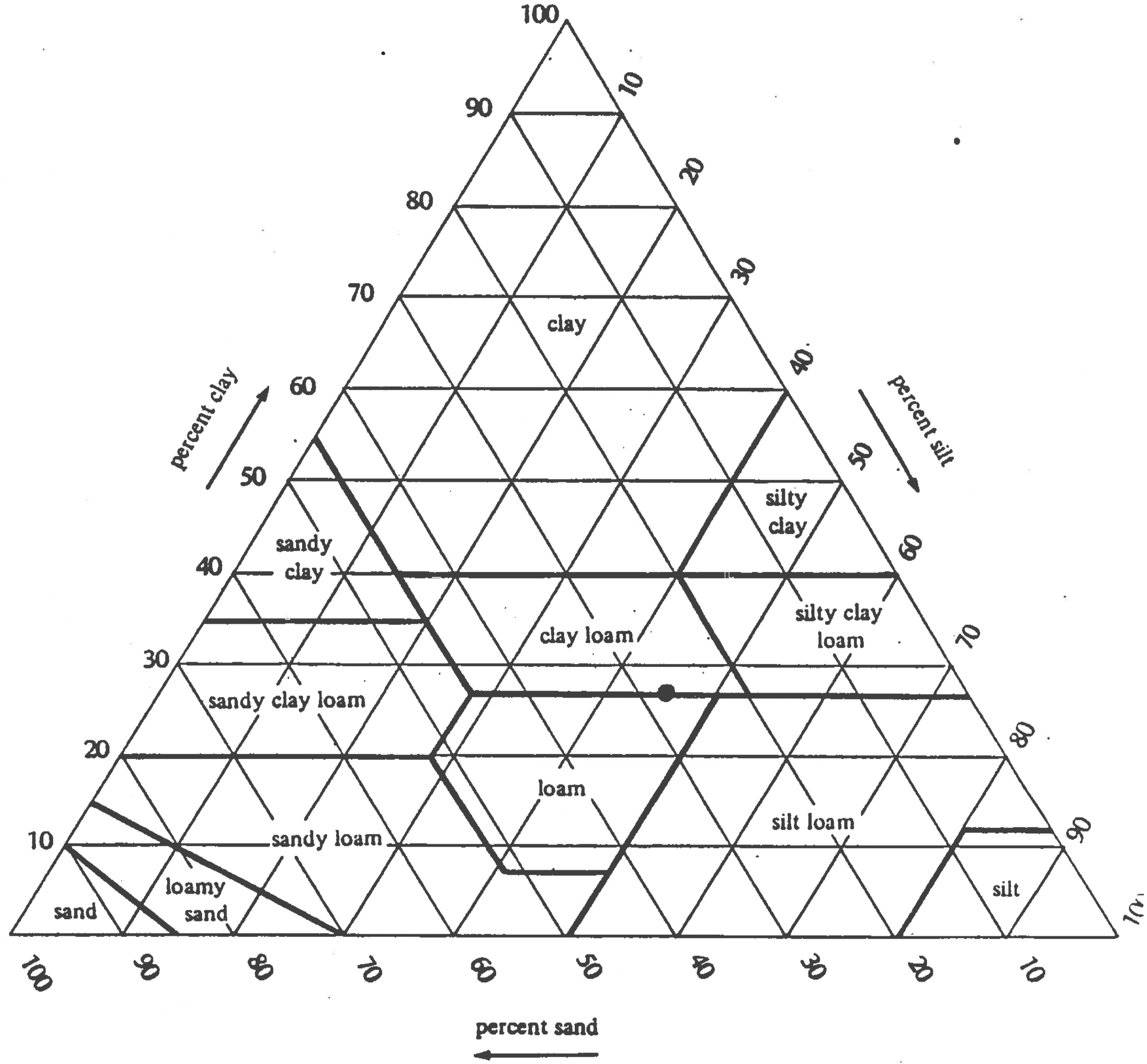
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #2, 29'-30'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 | 2 | 1 | 0.5 | 0.25 | 0.1 | 0.05 | 0.02 | 0.005 | 0.002 | 0.0002 | 0.00008

GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Me-dium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10 | 18 | 35 | 60 | 140 | 300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #2 Depth: 61'-62'

Classification (ASTM:D2487) CH

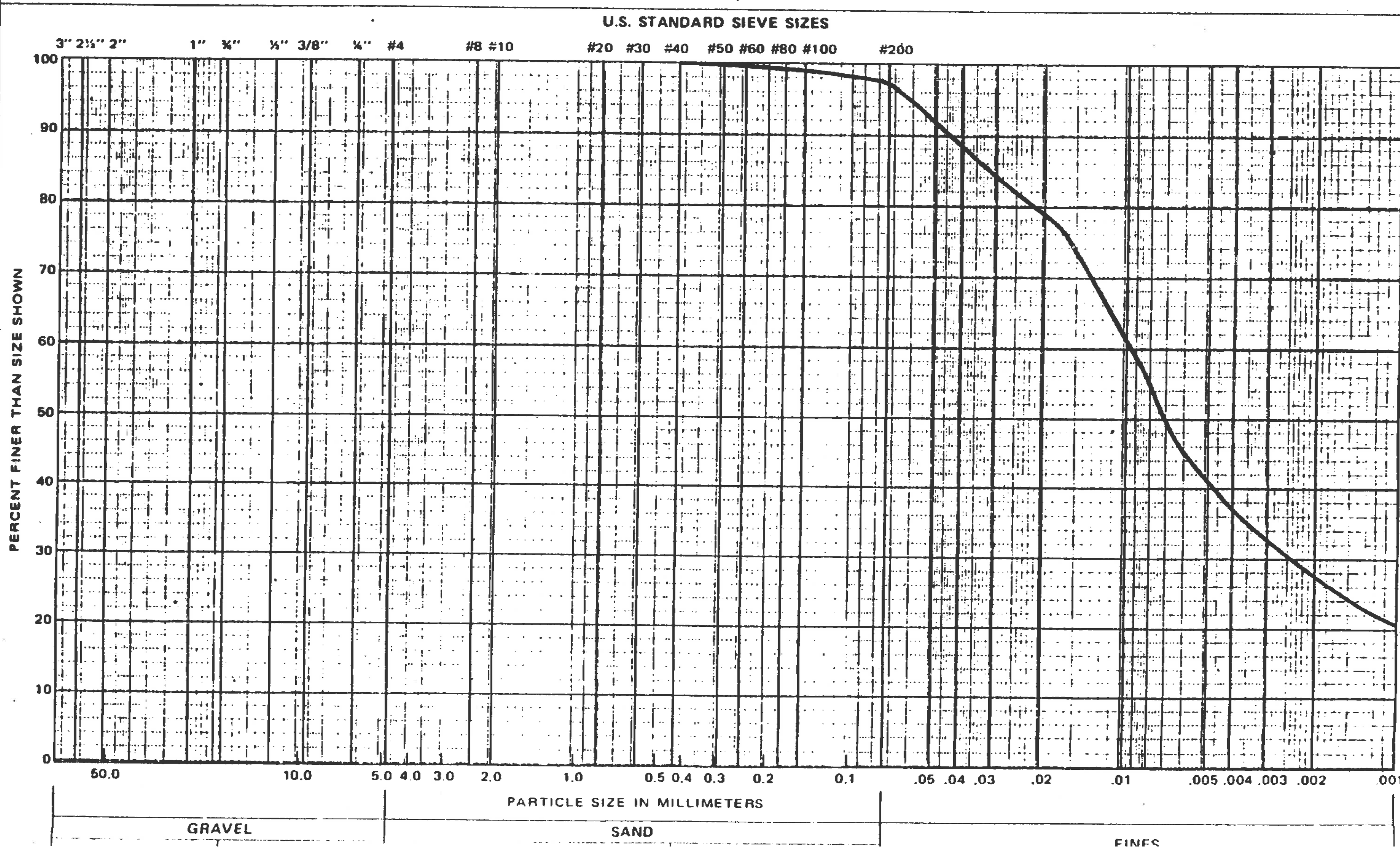
Description SHALE, (Textural Classification: Fat Clay)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

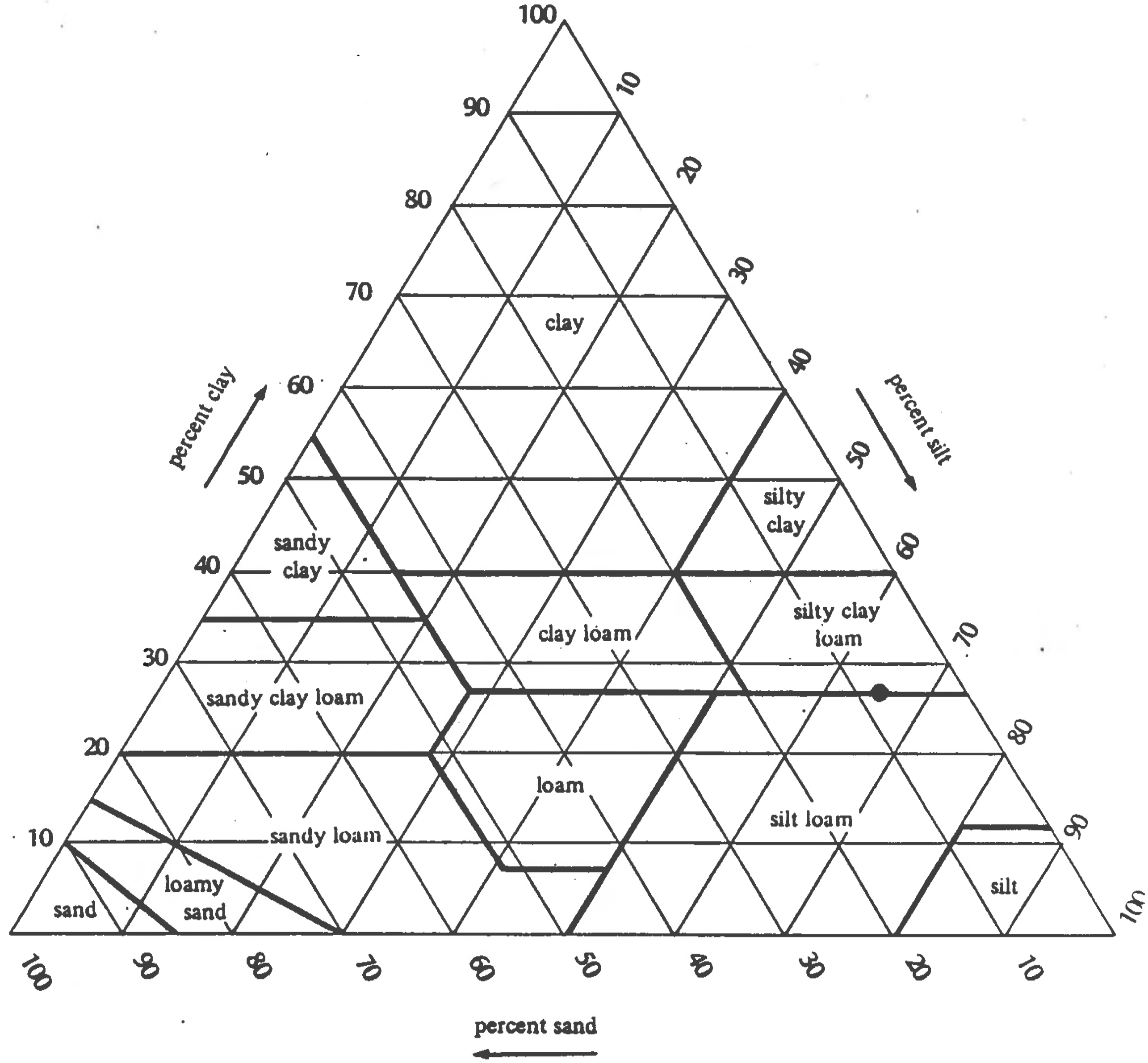
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #2, 61'-62'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

Size (mm)	75–2	2–1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.02	0.02–0.005	0.005–0.002	0.002–0.0002	0.0002–0.00008	<0.00008
Class	GRAVEL	SAND					SILT			CLAY		
Subclass		Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
U.S. Standard Sieve Numbers		10–18	18–35	35–60	60–140	140–300						

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #2 Depth: 73'-74'

Classification (ASTM:D2487) (CH)

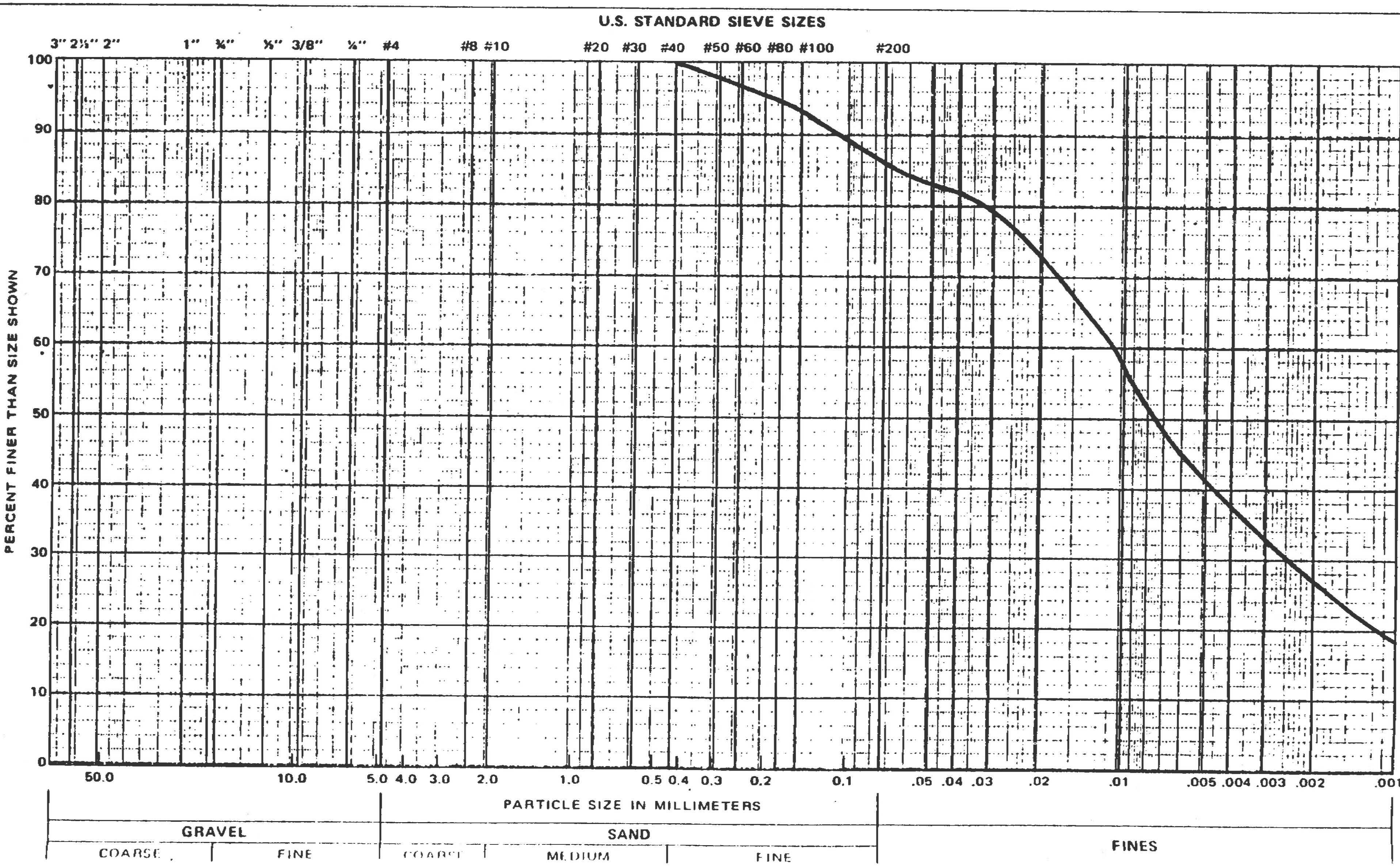
Description SHALE, (Textural Classification: Fat Clay)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

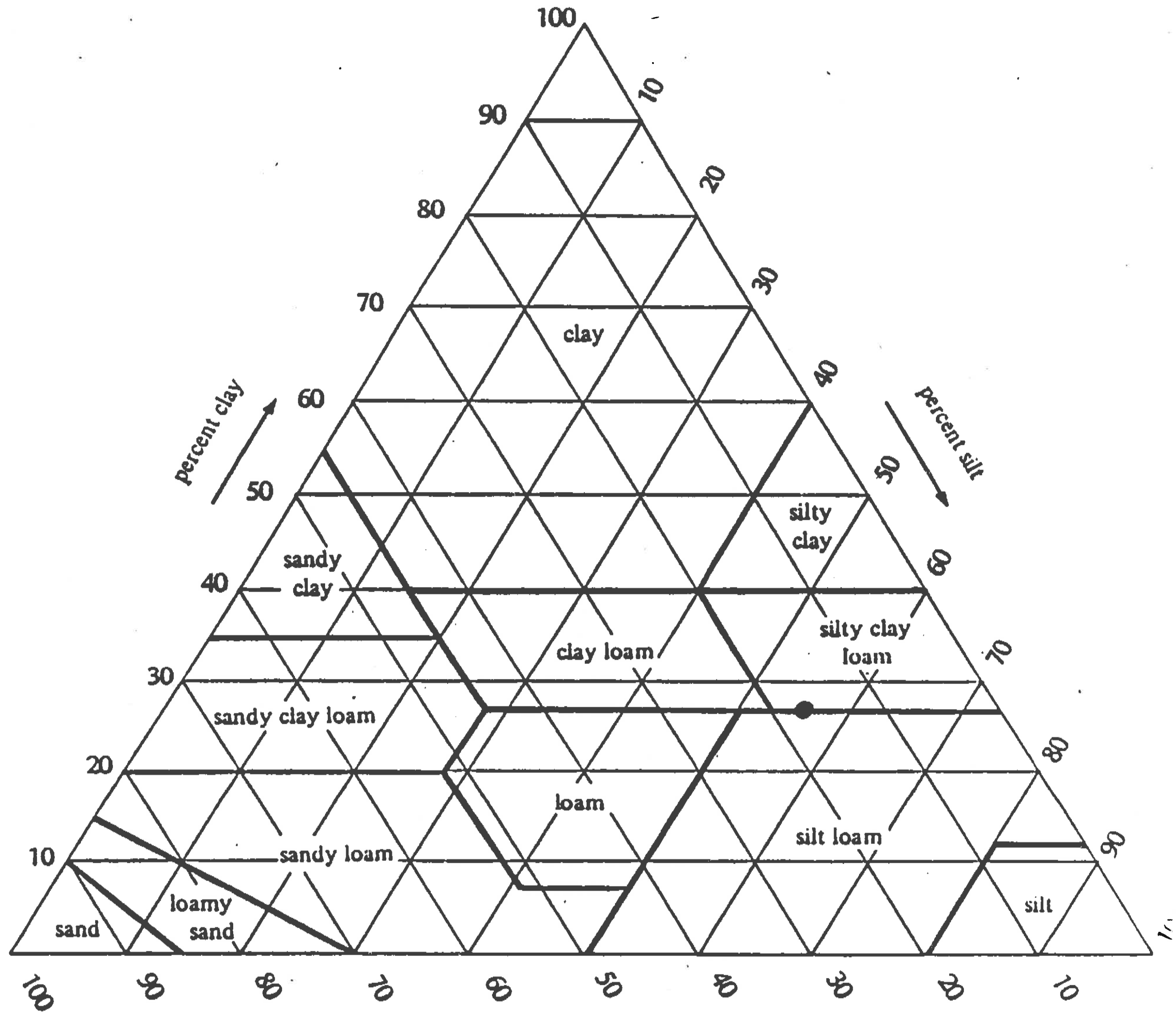
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #2, 73'-74'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10	18	35	60	140	300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #3 Depth: 15'-16'

Classification (ASTM:D2487) CL-ML

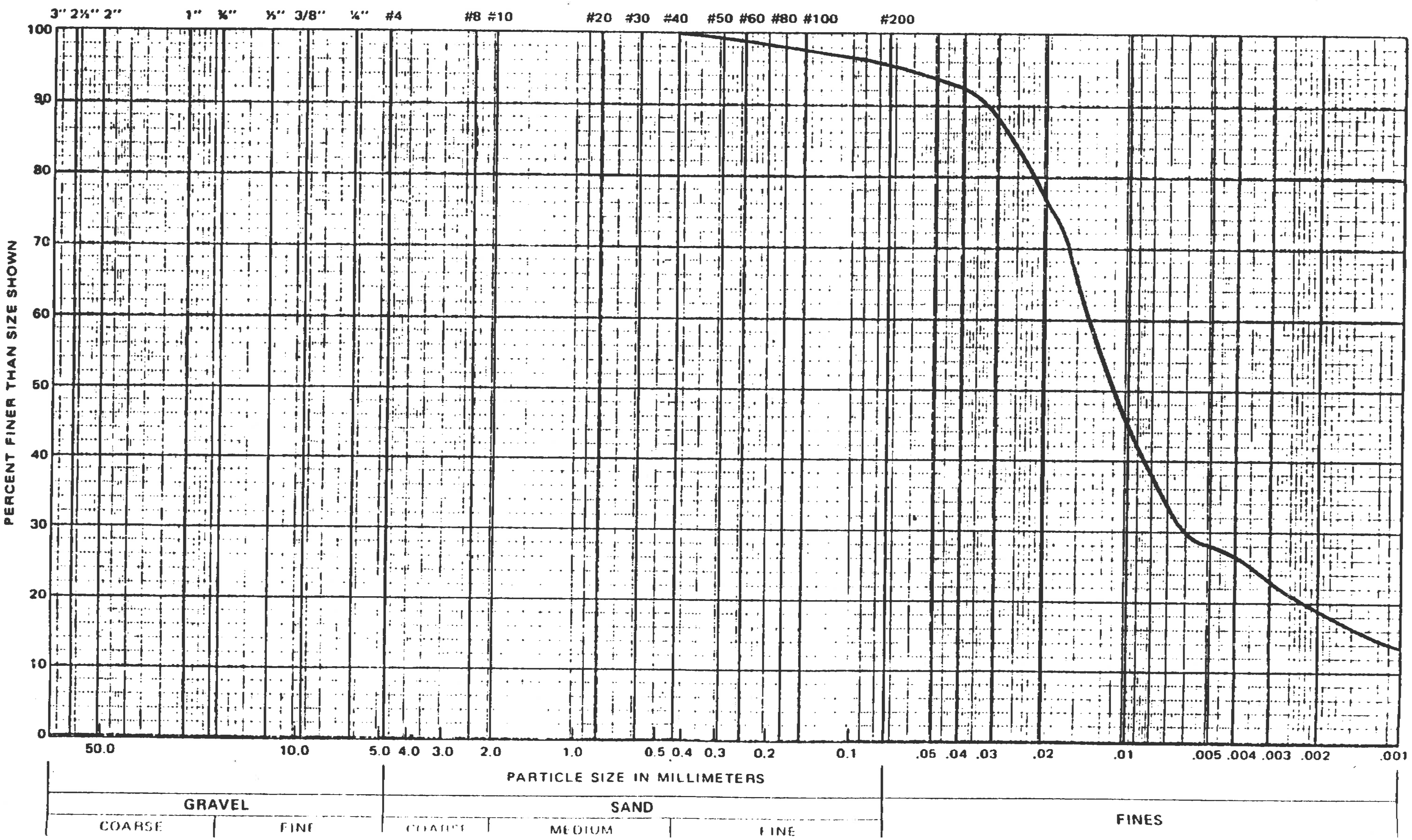
Description SILTY CLAY

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

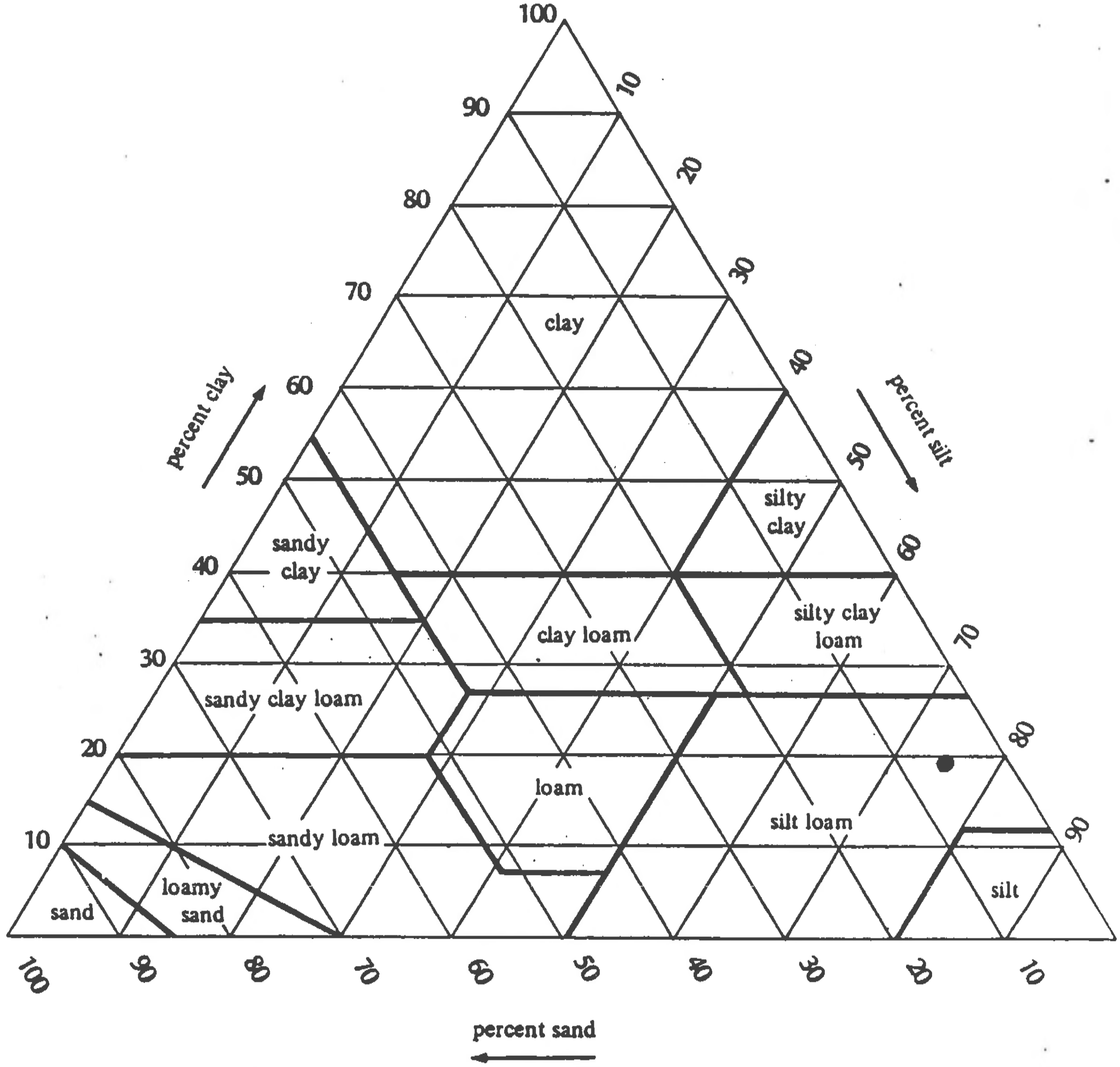
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #3, 15'-16'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Me-dium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fin
	10	18	35	60	140	300					

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #3 Depth: 19'-20'

Classification (ASTM:D2487) CH & CL

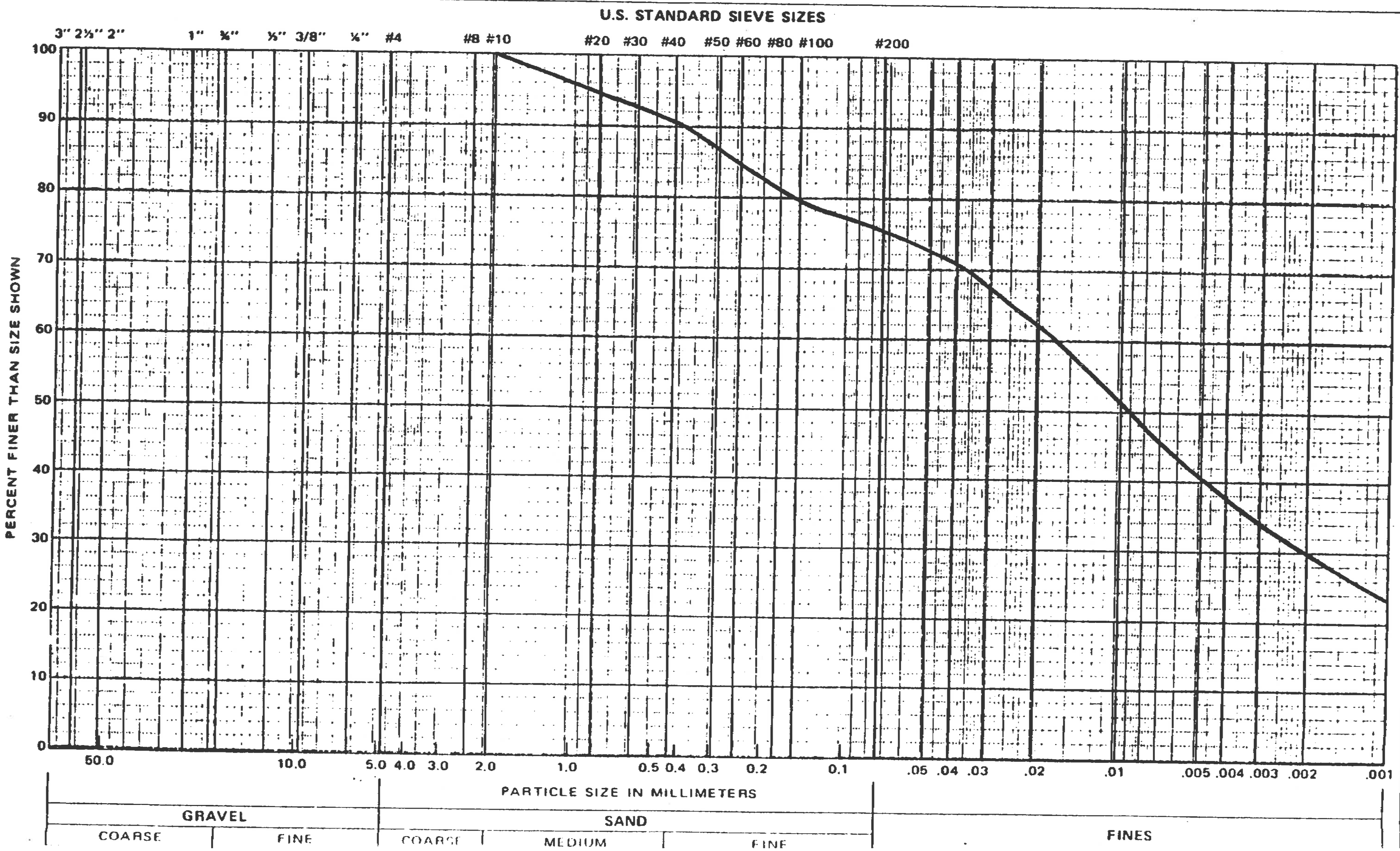
Description FAT CLAY & SILTY CLAY (Note: Distribution curve based on -10 material used for hydrometer test rather than total sample due to small boulder in a small sample.)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

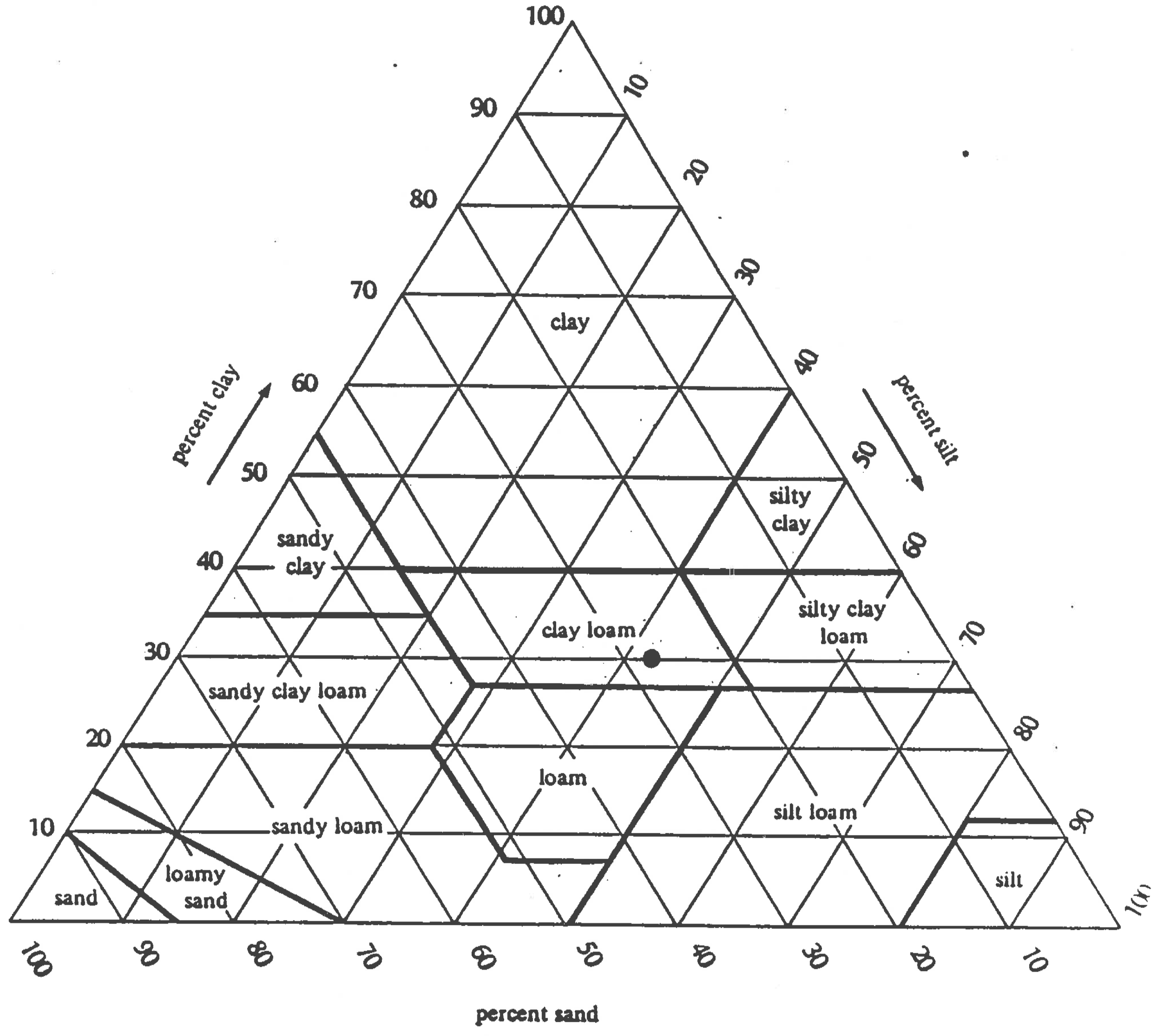
Reported To: Water Supply, Inc

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #3, 19'-20'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

Size (mm)	75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
Class	GRAVEL	SAND					SILT			CLAY		
Subclass		Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
U.S. Standard Sieve Numbers		10	18	35	60	140	300					

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #3 Depth: 31'-32'

Classification (ASTM:D2487) CL & CH

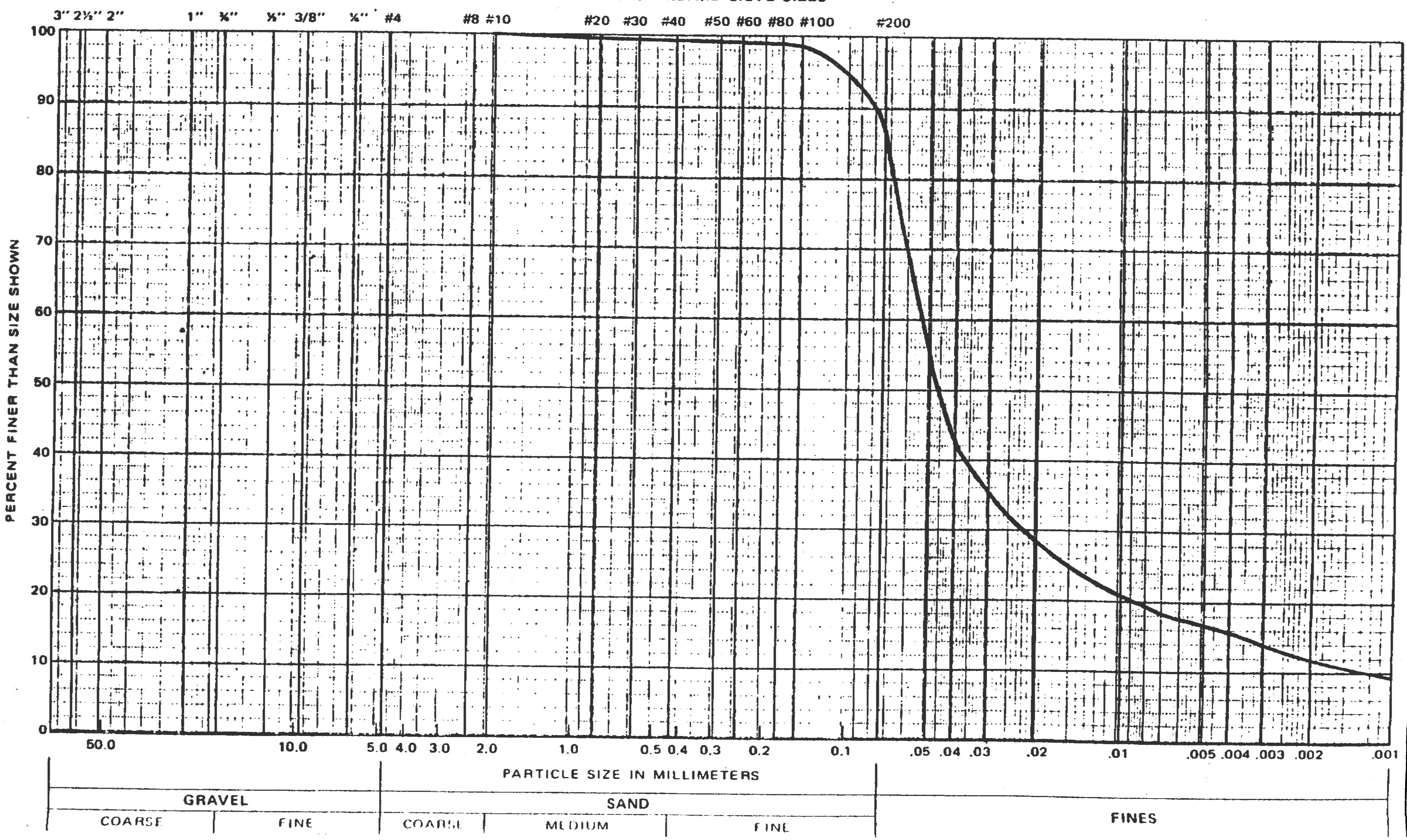
Description SILTY CLAY & FAT-CLAY

twin city testing
and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

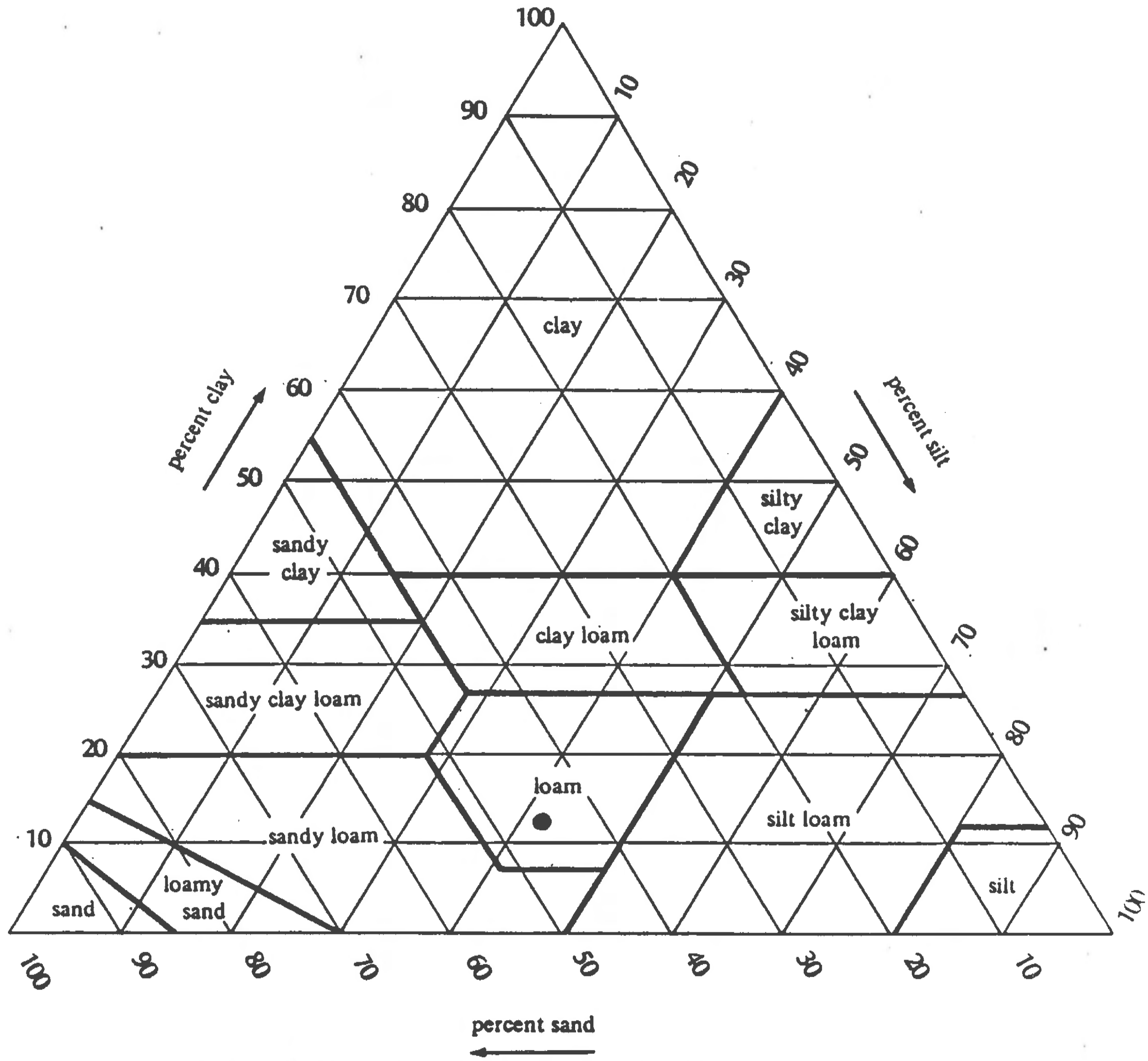
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #3, 31'-32'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 — 2 — 1 — 0.5 — 0.25 — 0.1 — 0.05 — 0.02 — 0.005 — 0.002 — 0.0002 — 0.00008

GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Me-dium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10 — 18 — 35 — 60 — 140 — 300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

SAMPLE NO. MDU Heskett #4 Depth: 9'-10'

Classification (ASTM:D2487) CH & CL

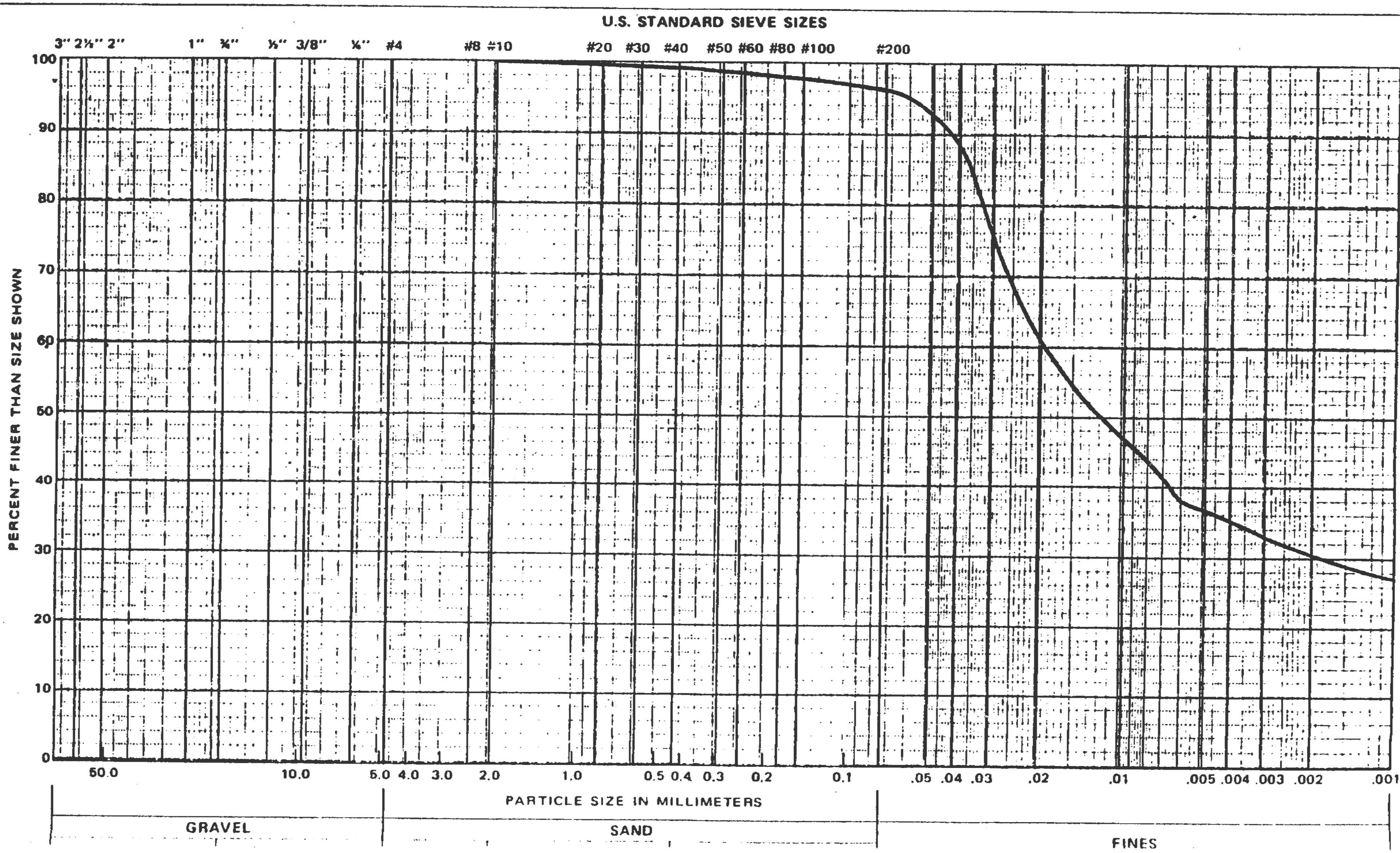
Description FAT CLAY & SILTY CLAY

twin city testing
and engineering laboratory, inc.
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

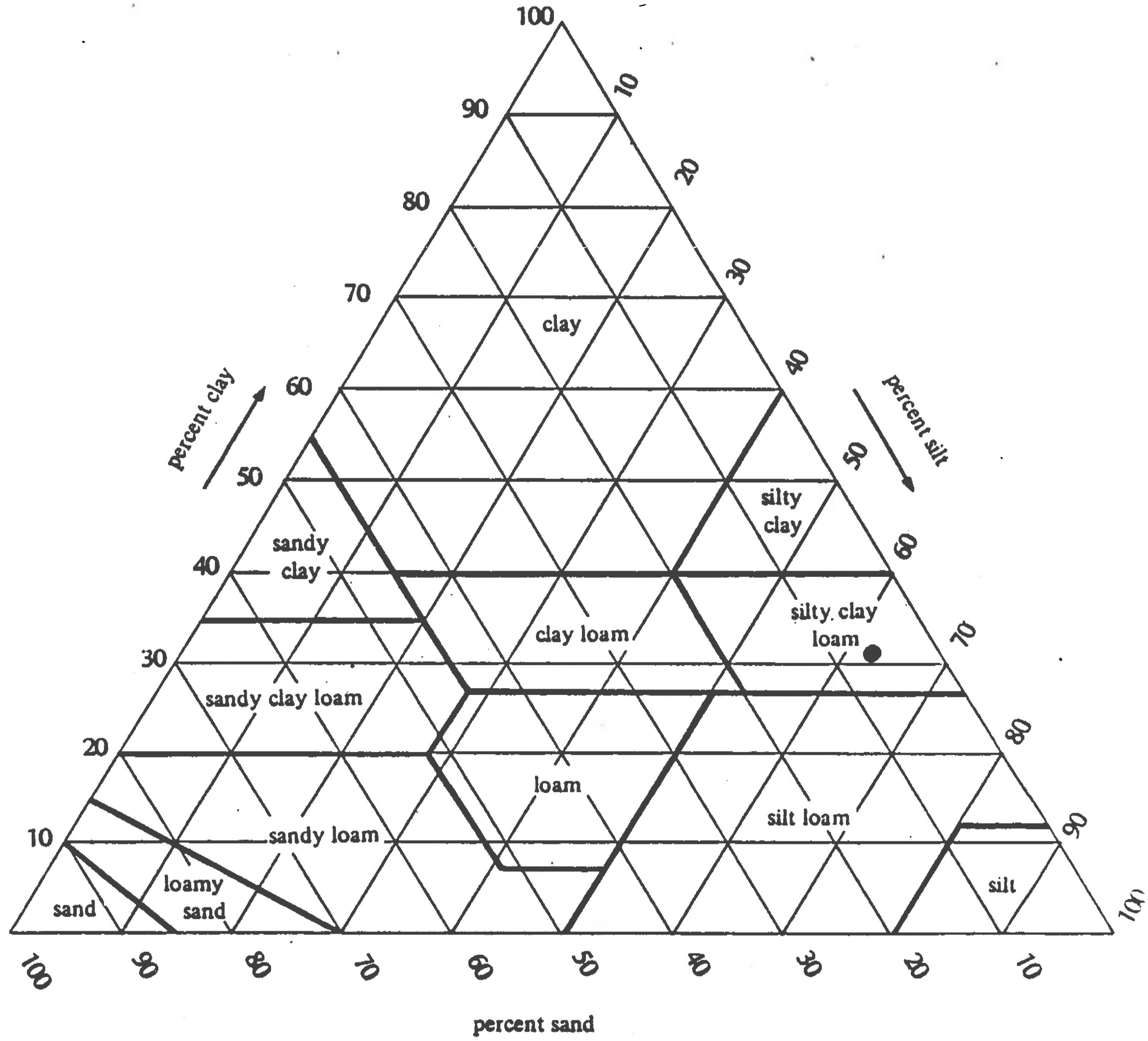
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #4, 9'-10'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 – 2	2 – 1	1 – 0.5	0.5 – 0.25	0.25 – 0.1	0.1 – 0.05	0.05 – 0.02	0.02 – 0.005	0.005 – 0.002	0.002 – 0.0002	0.0002 – 0.00008	< 0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Me-dium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
	10 – 18	18 – 35	35 – 60	60 – 140	140 – 300						

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

Job No. 52-0688

Sample No. MDU Heskett #4 Depth: 15'-16'

Classification (ASTM:D2487) CL & CH

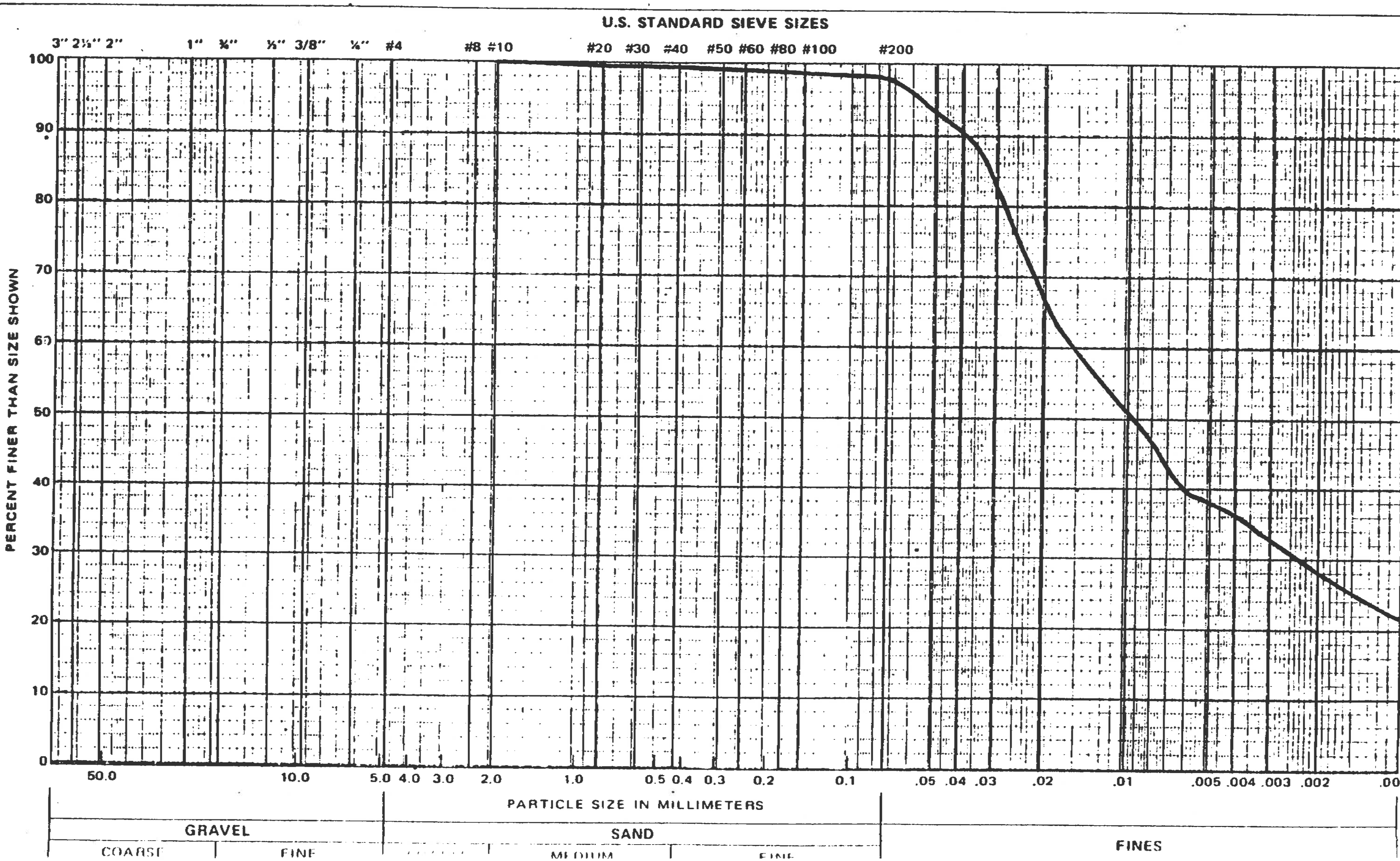
Description SILTY CLAY & FAT CLAY

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

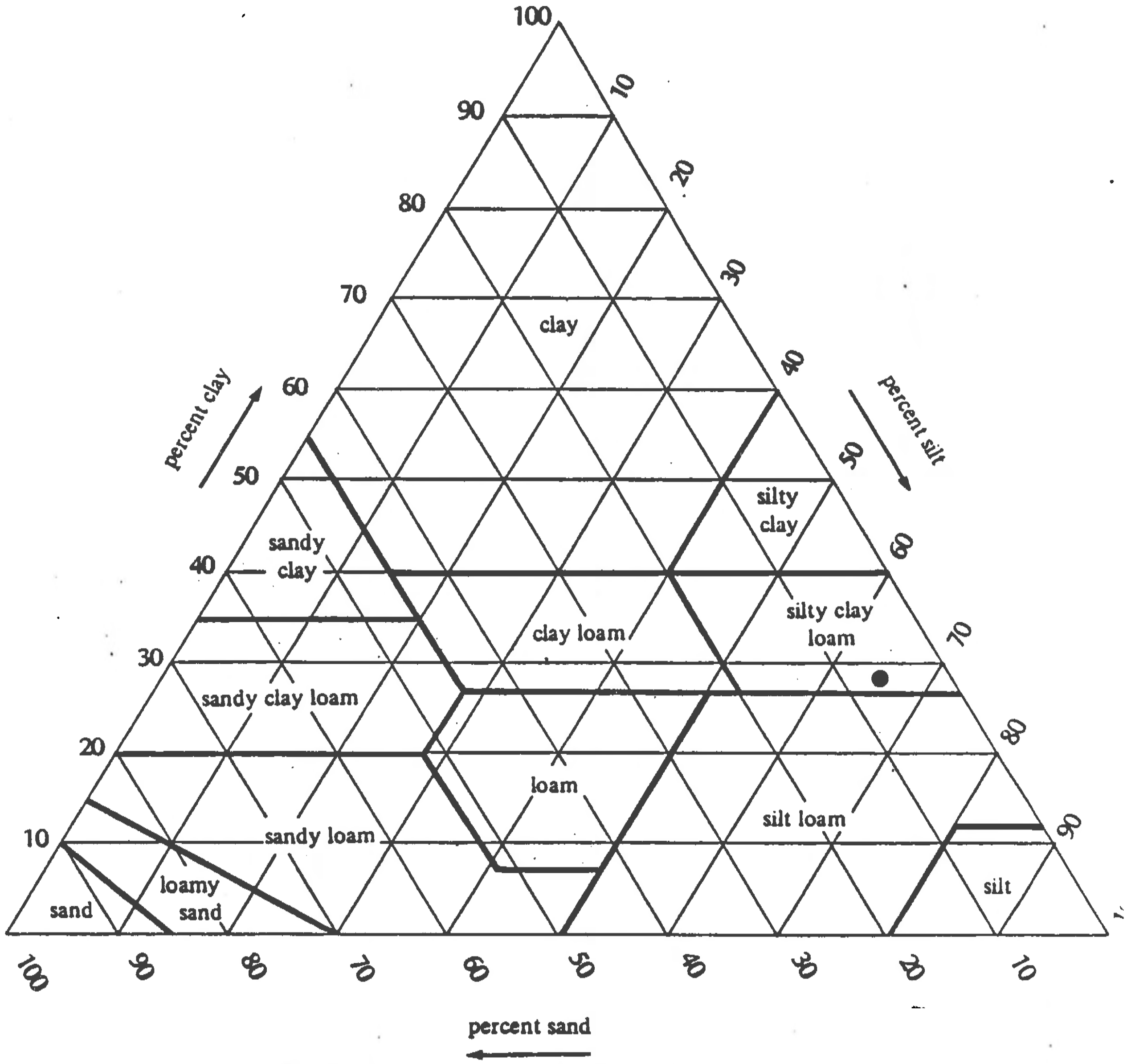
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #4, 15'-16'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
	10	18	35	60	140	300					

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #4 Depth: 31'-32'

Classification (ASTM:D2487) SM

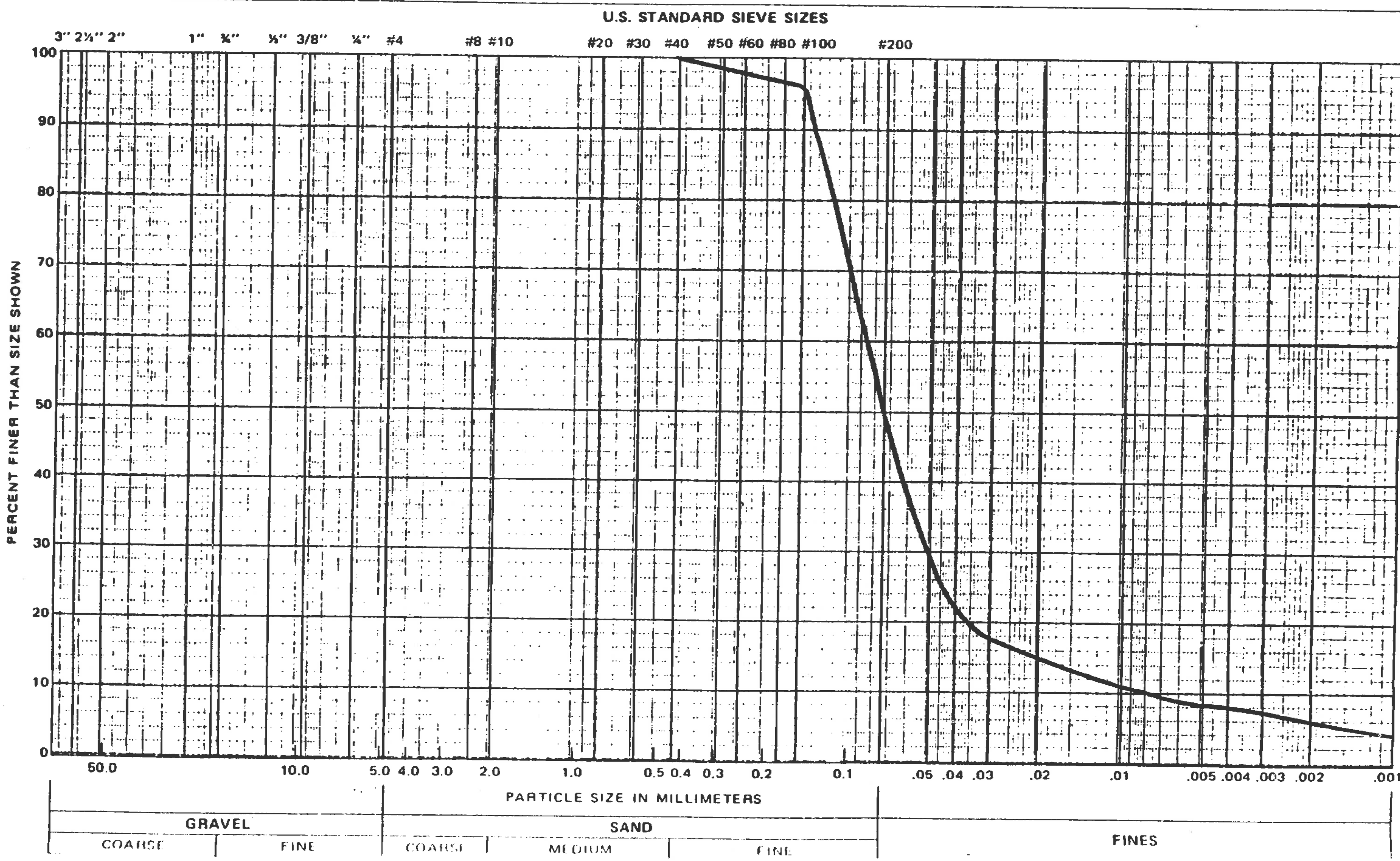
Description SILTY SAND, fine grained

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645 3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

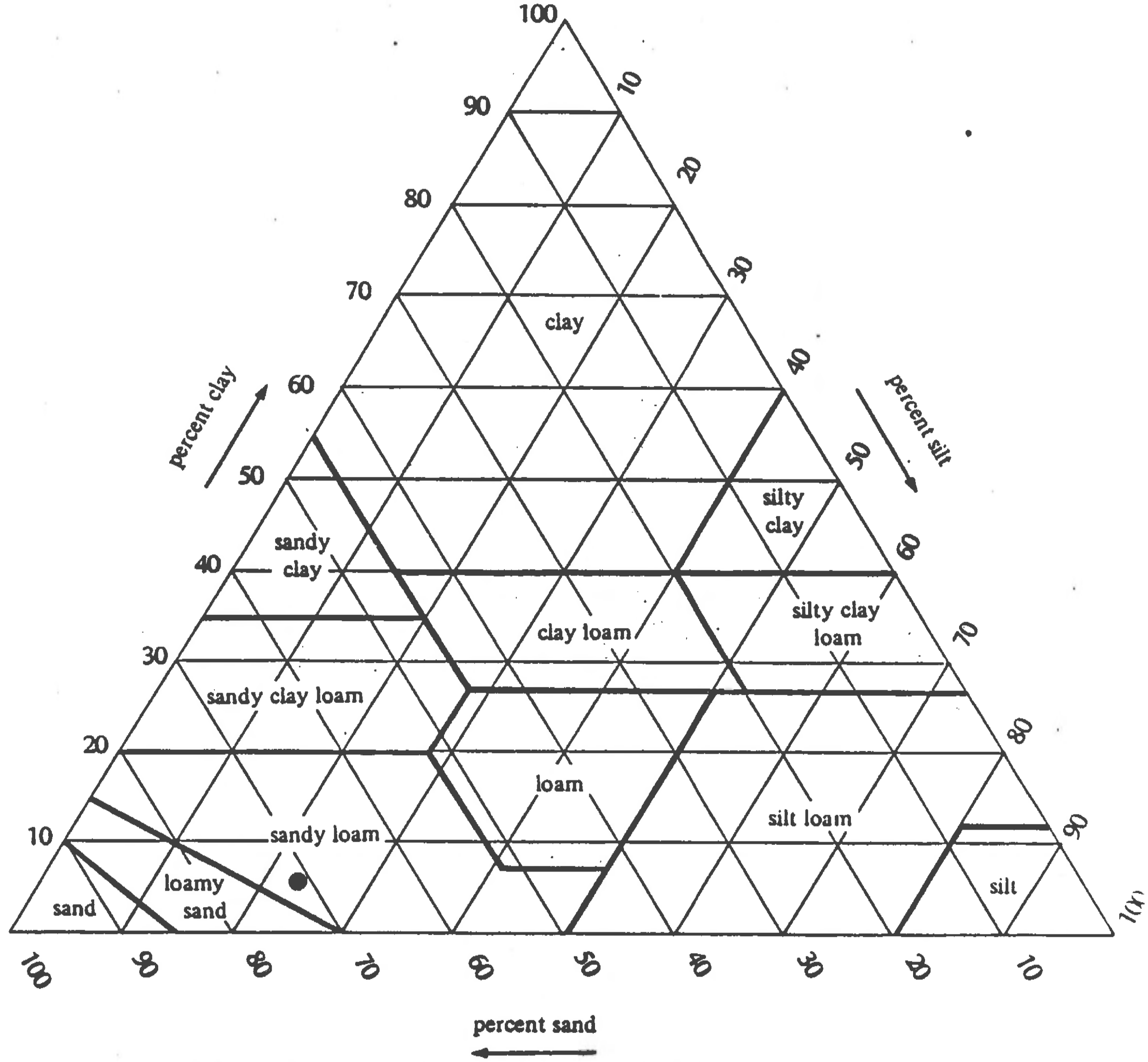
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #4, 31'-32'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75 2 1 0.5 0.25 0.1 0.05 0.02 0.005 0.002 0.0002 0.00008

GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

10 18 35 60 140 300

U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #4 Depth: 41'-42'

Classification (ASTM:D2487) CH-OH

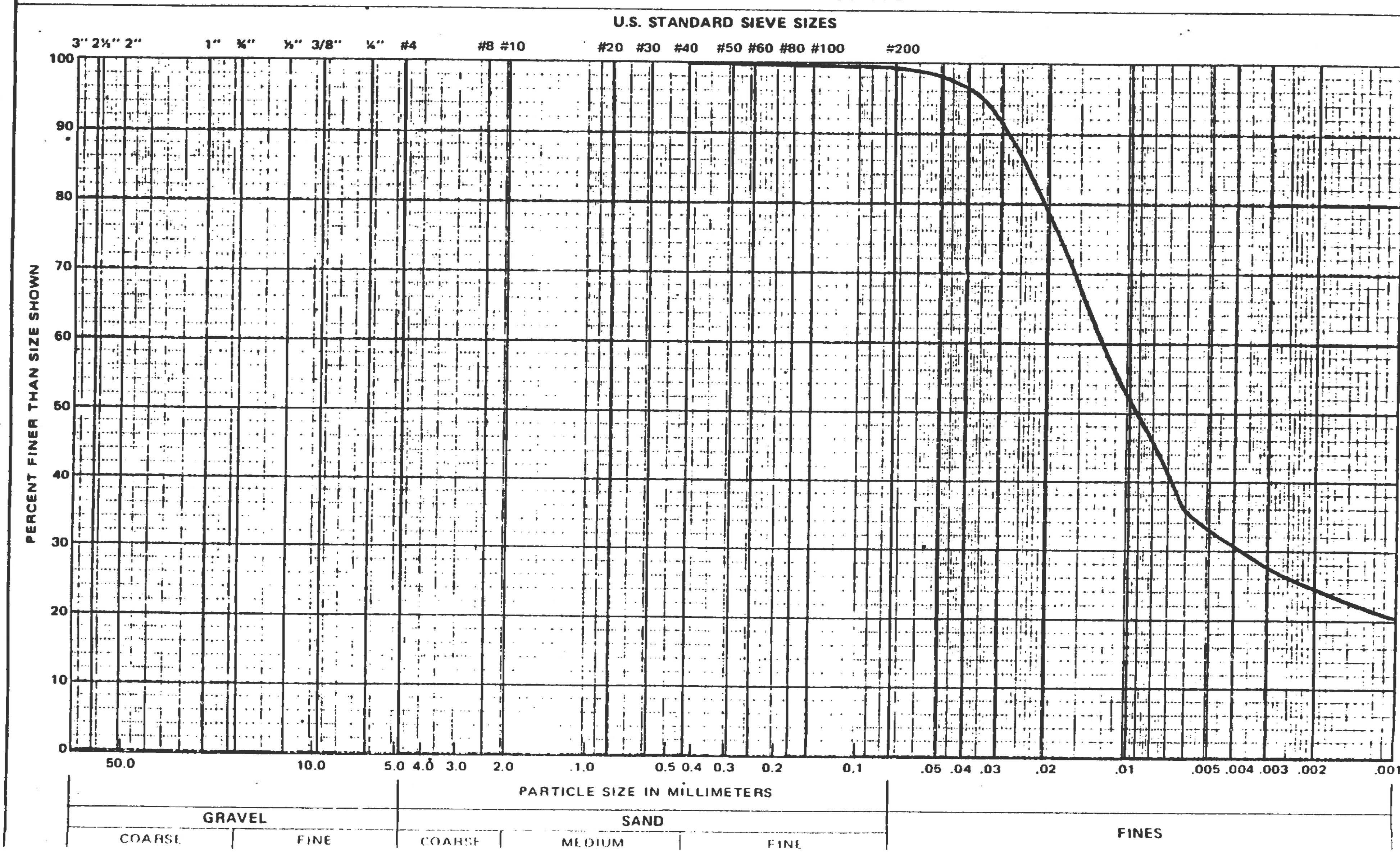
Description SHALE, (Textural Classification: Organic Fat Clay)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

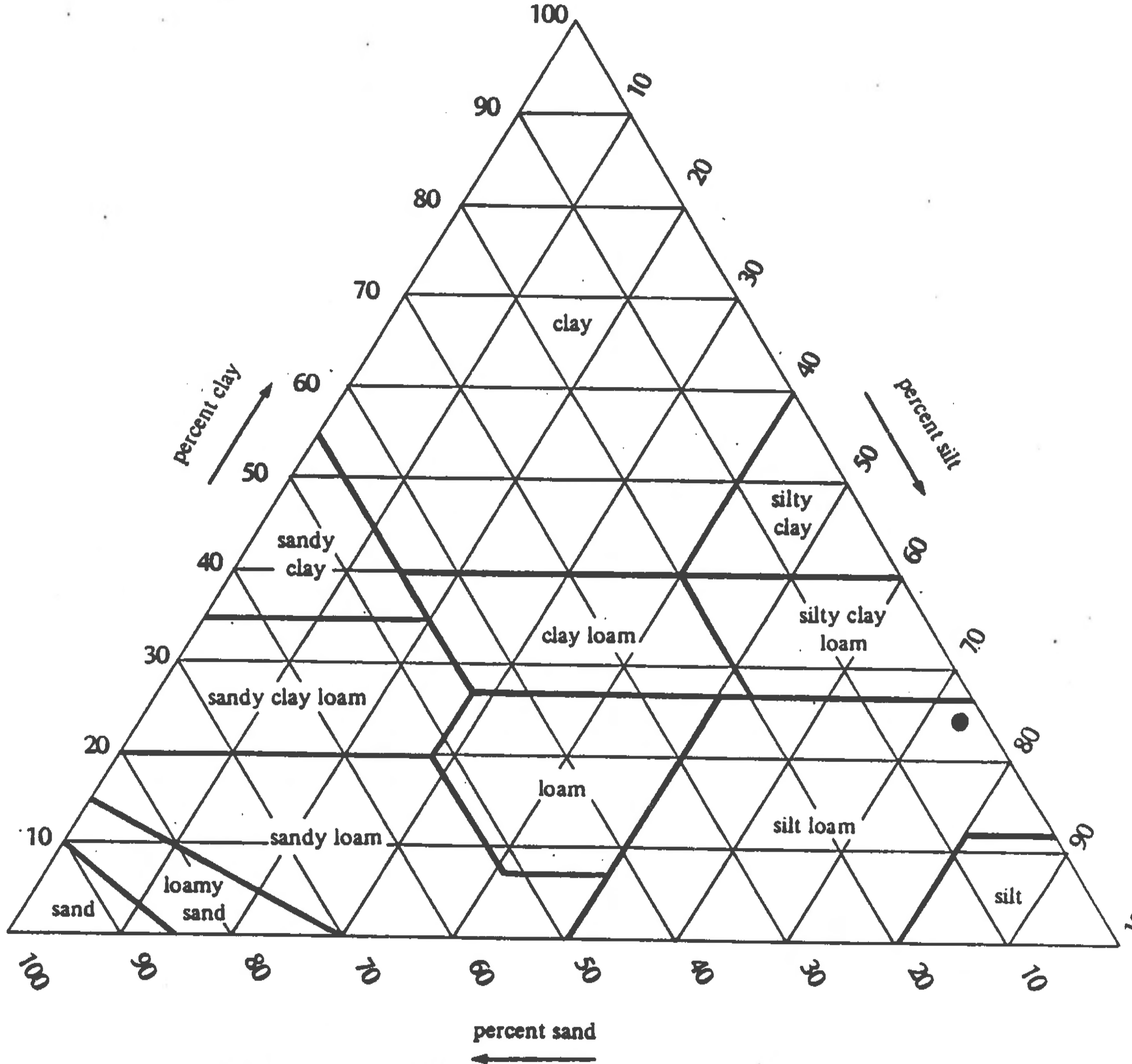
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #4, 41-42'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)

75	2	1	0.5	0.25	0.1	0.05	0.02	0.005	0.002	0.0002	0.00008
GRAVEL	SAND					SILT			CLAY		
	Very Coarse	Coarse	Medium	Fine	Very Fine	Coarse	Medium	Fine	Coarse	Medium	Fine

U.S. Standard Sieve Numbers: 10, 18, 35, 60, 140, 300

TWIN CITY TESTING LAB

SE-27(80-A)

Job No. 52-0688

Sample No. MDU Heskett #4 Depth: 51'-52'

Classification (ASTM:D2487) CL

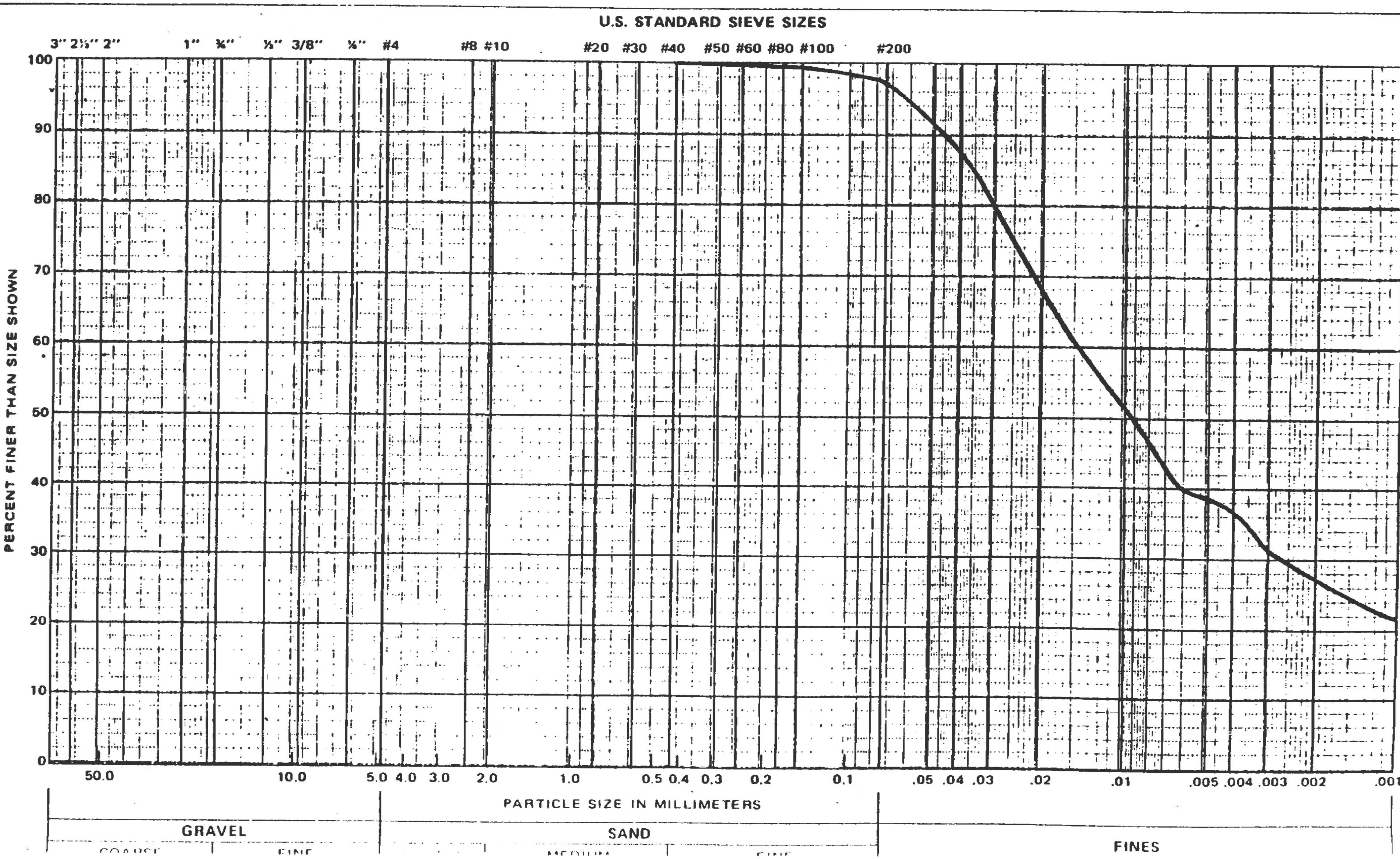
Description SHALE, (Textural Classification: Silty Clay)

twin city testing and engineering laboratory, inc.
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-3601

Project: SOIL TESTING FOR MDU HESKETT POWER PLANT - MANDAN, NORTH DAKOTA

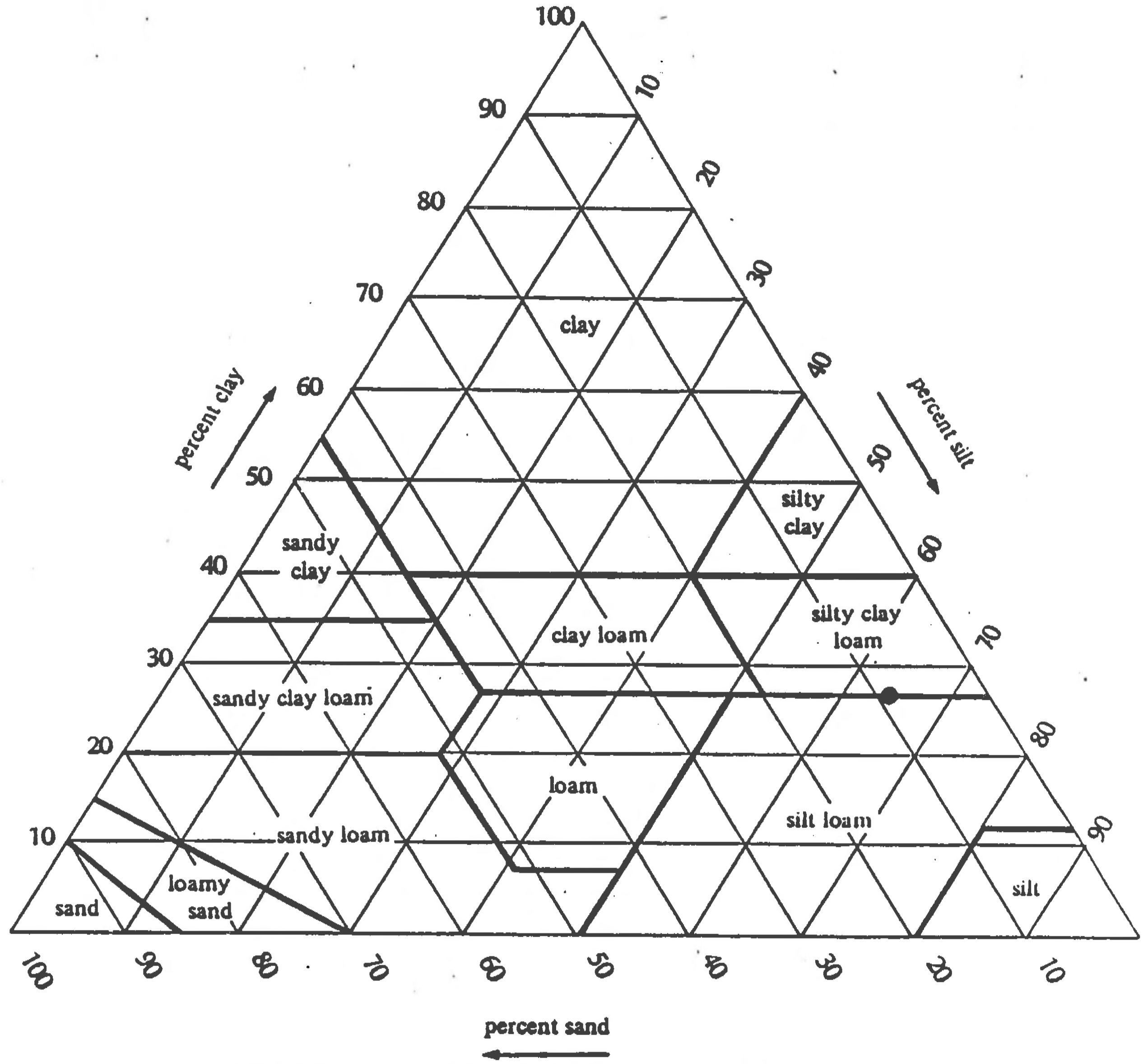
Reported To: Water Supply, Inc.

