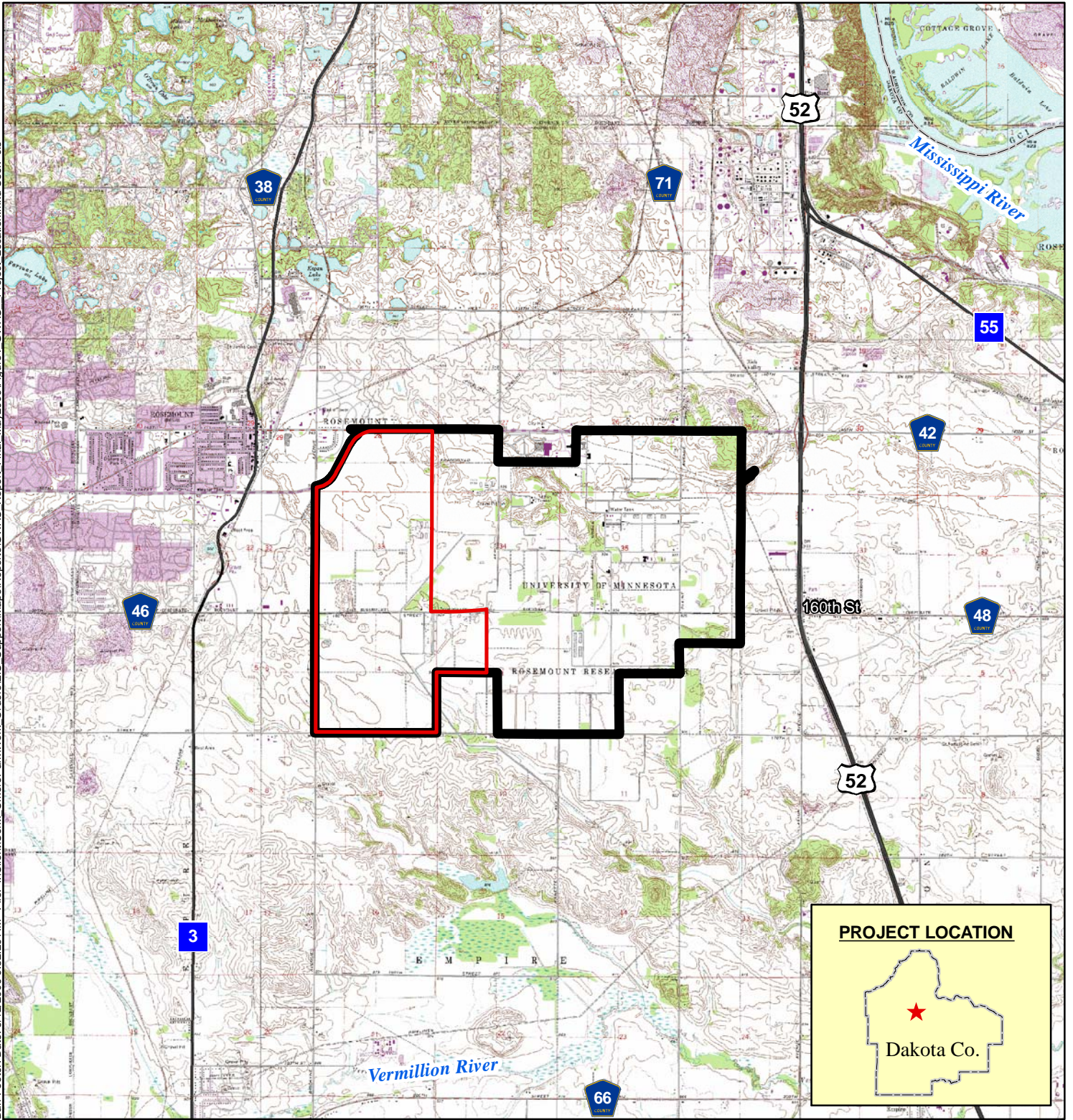


Figures



- UMore Mining Area (UMA)
- UMore Park Boundary

Figure 1

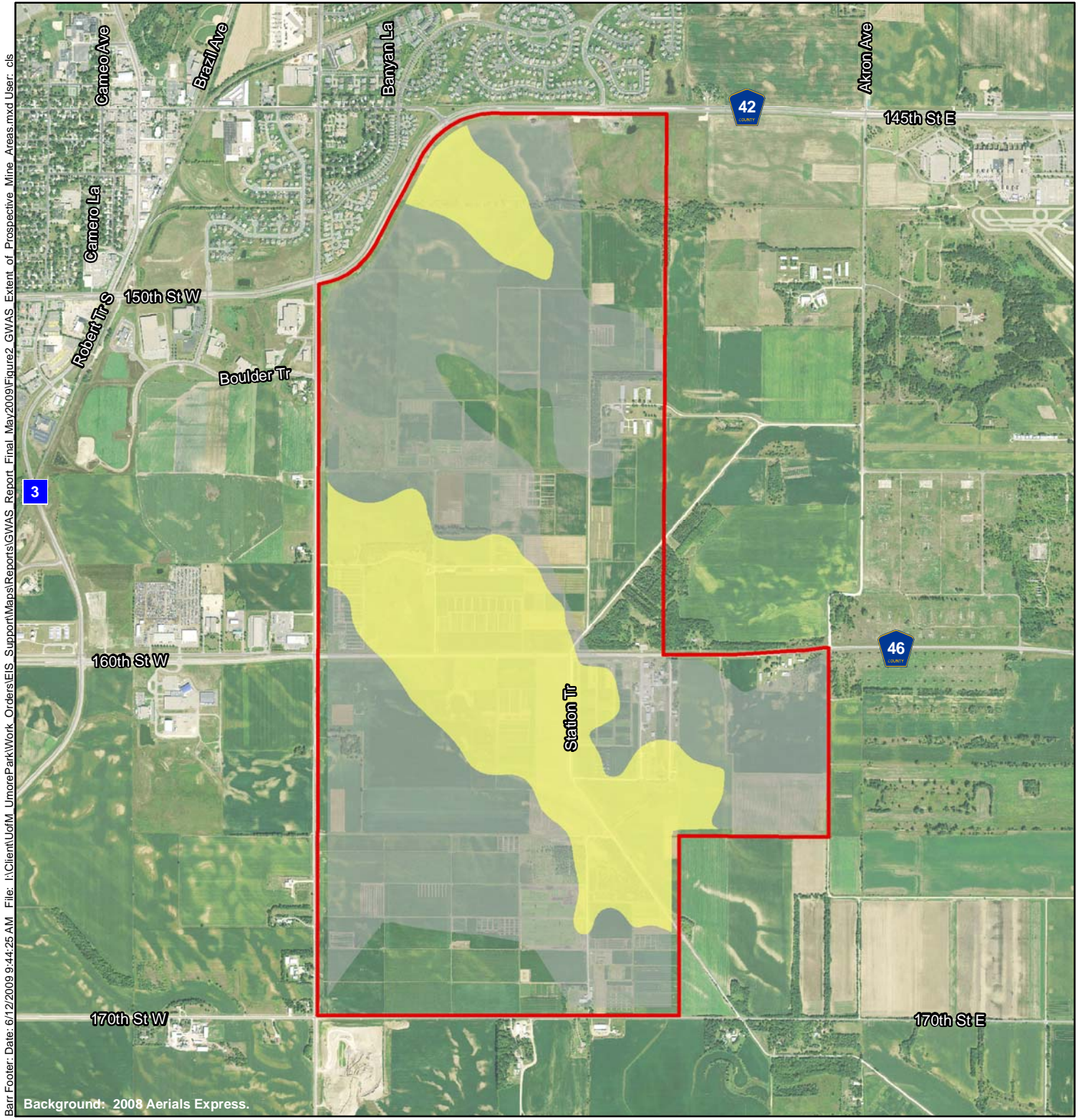
UMORE PARK AND
UMA LOCATION

Groundwater Assessment Report
Umore Mining Area
Dakota County, MN



Source: MnDOT, MN DNR, Dakota County, Barr, SEH, HKGI.
USGS topographic map background downloaded from the U.S.
Department of Agriculture, Natural Resources Conservation Service.





Barr Footer: Date: 6/12/2009 9:44:25 AM File: I:\Client\UofM_UmorePark\Work_Orders\EIS_Support\Maps\Reports\GWAS_Report_Final_May2009\Figure2_GWAS_Extent_of_Prospective_Mine_Areas.mxd User: ds

- UMore Mining Area (UMA)
- Economic Gravel Deposit Below the Water Table (Approximate)
- Gravel Deposit Areas (ProSource, 2008)

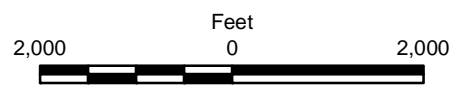
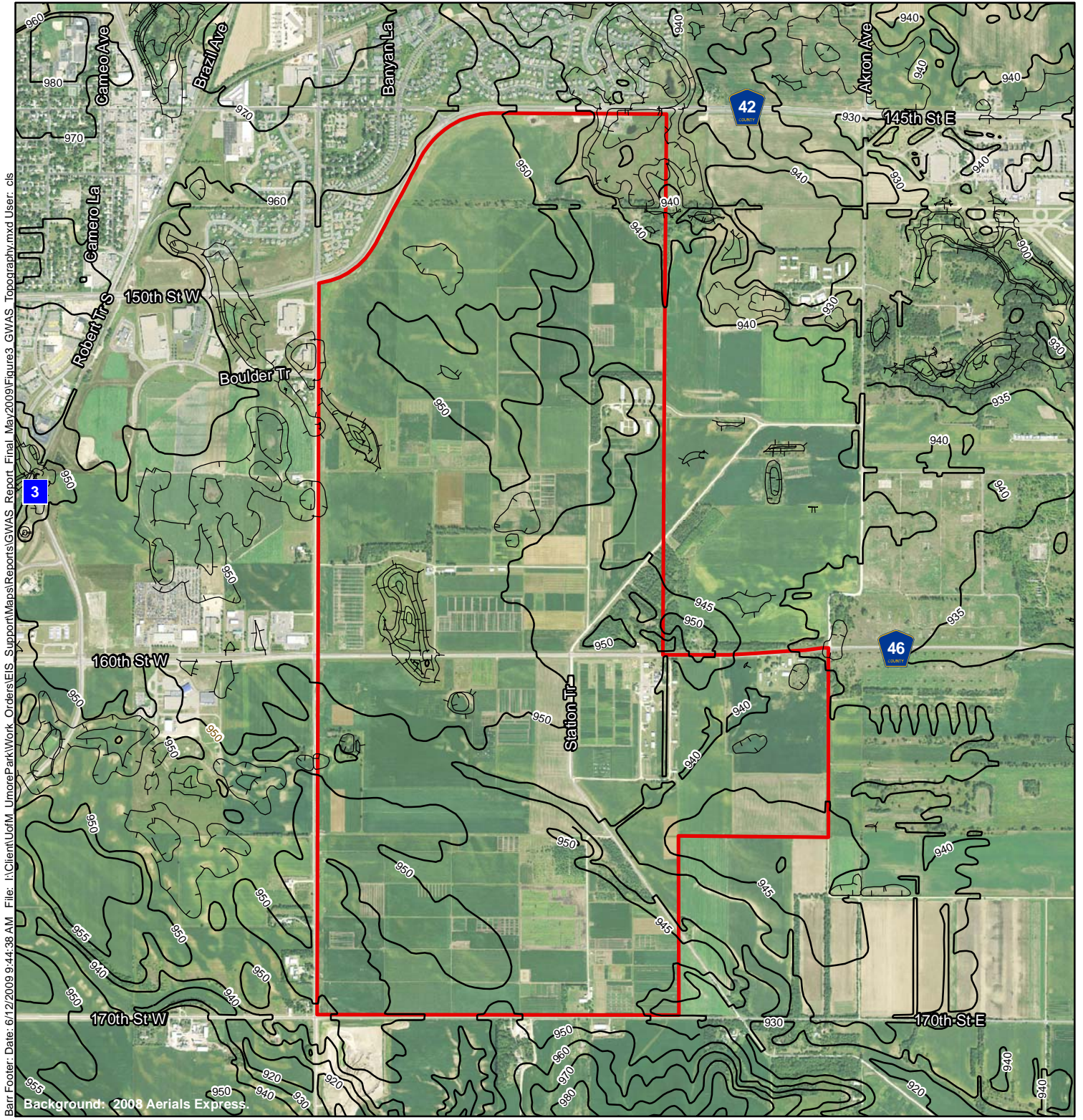


Figure 2

EXTENT OF PROSPECTIVE MINE AREAS

Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN





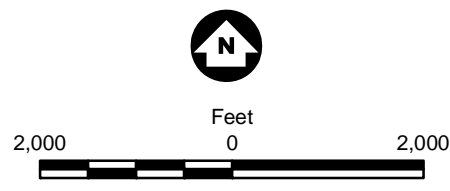
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- UMore Mining Area (UMA)
- Ground Surface Contour
- Depressional Ground Surface Contour

Figure 3

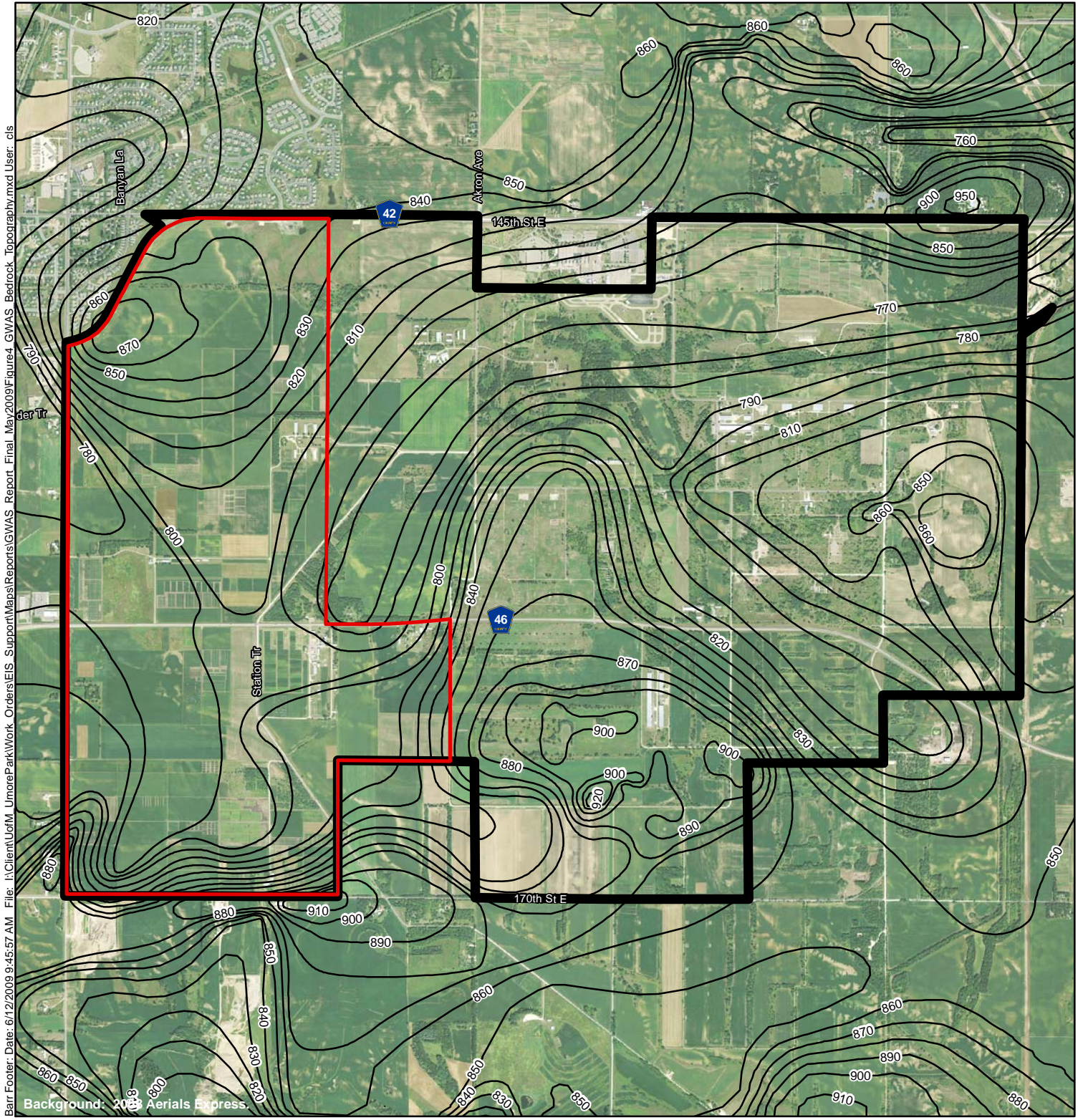
TOPOGRAPHY IN THE UMA

Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Source: Metropolitan Council, MnDOT, MN DNR, Dakota County, USGS, Barr, SEH.





Barr Footer: Date: 6/12/2009 9:45:57 AM File: I:\Client\UofM_UmorePark\Work_Orders\EIS_Support\Maps\Reports\GWAS_Report_Final_May2009\Figure4_GWAS_Bedrock_Topography.mxd User: cls

- UMore Mining Area (UMA)
- UMore Park Boundary
- Bedrock Contour

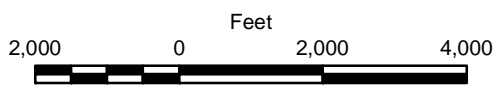


Figure 4

LOCAL BEDROCK TOPOGRAPHY

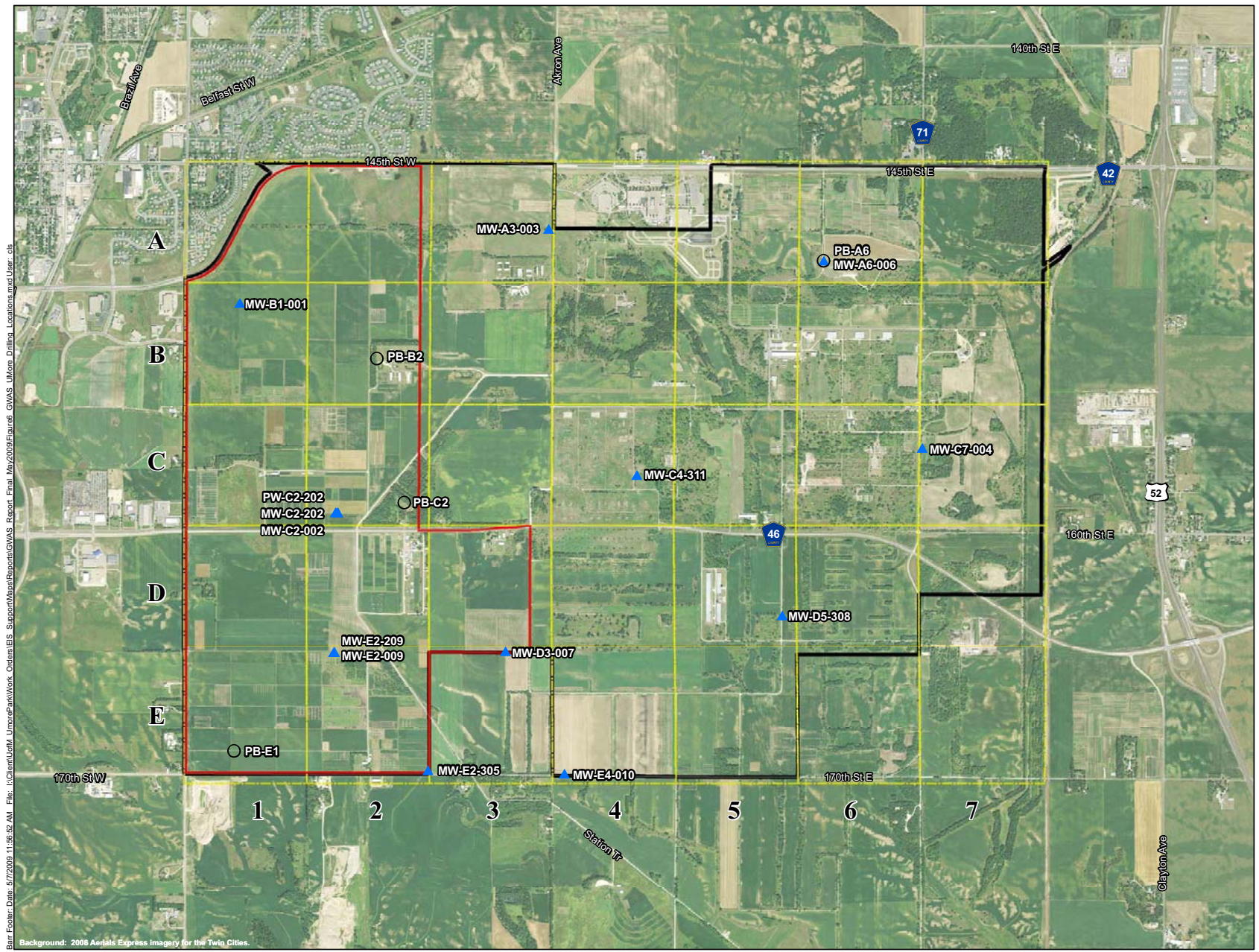
Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Formation Name and Graphic	Description	Site Nomenclature	Hydrogeologic Role
Unconsolidated Glacial Deposits	Unconsolidated sand and gravel containing fine grained diamicton and lacustrine deposits.	Outwash (sand & gravel deposit) Diamicton or Till Lacustrine - Lake bed silts & clays	Surficial Aquifer Leaky Confining Unit Leaky Confining Unit
St. Peter	Fine to medium grained sandstone	St. Peter Formation Sandstone	Aquifer (where saturated)
Shakopee and Oneota	Thin to medium-bedded crystalline dolomite	Prairie Du Chien Group	Aquifer
Jordan	Fine to coarse sandstone	Jordan Formation Sandstone	Aquifer
St. Lawrence	Dolomitic shale and siltstone	St. Lawrence Formation	Regional Confining Unit

Figure 5

GENERALIZED STRATIGRAPHIC COLUMN
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota



- ▲ Monitoring Well Location
 - Pilot Boring Location
 - ▭ UMore Mining Area (UMA)
 - ▭ UMore Park Boundary
 - ▭ Site Location Grid
- Source: MnDOT, Barr, SEH, HKGI.

