

REPORT

**WELLHEAD PROTECTION PLAN
PART I**

WHITE BEAR TOWNSHIP, MINNESOTA

**Date: July 23, 2007
Project No. 13707.000**

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PUBLIC WATER SUPPLY PROFILE

PUBLIC WATER SUPPLY

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GENERAL INFORMATION

UNIQUE WELL NUMBER(S) 226570, 226571, 676446, 224679, 226572,
151596, 596636

SIZE OF POPULATION SERVED Approximately 11,800

COUNTY Ramsey County

DOCUMENTATION LIST

<u>STEP</u>	<u>DATE PERFORMED</u>
Date MDH Notice Given (4720.5310, subp. 3)	_____
Mandatory Completion Date (4720.5310, subp. 3)	June 28, 2008
Plan Manager Designated (4720.5300, subp. 2)	_____
Plan Notice Sent to Local Units of Government (LUG) and MDH (4720.5300, subp. 3)	_____
Scoping 1 Meeting Held (4720.5310, subp. 1)	June 28, 2006
Scoping Decision Notice Received (4720.5310, subp. 2)	July 20, 2006
Aquifer Test Plan (ATP) Submitted (4720.5320, subp. 1)	2001
ATP Approval Review Notice Received From MDH (4720.5320, subp. 2)	_____
Delineation and Vulnerability Assessment (DVA) Submitted (4720.5205, 4720.5210)	July 23, 2007
DVA Approved Review Notice Received from MDH (4720.5330, subp. 2)	_____
WHPA and DWSMA Area Delineation and Vulnerability Assessment Submitted to LUGs (4720.5330, subp. 6)	_____
Public Information Meeting Held (4720.5330, subp. 7)	_____
Meeting with LUGs Held (4720.5300, subp. 3)	_____

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I. EXECUTIVE SUMMARY

This Report documents the delineation of Wellhead Protection Areas (WHPA) for the drinking water supply wells operated by White Bear Township (Township). Wellhead protection helps to prevent man-made contaminants from entering drinking water supply wells. Areas have been delineated in accordance with Minnesota Rules, Parts 4720.5100 to 4720.5590, which are under the jurisdiction of the Minnesota Department of Health (MDH). Leggette, Brashears & Graham, Inc. (LBG) was contracted by TKDA to complete the groundwater flow model and the associated WHPA delineation for this report. The WHPAs were delineated using MODFLOW (a numerical groundwater flow model) and the particle-tracking module, MODPATH. Findings in this Report are the result of collaboration between the Township, TKDA, LBG, and the MDH.

The Township is located on the west side of White Bear Lake in the north eastern portion of Ramsey County. The geologic units of interest in the vicinity of the Township and surrounding area consist of Quaternary-Aged glacial deposits that are underlain by Paleozoic-Aged bedrock including the St. Peter Sandstone, Prairie du Chien Group, Jordan Sandstone, and the underlying lower confining St. Lawrence Formation. Township Well Nos. 2A and 3 through 6 are completed in the Prairie du Chien and Jordan aquifers, and Well No. 1 is completed only in the Jordan aquifer with some possible contribution from below the St. Lawrence. Well No. 2 is now designated for emergency use only.

In eastern Ramsey and western Washington Counties, ground water is encountered in the Quaternary and bedrock aquifers, with the flow direction being generally from northeast to southwest toward the Mississippi River, which serves as a local and regional hydrologic discharge point for the flow systems. A model was developed by Ramsey Soil and Water Conservation District (RSWCD) personnel in 2003 to represent the unconsolidated, St. Peter, Prairie du Chien, and Jordan aquifers. The local model domain was divided into a three-dimensional, non-uniform grid with 376 rows, 414 columns, and 4 active layers.

The particle-tracking package, MODPATH, was used in conjunction with the calibrated flow model to create the 10-year time-of-travel pathlines necessary for partially delineating the WHPAs for the Township wells. Due to fracture flow conditions in the Prairie du Chien aquifer, a fracture analysis was also completed following MDH guidelines and composite capture zones were delineated. The composite capture zones were used to delineate the final WHPA for each well. A combined pumping rate from all wells of approximately 6,725 m³/day (1,235 gallons per minute [gpm] or 1.78 million gallons per day) was applied based on 2001 to 2005 water usage and the projected water demand, following the Minnesota Department of Health (MDH) guidelines.

In accordance with MDH guidance documents, the vulnerability of each Township well was based on the following six categories: Minnesota Department of Natural Resources (DNR) geologic sensitivity rating, casing integrity, casing depth, pumping rate, isolation distance from contaminant sources, and chemical and isotopic information. As a result of this rating system, all Township wells are considered vulnerable due to either tritium detections or total well vulnerability scores in excess of 45 points. The associated vulnerability in the vicinity of the Township wells and across the Drinking Water Supply Management Area (DWSMA) is very low to high.

A complete description of the modeling is detailed later in this Report. From the modeling results, a WHPA was delineated for all of the Township's wells. A DWSMA was established by overlaying the WHPAs over a map of the area. Property lines, roadways, and major bodies of water were used to delineate this area. Figure No. 2 shows the locations of all seven Township wells, Figure No. 12 shows the WHPA, and Figure 13 shows the final DWSMA.

II. DATA ELEMENTS AND ASSESSMENT (4720.5200)

A. REQUIRED DATA ELEMENTS

1. Physical Environment Data Elements

Physical data includes natural and man-made features that may have an influence on areas surrounding the wellhead, and ultimately the well itself. Whether or not an aquifer is confined throughout the area determines the value to the WHP effort of using specific elements.

- a) Precipitation. Recharge was considered in some areas of the model. More discussion on this will be included in the modeling section of this report.
- b) Geology. Data gathered from well logs and regional studies were used to construct a geologic map along with descriptions of the geology including aquifers, confining layers, recharge areas, discharge areas, and any sensitive areas.
- c) Soils. Soil characteristics influenced the subsequent delineation of the wellhead protection areas.
- d) Water Resources. Water bodies, watershed areas, and their characteristics did not influence the subsequent delineation of the wellhead protection areas due to their disconnect with the bedrock aquifers.

2. Land Use Data Elements

Regardless of whether an aquifer is unconfined or not, land use is always a factor in determining and managing the DWSMA around the WHPA. Unconfined aquifers, however, are particularly vulnerable to land use factors since they can enable the downward migration of groundwater.

- a) Land Use. Parcel boundaries, political boundaries, land surveys, and land use maps were used to establish a Drinking Water Supply Management Area for the Township wells.
- b) Public Utility Services. Maps of transportation routes, storm and sanitary sewers, water supply systems, petroleum and gas pipelines, and construction and maintenance records of public water supply wells were used to establish a DWSMA. This data will also be used in Phase II planning activities.

Well logs and pumping records were used for modeling and the vulnerability assessments.

3. Water Quantity Data Elements

Levels in lakes and streams can have an impact on an aquifer that is unconfined if there is a geologic connection between the two. From the review of geologic cross sections and select well logs, it does not appear that surface waters are in direct connection hydraulically with the bedrock aquifer. However, surrounding high capacity wells in the same aquifer can influence each other if the withdrawal rate is large enough.

- a) Surface Water Quantity. Surface water bodies did not influence the subsequent delineation of the wellhead protection areas, but were still included in the model.
- b) Groundwater Quantity. A list of high capacity wells in the area was obtained and is shown in Tables 1 and 2. Twenty other wells, besides the seven Township wells, were identified within the model domain. See Figure 2.

4. Water Quality Data Elements

Water quality is an indication of aquifer vulnerability.

- a) Surface Water Quality. Since surface water in the vicinity of the Township is not in direct hydraulic connection with the subject bedrock aquifers, water quality was not reviewed.
- b) Groundwater Quality. A summary of groundwater bacteriological tests and chemical tests, both organic and inorganic, has been

included as part of the Vulnerability Assessment of the wells. Tritium has been detected in Township Wells 1 and 6 and has not been tested for in the other wells. Tritium is an indicator of vertical migration travel time and aquifer vulnerability. The presence of tritium indicates that some portion of the water entered the aquifer(s) after 1953. Nitrate was also detected at low concentration in Well No.5 and not detected in the remaining wells.

B. ASSESSMENT OF DATA ELEMENTS

1. Use of the Wells

The Township wells provide all the water for the distribution system for White Bear Township and portions of the City of North Oaks. The Township currently has six active water supply wells (Well Nos. 1, 2A, 3, 4, 5, and 6), located in and around the Township (Figure 1). In the future, Well No. 2 is to be for emergency use. Well No. 2A was constructed to replace Well No. 2 and the past pumping data for Well No. 2 was applied to Well No. 2A as no change in its use is anticipated. Well construction details and well logs are in Appendix II. Past and projected pumping rates are presented in Table 1.

2. Quality and Quantity of Water Supplying the Public Water Supply Wells

Water samples are regularly obtained from the Township wells and tested for regulated contaminants. Report summaries from the past five years show no reports of contamination in a Township well. Well Nos. 1 and 6 have tested positive for tritium with the other wells not tested. Nitrate was detected at low concentration in Well No. 5 and tested for but not detected in the remaining wells.

Pumping records submitted to the Minnesota Department of Natural Resources were used to identify the extraction rates of the Township wells. Pumping data for the Township's six wells is included in the Appendix.

3. The Land/Groundwater Uses in the Drinking Water Supply Management Area

Land and groundwater uses within the DWSMA may have effects on the aquifer used by Township wells. The vulnerability assessment section of this report provides more detail on the subject of land use conclusions.

III. WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT
AREA DELINEATION (4720.5205)

A. BOUNDARIES, WELLHEAD PROTECTION AREA MAP

A Map of the WHPA is shown in Figure 12.

B. DOCUMENTATION

1. Physiographic and Hydrogeologic Setting

The geology in the vicinity of the Township consists of Quaternary-Aged glacial and post-glacial deposits that are underlain by Paleozoic-Aged bedrock. The glacial deposits consist of Superior Lobe sand and silt lacustrine deposits, till, and outwash. These are underlain by Pre-Late Wisconsinan Keewatin and Grantsburg Sublobe till, outwash and sandy lacustrine sediment. The Superior Lobe, due to its higher sand content, is generally not considered an effective hydraulic barrier. However, the underlying till deposits are an effective barrier as are the uppermost bedrock Glenwood or basal St. Peter shales.

Bedrock geology is presented in plan view on Figure 3 with unconsolidated and bedrock geology presented in cross section on Figure 4. Several buried bedrock valleys expose the surface of the St. Peter Sandstone and Prairie du Chien Group.

Ground-water flow in the uppermost bedrock aquifers generally to the southwest as shown by Figure 5, which is consistent with previously published data in the Ramsey County Geologic Atlas (MGS, 1992). The map of the Prairie du Chien–Jordan potentiometric surface was created from water level data obtained from the Minnesota County Well Index (CWI). Since the water level measurement dates varied by decades, a polynomial regression was used using Surfer 7 to contour the dataset.

An extensive discussion on regional and local geology and hydrogeology is also presented in Appendix I in the Draft Part I Wellhead Protection Plan Submittal (RSWCD,2003).

Well Nos. 2A and 3 through 6 are completed in the Prairie du Chien and Jordan Aquifers. Well No. 1 is completed in the Jordan sandstone only. Well No. 2 is only for emergency use.

2. Delineation Criteria.

The following discussion represents a summary of the five criteria for delineating the WHPA, which are specified in MR 4720.