GRAIN SIZE DISTRIBUTION CURVE



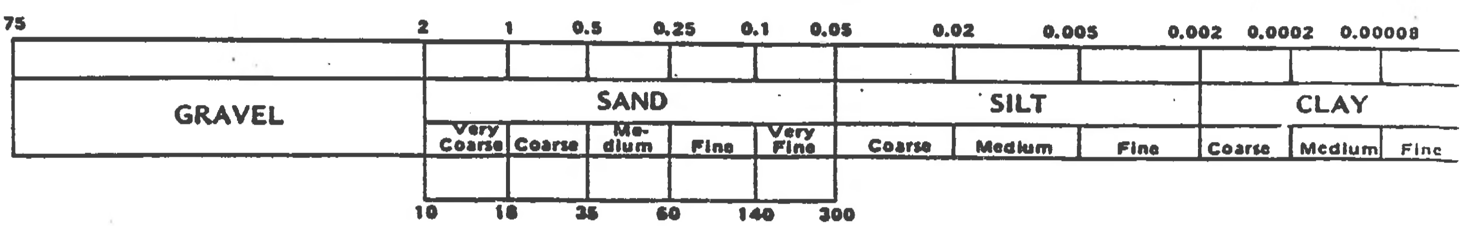
USDA SOIL TEXTURAL CLASSIFICATION

MDU HESKETT #4, 51'-52'



COMPARISON OF PARTICLE SIZES IN USDA SYSTEM

Size Range in Millimeters (Mean Diameter)



U.S. Standard Sieve Numbers

TWIN CITY TESTING LAB

SE-27(80-A)

6.0 FACILITY CONSTRUCTION, OPERATION AND CLOSURE

6.1 Site Preparation and Construction

6.1.1 Access and Preconstruction

Exhibit 5-F presents soil information on the Heskett site currently available through the Morton County Agricultural Stabilization and Conservation Service office. Because this data was gathered from fieldwork conducted several decades ago and provides little site-specific soil depth information, a new soil survey will be commissioned. The survey will be conducted prior to the onset of construction and cover the entire permit area. Soil profiles will be developed identifying soil types and topsoil (A horizon) and subsoil (B horizon) depths. This information will be used to establish plant growth material (SPGM) salvage and replacement depths during future construction and reclamation activities.

Surface water drainage of adjoining land east of the site will be improved by the permanent installation of a grass-lined ditch (Exhibit 6-B). This drainageway will be located along the base of an existing draw and enhance movement of surface runoff waters and permitted discharges from impoundments located to the south on Amoco Refinery property. The drainageway will be about 8 feet deep, 8 feet wide at the base, and provide a slope of 1% to a discharge at Rock Haven Creek. Existing surface water drainage patterns should not be significantly altered by this installation.

Primary access to the site will be along a dedicated haul road extending eastward to Heskett Station (Exhibit 6-B). Roadbed construction will require 34,500 cy of excess earthern material removed during the excavation of the initial disposal slot. The road surface will be covered with gravel to allow all weather access to the site. All haulage road construction activities will be performed on Montana-Dakota property and will not interfere with traffic on surrounding public roads.

Other points of access to the site will be restricted by the installation of a lockable personnel fence around the perimeter of the facility. Public access to the site will not be allowed.

6.1.2 Facility Construction

The first phase of the facility described in Exhibit 6-B will be constructed and made operational during the 1989 earthwork construction season. Waste placement will begin upon the completion of the initial waste disposal slot. To minimize impacts to the landscape and reduce potential fugitive dust and leachate generation, new disposal trenches of similar design will be excavated approximately every other year. Filled trenches will be closed and reclaimed concurrently with new trench construction

The 47 acre disposal facility will be developed in two phases. Phase I, comprising the disposal area on the north side of the haul road, will provide about 13 years (approximately 700,000 cy) of disposal capacity. The initial disposal slot will be constructed along the western edge of the Phase I area. Subsequent excavations will proceed eastward until the Phase I area is filled. Phase II of the disposal site lies south of the haul road and will provide disposal capacity for about 15 years (approximately 600,000 cy). Phase II development (Exhibit 6-C) will begin parallel to the southern edge of the haul road and proceed southward. The final trench excavation at the site will lie parallel to the southern edge of the site. It is not currently expected that ash will be placed directly beneath the on-site portion of the haul road. However, ash emplacement beneath the road may be considered as a contingency if needed.

Exhibit 6-D provides information regarding earth quantity movements for each disposal trench. These estimates (and the subsequent size of the trenches) may be adjusted somewhat if ash waste generation rates markedly differ from projections. The initial slot of Phase I will be constructed to contain slightly over one year of waste (60,000 cy). Subsequent trenches will be constructed to contain all ash generated during the ensuing one to two years.

All construction activities will be performed during the normal earthwork construction season. Equipment such as bulldozers, scrapers, graders, and compactors will remove, modify, and/or replace earthen materials. Most material excavation and relocation operations will rely upon scrapers.

Each trench will have a compacted in-situ clay liner along its base to restrict downward migration of in-pit liquids. Available information (see Exhibits 5-E and 5-K) indicates an abundance of naturally occurring clay and silt which will be uncovered in conjunction with trench excavations. These materials will be scarified to a depth of 18 inches and recompacted to a permeability of not more than 1×10^{-7} cm sec^{-1}. Occurrences of sand or gravel will be removed and replaced with clay-rich spoil. In-situ materials providing marginally acceptable rates of permeability will be replaced, treated with a soil liner admixture such as bentonite, or thickened to provide the equivalent permeability of 18 inches of 1×10^{-7} cm sec^{-1} material. The in-situ liner will cover the entire floor of the trench, the liquids collection sump, and be extended to include the lower five feet of the trench sidewall. Liner installations associated with new trench construction will be keyed into the previous trench liners, thereby providing contiguous liquids

6.1.3 Excavated Materials

The removal and stockpiling of suitable plant growth material (SPGM) will be completed prior to any operation which would interfere with the use and integrity of the top soil. Top soil thickness information provided by the soil survey (see Section 6.1.1) will be used to establish SPGM salvage depth. SPGM will be removed by scraper in two lifts; soil horizon A will be removed in the first lift, soil horizon B will comprise the second lift. Each lift will be separately stockpiled in an area described in the Site Plan of Exhibit 6-B. Because filled trenches will be closed in conjunction with new trench construction, removed SPGM shall be stockpiled only when it is not practical for direct placement in areas concurrently undergoing reclamation.

Exhibit 6-D projects the amount of earthen materials which will be excavated. The largest single Phase I excavation (59,000 cy) will be the initial trench construction. Resulting excess materials from drainage ditch and disposal slot excavation will be used in the construction of the access road, evaporation pond, and a permanent visual obstruction berm along the southern perimeter of the site. Excess spoil may be diverted to the closure of the adjacent Heskett ash pile if available. Because future excavations will generate volumes of materials which approximate requirements for closure (i.e., cap construction and overburden placement) relatively little material should require stockpiling along the western edge of the site. Stockpile Area No. 1 and 2 may be converted into an additional visual obstruction berm if excess spoils require permanent dislocation from the reclamation area.

All temporary SPGM and clay material stockpiles will be maintained in a manner which minimizes the effects of erosion yet maintains soil integrity. Protective measures will be applied and include the planting of cover crops, mulching, use of chemical binders, contour tillage, or other site specific infiltration protection. Verification of construction quality and attainment of proper rates of permeability will be made by an independent registered professional engineer.

Each trench floor will be positioned to provide at least five feet of separation between the waste and the 1986 water table elevation. Additionally, the base of each slot will be contoured to provide a positive drainage slope of not less than 1% both laterally and lengthwise, thus promoting rapid movement of in-pit liquids away from the waste and into the collection sump.

Exhibit 6-C, Section X-X illustrates a typical cross-section of the leachate collection pipe which will be permanently installed with each new trench. A perforated pipe will gather liquids from the operational and closed portions of the facility and discharge them into the liquids collection sump in use at that time. Liquids will continue to be gathered by the collection line after the closure of Phase I and discharge directly into the evaporation pond. Waste leachates collected by the Phase II line will not discharge into the active sump but rather directly into the evaporation pond.

All liquids collected within the pit sump and leachate collection lines will be evaporated in a 53,000 square foot evaporation pond (Exhibit 6-B, Section D-D). This pond will be constructed to contain in-pit liquids resulting from normally-occurring rainfall plus a single 24 hour 2.5 inch precipitation event. The evaporation pond will have 5 foot side walls and be equipped with a three foot thick clay liner possessing a permeability of not more than 1×10^{-7} cm sec^{-1}. The evaporation pond will service the disposal facility throughout the operational life of the site.

treatments. Annual cover crops may be planted in areas of frequent stockpile disturbance if necessary to control wind and water erosion. Obstructional berms will be permanently reclaimed to native grasses as soon as possible after completion.

6.2 Operation and Management

6.2.1 Waste Placement

Coal combustion ash will be loaded onto trucks and slightly wetted for dust control before transportation to the disposal site via the ash haul road. Haulage will take place daily during daylight hours; only in emergencies will ash haulage occur after nightfall. Spilled waste material on the haul road and at the site will be immediately cleaned-up and placed in the disposal trench. Ash waste will not be temporarily stored at the site prior to disposal.

Haul trucks will enter the trench by way of ramps located at the end of the trench with the highest elevation (Exhibit 6-B, Operational Schematic). Waste will be initially placed in each trench near the ramp and expanded to provide a surface for unloading activities. Vehicular traffic upon the disposal slot floor will be held to a minimum to reduce inadvertent liner damage. Dumped waste will be leveled with a front end loader and spread across the trench floor in lifts 5 to 8 feet thick. The active sump area will not be filled with waste. Ash will not be dumped from the pit highwall into the trench.

Because initial disposal activity will be conducted at an elevation below ground surface the waste will receive only moderate exposure to surface winds. Consequently, little fugitive dust is expected to be generated. As the waste elevation increases, however, strong surface winds might produce increasing amounts of airborne nuisance particulates. Dust suppression measures will be implemented as required to control fugitive dust. These measures will include the selective placement of AFBC bottom ash (a relatively low dust emitting material) over other ash wastes or the thin spreading of earthen or other dust control material. A 2,500 gallon water spray truck is available for dust control applications over the ash haul road. Water spray will not be used for dust control over the disposed of waste.

Montana-Dakota personnel will perform all daily operational monitoring and disposal activities at the site. Facility points-of-contact are:

Station Superintendent - Duane Steen

Fuel and Grounds Supervisor - Darhl Bowers

Facility Telephone - (701) 663-9576

The Fuel and Grounds Supervisor (or his designee) at Heskett Station will have general supervision of the site and verify that procedures specified in this permit application are adhered to. The site will be monitored daily in conjunction with normal ash haulage activities. Weekly log entries will be made concerning the amount of ash hauled, waste-contaminated water transferences, and unusual operational occurrences such as waste spillages or failures in site reclamation. Corrective actions will also be noted.

6.2.2 Surface Water Management

Ground surface runoff waters will be prevented from entering the pit by either a positive slope away from the edge of the pit or the construction of diversionary trenches or berms. Uncontaminated ground surface runoff waters will not be controlled at the site except in instances where erosion and/or sedimentation is occurring. Waste spillages at the site and on the haul road will be immediately cleaned-up after each incident; consequently no contaminated waters should be generated in these areas. The ash haul road will be graded to promote surface water run off away from the active disposal area (see Exhibit 6-B, Section b-b and Exhibit 6-C, Section b-b) and into the drainage ditch.

The in-pit sump will hold all meteoric-source precipitation falling within the trench (both waste contacting and non-contacting liquids) and infiltrated water gathered by the leachate collection line (Phase I only). Each collection sump will be sized to provide 100% retention of normal rainfall plus one 2.5 inch precipitation event occurring in a 24-hour period. The sumps will be equipped with an 18 inch compacted clay liner similar in design to the rest of the pit floor. When accumulated liquids approach 3 feet in depth (see Exhibit 6-B, Section X-X), the liquids will be transferred to the evaporation pond. It should be noted that restraints regarding weather, accessibility, equipment or personnel availability may occasionally change the 3 foot liquids volume transfer standard.

Liquid transfer to the evaporation pond will be performed through the use of a portable pump and an overland pipe constructed of PVC or similar material. Pumping activities will normally be conducted during periods of ash haulage and will be continually monitored for leakage during operation. Pumping will not be performed at night or during freezing conditions which could damage the pipe.

Minimal care should be required around the evaporation pond. Surface discharges will not be made from the pond. Growth of vegetation in the impoundment will be controlled through additions of herbicide or mechanical cutting whenever damage to the clay liner is considered likely. The pond will be monitored monthly for evidence of deterioration and leakage. The groundwater monitoring plan provides for the installation of a water table elevation and quality monitoring well immediately downgradient of the impoundment. Samples of impounded liquids will be taken (if available) semi-annually in conjunction with the groundwater sampling program and analyzed for the same chemical parameters. Surface impoundment analytical data will be combined with the groundwater quality information and submitted to the NDSDH according to the schedule specified in Section 7.3

6.2.3 Contingencies and Potential Impacts

The proposed waste facility was sited and designed to reasonably ensure that groundwater will not intrude upon the waste. Two consecutive years of potentiometric monitoring has shown a relatively stable water table elevation with little apparent seasonal fluctuation. This general stability, even during the severe drought of 1988, might be partially attributable to constant upgradient recharge provided by surface impoundments on Amoco Refinery property to the south. Discussions with Amoco personnel has indicated there are no proposals to expand or otherwise modify this impoundment system.

The facility will be located over a marginal groundwater resource. Groundwater chemical characterizations (Exhibit 5-J) indicate it to be of comparable quality with the waste leachate (Exhibit 2-A). Furthermore, recent studies (referenced in Section 5.2.4) have shown that heavy metals which exist in the leachate (such as arsenic, cadmium, and lead) are effectively attenuated by clay and silt materials which naturally occur in abundance throughout the Heskett Site. The Cannonball Formation water at the Heskett Site is unsuitable for most domestic or agricultural purposes without prior purification. Area residences rely upon other underlying aquifers such as the Ludlow for their domestic water supplies. Consequently, the proposed facility will not pose a threat to a desirable groundwater resource. Indeed, even major releases of Heskett ash leachate to the underlying groundwater might be expected to result in only minor deviations from normal background chemical makeup.

A number of simple remedial measures are available at the site should groundwater elevations rise to intrude upon the waste, thereby endangering an area resource. Because Rock Haven Creek on the west and north of the site, along with the small draw located to east, already provides natural points of surface discharge to a rising groundwater table, modification to these topographic depressions or the installation of a shallow subsurface drainage system in their vicinity would serve to allow groundwater discharge at a lower elevation. This would serve to permanently lessen the potentiometric level of the water table. Increasing the depth of the drainageway might be particularly appropriate due to its close proximity to the lowest point of waste placement (i.e. the eastern edges of Phases I and II). Another option includes the permanent installation of a subsurface drainage pipe or french drain five to eight feet below the southern edge of the last Phase II trench. Such a system would intercept the groundwater below and upgradient of the waste and divert flow laterally to a discharge point on the drainageway. This would hydraulically isolate the waste.

An in-pit leachate collection system will be constructed to detect and gather in-waste liquids that would occur during the operational life of the site. Significant leachate collections may extend the life of the gathering pipes (and evaporation pond) beyond the site closure date until the problem is remedied. The in-pit sump and evaporation pond will have compacted clay liners to assure minimal rates of subsurface leachate migration. The evaporation pond will be monitored monthly to determine liquids volume and detect evidence of deterioration, erosion, seepage, or overtopping. The in-put collection sump will be similarly inspected weekly and after precipitation events. Should a sudden drop occur in the liquids level of the impoundment or groundwater quality monitoring indicate significant leakage is occurring, repair or replacement of the liner with a soil-based or admixed liner will be performed. Similarly, the size of in-pit collection sumps will be expanded in subsequent trench excavations should it become apparent that more retention volume is needed.

Provisions have been made which allow for visual and acoustical obstructions (earthen berms and tree shelter belts) between facility operations and residences to the south. Additional tree plants and berm construction (depending upon materials availability) may be emplaced around the facility perimeter at a future date. Shelter belts or berms will not be placed over waste disposal areas. Decisions regarding these features will be made after the facility becomes operational and their need at a specific location becomes apparent. Dust control measures (as described in Section 6.2.1) will be implemented until these features become permanently established.

6.3 Closure and Reclamation

6.3.1 Closure Methods

As each trench is brought to its final waste elevation, a 1 to 3 inch layer of earthen material will be applied to the waste if fugitive waste dust requires suppression. New trenches will be first constructed adjacent to the disposal area intended for closure. Excavated materials from the new trench will be used to close the waste filled trench. Excess excavated material may be temporarily stockpiled in the area described in Exhibit 6-B or used in permanent berm construction. Similarly, new trenches providing inadequate volumes of earth for closure work will require withdrawal from stockpiled inventories.

A two-foot thick compacted clay cap will be constructed over the waste (Exhibit 6-C, Sections A-A and B-B). The cap will be developed from clay-rich spoil materials such as those documented in Exhibit 5-K. Earth moving equipment such as bulldozers, scrapers, graders, and compactors will emplace materials so that compaction of approximately 95% of maximum dry density and a permeability of 1 X 10^{-7} cm sec^{-1} or less is attained. If available materials cannot provide for a two-foot thickness of 1 X 10^{-7} cm sec^{-1} permeability, cap thickness will be increase commensurably and/or treated with an admixture to a point which affords equivalent moisture infiltration protection. Verification of adequate construction quality and permeability will be made by an independent registered professional engineer.

Uncompacted spoil will be immediately spread over the completed clay cap and shaped to prevent surface water ponding. Surface slopes will range from 4% to 10%. Spread depth will be adequate to create a total earthern material profile above the waste (i.e., clay cap, uncompacted spoil, and SPGM) of not less than eight feet.

SPGM will be spread over the spoil material at a uniform depth determined by material availability. The respread will be done in accordance with currently accepted practices and procedures which assure proper interlift adhesion. Compaction of materials will be held to a minimum.

The final Phase II trench closure (thus leading to final site closure) will include the removal of the waste haulage road surface and the evaporation pond. All waste-contaminated material will be placed with the waste in the final disposal trench. Disturbed areas will be shaped to the topography illustrated in the site plan of Exhibit 6-D and reclaimed. The leachate collection lines will be abondoned in-place and will not be monitored or maintained. Points of access to the leachate collection line will be sealed during final closure for purposes of safety. The drainageway will not be modified or restored to original contours during or after final closure of the site unless deemed necessary at the time.

6.3.2 Reclamation

SPGM will be sampled and tested to determine soil nutrient status. Fertilizer application recommendations will be solicited from a soil testing laboratory and utilized in consideration of existing soil properties, topography, seed mix components, and practical experience.

The seedbed will be prepared in a fashion which would promote a stable, self-supporting prairie grassland. Rates for seed mixture will approximate:

Species	Rate (lb/acre)
Western Wheatgrass	6.0
Pubescent Wheatgrass	4.0
Smooth Brome	2.0

Seed implantation will be performed with a seed drill during the first favorable planting period; typically from April 15 through June 7, August 10 through September 15, or after October 20. A straw mulch or cover crop will be applied immediately after seeding to provide temporary erosion control. Reseeding or interseeding will be performed if grass fails to establish over large areas. Bale dikes, excelsior mats, or other appropriate measures will be utilized for control of significant erosion features.

6.3.3 Post-Closure Surface Care

The Heskett Site will be incrementally reclaimed as individual disposal trenches are filled and closed. Post-closure surface care will continue until five years after final closure of the facility. Reclamation failures at the site would extend the surface care requirement period until such time as the deficiency is permanently corrected.

The post-closure maintenance will begin from the date of vegetation seeding. During the first year, each reclaimed area will be examined monthly and after storm events to:

1. Verify that final contours and drainages are maintained,
2. Ensure that healthy vegetative cover is established, and
3. Maintain proper erosion control measures which may be in-place at the site.

Post-closure inspections will be performed quarterly for the remaining four years of the surface care period. Inspection results and corrective actions will be logged. These records will be summarized into an annual facility status report and forwarded to the NDSDH.

The reclaimed area will resemble a gently sloping hill supporting a typical grassland prairie. The growth of woody species (whose root system might penetrate the underlying clay cap) will be suppressed through cutting or chemical treatment. Montana-Dakota may eventually sell hayland or pasture rights if the integrity and plant growth productivity of the site can be maintained with minimal care. No haying or grazing activities will be allowed for at least three years following initial vegetation establishment of each reclaimed increment.

Montana-Dakota intends to continue ownership of the site for the forseeable future. No plans to allow surface disturbance or agricultural utilization (except hayland or pasture usage) of the reclaimed area exist. The current industrial land use zoning classification will be retained.

EXHIBIT 6-A

EXISTING CONDITIONS AND AREA MAPS

EXHIBIT 6-B

PHASE I DEVELOPMENT

EXHIBIT 6-C

PHASE I CLOSURE - PHASE II DEVELOPMENT

EXHIBIT 6-D

FINAL CLOSURE

7.0 GROUNDWATER MONITORING

7.1 Operational Monitoring

Analysis of disposal site groundwater quality and potentiometric surfaces will focus upon the uppermost 15 feet of the Cannonball Formation saturated zone. Because facility expansion will eventually destroy most of the existing site instrumentation positioned for possible water quality monitoring purpose~~s, a~~ new series of monitoring wells will be installed prior to waste placement. Four new wells (3 downgradient, 1 upgradient) will be placed in the approximate areas described in Exhibit 6-B. These wells will be constructed similarly to existing site wells and fitted with a 20 foot screen, the lower 15 feet of which will be positioned below the existing water table. Each well will be lithologically logged during installation.

With the possible exception of infrequent potentiometric level determinations, all other wells existing at the site will not be relied upon for any monitoring functions. These deactivated wells will remain undisturbed until such time as their permanent closure is warrented by facility expansion. Permanently closed wells will be sealed their entire length with grout or other appropriate material in order to assure that groundwater communication between subsurface strata does not occur along the well casing.

Wells which monitor facility operations will be sampled quarterly for the first year to establish background chemical data. The first quarterly sample will be acquired before waste is placed in the facility. The sampling frequency will thereafter be reduced to a semi-annual basis throughout the remaining operational life of the facility.

Water quality samples will be collected and analyzed by personnel experienced in groundwater characterization protocols. Static water table elevation measurements will be made in advance of any well disturbances. Wells will be purged by pumping three to five well volumes (or until dry) immediately prior to well sampling. Delays in sampling greater than 24 hours will require re-purging.

All first-year background groundwater samples will be analyzed for water quality parameters specified in Table 7-1. This list of parameters will be reduced to a semi-annual groundwater quality characterization of Table 7-2 constituents subsequent to the completion of the first year collection of background data gathering.

7.2 Post-Closure Monitoring

Annual post-closure groundwater monitoring will continue for 30 years after final closure of the entire facility. Sampling for the first five years of the closure period will be performed on the same wells for the same chemical parameters as is in effect for operational monitoring program at the time of closure (i.e., Table 7-2 constituents).

If, after review of all accumulated operational and five years of post-closure data, no leachate contamination is statistically evident in the groundwater when compared to background levels, the suite of annually-monitored parameters will be reduced to:

pH	Static Water Level
Specific Conductance	Arsenic
Total Dissolved Solids	Boron
Carbonate	Selenium
Bicarbonate	Calcium
Sodium	Lead
Sulfate	Temperature

TABLE 7-1

Background Groundwater Quality Analysis Parameters

Alkalinity, total (as $CaCO_3$)	Magnesium (Mg)
Arsenic (As)*	Manganese (Mn)*
Barium (Ba)*	Mercury (Hg)*
Bicarbonate (HCO_3)	Molybdenum (Mo)*
Boron (B)*	Nitrate (NO_3)
Cadmium (Cd)*	pH**
Calcium (Ca)	Potassium (K)*
Carbonate (CO_3)	Selenium (Se)*
Chloride (Cl)	Silver (Ag)*
Chromium, total (Cr)*	Sodium (Na)
Fluorine (F)	Specific Conductance**
Hardness (as $CaCO_3$)	Sulfate (SO_4)
Iron (Fe)*	Temperature**
Lead (Pb)*	Total Dissolved Solids (TDS)

*Analyses only for dissolved metal concentration

**Field determinations

Static water levels will be measured from top-of-pipe.

TABLE 7-2

Operational Groundwater Quality Analysis Parameters

Alkalinity, total (as $CaCO_3$)	Molybdenum (Mo)*
Arsenic (As)*	pH**
Bicarbonate (HCO_3)	Potassium (K)*
Boron (B)*	Selenium (Se)*
Cadmium (Cd)*	Sodium (Na)
Calcium (Ca)	Specific Conductance**
Carbonate (CO_3)	Sulfate (SO_4)
Hardness (as $CaCO_3$)	Temperature**
Lead (Pb)*	Total Dissolved Solids (TDS)
Magnesium (Mg)	

*Analyses only for dissolved metal concentration

**Field determinations

Static water levels will be measured from top-of-pipe.

Characterization of these groundwater quality indicator parameters will continue for the remaining 25 year post-closure groundwater monitoring period.

7.3 Quality Assurance and Data Management

Montana-Dakota currently relies upon experienced independent contractors to acquire analytical and potentiometric groundwater information. This practice is expected to continue for the forseeable future. Minimum levels of performance for such contractors will include:

- Use of non-contaminating, non-aerating equipment for all monitoring activities. Equipment other than bailers or submersible diaphragm pumps for purging and sampling must be specifically approved by Montana-Dakota before use. Air-lift pumps may not be used in any circumstance.
- All samples must be conditioned, preserved, and analyzed according to methods and limitations prescribed in Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (revised March 1983).
- Description of field sampling methods and analytical quality controls will be required of each contractor. Evidence of appropriate laboratory certification and participation in interlaboratory comparison will be requested. Brief resumes of involved personnel must also be provided.
- Cation/anion balances and replicate values for each set of data must be identified on the analysis report.

Montana-Dakota shall annually evaluate accumulated water table elevation and groundwater quality information gathered from site instrumentation by the contractor. Post-closure groundwater data obtained from wells surrounding the adjacent Heskett ash waste pile (WS-series wells) will also be examined to determine their possible contribution to Heskett Site contamination monitoring. Data evaluation techniques will include chemical constituent comparisons between upgradient and downgradient wells at the same point in time and comparisons of individual wells to their historic backround concentrations. A variety of statistical tools will be examined for application against the data base. Goodness-of-fit testing will confirm or deny the existence of normally distributed data. Specific test procedures might include hypothesis testing (t-test), parametric analysis of variance (ANOVA), ANOVA's based upon ranks, and perhaps tolerance intervals. Significance will be established at the 0.05 confidence level.

Operational groundwater monitoring will typically be performed in the second and fourth calendar quarters. Annual post-closure groundwater monitoring will be performed during the second or third quarter. All groundwater sample analysis results, water table surface elevations, and other associated information will be forwarded to the North Dakota State Department of Health within 30 days of its receipt from the independent groundwater sampling contractor. Cumulative statistical data summaries (including descriptions of the statistical methods employed) will be forwarded to the Department annually as they are completed.

8.0 PERMITTING

Upon approval by the North Dakota State Department of Health of the proposed solid waste disposal facility but before the onset of actual disposal activities, a notarized affidavit shall be recorded in the tract system of the Morton County Registrar of Deeds. This affidavit shall specify that the SW1/4 of Section 10, Range 81 West, Township 139 North, has been permitted to receive solid waste for disposal. Another affidavit shall be similarly filed upon final closure of the site which provides information concerning waste types, location, construction, and management. Copies of both instruments shall be forwarded to the North Dakota State Department of Health within 30 days of recording.

Other requirements, as specified by the North Dakota State Department of Health and other regulatory authorities, will be complied with as they become evident.

Upon the beginning of normal operations of the proposed disposal facility all waste placement at the current disposal facility (i.e. the Heskett Ash Pile) will cease. The ash pile will then be closed according to the specifications described in the relevant Special Use Disposal Site permit application (submitted to the North Dakota State Department of Health on March 10, 1986: Solid Waste Permit issuance still pending).

APPLICATION FOR PERMIT TO CONSTRUCT/OPERATE A
SPECIAL USE DISPOSAL SITE
NORTH DAKOTA STATE DEPARTMENT OF HEALTH
SFN 8376 (01/86)

NOTE: Please read the instructions for details on information and documents required to support your application.

PERSON TO BE RESPONSIBLE FOR OPERATION (APPLICANT) Station Manager, Heskett Station				APPLICATION DATE March 1, 1989
ADDRESS OF APPLICANT 400 North Fourth Street, Bismarck, ND 58501				TELEPHONE NUMBER (701) 222-7900
NAME OF SITE Heskett Ash Site	ADDRESS OF SITE Heskett Station, 2 Miles North of Mandan, ND			TELEPHONE NUMBER (701) 663-9576
PROPERTY OWNER Montana-Dakota Utilities	ADDRESS OF PROPERTY OWNER 400 North Fourth St., Bismarck, ND 58501			TELEPHONE NUMBER (701) 222-7900
LEGAL DESCRIPTION OF SITE A Portion of the SW¼	SECTION 10	TOWNSHIP 139N	RANGE 81W	COUNTY Morton
PRESENT ZONING CLASSIFICATION OF SITE Industrial	DOES PRESENT ZONING ALLOW THIS PROPOSED USE? _x_ YES ___ NO			EXPECTED LIFETIME OF SITE _28_ YEARS

I hereby affirm all information in this application is true and accurate to the best of my knowledge and belief.

Bruce Imsdahl

SIGNATURE OF APPLICANT

SEND COMPLETED APPLICATION TO:

NORTH DAKOTA STATE DEPARTMENT OF HEALTH
DIVISION OF HAZARDOUS WASTE MANAGEMENT AND SPECIAL STUDIES
1200 MISSOURI AVENUE, ROOM 302
BOX 5520
BISMARCK, ND 58502-5520

INSTRUCTIONS FOR COMPLETING AN APPLICATION FOR A PERMIT TO CONSTRUCT AND/OR OPERATE A SPECIAL USE DISPOSAL SITE

APPLICATION AND ALL ACCOMPANYING DOCUMENTS MUST BE SUBMITTED IN QUADRUPLICATE

These instructions are considered to be general guidelines only. More or less data may be required by the Department depending on the waste and on conditions at the specific disposal sites. The information required for a specific site will be determined by a preliminary site evaluation by the Department. This may eliminate the expense of investigations at some sites which are obviously unacceptable. After the required site investigation has been completed by the applicant, further work may be required as deemed necessary by the results of the initial investigation.

Permit applications must be prepared and compiled as one cohesive document that logically presents all information necessary to review a permit. Any modifications or information submitted to the Department subsequent to the initial permit application should be in a format that can be physically incorporated into the formal permit application. <u>The Department reserves the right to reject or return a permit application if it is not complete, or if the information is not presented in an orderly and logical format.</u>

The instructions below address the following required information:

I. Waste Information

II. Location Information

III. General Geographic Setting

IV. Site Specific Characteristics (Geology and Hydrology)

V. Construction Plans and Specifications

VI. Groundwater Monitoring

VII. Operation and Management Methods

VIII. Record Solid Waste Activity with County Registrar of Deeds

IX. Closure

I. **WASTE INFORMATION:** For each type of solid waste to be managed, specify (a) amount in tons per day or cubic yards per day, or gallons per day; (b) physical description; and (c) qualitative and quantitative chemical analyses.

II. **LOCATION INFORMATION:** Show the facility location on a USGS 7 ½ minute quadrangle map (scale not less than 1:24,000). Also include a current map or aerial photograph of the area showing existing land use. Aerial photographs are often available from the Agricultural Stabilization and Conservation Service (ASCS). The map or aerial photograph shall be of sufficient scale to show those man-made and natural features of the area, such as water courses, flood plains, dry runs, wells, roads, and other appropriate details and the general topography of the area.

This section should also address the zoning within a quarter mile of the proposed location and any proposed changes in zoning required for waste disposal activities. The Department may request additional information from the applicant and/or the local zoning authorities regarding the zoning requirements for the site.

III. **GENERAL GEOGRAPHIC SETTING:** This narrative should be a general description of the site. It should include a general treatment of the geography, climate, soils, vegetation, geology, and groundwater to give an adequate background and foundation for effective presentation of the hydrogeology of the site and adjacent areas. The description should not be more elaborate than is necessary to accomplish this purpose.

IV. **SITE SPECIFIC CHARACTERISTICS:** (Geology and Hydrology) - This information shall be a detailed, integrated evaluation of the hydrogeologic conditions beneath and adjacent to the proposed site pertinent to the production and migration of refuse leachate, and to the capability for leachate containment and attenuation to acceptable quality before reaching a present or potential water source.

A qualitative and quantitative analysis of the effects of the emplacement of the refuse on the existing hydrologic regime must be addressed. Hydrogeologic data must be based on a systematic investigation utilizing data from borings, piezometers, water wells and other nearby water sources, the chemical characteristics of subsurface waters, and other available information.

After all pertinent information has been obtained, site investigation borings must be properly sealed or grouted in a manner that will prevent cross-contamination or interconnection of formations of strata.

A. TYPE AND EXTENT OF SUBSURFACE MATERIALS: A minimum of one boring is required for each ten (10) acres at the site. Regardless of minimum requirements, the degree of subsurface information obtained must be sufficiently comprehensive to allow the design hydrologist/geologist or engineer to make a detailed evaluation of the hydrologic and geologic properties of the subsurface materials, both at the site and laterally extrapolated, such that a reasonable estimate of the effects of these materials on the containment, migration, and attenuation of the leachate can be made. The site specific details must be incorporated into <u>at least</u> two or three cross-sections showing details on the site's geology, hydrology, and elevation. Any clay-rich soil to be used for compacted clay liners or cap must be accurately identified, located, and analyzed.

Borings used for the cross-sections must extend to a minimum depth of fifty (50) feet below the proposed elevation of the buried refuse, or if pertinent, a sufficient depth into bedrock to determine its character and hydraulic characteristics. In-situ permeability tests may be necessary to determine the permeability of the formations surrounding and underlying the proposed facility. A lithologic and geophysical log may be required for each boring. The geophysical log may include a gamma-gamma and a gamma-density log.

The placement, construction and design of borings piezometer(s) and/or monitoring well(s) should be coordinated with an appropriate representative of the Department. The complete logs of each boring must be provided as well as the following information.

1. Date of boring

2. Location of boring

3. Method of drilling including the circulation technique (air, air-mist, water, mud)

4. Method of sampling

5. Diameter of borehole

6. Elevation at surface of boring, referenced to mean sea level to the nearest 0.1 foot

7. For monitoring wells, the elevations of the screened interval

8. Depth and elevation of the water level in the borehole or piezometer

9. Method of piezometer and/or monitor well completion or method used to seal and abandon borehole, whichever is applicable

B. MATERIAL CLASSIFICATION AND ANALYSIS: Material samples should be taken by split spoon or shelby tube at depths in the boring operation where the type of material encountered differs from that immediately overlying, or in homogeneous materials, at regular intervals. These samples and any samples of clay-rich soil to be used for clay liners must be classified, tested, and analyzed in a materials testing laboratory and the following data reported:

   1. Textural classification (USDA System or Unified System) plotted on the appropriate textural classification.

   2. Particle size distribution curves of representative samples.

   3. Coefficient of permeability - based on field (preferred) and/or laboratory tests.

   4. Ion-exchange capacity of samples and ability to adsorb and "fix" heavy metals. Results should be reported in millequivalents per 100 grams of sample. Most fine textured materials will favor ion-exchange because of their mineralogy,

low permeability and large surface area. Sands and gravels are less effective and hence will permit less attenuation of leachate per unit of flow path, and will allow more rapid rates of travel.

C. HYDROLOGY: The hydrology of the site will dictate its ultimate suitability and the final design of the facility.

The design and operation, if soundly based on hydrogeologic principles, will incorporate one or more of the following: elevating the base of the disposal facility above any existing or potential zones of saturation; utilization of existing natural environment to contain and "treat" the leachate; modification of the natural environment to provide the desired hydrogeologic characteristics to either contain the leachate within the refuse, or to provide attenuation in the resulting hydrologic flow system and; isolate the refuse from the surrounding flow system by the use of a natural or artificially-installed liner, and thence collecting and treating the leachate by an engineered system.

Placement of refuse above the zone of saturation does not preclude all leachate production and resultant groundwater pollution, since precipitation during site operation as well as after site closure may generate leachate.

The hydrogeological factors which must be sufficiently considered include:

1. The permeability of the subsurface materials beneath and surrounding the area to be filled with waste;

2. The rate(s) and direction(s) of groundwater movement;

3. The spatial distribution of the potentiometric surface(s) at the time instrumentation is completed, as well as after the facility is constructed, including the water table and the potentiometric surfaces for aquifers in the vicinity of the site;

4. Any structural features which may affect the flow path for groundwater and/or leachate migration. Facilities proposed for areas underlain by significant lignite seams or for areas where lignite has been mined should include a structural contour map of the base of the lignite seam;

5. The effects of facility construction and the emplacement of the refuse on the existing hydrologic regimen, including consideration of flow-system changes as a result of site disruption, construction, or pumpage from present or potential water sources; and

6. The thickness, composition, and configuration of the final cover of the filled area, as well as the post-reclamation vegetation and its effect on surface water infiltration.

V. **CONSTRUCTION PLANS AND SPECIFICATIONS:** Submit a detailed narrative report with the following:

A. A detailed topographic map of the existing site, (scale 1" = 200' or larger) using a contour interval of five (5) feet where the relief exceeds twenty (20) feet, and two (2) foot contour intervals where the relief is less than twenty (20) feet. The map should show all buildings, ponds, streams, ditches, utilities, roads, fences, location(s) of boreholes, and any other items of significance.

B. A second topographic map, matched to the scale of the above map, prepared to completely describe the final construction of the proposed site. This should include the construction of disposal areas of trenches; the development of control features for surface water run-off, run-on, and drainage; any installation for the collection and treatment of leachate; access roads; buildings; utilities; fencing; monitoring wells; topsoil and subsoil stockpiles; cover material stockpiles; liner and clay cap material stockpiles; and all other features of the developed facility.

C. A soil survey report with appropriate maps and a narrative. This section should describe the types of soils at the site and describe the thickness of the topsoil ("A" horizons) and the subsoil ("B" horizons). A description of how these horizons will be removed, handled, and stockpiled for later respreading during site reclamation must be included in detail. This stockpiled soil material (Suitable Plant Growth Material or SPGM) must be handled, stockpiled, and the piles revegetated in a manner that minimizes erosion and/or contamination of the material. The maps included in the construction plans should identify locations of SPGM stockpiles.

D. Submit a series of cross-sections or profiles (scale 1" = 200'or larger) of the developed site. These sections should number no less than three (3), but in any case must be adequate to define the three dimensional distribution of materials to a depth of fifty (50) feet below the proposed elevation of refuse.

These profiles should clearly indicate the constructed pits, the geologic strata or lithology surrounding and underlying the disposal facility, the placement of any required side and/or bottom liners, the placement of any surface water sumps, the placement and screened interval of appropriate monitoring wells, the levels of the water table, groundwater flow directions, the proposed sequence of placement and total compacted thickness of each lift of waste, thickness of cover material for each lift, and the slope of the completed landfill with final cover in place. These cross-sections should be in a format that allows permit reviewers to obtain a quick and concise view of the proposed facility.