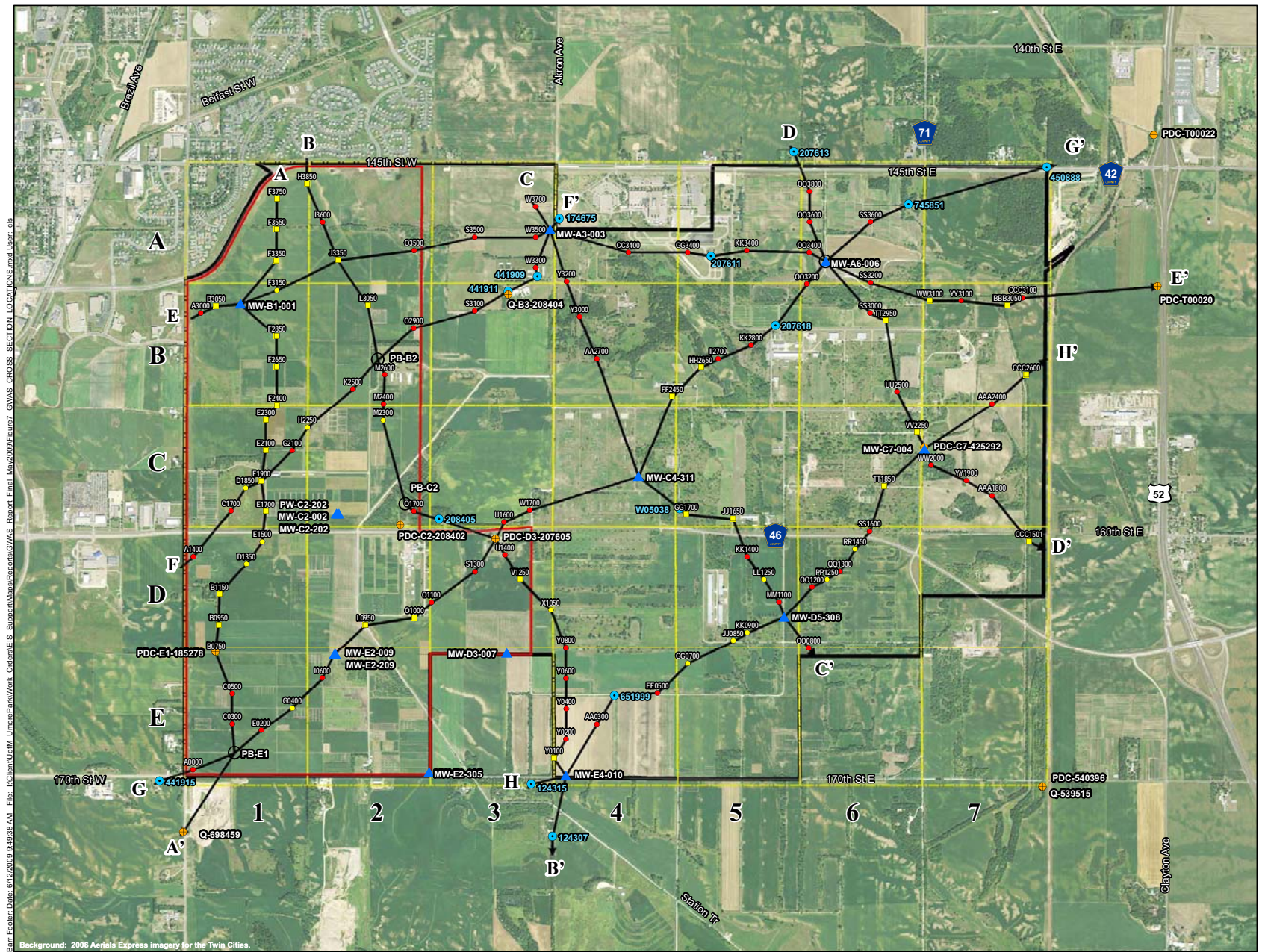


Figure 6
 DRILLING LOCATIONS
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Barr Footer: Date: 5/7/2009 11:56:52 AM. File: I:\Client\UM UMorePark\Work Orders\GIS Support\Map\Reports\GWAS UMore Drilling Locations.mxd User: cbs

Background: 2008 Aerials Express imagery for the Twin Cities.



- Existing Well
 - ▲ Monitoring Well Location
 - Pilot Boring Location
 - Dakota Co. Wells (from Dak. Co. WR Dept. 10/23/08)
 - Boring Locations (from ProSource)
 - Phase I, Auger
 - Phase II, Auger
 - Phase II, Coring
 - Cross Section
 - ▭ UMore Mining Area (UMA)
 - ▭ UMore Park Boundary
 - ▭ Site Location Grid
- Source: MnDOT, ProSource, Dakota County, Barr, SEH, HKGI.

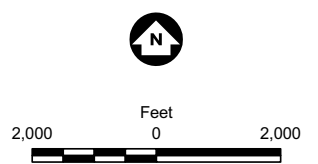
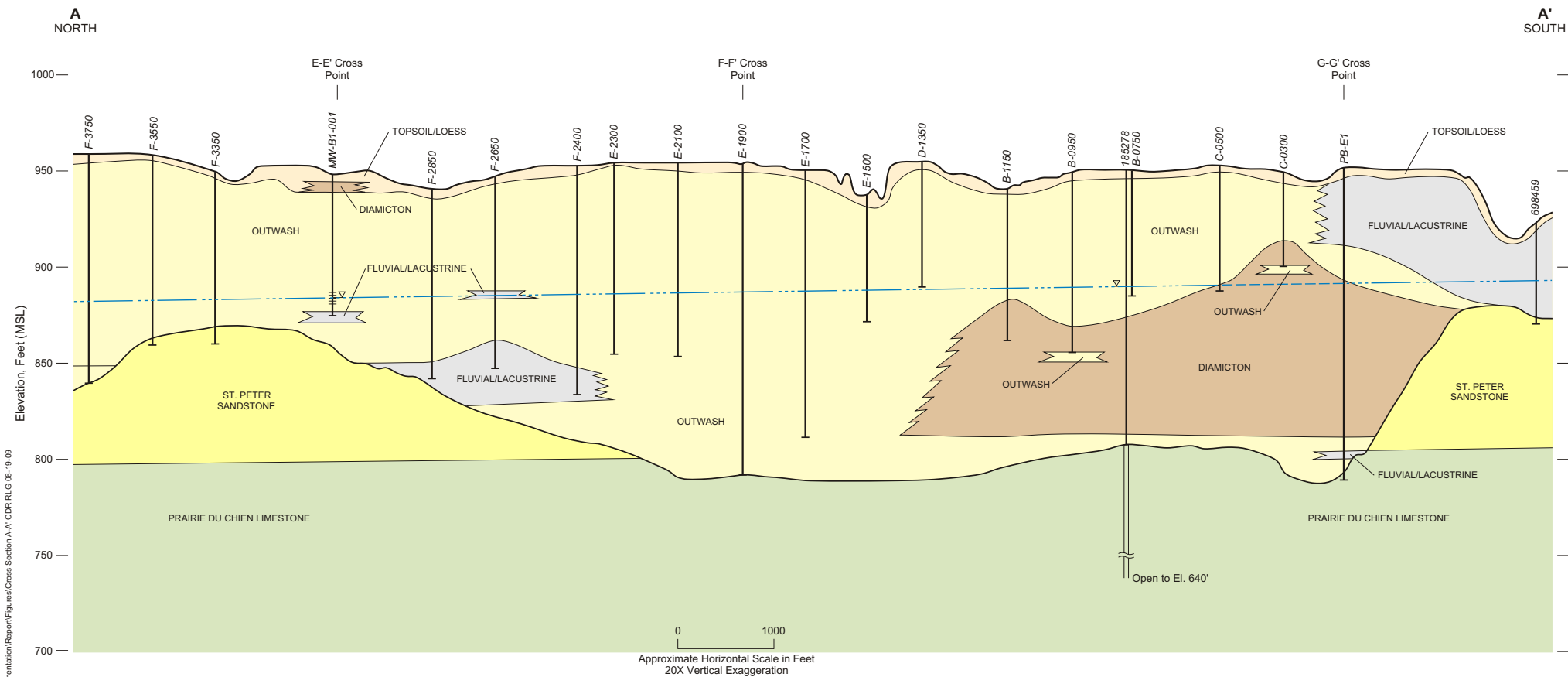


Figure 7
 CROSS SECTION LOCATIONS
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Barr Footer: Date: 01/22/2009 9:49:38 AM File: I:\Client\U\UmorePark\Work Orders\GIS Support\Map\Reports\GWAS Report_Final_May2009\Figure7_GWAS_CROSS_SECTION_LOCATIONS.mxd User: cbs

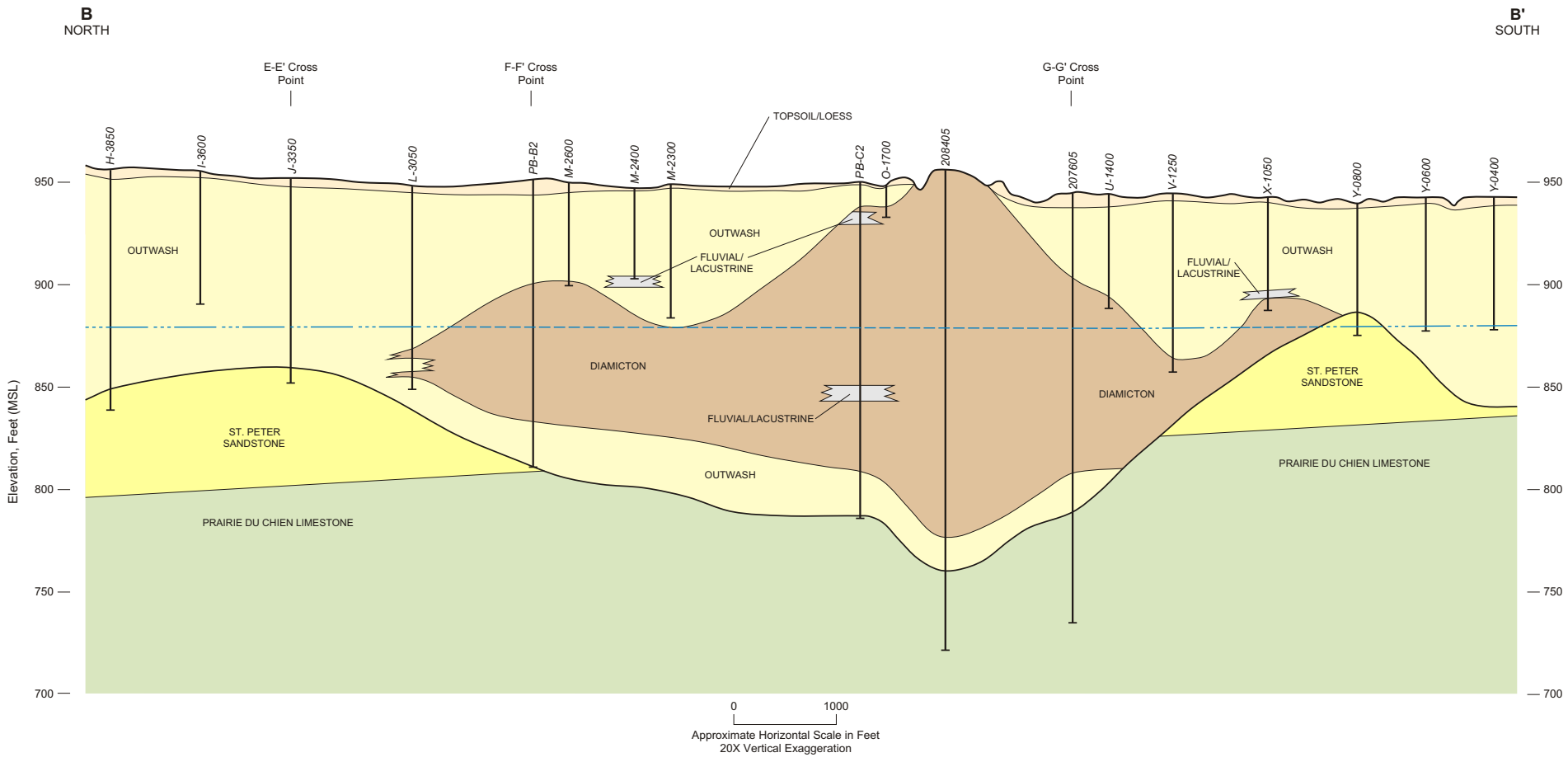
Background: 2008 Aerials Express imagery for the Twin Cities.



P:\Mpl\23.MN1923198505\WorkFiles\GW Assessment Invest\WCA2 and #3\Implementation\Report\Figures\Cross Section A-A' CDR RLG 08-19-09

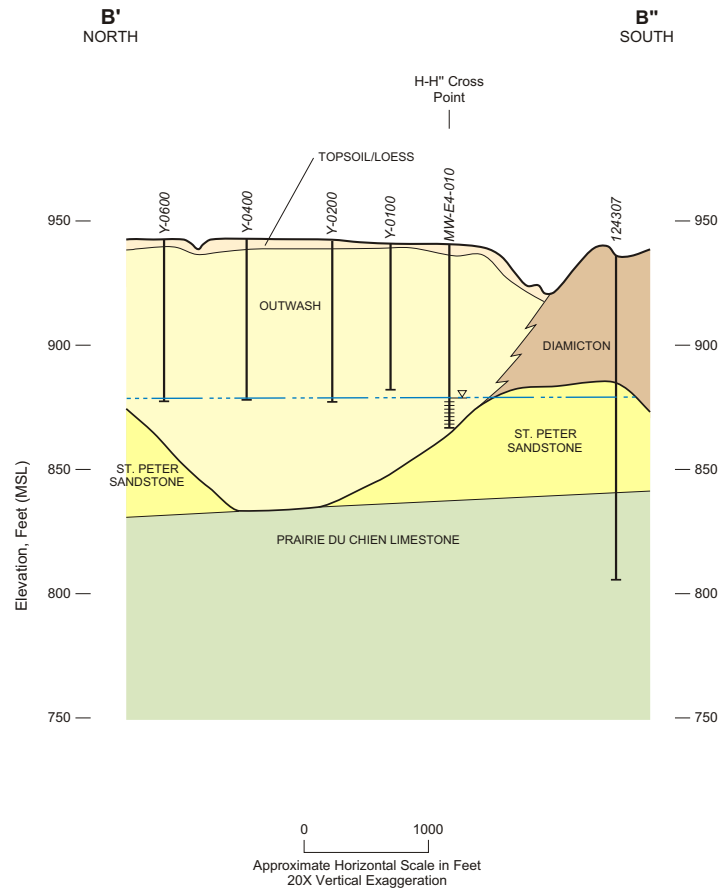
Legend		Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
	Approximate Water Table Elevation (Dashed where inferred)		Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML	1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
	Approximate Groundwater Elevation (04-03-09)		Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP	
	Soil Boring		Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC	2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
	Well Screen		Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL	
	Open Hole Interval (for pre-existing wells)		St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA	<p>Figure 8</p> <p>CROSS SECTION A-A'</p> <p>UMore Mining Area Groundwater Assessment</p> <p>Dakota County, Minnesota</p>
			Prairie du Chien	Dolomite (Bedrock)	NA	

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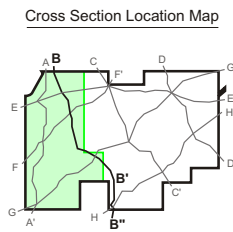


Legend		Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
	Approximate Water Table Elevation (Dashed where inferred)		Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt		<ol style="list-style-type: none"> Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
	Approximate Groundwater Elevation (04-03-09)		Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)		
	Soil Boring		Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)		
	Well Screen		Fluvial(low energy)/Lacustrine	Sandy Silt, Silt or Interbedded Clays		
	Open Hole Interval (for pre-existing wells)		St. Peter Sandstone	Fine Grained Sandstone (Bedrock)		
			Prairie du Chien	Dolomite (Bedrock)		

Figure 9a
CROSS SECTION B-B'
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota

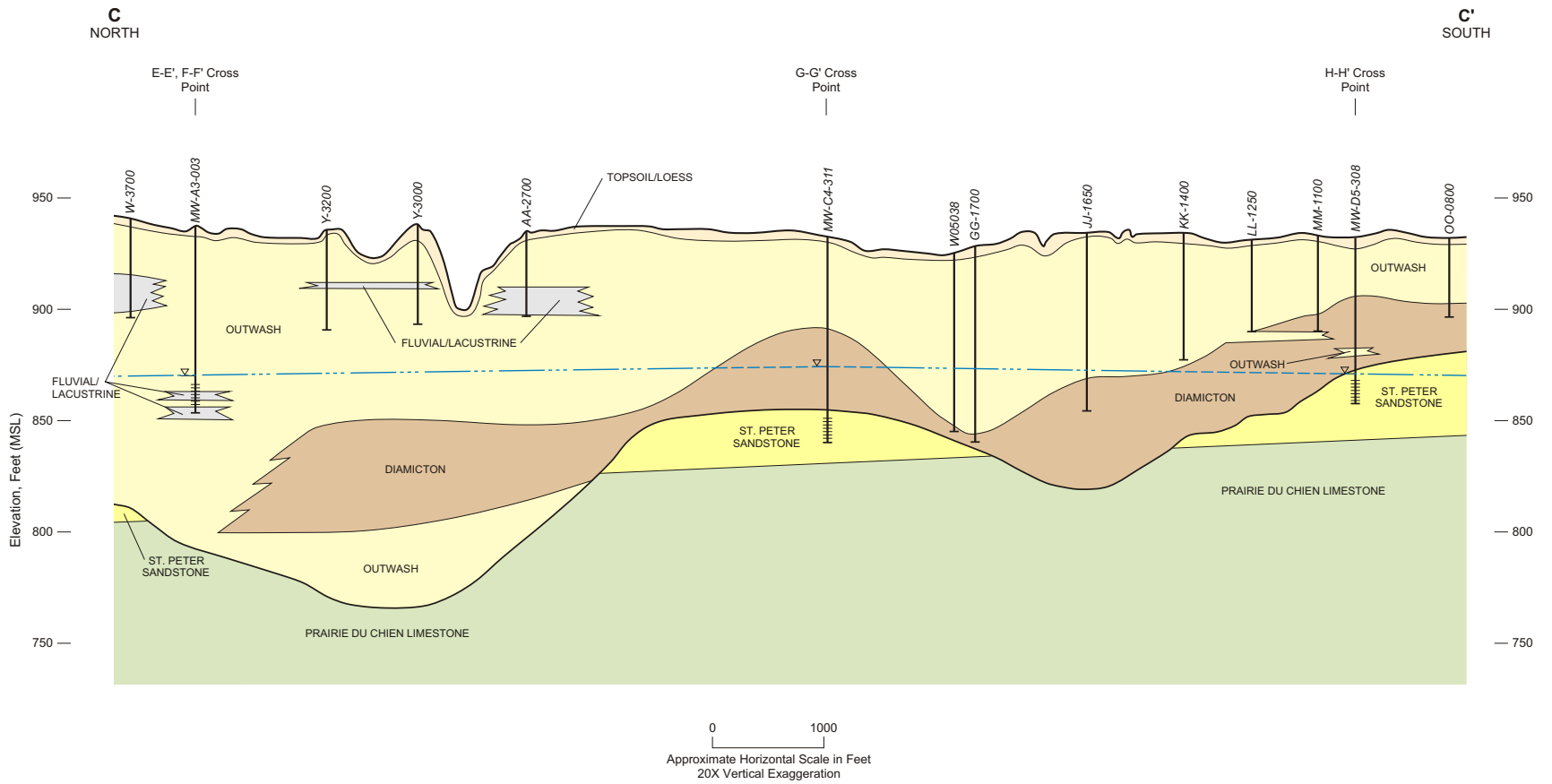


Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial (low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



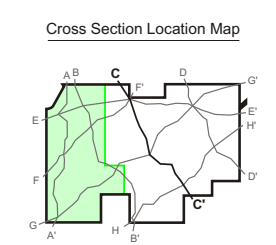
- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
 2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

Figure 9b
CROSS SECTION B'-B''
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota



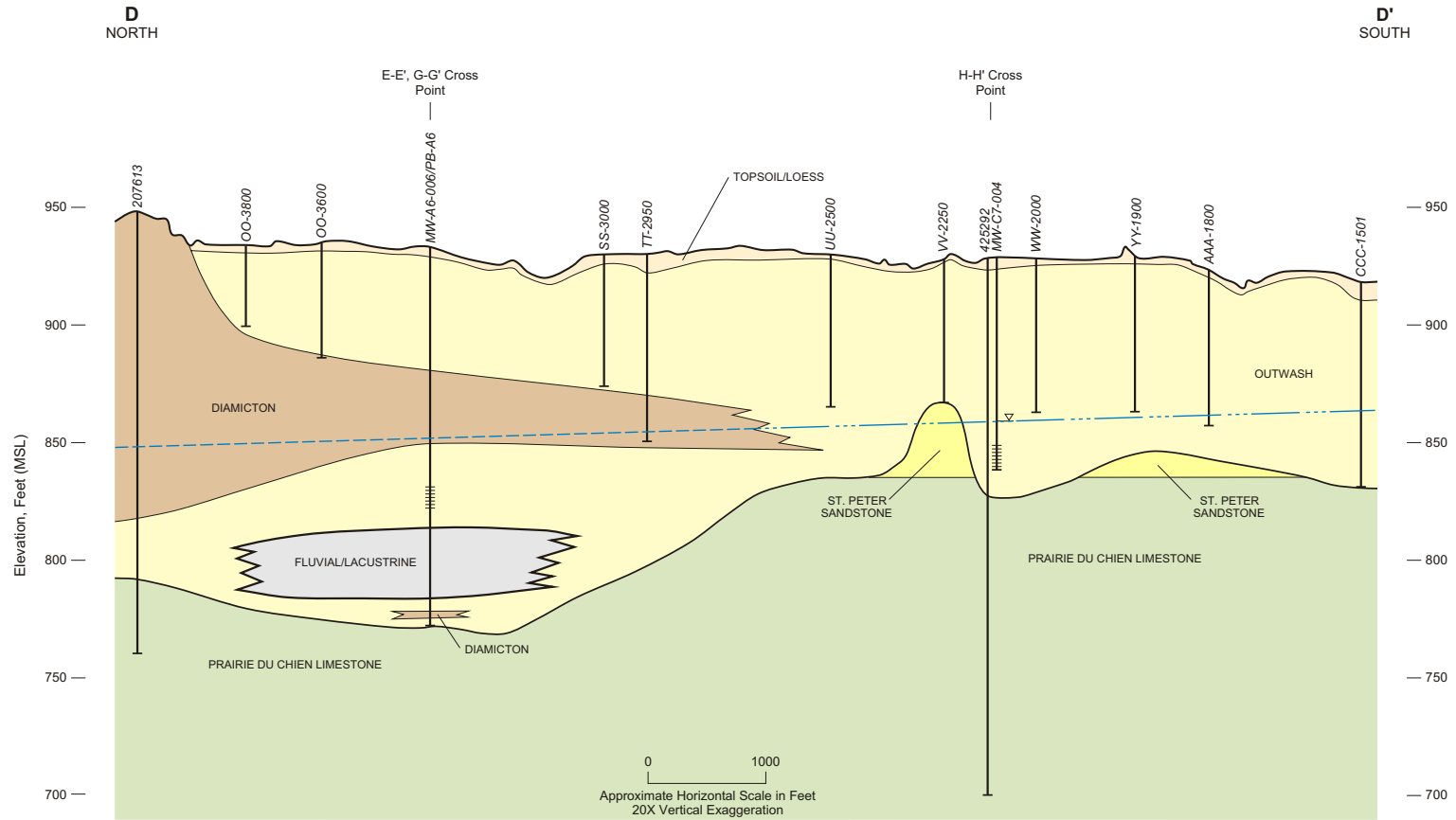
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Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



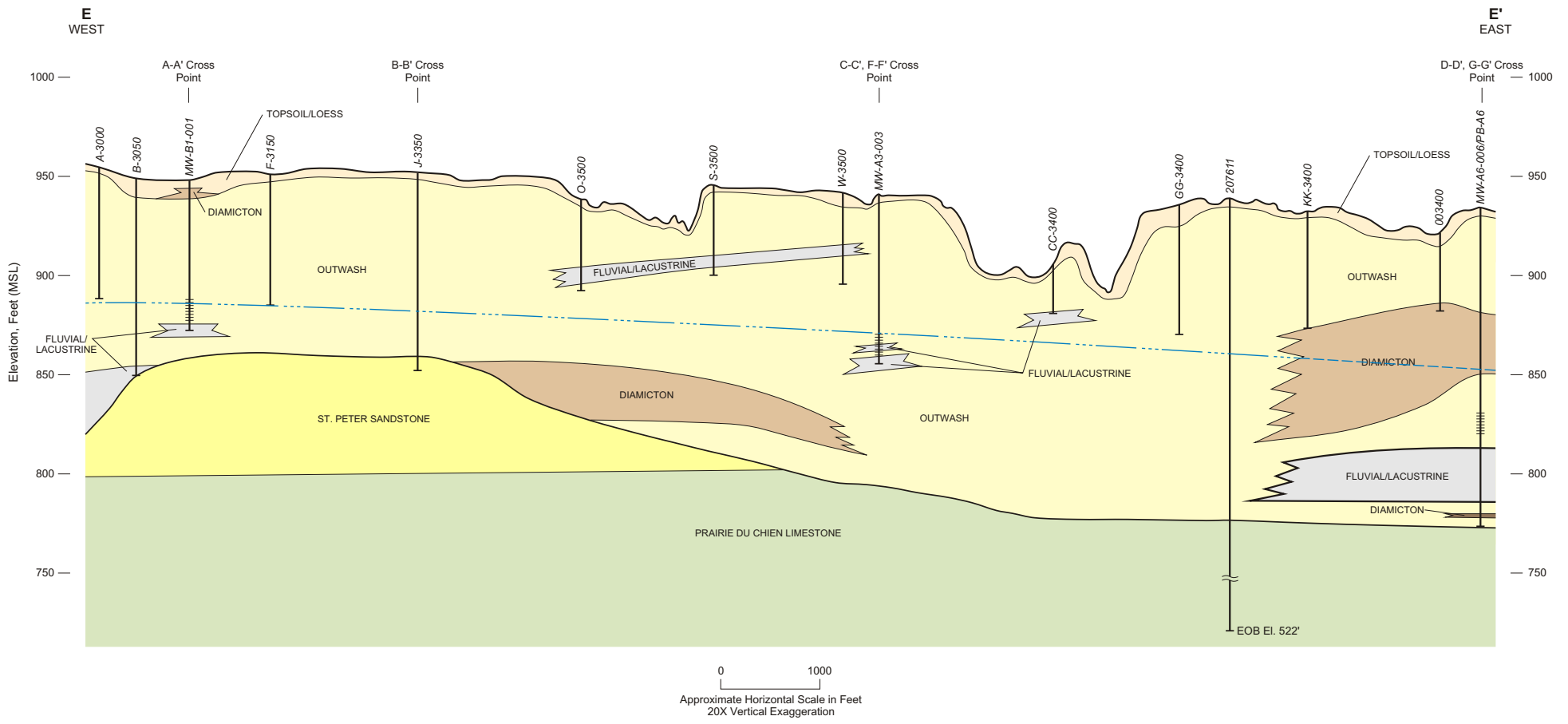
- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
 2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

Figure 10
CROSS SECTION C-C'
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota



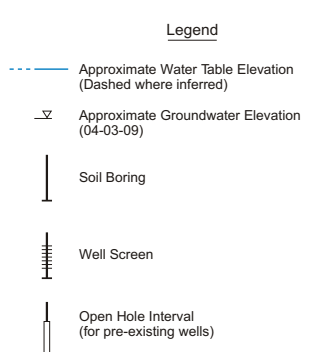
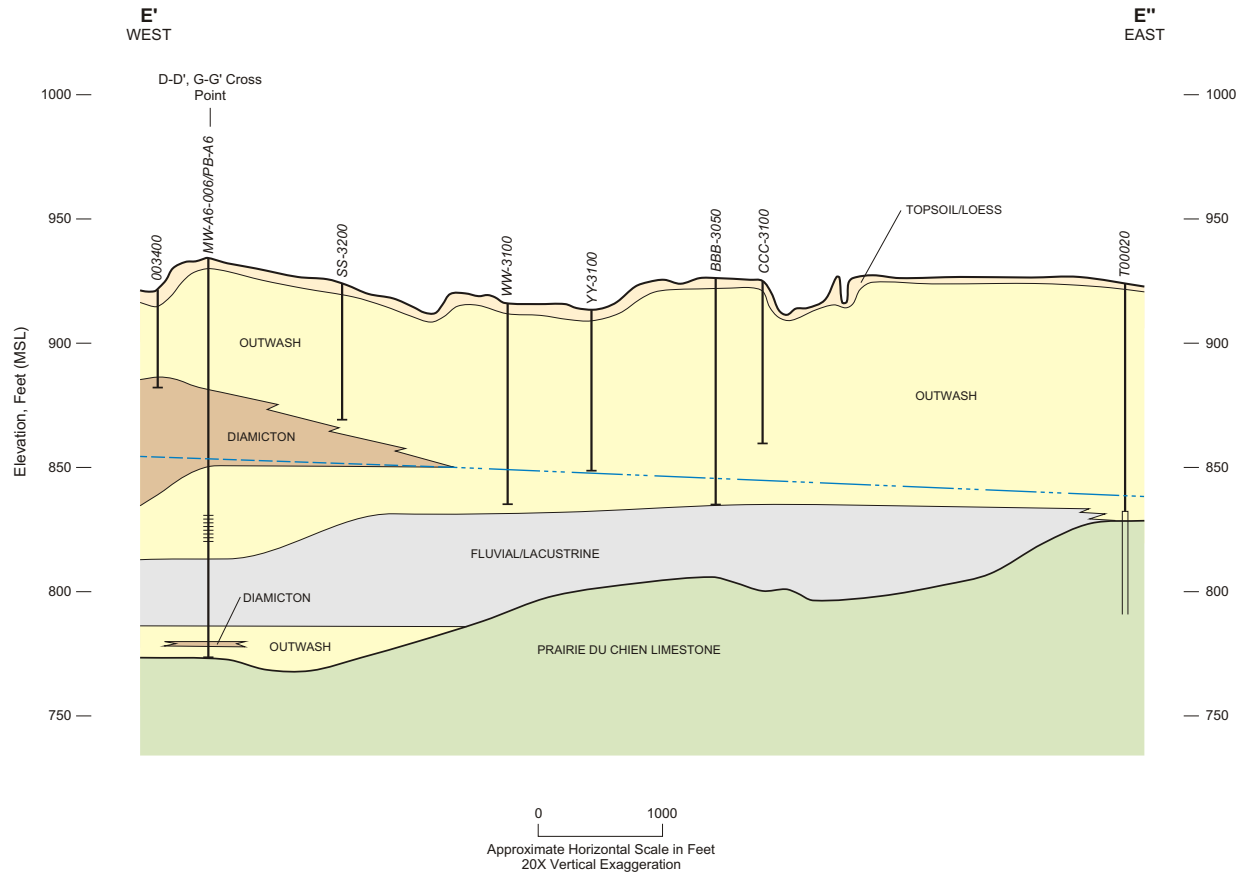
Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 11
CROSS SECTION D-D'
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota

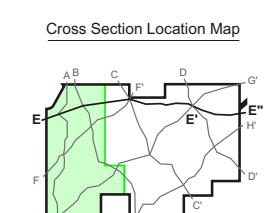


Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 12a
CROSS SECTION E-E'
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota

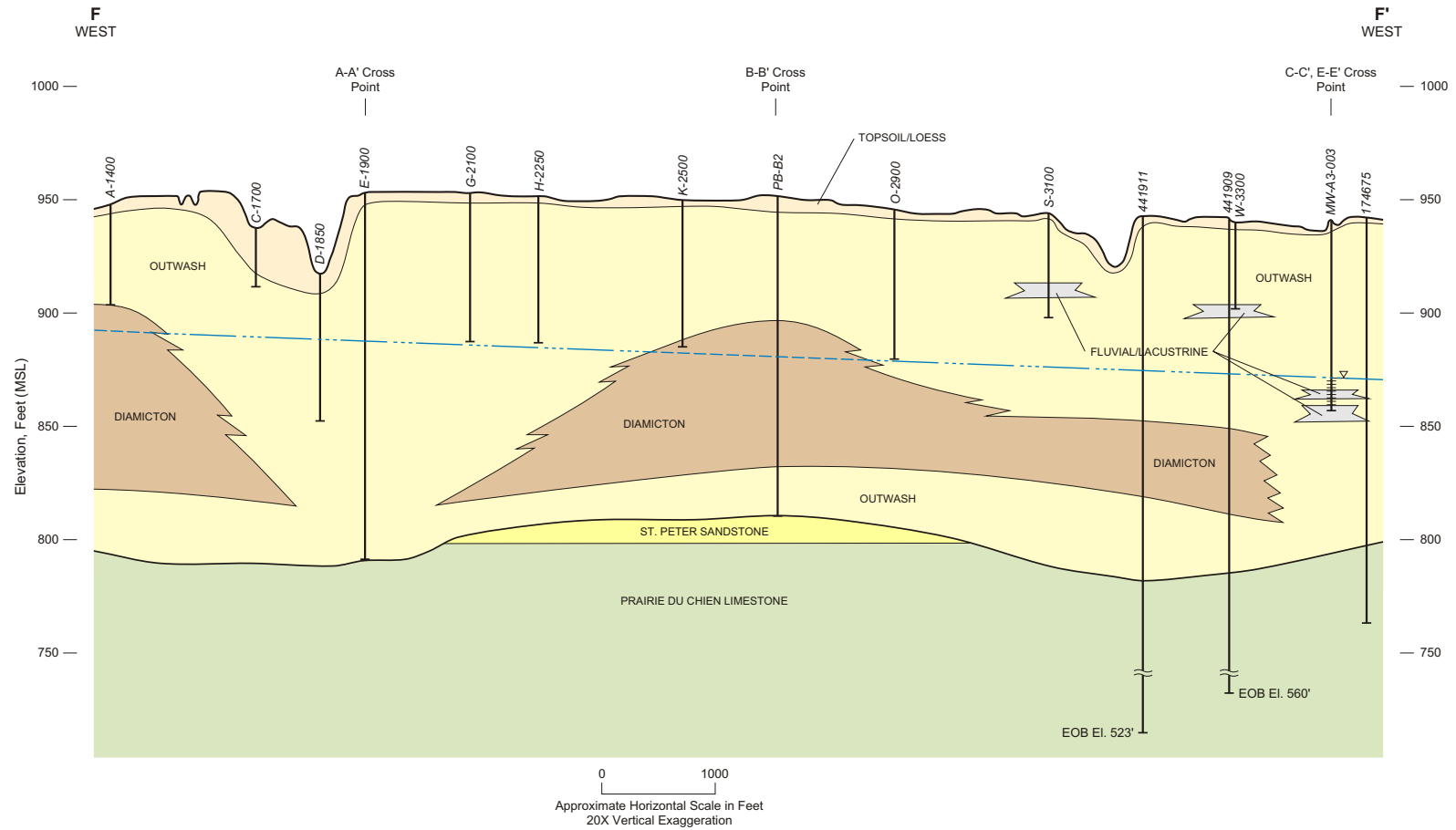


Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
Prairie du Chien	Dolomite (Bedrock)	NA



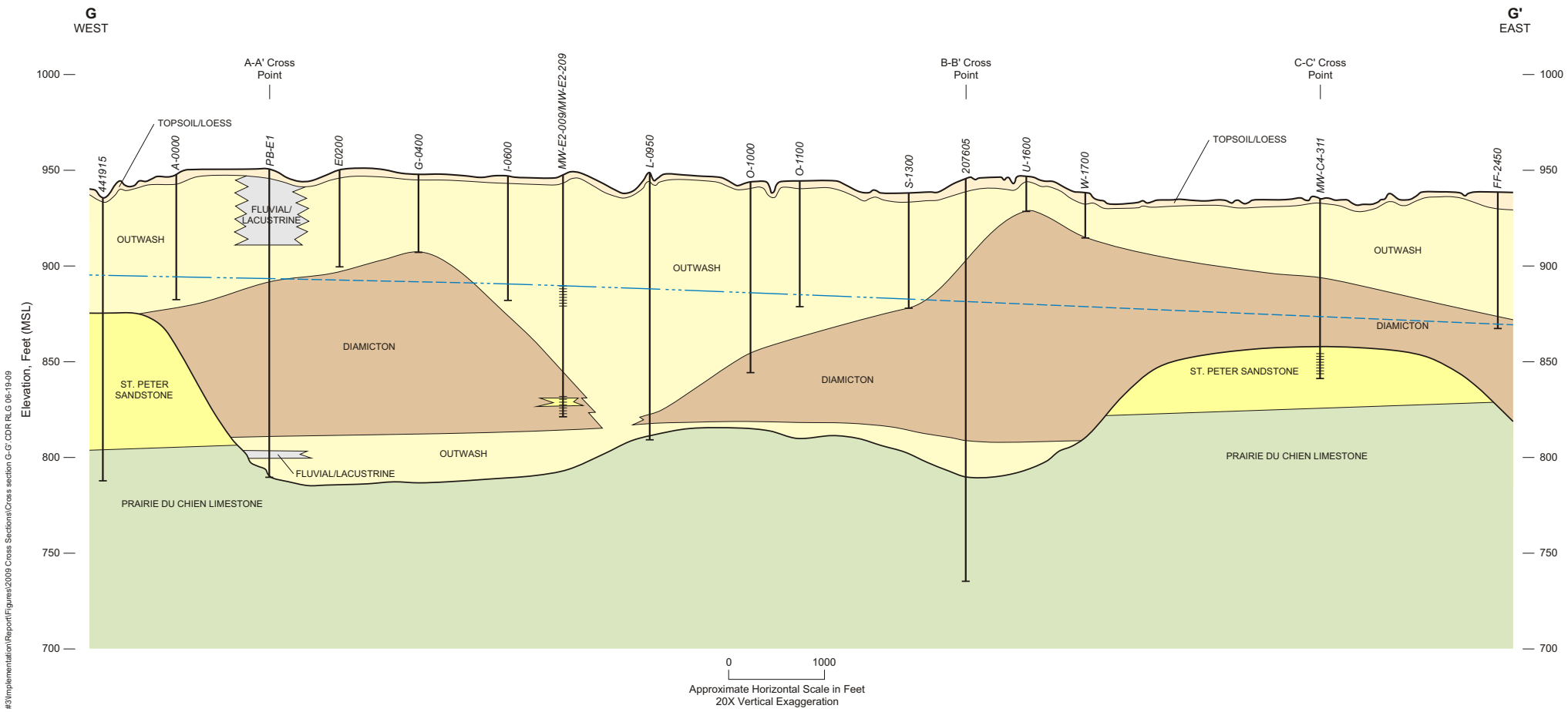
- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
 2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

Figure 12b
CROSS SECTION E'-E''
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota



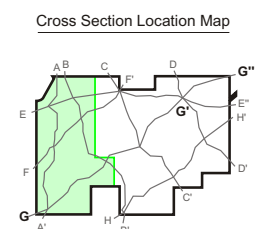
Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 13
CROSS SECTION F-F'
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota



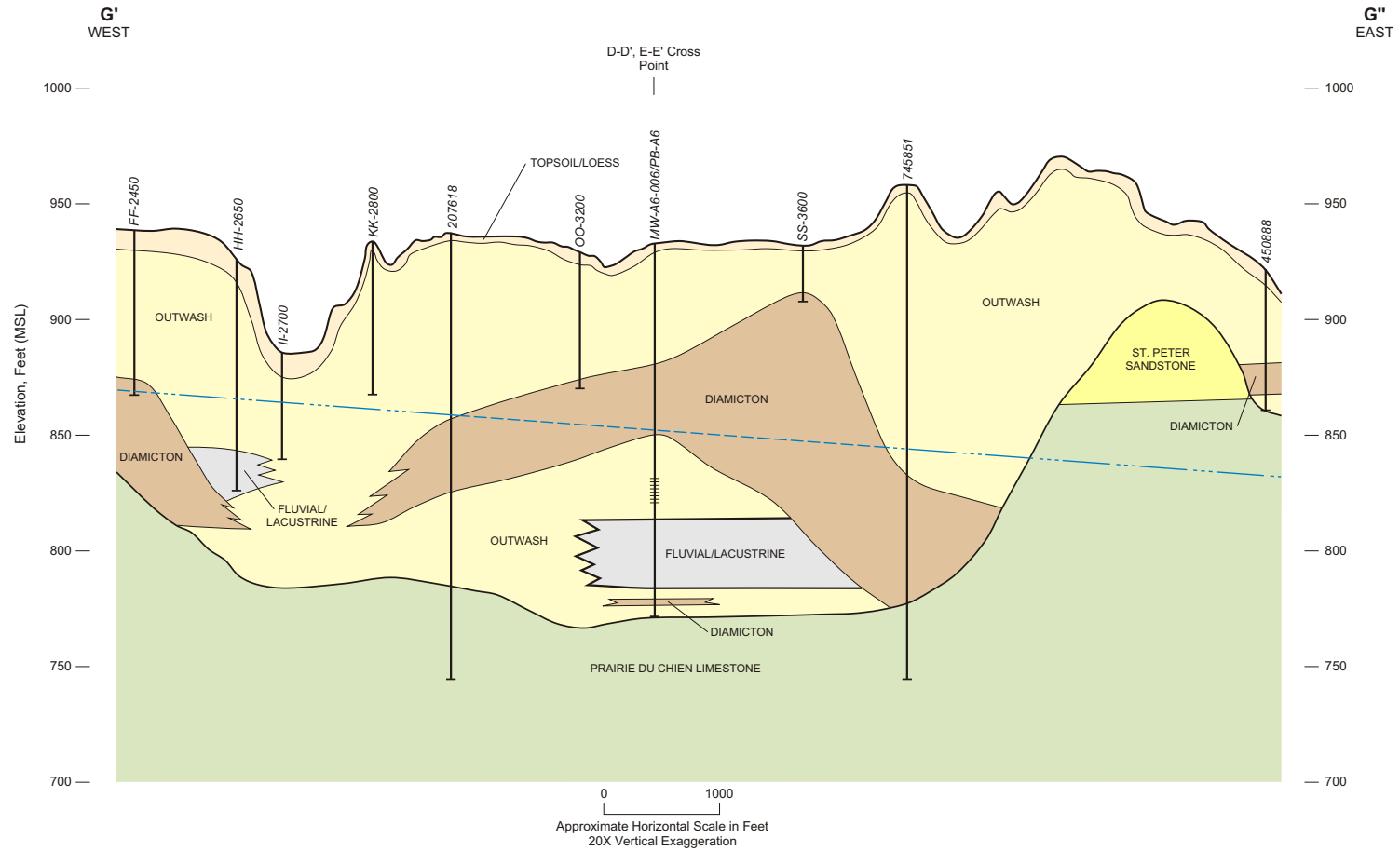
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Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA

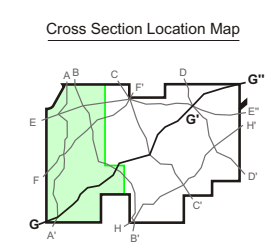


- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
 2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

Figure 14a
CROSS SECTION G-G'
UMore Mining Area Groundwater Assessment
Dakota County, Minnesota



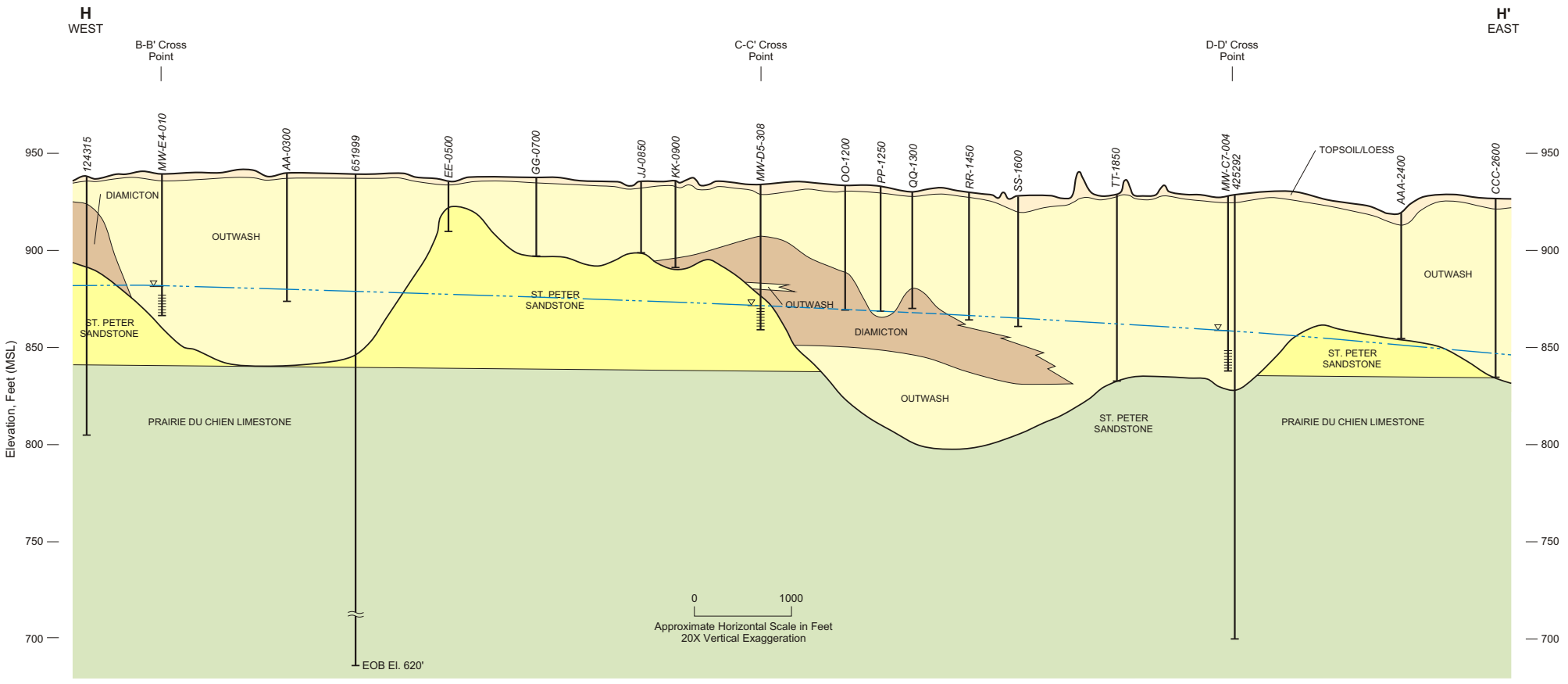
Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA
	Prairie du Chien	Dolomite (Bedrock)	NA



- Notes**
1. Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line.
 2. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.

Figure 14b
CROSS SECTION G'-G''
 UMore Mining Area Groundwater Assessment
 Dakota County, Minnesota

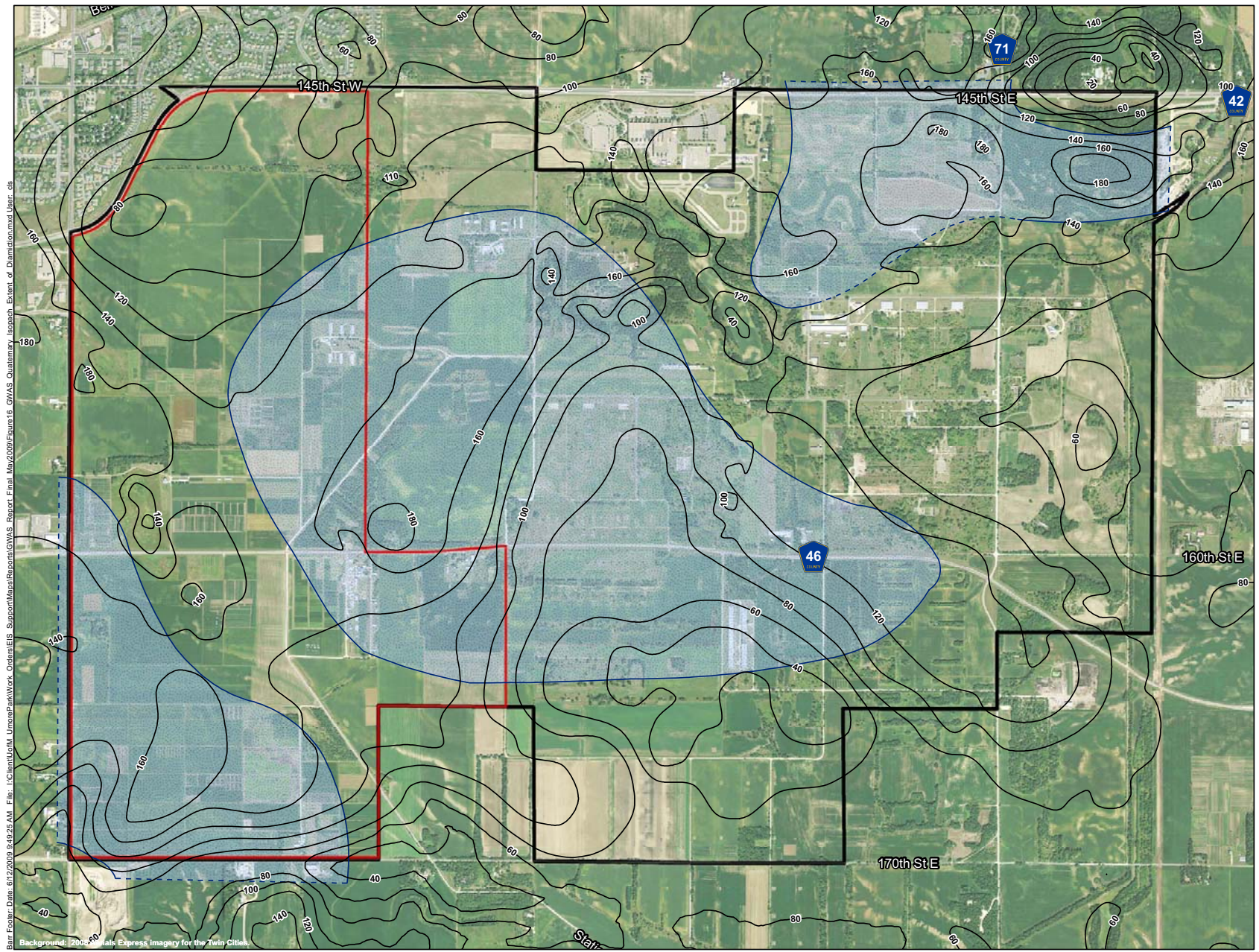
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0 1000
Approximate Horizontal Scale in Feet
20X Vertical Exaggeration

Legend	Common Name	Generalized Field Descriptions	Predominant USCS Descriptions	Cross Section Location Map	Notes
Approximate Water Table Elevation (Dashed where inferred)	Topsoil/Loess	Surface Deposit - Organic Topsoil At Depth - Silt	OL, ML		<ol style="list-style-type: none"> Contacts are based on interpolation between borings shown on this figure and other borings in the vicinity of the cross section line. The contact between the St. Peter Sandstone Formation and the Prairie du Chien Formation is based on the few borings that penetrate both units and should be considered generalized.
Approximate Groundwater Elevation (04-03-09)	Outwash	Poorly Graded Sand with Gravel (content ranging from 0 to 30%)	SP, SW, GP		
Soil Boring	Diamicton	Lean Clay Matrix with Sand and Gravel (content ranging from 10% to 40%)	CL, SC		
Well Screen	Fluvial(low energy)/ Lacustrine	Sandy Silt, Silt or Interbedded Clays	ML, SM, SM/CL		
Open Hole Interval (for pre-existing wells)	St. Peter Sandstone	Fine Grained Sandstone (Bedrock)	NA		
	Prairie du Chien	Dolomite (Bedrock)	NA		

Figure 15
CROSS SECTION H-H'
UMore Mining Area Groundwater Assessment
Dakota County, Minnesota



UMore Mining Area (UMA)
 UMore Park Boundary
 — Quaternary Deposit Isopach
 (Thickness in feet)
 Approximate Extent of Diamicton
 (below water table)

Source: MnDOT, Barr, SEH, HKGi,
 Geologic Logs from Assessment,
 ProSource (2008), and County Well Index

Note: Where shaded, diamicton comprises at least half of the saturated Quaternary deposits.

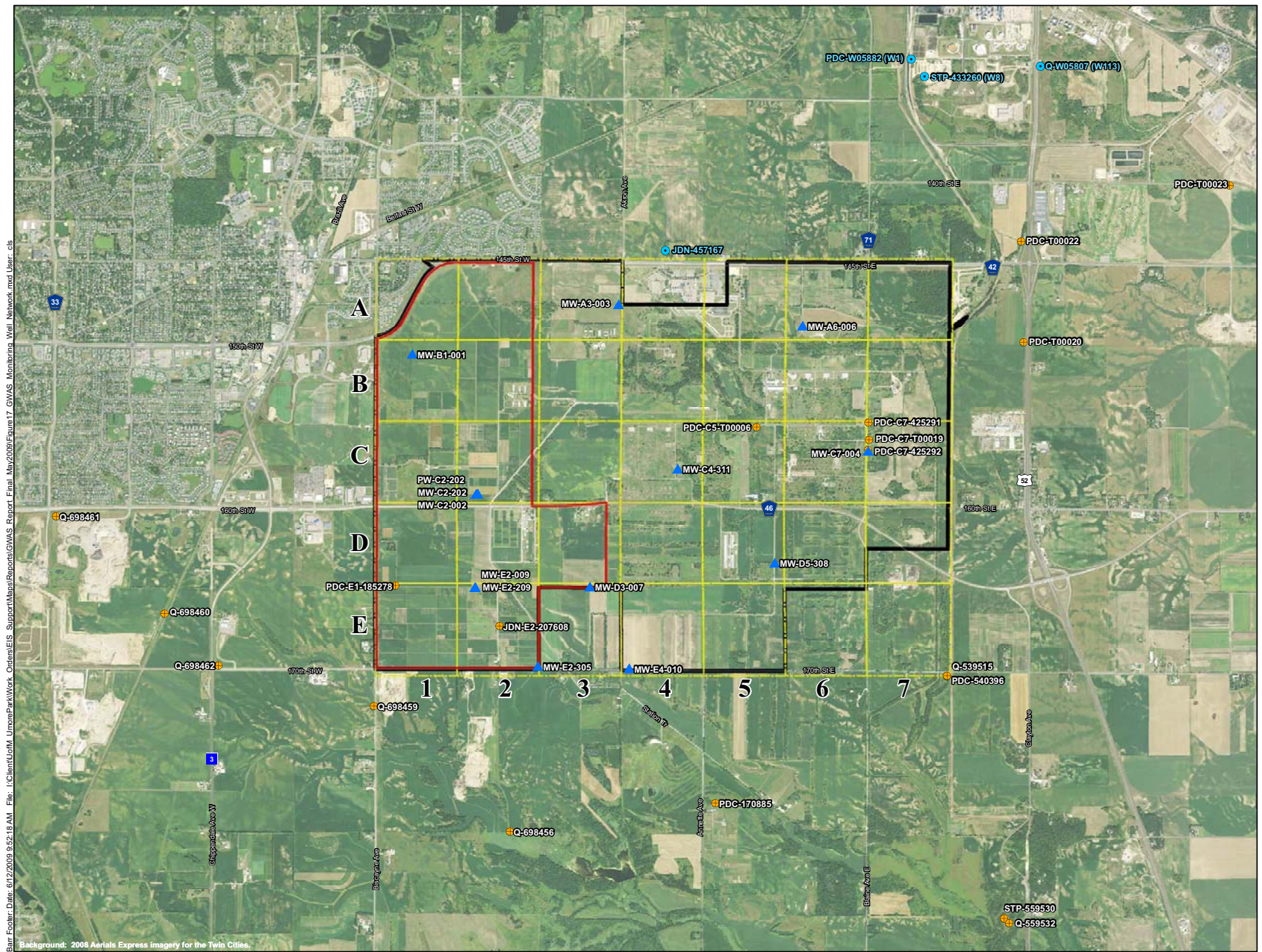


Figure 16

**QUATERNARY ISOPACH AND
 EXTENT OF DIAMICTON**
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Barr Footer: Date: 6/12/2009 9:49:25 AM. File: I:\Client\UoM_UmorePark\Work Orders\EIS_Support\Map\Reports\GWAS_Report_Final_May2009\Figure16_GWAS_Quaternary_Isopach_Extent_of_Diamicton.mxd User: ds



- Existing Well
 - ▲ Monitoring Well Location
 - Dakota Co. Wells (from Dak. Co. WR Dept. 10/23/08)
 - ▭ UMore Mining Area (UMA)
 - ▭ UMore Park Boundary
 - ▭ Site Location Grid
- Source: MnDOT, Barr, Dakota County, SEH, HKGI.

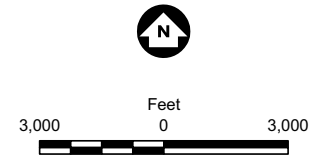


Figure 17
 MONITORING WELL NETWORK
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN

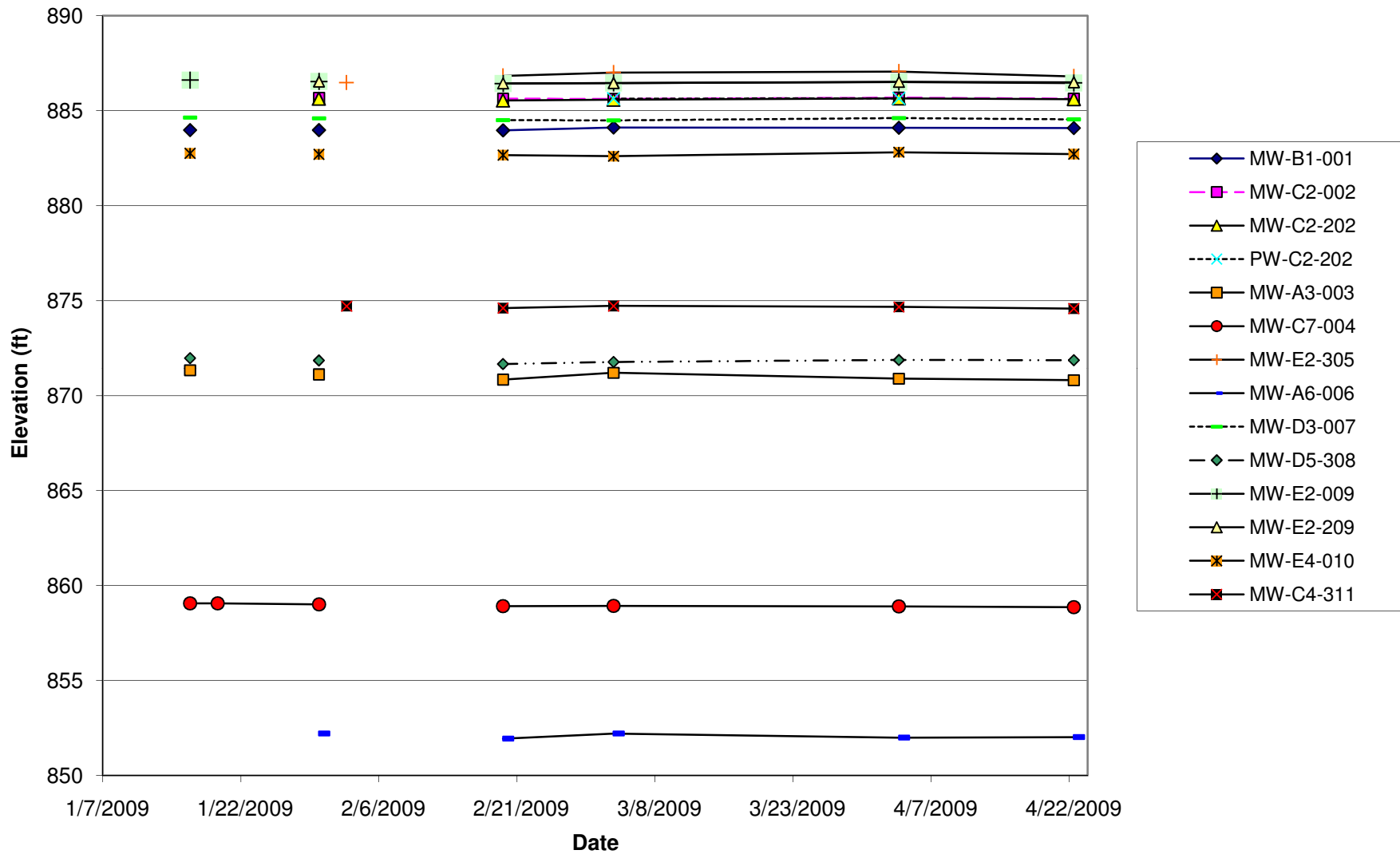


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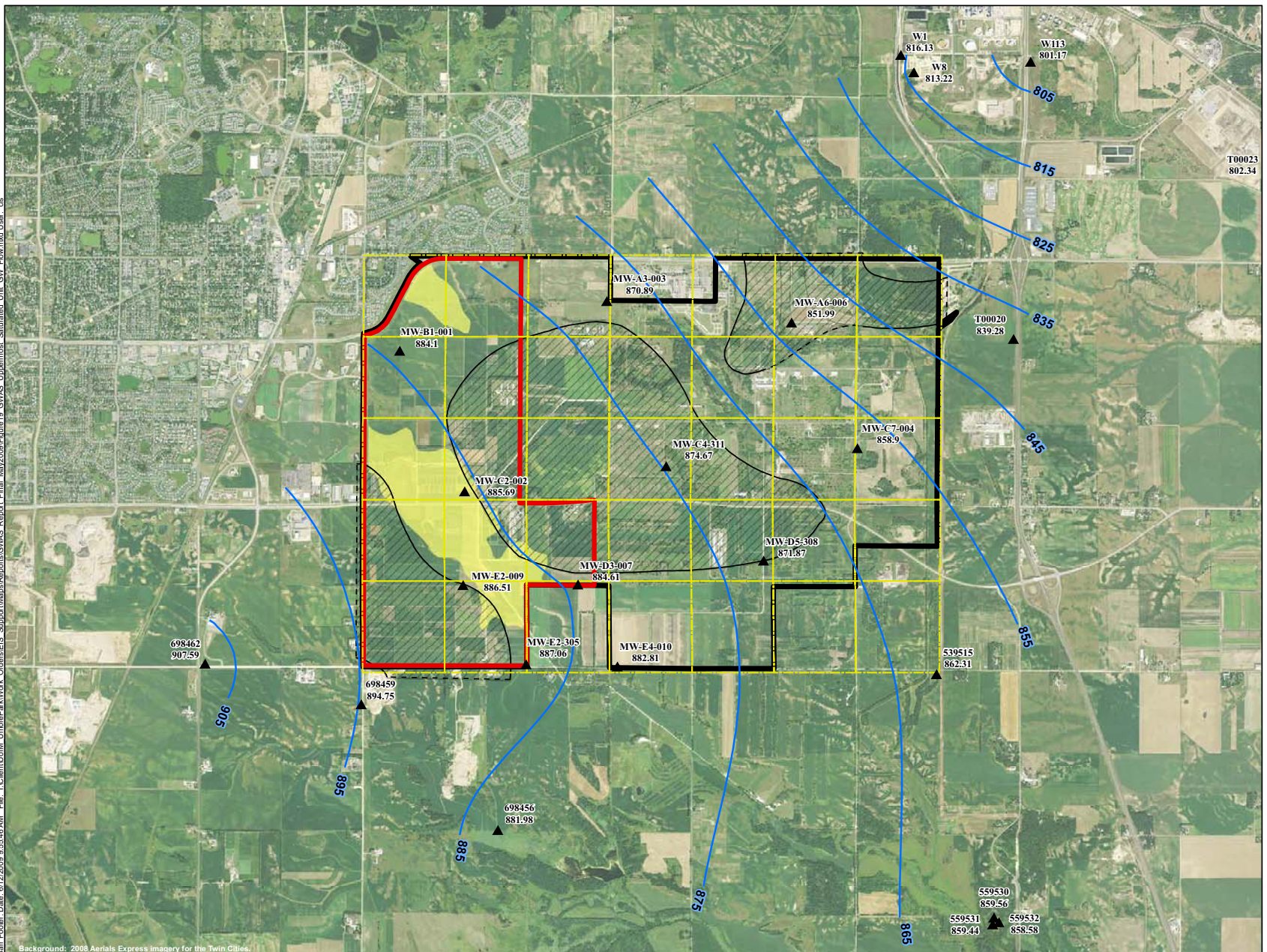
Background: 2008 Aerials Express imagery for the Twin Cities.