- a) Time of Travel. Pathline analysis, using a 10-year time of travel, were used when simulating ground-water movement in the Prairie du Chien and Jordan aquifers which supply all Township wells. In addition, the fracture flow delineation method developed by the MDH (MDH, 2005) was implemented to calculate fixed radii and upgradient extension delineations for each well.
- b) Aquifer Transmissivity. The transmissivity (T) of an aquifer is defined as the rate at which water is transmitted through a unit width of aquifer under a hydraulic gradient. It equals the hydraulic conductivity multiplied by the aquifer thickness. An aquifer pumping test was performed in 2001 using Township Well No. 3, which lies between White Bear and Bald Eagle Lakes. Township Well Nos. 4 and 6 (west and east, respectively) were used as observation wells. Several interpretations of the data were made, but the range of values recommended by MDH indicated transmissivities in the area range from 5,185 to 6,193 m²/d. This translates to a hydraulic conductivity of between 76.6 and 91.5 m/d for the combined Prairie du Chien - Jordan aquifer. The value for the Prairie du Chien and Jordan aquifers used in the Minnesota Pollution Control Agency's Metro Model is 12 m/d (Seaberg and Hansen, 2000). These two values would provide the range used for the Prairie du Chien - Jordan aquifer in the flow model.
- c) Daily Volume of Water Pumped. The daily volume selected for each well used in the WHPA was based on MR 4720.5510,

subpart 4 and MDH guidelines, which state that volumes used in the WHPA delineation can be determined from either 1) the projected use of each well as a percent of the total system, or 2) the greatest annual volume of water used over the previous 5 years, whichever is greater. Historical usage from 2001 to 2005 was used to determine the pumping rates for each well to delineate the WHPA. The Township's historical pumping records from 2001 to 2005 indicate that the sum of the maximum annual usage for each well was 649.1 million gallons per year (mgy) (approximately 2.46 million cubic meters per year [m³/yr]) based on the maximum rates for each well over the 5-year period, or approximately 1.78 million gallons per day (mgd) (approximately 6,725 cubic meters per day [m³ /day]). The projected pumping rates for each well used in the model are listed in Table 1.

d) Hydrologic Boundaries. Hydrologic boundaries that affect the delineation criteria are:

- (1) Surface water features. The Mississippi River is the local and regional discharge point of the flow systems of interest, therefore, the River affects the direction of ground-water flow and was included in the regional flow model as a constant-head boundary. Area lakes near the Township Wells were included as river boundaries and lakes near the edge of the local model were included as constant-head boundaries.
- (2) Geological boundaries. Well records from the CWI, as well as information from county geologic atlases were used in the development of the conceptual hydrogeologic model and in the vulnerability assessments.
- (3) High capacity wells. LBG obtained ground-water appropriation permit data from the Minnesota Department of Natural Resources (DNR) and determined there are 20 high capacity wells other than the Township's wells located

in the model domain, whose pumping could influence ground-water flow and/or create negative boundary conditions. These wells were included in the model using their historical maximum pumping rates from the previous 5 years (2001 to 2005), as obtained from the DNR Water Appropriations Permit Program website (www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html). The high-capacity wells are illustrated on Figure 2, and summarized in Table 2.

- (4) Overland Drainage. Surface runoff is directed toward local streams, wetlands and lakes.

3. Delineation Method.

The ground-water flow field was determined by using MODFLOW. Simulated heads were compared to static water levels obtained from the calibration data sets used in earlier models. Static levels from 1,075 wells screened in various geologic units were used for calibrating the ground-water flow model.

- a) Ground-Water Flow Models. The models used in this project were originally developed by the Ramsey Soil and Water Conservation District (RSWCD) in 2003 and these were based on even earlier models. The draft report discussing their development can be found in Appendix I. The previous modeling effort used two models; a large, regional-scale model with distant and well-defined natural boundaries and a smaller, local-scale model. The purpose for this ‘telescopic mesh refinement’ is to use the large model with the well-defined boundaries to establish the boundaries for the smaller, more refined, local model. For the purposes of this study, the regional-scale model was not modified and minor modifications were made to the local model to improve accuracy, achieve a better calibration, and incorporate updated information in the form of more recent pumping rates and any new wells that may have been installed since 2003. The regional and

local model domains are presented on Figure 6. The local model domain was divided into a three-dimensional, non-uniform grid with 376 rows, 414 columns, and 4 active layers. The model grid in the vicinity of the Township wells is presented on Figure 7.

- (1) Boundary Conditions. Modifications to the model's boundary conditions included minor changes to the constant-head conditions applied to the northeastern bounds to more accurately reflect ground water levels in that area. Also, the lakes in the area of the wells were changed from constant-head cells to river cells so as to better simulate the interaction between ground water and surface water in these areas. A re-analysis of the 2001 pumping test results necessitated a change in the hydraulic conductivity values for the Prairie du Chien and Jordan aquifers in the area of interest. Finally, all of the high-capacity wells were redefined using the highest pumping rate for the period 2001-2005, with any post-2003 wells added.
- (2) Discretization of Aquifer Properties. Discretization of aquifer properties involves assigning initial values to each cell in the model domain. Hydraulic properties input for this model included horizontal components for hydraulic conductivity (k_x and k_y), vertical hydraulic conductivity (k_z), specific yield (S_y), specific storage (S_s), and effective porosity (n_e) (required for MODPATH to calculate linear flow velocity).

The initial hydraulic conductivities for the model were those that were used in the original RSWCD model. Some of the conductivity values in the surficial drift aquifer were changed to better reflect actual conditions and improve the calibration. The values for the Prairie du Chein and Jordan aquifers were also modified to reflect the pumping test

results. The porosity values for the Prairie du Chien and Jordan aquifers were reduced from a global 0.30, to 0.056 for the Prairie du Chien and 0.25 for the Jordan.

4. Delineation Results.

- a) Calibration and Uncertainty. The goal of numerical model calibration is to obtain a reasonable correlation between the simulated model results and observed field data. The calibration process is completed by running several steady-state simulations and comparing calculated heads to the measured head data at known calibration points within the model domain. For the local model calibration, 1,075 well locations were used for comparison. These wells are private or municipal and are completed in the glacial sediments and bedrock units.

Figure 8 presents the calibration wells and simulated potentiometric contour map for steady-state conditions in the Prairie du Chien - Jordan aquifer. Flow direction is variable, but generally flows to the southwest. Using the head values from the 1,075 calibration well locations, an error analysis on the steady-state model was performed. Figure 9 presents a plot of the results of this analysis indicating that the overall root mean squared (RMS) error for the unconsolidated and bedrock aquifers is approximately 4.9 percent. Most of the wells are completed in the St. Peter Sandstone, and Prairie du Chien and Jordan aquifers (layers 3 and 4). In general, a RMS of approximately 10 percent or less is acceptable (National Ground Water Association, 1998).

The calibration data (Figure 9) shows a reasonably close correlation between measured and calculated head values. While the model is based on a large amount of data, the head measurements used in the calibration are single measurements that are listed on each well record, and were collected during different seasons over several decades.

More extensive observation data collected within the same general time period, and more accurate, site-specific T values throughout the model domain could improve calibration and model confidence.

In areas where fracture flow is likely, the uncertainty can be unacceptably high. To address this situation, the MDH had developed a procedure to minimize the uncertainty associated with fracture flow conditions. As defined in the MDH guidance (MDH, 2005), delineation techniques were used to determine fixed radii and upgradient extensions for each of the Township wells.

A sensitivity analysis was begun as part of the modeling effort, but it became apparent that any changes in the modeled capture zones for the wells would still fall completely within the calculated capture zones from the fracture analysis.

- b) WHPA Delineation. With the flow fields calibrated, a ground-water pathline analysis and fracture flow analysis were performed to delineate the capture zones and ultimately the WHPA.

The pathline analysis consisted of using MODPATH, a flowpath calculation program, to trace the 10-year capture zone for each of the wells by backtracing 20 flow paths from the wells for a 10-year period (Figure 10).

Township Well Nos. 2A and 3 through 6 are wells that are open to both a porous media aquifer, the Jordan, and a solution weathered or fractured aquifer, the Prairie du Chien. This requires a fracture flow analysis as described by the MDH (MDH, 2005). Township Well No. 1 is open only to the Jordan aquifer; however, the Jordan aquifer is hydraulically connected to the Prairie du Chien with a high likelihood of leakage between the two. This requires a slightly different fracture flow analysis. Both of these analyses are essentially calculations that establish a radial capture zone based on the 10-year volume of water pumped.

Special considerations had to be made for Well Nos. 3 and 6, whose initial fixed radii overlapped. This radial zone is then extended upgradient in the direction of ground-water flow (also plus or minus 10 degrees) to create a conservative wellhead capture area to account for the uncertainties related to fracture flow (Table 3 and Figure 11).

After both the pathline analysis and fracture flow analysis were completed, the capture zones delineated for each method were merged with one another. This concatenation created a final composite WHPA capture zone (Figure 12) for use in delineating the DWSMA.

5. Conjunctive Delineation.

A conjunctive delineation involving the consideration of surface waters in making the final wellhead protection area delineation was not considered necessary for White Bear Township. The reason is that the Township's wells are completed in either the Jordan sandstone, cased at depths of about 300 to 365 feet or in the combined Prairie du Chien – Jordan aquifer, cased at depth of about 175 to 260 feet. While there are significant areas in the DWSMA that are not covered by the St. Peter sandstone, most areas offer some degree of hydraulic separation between the bedrock and the ground surface by clayey till (L-score ranging from 1 to 24), or offer hydraulic separation simply by the distance to bedrock through the unconsolidated materials. An increased depth to bedrock translates to sufficient increases in travel time through the unconsolidated materials; resulting in significant potential attenuation of pathogens and nitrates. MDH water quality support this assertion that no systemic pathogen or nitrate contamination has been reported for White Bear Township (except for a low level nitrate detection of 0.69 mg/l at Well 5 in April 2005) since 1993, when these data started to be archived in computer databases.

Accordingly, the setting offers sufficient hydraulic though either geologic confining material or thickness of unconsolidated materials to render a conjunctive delineation unnecessary (Figure 1 in Appendix IV).

C. BOUNDARIES FOR THE DWSMA.

The criteria used to delineate the DWSMA (Figure 13) are based on public land survey features such as sections, half sections, and quarter sections that encompass the maximum time of travel simulated as defined in MR 4720.5100. In the case of this delineation, the DWSMA encompasses the concatenated capture zone presented on Figure 12. The 10- year pathlines and fracture flow delineation extend across White Bear and Bald Eagle Lakes, however, the DWSMA is not inclusive of the entire lakes because a conjunctive delineation was not necessary due to the lack of hydraulic connection between the lakes and the subject bedrock aquifers. Figure 1 in Appendix IV illustrates laterally extensive clay beneath both lakes.

IV. VULNERABILITY ASSESSMENT

A. WELL VULNERABILITY

The well vulnerability assessment was conducted in accordance with the MDH guidance document, *Assessing Well Vulnerability for Wellhead Protection* (MDH, 1997). A well's vulnerability is scored on a Vulnerability Assessment Worksheet based on the following six categories: DNR geologic sensitivity rating, casing integrity, casing depth, pumping rate, isolation distance from contaminant sources, and chemical and isotopic information.

The DNR geologic sensitivity rating is an empirical value determined by dividing the cumulative thickness of low permeability units (e.g. clay) above the aquifer by 10 (DNR, 1991). The resulting score is termed the "L-score". A higher L-score indicates more low-permeability material above the aquifer, and therefore a lower vulnerability. A low L-score represents higher vulnerability. For example, a rating of L-1 has a higher vulnerability than L-9, because there is less low-permeability material present above the aquifer. This type of assessment is defined by the DNR as Level 3. A Level 3 assessment was conducted for the Township wells since the aquifer is overlain by varying thicknesses of clay. As mentioned above, points are also assigned to casing integrity and depth, pumping rate, isolation distance to contaminant sources, and chemical data, in addition to the geologic sensitivity.