E. The construction plans should address the Quality Control and Assurance Procedures to be used during site construction, liner installation, groundwater monitoring, site operation, and site closure. The Department may require a routine report from the facility on the status of the operation and its construction (especially the liners) and its operation (especially surface water control and dust control). The description of the Quality Control Procedures for liner construction or any other appropriate construction (clay cap, etc.) should be signed by an independent registered engineer. A routine status report could be included with the quarterly groundwater monitoring report.

VI. **GROUNDWATER MONITORING:** The design of a groundwater monitoring system and the parameters for water analysis should be based on an assessment of the waste analysis, the site's geology and hydrology, the plans for construction, and the facility's method of operation. Items that should be discussed include:

A. The water level in the boreholes immediately after boring completion and sufficient periodic measurements of the depth to water until stabilization has been attained.

B. The vertical and horizontal components of the hydraulic gradients; a contour map for each potentiometric surface (data for which may be based on local domestic and industrial wells, and on-site piezometers and boreholes).

C. The location of one or more up-gradient groundwater quality monitoring well nests and a minimum of two down-gradient groundwater quality monitoring piezometer nests to be located in the expected path(s) of the leachate migration. The location and construction of the piezometers should be in accordance with the hydrogeology of the site as determined by the exploratory program, subject to final approval by the Department.

D. All monitoring wells must be cased and must be installed in compliance with Chapter 43-35 of the North Dakota Century Code and in compliance with Chapter 33-18-01 of the North Dakota Administrative Code governing water well construction. Monitoring wells must be completed in a manner that maintains the integrity of the borehole and precludes cross-contamination or interconnection of aquifers or geologic strata. The casing must be screened with an appropriately sized factory slotted pipe and packed with clean sand or gravel to allow collection of groundwater samples. The annular space between the well casing and borehole must be properly sealed to prevent contamination of samples and the groundwater.

At the surface, all wells must have a proper apron to prevent surface water infiltration and a protective outer casing to prevent physical damage to the well. The outer casing should include a cap and lock.

The monitoring piezometer should be constructed of non-metallic material, with a two (2) inch or greater inside diameter. Such piezometers will aid in evaluation of the effectiveness of the proposed facility design, and provide an early warning of design malfunction so that timely remedial measures can be initiated.

E. Background analysis for the following chemical characteristics shall be mandatory for at least one groundwater sample taken from a piezometer installed in the expected flow path(s) of the leachate.

EPA standard procedure shall be used for obtaining, transporting, and analyzing samples. The results of the analysis shall be submitted to the Department before an operating permit can be issued.

CHEMICAL PARAMETERS FOR GROUNDWATER ANALYSIS

1. Total Alkalinity ($CACO_3$)
2. Arsenic (AS*)
3. Bicarbonate (HCO_3)
4. Cadmium (Cd)*
5. Calcium (Ca)*
6. Carbonate (CO_3)
7. Chloride (Cl)
8. Total Chromium *
9. Fluoride (F-)
10. Hardness (as calcium carbonate)
11. Iron (Fe)*
12. Lead (pb)*
13. Magnesium (Mg)*
14. Manganese (Mn)*
15. Mercury (Hg)*
16. Nitrate (NO_3)
17. pH
18. Potassium (K)*
19. Sodium (Na)*
20. Specific Conductance**
21. Sulfate (SO_4)
22. Total Dissolved Solids
23. Selenium (Se)*
24. Barium (Ba)*
25. Silver (Ag)*
26. Molybdenum *

* Analyzed for "dissolved" metals. (i.e. samples filtered through an 0.45u membrane filter.

** Reported in micromhos at 25 degrees C.

Additional parameters may be assigned by the Department. These parameters will be determined by the detailed chemical analysis of the waste.

All constituents reported in milligrams per liter (mg/l).

Periodic groundwater samples shall be collected and analyzed by the applicant, or his designated representative, to monitor for alterations in groundwater quality. The frequency of samples and parameters required for analysis will be specified by the Department.

VII. **OPERATION AND MANAGEMENT METHODS:** The permit application must contain details on the facility's operation and maintenance. This should include in detail:

A - Personnel
B - Contingency and emergency plans
C - Control of access to the site (fence, gates, signs, etc.)
D - Roads (including maintenance)
E - Confining disposal to as small an area as possible
F - Dust control
G - Spill prevention and cleanup
H - Storage (if any)
I - Source and thickness of cover
J - Frequency of covering
K - Methods of waste handling and haulage
L - Leachate (including pit water) and surface water run-on/run-off control, handling, and disposal
M - Recordkeeping
N - Development Plans
O - Quality Assurance and Quality Control

VIII. **RECORD OF SOLID WASTE DISPOSAL ACTIVITY WITH THE COUNTY REGISTER OF DEEDS:** Prior to onset of disposal activities, the permittee shall record a notarized affidavit with the County Register of Deeds to place a notation in the County's tract system specifying that this solid waste management site, as specified in the legal description, is permitted to accept solid wastes for disposal.

This affidavit shall specify that another affidavit must be recorded upon the facility's final closure.

Upon closure, an additional affidavit shall be recorded, as above, specifying any final details regarding the types of wastes disposed at the site, as well as any final details regarding the site's location, construction, management, etc.

The Department must be provided with a copy of both affidavits certified by the County Register of Deeds in the county in which the disposal site is located, within thirty (30) days of their recorded dates.

IX. **CLOSURE:** A closure plan must be included which describes in detail the procedures to be followed and the materials and manpower to be used in accomplishing final closure of the disposal facility. Generally, closed sites should have an adequate slope to promote surface water run-off without causing active erosion of the final cover.

The plan should include whatever maps, cross-sections, diagrams, and narrative is necessary to detail such things as:

A. Schedule or timetable of closure.

B. Final elevation of disposed wastes.

C. Equipment necessary to accomplish closure.

D. Type, volume, and source of cover material.

E. Construction and placement of clay and/or synthetic cap and any drainage layers.

F. Final grading/contouring of the facility.

G. Topsoil replacement.

H. Seed, fertilizer, and irrigation necessary to establish cover.

I. Surface water run-off.

J. Schedule for post-closure groundwater monitoring.

K. Maintenance of leachate control or collection system.

L. A short description of the utilization and maintenance of the disposal area after closure. The closed site should be managed in a careful manner that will prevent deterioration of the desired plant community and the low permeability final cover. The closure plan should provide for routine inspection and maintenance of the closed site, including the replanting of vegetation and the replacement of any eroded final cover.

9.0 SUMMARY

A permanent coal combustion ash disposal facility will be constructed north of Mandan, ND adjacent to the R. M. Heskett power station. The disposal site will be incrementally developed to minimize impact upon the landscape and reduce potential for fugitive dust emissions and waste leachate generation. Disposal trenches will be bi-annually constructed and equipped with an in situ clay liner sloping towards an in-pit leachate collection system. Collected leachate will be evaporatively treated in a clay-lined surface impoundment.

Earthen berms and tree plantings will provide visual and acoustical obstructions between facility operations and adjacent dwellings to the south. Additional landscaping may be performed as needed. Filled trenches will be covered with a compacted clay cap along with uncompacted overburden and plant growth materials to a total depth of eight feet. Reclamation will be performed with each disposal trench closure and produce a gently sloping grassland.

The groundwater immediately beneath the site is of poor quality and marginally useful as a domestic or agricultural resource. All waste will be emplaced above the historic water table. Facility operations should not effect local groundwater flow. A monitoring program will be established to characterize deviations in groundwater hydrology and chemistry. Contingencies have been identified in the event of site characterization errors, incompatible facility design, or operational difficulties as outlined in this permit application.

10.0 REFERENCES

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Appendix D

2014 and 2016 Boring Logs

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description	Elevation, feet
0				TOPSOIL: Brown (5/4 7.5YR).	
	1	4-4-4-6.		SANDY LEAN CLAY WITH GRAVEL (CL): fine to medium grained; Brown (5/3 7.5YR); moist; thinly laminated; some mottling; low plasticity; [Cannonball Formation].	1715
				At 2': Start to see gravel inclusions.	
	2	4-6-6-7.			
				At 4': Oxidized staining.	
5	3	7-9-14-16.		At 5': Oxidized staining.	
	4	8-9-12-15.		At 7': Oxidized staining and white staining.	1710
	5	10-15-21-26.			
10	6	7-18-24-27.	CL	At 11': Oxidized staining.	1705
	7	8-12-19-23.			
15	8	8-14-18-23.		At 15': Gypsum.	
				16-20': No recovery.	1700
20				At 20.5': Gypsum.	
	9	7-10-13-15.		LEAN CLAY (CL): Dark Brown (3/2 7.5YR); oxidized staining, some mottling; medium to high plasticity; [Cannonball Formation].	1695
				At 22': Color change to Brown (4/2 7.5YR).	
	10	7-9-13-15.	CL		
25				At 24': Interbedded sand, fine grained.	

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started: 8/18/15
Date Boring Completed: 8/19/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
25	11	7-11-13-15.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); oxidized staining, some mottling; medium to high plasticity; [Cannonball Formation]. *(continued)* At 25' and 25.5': Gypsum.	
				At 26.5': Gypsum.	1690
	12	8-11-15-19.			
	13	8-11-13-15.			
30				At 29.5': Gypsum.	
	14	6-11-14-17.			1685
	15	8-13-17-22.		At 33': Gypsum.	
35	16	8-14-19-21.		At 34.5': Gypsum.	
				At 35.5-36': Color change to Black (2.5/1 7.5YR), turns back to brown.	
			CH	FAT CLAY (CH): Black (2.5/1 7.5YR); very stiff; hight plasticity; wet at 43'; [Cannonball Formation].	1680
	17	11-16-20-27.			
				At 38': Oxidized staining.	
	18	9-13-20-25.			
40	19	7-14-23-26.		At 41': Oxidized staining.	1675
	20	9-16-23-26.			
45					
					1670
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started:	8/18/15
Date Boring Completed:	8/19/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft

Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
50				CH		FAT CLAY (CH): Black (2.5/1 7.5YR); very stiff; hight plasticity; wet at 43'; [Cannonball Formation]. *(continued)*	1665
55							1660
58						End of boring 58.0 feet	
60							
65							
70							
75							

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started:	8/18/15
Date Boring Completed:	8/19/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-102
DRAFT

Project: R.M. Haskett Station CCR Monitoring Network
Project No.: 34300014.12
Location: Mandan, ND
Coordinates: Lat: 438161.145° Long: 1868782.871°
Datum: NAD 83

Surface Elevation: 1703.8 ft
Drilling Method: HSA
Sampling Method: SPT
Completion Depth: 46.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description
0				TOPSOIL: Brown (5/4 7.5YR).
1	1	3-3-3-2.	CL	LEAN CLAY (CL): medium grained; Brown (4/3 7.5YR); moist; low to medium plasticity; with gravel to 4'; [Cannonball Formation].
	2	3-2-2-3.	CL	
5	3	3-3-4-5.	CL	
	4	3-4-5-7.	CL	
	5	4-8-7-4.	ML	SANDY SILT WITH GRAVEL (ML): Strong Brown (5/6 7.5YR); fine to coarse sand, fine to medium gravel, unconsolidated; [Cannonball Formation].
10	6	4-3-5-9.	CL	LEAN CLAY WITH GRAVEL (CL): fine to medium grained; Brown (5/3 7.5YR); some mottling; medium plasticity; [Cannonball Formation].
12	7	3-5-7-9.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); medium to high plasticity; [Cannonball Formation].
15	8	6-8-12-14.	CL	
	9	6-10-12-16.	CL	
	10	5-9-14-16.	CL	
20	11	5-12-15-18.	CL	At 21': Color changes to Black (2.5/1).
	12	9-15-18-22.	CL	
25				

Elevation, feet: 1700, 1695, 1690, 1685, 1680

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.85' ags - 10' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 8' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **8 - 31' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **20 - 30' bgs**

Date Boring Started: 8/18/15
Date Boring Completed: 8/18/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: Lithological descriptions for a hole that was abandoned. Monitoring well blind drilled and installed next to abandoned hole.
DTW = 17.09' TOR on 8/21/2015 (elev. 1689.51

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-102
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438161.145° Long: 1868782.871°
Datum:NAD 83

Surface Elevation:1703.8 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:46.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description	Elevation, feet
25	13	9-14-19-22.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); medium to high plasticity; [Cannonball Formation]. *(continued)*	
	14	10-17-18-24.			
	15	6-15-18-26.		At 29': Gypsum.	1675
30	16	7-14-18-22.			
	17	11-16-20-27.		At 33.5' and 34': Gypsum.	1670
35	18	10-14-15-24.			
	19	13-19-25-35.			
	20	8-17-26-31.			1665
40	21	10-20-27-38.			
	22	13-20-27-37.			1660
45	23	15-27-27-32.	SM	SILTY SAND (SM): fine to medium grained; Dark Gray (4/1 7.5YR); wet; [Cannonball Formation].	
				End of boring 46.0 feet	
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.85' ags - 10' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 8' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **8 - 31' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **20 - 30' bgs**

Date Boring Started: 8/18/15
Date Boring Completed: 8/18/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: Lithological descriptions for a hole that was abandoned. Monitoring well blind drilled and installed next to abandoned hole.
DTW = 17.09' TOR on 8/21/2015 (elev. 1689.51

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-103
DRAFT

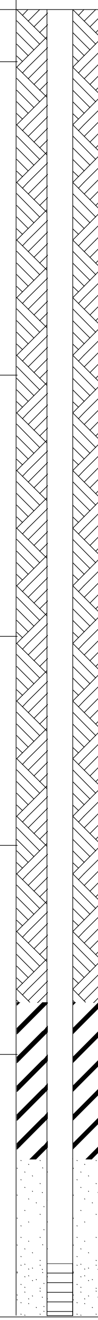
Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 437578.205° Long: 1869355.992°
Datum:NAD 83

Surface Elevation:1714.7 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:44.0 ft

Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
0		1	3-4-5-5.	OL/OH		TOPSOIL (OL/OH): Brown (5/4 7.5YR).	
		2	5-5-8-8.	CL		LEAN CLAY (CL): Very Dark Gray (3/1 7.5YR); moist; stiff; medium to high plasticity; [Cannonball Formation].	
5		3	5-8-10-11.				1710
		4	6-9-15-15.	SP		POORLY GRADED SAND WITH GRAVEL (SP): fine to coarse grained; Brown (5/4 7.5YR); some oxidized staining, some mottling; [Cannonball Formation].	
		5	5-6-5-4.				
10		6	4-5-5-7.				1705
		7	2-2-2-3.	SP-SM		POORLY GRADED SAND WITH SILT (SP-SM): fine to medium grained; Brown (5/4 7.5YR); [Cannonball Formation].	
15		8	3-3-3-3.				1700
						NO RECOVERY (16 - 20').	
20		9	3-3-5-5.	CL		SANDY LEAN CLAY (CL): fine to medium grained; Light Brown (6/4 7.5YR); wet; some mottling and oxidized staining, cohesive; low to medium plasticity; [Cannonball Formation].	1695
25							1690

WELL OR PIEZOMETER CONSTRUCTION DETAIL



PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.79' ags - 24' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 19' bgs**

SEAL
Type: **Bentonite chips**
Interval: **19 - 22' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **22 - 44' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **24 - 44' bgs**

Date Boring Started:	8/19/15
Date Boring Completed:	8/20/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 33.24' TOR on 8/20/2015 (elev. 1684.29)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-103
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 437578.205° Long: 1869355.992°
Datum:NAD 83

Surface Elevation:1714.7 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:44.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
25	10	2-2-4-4.	CL	SANDY LEAN CLAY (CL): fine to medium grained; Light Brown (6/4 7.5YR); wet; some mottling and oxidized staining, cohesive; low to medium plasticity; [Cannonball Formation]. *(continued)*	
30			SM	SILTY SAND WITH GRAVEL (SM): wet; [Cannonball Formation].	1685
	11	10-10-7-9.	CL	LEAN CLAY (CL): Brown (4/4 7.5YR); moist; oxidized staining; medium to high plasticity; [Cannonball Formation].	
	12	8-15-17-22.		At 32.5': Sand lens, color changes to Black (2.5/1 7.5YR).	
				At 33.5': Sand lens.	
				At 34': Interbedded sand with oxidized staining.	
35	13	7-19-15-25.			1680
	14	11-16-21-50 for 5".		At 36.5': Sand lens.	
				At 37': Sand lens.	
				At 37.5': Color change to Gray (5/1 7.5YR).	
				At 38-38.5': 6" thick layer of hard material.	
	15	50 for 2"'-.			
40					1675
	16	12-17-22-30.		At 42-42.5': Silt layer.	
	17	9-18-24-50.		At 43.5-44': Silt layer.	
				End of boring 44.0 feet	
45					
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.79' ags - 24' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 19' bgs**

SEAL
Type: **Bentonite chips**
Interval: **19 - 22' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **22 - 44' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **24 - 44' bgs**

Date Boring Started: 8/19/15
Date Boring Completed: 8/20/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: DTW = 33.24' TOR on 8/20/2015 (elev. 1684.29)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-104
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438853.542° Long: 1869832.72°
Datum:NAD 83

Surface Elevation:1681.5 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:32.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0				TOPSOIL: Brown (5/4 7.5YR).
	1	4-5-5-5.	CL	LEAN CLAY WITH SAND (CL): fine to medium grained; Brown (5/4 7.5YR); moist; gravel; medium plasticity; [Cannonball Formation].
	2	3-5-6-8.		
5	3	3-7-9-10.	CL	LEAN CLAY (CL): Brown (4/4 7.5YR); oxidized staining and mottling; medium to high plasticity; with gypsum throughout; [Cannonball Formation].
	4	5-7-9-10.		
	5	5-9-9-10.		
10	6	5-7-9-10.		
				At 12': Heavily oxidized.
	7	5-8-8-12.		
15	8	5-9-11-15.		At 15': Start seeing black staining.
	9	6-9-11-13.		At 17': Heavily oxidized.
	10	4-7-16-19.	SM	SILTY SAND (SM): Strong Brown (5/6 7.5YR); wet; [Cannonball Formation].
				At 19.5': Color change to Brown (5/4 7.5YR).
20	11	5-16-22-26.		At 21': Oxidized layer.
	12	7-11-14-16.	CH	FAT CLAY (CH): Dark Gray (4/1 7.5YR); moist; stiff; high plasticity; with interbedded sand layers below 27'; [Cannonball Formation].
25				

Elevation, feet: 1680, 1675, 1670, 1665, 1660

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.06' ags - 9' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 32' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **9 - 29' bgs**

Date Boring Started: 8/20/15
Date Boring Completed: 8/20/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: DTW = 13.25' TOR on 8/21/2015 (elev. 1671.26)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-104
DRAFT

Project: R.M. Haskett Station CCR Monitoring Network
Project No.: 34300014.12
Location: Mandan, ND
Coordinates: Lat: 438853.542° Long: 1869832.72°
Datum: NAD 83

Surface Elevation: 1681.5 ft
Drilling Method: HSA
Sampling Method: SPT
Completion Depth: 32.0 ft
Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
25		13	6-12-16-17.	CH		FAT CLAY (CH): Dark Gray (4/1 7.5YR); moist; stiff; high plasticity; with interbedded sand layers below 27'; [Cannonball Formation]. *(continued)*	1655
		14	8-12-16-21.				
		15	8-12-16-20.				
30		16				Driller notes: sluff.	1650
						End of boring 32.0 feet	
35							
40							
45							
50							

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.06' ags - 9' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 32' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **9 - 29' bgs**

Date Boring Started:	8/20/15
Date Boring Completed:	8/20/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 13.25' TOR on 8/21/2015 (elev. 1671.26)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-105
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438042.079° Long: 1870325.657°
Datum:NAD 83

Surface Elevation:1686.0 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:30.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
0				TOPSOIL: Brown (5/4 7.5YR).	
	1	6-7-6-5.	CL	SANDY LEAN CLAY (CL): fine to medium grained; Brown (4/2 7.5YR); moist; gravel; medium plasticity; [Cannonball Formation].	1685
	2	5-5-5-6.			
5	3	3-2-4-5.			1680
	4	2-2-2-3.			
	5	2-1-2-2.	CL	LEAN CLAY (CL): Brown (4/2 7.5YR); soft; high plasticity; wet at 16'; [Cannonball Formation].	
10	6	2-1-2-1.		At 10.5': Color change to Reddish-Yellow (6/6 7.5YR).	1675
	7	2-1-1-3.			
15	8	4-3-5-5.		At 14.5-15.5': Gravel inclusions. At 15.5': Color change to Brown (4/3 7.5YR).	1670
	9	7-9-11-13.		At 18': Color change to Brown (5/3 7.5YR).	
20	10	7-9-11-13.			
	11	7-9-13-15.			1665
	12	19-26-28-30.	SP-SM	POORLY GRADED SAND WITH SILT (SP-SM): medium to coarse grained; Brown (5/4 7.5YR); [Cannonball Formation].	
25					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4"
Type: Steel pipe
Interval: 3.5' ags - 1.5' bgs

RISER CASING
Diameter: 2"
Type: PVC SCH 80
Interval: 3.16' ags - 10' bgs

GROUT
Type: None
Interval: None

SEAL
Type: Bentonite chips
Interval: 0 - 7' bgs

SANDPACK
Type: Silica 40-70
Interval: 7 - 30' bgs

SCREEN
Diameter: 2"; No.6 slot
Type: PVC SCH 80
Interval: 10 - 30' bgs

Date Boring Started: 8/17/15
Date Boring Completed: 8/17/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: DTW = 13.22' TOR on 8/21/2015 (elev. 1675.92)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-105
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438042.079° Long: 1870325.657°
Datum:NAD 83

Surface Elevation:1686.0 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:30.0 ft
Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
25		13	15-25-31-40.					
				CL		FAT CLAY (CL): Dark Brown (3/4 7.5YR); high plasticity; sand lens at 26.5'; [Cannonball Formation]. At 26': Color change to Gray (5/1 7.5YR).		1660
		14	10-15-18-30.					
		15	11-16-22-32.					
30						End of boring 30.0 feet		
35								
40								
45								
50								

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.16' ags - 10' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 30' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **10 - 30' bgs**

Date Boring Started:	8/17/15
Date Boring Completed:	8/17/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 13.22' TOR on 8/21/2015 (elev. 1675.92)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING MW-44 R

Project: Heskett Station
Project No.: 34301012
Location: Mandan, ND
Coordinates: Lat: 46.86620° Long: -100.89313°
Datum:

Surface Elevation:
Drilling Method: HSA
Sampling Method: Split Spoon
Completion Depth: 46.0 ft

Unique Well No.: MW-44 R

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0	1	3-3-5-8.	OL/OH	0-1': TOPSOIL (OL/OH): Very Dark Brown (2.5/2 7.5YR); low to medium plasticity; roots, fine to medium grained sand.
				1-46': SANDY CLAY (CL): Brown (5/4 7.5YR) to Dark Gray (4/1 7.5YR); medium to high plasticity; massive; fine to medium grained sand. Moist; 20% gravel, 30% sand, 50% fines. At 1-5': Gravel sized inclusions.
	2	9-9-7-7.		Moist; 10% gravel, 20% sand, 70% fines.
5	3	7-5-5-7.		Moist; 0% gravel, 30% sand, 70% fines.
	4	7-9-11-13.		Moist; 0% gravel, 20% sand, 80% fines.
				At 8': Oxidized staining.
	5	7-9-12-13.		
10	6	6-7-11-13.		
	7	7-10-12-14.	CL	
15	8	6-10-14-14.		
20	9	10-10-13-16.		At 20': Interbedded layer of sand.
25	10	10-10-12-16.	CL	(CL): At 24': Color change to dark brown (3/3 7.5YR). Moist; 0% gravel, 20% sand, 80% fines. At 25': Sand lens.

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4" by 4"**
Type: **Steel**
Interval: **3' up & 3' down**

RISER CASING
Diameter: **2"**
Type: **Schd 40 PVC**
Interval: **Stick up to screen (23')**

GROUT
Type: **Cement**
Interval: **0-0.5' BGS**

SEAL
Type: **Bentonite**
Interval: **Chips 0.5-21' BGS**

SANDPACK
Type: **Granusil**
Interval: **21-46' BGS**

SCREEN
Diameter: **2"**
Type: **No. 10 Slot**
Interval: **23-43' BGS**

Elevation, feet

Date Boring Started: 10/20/14
Date Boring Completed: 10/20/14
Logged By: JEG3
Drilling Contractor: Midwest Testing (Terracon)
Drill Rig:

Remarks: Water encountered at 28.7' BGS in MW-44R while drilling on 10/2014

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
BARR Telephone: 701-255-5460

LOG OF BORING MW-44 R

Project:Heskett Station
Project No.:34301012
Location:Mandan, ND
Coordinates:Lat: 46.86620° Long: -100.89313°
Datum:

Surface Elevation:
Drilling Method:HSA
Sampling Method:Split Spoon
Completion Depth:46.0 ft

Unique Well No.:MW-44 R

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION
						(CL): At 24': Color change to dark brown (3/3 7.5YR). *(continued)*
30		11	8-12-14-18.	CL		Wet; 0% gravel, 20% sand, 80% fines.
						At 30.5': Sand lens.
						(CL): At 32': Color change to dark gray (4/1 7.5YR).
35		12	8-13-16-27.			
40		13	11-19-25-27.	CL		
45		14	14-18-27-34.			
				SC		(SC): At 45.8': Clayey Sand (SC), fine to medium grained, low to medium plasticity, dark greenish gray (4/10G Gley 2).
50						
55						

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4" by 4"**
Type: **Steel**
Interval: **3' up & 3' down**

RISER CASING
Diameter: **2"**
Type: **Schd 40 PVC**
Interval: **Stick up to screen (23')**

GROUT
Type: **Cement**
Interval: **0-0.5' BGS**

SEAL
Type: **Bentonite**
Interval: **Chips 0.5-21' BGS**

SANDPACK
Type: **Granusil**
Interval: **21-46' BGS**

SCREEN
Diameter: **2"**
Type: **No. 10 Slot**
Interval: **23-43' BGS**

Elevation, feet

Date Boring Started: 10/20/14
Date Boring Completed: 10/20/14
Logged By: JEG3
Drilling Contractor: Midwest Testing (Terracon)
Drill Rig:

Remarks: Water encountered at 28.7' BGS in MW-44R while drilling on 10/2014

Additional data may have been collected in the field which is not included on this log.
Weather:

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: MDU-Heskett Station

Address: 2025 38th Street
Mandan, North Dakota

2. WELL LOCATION **(MW-44R)**

Address (if in city): (see attached drawing)

County: Morton

SE ¼ SE ¼ SW ¼ Sec. 10 Twp. 139 N. Rge. 81 W.

Lat. 46.86620 Long.: -100.89313

Altitude:

3. METHOD DRILLED

■ Auger Other

4. WELL CONSTRUCTION

Diameter of Hole 8 inches Depth 46 feet

Riser: ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR ______ Schedule 40

Diameter 2.0 inches

From +2 ft. to 23 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 23 feet to 43 feet

Sand packed from 21 ft to 46 ft

Depth grouted from 1 ft to 21 ft

Grouting Material

Bentonite x Other

If other explain:

One foot concrete collar at surface

Well head completion:

24" above grade ______ Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 28.5 feet below surface

If flowing: closed in pressure ______ psi or ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) From	To
Topsoil	0	0.5
Sandy lean clay	0.5	5
Sandy fat clay	5	46

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how?

8. REMARKS

3 steel bumpers installed around well head

9. DATE COMPLETED 10-21-14

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

[signature] 10-22-14

Signature Date

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
BARR Telephone: 701-255-5460

LOG OF BORING MW-80 R

SHEET 1 OF 1

Project: Heskett Station
Project No.: 34301012
Location: Mandan, ND
Coordinates: Lat: 46.86789° Long: -100.89320°
Datum:

Surface Elevation:
Drilling Method: HSA
Sampling Method: Split Spoon
Completion Depth: 27.0 ft

Unique Well No.: MW-80 R

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION
0				OL/OH		0-0.5': TOPSOIL (OL/OH): Black; organic roots.
		1	4-4-4-5.	CL		0.5-27': SANDY CLAY (CL): Brown (4/4 7.5 YR) to Black (2.5/1 7.5YR); medium to high plasticity; fine to medium grained sand. Moist; 0% gravel, 30% sand, 70% fines. At 2': Gravel inclusions.
		2	4-5-7-9.			Moist; 10% gravel, 30% sand, 60% fines.
5		3	4-4-5-8.			Moist; 0% gravel, 20% sand, 80% fines.
		4	4-4-6-6.			
		5	3-4-5-6.	CL		(CL): At 8': Color change to 2.5/1 7.5YR black, no odor.
10				CL		(CL): At 9': Color change to 2.5/2 7.5YR very dark brown. Moist; 0% gravel, 20% sand, 80% fines.
		6	1-3-3-4.	CL		(CL): At 11': Color change to 3/3 7.5YR dark brown. Moist; 0% gravel, 20% sand, 80% fines.
		7	1-1-2-1.			(CL): At 13': Color change to 4/4 7.5YR brown. Wet; 0% gravel, 20% sand, 80% fines.
15		8	1-2-2-1.			
20				CL		
		9	7-11-12-17.			At 21': Thin sand lens less than 0.1" thick. Wet; 0% gravel, 20% sand, 80% fines. At 21.5': Thin sand lens less than 0.1" thick.
25		10	7-11-17-17.			Wet; 0% gravel, 20% sand, 80% fines. At 26.5': Thin sand lens less than 0.1" thick.

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4" by 4"**
Type: **Steel**
Interval: **3' up & 3' down**

RISER CASING
Diameter: **2"**
Type: **Schd 40 PVC**
Interval: **Stick up to screen (7')**

GROUT
Type: **Cement**
Interval: **0-0.5' BGS**

SEAL
Type: **Bentonite**
Interval: **Chips 0.5-5' BGS**

SANDPACK
Type: **Granusil**
Interval: **5-27' BGS**

SCREEN
Diameter: **2"**
Type: **No 10 Slot**
Interval: **7-27' BGS**

Elevation, feet

Date Boring Started: 10/20/14
Date Boring Completed: 10/20/14
Logged By: JEG3
Drilling Contractor: Midwest Testing (Terracon)
Drill Rig:

Remarks: Water encountered at 11.8' BGS in MW-80R while drilling on 10/20/14

Additional data may have been collected in the field which is not included on this log.
Weather:

O:\GINT\PROJECTS\34301012.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

State of North Dakota
BOARD OF WATER WELL CONTRACTORS
900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: MDU-Heskett Station

Address: 2025 38th Street

Mandan, North Dakota

2. WELL LOCATION **(MW-80R)**

Address (if in city): (see attached drawing)

County: Morton

NE ¼ SE ¼ SW ¼ Sec. 10 Twp. 139 N. Rge. 81 W.

Lat. 46.86789 Long.: -100.89320

Altitude:

3. METHOD DRILLED

■ Auger Other

4. WELL CONSTRUCTION

Diameter of Hole 8 inches Depth 27 feet

Riser: ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR Schedule 40

Diameter 2.0 inches

From +2.5 ft. to 7 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 7 feet to 27 feet

Sand packed from 5 ft to 27 ft

Depth grouted from 1 ft to 5 ft

Grouting Material

Bentonite x Other

If other explain:

One foot concrete collar at surface

Well head completion:

24" above grade Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 12 feet below surface

If flowing: closed in pressure psi or ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) From	To
Topsoil	0	0.5
Sandy lean clay	0.5	27

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how?

8. REMARKS

3 steel bumpers installed around well head

9. DATE COMPLETED 10-21-14

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

[signature] 10-22-14

Signature Date

Alternative Source Demonstration: April 2019 Event

R.M. Heskett Station

Prepared for
Montana-Dakota Utilities Co.

November 2019

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Alternative Source Demonstration
April 2019 Event

November 2019

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Certifications

I hereby certify that I, or my agent, have examined this written demonstration and attest that this Coal Combustion Residuals Facility Alternative Source Demonstration (ASD) is accurate and has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and the requirements of 40 CFR §257.94. I further certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of North Dakota.

Revision	Date	Summary of Revisions
0	November 4, 2019	Initial Alternative Source Demonstration

Thomas J. Radue, P.E.
Barr Engineering Co.
ND Registration Number PE – 3632

1.0 Introduction

Montana-Dakota Utilities Co. (MDU) owns and operates R.M. Heskett Station (Site), a coal-fired generating station and a gas-fired turbine located in Mandan, Morton County, North Dakota (Figure 1). One CCR (coal combustion residual) unit, as defined by 40 CFR 257.53, is located on the property. The CCR unit contains coal combustion by-products, asbestos wastes generated from construction activity associated with MDU-owned facilities, and ash derived from burning of tire-derived fuel (TDF) at the facility.

The CCR Rule (US EPA, 2015) §257.94(e)(2) allows for an alternative source demonstration (ASD) in the event of an identified statistically significant increase (SSI) in a water quality parameter in a downgradient monitoring well over background levels:

The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report.

The purpose of this work is to evaluate the data collected as part of the April 2019 monitoring event, along with historical data, to demonstrate if the proposed SSIs are the results of a "source other than the CCR unit" or due to natural variation in groundwater quality, an error in sampling, analysis, or statistical evaluation.

2.0 April 2019 SSIs

Sampling for the first detection monitoring event in 2019 was conducted on April 1-2. Four potential SSIs over background were identified: chloride at MW-105, sulfate and total dissolved solids (TDS) at MW-104, and fluoride at MW-2-90.

Evaluations were undertaken to review potential alternative sources for the SSIs. These evaluations include comparing the following:

- Leaching tests of on-site CCR materials;
- Leachate collected in the Evaporation Pond (non-CCR unit);
- Regional (background) groundwater quality data; and
- Groundwater quality collected at the site prior to construction of the CCR unit.

Several characteristics of the CCR unit site geology, groundwater monitoring well locations, and historic groundwater quality data prompted consideration of potential alternative sources for the potential SSIs, including:

- Elevated water quality parameters in pre-landfill groundwater monitoring data;
- Site-specific geologic conditions; and
- Leakage from the Evaporation Pond (non-CCR unit).

A successful alternative source demonstration is discussed in Section 3.0.

2.1 April Sampling Event

Methods used to evaluate potential alternative sources as the basis for water quality parameter concentrations over background from the April 2019 detection monitoring event are discussed below. Concentrations for potential SSIs observed in April 2019 are similar to those observed during prior detection monitoring events (Table 1).

Table 1. Detection Monitoring Results for Potential SSI Well-Parameter Pairs

Well	Parameter	Interwell Prediction Limit (mg/L)	Detection Monitoring Results			
			October 2017 (mg/L)	April 2018 (mg/L)	October 2018 (mg/L)	April 2019 (mg/L)
MW-105	Chloride	271	**346**	**333**	**384**	**282**
MW-104	Sulfate	6,770	**10,200**	**10,700**	**11,000**	**11,100**
MW-104	TDS	9,970	**15,400**	**17,400**	**18,000**	**17,700**
MW-2-90	Fluoride	0.93	0.93	**1.03**	**1.00**	**1.02**

Bolded values indicate concentrations exceed the associated interwell predication limits.

2.2 Verification Sampling

Verification sampling was conducted on potential SSIs. Results of verification sampling are outlined in Table 2.

Table 2. Verification Sampling Results

Well	Parameter	Interwell Prediction Limit (mg/L)	Detection Monitoring April 2019 (mg/L)	Verification Sampling Aug 2019 (mg/L)
MW-105	Chloride	271	**282**	**279**
MW-104	Sulfate	6,770	**11,100**	**11,000**
MW-104	TDS	9,970	**17,700**	**17,300**
MW-2-90	Fluoride	0.93	**1.02**	**1.00**

Bolded values indicate concentrations exceed the associated interwell predication limits.

All the initial SSI determinations were verified by the resampling. Therefore, the initial values collected in April will be used moving forward.

3.0 Alternative Source Demonstration

Successful demonstrations of alternative sources have previously been documented for the four potential SSIs. The associated ASD Reports (Barr, 2018a; Barr, 2018b; Barr, 2019) documented that each of the SSIs could be explained by natural groundwater quality variability based on concentrations that were either present at the Site before the landfill was constructed and/or consistent with regional groundwater quality data. The purpose of this ASD Report is to validate the results of prior findings with the April 2019 data. For each potential SSI, three hypotheses regarding the potential source of the SSI are assessed: 1) a release of leachate from the CCR unit is the source of one or more of the potential SSIs; 2) natural variations of pre-landfill or regional groundwater quality is the source of one or more of the potential SSIs; or 3) a release of leachate from the Evaporation Pond (non-CCR unit) is the source of one or more of the potential SSIs.

3.1 Source Hypothesis #1: CCR Unit Release

To accept the hypothesis that a release of leachate from the CCR unit is the source of one or more of the potential SSIs, it would be assumed that groundwater chemistry at one or more of the potentially impacted wells (MW-2-90, MW-104, and MW-105) would be geochemically similar to impacted water from the CCR unit. However, if they are geochemically dissimilar, this indicates that a source "other than the CCR unit" may be responsible for the potential SSI. Therefore, major ion chemistry from the CCR monitoring locations (upgradient and downgradient) were compared to CCR ash Synthetic Precipitation Leaching Procedure (SPLP method; EPA Method 1312) data collected July 2011 (Appendix A).

In order to test this hypothesis, Piper diagrams were used to visually compare the CCR SPLP results (Appendix A) and the measured groundwater quality at the Site (Figure 2). Piper diagrams are plots of major ion chemistry of water samples (calcium, magnesium, potassium, sodium, chloride, sulfate, and alkalinity) that are used to differentiate between water types and to identify potential mixing of water types. This method is a means to identify or "fingerprint" water samples by their common characteristics (major ions) to assess which types of water are similar or dissimilar to potential source water types (Hensel and Hirsch, 2002).

Downgradient water quality (including the potential SSI parameter-well pairs) is characterized as a Mg-SO_4 type water, whereas the ash SPLP results are Na-SO_4 type water. The major difference observed between the downgradient water quality and the SPLP results is the dominant cation concentration (magnesium vs. sodium). Because water quality data from SSI well-parameter pairs are clustered within the upgradient wells rather than near the SPLP results, it indicates that the water chemistry at those locations are more like upgradient groundwater than a potential release from the CCR unit. **Therefore, we reject the hypothesis that the CCR unit is the source of the fluoride observed at MW-2-90, sulfate and TDS observed at MW-104, and chloride at MW-105.**

3.2 Source Hypothesis #2: Natural Variations of Pre-Landfill or Regional Groundwater Quality

As Source Hypothesis #1 (CCR Unit Release) was rejected as a potential source of the SSIs, natural variations of pre-landfill conditions and/or regional groundwater quality were evaluated for each of the potential SSIs. The second hypothesis evaluated is that concentrations of fluoride at MW-2-90, sulfate and TDS at MW-104, and chloride at MW-105 are consistent with historical (pre-landfill) or regional (background) groundwater data. To test this hypothesis, results of April 2019 Detection Monitoring were compared to pre-landfill data and/or regional groundwater quality data from the Cannonball Formation and associated units to determine if natural variation is a potential alternative source for the SSIs.

3.2.1 Chloride at MW-105

Groundwater samples collected in 1986 (prior to construction of the CCR unit; an aerial photograph from March 30, 1988 shows the area of the CCR unit, which appears to be undisturbed (Appendix B)) were included in the 1989 Special Use Disposal Site Permit Application (Permit Application; MDU, 1989). Pre-landfill chloride concentrations collected from groundwater at the Site were measured as high as 558 mg/L (Well 44, 1986), indicating that high chloride concentrations pre-date construction of the CCR unit. Additionally, the North Dakota State Water Commission conducted a groundwater study in Morton County (Ackerman, 1980); 45 wells screened in the Cannonball and Ludlow Formations were sampled for various parameters including chloride. Chloride concentrations ranged from 0 to 500 mg/L (37% of which had concentrations greater than 250 mg/L).

Historic data shows that concentrations of chloride in groundwater at the Site measured prior to the construction of the CCR unit (558 mg/L) as well as regional groundwater quality data (0 to 500 mg/L) are consistent with and/or higher than chloride measured at MW-105 in April 2019 (282 mg/L). This supports the hypothesis that the SSI for chloride at MW-105 is due to a "source other than the CCR unit." **Therefore, we accept the hypothesis that chloride concentrations observed at MW-105 are consistent with regional (background) groundwater data.**

3.2.2 Fluoride at MW2-90

This hypothesis was tested by comparing fluoride concentrations collected as part of several regional groundwater quality studies on the Cannonball Formation and associated units. A summary of the range of fluoride concentrations in the Cannonball Formation and associated units are included in the table below.