Figure 18

Groundwater Elevation Hydrographs
Groundwater Assessment Report
UMore Mining Area
Dakota County, Minnesota



Barr Footer Date: 6/12/2009 9:55:46 AM File: I:\Client\UofM\UmorePark\Work_Corps\GIS\Support\Maps\Reports\GWAS_Report_Final_May2009\Figure19_GWAS_Uppermost_Saturated_Unit_GW_Flow.mxd User: cbs



- ▲ Monitoring Wells
- Groundwater Elevation Contours
- ▭ Umore Park Boundary
- ▭ Umore Mining Area (UMA)
- ▭ Site Location Grid
- ▨ Approximate Extent of Diamicton
- Economic Gravel Deposit Below the Water Table (Approximate)

Source: Metropolitan Council, MndOT, Dakota County, Barr, ProSource, SEH, HKGI.

Water levels used for this map are from wells completed in the uppermost saturated unit and within 25 feet of the water table. Most of the wells used are completed in Quaternary deposits or the St Peter formation, except W1, which is completed in the Prairie du Chien formation, and T00020, which is completed across Quaternary deposits and the Prairie du Chien formation. Well MW-C4-311 completed in St. Peter Sandstone confirmed by diamicton.

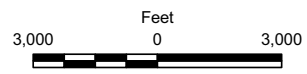


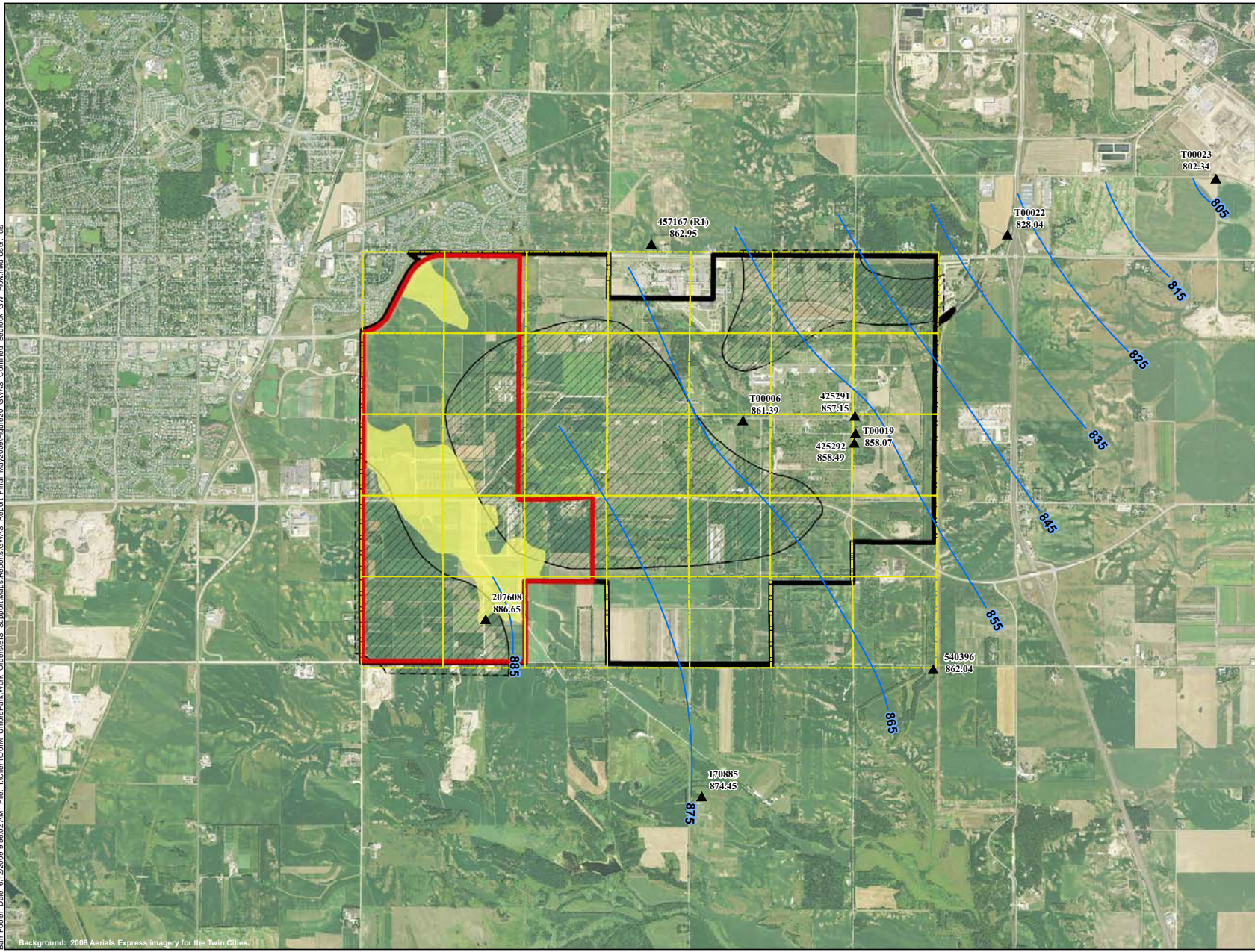
Figure 19
GROUNDWATER FLOW MAP
(UPPERMOST SATURATED UNIT)
APRIL 3, 2009

Groundwater Assessment Report
Umore Mining Area
Dakota County, MN



Background: 2008 Aerials Express imagery for the Twin Cities.

Barr Footer Date: 6/12/2009 8:56:02 AM File: I:\Client\UofM\UmorePark\Work_Corps\GIS\Support\Mapa\Reports\GWAS_Report_Final_May2009\Figures\GWAS_Report_Final_May2009\Figures20_GWAS_Confined_Bedrock_GW_Flow.mxd User: db



- ▲ Monitoring Wells
- ▭ UMore Park Boundary
- ▭ UMore Mining Area (UMA)
- ▭ Site Location Grid
- ▨ Approximate Extent of Diamicton
- Economic Gravel Deposit Below the Water Table (Approximate)

Source: Metropolitan Council, MnDOT, Dakota County, Barr, ProSource, SEH, HKGI.

Water levels used for this map are from wells completed in the Prairie du Chien and Jordan formations.



Figure 20
 BEDROCK
 GROUNDWATER FLOW MAP
 APRIL 3, 2009
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



Background: 2008 Aerials Express imagery for the Twin Cities.

P:\Mpl\23.MN19\2319B5\WorkFiles\GW Assessment Invest\W042 and #3\Implementation\Report\Figures\Conceptual Cross Section 2.CDR.RLG.06-12-09

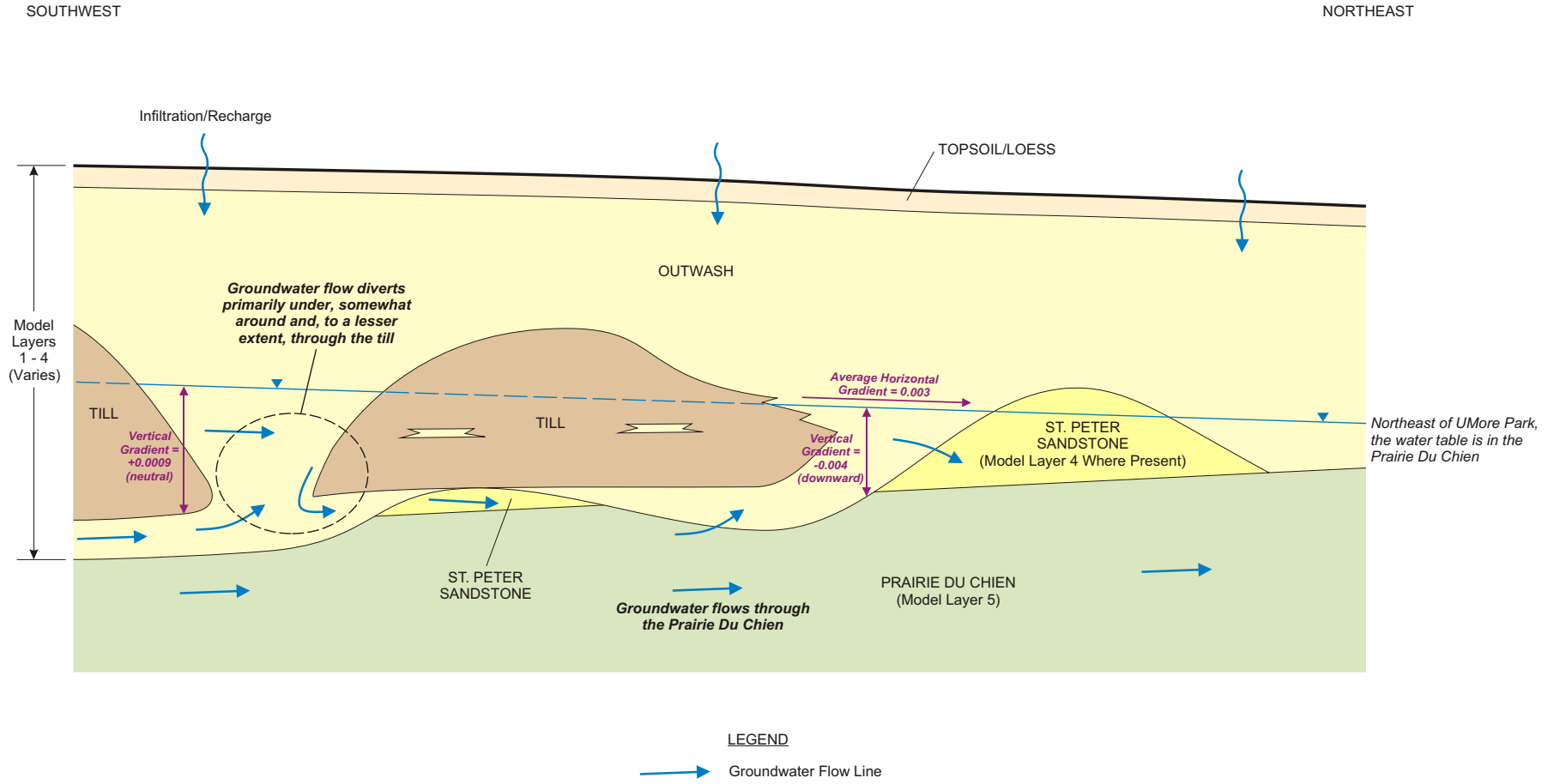


Figure 21
 CONCEPTUAL CROSS SECTION
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, Minnesota

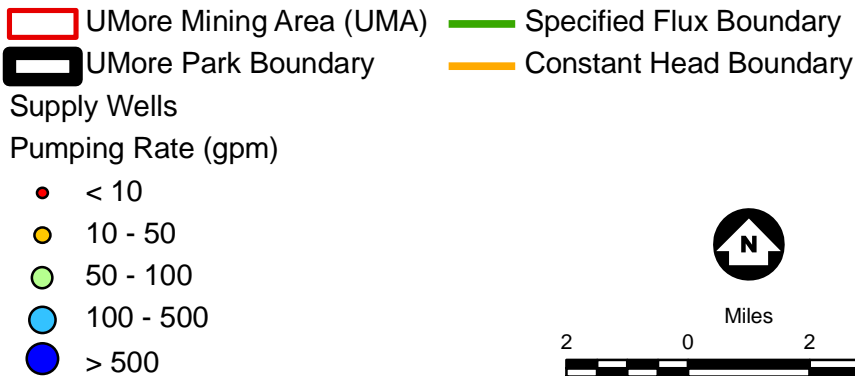
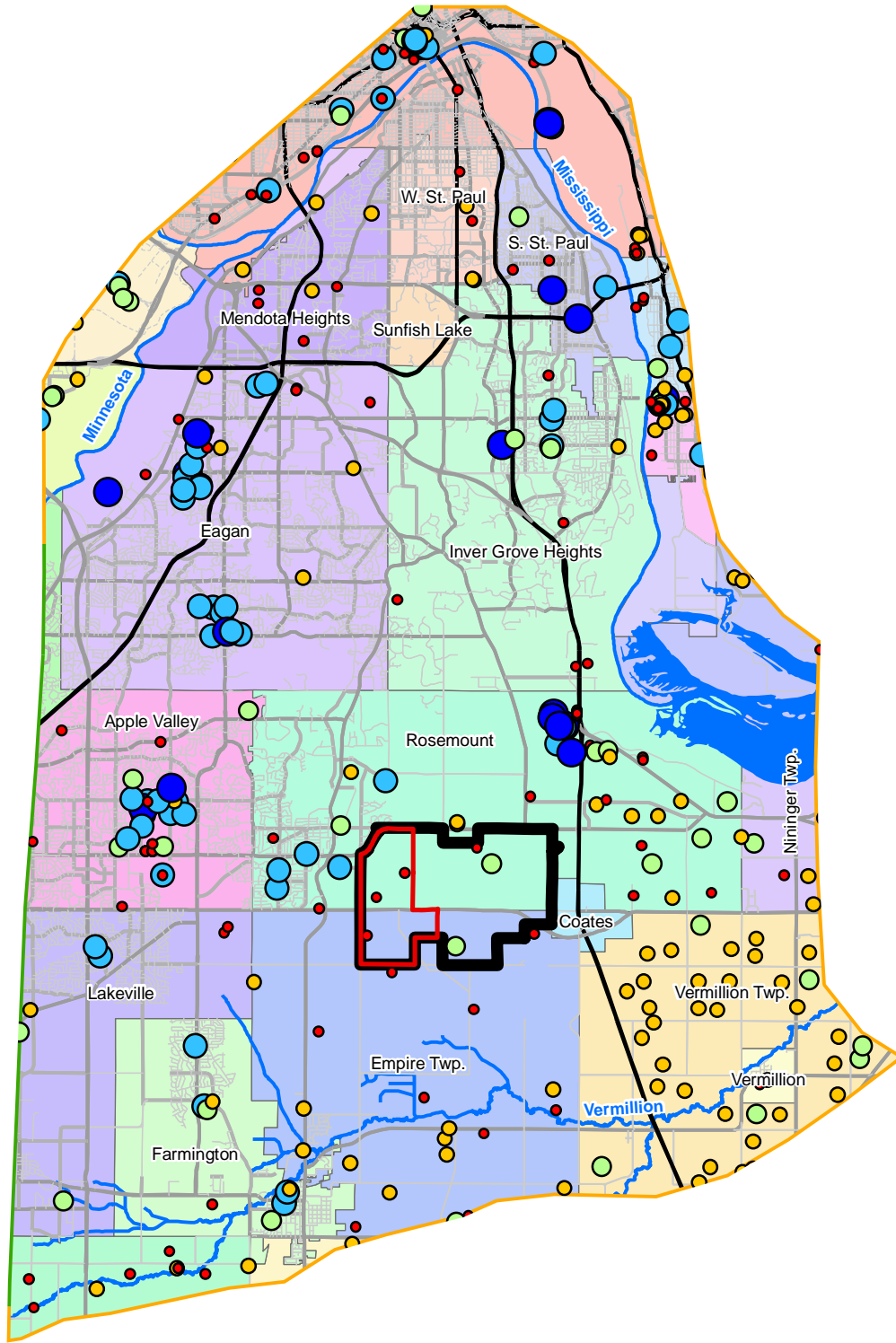


Figure 22

MODEL DOMAIN AND BOUNDARY CONDITIONS

Groundwater Assessment Report
Umore Mining Area
Dakota County, MN

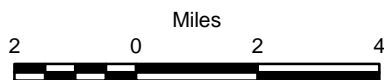
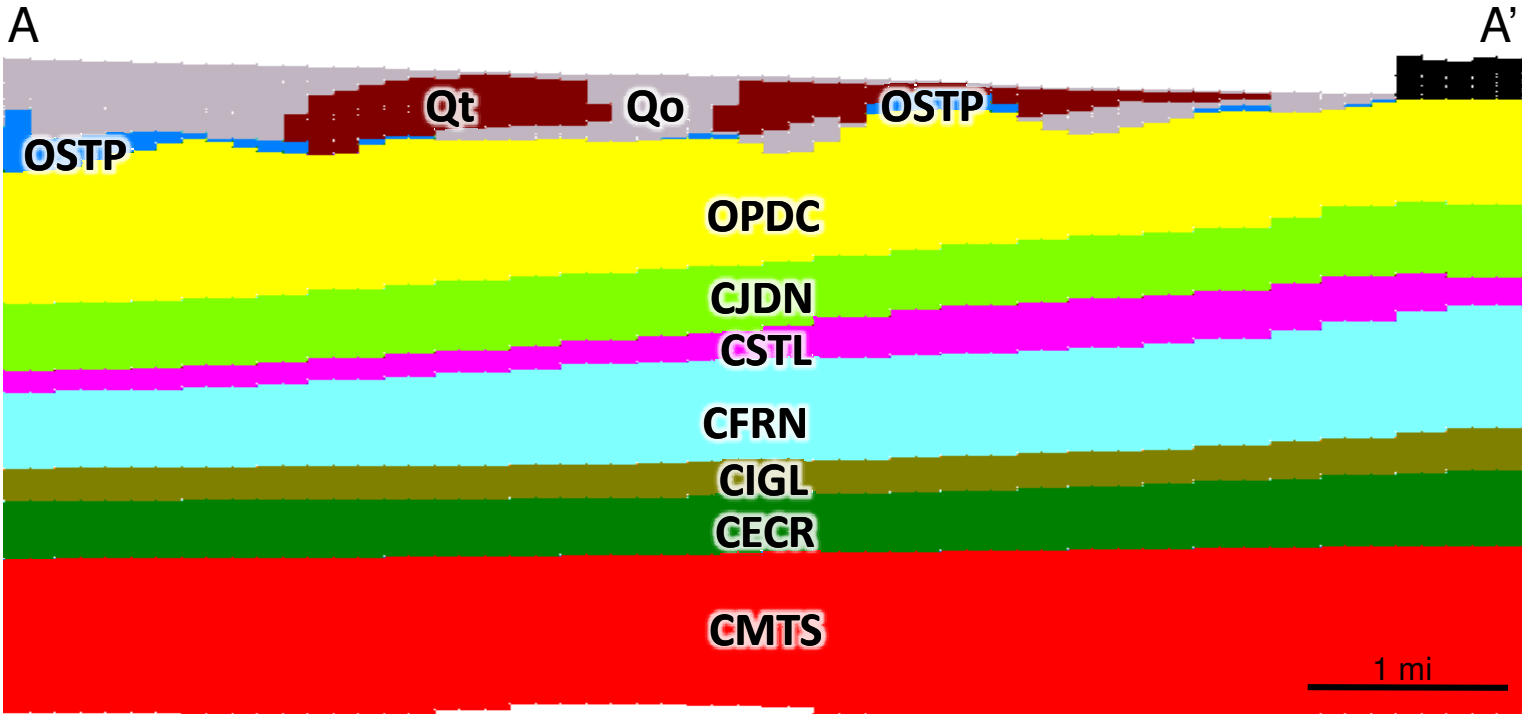


Figure 23
Groundwater Model Cross Section



- Till (Qt)
- Outwash / Quaternary Undifferentiated (Qo)
- St Peter Sandstone (OSTP)
- Prairie du Chien Group (OPDC)
- Jordan Sandstone (CJDN)
- St. Lawrence Formation (CSTL)
- Franconia Formation (CFRN)
- Ironton and Galesville Sandstone (CIGL)
- Eau Claire Formation (CECR)
- Mt. Simon Sandstone (CMTS)