Vulnerability assessment worksheets and the total score of the six vulnerability categories for Well Nos. 1, 2A, and 3 through 6 are presented in Appendix III. Per MDH guidance, any well that receives an assessment rating of 45 points or greater is considered a vulnerable well. Well Nos. 2A, 3, 4, and 6 had vulnerability scores or 45 or greater. Well Nos. 1 and 5 had vulnerability scores of 10 and 40, respectively, but are still considered vulnerable due to the tritium detections in groundwater. Tritium was detected in Well Nos. 1 and 6. Tritium in ground water is a result of nuclear testing and is used as an indicator of post-1953 recharge. Nitrate was detected at low concentration in Well No. 5 and tested for but not detected in the remaining wells.

B. DRINKING WATER SUPPLY MANAGEMENT AREA VULNERABILITY

In the proposed DWSMA, the ground water that supplies the Township wells is from the Prairie du Chien - Jordan aquifer that underlies glacial deposits (Ramsey and Washington County Atlas Series, Atlas C-7 and C-5, respectively). The glacial deposits are composed of Superior Lobe sand and silt lacustrine deposits, till, and outwash. Deposits also consist of Pre-Late Wisconsinan Keewatin and Grantsburg Sublobe till, outwash and sandy lacustrine sediment. The Superior Lobe, due to its higher sand content, is generally not considered an effective barrier to the downward migration of contaminants from grade. Underlain deposits, however, do act as effective barriers where till is present or where Glenwood or basal St. Peter shales are present (Figure 4, and Figure 1 in Appendix IV).

Although the Township wells are constructed in the Prairie du Chien - Jordan aquifer, they may be receiving water laterally that has been recharged from the unconsolidated aquifer in the vicinity of the Township well field, where the Prairie du Chien Group is bisected by bedrock valleys (Figure 3). These erosional features are areas where the bedrock aquifer is in direct contact with the unconsolidated aquifer, therefore, in contact with relatively younger ground water as indicated by the tritium results.

The geologic sensitivity in the vicinity of the DWSMA was previously delineated in the Ramsey and Washington County Geologic Atlases. MDH reviewed 358 CWI lithology logs, and calculated L-scores for each well within the DWSMA with approximate delineations as illustrated on Figure 14. As discussed in Section IV-A the DNR geologic sensitivity rating is an empirical value determined by dividing the cumulative thickness of low permeability units (e.g. clay) above the aquifer by 10 (DNR, 1991). LBG reviewed select logs and concurred with MDH's results, indicating the geologic sensitivity differs from that previously delineated in the local county atlases. The L-score results ranged from 1 to 24; which, indicates much of the DWSMA is underlain by low-permeable material creating hydraulic separation from grade.

Geologic sensitivity was not completed beneath the lakes. As a result, a north-south cross-section was created to illustrate laterally extensive clay beneath both lakes (Figure 1 in Appendix IV), and cross-sections (Figure 4) from the Ramsey

and Washington County Atlas Series (Atlas C-7 and C-5, respectively) were reviewed and illustrated the same.

For the DWSMA vulnerability assessment, and pursuant to MDH guidance (MDH, 1997), all geologic sensitivity ratings were automatically increased by one classification due to the presence of tritium. As a result, the vulnerability in the vicinity of the Township wells and across the DWSMA ranges from very low to high (Figure 15).

V. CONCLUSIONS AND RECOMMENDATIONS

The WHPA delineations for the Township Wells were created using maximum pumping rates and conservative assumptions in the fracture flow delineation. These factors combine to 'build in' a safety factor, which is necessary when attempting to simulate natural systems and their inherent heterogeneity.

While the delineations are considered to be conservative and are based on the best available data, there is some information that could improve the quality of any future re-evaluations. Recommended future tasks include,

- Sample all of the Township Wells for tritium. This will indicate the relative age of the water each of the wells is producing and provide information as to its source.
- The Township Wells and White Bear and Bald Eagle Lakes be studied for stable isotopes of oxygen (O^{18}) and deuterium (H^2) to indicate the possible mixing of lake water with ground water.
- Lastly, studies should be conducted to assess the extent of the clay layer beneath the lakes to determine its full extent and effectiveness as a separating layer between the lakes and deeper ground water.

VI. REFERENCES

Minnesota Geological Survey, 1990. *Geologic Atlas of Washington County, Minnesota*.

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TABLES

Table 1

Municipal Well Pumpage and Pumping Rates used in the WHPA Delineation
 Part I Wellhead Protection Plan
 White Bear Township, Ramsey County, Minnesota

Well	Aquifer	Casing Depth (feet)	Well Depth (feet)	Past Use (MGY)					Projected value used in the WHPA delineation analysis (MGY)	Projected value used in the WHPA delineation analysis (m3/d)
				2005	2004	2003	2002	2001		
1	CJDN	365	445	21.2	30.4	52.2	41.9	55.9	55.9	579.3
2	CJDN	375	435	0.0	0.0	1.7	3.3	2.7	3.3	34.2
2A	OPDC-CJDN	299	420						0.0	0.0
3	OPDC-CJDN	200	372	36.9	13.8	38.7	6.7	26.2	38.7	401.1
4	OPDC-CJDN	263	408	12.9	1.7	6.4	0.9	6.5	12.9	133.7
5	OPDC-CJDN	230	412	280.1	296.4	231.8	238.5	231.9	296.4	3071.9
6	OPDC-CJDN	175	360	190.0	235.0	216.9	183.6	241.9	241.9	2507.1
Totals				541.1	577.3	547.7	474.9	565.1	649.1	6727.3

Notes:

*: Projected use is the maximum annual pumping volume between 2001 and 2005.

CJDN: Jordan

OPDC-CJDN: Prairie du Chien - Jordan

MGY: Million gallons per year

m³/day: cubic meters per day

Values used in the WHPA delineation analysis represent the maximum value of the previous five years.

Maximum annual pumping volume for the municipal system for the past five years.

Projected annual and daily pumping volume for the municipal system.

Table 2

Appropriation Permit Wells in Model Domain -
Wellhead Protection Plan- Part I
White Bear Township, Ramsey County, Minnesota

Well	MN CWI Unique Well ID	Coordinates		Pumping Rate (2001-2005 Maximum) MGY
		Easting	Northing	
DELLWOOD HILLS GOLF CLUB 2	224611	501848	4994729	6.4
DELLWOOD HILLS GOLF CLUB 1	215930	501745	4994129	9.8
GEM LAKE HILLS INC	151584	497492	4990044	31.8
H B FULLER	151562	495939	4988090	49.3
MAHTOMEDI 5, CITY OF	433255	501697	4988635	111
MAHTOMEDI 4, CITY OF	208506	501844	4988585	132.8
MAHTOMEDI 3, CITY OF	208497	503922	4990807	103.6
MANITOU RIDGE GOLF CLUB A	127293	499902	4987223	33.9
M-FOODS DAIRY LLC	233149	497841	4989995	220.9
PINE TREE APPLE ORCHARD	450669	503641	4995514	5.9
VADNAIS HEIGHTS 2, CITY OF	127265	495736	4988191	167.8
VADNAIS HEIGHTS 1, CITY OF	112222	496846	4988186	160.9
VADNAIS HEIGHTS 4, CITY OF	127271	495042	4991212	192.3
VEECO INSTRUMENTS INC-COOLING	597075	495687	4993278	33.6
WHITE BEAR LAKE AREA SCHOOLS	655934	500201	4989535	4.9
WHITE BEAR LAKE AREA SCHOOLS 2	626779	499102	4992662	4.3
WHITE BEAR LAKE 4, CITY OF	226566	499552	4987778	606.7
WHITE BEAR LAKE 1, CITY OF	14005	499955	4987878	111.2
WHITE BEAR LAKE 3, CITY OF	205733	500157	4987778	472.8
WHITE BEAR YACHT CLUB	866165*	502091	4993073	18

Notes:

- Well pumping rates were downloaded from the MN DNR Water Appropriation Permit Program website. The five-year maximum rate was calculated from 2001 to 2005 data for the above listed wells.
- Coordinates are UTM, Zone 15, NAD83, and are from the MN County Well Index (CWI) except for * which is from the appropriation database.

MGY: Million gallons per year

MN CWI: Minnesota County Well Index

*: MN CWI Unique ID not available (may be 676449). This is the Appropriation Permit Number.

Table 3

**Fracture Flow Fixed Radii and Upgradient Extension Calculations
Part I Wellhead Protection Plan
White Bear Township, Ramsey County, Minnesota**

Well No.	Pumping Rate m ³ /d	Duration days	Effective Porosity	Aquifer Thickness ft	Aquifer Thickness m	Capture Zone Radius m	Volume of Capture Zone for Revised Radius Calculations m ³	Revised Capture Zone Radius m	Upgradient Length to Radius Center (using revised Capture Zone)* m	Primary Angle then +/- 10 degrees from this angle degrees
1	41.1	3650	0.056	135	41.148	143.95	na	143.95	228.01	44
2A	34.2	3650	0.056	30	9.144	278.56	na	278.56	437.34	44.1
3	401.1	3650	0.056	82	24.9936	577.02	26143125	604.24	948.66	21.4
4	133.7	3650	0.056	52	15.8496	418.34	na	418.34	656.80	20.9
5	3071.9	3650	0.056	105	32.004	1411.17	na	1411.17	2215.54	31.8
6	2507.1	3650	0.056	97	29.5656	1326.39	163409196	1388.96	2180.67	31.5

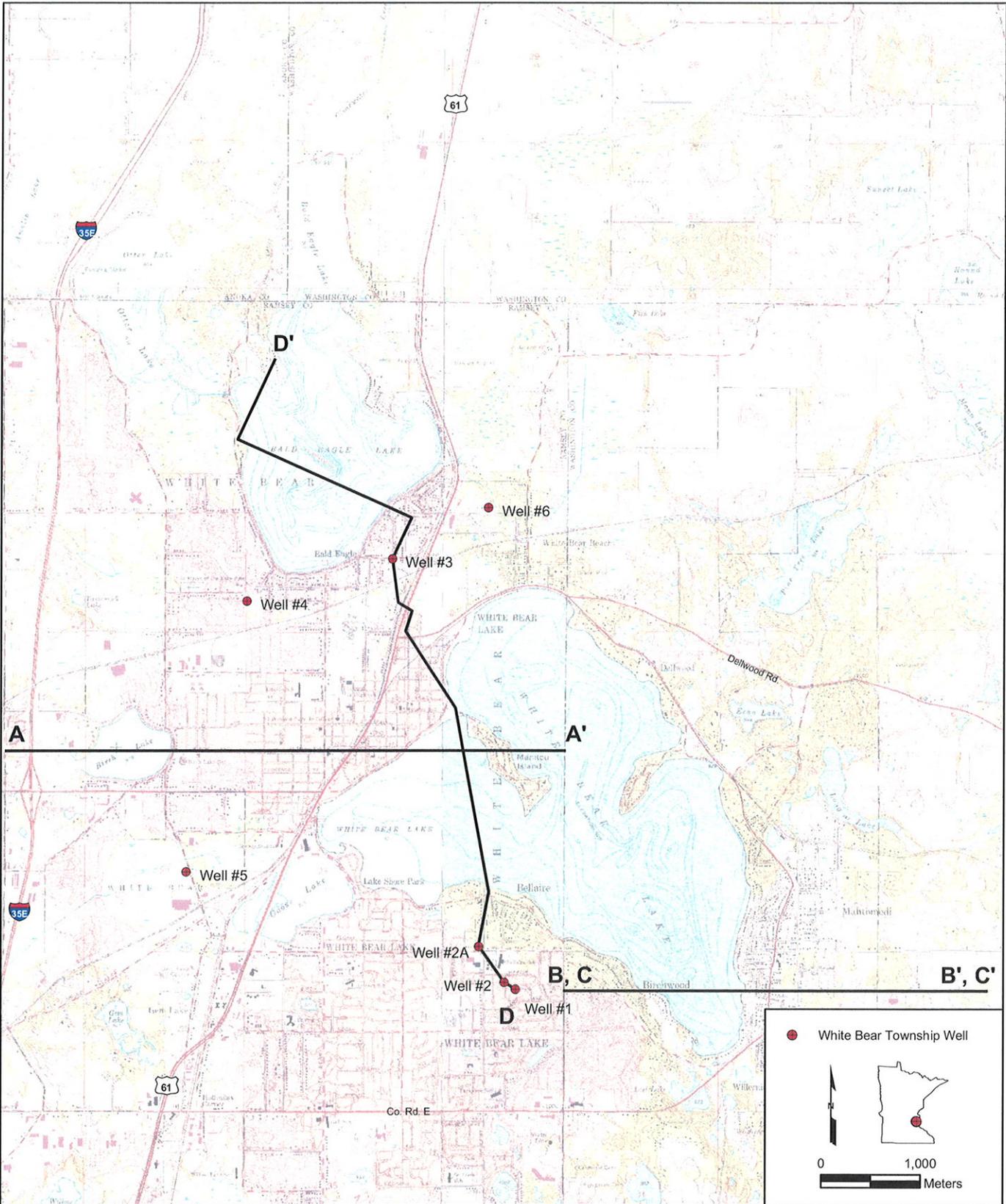
Area of Well 3&6 Overlap	732293 m ²
Overlap Aquifer Thickness	25 m
Volume of Well 3&6 Overlap	18307328 m ³
Volume Well #3	26143125 m ³
Volume Well #6	163409196 m ³
Overlap volume apportioned to Well #3	2524953 m ³
Overlap volume apportioned to Well #6	15782374 m ³
Revised Well #3 volume	26668078 m ³
Revised Well #6 volume	179191571 m ³
Revised Well #3 radius	604 m
Revised Well #6 radius	1389 m