Table 3. Fluoride Concentrations in Morton County, North Dakota

Reference	Fluoride Conc. Range	Formation/Units	Data Source Location
Ackerman, D.J., 1980. Ground-Water Resources of Morton County, North Dakota. North Dakota Geological Survey Bulletin 72, Part III. 51 p.	0.0 to 4.0 mg/L	Cannonball and Ludlow formations, undifferentiated	Morton County
Crosby, O.A. and Klausing, R.L., 1984. Hydrology of Area 47, Northern Great Plains and Rocky Mountain Coal Provinces, North Dakota, South Dakota, and Montana. USGS Water-Resources Investigations Open-File Report 83-221, 93 p.	0.1 to 6.3 mg/L	Entire Fort Union Formation (includes Cannonball Formation)	Morton County

The Ackerman study provides summary statistics for the fluoride concentrations observed in Morton County. Forty-six samples were analyzed for fluoride; of those, 20 (or 43%) had concentrations greater than 1.3 mg/L (Ackerman, 1980). The fluoride concentration observed at MW-2-90 in April 2019 (1.02 mg/L) is within the range of values consistent with naturally-occurring concentrations of fluoride associated with the Cannonball Formation in Morton County. **Therefore, we accept the hypothesis that fluoride concentrations observed at MW-2-90 are consistent with regional (background) groundwater data.**

3.2.3 Sulfate and TDS at MW-104

Analyses of groundwater samples collected prior to construction of the CCR unit included in the Permit Application notes that high sulfate and TDS was observed at the Site. Maximum sulfate and TDS concentrations reported in 1986 were 11,632 mg/L and 14,917 mg/L, respectively, in Well 60 (approximately 700 feet southwest of MW-104), with similar concentrations observed two years later. Sulfate concentrations reported in April 2019 (11,100 mg/L) at MW-104 are within range of historically observed concentrations, but TDS concentrations are somewhat higher than historically observed (17,700 mg/L). Figures 3 and 4 show the range of sulfate and TDS concentrations, respectively, across the Site, including recent and historical monitoring well data.

The mineralogy of the underlying geology may yield an explanation for the elevated sulfate concentrations (which leads to elevated TDS concentrations). The dominant lithology observed at the Site is unconsolidated silt in a clay matrix with interspersed fine to medium-grained sand (10% to 30%). Small gypsum crystals are documented discontinuously throughout the upper 30 feet of the surface materials, which have been presumed to be the result of diagenetic processes which occur above the water table during alternating wetting and drying cycles (Groenewold et al, 1983). Gypsum is a hydrated calcium sulfate mineral that can be a source of high sulfate concentrations in groundwater. Dissolution of gypsum will occur until equilibrium concentrations are attained in the groundwater or until all the minerals are consumed.

The boring log for MW-104 (Appendix C) notes gypsum present throughout the upper layer of the screened interval. Boring logs for other CCR wells and pre-landfill wells note gypsum occurrences across the Site (Appendix C). The water level and screened interval in MW-104 are within the gypsum-bearing unit. In other wells with lower sulfate and TDS concentrations, the water levels and/or screened units are below the documented gypsum occurrences. As groundwater fluctuates and surface water infiltration occurs, periodic dissolution of gypsum into the water column may occur, resulting in elevated sulfate concentrations (and therefore elevated TDS, too).

Based on presence of gypsum in native subsurface deposits and documentation of elevated sulfate and TDS in pre-landfill groundwater, the hypothesis that the SSI for sulfate and TDS at MW-104 may be due to natural conditions (a "source other than the CCR unit.") is possible. However, a statistically significant increasing trend for TDS at MW-104 was observed. Although natural/background groundwater can be affected by seasonality and/or site-wide aquifer changes, resulting in trending data, no other monitoring wells at the Site has observed trends for TDS (or sulfate). Additionally, seasonality was not detected in TDS or sulfate at MW-104. **Therefore, sulfate and TDS concentrations at MW-104 may be due to natural conditions, however additional source considerations were evaluated.**

3.3 Source Hypothesis #3: Evaporation Pond Release

Two conditions are necessary in order to accept the hypothesis that a release of Evaporation Pond water is the source of one or more of the potential SSIs:

- Mechanism of release (such as an issue with Evaporation Pond liner integrity) and
- Geochemically similar groundwater chemistry at one or more of the potentially impacted wells with water from the Evaporation Pond.

Based on proximity, only the SSIs observed at MW-104 (TDS and sulfate) are being evaluated for this potential source.

3.3.1 TDS and Sulfate at MW-104

A statistically significant increasing trend in TDS was observed at MW-104 following the April 2019 detection monitoring event. No other statistically significant trends were observed for Appendix III parameters at this location. Past ASD Reports (Barr, 2018a; Barr, 2018b; Barr, 2019) attributed elevated sulfate and TDS concentrations at MW-104 to natural conditions, as the values observed were consistent with historically observed concentrations. However, with the addition of the increasing trend for TDS, it was deemed prudent to evaluate for the potential of a source impacting MW-104 beyond natural conditions. MW-104 is located between the CCR unit and the Evaporation Pond (a non-CCR unit). The Evaporation Pond was constructed to collect surface water run-off from the Site as well as leachate from the CCR Unit. Due to the relative proximity of MW-104 to the Evaporation Pond, an evaluation was conducted to assess the Evaporation Pond liner integrity, potential impacts to downgradient wells, and determine the geochemical feasibility of Evaporation Pond water contributing to the conditions observed at MW-104.

Liner Integrity Evaluation

In the 2010 Annual Report for the Special Waste Disposal Permit (SP-087), it was noted that erosion was encountered at the Evaporation Pond. More specifically, "cuts in the banks of the pond ranged from 8 to

24-inches. Erosion was caused from storm water running into the evaporation pond from closed Slots and the haul road" (MDU, 2011). No repairs were made at that time due to standing water in the pond. Similar erosional features were noted in the 2011 and 2012 Annual Reports, citing erosion cuts of 8 to 48-inches (MDU, 2012 and MDU, 2013). These erosion cuts were repaired in 2013 during the construction of Slot 10. Additionally, the 2013 Annual Report stated that "the west wall of the evaporation pond was raised and graded to reroute storm water that accumulates outside of the ash disposal area from the cover of Phase I ash disposal site away from the pond during rain events" (MDU, 2014).

These reports did not specify if the erosional cuts were 8 to 48-inches wide or 8 to 48-inches deep. Based on the Phase I Development "as-constructed" Plan Sheets (January and November 1990), the Evaporation Pond was built with a 3-foot-thick compacted clay liner (MDU, 1989 Exhibit 6-B). If the erosional cuts were up to 48-inches deep, then the cuts would extend through the entirety of the liner thickness, creating a conduit for Evaporation Pond water to enter the groundwater. Additionally, no details were provided on the materials used for repairing the Evaporation Pond (i.e. if the liner was impacted, were the erosion cuts filled in with a comparable clay liner material).

Additionally, the integrity of the Evaporation Pond liner may have been compromised due to cation exchange. If the Evaporation Pond liner is comprised of sodium-bentonite clay, a cation exchange may occur between the sodium in the clay and positively charged cations in the evaporation pond water (potassium, calcium, magnesium, and aluminum), displaced from the liner. Over time this exchange may decrease swelling potential and increase hydraulic conductivity of the clay constituting the pond liner. Time series plots of groundwater quality at nearby wells, MW1-90 (Appendix D), show an increase in sodium and magnesium; these increases are most apparent at MW1-90 between 2012 and 2019.

Downgradient Impacts

The base of the Evaporation Pond sits at approximately 1675 feet above MSL whereas the most recent groundwater elevation in MW-104 and MW1-90 were measured at roughly 1670 feet above MSL and 1665 feet above MSL, respectively. Therefore, any water leaking from the Evaporation Pond would report radially downward into the groundwater, toward both MW-104 and MW1-90, making both wells downgradient of the Pond.

As MW-104 was installed on August 20, 2015, it is not possible to determine if the erosional cuts observed in the early 2010s impacted the water quality at this location. However, data has consistently been collected from nearby well MW1-90, also downgradient of the Evaporation Pond. As seen in the time series plots (Appendix D), in approximately 2010 concentrations of chloride, sulfate, TDS, magnesium, sodium, hardness, and specific conductance at MW1-90 began increasing more rapidly. To a lesser extent, changes in concentrations were observed around this same time for calcium, potassium, nitrogen, and total alkalinity. This timing corresponds to when the erosional cuts at the Evaporation Pond were first observed in the Annual Monitoring Reports. The increasing trends have since continued, despite reports of the erosional cuts being repaired.

Geochemical Feasibility

A simple mixing model was developed to determine the potential of producing a similar water quality observed at MW-104 (and MW1-90, as a historical analogue) when mixing Evaporation Pond water with unimpacted upgradient water. This mixing model was conducted in Geochemist's Workbench® v.12.0, using a water sample collected from the Evaporation Pond in September 2014 and a water sample from upgradient monitoring wells MW-13 and MW-103 on September 2014 and April 2019, respectively, and historical well MW-60. Both wells are hydraulically upgradient of MW-104. It should be noted that this is not a perfect model, as the groundwater quality in the upgradient monitoring wells has slightly different major ion chemistry than downgradient wells, due to heterogeneity of the geology at the Site. Due to the lack of historical (pre-landfill) data at MW-104, it was decided to use upgradient (non-impacted) water. Therefore, the ultimate purpose of this model is to evaluate the potential to produce a similar water sample to what has been observed at MW-104, not an identical match.

The results of the model, using Stiff and Piper plots are provided in Appendix E. Figures E.1 and E.3 show the results of the mixing model on a stiff diagram for MW-13 and MW-103, respectively. Downgradient wells MW-104 and MW1-90 are shown as gray and green diamonds, respectively, in each figure. The blue line in each figure represents the various possible outcomes when mixing the upgradient water quality with the Evaporation Pond. The purple squares (E.1) or black circles (E.3) represent specific proportions (1-part upgradient water to 0.01-, 0.05-, 0.1-, 0.5-, and 1-part Evaporation Pond water). Figures E.2 and E.4 show the results as stiff plots. Table E.1 provides the numerical inputs and results of the various mixed proportions.

As seen in Figure E.1, mixing of the upgradient monitoring well, MW-13, with the Evaporation Pond water does not result in an impacted water chemically similar to MW-104, as the path of the mixing reaction does not intersect the location of the MW-104 sample. However, mixing of MW-103 with Evaporation Pond water may potentially result in a water sample with concentrations similarly observed at MW-104. As seen in Figure E.3, the path of the mixing reaction from MW-103 to the Evaporation Pond transects MW-104, when 1-part upgradient (MW-103) water is mixed with 0.05-part Evaporation Pond water. Therefore, it is plausible that only a small portion of Evaporation Pond water would be needed to "impact" upgradient groundwater such to get a similar chemistry as observed in MW-104.

Based on the description of erosional features extending upwards of 48-inches in the liner of the Evaporation Pond in 2010-2013 corresponding with the increased concentrations of several parameters observed in downgradient monitoring well MW1-90, it's possible that a release from the Evaporation Pond occurred starting in approximately 2011. Furthermore, the results of the geochemical modelling exercise along with the general proximity and hydraulic position of MW-104 relative to the Evaporation Pond supports the hypothesis that the SSI for TDS and sulfate at MW-104 is due to a "source other than the CCR unit." **Therefore, we accept the hypothesis that TDS and sulfate concentrations observed at MW-104 are consistent with a potential release from the Evaporation Pond, a non CCR unit.**

4.0 Conclusions

Four SSIs were identified from the April 2019 detection monitoring event. This report demonstrates that a "source other than the CCR unit" caused the potential SSIs (natural variation in regional and/or pre-landfill groundwater quality and the Evaporation Pond), as allowed by §257.94(e)(2). The results of this alternative source demonstration are summarized in the table below.

Table 4. Summary of SSIs and Alternative Sources

Well	Parameter	Report Section	Evidence for Alternative Source
MW-105	Chloride	3.2.1	Natural variability (pre-landfill values and geologic background)
MW-104	Sulfate	3.3.1	Natural variability or Other (Evaporation Pond, a non CCR unit)
MW-104	Total Dissolved Solids	3.3.1	Natural Variability or Other (Evaporation Pond, a non CCR unit)
MW-2-90	Fluoride	3.2.2	Natural variability (pre-landfill values and geologic background)

Based on the foregoing, the alternative source demonstration presented herein meets the requirements of CCR Rule §257.94(e)(2). As coal unit operations will cease by about the end of March 2022, MDU will work with the ND DEQ on closure options for the Evaporation Pond as it is regulated under a permit through the ND DEQ.

5.0 References

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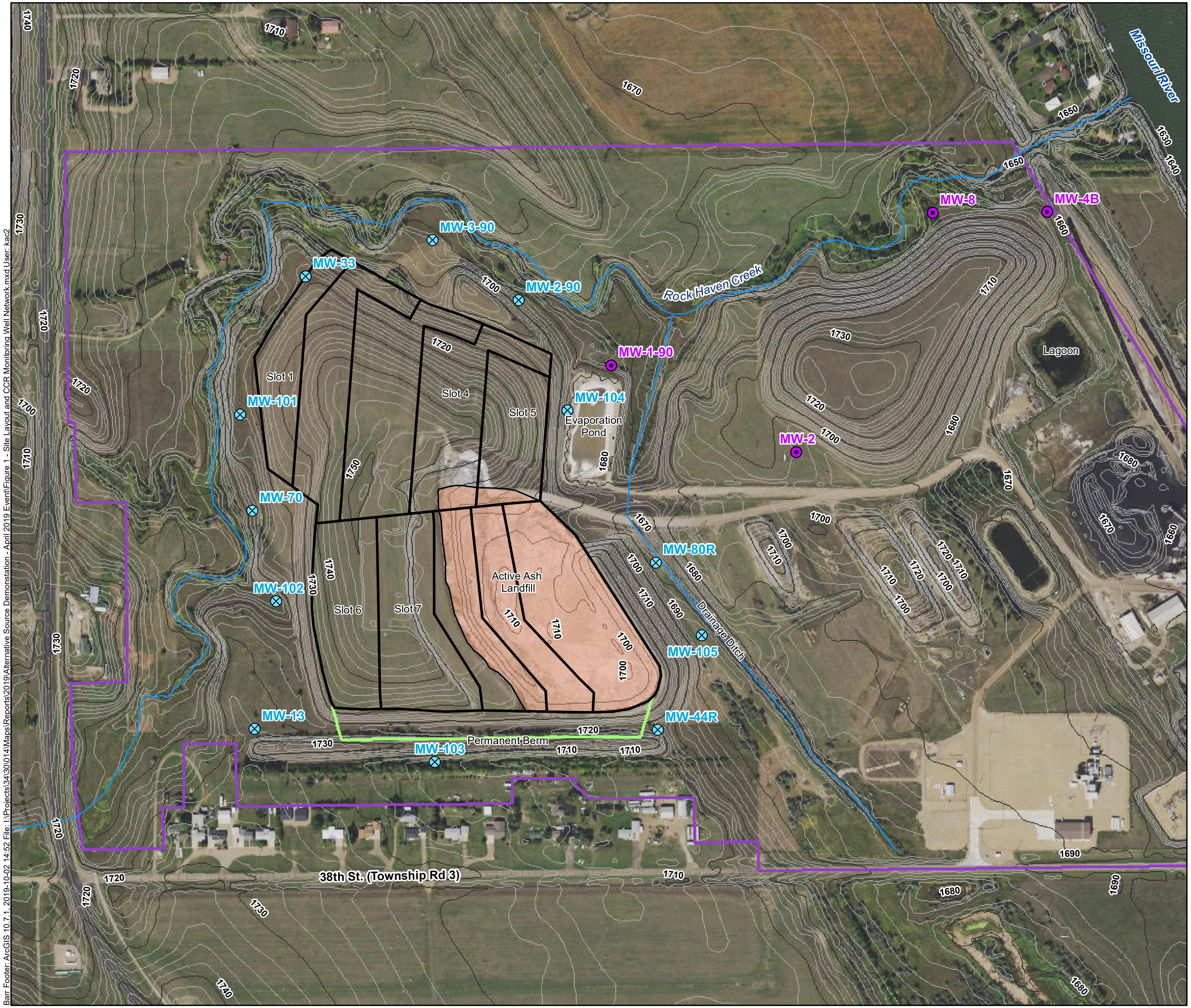
Figures



Monitoring Well Location

Monitoring Well Location - Water Level Only

Existing Slot Boundaries

Streams

Property Line

Future Landfill Boundary

10ft Contours

2ft Contours

Active Portion of Landfill

Image Source: 2019 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg

N

Feet

350 0 350

BARR

Figure 1

SITE LAYOUT AND CCR MONITORING WELL NETWORK
R. M. Heskett Station
Alternative Source Demonstration: April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

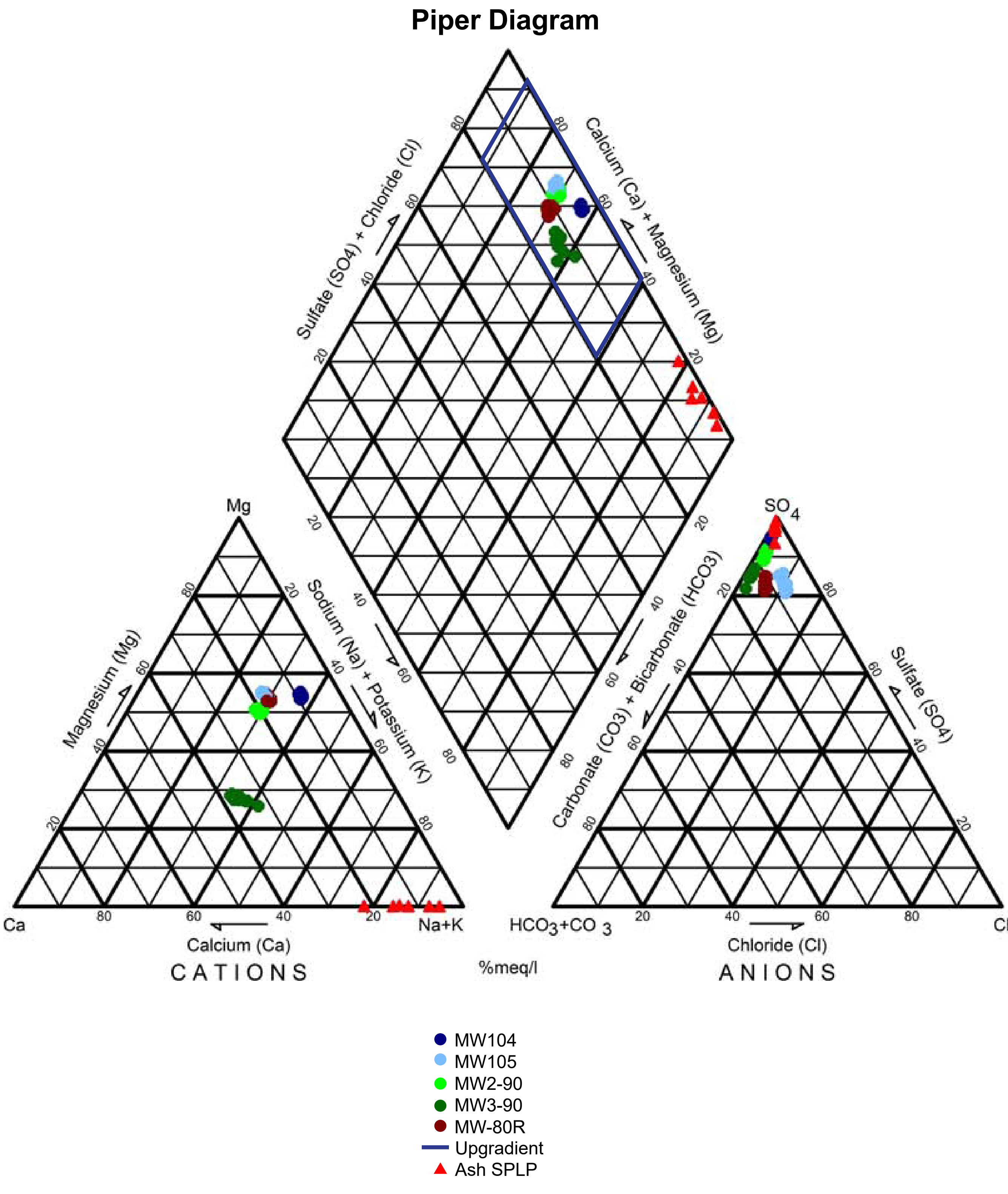
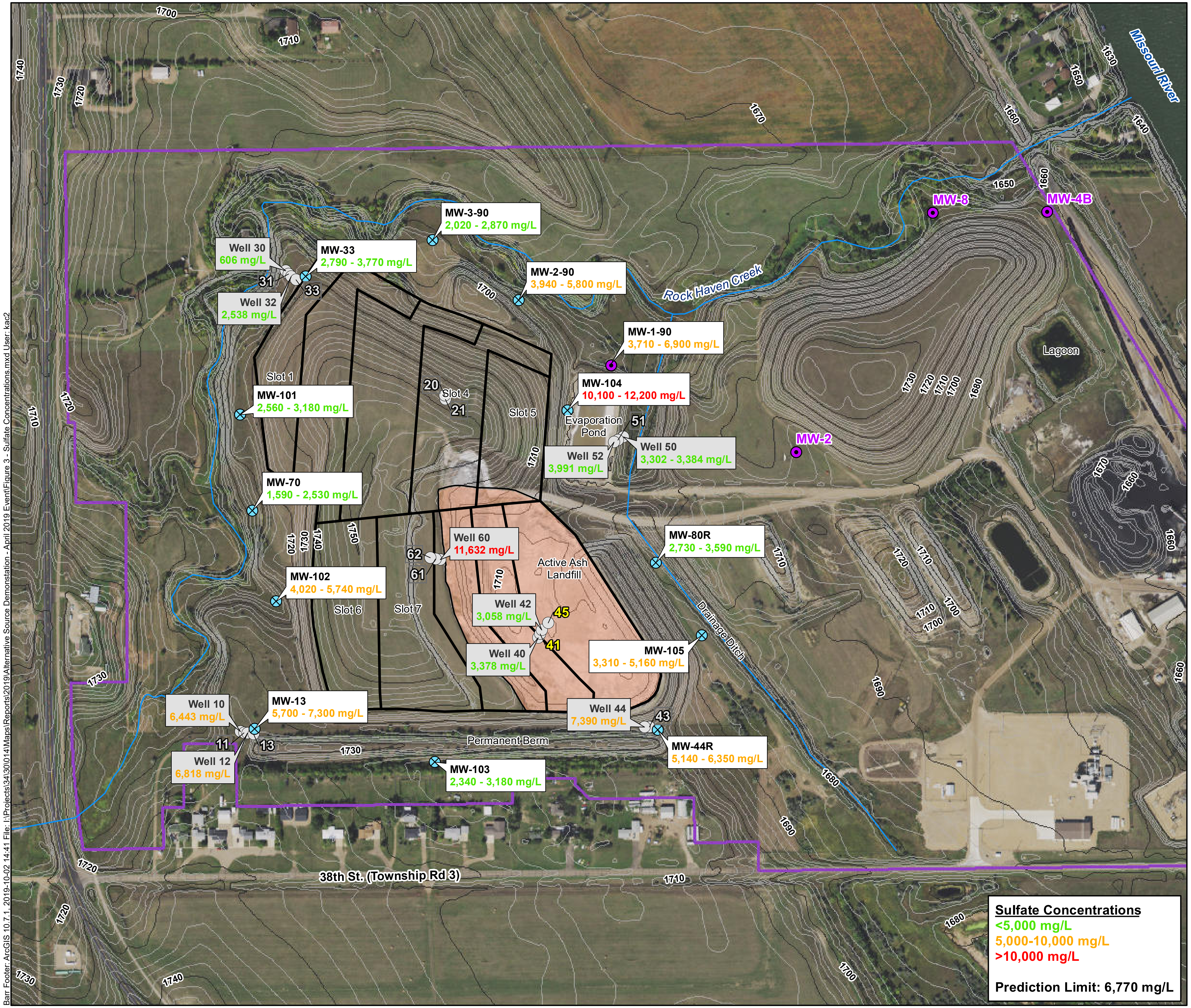


Figure 2

PIPER PLOT
R.M. Heskett Station
Alternative Source Demonstration
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

\\Barr.com\projects\Mpls\34 ND\30\34300014 Heskett Station Ash Management\WorkFiles\Groundwater Monitoring\Statistical Evaluation\2019_DME1\ASD\ASD Report_support\Piper.ai User: SAT



Barr Footer: ArcGIS 10.7.1, 2019-10-02 14:41 File: I:\Projects\34\30\014\Maps\Reports\2019\Alternative Source Demonstration - April 2019 Event\Figure 3 - Sulfate Concentrations.mxd User: kac2

Monitoring Well Location

Monitoring Well Location - Water Level Only

Pre-Landfill Wells (Approximate)

Existing Slot Boundaries

Streams

Property Line

10ft Contours

2ft Contours

Active Portion of Landfill

Image Source: 2018 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg
Pre-Landfill well concentrations are from 9/11/1986, 11/21/1986 (MDU, 1989), and CCR Rule monitoring well concentrations are from 2016-2019.

N

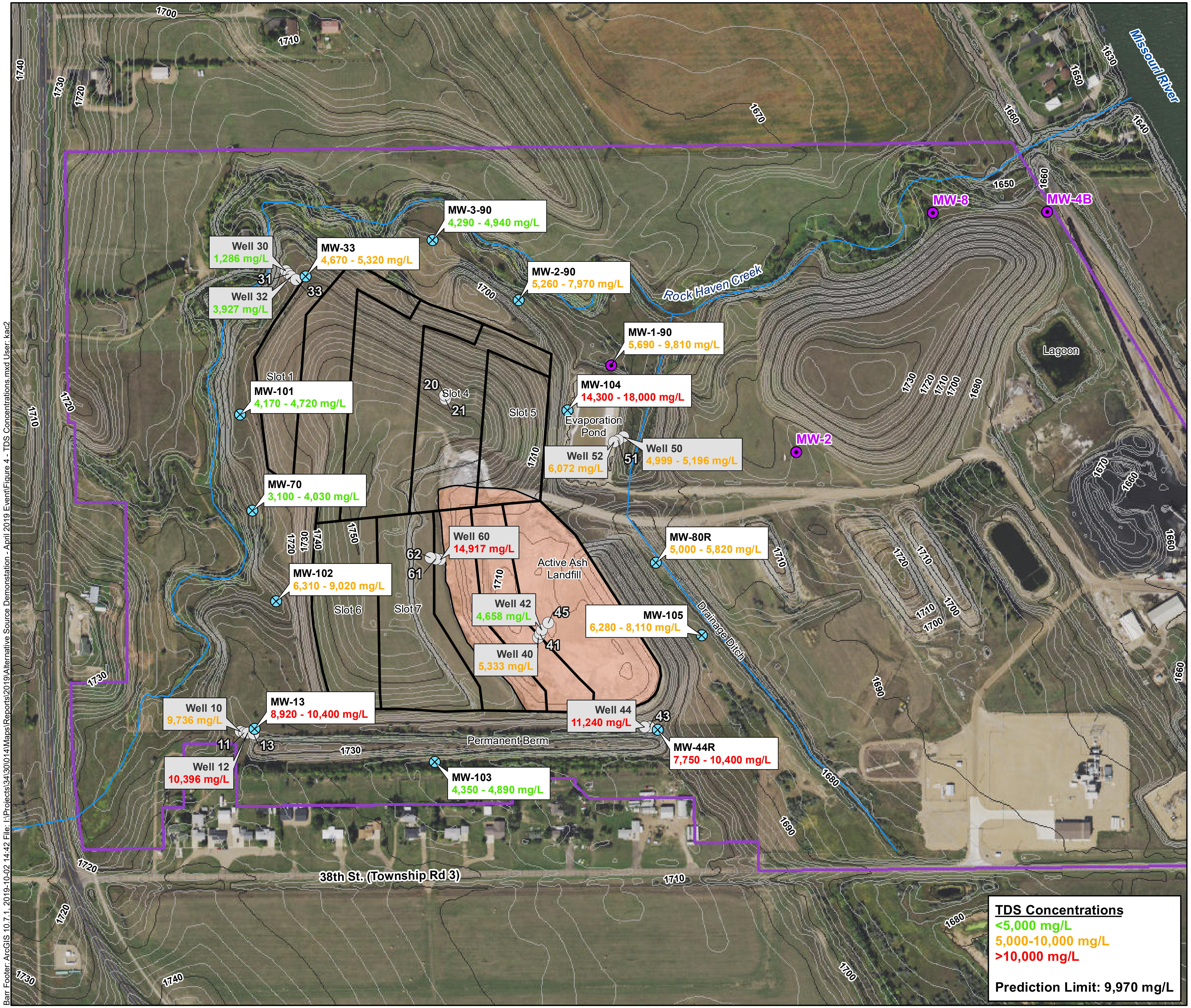
Feet

350 0 350

BARR

Figure 3

SULFATE CONCENTRATIONS
R. M. Heskett Station
Alternative Source Demonstration:
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota



Monitoring Well Location

Monitoring Well Location - Water Level Only

Pre-Landfill Wells (Approximate)

Existing Slot Boundaries

Streams

Property Line

10ft Contours

2ft Contours

Active Portion of Landfill

Image Source: 2018 Statewide Imagery (ND GIS Hub)

CAD Data Source: Slot Linework.dwg
Pre-Landfill well concentrations are from 9/11/1986, 11/21/1986 (MDU, 1989), and CCR Rule monitoring well concentrations are from 2016-2019.

Feet
350 0 350

BARR

Figure 4

TDS CONCENTRATIONS
R. M. Heskett Station
Alternative Source Demonstration:
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

Barr Footer: ArcGIS 10.7.1, 2019-10-02 14:42 File: I:\Projects\34\30\0141\Maps\Reports\2019\Alternative Source Demonstration - April 2019 Event\Figure 4 - TDS Concentrations.mxd User: kac2

Appendix A

Ash SPLP Laboratory Report (2011)

MINNESOTA VALLEY TESTING LABORATORIES, INC.
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2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2450
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Bottom Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.2	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	8778	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	3	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	1120	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	1090	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	60	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	1060	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	4860	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	524	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	30.7	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	74.3	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	74.6	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	-0.24	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	27.1		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	0.7	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	2440	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	50.5	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.21	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	0.32	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	< 5	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	210	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 2.5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	1440	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	44.8	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	28.2	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 0.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	< 0.5	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2450
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Bottom Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.0044	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.1135	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00164	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0065	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.0213	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0027	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.6860	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0074	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.0133	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.0189	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.0151	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Zander

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2451
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Sand Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	11.1	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	20110	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	21	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	203	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	171	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	64	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	139	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	22500	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1200	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	70.2	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	318	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	314	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	0.65	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	80.9		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	See Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	< 0.5	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	< 0.1	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	14900	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	2.0	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	< 0.1	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	0.10	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	< 5	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	481	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	6500	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	459	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	1.09	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 1	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	66.0	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 1	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	5.96	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity

\# = Due to sample concentration
\+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 North Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 East Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 West Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2451
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Sand Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.0822	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.0930	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00182	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0244	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.1108	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0052	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.1000	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0136	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.0937	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.3026	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.0327	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Zander

RL = Method Reporting Limit

Elevated "Less Than Result" (<): @ = Due to sample matrix
! = Due to sample quantity
= Due to sample concentration
+ = Due to extract volume

CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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Report Date: 8 Sep 11
Lab Number: 11-M2452
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.9	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	50660	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	30	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	7020	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Phenolphthalein Alk	6900	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Carbonate	240	mg/l CaCO3	4	SM2320-B	25 Jul 11 17:00	Claudette
Hydroxide	6780	mg/l CaCO3	0	SM2320-B	25 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	42200	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1750	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	102	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	663	meq/L	NA	SM1030-F	3 Aug 11 8:40	Calculated
Anion Summation	613	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	3.99	%	NA	SM1030-F	3 Aug 11 8:40	Calculated
Sodium Adsorption Ratio	143		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	1.5	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	5.60	mg/l	0.10	SM4500-F-C	10 Aug 11 17:00	CLB
Sulfate	22600	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	53.8	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.68	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	7.22	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	22.4	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	700	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 25	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	14100	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	580	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Iron - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Strontium - Total	59.5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Titanium - Total	< 5	mg/l	0.10	6010	2 Aug 11 9:30	Stacy
Boron - Total	1.89	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

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MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2452
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit I Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
Antimony - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Arsenic - Total	0.1128	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Barium - Total	0.0906	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Beryllium - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Cadmium - Total	0.00244	mg/l	0.00100	6020	25 Jul 11 16:18	Claudette
Chromium - Total	0.0270	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Cobalt - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Copper - Total	0.2934	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Lead - Total	0.0161	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Manganese - Total	0.0102	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Molybdenum - Total	0.9246	mg/l	0.0020	6020	26 Jul 11 12:46	Claudette
Nickel - Total	0.0175	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Selenium - Total	0.1959	mg/l	0.0020	6020	26 Jul 11 9:46	Claudette
Silver - Total	< 0.001	mg/l	0.0010	6020	25 Jul 11 16:18	Claudette
Thallium - Total	< 0.002	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Tin - Total	< 0.05	mg/l	0.0500	6020	25 Jul 11 16:18	Claudette
Vanadium - Total	0.0158	mg/l	0.0020	6020	25 Jul 11 16:18	Claudette
Zinc - Total	0.3984	mg/l	0.0100	6020	25 Jul 11 16:18	Claudette
Uranium	< 0.002	mg/l	0.002	6020	25 Jul 11 16:18	Claudette

All analyses were performed on the extract from Method 1312 (SPLP) with a modified solution to solids ratio of 4:1.

Approved by: D. Lordu

RL = Method Reporting Limit

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CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

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MEMBER ACIL

Report Date: 8 Sep 11
Lab Number: 11-M2453
Work Order #:81-818
Account #: 013479
Date Sampled:
Date Received: 28 Jun 11 9:00
PO #: 131460 OP

Duane Leingang
Montana Dakota Utilities
PO Box 40
Mandan ND 58554

Sample Description: Unit II Fly Ash
Sample Site: MDU Heskett

	As Received Result		Method RL	Method Reference	Date Analyzed	Analyst
SPLP Extraction				1312	22 Jul 11	SS
pH	12.8	units	N/A	SM4500 H+ B	22 Jul 11 17:00	Claudette
Specific Conductance	27240	umhos/cm	N/A	SM2510-B	22 Jul 11 17:00	Claudette
Total Suspended Solids	13	mg/l	1	SM2540-D	22 Jul 11 14:00	CLB
Total Alkalinity	4570	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Phenolphthalein Alk	4520	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Bicarbonate	< 4	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Carbonate	100	mg/l CaCO3	4	SM2320-B	22 Jul 11 17:00	Claudette
Hydroxide	4470	mg/l CaCO3	0	SM2320-B	22 Jul 11 17:00	Claudette
Tot Dis Solids(Summation)	16000	mg/l	NA	SM1030-F	3 Aug 11 8:40	Calculated
Total Hardness as CaCO3	1960	mg/l	NA	SM2340-B	3 Aug 11 8:40	Calculated
Hardness in grains/gallon	115	gr/gal	NA	SM2340-B	3 Aug 11 8:40	Calculated
Cation Summation	252	meq/L	NA	SM1030-F	9 Aug 11 9:09	Calculated
Anion Summation	247	meq/L	NA	SM1030-F	28 Jul 11 14:30	Calculated
Percent Error	1.00	%	NA	SM1030-F	9 Aug 11 9:09	Calculated
Sodium Adsorption Ratio	46.1		NA	USDA 20b	3 Aug 11 8:40	Calculated
Gross Alpha Radiation	Attached	pCi/l			22 Aug 11 2:03	
Radon 222	Attached				28 Jul 11 4:37	
Radium 226	Attached	pCi/l			22 Aug 11 22:20	
Radium 228	Attached	pCi/l			16 Aug 11 16:50	
Total Organic Carbon	1.6	mg/l	0.5	SM5310-C	1 Aug 11 8:00	Eric
Fluoride	3.60	mg/l	0.10	SM4500-F-C	4 Aug 11 17:00	CLB
Sulfate	7400	mg/l	5.00	ASTM D516-02	27 Jul 11 9:00	KMP
Chloride	66.0	mg/l	1.0	SM4500-Cl-E	27 Jul 11 14:00	KMP
Nitrate-Nitrite as N	0.38	mg/l	0.10	EPA 353.2	28 Jul 11 14:30	KMP
Ammonia-Nitrogen as N	15.0	mg/l	0.10	EPA 350.1	28 Jul 11 10:45	KMP
Phosphorus as P - Total	< 0.1	mg/l	0.10	EPA 365.1	28 Jul 11 13:00	KMP
Mercury - Total	< 0.0002	mg/l	0.0002	EPA 245.1	28 Jul 11 8:00	Eric
Chemical Oxygen Demand	9.4	mg/l	5.0	HACH 8000	1 Aug 11 8:30	Wayne
Calcium - Total	785	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Magnesium - Total	< 5	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Sodium - Total	4720	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Potassium - Total	275	mg/l	1.0	6010	3 Aug 11 8:40	Stacy
Aluminum - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Iron - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Strontium - Total	85.0	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Titanium - Total	< 1	mg/l	0.10	6010	9 Aug 11 9:09	Stacy
Boron - Total	< 1	mg/l	0.10	6010	11 Aug 11 8:40	Stacy

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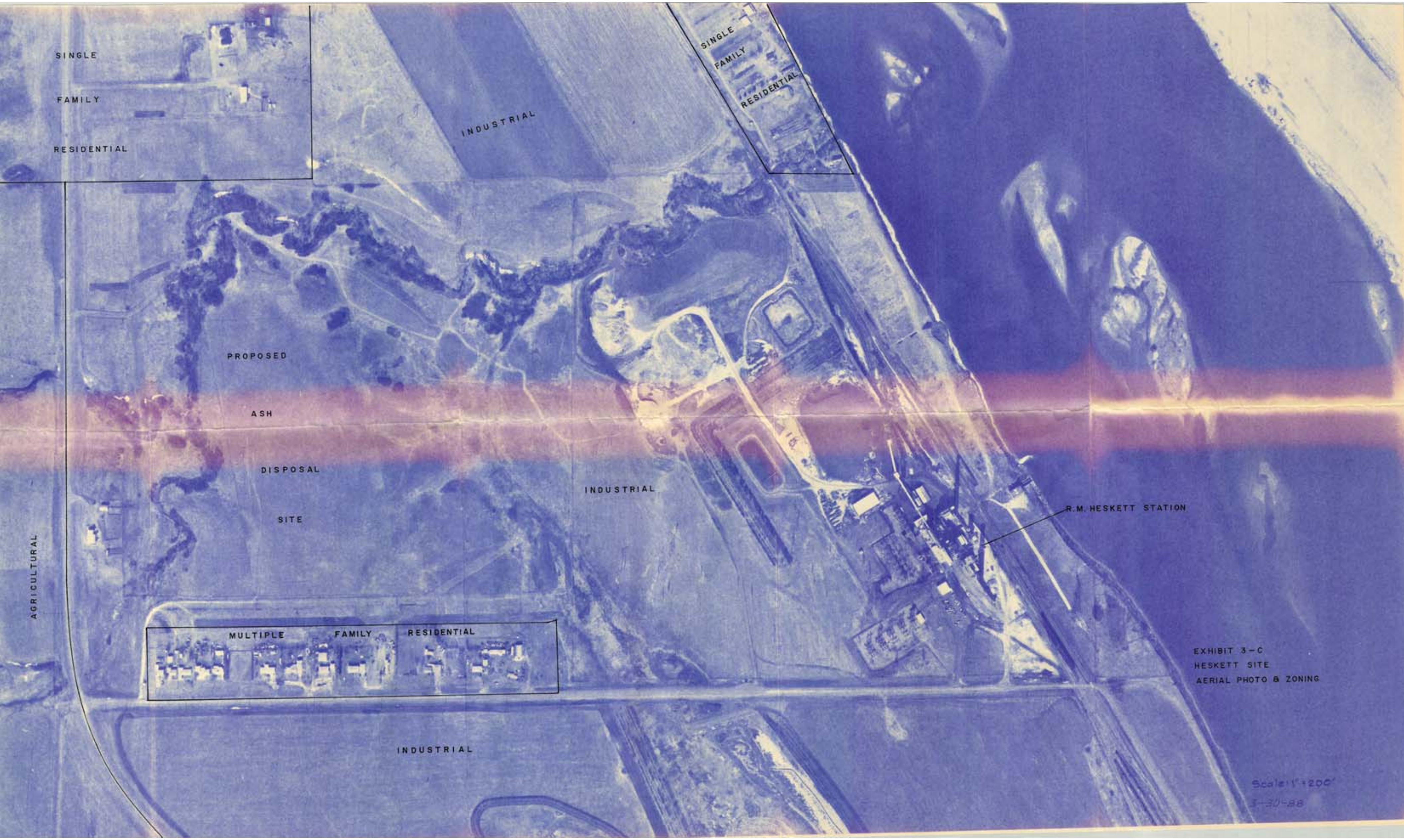
CERTIFICATION: MN LAB # 038-999-267 ND # ND-00016

Appendix B

Aerial Photo (March 30, 1988)


SINGLE
FAMILY
RESIDENTIAL
INDUSTRIAL
SINGLE
FAMILY
RESIDENTIAL
PROPOSED
ASH
DISPOSAL
SITE
INDUSTRIAL
R.M. HESKETT STATION
AGRICULTURAL
MULTIPLE FAMILY RESIDENTIAL
INDUSTRIAL
EXHIBIT 3-C
HESKETT SITE
AERIAL PHOTO & ZONING
Scale 1" = 200'
3-30-88

Appendix C

2014 and 2016 Boring Logs

EXHIBIT 5-E

LITHOLOGIC LOGS

Wells 10, 11, 12 and 13

0-1	Top soil, silty, clayey, sandy, brown, calcareous; with some limestone pebbles.
1-11	Silt, clayey, brownish-tan, slightly indurated, very dry, calcareous; with thin coarse-grained, clean silt lenses and a few small (less than .5 in.) iron oxide concretions. Abundant small gypsum crystals (less than .13 in. long). Some small, black flakes of organic plant material. Cannonball-Ludlow Formations.
11-14	Silt, as above, with some (less than 20%) very fine- to fine-grained sand interspersed.
14-30	Silt, as above, clayey, less sand than above interval, oxidized; with very fine-grained silty sand lenses and very few gypsum crystals.
30-41	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with fewer small gypsum crystals than above intervals.
41-59	Silt, as above, very clayey, with some (less than 20%) fine- to medium-grained sand interspersed in a silt and clay matrix.
59-65	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
65-81	Silt, clayey, steel-gray to bluish, moderately indurated; with thin coarse-grained silt to very fine-grained sand lenses in an otherwise fine silt to clay matrix.
81-84	Clay, silty, steel-gray to bluish, moderately indurated, dense.
84-91	Siltstone, sandy, clayey, steel-gray to bluish, slightly indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.
91-110	Silt, clayey, bluish-gray, moderately indurated; with thin (less than 1 foot) mudstone lenses.
110-120	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

Wells 20 and 21

0-1	Top soil, silty, sandy, clayey, dark-brown, calcareous; with some limestone and granite pebbles.
1-21	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.
21-26	Silt, as above, steel-gray (color change).
26-49	Silt, clayey, with some (less than 20%) very fine- to medium-grained sand interspersed, steel-gray to bluish, slightly indurated; with very few small gypsum crystals and some thin (less than 1 foot) siltstone lenses.
49-53	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
53-63	Silt, as above, clayey, less sand, with thin (less than 1 foot) siltstone to mudstone lenses.
63-80	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

Wells 30, 31, 32 and 33

0-1	Top soil, silty, sandy, brownish, calcareous; with some granite and limestone pebbles.
1-2	Pebble-loam (glacial till), silty, sandy, clayey, yellowish-brown, dry, calcareous.
2-31	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions. Some small, black flakes organic plant material. Cannonball-Ludlow Formations.
31-44	Silt, clayey, steel-gray (color change), slightly indurated, calcareous; with small iron oxide concretions, thin coarse silt lenses, small gypsum crystals and gray to reddish-brown mottling.