Vertical exaggeration = ~18x

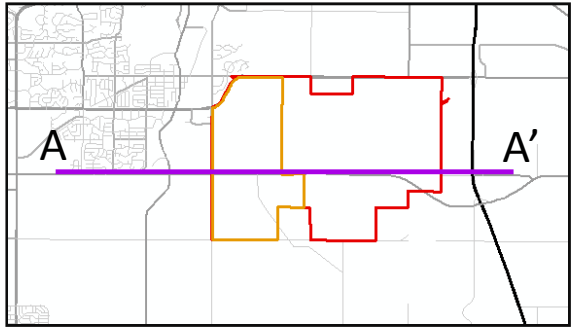


Figure 24
Observed vs Computed Hydraulic Head Values

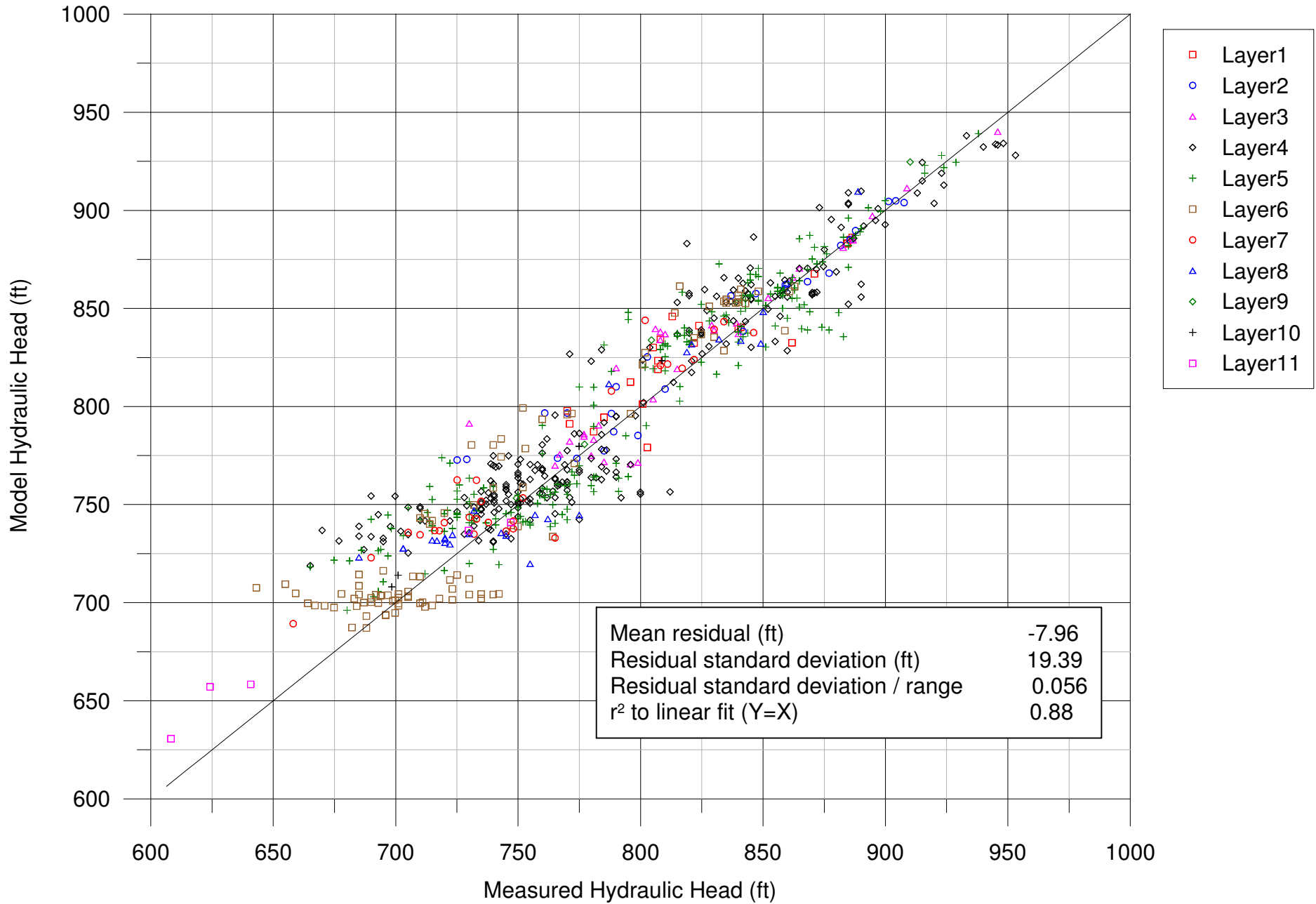
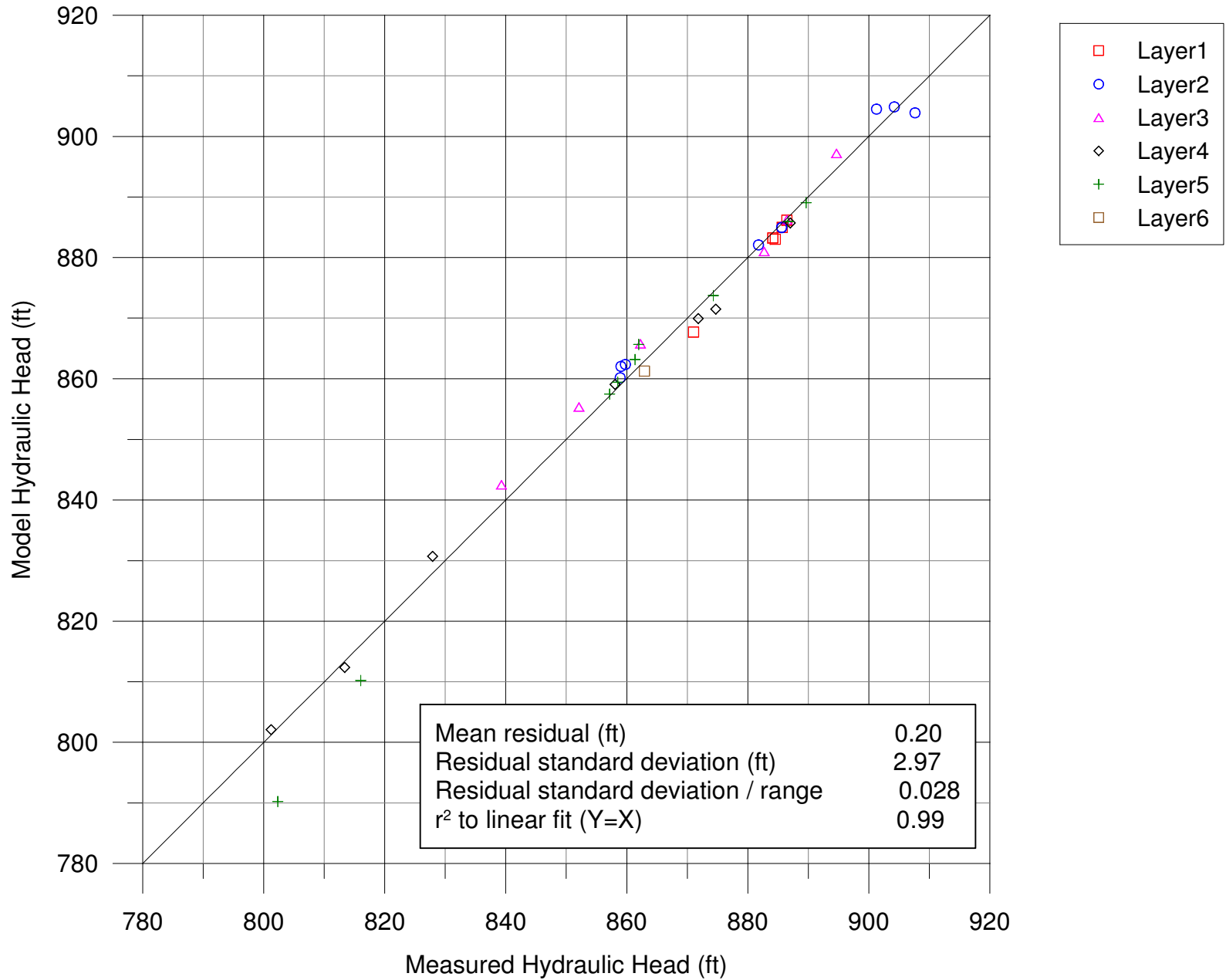
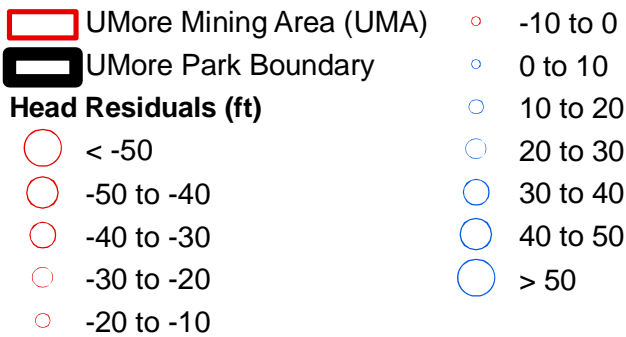
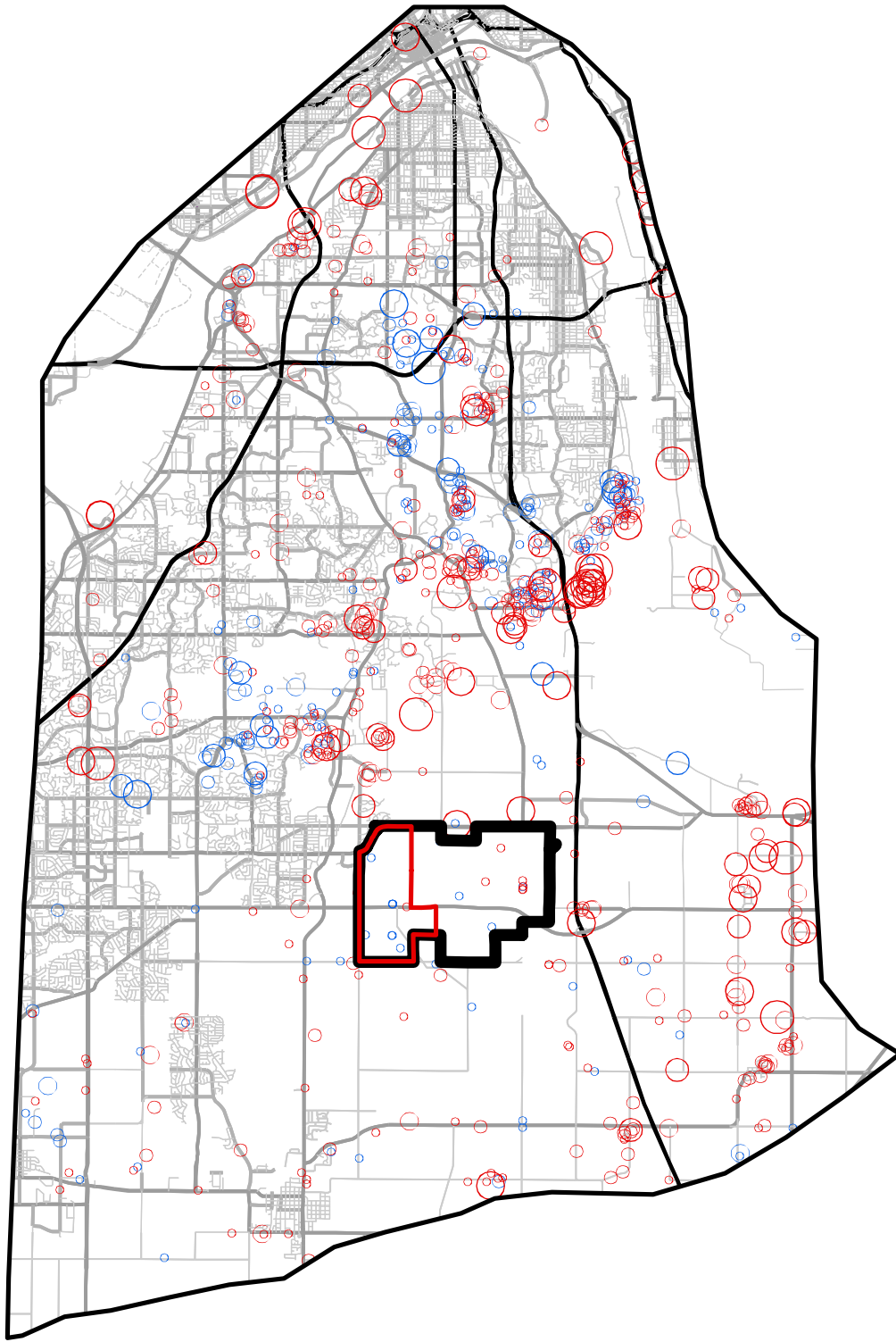


Figure 25
Observed vs. Computed Hydraulic Head Values
Measurements taken as part of this study





Miles



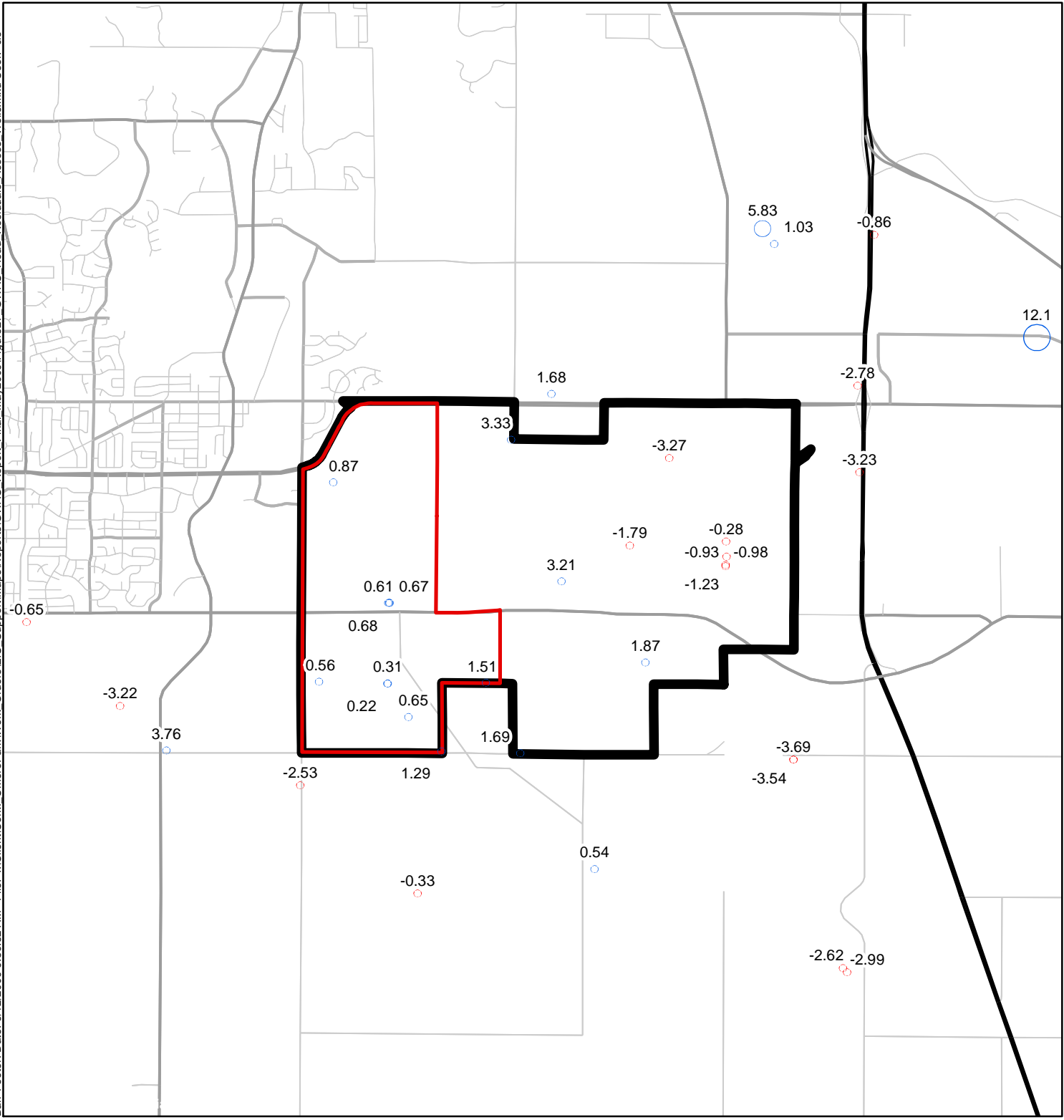
Residuals calculated as: measured value - model value
 Source: MnDOT, MN DNR, Barr, SEH.

Figure 26

HEAD RESIDUALS

Groundwater Assessment Report
 Umore Mining Area
 Dakota County, MN



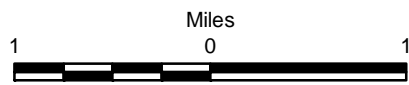


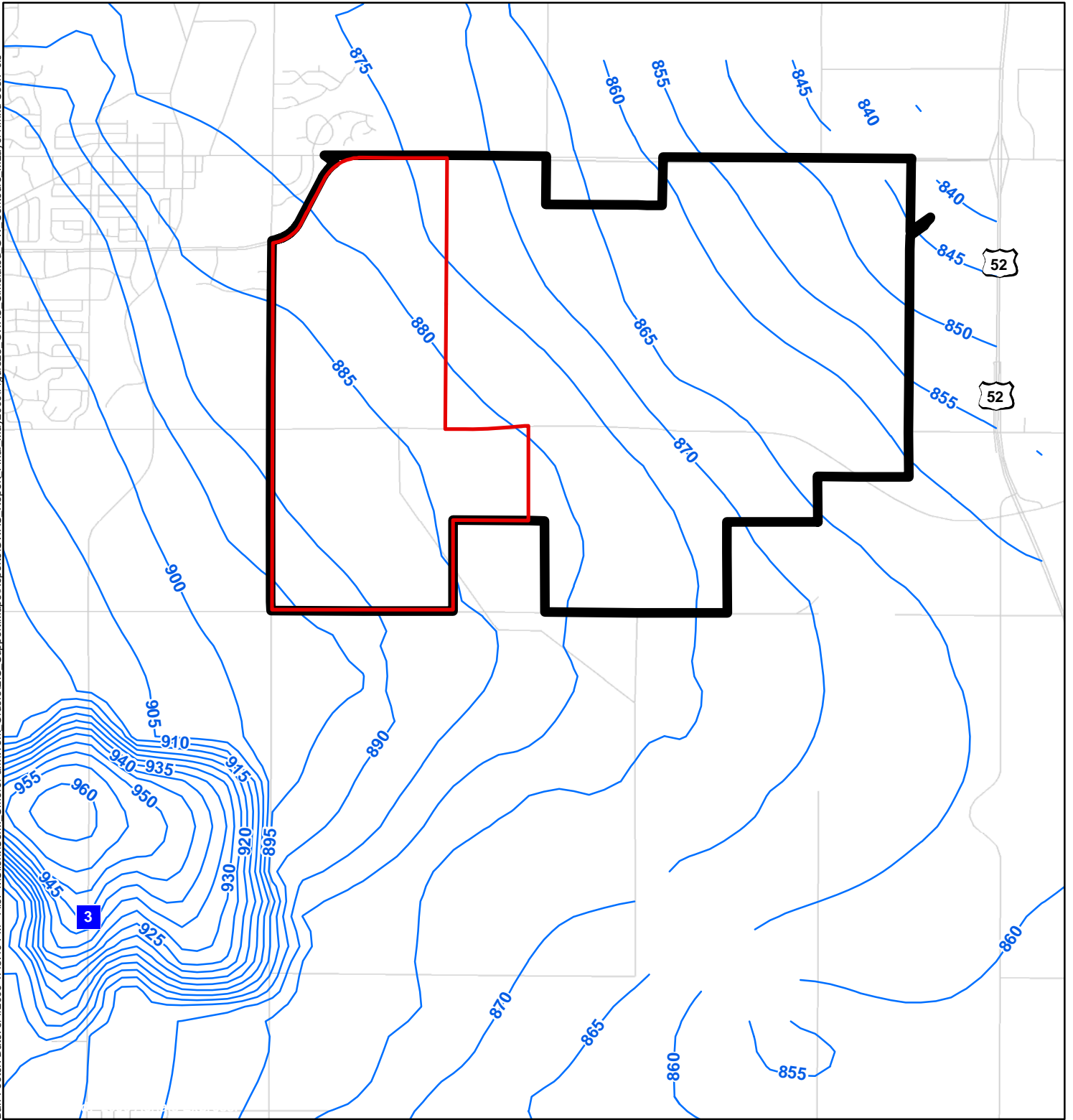
- Umore Mining Area (UMA)
 - Umore Park Boundary
 - Head Residuals (ft)**
 - < -10
 - 5 to -10
 - 5 to 0
 - 0 to 5
 - 5 to 10
 - > 10
- Residuals caclulated as: measured value - model value

Figure 27

HEAD RESIDUALS,
ASSESSMENT WELLS

Groundwater Assessment Report
Umore Mining Area
Dakota County, MN








-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Head Contour (Contour Interval = 5 ft)