Notes:

- m³/d: cubic meters per day
- m: meters
- m²: square meters
- m³: cubic meters
- ft: feet
- na: not applicable
- *: Equals Revised Capture Zone Radius multiplied by 1.57.

Reference: MDH, 2005. Guidance for Delineating Wellhead Protection Areas in Fractured and Solution-Weathered Bedrock in Minnesota, pp. 8-12.

FIGURES



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.



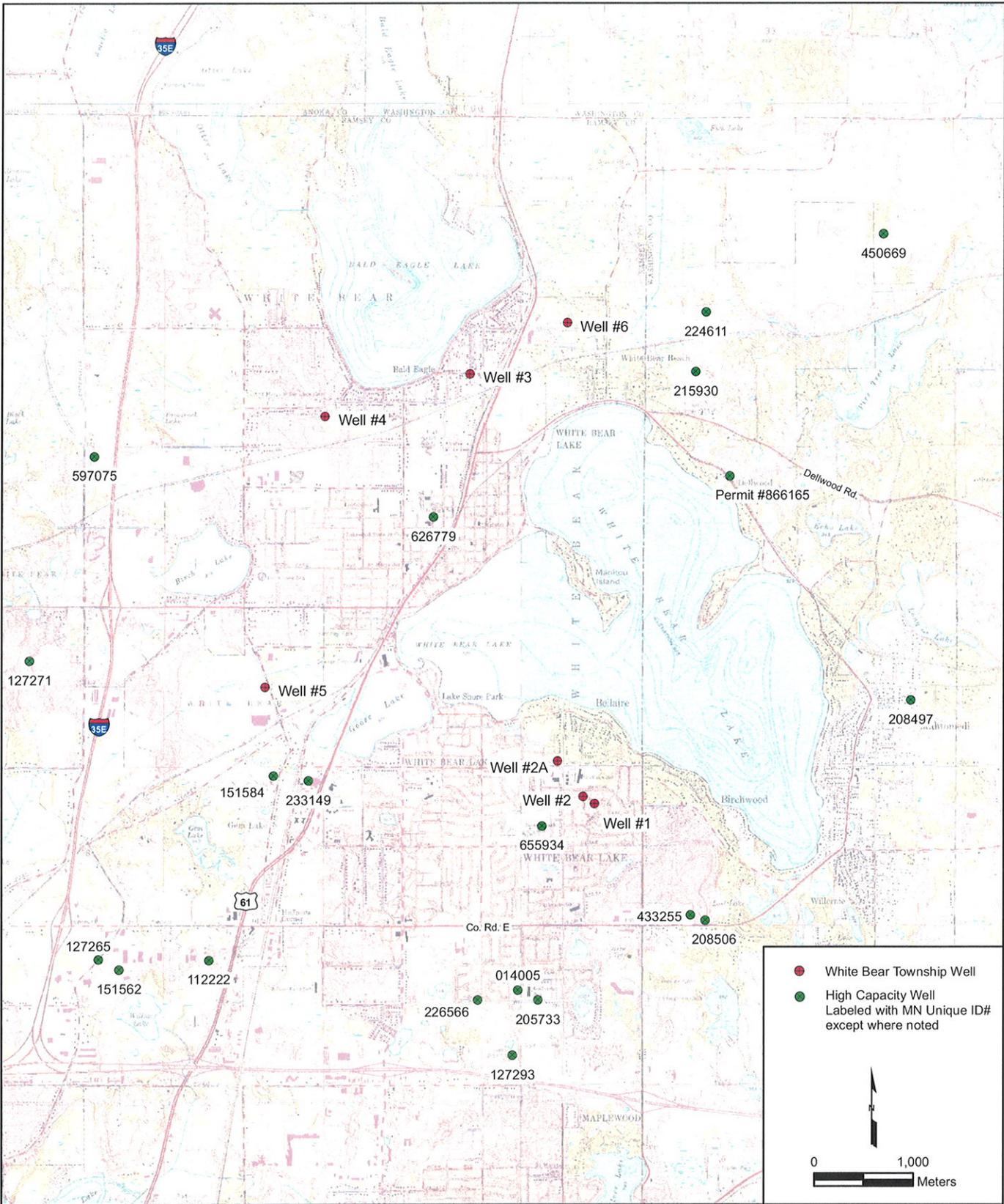
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TKDA / WHITE BEAR TOWNSHIP
 PART I WELLHEAD PROTECTION PLAN
 WHITE BEAR TOWNSHIP, MINNESOTA

**SITE LOCATION MAP AND
 GEOLOGIC CROSS-SECTION LOCATIONS**

FILE: G3WBT01Q.MXD	DATE: 06/14/2007	FIGURE: 1
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Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles, and Bedrock Geology of the Twin Cities Metro Area (Misc. Map M-104, 2000).

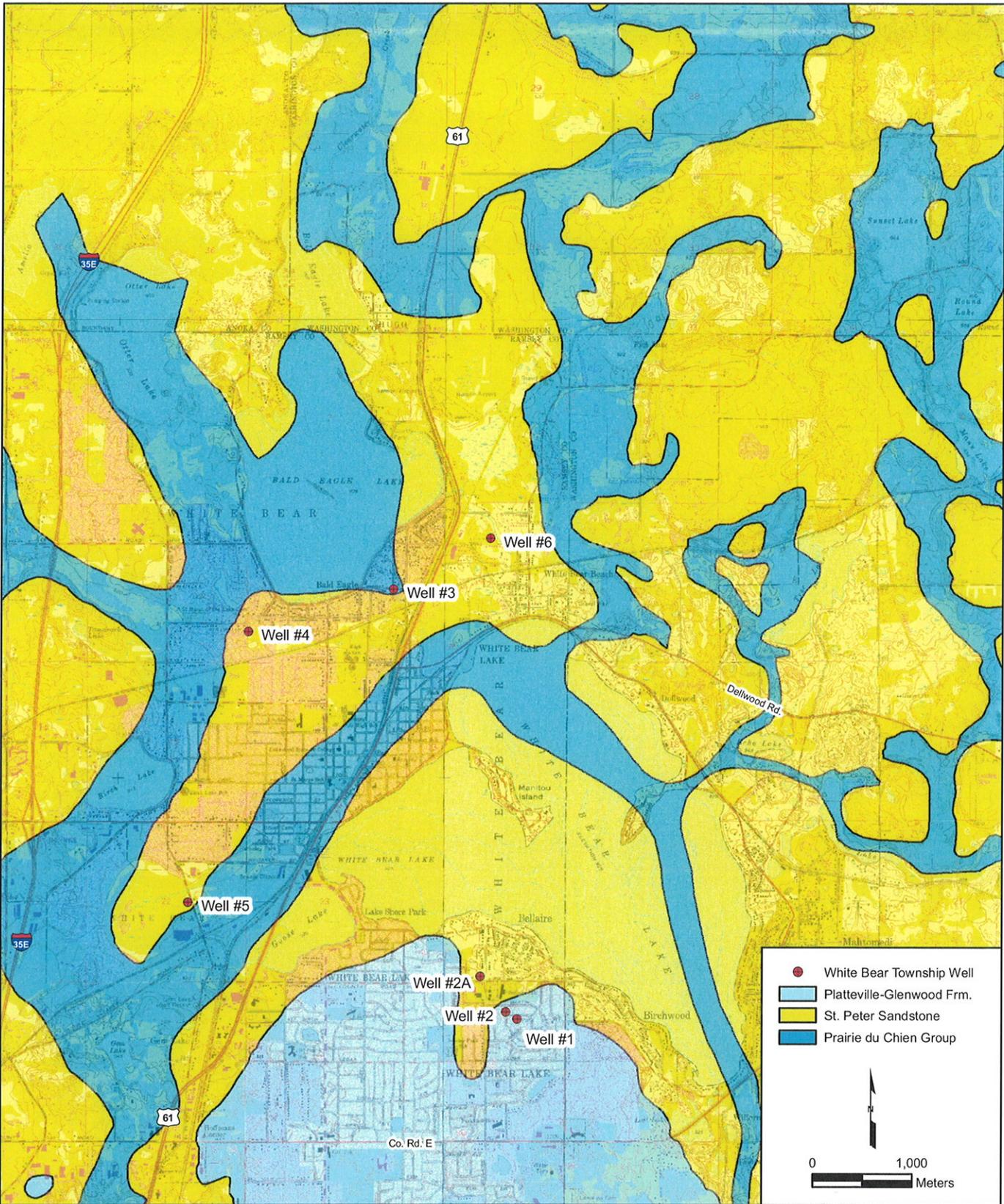


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**LOCATION OF TOWNSHIP AND SURROUNDING HIGH CAPACITY WELLS
 USED IN THE GROUNDWATER FLOW MODEL**

FILE: G3WBT01K.MXD DATE: 01/04/2007 FIGURE: 2



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles, and Bedrock Geology of the Twin Cities Metro Area (Misc. Map M-104, 2000).



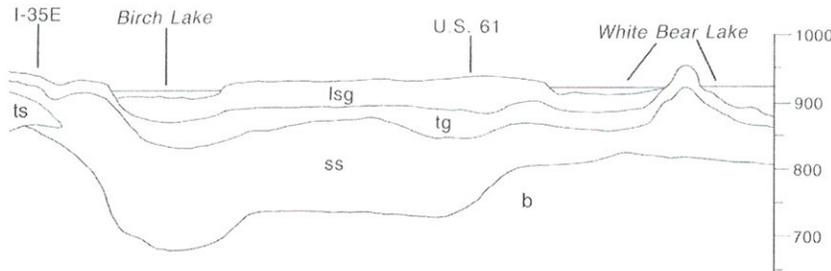
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BEDROCK GEOLOGY MAP

FILE: G3WBT011.MXD	DATE: 12/21/2006	FIGURE: 3
--------------------	------------------	-----------

West
A



Source: Ramsey County Atlas Series, C-7, Plate 5 (Mossler and Cleland, 1992).