44-61	Silt, as above, with some (less than 20%) fine- to medium-grained sand interspersed.
61-65	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed, dense.
65-76	Silt, as above, clayey, less sand, some thin (less than 1 foot) lenses of siltstone to mudstone.
76-80	Siltstone, sandy, clayey, steel-gray to bluish, slightly indurated; with small fine-grained sand lenses and abundant (more than 20%) fine-grained sand interspersed in the matrix.
80-92	Silt, clayey, steel-gray to bluish, moderately indurated, with some (less than 20%) very fine- to fine grained sand interspersed.
92-120	Silt, very clayey, steel-gray to bluish, moderately indurated, very dense. Cannonball-Ludlow Formations.

<u>Well 40</u>

0-1	Top soil, sandy, silty, brownish-tan, calcareous; with some granite and limestone pebbles.
1-5	Pebble-loam (glacial till), sandy, silty, with detrital lignite and organic matter, yellowish-brown, very dry, calcareous.
5-22	Sand, very fine- to medium-grained, unconsolidated, with thin lenses of clay and detrital lignite, brownish-yellow, calcareous.
22-40	Silt, clayey, with minor amounts (less than 10%) very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, oxidized; with small iron oxide concretions and small gypsum crystals; Cannonball-Ludlow Formations.
40-51	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with some reddish-brown mottling and some very thin (less than 6 inches) mudstone lenses.
51-58	Silt, as above, with abundant (more than 20%) fine-grained sand and thin silty-clay lenses.

58-62	Siltstone, sandy, clayey, steel-gray to bluish, moderately indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.
62-70	Silt, clayey, with some (less than 20%) fine- to medium-grained sand interspersed, steel-gray to bluish, moderately indurated; with thin (less than 2 feet) sandy lenses.
70-80	Silt, as above, very clayey, some (less than 10%) fine-grained sand interspersed; less sand than above interval.
80-120	Silt, as above, dark-steel-gray. Cannonball-Ludlow Formations.

<u>Wells 41, 42 and 43</u>

0-1	Top soil, sandy, silty, dark-brown, calcareous; with some granite and limestone pebbles.
1-4	Pebble-loam (glacial till), sandy, silty, clayey, yellowish-brown, very dry, calcareous.
4-40	Silt, clayey, with some (less than 20%) very fine-grained sand interspersed, brownish-tan, unconsolidated, noncompacted, calcareous to 25 feet, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.
40-51	Silt, clayey, with minor amounts (less than 10%) of very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with some reddish-brown mottling and some very thin (less than 6 inches) mudstone lenses.
51-58	Silt, as above, with abundant (more than 20%) fine-grained sand and thin silty-clay lenses.
58-62	Siltstone, sandy, clayey, steel-gray to bluish, moderately indurated; with small fine-grained sand lenses and abundant (more than 20%) sand interspersed in the matrix.
62-70	Silt, clayey, with some (less than 20%) fine- to medium-grained sand interspersed, steel-gray to bluish, moderately indurated; with thin (less than 2 feet) sandy lenses.

70-80	Silt, as above, very clayey, some (less than 10%) fine-grained sand interspersed; less sand than above interval.

<u>Wells 43 and 44</u>

0-2	Top soil, clayey, silty, some sand, brownish-tan to light-gray, calcareous.
2-20	Silt, clayey, with some (less than 20%) fine-grained sand interspersed, brownish-tan, slightly indurated, very dry, calcareous; with small iron oxide concretions, abundant small gypsum crystals and occasional thin silt lenses. Cannonball-Ludlow Formations.
20-25	Silt, as above, very clayey, oxidized, with minor amounts (less than 10%) of fine-grained sand.
25-35	Silt, as above, dark-brownish-tan to bluish-gray (color change), with thin very fine-grained sand lenses.
35-60	Silt, clayey, with some (less than 20%) fine- to medium-grained sand interspersed, steel-gray to bluish, moderately indurated; with some indurated silty sand lenses. Cannonball-Ludlow Formations.

<u>Wells 50, 51 and 52</u>

0-4	Top soil, clayey, silty, very dark-brown.
4-10	Clay, silty, with some (less than 20%) fine-grained sand, dark-brownish-tan, soft, cohesive, wet, sticky; with some pebbles.
10-22	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, brownish-tan, slightly indurated, calcareous, dense; with abundant small gypsum crystals and very thin silt and sand lenses; Cannonball-Ludlow Formations.
22-23	Sandstone, fine-grained, silty, indurated, oxidized, dark-brown.
23-30	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with thin medium grained sand lenses.

30-40	Silt, as above, very clayey, less sand than above interval, dark-steel-gray. Cannonball-Ludlow Formations.

<u>Wells 53 and 54</u>

0-4	Top soil, clayey, silty, very dark-brown, wet, sticky.
4-15	Clay, silty, with some (less than 20%) fine- to medium-grained sand interspersed, brownish-tan, slightly indurated, dry, calcareous; with small iron oxide concretions, small gypsum crystals and occasional reddish-brown mottling; Cannonball-Ludlow Formations.
15-20	Sand, very fine-grained to medium-grained, silty, clayey, unconsolidated, yellowish-brown, oxidized.
20-30	Silt, clayey, with some (less than 20%) fine-grained sand interspersed, steel-gray (color change), slightly indurated; with clay and sand lenses, some small concretions and some small gypsum crystals.
30-45	Silt, as above, very clayey.
45-60	Silt, as above, clayey, brownish-gray, moderately indurated, some reddish-brown mottling. Cannonball-Ludlow Formations.

<u>Wells 55 and 56</u>

0-5	Sandy-loam (glacial), with fine- to medium-grained sand, silty, calcareous; with small granite and limestone pebbles.
5-26	Clay, silty, with minor amounts (less than 10%) of very fine-grained sand, dark-brownish-tan, moderately indurated, brittle, very dry, calcareous; with small iron oxide concretions, small gypsum crystals and occasional thin sandstone laminae. Some small, black flakes of organic plant material. Cannonball-Ludlow Formations.
26-35	Clay, as above, very silty, sandy, brownish-tan, oxidized.

35-40	Silt, clayey, with some (less than 20%) very fine- to fine-grained sand interspersed, steel-gray (color change) moderately indurated; with small gypsum crystals and occasional clay lenses.
40-60	Silt, as above, with minor amounts (less than 10%) of fine-grained sand interspersed.
60-85	Silt, as above, clayey, less sand than above interval.
85-100	Silt, as above, very clayey, with minor amounts (less than 10%) of sand interspersed, light-gray. Cannonball-Ludlow Formations.

Wells 60, 61 and 62

0-2	Top soil, silty, clayey, dark-brown to tanish-brown, calcareous.
2-25	Silt, very clayey, with some minor amounts (less than 10%) of very fine- to fine-grained sand interspersed, brownish-tan, slightly indurated, dry, calcareous; with abundant small gypsum crystals and thin silt and sand lenses; Cannonball-Ludlow Formations.
25-29	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand interspersed.
29-36	Silt, as above, clayey, less sand than above interval, dark-brownish-tan, oxidized.
36-60	Silt, very clayey, with some (less than 20%) very fine-grained sand interspersed, steel-gray (color change), moderately indurated; with thin (less than 1 foot) sandy-silt lenses. Cannonball-Ludlow Formations.

Well 70

0-2	Pebble-loam (glacial till), clayey, sandy, yellowish-brown, unconsolidated, damp, calcareous.
2-21	Silty, clayey, with some (less than 20%) fine-grained sand interspersed, brownish-tan, moderately indurated, very dry, calcareous, oxidized; with small iron oxide concretions and abundant small gypsum crystals. Cannonball-Ludlow Formations.

21-24	Shale, silty, steel- to dark-gray (color change), indurated, fissile, very dry; with occasional thin silt and sand lenses.
24-31	Silt, clayey, with abundant (more than 30%) sand, steel-gray, moderately indurated.
31-62	Silt, clayey, with some (less than 20%) very fine- to fine- grained sand interspersed, steel-gray, moderately indurated; with some small gypsum crystals and small iron oxide concretions.
62-76	Silt, as above, with some (less than 20%) fine-grained sand interspersed.
76-82	Silt, as above, with abundant (more than 20%) fine- to medium-grained sand.
82-100	Silt, as above, clayey, with some (less than 20%) fine-grained sand interspersed, dark-gray. Cannonball-Ludlow Formations.

The litnologic logs for wells 1-4 were described by personal from Water Supply Incorporated (WS), Bismarck, North Dakota. The wells were installed during a previous ground water investigation at Heskett Station.

Well WS 2	
0-1	Top soil, silty, black.
1-4	Pebble-loam (glacial till), silty, clayey, some cobbles, yellowish-brown.
4-7	Gravel, sand and rocks.
7-21	Sand, fine- to coarse-grained, some pebbles.
21-39	Clay, silty, sandy, yellowish-brown to gray.
39-52	Clay, silty, sandy, gray.
52-67	Sand, fine-grained, bluish, with some clay layers.
67-89	Clay, silty, sandy, brown to gray.

Wells WS 1, 1A and 1B	
0-1	Top soil, silty, black
1-4	Clay, (glacial), silty, with pebbles, yellowish-brown.
4-21	Sand, fine- to medium-grained, yellowish-brown; with clay and silt lenses.
21-25	Clay, silty, yellowish-brown.
25-30	Sand, fine-grained, yellowish-brown, some indurated layers.
30-35	Clay, silty, yellowish-brown.
35-45	Sand, fine-grained, yellowish-brown.
45-50	Clay, silty, sandy, gray, about 50 percent shale.
50-56	Sand, fine-grained, with clay layers.
56-73	Clay, silty, sandy, gray.

WElls WS 4, 4A and 4B	
0-13	Pebble-loam (glacial till), silty, sandy, with some cobbles, yellowish-brown.
13-23	Sand, fine- to medium-grained, yellowish-brown.
23-25	Slay, silty, sandy, yellowish-brown.
25-27	Sandstone, indurated.
27-30	Clay, sandy, silty, gray.
30-36	Sand, fine-grained, gray.
36-52	Clay, silty, sandy, gray; with some sand layers.

Wells WS 3 and 3A	
0-1	Top soil, silty, black.
1-12	Pebble-loam, clayey, silty, with some cobbles, yellowish-brown.
12-16	Clay, silty, gray; with some shale layers.
16-18	Limestone, indurated.
18-23	Clay, silty, yellowish-brown; with some sand layers.
23-44	Sand, fine- to medium-grained, gray; with some clay layers.
44-50	Clay, silty, medium-gray.

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING MW-44 R

Project: Heskett Station
Project No.: 34301012
Location: Mandan, ND
Coordinates: Lat: 46.86620° Long: -100.89313°
Datum:

Surface Elevation:
Drilling Method: HSA
Sampling Method: Split Spoon
Completion Depth: 46.0 ft

Unique Well No.: MW-44 R

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description
0	1	3-3-5-8	OL/OH	0-1': TOPSOIL (OL/OH): Very Dark Brown (2.5/2 7.5YR); low to medium plasticity; roots, fine to medium grained sand.
				1-46': SANDY CLAY (CL): Brown (5/4 7.5YR) to Dark Gray (4/1 7.5YR); medium to high plasticity; massive; fine to medium grained sand. Moist; 20% gravel, 30% sand, 50% fines. At 1-5': Gravel sized inclusions.
	2	9-9-7-7		Moist; 10% gravel, 20% sand, 70% fines.
5	3	7-5-5-7		Moist; 0% gravel, 30% sand, 70% fines.
	4	7-9-11-13		Moist; 0% gravel, 20% sand, 80% fines.
				At 8': Oxidized staining.
	5	7-9-12-13		
10	6	6-7-11-13		
	7	7-10-12-14	CL	
15	8	6-10-14-14		
20	9	10-10-13-16		At 20': Interbedded layer of sand.
				(CL): At 24': Color change to dark brown (3/3 7.5YR). Moist; 0% gravel, 20% sand, 80% fines.
25	10	10-10-12-16	CL	At 25': Sand lens.

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4" by 4"
Type: Steel
Interval: 3' up & 3' down

RISER CASING
Diameter: 2"
Type: Schd 40 PVC
Interval: Stick up to screen (23')

GROUT
Type: Cement
Interval: 0-0.5' BGS

SEAL
Type: Bentonite
Interval: Chips 0.5-21' BGS

SANDPACK
Type: Granusil
Interval: 21-46' BGS

SCREEN
Diameter: 2"
Type: No. 10 Slot
Interval: 23-43' BGS

Date Boring Started: 10/20/14
Date Boring Completed: 10/20/14
Logged By: JEG3
Drilling Contractor: Midwest Testing (Terracon)
Drill Rig:

Remarks: Water encountered at 28.7' BGS in MW-44R while drilling on 10/2014

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING MW-44 R

Project: Heskett Station
Project No.: 34301012
Location: Mandan, ND
Coordinates: Lat: 46.86620° Long: -100.89313°
Datum:

Surface Elevation:
Drilling Method: HSA
Sampling Method: Split Spoon
Completion Depth: 46.0 ft

Unique Well No.: MW-44 R

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION
						(CL): At 24': Color change to dark brown (3/3 7.5YR). *(continued)*
30		11	8-12-14-18	CL		Wet; 0% gravel, 20% sand, 80% fines.
						At 30.5': Sand lens.
						(CL): At 32': Color change to dark gray (4/1 7.5YR).
35		12	8-13-16-27			
				CL		
40		13	11-19-25-27			
45		14	14-18-27-34			
				SC		(SC): At 45.8': Clayey Sand (SC), fine to medium grained, low to medium plasticity, dark greenish gray (4/10G Gley 2).
50						
55						

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4" by 4"
Type: Steel
Interval: 3' up & 3' down

RISER CASING
Diameter: 2"
Type: Schd 40 PVC
Interval: Stick up to screen (23')

GROUT
Type: Cement
Interval: 0-0.5' BGS

SEAL
Type: Bentonite
Interval: Chips 0.5-21' BGS

SANDPACK
Type: Granusil
Interval: 21-46' BGS

SCREEN
Diameter: 2"
Type: No. 10 Slot
Interval: 23-43' BGS

Elevation, feet

Date Boring Started: 10/20/14
Date Boring Completed: 10/20/14
Logged By: JEG3
Drilling Contractor: Midwest Testing (Terracon)
Drill Rig:

Remarks: Water encountered at 28.7' BGS in MW-44R while drilling on 10/2014

Additional data may have been collected in the field which is not included on this log.
Weather:

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: MDU-Heskett Station

Address: 2025 38th Street
Mandan, North Dakota

2. WELL LOCATION **(MW-44R)**

Address (if in city): (see attached drawing)

County: Morton

SE ¼ SE ¼ SW ¼ Sec. 10 Twp. 139 N. Rge. 81 W.

Lat. 46.86620 Long.: -100.89313

Altitude:

3. METHOD DRILLED

■ Auger Other

4. WELL CONSTRUCTION

Diameter of Hole 8 inches Depth 46 feet

Riser: ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR Schedule 40

Diameter 2.0 inches

From +2 ft. to 23 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 23 feet to 43 feet

Sand packed from 21 ft to 46 ft

Depth grouted from 1 ft to 21 ft

Grouting Material

Bentonite x Other

If other explain:

One foot concrete collar at surface

Well head completion:

24" above grade Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 28.5 feet below surface

If flowing: closed in pressure psi or ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) From	To
Topsoil	0	0.5
Sandy lean clay	0.5	5
Sandy fat clay	5	46

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how?

8. REMARKS

3 steel bumpers installed around well head

9. DATE COMPLETED 10-21-14

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

Signature 10-22-14
Date

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
BARR Telephone: 701-255-5460

LOG OF BORING MW-80 R

SHEET 1 OF 1

Project:Heskett Station
Project No.:34301012
Location:Mandan, ND
Coordinates:Lat: 46.86789° Long: -100.89320°
Datum:

Surface Elevation:
Drilling Method:HSA
Sampling Method:Split Spoon
Completion Depth:27.0 ft

Unique Well No.:MW-80 R

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0			OL/OH	0-0.5': TOPSOIL (OL/OH): Black; organic roots.
	1	4-4-4-5.		0.5-27': SANDY CLAY (CL): Brown (4/4 7.5 YR) to Black (2.5/1 7.5YR); medium to high plasticity; fine to medium grained sand. Moist; 0% gravel, 30% sand, 70% fines. At 2': Gravel inclusions.
	2	4-5-7-9.		Moist; 10% gravel, 30% sand, 60% fines.
			CL	
5	3	4-4-5-8.		Moist; 0% gravel, 20% sand, 80% fines.
	4	4-4-6-6.		
			CL	(CL): At 8': Color change to 2.5/1 7.5YR black, no odor.
	5	3-4-5-6.		(CL): At 9': Color change to 2.5/2 7.5YR very dark brown. Moist; 0% gravel, 20% sand, 80% fines.
10			CL	
	6	1-3-3-4.	CL	(CL): At 11': Color change to 3/3 7.5YR dark brown. Moist; 0% gravel, 20% sand, 80% fines.
	7	1-1-2-1.		(CL): At 13': Color change to 4/4 7.5YR brown. Wet; 0% gravel, 20% sand, 80% fines.
15	8	1-2-2-1.		
20			CL	
	9	7-11-12-17.		At 21': Thin sand lens less than 0.1" thick. Wet; 0% gravel, 20% sand, 80% fines. At 21.5': Thin sand lens less than 0.1" thick.
25	10	7-11-17-17.		Wet; 0% gravel, 20% sand, 80% fines. At 26.5': Thin sand lens less than 0.1" thick.

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4" by 4"
Type: Steel
Interval: 3' up & 3' down

RISER CASING
Diameter: 2"
Type: Schd 40 PVC
Interval: Stick up to screen (7')

GROUT
Type: Cement
Interval: 0-0.5' BGS

SEAL
Type: Bentonite
Interval: Chips
0.5-5' BGS

SANDPACK
Type: Granusil
Interval: 5-27' BGS

SCREEN
Diameter: 2"
Type: No 10 Slot
Interval: 7-27' BGS

Elevation, feet

Date Boring Started:	10/20/14
Date Boring Completed:	10/20/14
Logged By:	JEG3
Drilling Contractor:	Midwest Testing (Terracon)
Drill Rig:	

Remarks: Water encountered at 11.8' BGS in MW-80R while drilling on 10/20/14

Additional data may have been collected in the field which is not included on this log.
Weather:

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: MDU-Heskett Station
Address: 2025 38th Street
Mandan, North Dakota

2. WELL LOCATION **(MW-80R)**

Address (if in city) (see attached drawing)

County Morton

NE ¼ SE ¼ SW ¼ Sec. 10 Twp. 139 N. Rge. 81 W.

Lat. 46.86789 Long.: -100.89320

Altitude:

3. METHOD DRILLED

■ Auger Other

4. WELL CONSTRUCTION

Diameter of Hole 8 inches Depth 27 feet

Riser: ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR ____ Schedule 40

Diameter 2.0 inches

From +2.5 ft. to 7 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 7 feet to 27 feet

Sand packed from 5 ft to 27 ft

Depth grouted from 1 ft to 5 ft

Grouting Material

Bentonite x Other

If other explain:

One foot concrete collar at surface

Well head completion:

24" above grade ____ Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 12 feet below surface

If flowing: closed in pressure ____ psi or ft. above land surface

6. WELL LOG

Formation	From (Depth, Ft.)	To (Depth, Ft.)
Topsoil	0	0.5
Sandy lean clay	0.5	27

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how?

8. REMARKS

3 steel bumpers installed around well head

9. DATE COMPLETED 10-21-14

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

[signature] 10-22-14

Signature Date

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description
0				TOPSOIL: Brown (5/4 7.5YR).
	1	4-4-4-6.		SANDY LEAN CLAY WITH GRAVEL (CL): fine to medium grained; Brown (5/3 7.5YR); moist; thinly laminated; some mottling; low plasticity; [Cannonball Formation].
				At 2': Start to see gravel inclusions.
	2	4-6-6-7.		
				At 4': Oxidized staining.
5	3	7-9-14-16.		At 5': Oxidized staining.
	4	8-9-12-15.		At 7': Oxidized staining and white staining.
	5	10-15-21-26.		
10				
	6	7-18-24-27.	CL	At 11': Oxidized staining.
	7	8-12-19-23.		
15	8	8-14-18-23.		At 15': Gypsum.
				16-20': No recovery.
20				
	9	7-10-13-15.		At 20.5': Gypsum.
				LEAN CLAY (CL): Dark Brown (3/2 7.5YR); oxidized staining, some mottling; medium to high plasticity; [Cannonball Formation].
				At 22': Color change to Brown (4/2 7.5YR).
	10	7-9-13-15.	CL	
				At 24': Interbedded sand, fine grained.
25				

Elevation, feet: 1715, 1710, 1705, 1700, 1695

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started: 8/18/15
Date Boring Completed: 8/19/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description	Elevation, feet
25	11	7-11-13-15.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); oxidized staining, some mottling; medium to high plasticity; [Cannonball Formation]. *(continued)* At 25' and 25.5': Gypsum.	
				At 26.5': Gypsum.	1690
	12	8-11-15-19.			
	13	8-11-13-15.			
30				At 29.5': Gypsum.	
	14	6-11-14-17.			1685
	15	8-13-17-22.		At 33': Gypsum.	
35	16	8-14-19-21.		At 34.5': Gypsum.	
				At 35.5-36': Color change to Black (2.5/1 7.5YR), turns back to brown.	
			CH	FAT CLAY (CH): Black (2.5/1 7.5YR); very stiff; hight plasticity; wet at 43'; [Cannonball Formation].	1680
	17	11-16-20-27.			
				At 38': Oxidized staining.	
	18	9-13-20-25.			
40					
	19	7-14-23-26.		At 41': Oxidized staining.	1675
	20	9-16-23-26.			
45					
					1670
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started:	8/18/15
Date Boring Completed:	8/19/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-101
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438844.919° Long: 1868647.777°
Datum:NAD 83

Surface Elevation:1716.6 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:58.0 ft

Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
50				CH		FAT CLAY (CH): Black (2.5/1 7.5YR); very stiff; hight plasticity; wet at 43'; [Cannonball Formation]. *(continued)*		1665
55								1660
58						End of boring 58.0 feet		
60								
65								
70								
75								

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.98' ags - 34' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 29' bgs**

SEAL
Type: **Bentonite chips**
Interval: **29 - 32' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **32 - 56' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **34 - 54' bgs**

Date Boring Started:	8/18/15
Date Boring Completed:	8/19/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: Hole caved in from 56 - 58' bgs.
DTW = 36.66' TOR on 9/23/2015 (elev. 1682.87)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-102
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438161.145° Long: 1868782.871°
Datum:NAD 83

Surface Elevation:1703.8 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:46.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0				TOPSOIL: Brown (5/4 7.5YR).
	1	3-3-3-2.	CL	LEAN CLAY (CL): medium grained; Brown (4/3 7.5YR); moist; low to medium plasticity; with gravel to 4'; [Cannonball Formation].
	2	3-2-2-3.		
5	3	3-3-4-5.		
	4	3-4-5-7.		
	5	4-8-7-4.	ML	SANDY SILT WITH GRAVEL (ML): Strong Brown (5/6 7.5YR); fine to coarse sand, fine to medium gravel, unconsolidated; [Cannonball Formation].
10	6	4-3-5-9.	CL	LEAN CLAY WITH GRAVEL (CL): fine to medium grained; Brown (5/3 7.5YR); some mottling; medium plasticity; [Cannonball Formation].
	7	3-5-7-9.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); medium to high plasticity; [Cannonball Formation].
15	8	6-8-12-14.		
	9	6-10-12-16.		
	10	5-9-14-16.		
20	11	5-12-15-18.		At 21': Color changes to Black (2.5/1).
	12	9-15-18-22.		
25				

Elevation, feet: 1700, 1695, 1690, 1685, 1680

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4"
Type: Steel pipe
Interval: 3.5' ags - 1.5' bgs

RISER CASING
Diameter: 2"
Type: PVC SCH 80
Interval: 2.85' ags - 10' bgs

GROUT
Type: None
Interval: None

SEAL
Type: Bentonite chips
Interval: 0 - 8' bgs

SANDPACK
Type: Silica 40-70
Interval: 8 - 31' bgs

SCREEN
Diameter: 2"; No.6 slot
Type: PVC SCH 80
Interval: 20 - 30' bgs

Date Boring Started: 8/18/15
Date Boring Completed: 8/18/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: Lithological descriptions for a hole that was abandoned. Monitoring well blind drilled and installed next to abandoned hole.
DTW = 17.09' TOR on 8/21/2015 (elev. 1689.51

Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\34300014.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-102
DRAFT

Project: R.M. Haskett Station CCR Monitoring Network
Project No.: 34300014.12
Location: Mandan, ND
Coordinates: Lat: 438161.145° Long: 1868782.871°
Datum: NAD 83

Surface Elevation: 1703.8 ft
Drilling Method: HSA
Sampling Method: SPT
Completion Depth: 46.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	Lithologic Description
25	13	9-14-19-22.	CL	LEAN CLAY (CL): Dark Brown (3/2 7.5YR); medium to high plasticity; [Cannonball Formation]. *(continued)*
	14	10-17-18-24.		
	15	6-15-18-26.		At 29': Gypsum.
30	16	7-14-18-22.		
	17	11-16-20-27.		At 33.5' and 34': Gypsum.
35	18	10-14-15-24.		
	19	13-19-25-35.		
	20	8-17-26-31.		
40	21	10-20-27-38.		
	22	13-20-27-37.		
45	23	15-27-27-32.	SM	SILTY SAND (SM): fine to medium grained; Dark Gray (4/1 7.5YR); wet; [Cannonball Formation].
				End of boring 46.0 feet
50				

Elevation, feet: 1675, 1670, 1665, 1660

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.85' ags - 10' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 8' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **8 - 31' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **20 - 30' bgs**

Date Boring Started:	8/18/15
Date Boring Completed:	8/18/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: Lithological descriptions for a hole that was abandoned. Monitoring well blind drilled and installed next to abandoned hole.
DTW = 17.09' TOR on 8/21/2015 (elev. 1689.51

Additional data may have been collected in the field which is not included on this log.
Weather:

LOG OF BORING MW-103
DRAFT

BARR
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 437578.205° Long: 1869355.992°
Datum:NAD 83

Surface Elevation:1714.7 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:44.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0			OL/OH	TOPSOIL (OL/OH): Brown (5/4 7.5YR).
	1	3-4-5-5.	CL	LEAN CLAY (CL): Very Dark Gray (3/1 7.5YR); moist; stiff; medium to high plasticity; [Cannonball Formation].
	2	5-5-8-8.		
5	3	5-8-10-11.		
	4	6-9-15-15.	SP	POORLY GRADED SAND WITH GRAVEL (SP): fine to coarse grained; Brown (5/4 7.5YR); some oxidized staining, some mottling; [Cannonball Formation].
	5	5-6-5-4.		
10	6	4-5-5-7.		
	7	2-2-2-3.	SP-SM	POORLY GRADED SAND WITH SILT (SP-SM): fine to medium grained; Brown (5/4 7.5YR); [Cannonball Formation].
15	8	3-3-3-3.		
				NO RECOVERY (16 - 20').
20	9	3-3-5-5.	CL	SANDY LEAN CLAY (CL): fine to medium grained; Light Brown (6/4 7.5YR); wet; some mottling and oxidized staining, cohesive; low to medium plasticity; [Cannonball Formation].
25				

Elevation, feet: 1710 (5 ft), 1705 (10 ft), 1700 (15 ft), 1695 (20 ft), 1690 (25 ft)

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.79' ags - 24' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 19' bgs**

SEAL
Type: **Bentonite chips**
Interval: **19 - 22' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **22 - 44' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **24 - 44' bgs**

Date Boring Started:	8/19/15
Date Boring Completed:	8/20/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 33.24' TOR on 8/20/2015 (elev. 1684.29)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-103
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 437578.205° Long: 1869355.992°
Datum:NAD 83

Surface Elevation:1714.7 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:44.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
25	10	2-2-4-4.	CL	SANDY LEAN CLAY (CL): fine to medium grained; Light Brown (6/4 7.5YR); wet; some mottling and oxidized staining, cohesive; low to medium plasticity; [Cannonball Formation]. *(continued)*	
30			SM	SILTY SAND WITH GRAVEL (SM): wet; [Cannonball Formation].	1685
	11	10-10-7-9.	CL	LEAN CLAY (CL): Brown (4/4 7.5YR); moist; oxidized staining; medium to high plasticity; [Cannonball Formation].	
	12	8-15-17-22.		At 32.5': Sand lens, color changes to Black (2.5/1 7.5YR).	
				At 33.5': Sand lens.	
				At 34': Interbedded sand with oxidized staining.	
35	13	7-19-15-25.			1680
	14	11-16-21-50 for 5".		At 36.5': Sand lens.	
				At 37': Sand lens.	
				At 37.5': Color change to Gray (5/1 7.5YR).	
				At 38-38.5': 6" thick layer of hard material.	
	15	50 for 2"'-.			
40	16	12-17-22-30.			1675
				At 42-42.5': Silt layer.	
	17	9-18-24-50.		At 43.5-44': Silt layer.	
				End of boring 44.0 feet	
45					
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **2.79' ags - 24' bgs**

GROUT
Type: **Neat cement**
Interval: **0 - 19' bgs**

SEAL
Type: **Bentonite chips**
Interval: **19 - 22' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **22 - 44' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **24 - 44' bgs**

Date Boring Started:	8/19/15
Date Boring Completed:	8/20/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 33.24' TOR on 8/20/2015 (elev. 1684.29)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-104
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438853.542° Long: 1869832.72°
Datum:NAD 83

Surface Elevation:1681.5 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:32.0 ft

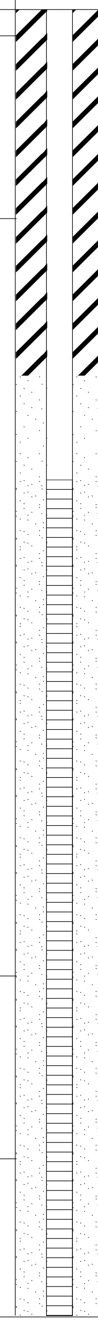
Unique Well No.:

Sample No.	Blows/6in.
1	4-5-5-5.
2	3-5-6-8.
3	3-7-9-10.
4	5-7-9-10.
5	5-9-9-10.
6	5-7-9-10.
7	5-8-8-12.
8	5-9-11-15.
9	6-9-11-13.
10	4-7-16-19.
11	5-16-22-26.
12	7-11-14-16.

USCS	LITHOLOGIC DESCRIPTION
	TOPSOIL: Brown (5/4 7.5YR).
CL	LEAN CLAY WITH SAND (CL): fine to medium grained; Brown (5/4 7.5YR); moist; gravel; medium plasticity; [Cannonball Formation].
CL	LEAN CLAY (CL): Brown (4/4 7.5YR); oxidized staining and mottling; medium to high plasticity; with gypsum throughout; [Cannonball Formation]. At 12': Heavily oxidized. At 15': Start seeing black staining. At 17': Heavily oxidized.
SM	SILTY SAND (SM): Strong Brown (5/6 7.5YR); wet; [Cannonball Formation]. At 19.5': Color change to Brown (5/4 7.5YR). At 21': Oxidized layer.
CH	FAT CLAY (CH): Dark Gray (4/1 7.5YR); moist; stiff; high plasticity; with interbedded sand layers below 27'; [Cannonball Formation].

Depth, feet: 0, 5, 10, 15, 20, 25
Elevation, feet: 1680, 1675, 1670, 1665, 1660

WELL OR PIEZOMETER CONSTRUCTION DETAIL



PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.06' ags - 9' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 32' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **9 - 29' bgs**

Date Boring Started: 8/20/15
Date Boring Completed: 8/20/15
Logged By: JEG3
Drilling Contractor: Terracon
Drill Rig: Rig mounted HSA

Remarks: DTW = 13.25' TOR on 8/21/2015 (elev. 1671.26)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-104
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438853.542° Long: 1869832.72°
Datum:NAD 83

Surface Elevation:1681.5 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:32.0 ft
Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
25	13	6-12-16-17.	CH	FAT CLAY (CH): Dark Gray (4/1 7.5YR); moist; stiff; high plasticity; with interbedded sand layers below 27'; [Cannonball Formation]. *(continued)*	1655
	14	8-12-16-21.			
	15	8-12-16-20.			
30	16			Driller notes: sluff.	1650
				End of boring 32.0 feet	
35					
40					
45					
50					

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.06' ags - 9' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 32' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **9 - 29' bgs**

Date Boring Started:	8/20/15
Date Boring Completed:	8/20/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 13.25' TOR on 8/21/2015 (elev. 1671.26)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-105
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438042.079° Long: 1870325.657°
Datum:NAD 83

Surface Elevation:1686.0 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:30.0 ft

Unique Well No.:

Depth, feet	Sample No.	Blows/6in.	USCS	LITHOLOGIC DESCRIPTION
0				TOPSOIL: Brown (5/4 7.5YR).
	1	6-7-6-5.	CL	SANDY LEAN CLAY (CL): fine to medium grained; Brown (4/2 7.5YR); moist; gravel; medium plasticity; [Cannonball Formation].
	2	5-5-5-6.		
5	3	3-2-4-5.		
	4	2-2-2-3.		
	5	2-1-2-2.	CL	LEAN CLAY (CL): Brown (4/2 7.5YR); soft; high plasticity; wet at 16'; [Cannonball Formation].
10	6	2-1-2-1.		At 10.5': Color change to Reddish-Yellow (6/6 7.5YR).
	7	2-1-1-3.		
15	8	4-3-5-5.		At 14.5-15.5': Gravel inclusions. At 15.5': Color change to Brown (4/3 7.5YR).
	9	7-9-11-13.		At 18': Color change to Brown (5/3 7.5YR).
	10	7-9-11-13.		
20	11	7-9-13-15.		
	12	19-26-28-30.	SP-SM	POORLY GRADED SAND WITH SILT (SP-SM): medium to coarse grained; Brown (5/4 7.5YR); [Cannonball Formation].
25				

Elevation, feet: 1685, 1680, 1675, 1670, 1665

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: 4"
Type: Steel pipe
Interval: 3.5' ags - 1.5' bgs

RISER CASING
Diameter: 2"
Type: PVC SCH 80
Interval: 3.16' ags - 10' bgs

GROUT
Type: None
Interval: None

SEAL
Type: Bentonite chips
Interval: 0 - 7' bgs

SANDPACK
Type: Silica 40-70
Interval: 7 - 30' bgs

SCREEN
Diameter: 2"; No.6 slot
Type: PVC SCH 80
Interval: 10 - 30' bgs

Date Boring Started:	8/17/15
Date Boring Completed:	8/17/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 13.22' TOR on 8/21/2015 (elev. 1675.92)

Additional data may have been collected in the field which is not included on this log.
Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING MW-105
DRAFT

Project:R.M. Haskett Station CCR Monitoring Network
Project No.:34300014.12
Location:Mandan, ND
Coordinates:Lat: 438042.079° Long: 1870325.657°
Datum:NAD 83

Surface Elevation:1686.0 ft
Drilling Method:HSA
Sampling Method:SPT
Completion Depth:30.0 ft

Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Blows/6in.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
25		13	15-25-31-40.				
				CL		FAT CLAY (CL): Dark Brown (3/4 7.5YR); high plasticity; sand lens at 26.5'; [Cannonball Formation]. At 26': Color change to Gray (5/1 7.5YR).	1660
		14	10-15-18-30.				
		15	11-16-22-32.				
30						End of boring 30.0 feet	
35							
40							
45							
50							

WELL OR PIEZOMETER CONSTRUCTION DETAIL

PRO. CASING
Diameter: **4"**
Type: **Steel pipe**
Interval: **3.5' ags - 1.5' bgs**

RISER CASING
Diameter: **2"**
Type: **PVC SCH 80**
Interval: **3.16' ags - 10' bgs**

GROUT
Type: **None**
Interval: **None**

SEAL
Type: **Bentonite chips**
Interval: **0 - 7' bgs**

SANDPACK
Type: **Silica 40-70**
Interval: **7 - 30' bgs**

SCREEN
Diameter: **2"; No.6 slot**
Type: **PVC SCH 80**
Interval: **10 - 30' bgs**

Date Boring Started:	8/17/15
Date Boring Completed:	8/17/15
Logged By:	JEG3
Drilling Contractor:	Terracon
Drill Rig:	Rig mounted HSA

Remarks: DTW = 13.22' TOR on 8/21/2015 (elev. 1675.92)

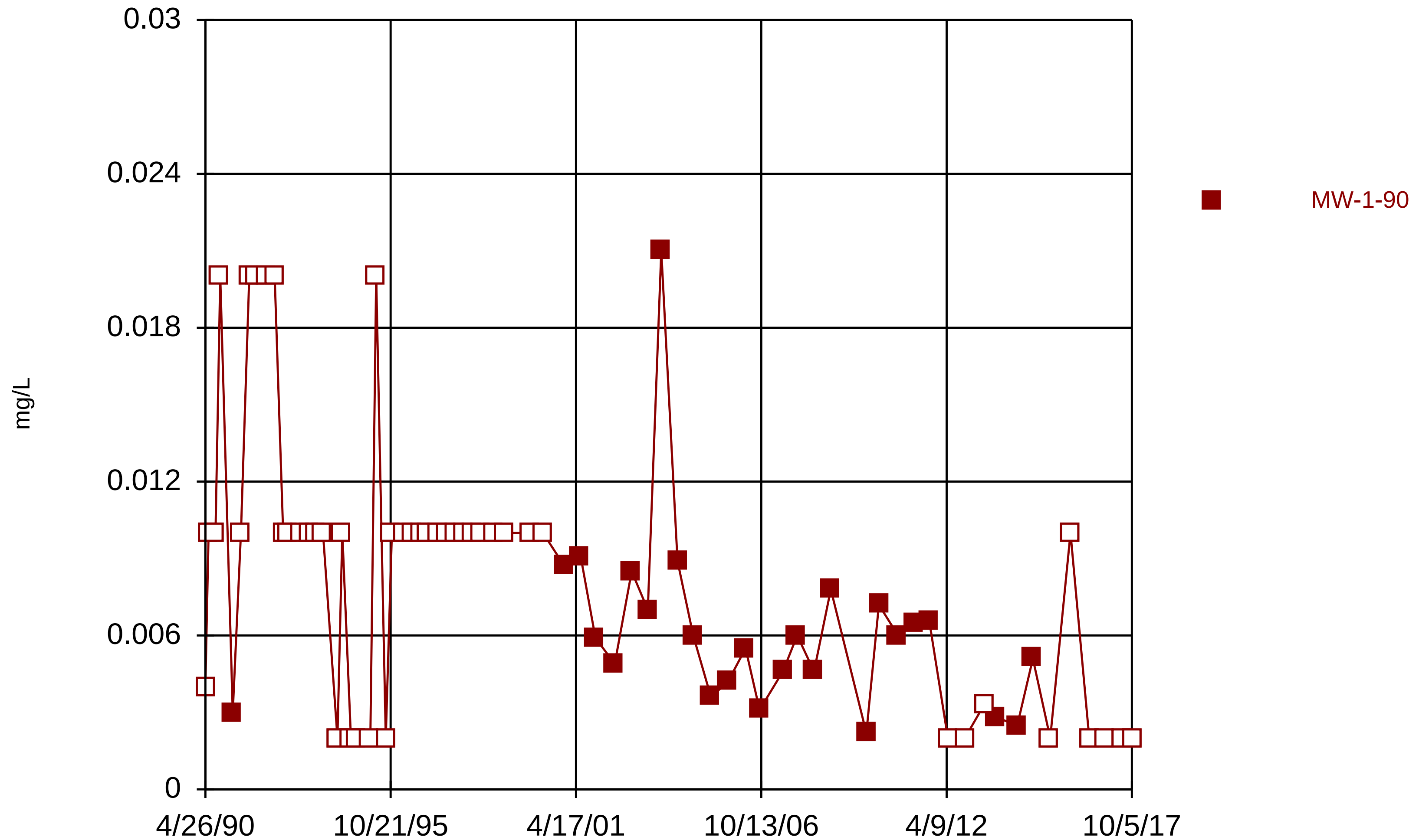
Additional data may have been collected in the field which is not included on this log.
Weather:

Appendix D

MW1-90 Time Series Plots

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG
Hollow symbols indicate censored values.