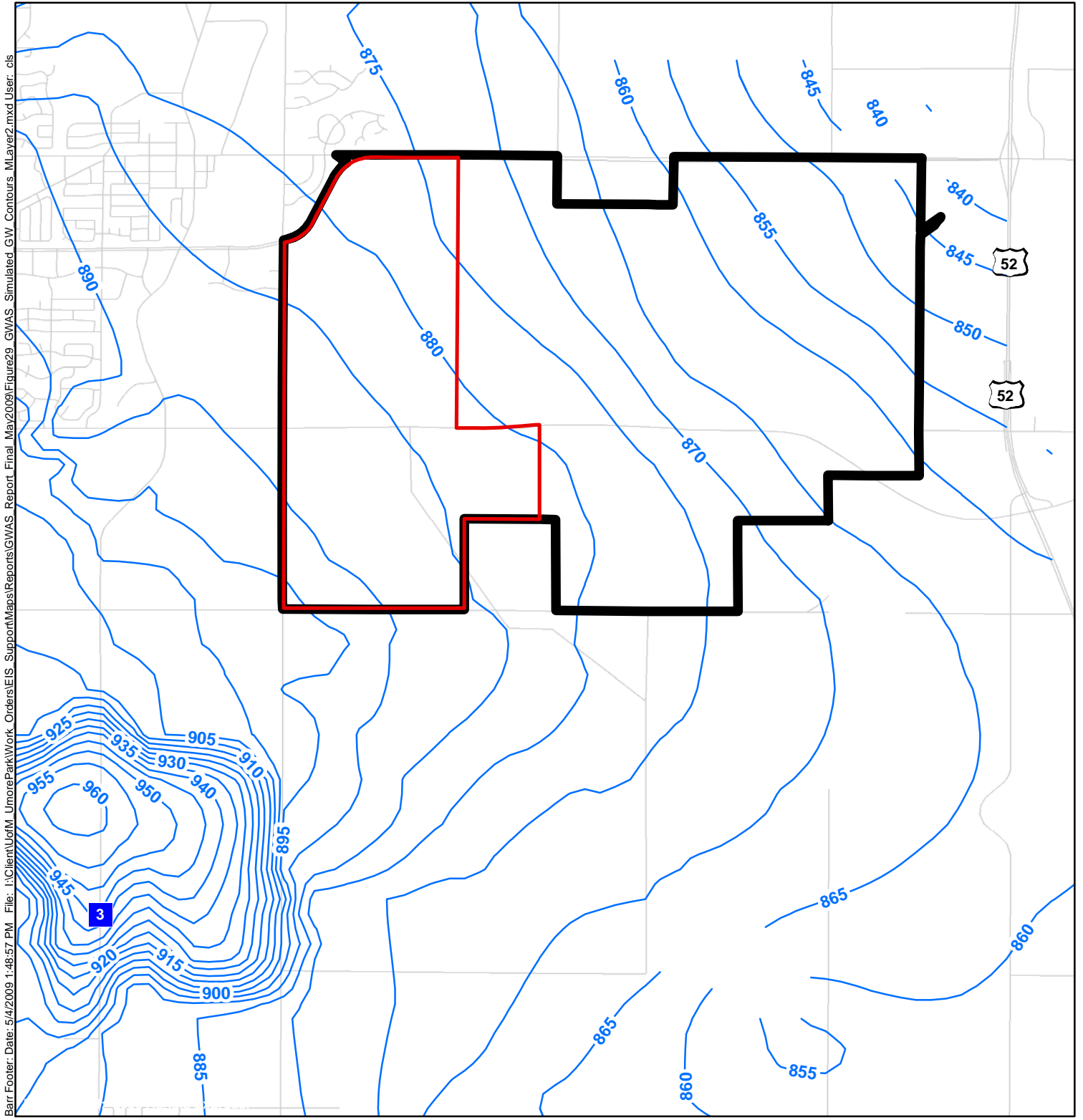


Figure 28

SIMULATED GROUNDWATER
CONTOURS
MODEL LAYER 1
QUATERNARY

Groundwater Assessment Report
UMore Mining Area
Dakota County, MN





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- UMore Mining Area (UMA)
- UMore Park Boundary
- Head Contour (Contour Interval = 5 ft)

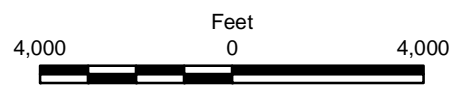
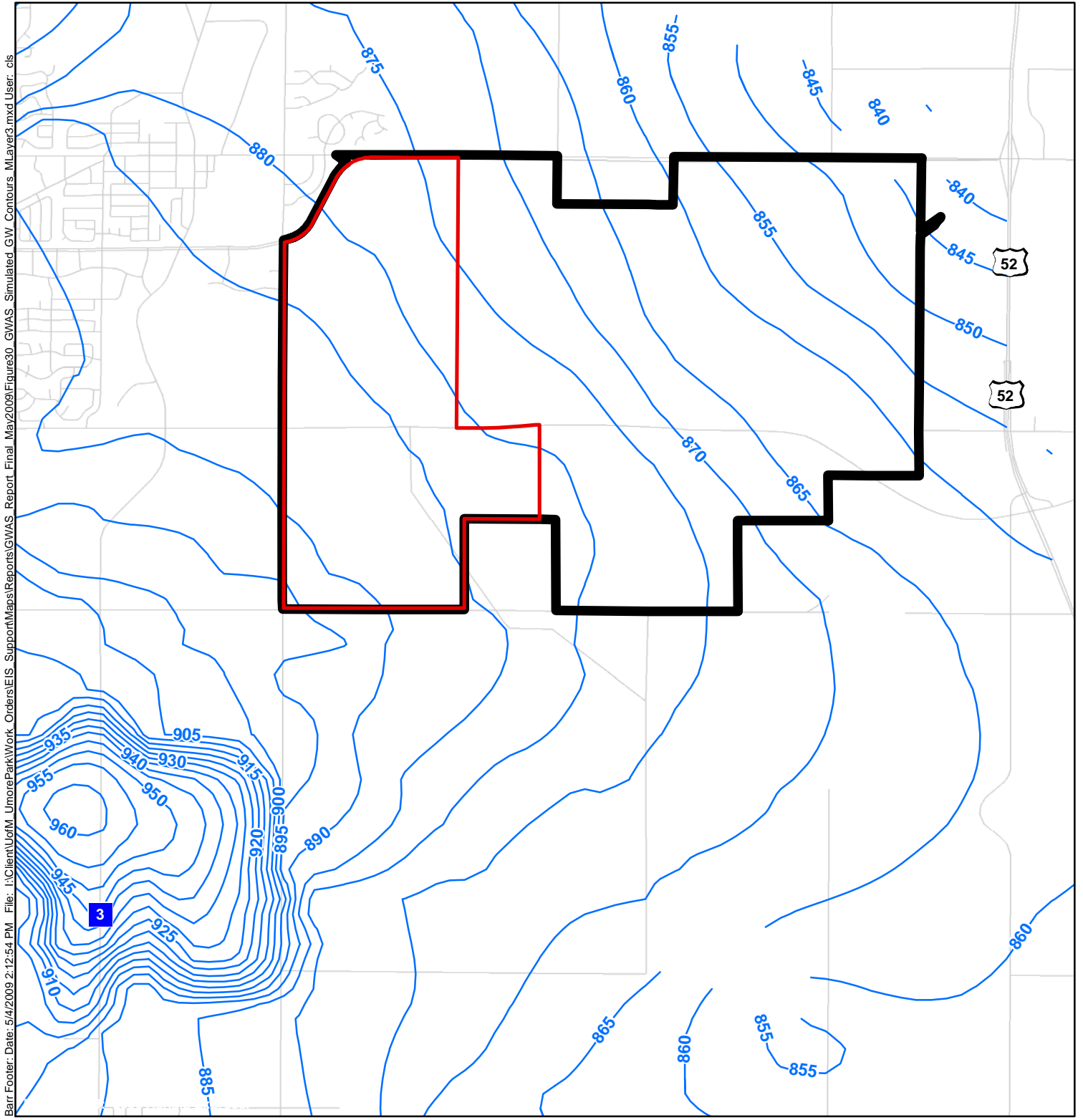


Figure 29

SIMULATED GROUNDWATER
CONTOURS
MODEL LAYER 2
QUATERNARY

Groundwater Assessment Report
UMore Mining Area
Dakota County, MN





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- UMore Mining Area (UMA)
- UMore Park Boundary
- Head Contour (Contour Interval = 5 ft)

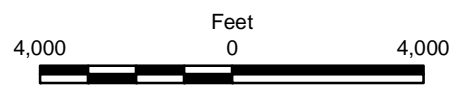
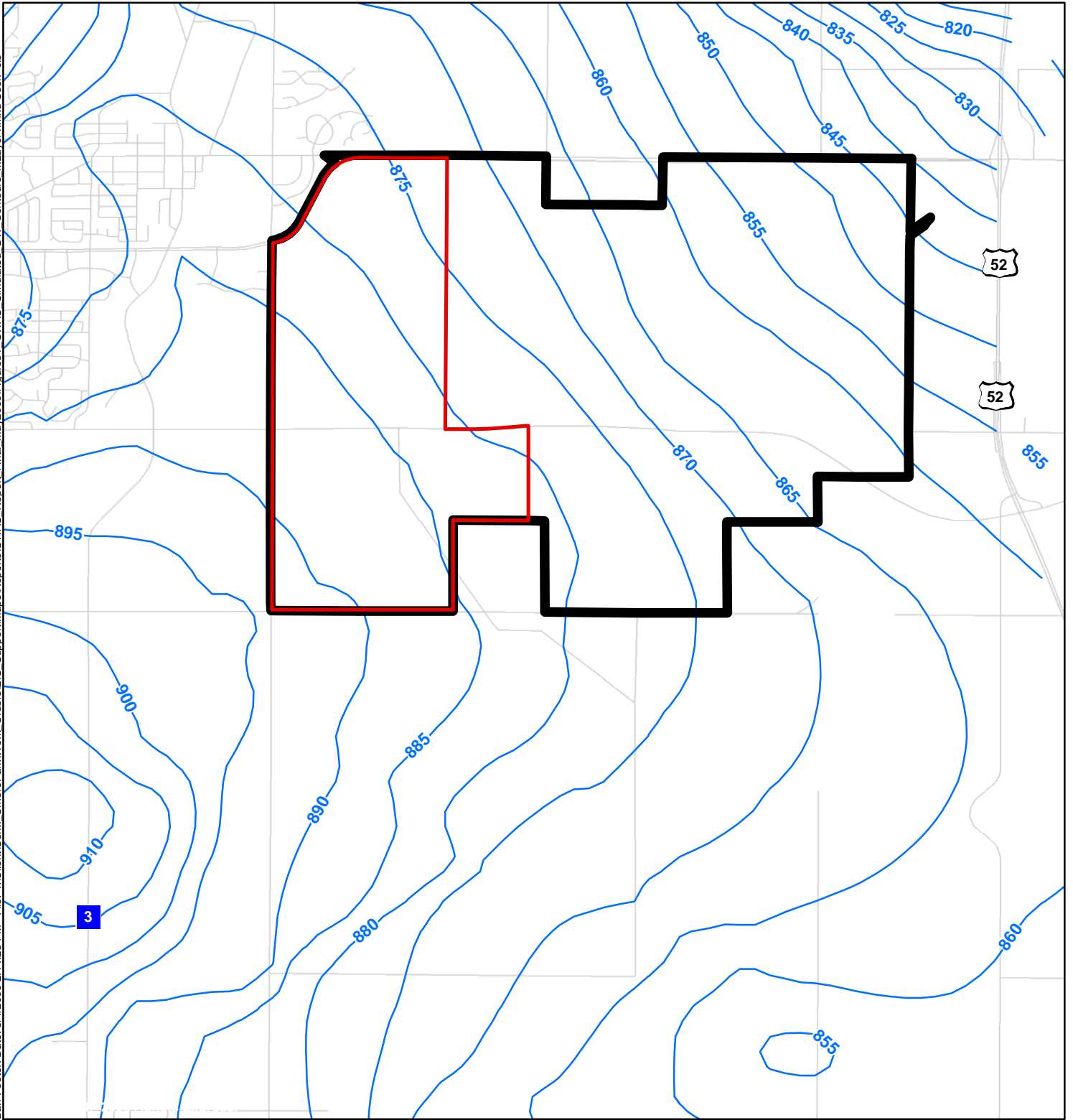


Figure 30

SIMULATED GROUNDWATER
CONTOURS
MODEL LAYER 3
QUATERNARY

Groundwater Assessment Report
UMore Mining Area
Dakota County, MN








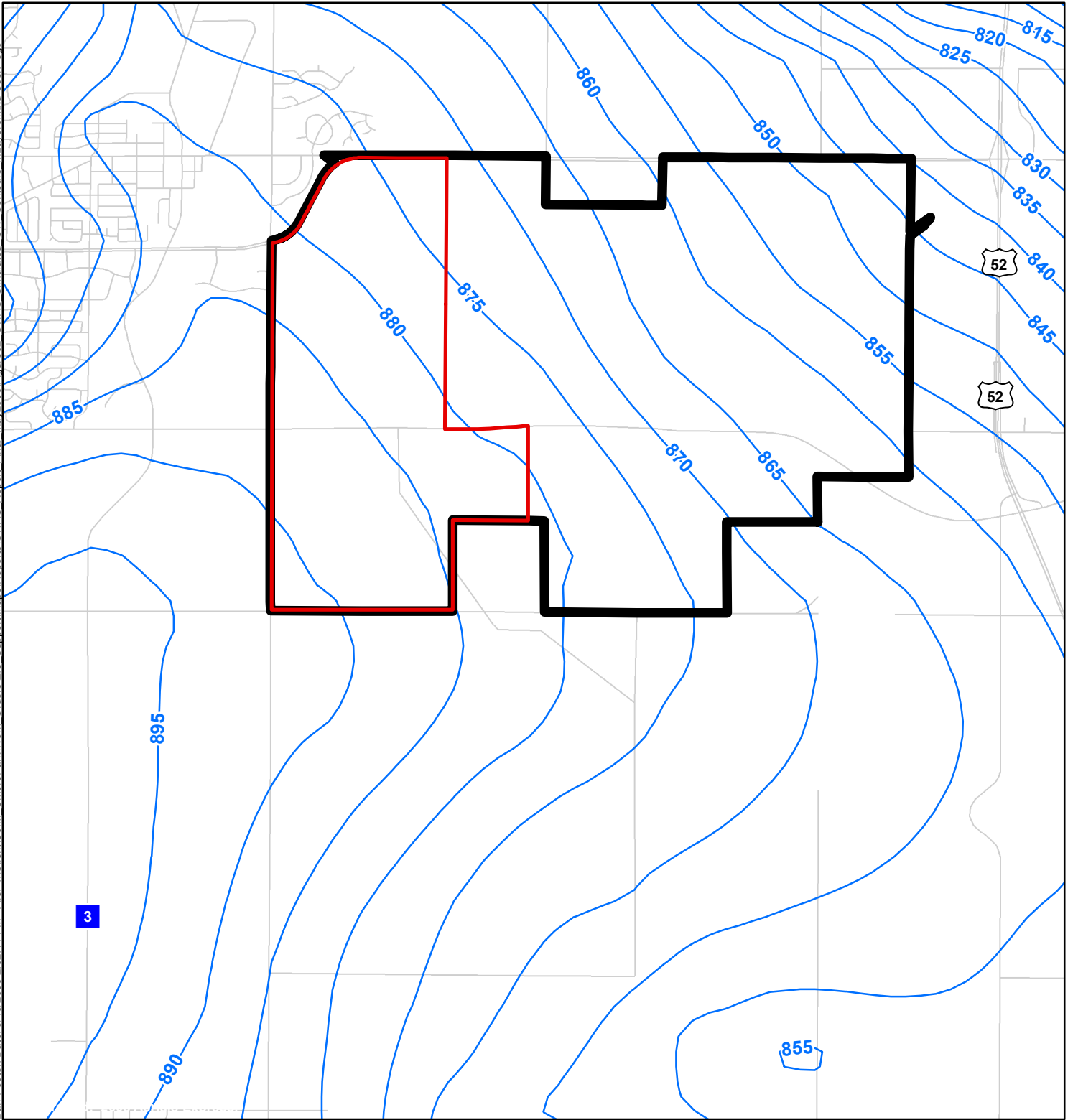
-  Umore Mining Area (UMA)
-  Umore Park Boundary
-  Head Contour (Contour Interval = 5 ft)



Figure 31
SIMULATED GROUNDWATER
CONTOURS
MODEL LAYER 4
QUATERNARY & ST. PETER
SANDSTONE (WHERE PRESENT)
Groundwater Assessment Report
Umore Mining Area
Dakota County, MN








-  UMore Mining Area (UMA)
-  UMore Park Boundary
-  Head Contour (Contour Interval = 5 ft)



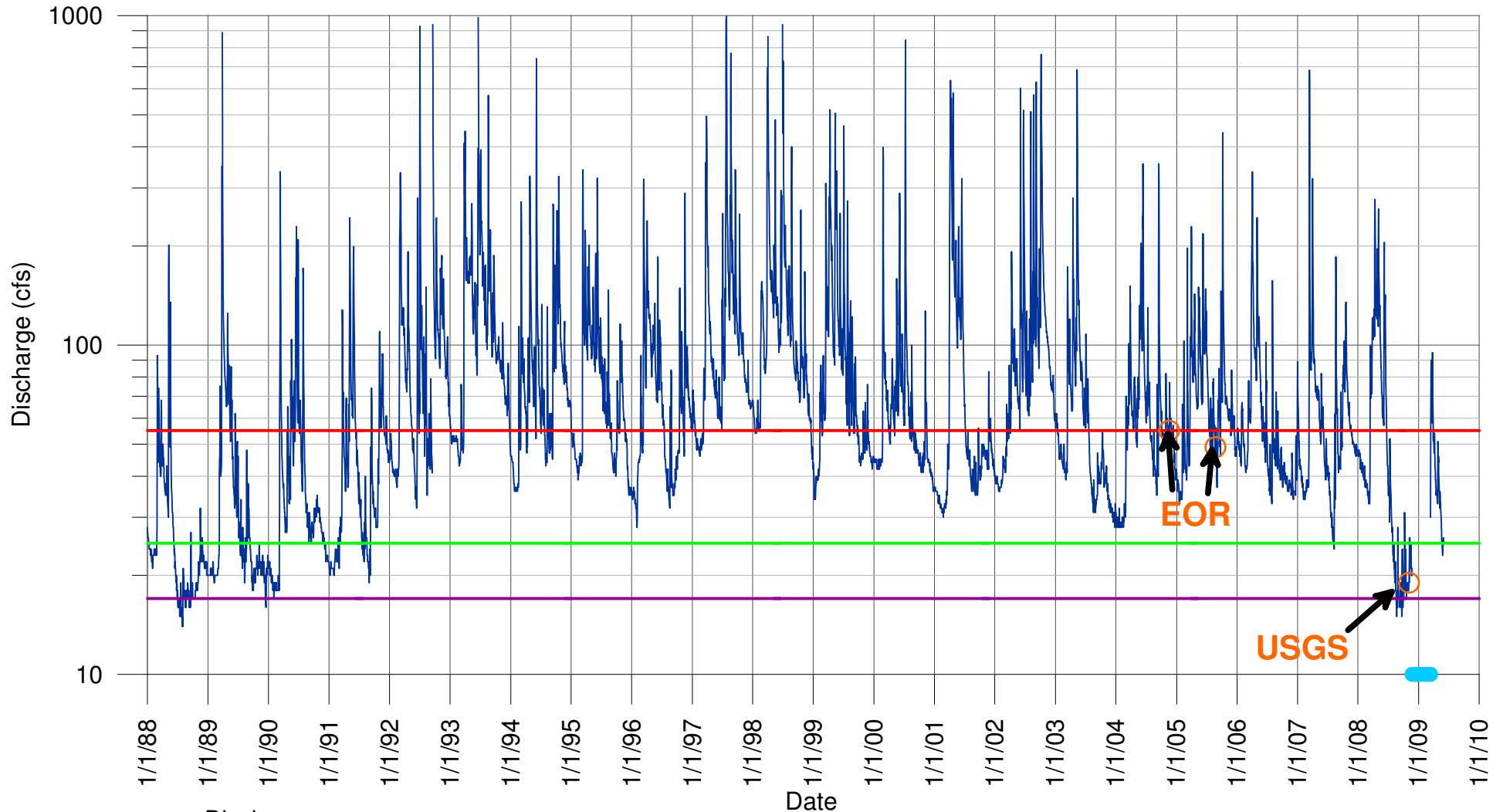
Figure 32

SIMULATED GROUNDWATER
CONTOURS
MODEL LAYER 5
PRAIRIE DU CHIEN GROUP
(WHERE PRESENT)