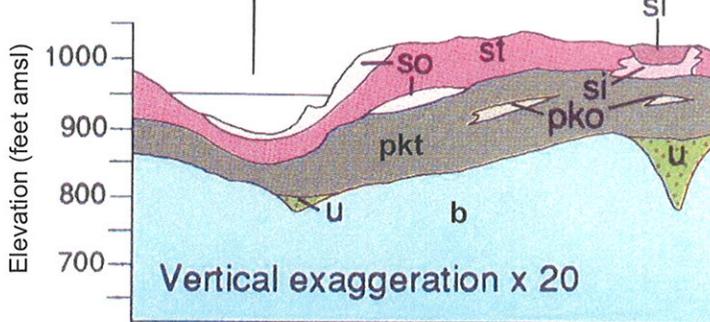
East
A'

- Grantsburg Sublobe Deposits
lsg: Sandy Lake Sediment
tg: Till
- Superior Lobe Deposits
ss: Metwater Stream Sediment (medium to coarse sand with pebbles)
ts: Till
- Bedrock
b: Ordovician and Cambrian Bedrock

Elevation (feet amsl)

West
B

White Bear Lake



Source: Washington County Atlas Series, C-5, Plate 3 (Meyer, Baker, and Patterson, 1990).

East
B'

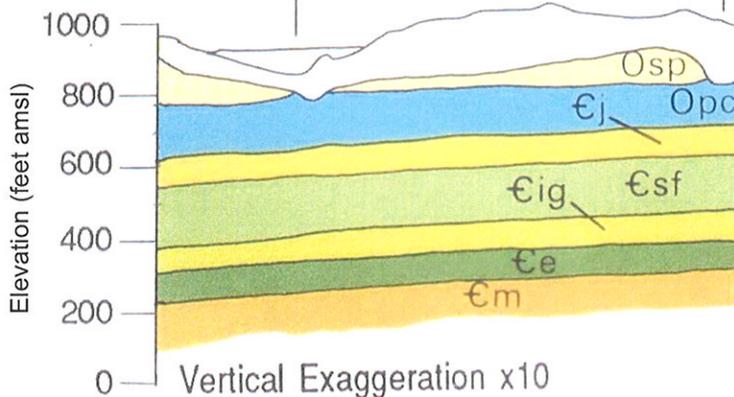
- Superior Lobe Deposits
si: Ice-Contact Stratified Deposits (sand, loamy sand, and gravel)
sl: Lacustrine Sand and Silt
so: Outwash (sand, loamy sand, and gravel)
st: Glacial Till
- Pre-Late Wisconsinan Keewatin Deposits
pko: Outwash and Ice-Contact Deposits
pkt: Glacial Till
- Undifferentiated Sediment
u: Deposits of Unknown Age
- Bedrock
b: Ordovician and Cambrian Bedrock

West
C

White Bear Lake

Co. Rd 9

East
C'



Source: Washington County Atlas Series, C-5, Plate 2 (Mossler and Bloomgren, 1990).

- Osp: St. Peter Sandstone
εj, Opc: Prairie du Chien Group
εig, εsf: Jordan Sandstone
εe: St. Lawrence Formation
εm: Ironton & Galesville Sandstones
Eau Claire Formation
Mt. Simon Sandstone

Source: Ramsey and Washington County Atlas Series, C-7 and C-5, respectively.

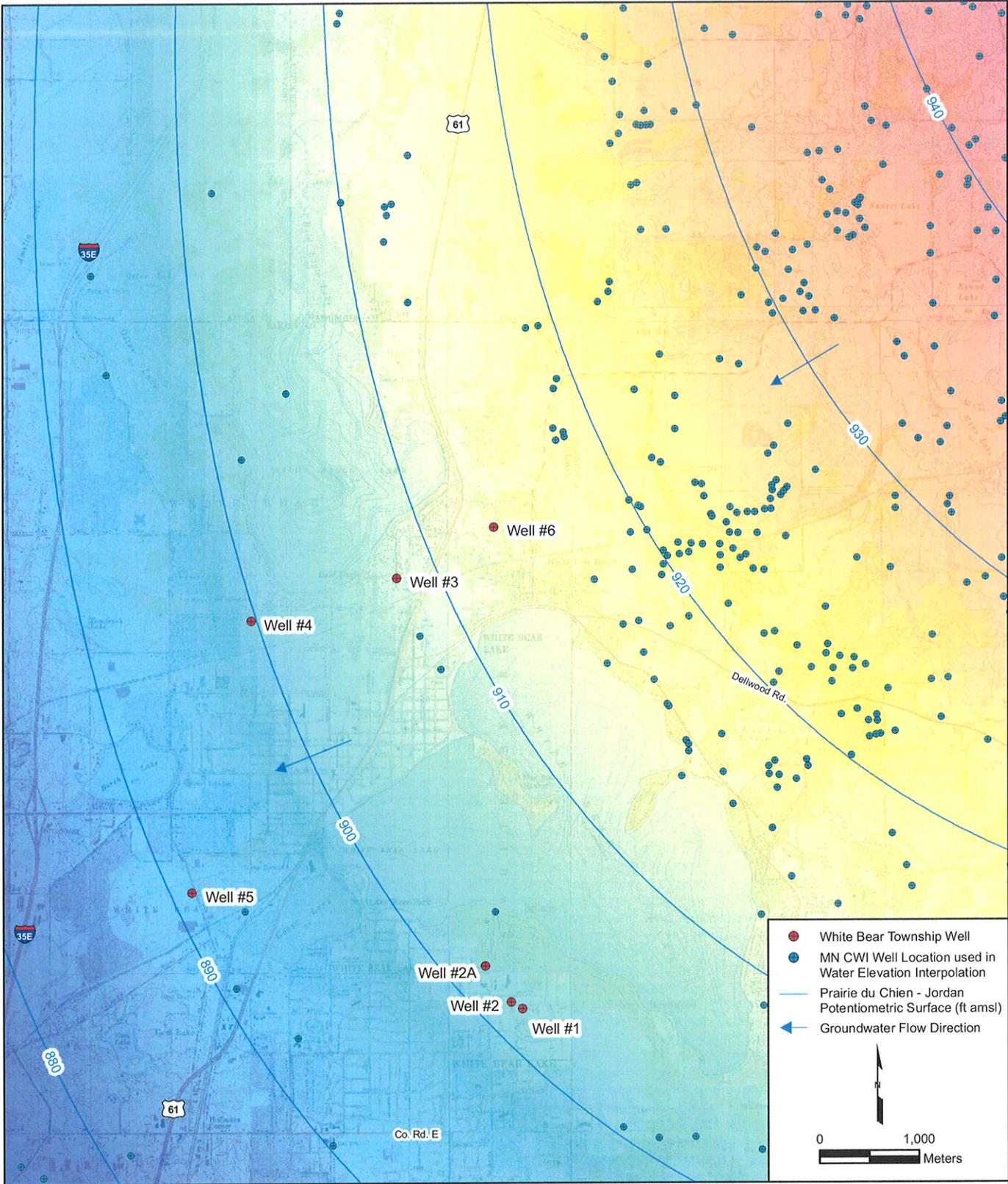


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GEOLOGIC CROSS-SECTIONS A-A', B-B', AND C-C'

FILE: G3WBT010.MXD DATE: 01/04/2007 FIGURE: 4



- White Bear Township Well
- MN CWI Well Location used in Water Elevation Interpolation
- Prairie du Chien - Jordan Potentiometric Surface (ft amsl)
- ← Groundwater Flow Direction



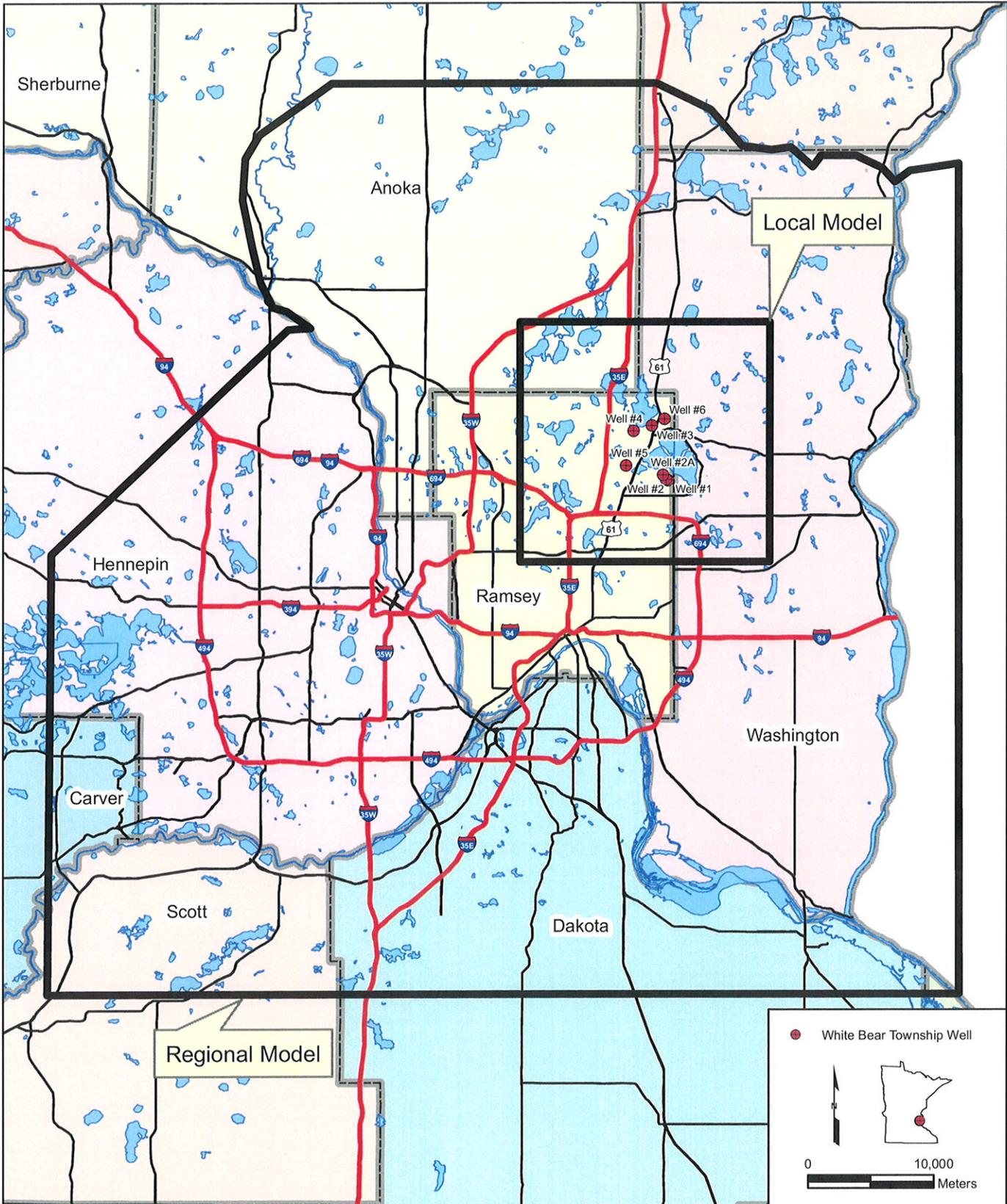


Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles, and MN CWI Prairie du Chien - Jordan water elevation surface created in Surfer 7.0 using a quadratic regression.