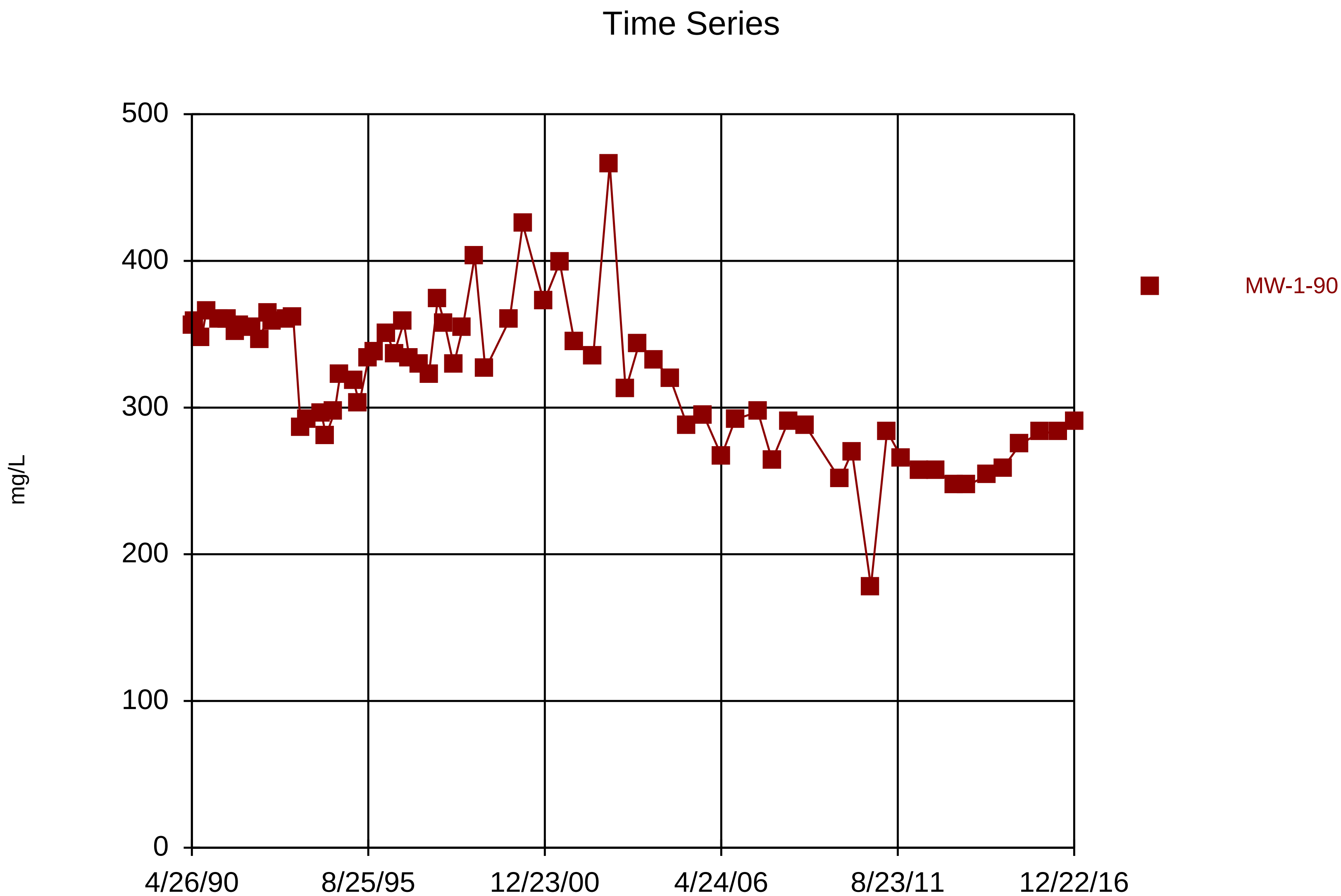
Time Series



Constituent: Arsenic   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

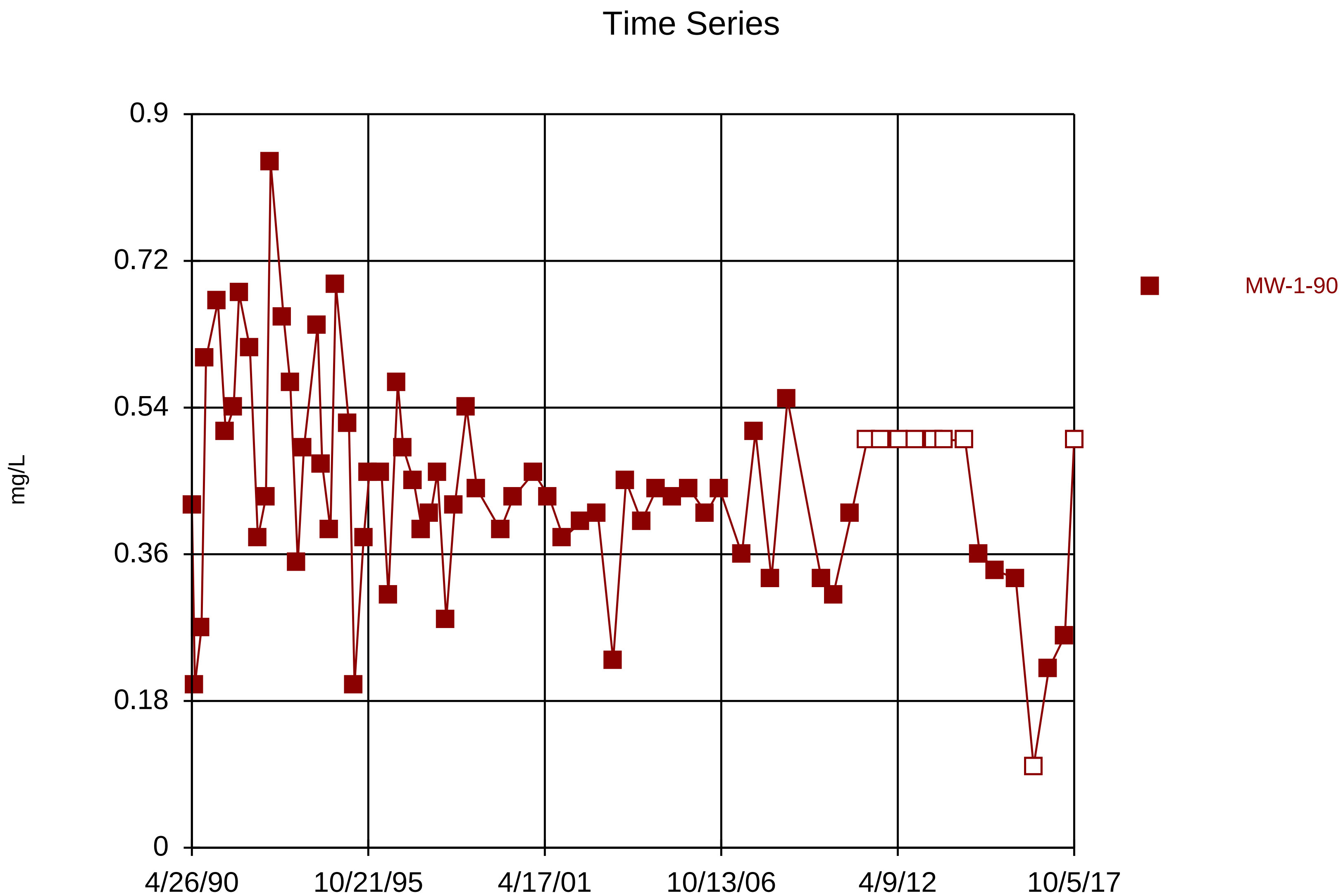
Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG



Constituent: Bicarbonate   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

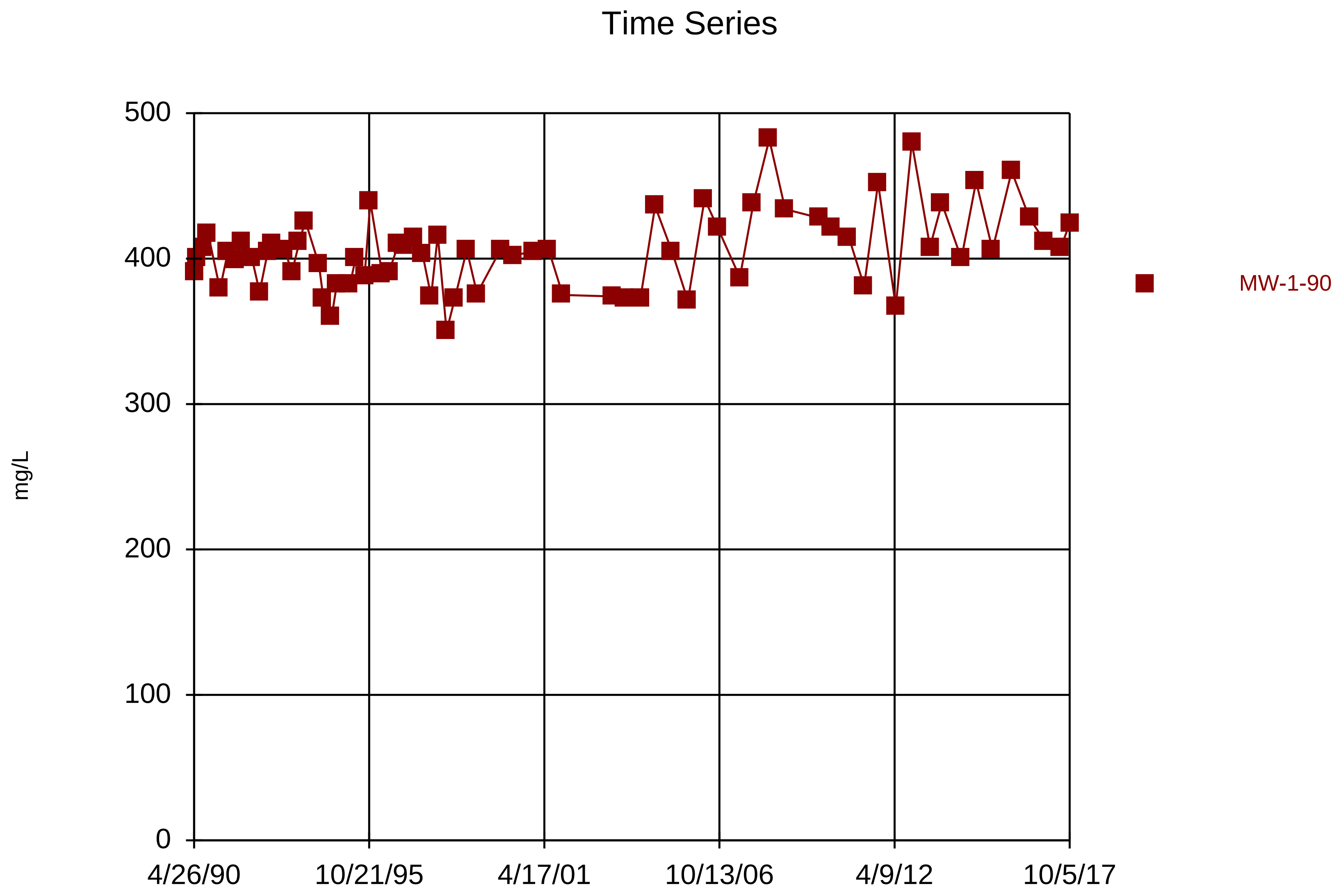
Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG
Hollow symbols indicate censored values.



Constituent: Boron Analysis Run 11/4/2019 3:17 PM

Heskett Station Client: Barr Engineering Company Data: MDUHeskett_AMR_HistoricalALL

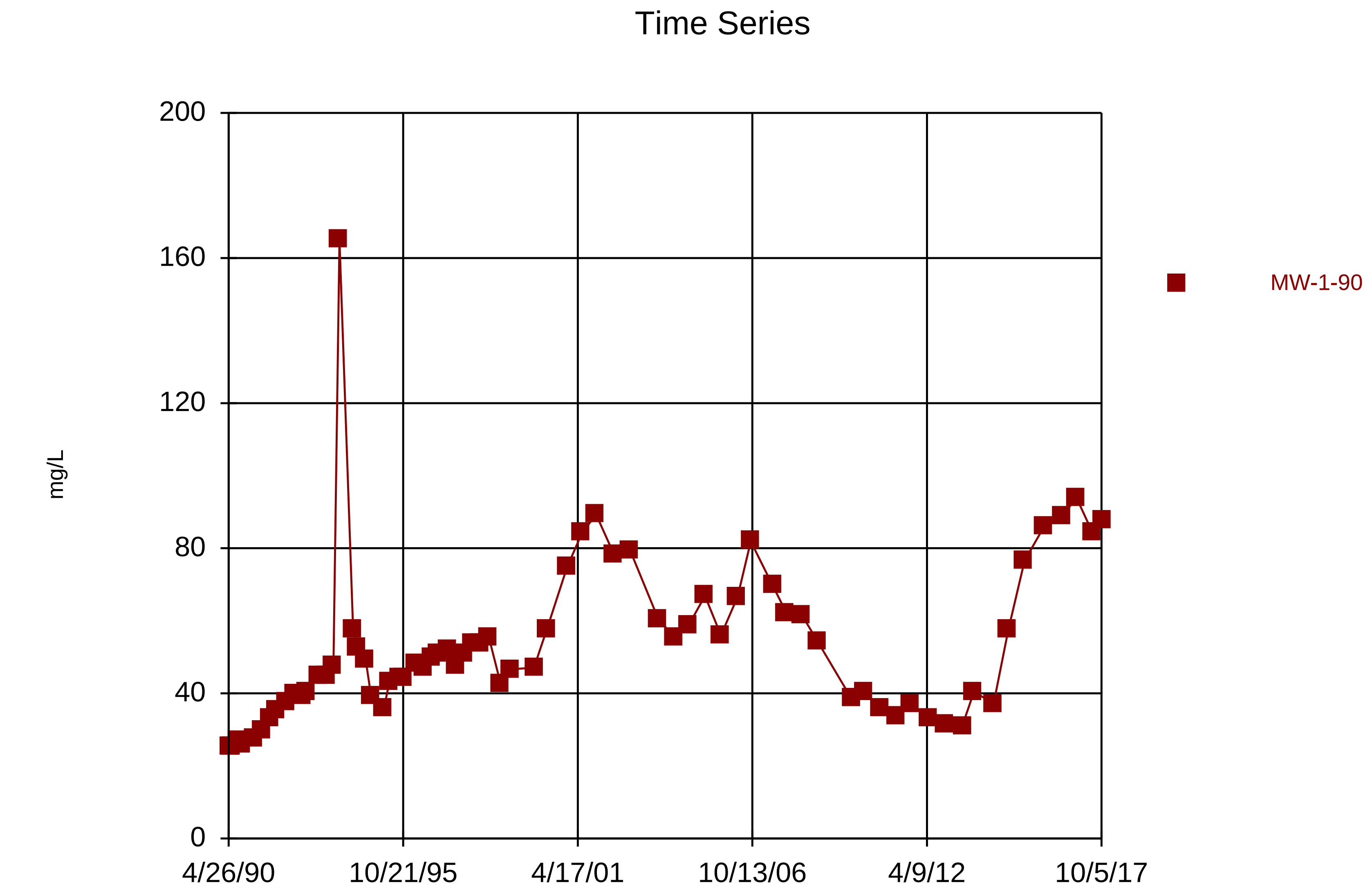
Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG



Constituent: Calcium   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

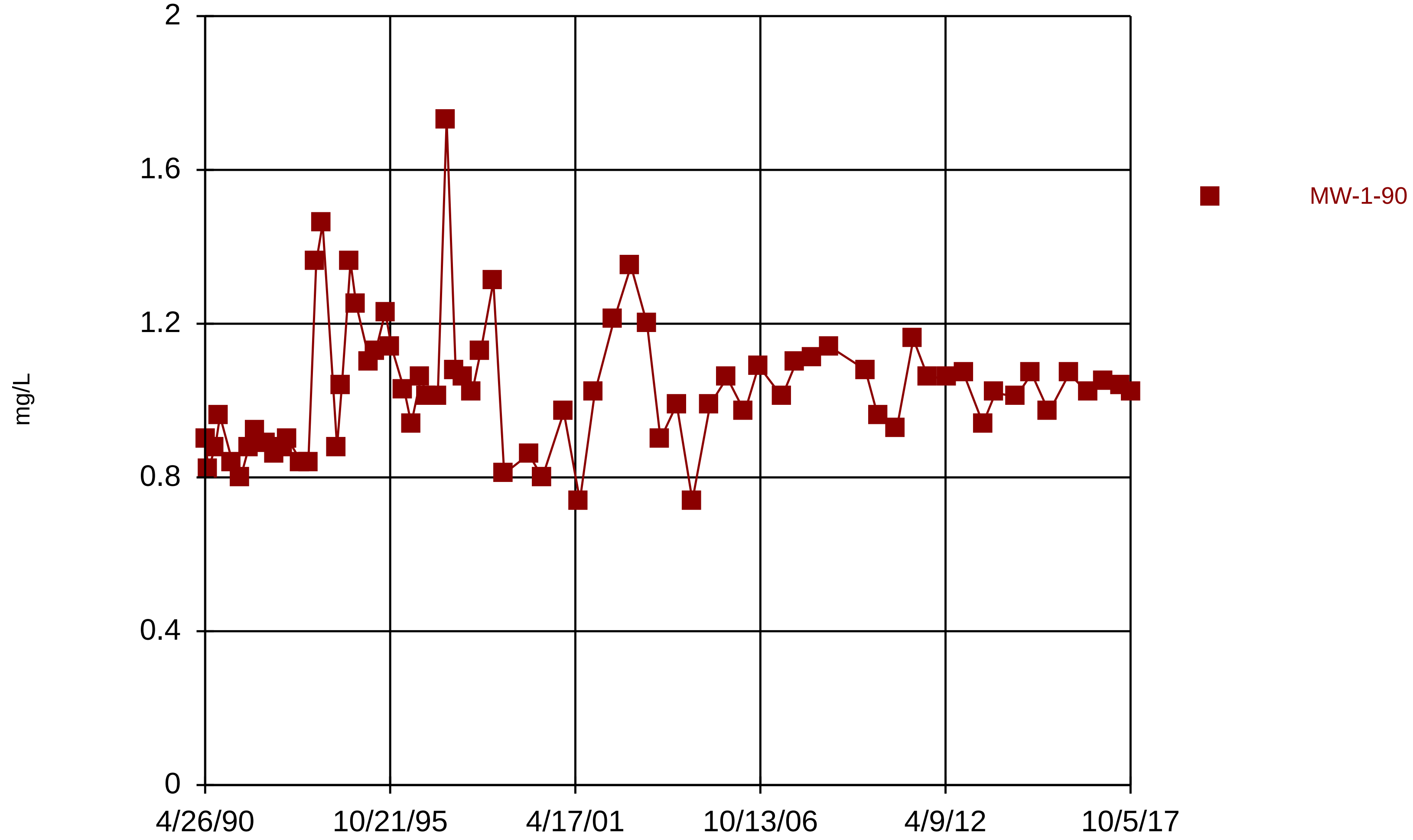


Constituent: Chloride   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

Time Series

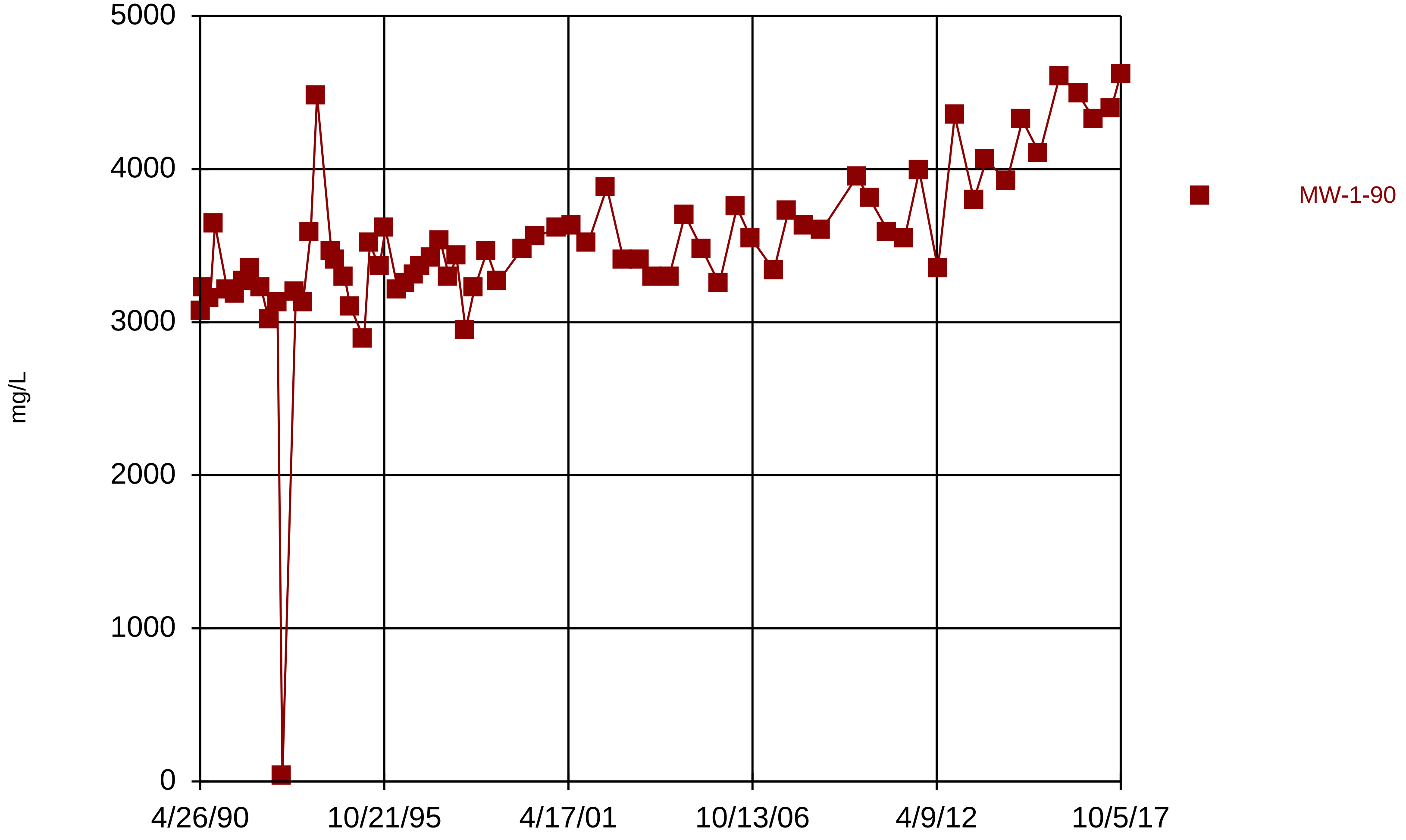


Constituent: Fluoride   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

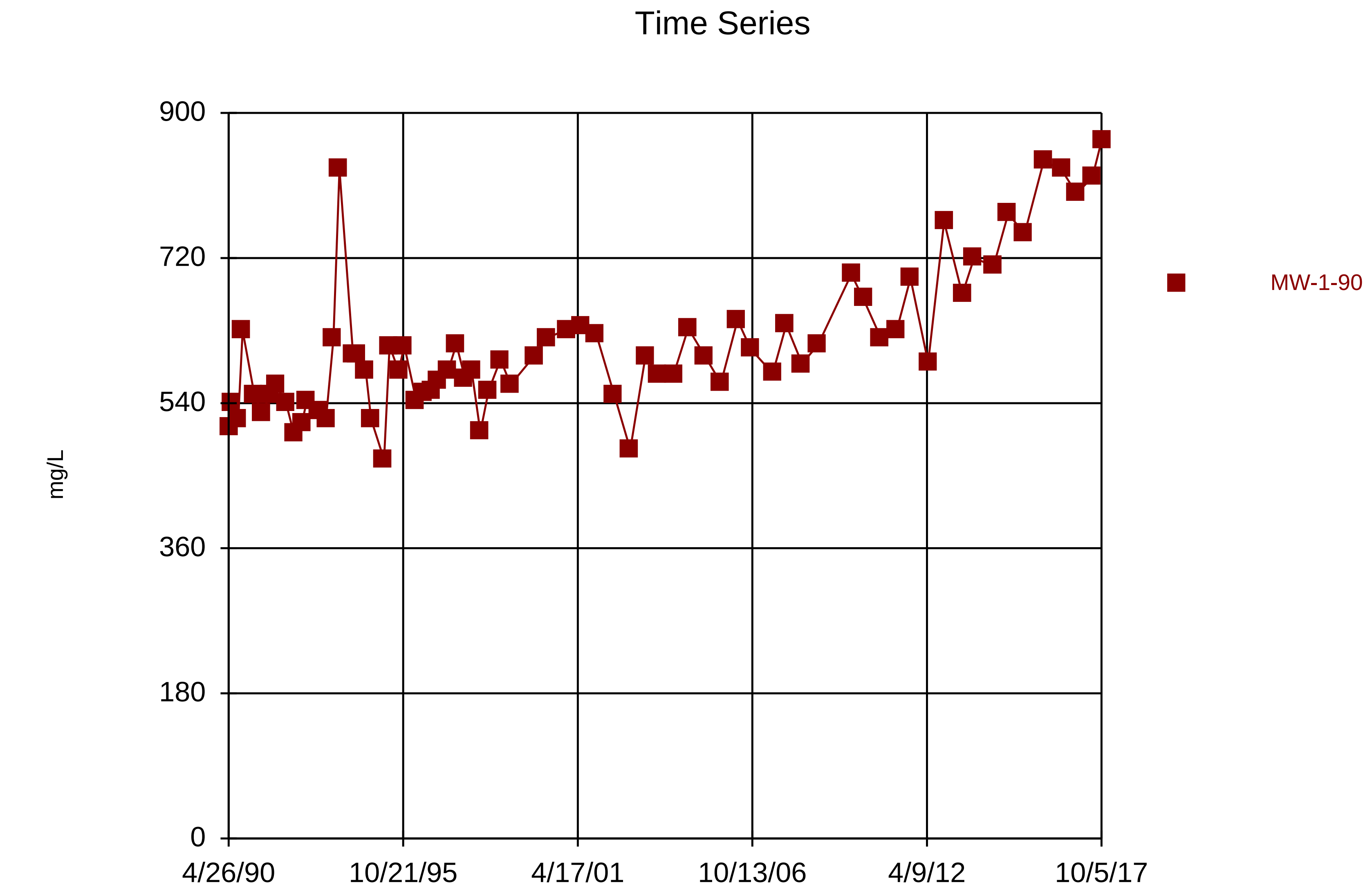
Time Series



Constituent: Hardness Analysis Run 11/4/2019 3:17 PM

Heskett Station Client: Barr Engineering Company Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG



Constituent: Magnesium   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

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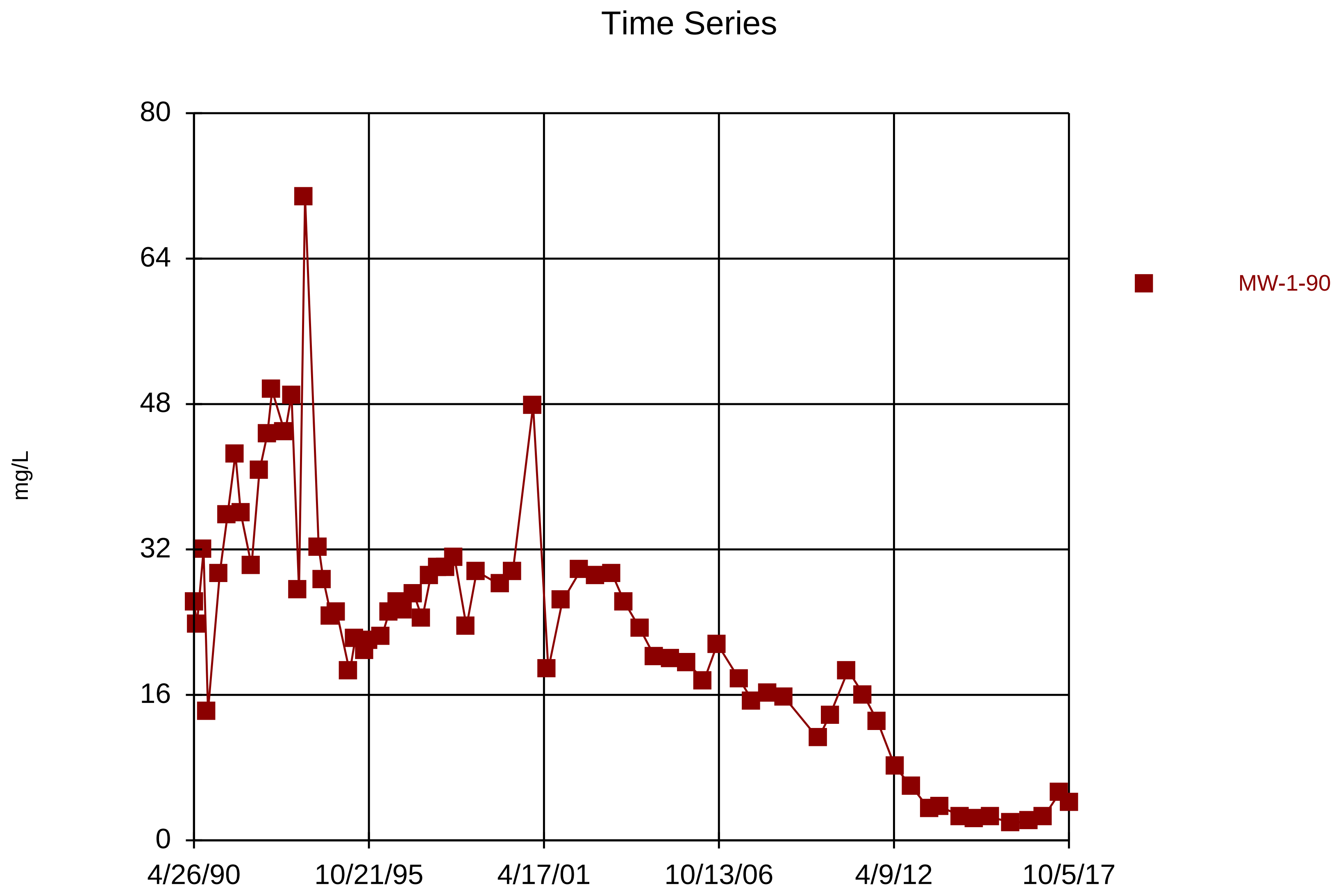

Constituent: Nitrogen   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

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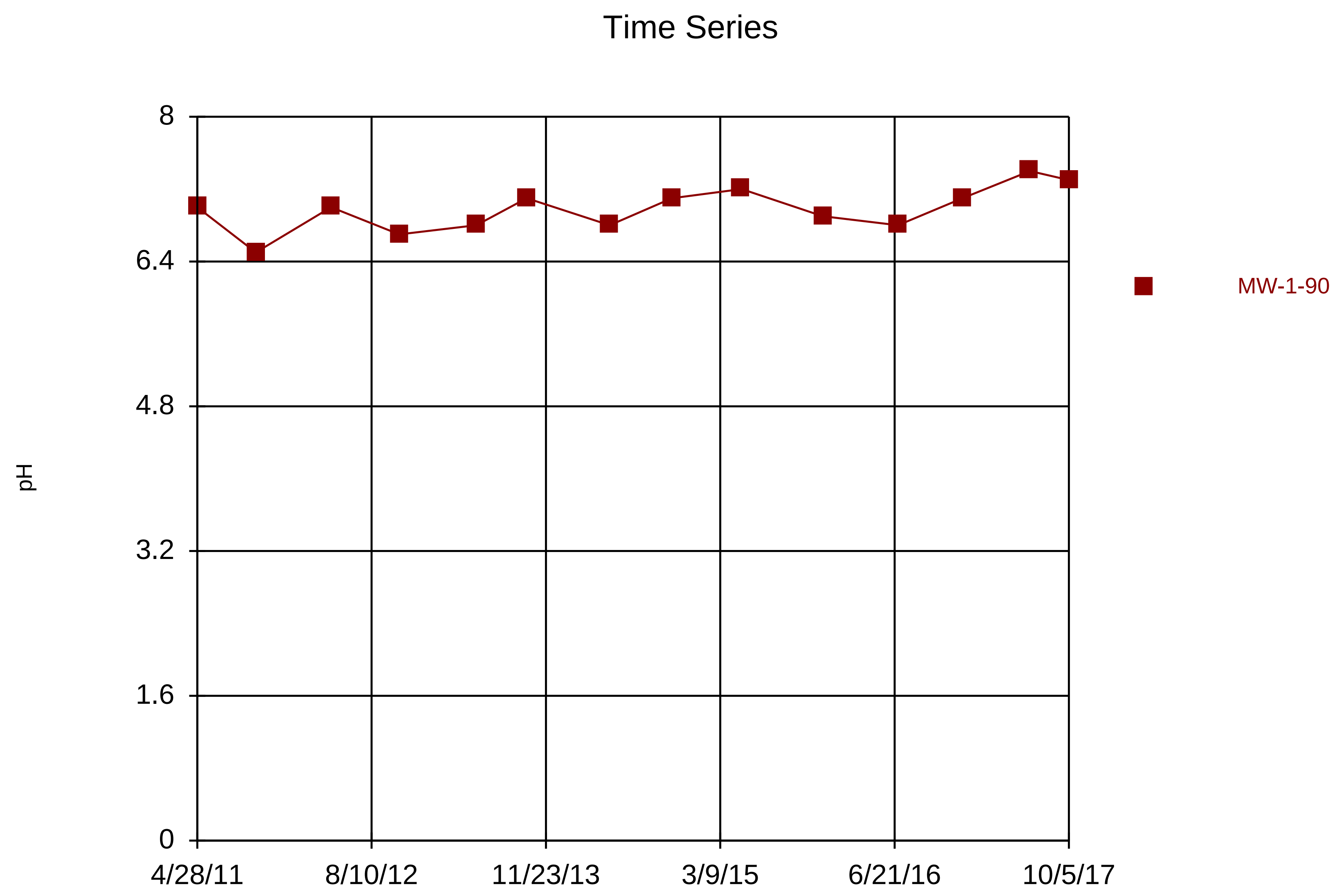

Constituent: pH   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

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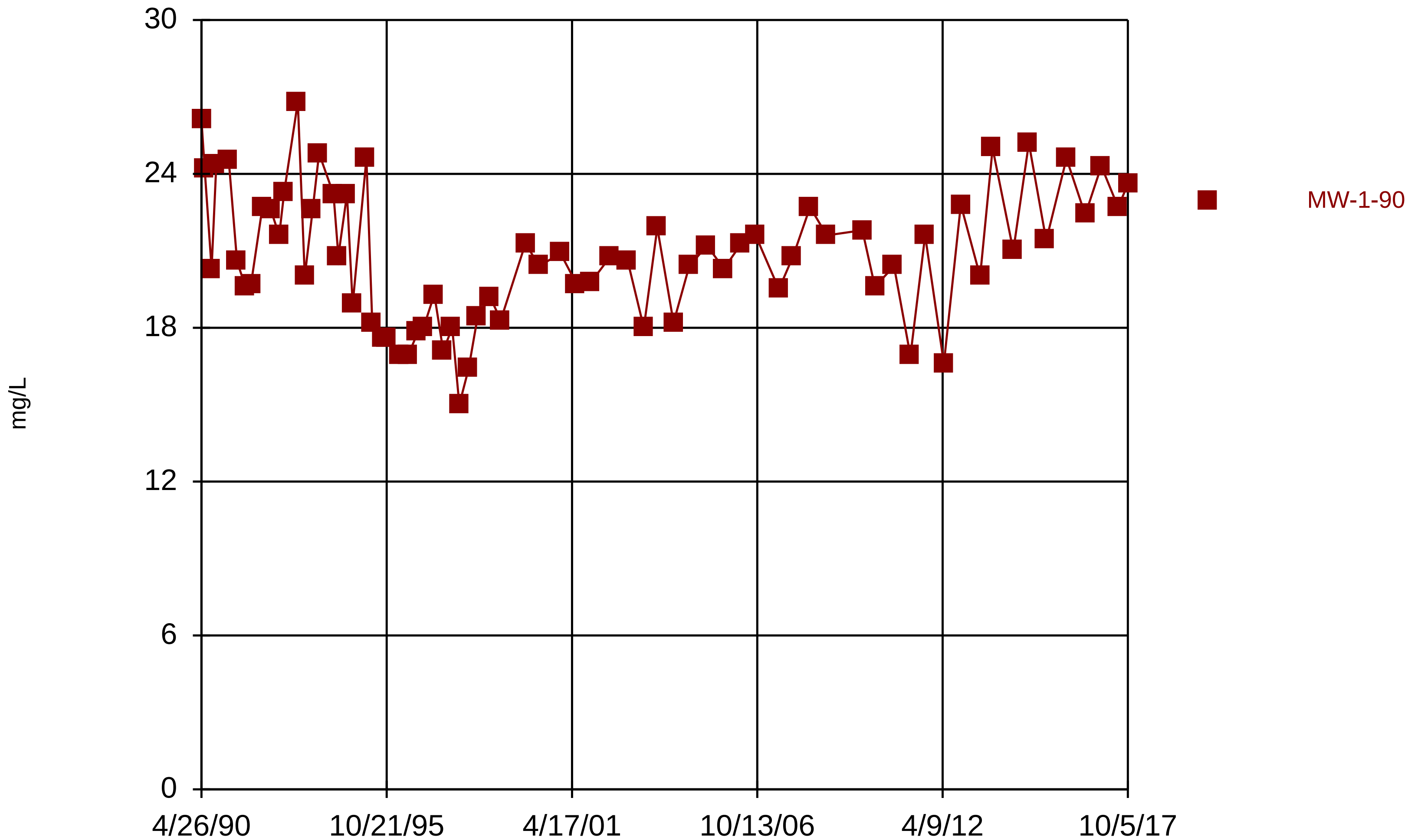
Time Series