Groundwater Assessment Report
UMore Mining Area
Dakota County, MN

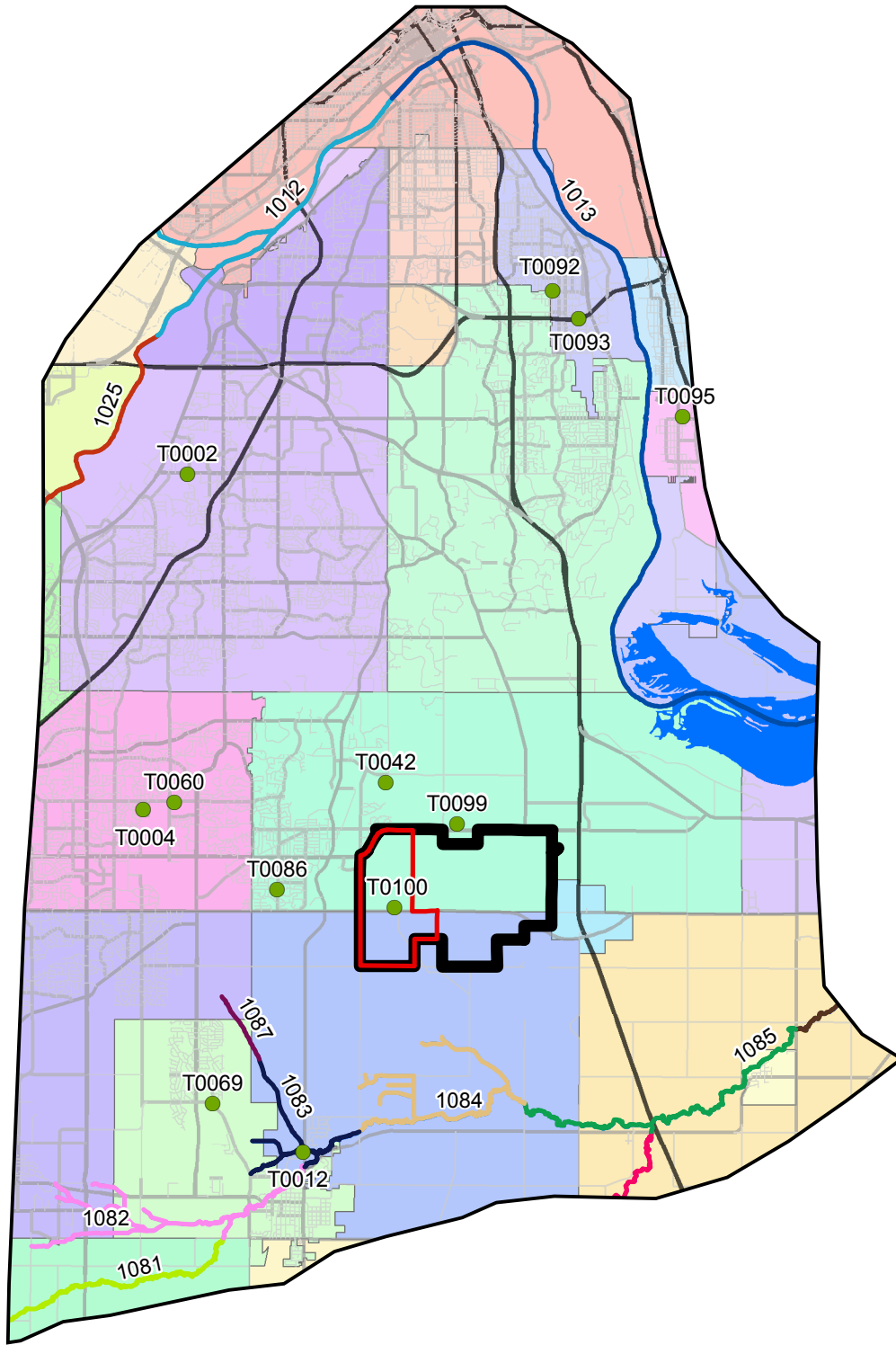


Figure 33
Daily Mean Stream Discharge
Vermillion River near Empire, MN
USGS Station 05345000



- Discharge
- Median (record shown)
- 10th Percentile (record shown)
- 1st Percentile (record shown)
- Flow at station affected by ice

EOR data collected on November 17, 2004 and August 22-24, 2005 (EOR, 2007)
 USGS data collected on November 3, 2008 (Cowdery, 2009)






-  Umore Mining Area (UMA)
-  Umore Park Boundary
-  Transmissivity Targets

Figure 34

BASEFLOW REACHES & TRANSMISSIVITY TARGETS

Groundwater Assessment Report
Umore Mining Area
Dakota County, MN

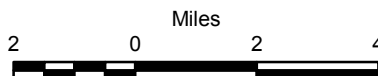
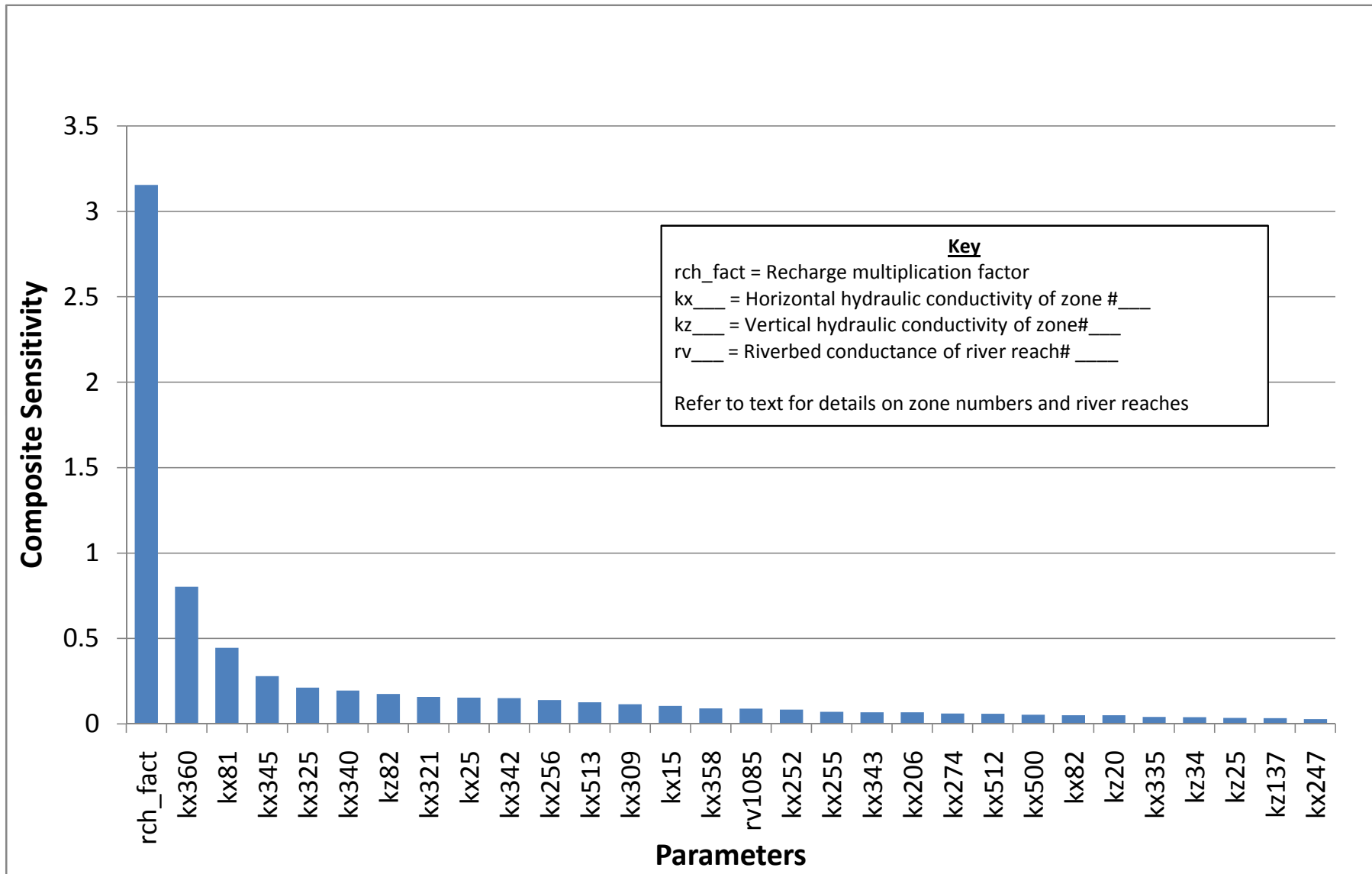
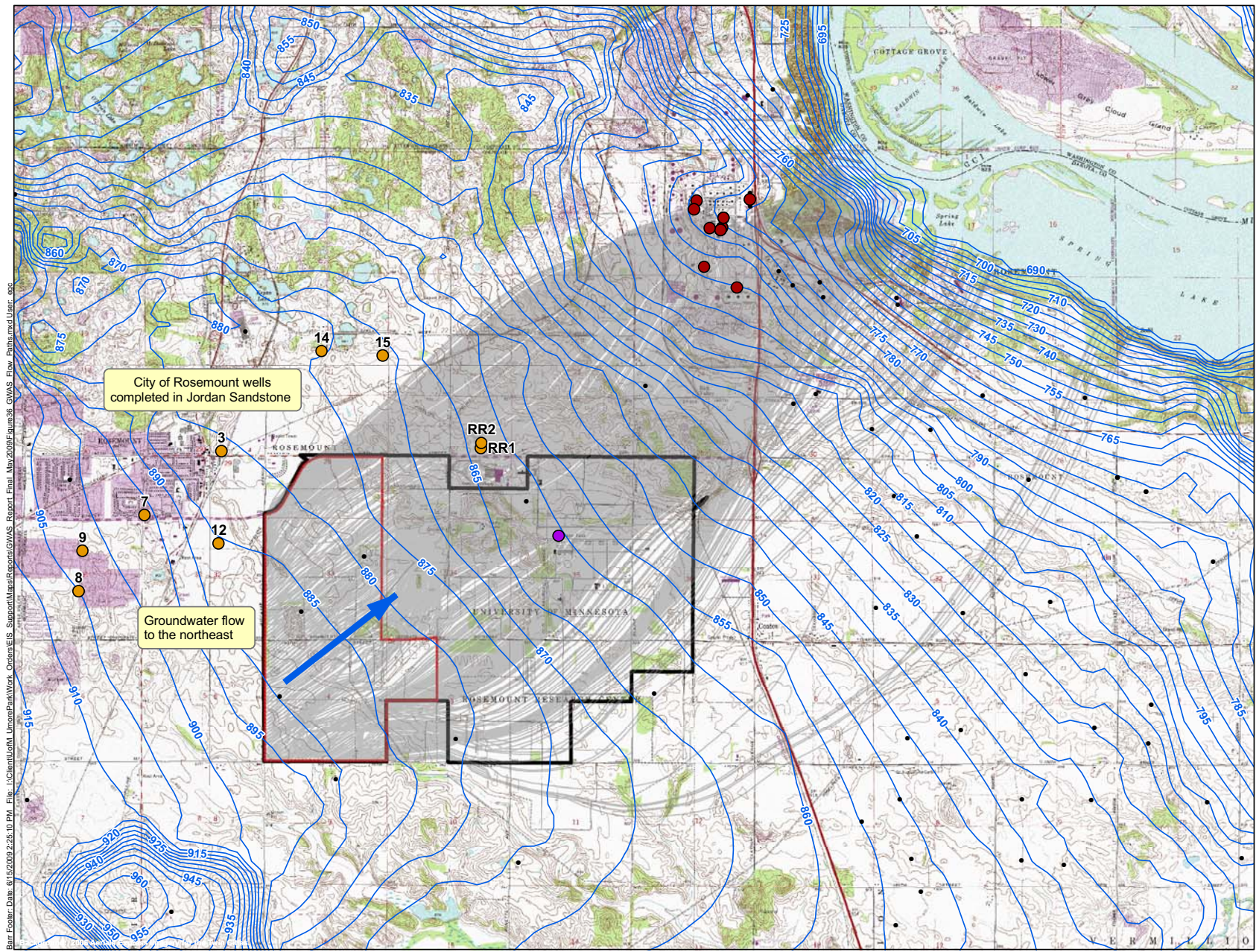


Figure 35
Parameter Sensitivities





- Wells**
- Flint Hills Resources
 - U of M (CJDN-CSTL)
 - City of Rosemount (CJDN)
 - Additional Supply Wells In Model
- Flow Lines
- Groundwater Contours (ft)
- UMore Mining Area (UMA)
- UMore Park Boundary
- Source: MnDOT, Barr, Dakota County, SEH, HKGI, USGS topographic map background downloaded from the U.S. Department of Agriculture, Natural Resources Conservation Service.

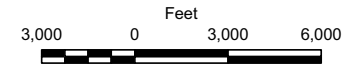
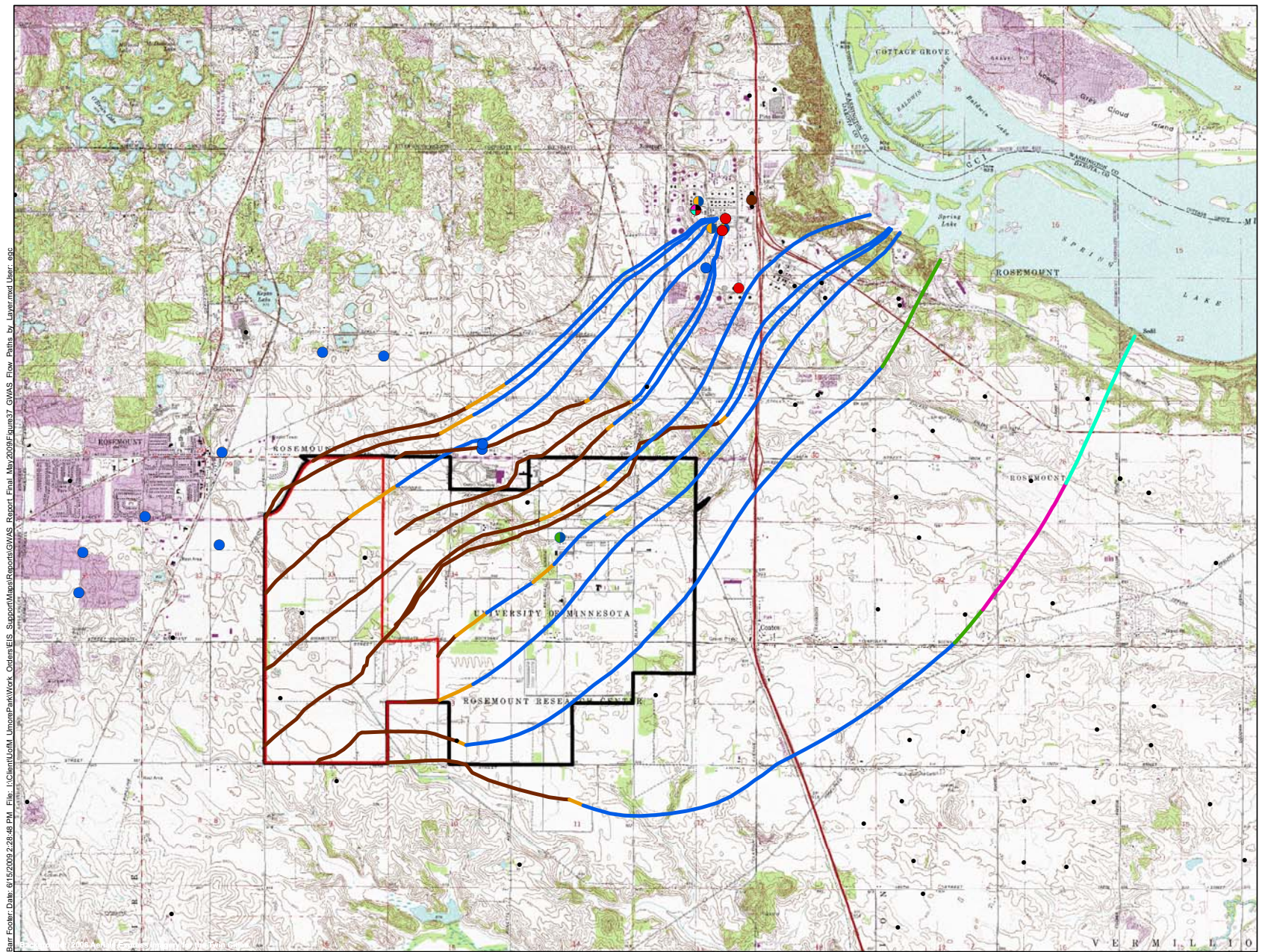


Figure 36
 MODEL-DERIVED
 FLOW PATHS FROM
 UMA BOUNDARY
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



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- Wells of interest by aquifer unit**
- Quaternary
 - OPDC - CJDN
 - CJDN
 - CJDN - CSTL
 - CFRN - CMTS
 - CMTS
 - Additional Supply Wells In Model
- Wells of Interest by Aquifer Unit**
- Quaternary - OSTP
 - OPDC
 - CJDN
 - CSTL
 - CFRN
 - CIGL
 - UMore Mining Area (UMA)
 - UMore Park Boundary

Source: MnDOT, Barr, Dakota County, SEH, HKGI.
 USGS topographic map background downloaded from the U.S. Department of Agriculture, Natural Resources Conservation Service.

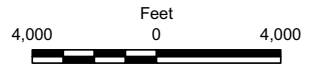


Figure 37

SELECTED FLOW PATHS BY LAYER

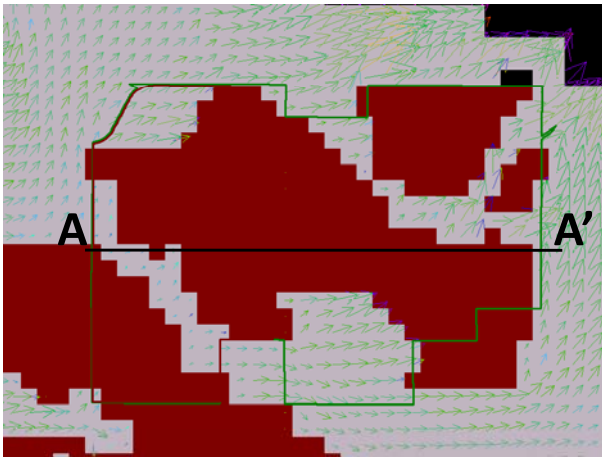
Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN



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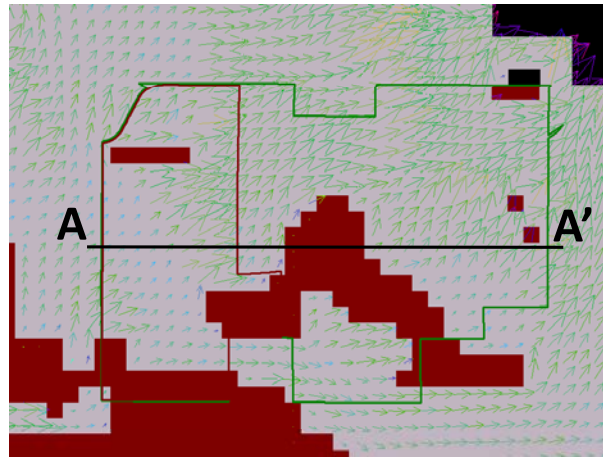
Figure 38
 Groundwater Flow Vectors
 Groundwater Assessment Report
 UMore Mining Area
 Dakota County, MN

Model Layer 2



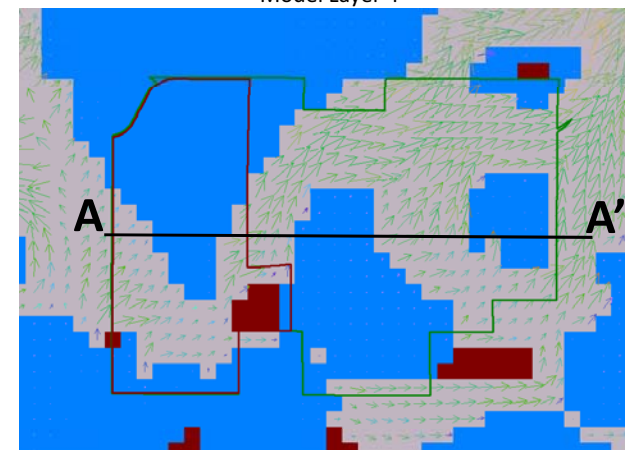
- Groundwater flow around till to northwest and southeast.
- Groundwater flow towards till flows under till through lower outwash and bedrock.
- Vectors within the till are too small to be visible at this scale.

Model Layer 3

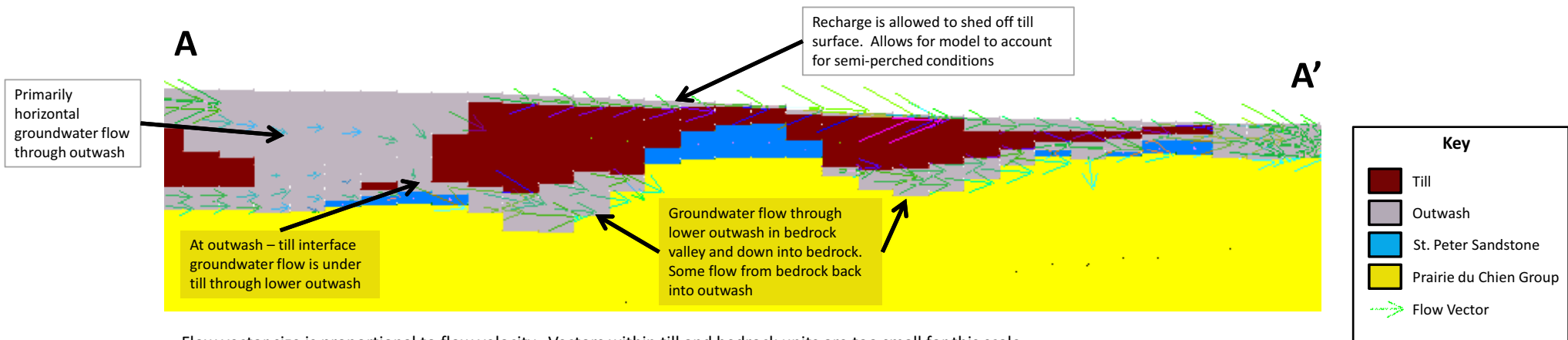


- Groundwater flow in north-central part of site is under till within lower outwash unit.

Model Layer 4



- Active groundwater flow through outwash filled bedrock valley.
- Vectors within the St. Peter Sandstone are too small to be visible at this scale.



Flow vector size is proportional to flow velocity. Vectors within till and bedrock units are too small for this scale. Flow vectors vertically exaggerated.