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PRAIRIE DU CHIEN - JORDAN POTENTIOMETRIC SURFACE MAP		
FILE: G3WBT01J.MXD	DATE: 01/04/2007	FIGURE: 5

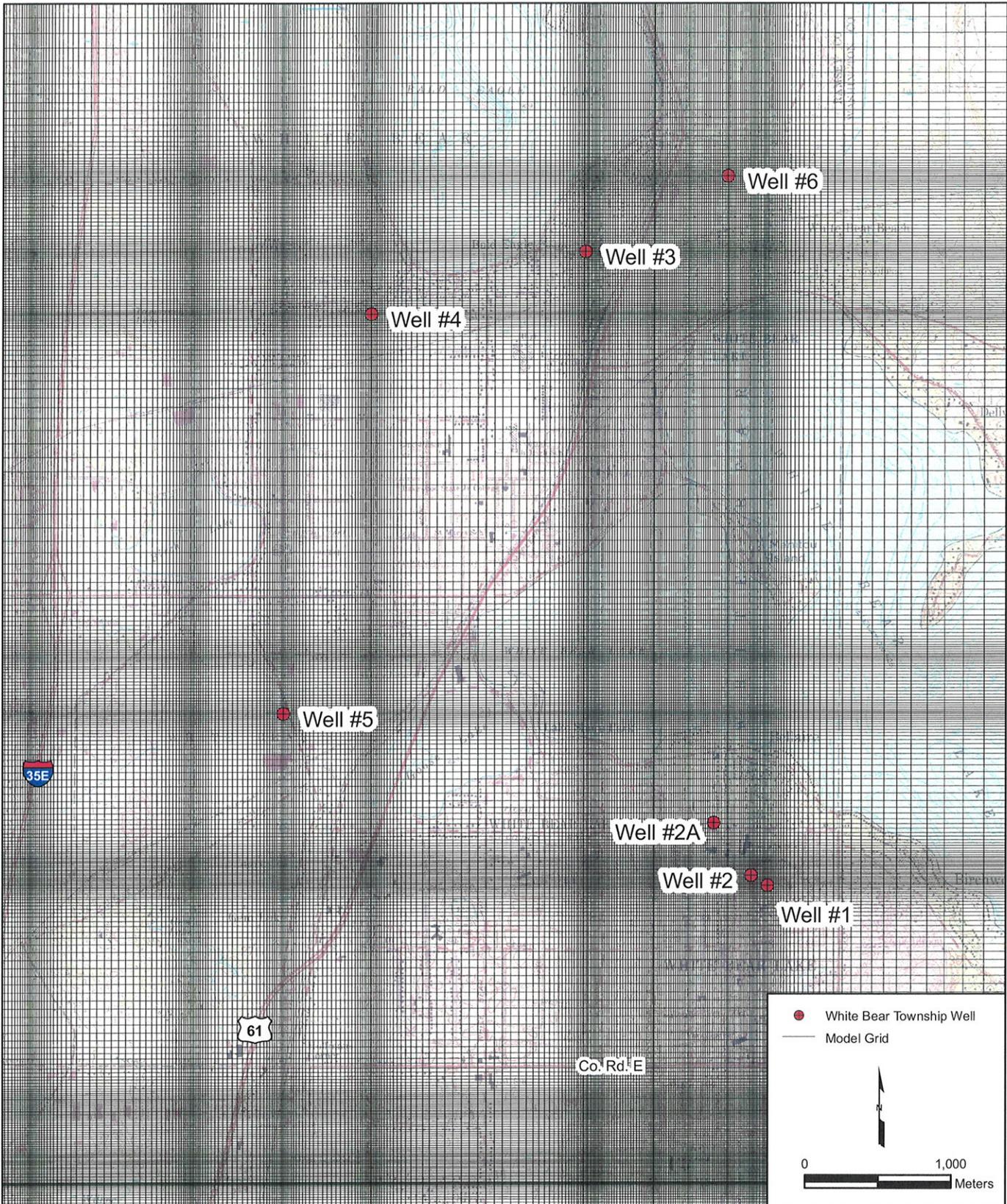


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REGIONAL AND LOCAL MODEL DOMAINS

FILE: G3WBT01N.MXD	DATE: 01/04/2007	FIGURE: 6
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Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.

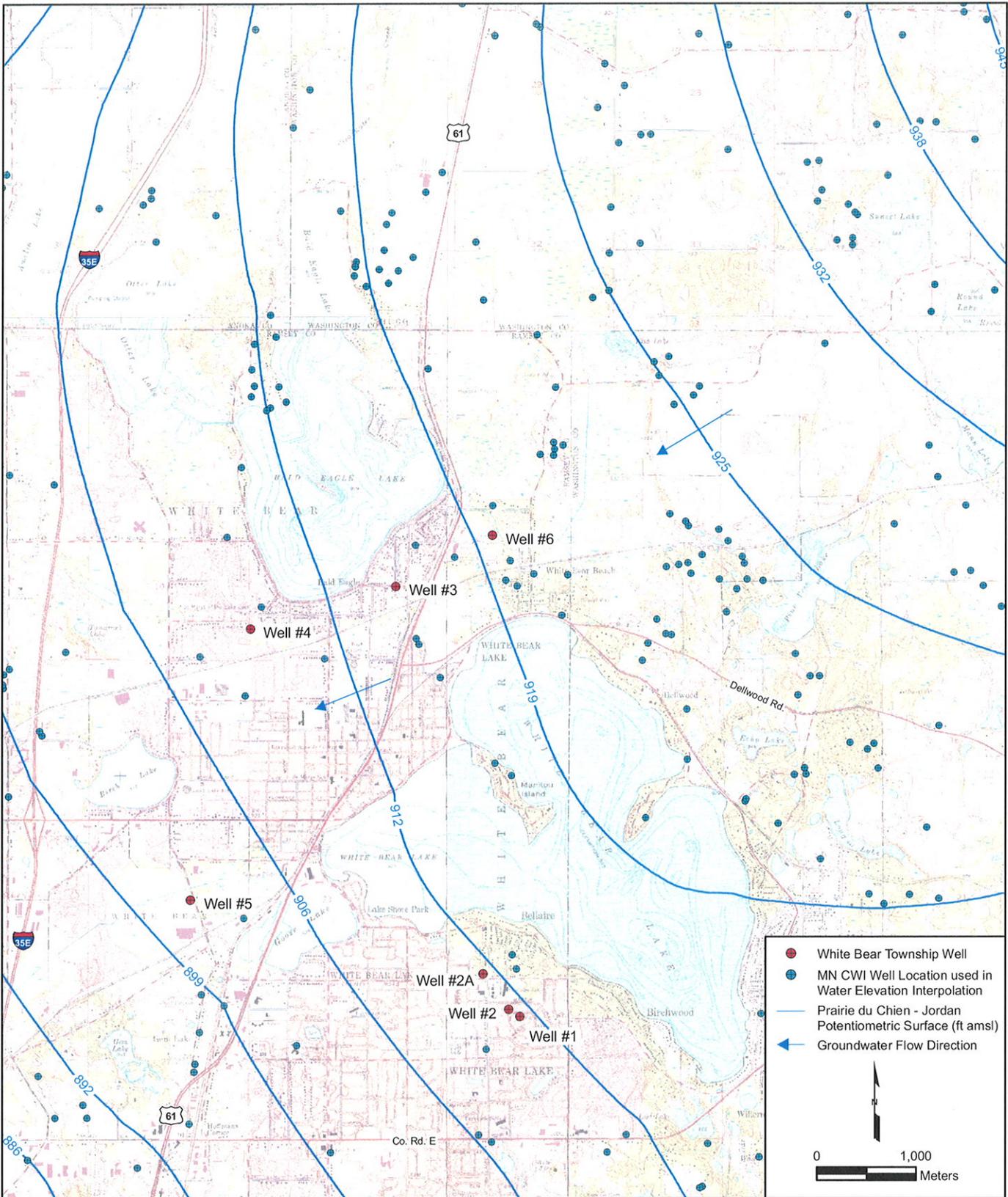


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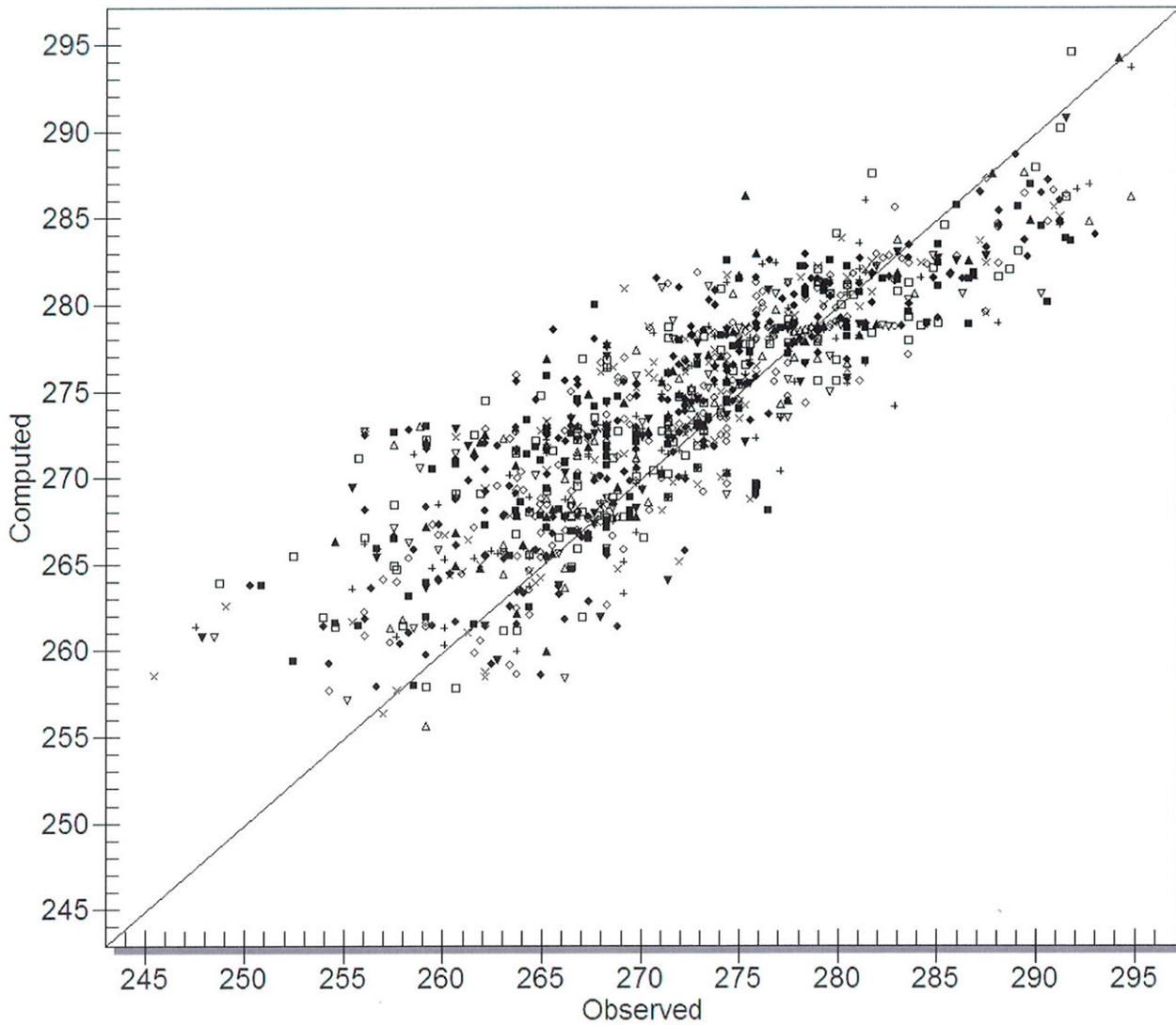
MODEL GRID IN VICINITY OF TOWNSHIP WELLS