Constituent: Potassium   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

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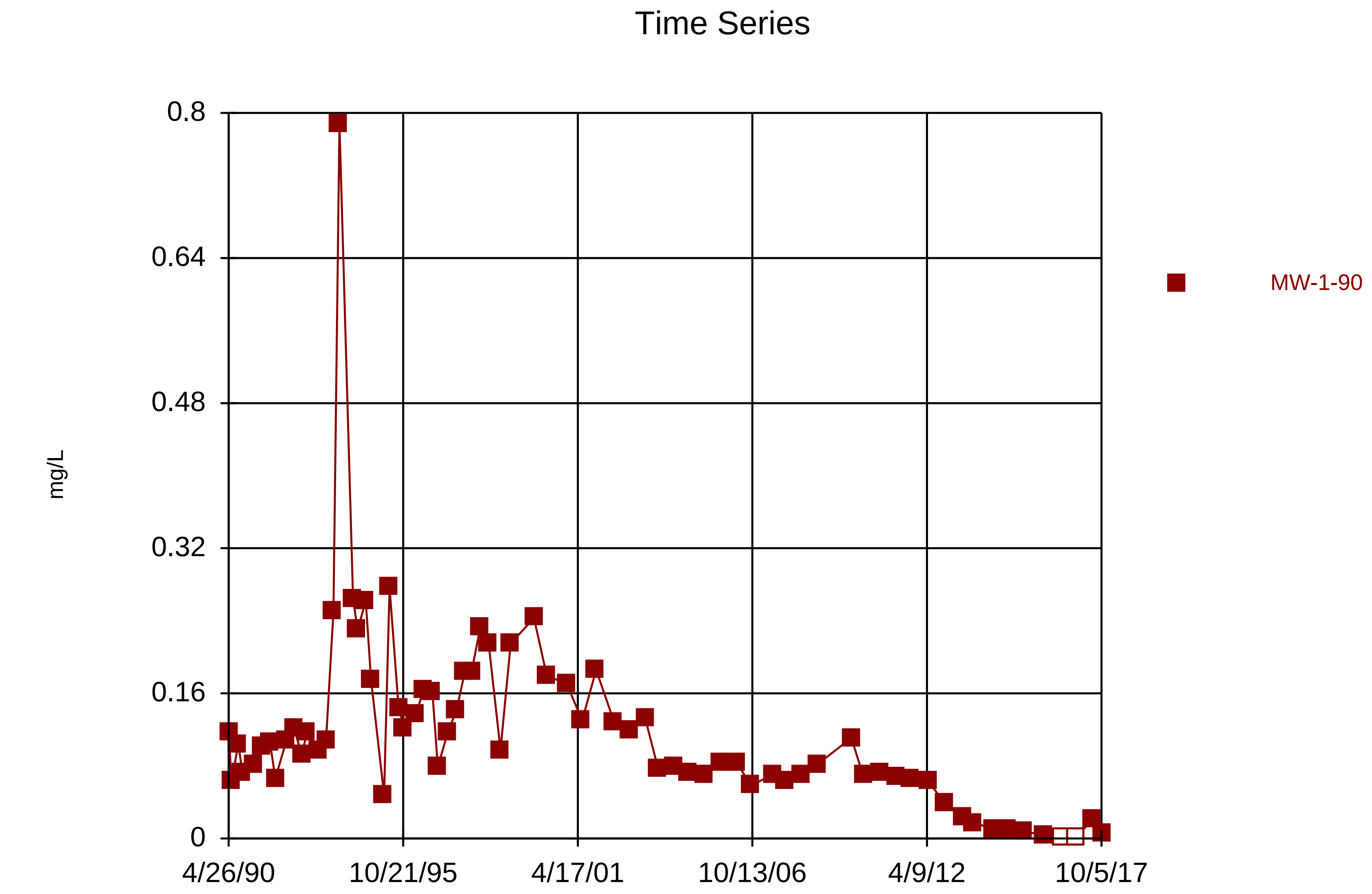
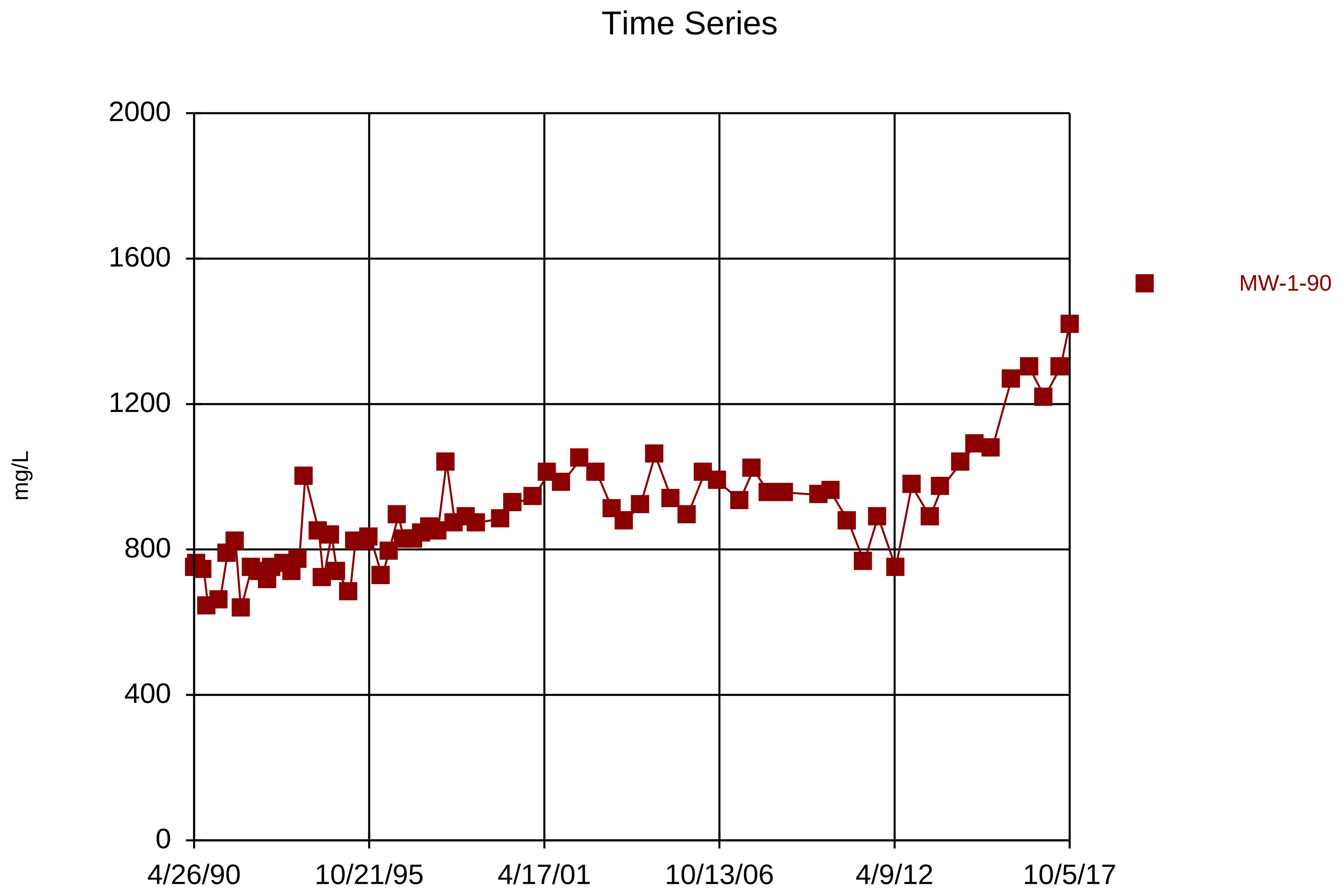
Hollow symbols indicate censored values.



Constituent: Selenium   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

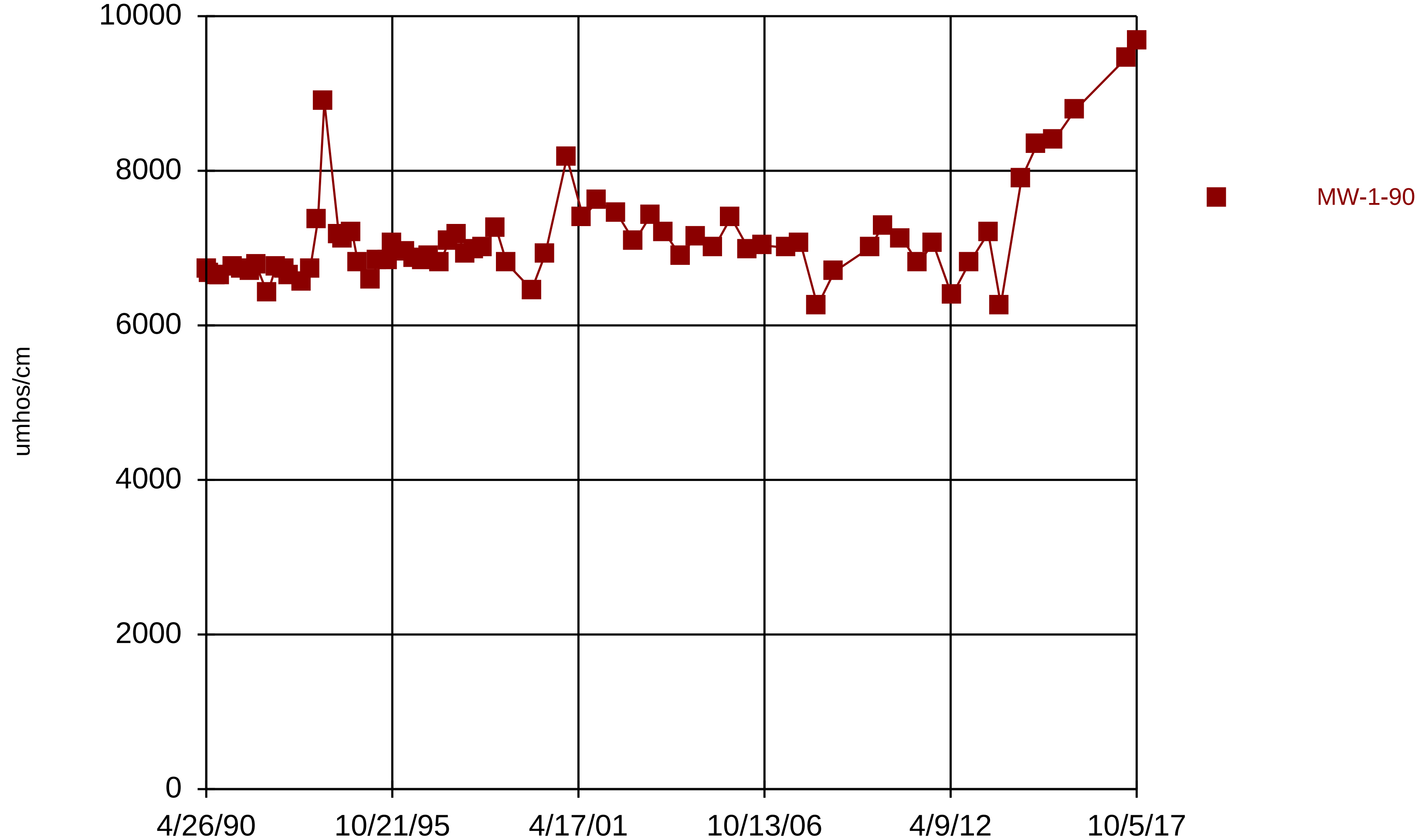


Constituent: Sodium   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

Time Series



Constituent: Specific conductivity   Analysis Run 11/4/2019 3:17 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

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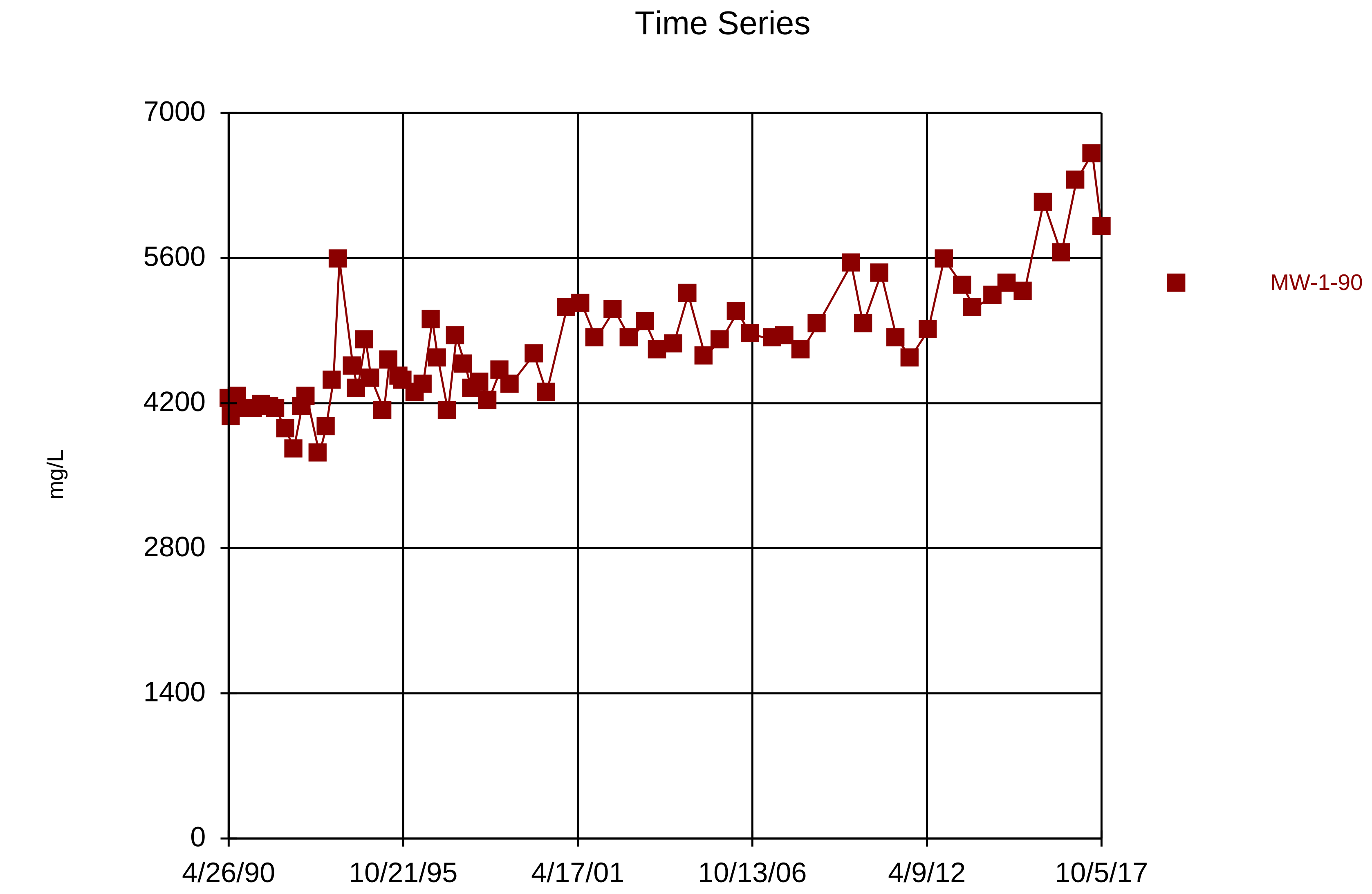
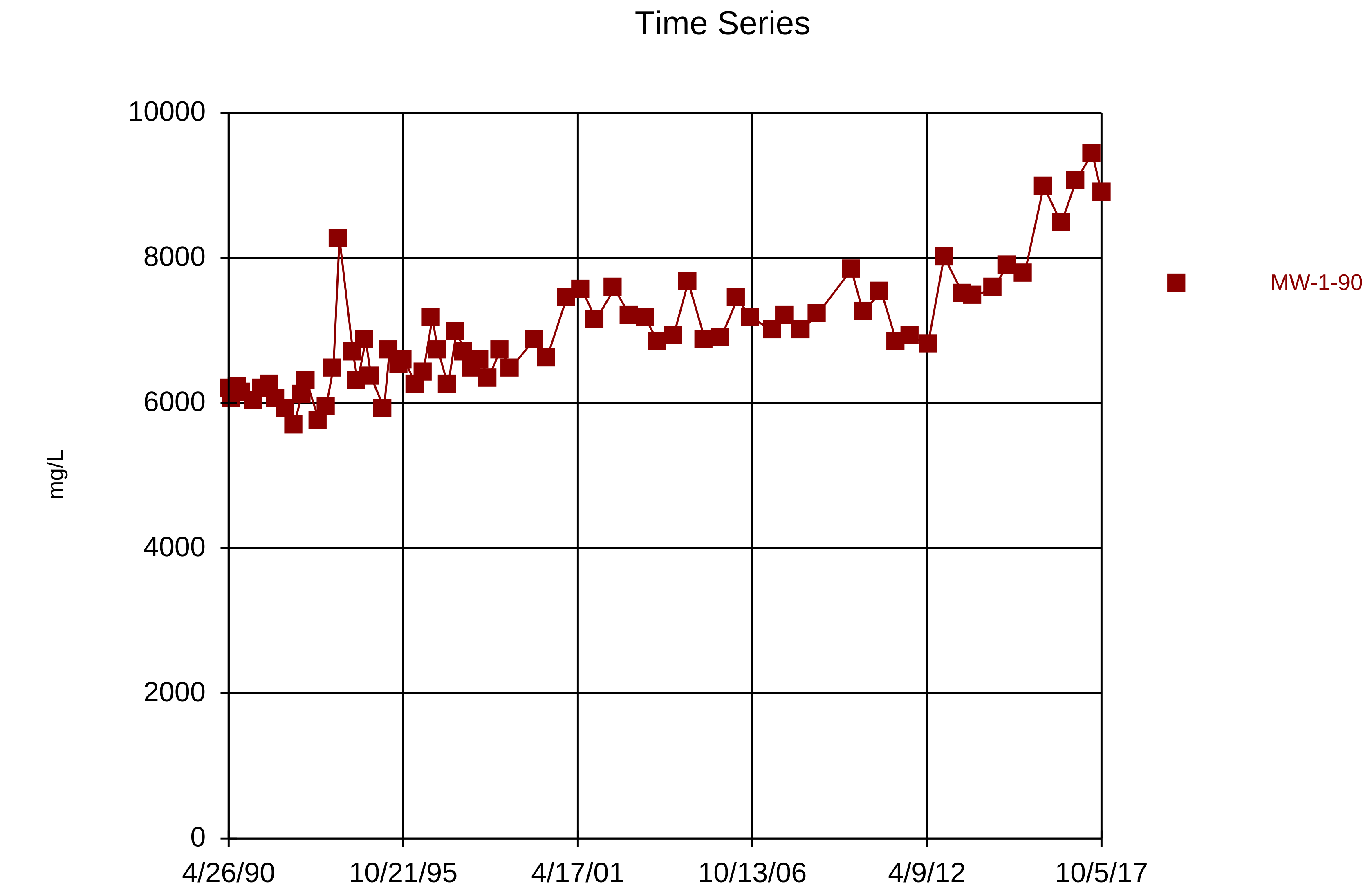


Constituent: Sulfate   Analysis Run 11/4/2019 3:18 PM

Heskett Station   Client: Barr Engineering Company   Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

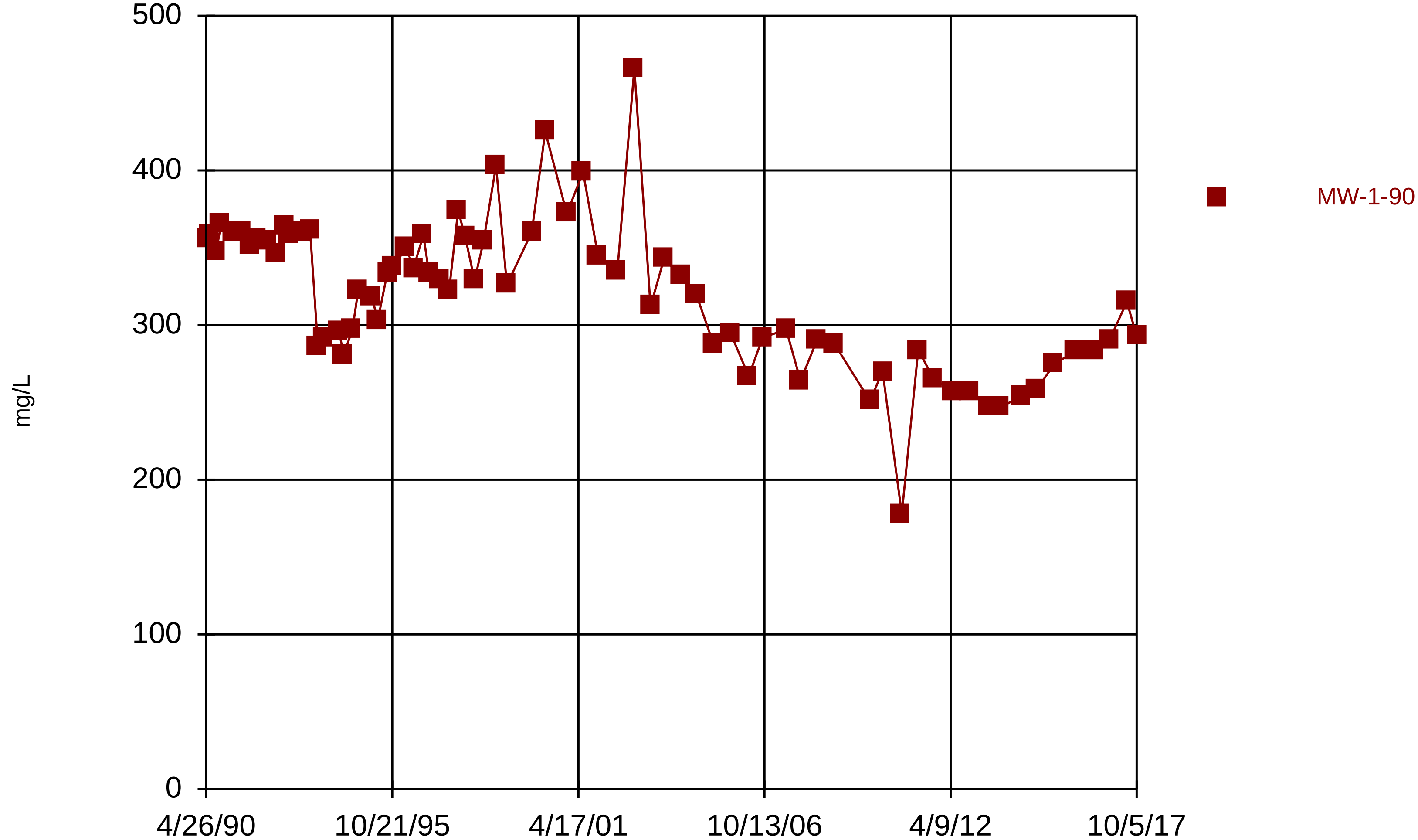


Constituent: TDS Analysis Run 11/4/2019 3:18 PM

Heskett Station Client: Barr Engineering Company Data: MDUHeskett_AMR_HistoricalALL

Sanitas™ v.9.6.23 For the statistical analyses of ground water by Barr Engineering Company only. UG

Time Series

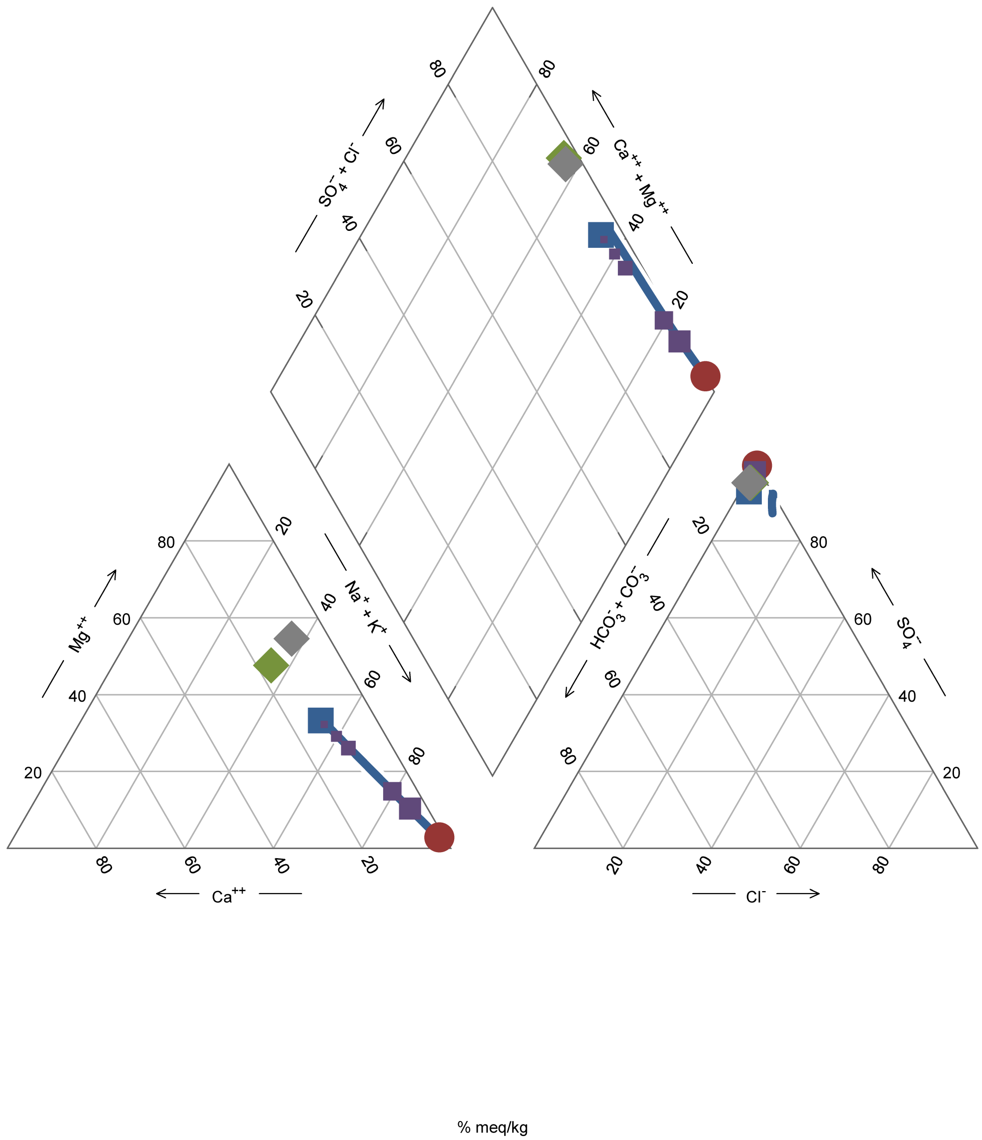


Constituent: Total alkalinity Analysis Run 11/4/2019 3:18 PM

Heskett Station Client: Barr Engineering Company Data: MDUHeskett_AMR_HistoricalALL

Appendix E

Geochemist's Workbench Results



- MW-13
- Evap Pond
- 1 part MW-13 : 1 part Evap Pond
- 1 part MW-13 : 0.50 part Evap Pond
- 1 part MW-13 : 0.10 part Evap Pond
- 1 part MW-13 : 0.05 part Evap Pond
- 1 part MW-13 : 0.01 part Evap Pond
- MW1-90
- MW104_2019

Figure E.1
Piper Plot for Mixing
Evaporation Pond into MW-13
R.M. Heskett Station
Alternative Source Demonstration
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

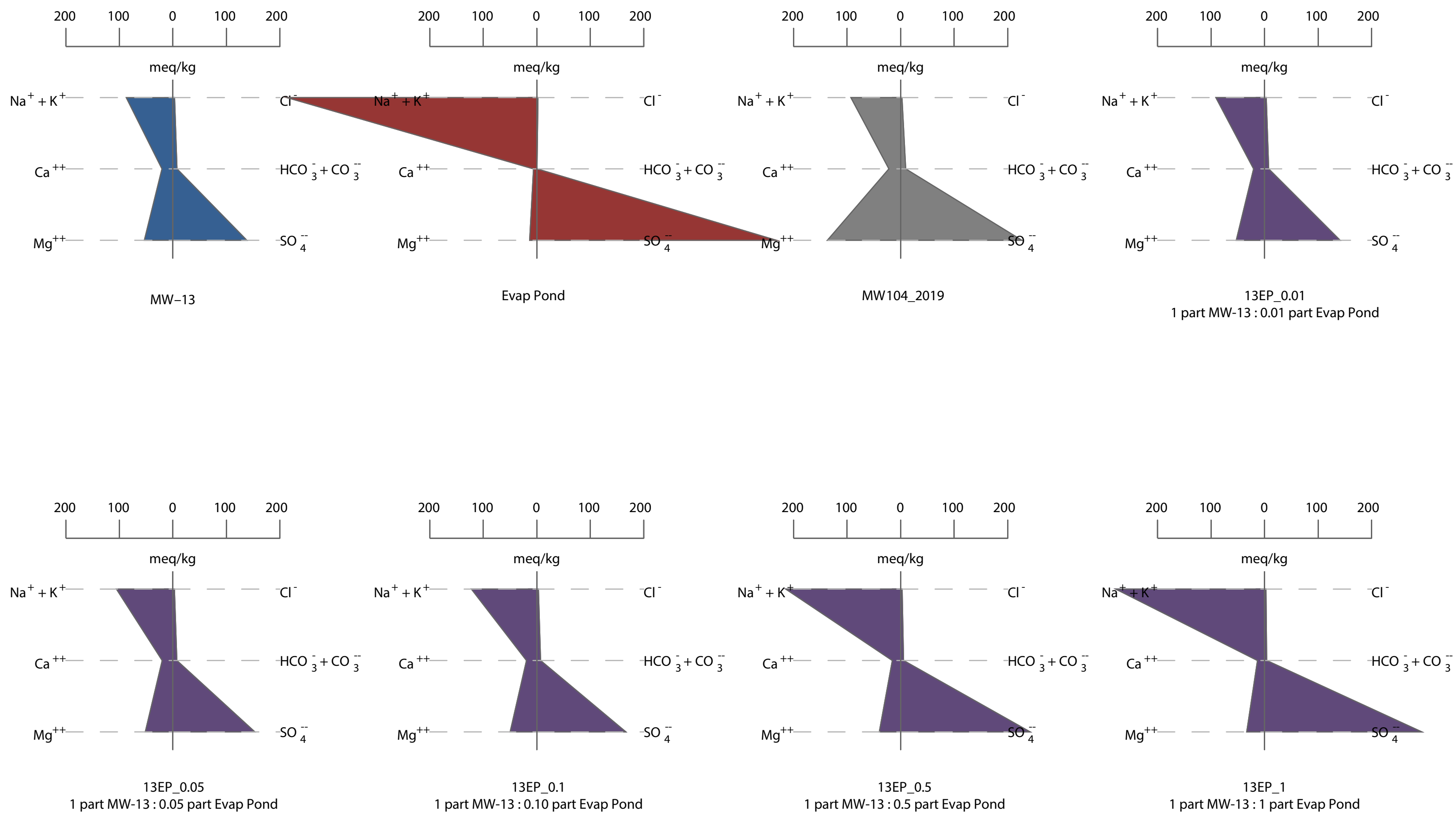
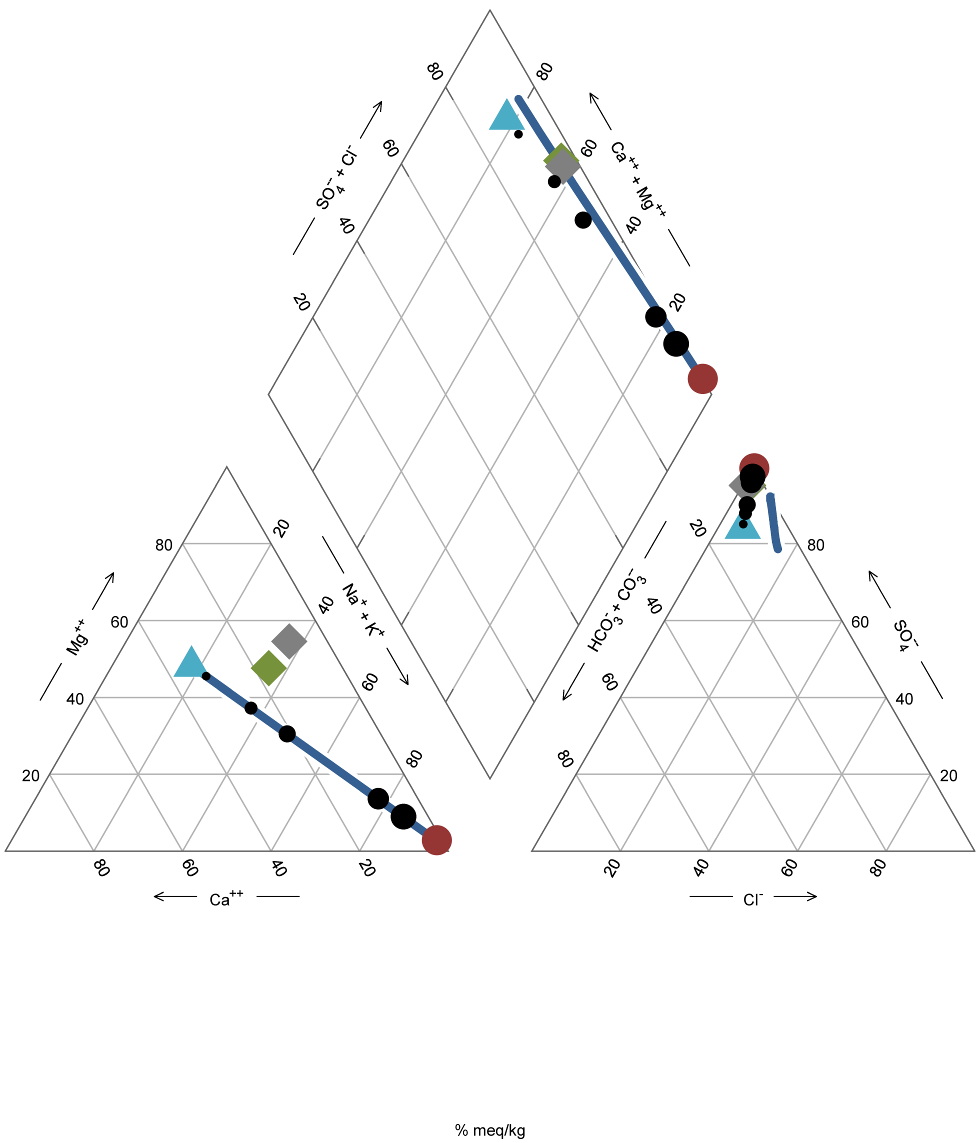


Figure E.2
Stiff Plot for Mixing
Evaporation Pond into MW-13
R.M. Heskett Station
Alternative Source Demonstration
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota



MW103_2019
Evap Pond
1 part MW-103 : 1 part Evap Pond
1 part MW-103 : 0.50 part Evap Pond
1 part MW-103 : 0.10 part Evap Pond
1 part MW-103 : 0.05 part Evap Pond
1 part MW-103 : 0.01 part Evap Pond
MW1-90
MW104_2019

Figure E.3
Piper Plot for Mixing
Evaporation Pond into MW-103
R.M. Heskett Station
Alternative Source Demonstration
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

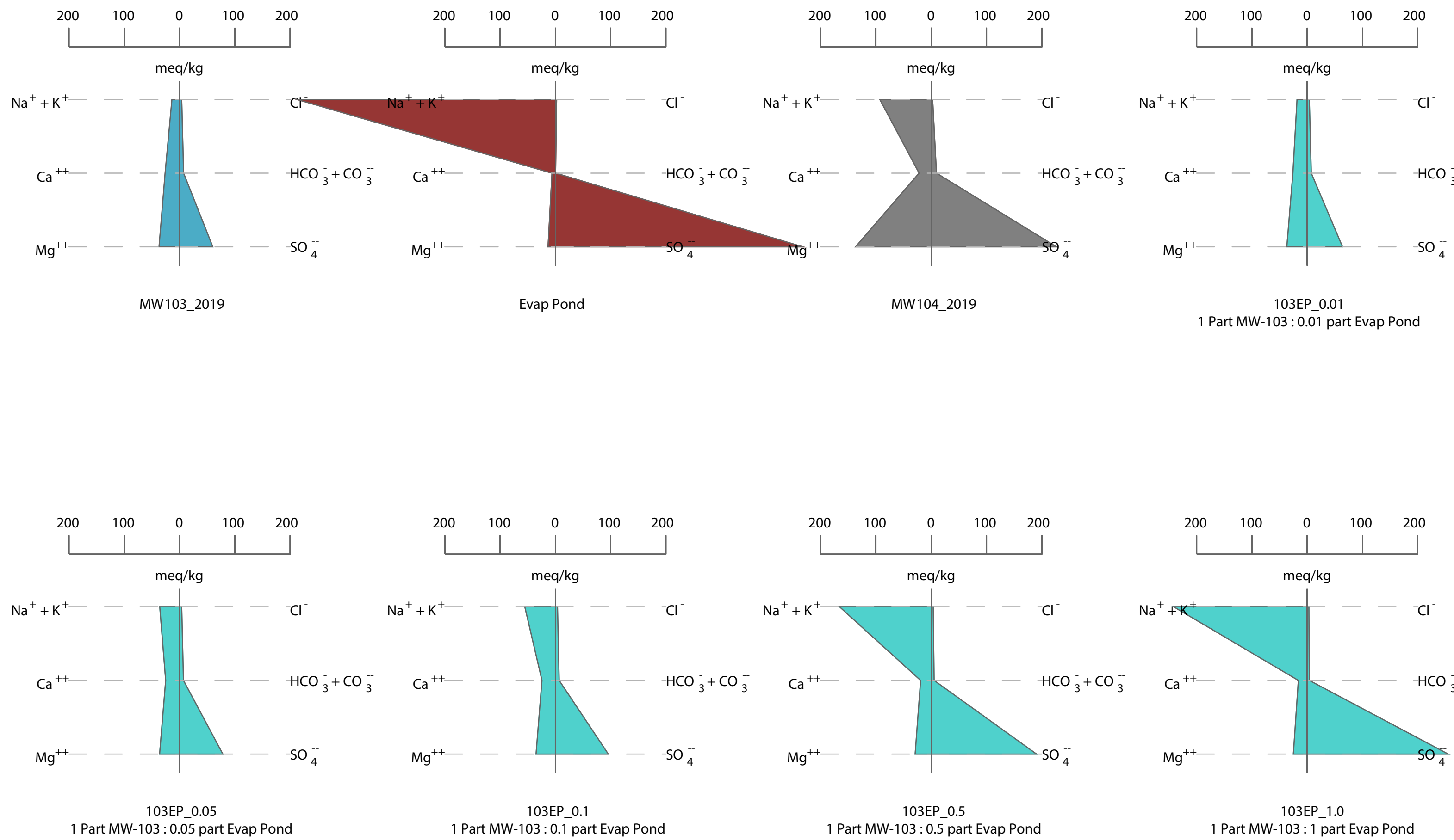


Figure E.4
Stiff Plot for Mixing
Evaporation Pond into MW-103
R.M. Heskett Station
Alternative Source Demonstration
April 2019 Event
Montana Dakota Utilities
Mandan, North Dakota

Table E.1
Geochemist's Workbench Mixing Model Results

Description		Upgradient Wells		Evap Pond	Mixing Ratio MW-13 : Evaporation Pond					Mixing Ratio MW-103 : Evaporation Pond					Downgradient Wells	
Sample ID		MW-13	MW103	Evap Pond	1 : 0.01	1 : 0.05	1 : 0.1	1 : 0.5	1 : 1	1 : 0.01	1 : 0.05	1 : 0.1	1 : 0.5	1 : 1	MW1-90	MW-104
HCO3-	mg/l	482	457	20	477.4	460	440	328	251	452.7	436.2	417.3	311.3	238.5	259	591
Ca++	mg/l	418	530	125	415.1	404	391.4	320.3	271.5	526	510.7	493.2	395	327.5	453	448
Cl-	mg/l	109	142	79.8	108.7	107.6	106.3	99.28	94.42	141.4	139	136.3	121.3	110.9	57.4	87.6
F-	mg/l	0.73	0.15	0.1	0.7237	0.7	0.6727	0.52	0.415	0.1495	0.1476	0.1455	0.1334	0.125	1.07	0.55
Mg++	mg/l	660	458	165	655.1	636.4	615	495	412.5	455.1	444.1	431.4	360.4	311.5	775	1700
pH	SU	7.1	6.5	10.7	7.106	7.133	7.17	7.62	8.435	6.502	6.511	6.523	6.643	6.854	7.1	6.8
K+	mg/l	29.4	18.8	734	36.38	62.97	93.48	264.4	381.9	25.88	52.87	83.85	257.3	376.6	25.2	37
Na+	mg/l	2020	311	10600	2105	2429	2800	4882	6312	412.9	801.2	1247	3742	5458	1090	2160
SO4--	mg/l	6750	2930	22100	6902	7481	8146	11869.8	14429.8	3120	3843	4674	9323	12520	5350	11100
TDS	mg/kg	10300	4860	34000	10537.2	11440.3	12476	18257.4	22214.5	5152	6265	7541	14660.2	19527.5	7910	17700