FILE: G3WBT01M.MXD	DATE: 01/04/2007	FIGURE: 7
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Computed vs. Observed Values

Head



Error Summary

Head

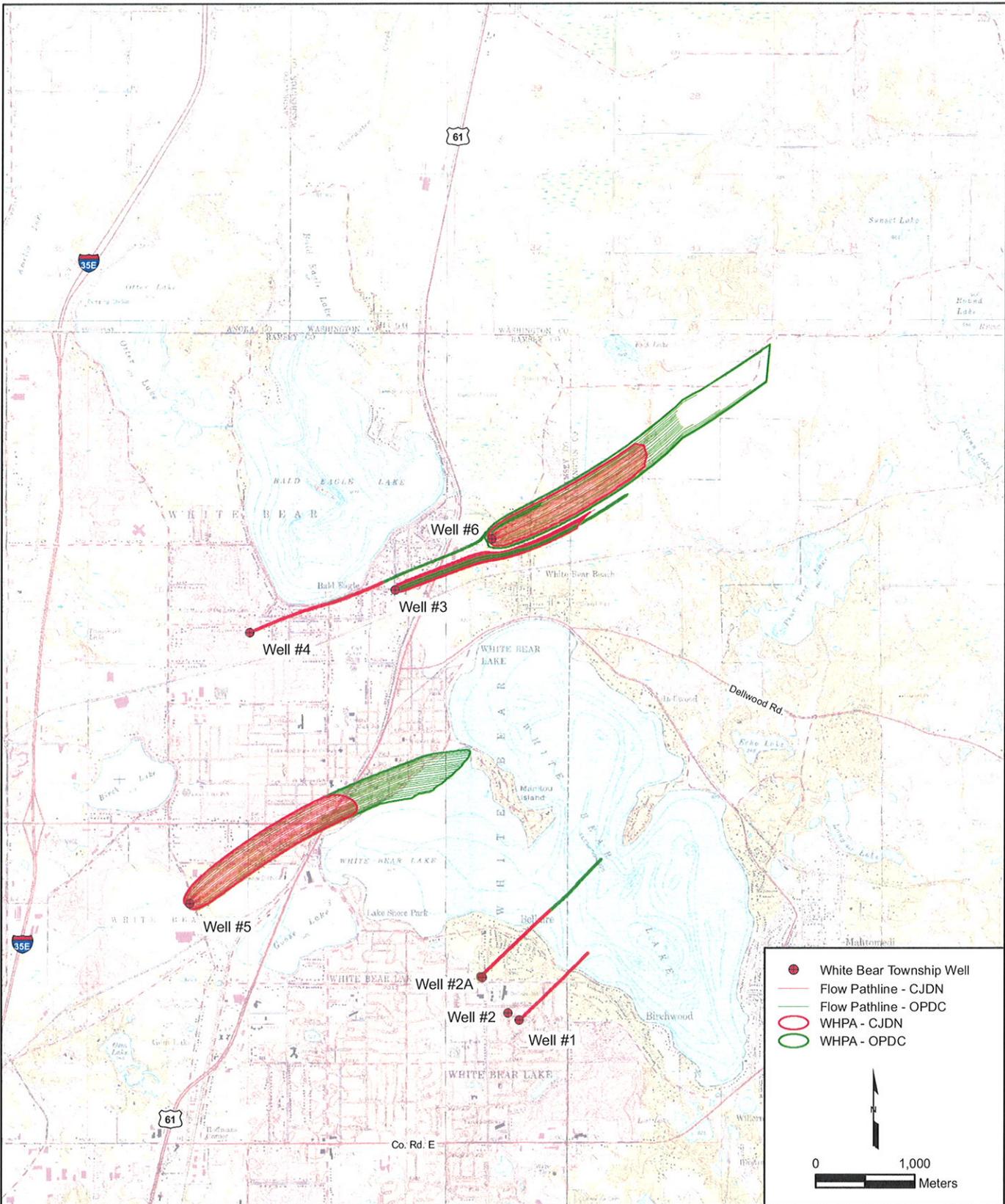
Mean Error:	2.067
Mean Abs. Error:	3.812
Root Mean Sq. Error:	4.973



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 WHITE BEAR TOWNSHIP, MINNESOTA
 STEADY-STATE MODEL CALIBRATION DATA
 AND MODEL STATISTICS

FILE: G3WBT01G.MXD DATE: 01/04/2007 FIGURE: 9



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.

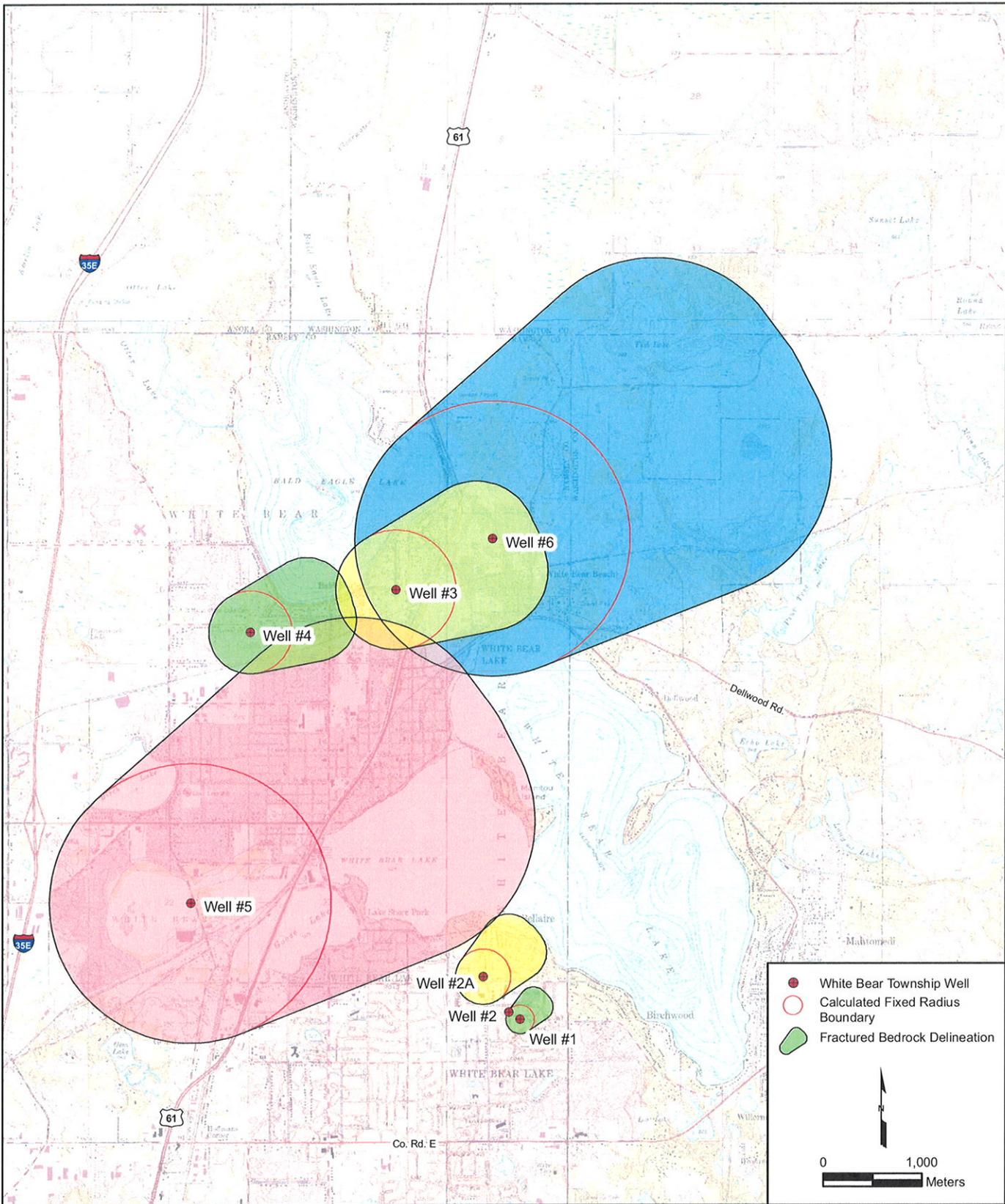


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10-YEAR TIME-OF-TRAVEL PATHLINES

FILE: G3WBT01B.MXD	DATE: 01/04/2007	FIGURE: 10
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Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.

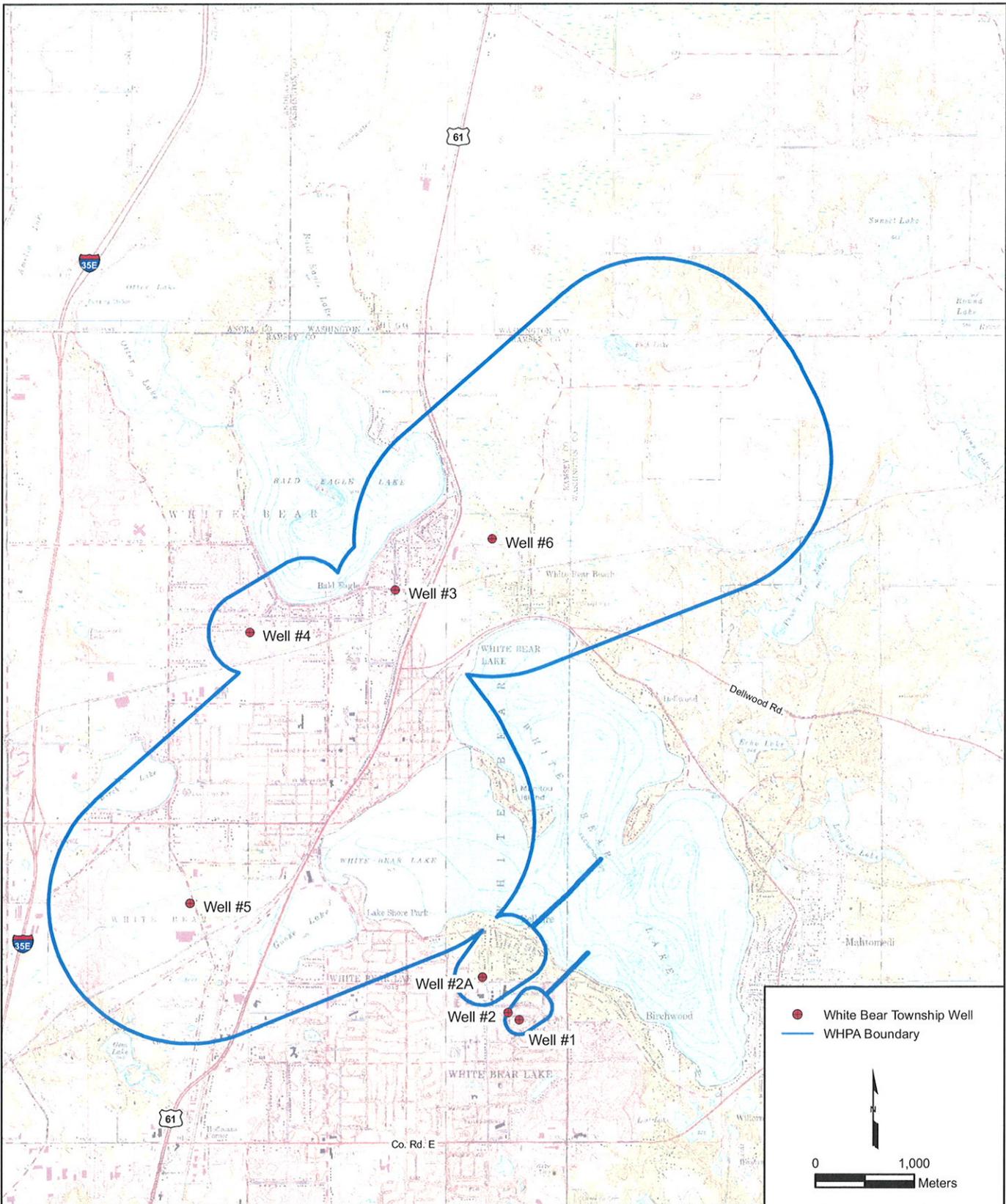


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FRACTURE FLOW DELINEATION BOUNDARIES

FILE: G3WBT01A.MXD DATE: 12/21/2006 FIGURE: 11



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.



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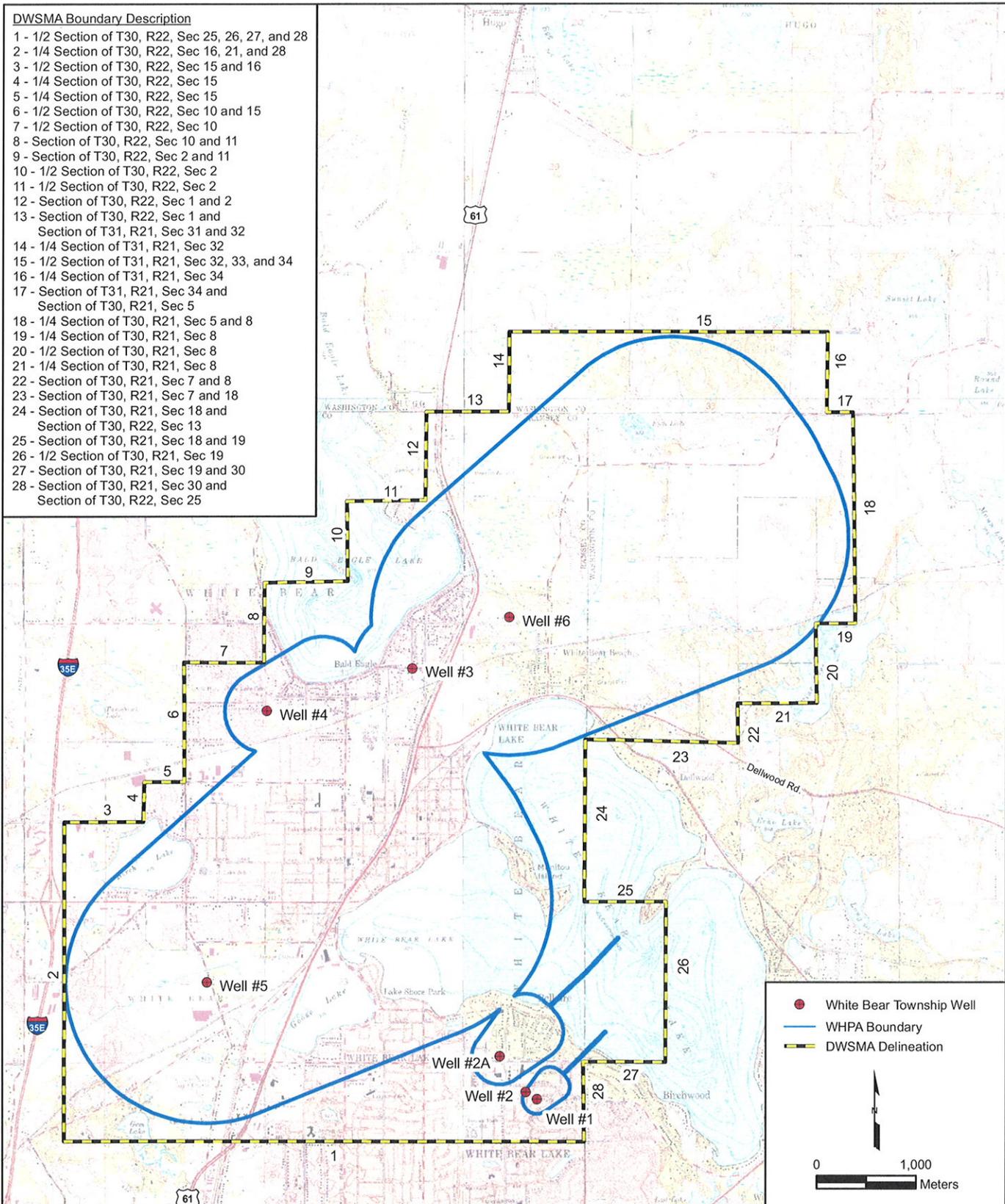
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WELLHEAD PROTECTION AREA BOUNDARY

FILE: G3WBT01E.MXD	DATE: 12/21/2006	FIGURE: 12
--------------------	------------------	------------

DWSMA Boundary Description

- 1 - 1/2 Section of T30, R22, Sec 25, 26, 27, and 28
- 2 - 1/4 Section of T30, R22, Sec 16, 21, and 28
- 3 - 1/2 Section of T30, R22, Sec 15 and 16
- 4 - 1/4 Section of T30, R22, Sec 15
- 5 - 1/4 Section of T30, R22, Sec 15
- 6 - 1/2 Section of T30, R22, Sec 10 and 15
- 7 - 1/2 Section of T30, R22, Sec 10
- 8 - Section of T30, R22, Sec 10 and 11
- 9 - Section of T30, R22, Sec 2 and 11
- 10 - 1/2 Section of T30, R22, Sec 2
- 11 - 1/2 Section of T30, R22, Sec 2
- 12 - Section of T30, R22, Sec 1 and 2
- 13 - Section of T30, R22, Sec 1 and Section of T31, R21, Sec 31 and 32
- 14 - 1/4 Section of T31, R21, Sec 32
- 15 - 1/2 Section of T31, R21, Sec 32, 33, and 34
- 16 - 1/4 Section of T31, R21, Sec 34
- 17 - Section of T31, R21, Sec 34 and Section of T30, R21, Sec 5
- 18 - 1/4 Section of T30, R21, Sec 5 and 8
- 19 - 1/4 Section of T30, R21, Sec 8
- 20 - 1/2 Section of T30, R21, Sec 8
- 21 - 1/4 Section of T30, R21, Sec 8
- 22 - Section of T30, R21, Sec 7 and 8
- 23 - Section of T30, R21, Sec 7 and 18
- 24 - Section of T30, R21, Sec 18 and Section of T30, R22, Sec 13
- 25 - Section of T30, R21, Sec 18 and 19
- 26 - 1/2 Section of T30, R21, Sec 19
- 27 - Section of T30, R21, Sec 19 and 30
- 28 - Section of T30, R21, Sec 30 and Section of T30, R22, Sec 25



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles.



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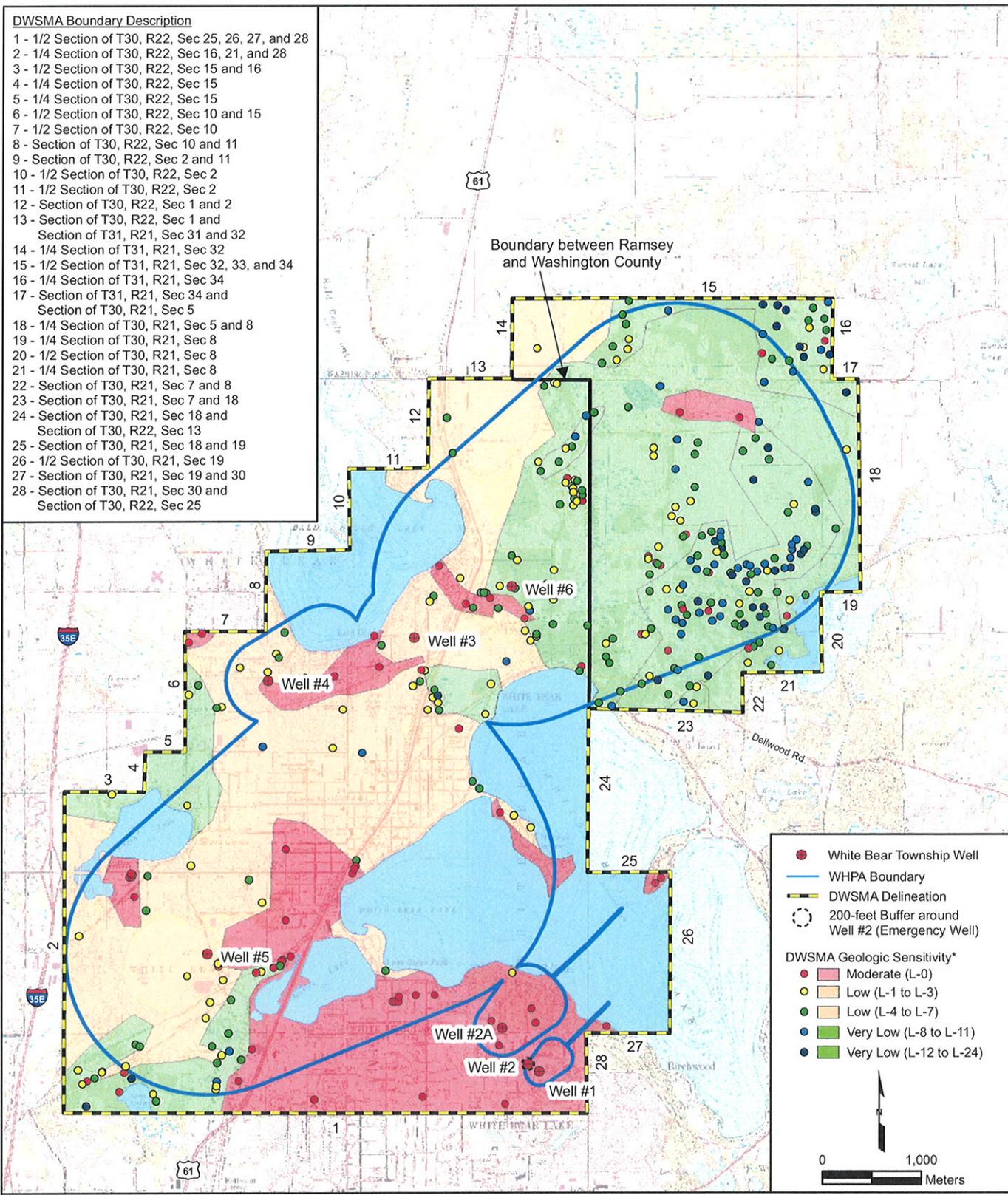
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 PART I WELLHEAD PROTECTION PLAN
 WHITE BEAR TOWNSHIP, MINNESOTA

DWSMA DELINEATION

FILE: G3WBT01D.MXD DATE: 01/04/2007 FIGURE: 13

DWSMA Boundary Description

- 1 - 1/2 Section of T30, R22, Sec 25, 26, 27, and 28
- 2 - 1/4 Section of T30, R22, Sec 16, 21, and 28
- 3 - 1/2 Section of T30, R22, Sec 15 and 16
- 4 - 1/4 Section of T30, R22, Sec 15
- 5 - 1/4 Section of T30, R22, Sec 15
- 6 - 1/2 Section of T30, R22, Sec 10 and 15
- 7 - 1/2 Section of T30, R22, Sec 10
- 8 - Section of T30, R22, Sec 10 and 11
- 9 - Section of T30, R22, Sec 2 and 11
- 10 - 1/2 Section of T30, R22, Sec 2
- 11 - 1/2 Section of T30, R22, Sec 2
- 12 - Section of T30, R22, Sec 1 and 2
- 13 - Section of T30, R22, Sec 1 and Section of T31, R21, Sec 31 and 32
- 14 - 1/4 Section of T31, R21, Sec 32
- 15 - 1/2 Section of T31, R21, Sec 32, 33, and 34
- 16 - 1/4 Section of T31, R21, Sec 34
- 17 - Section of T31, R21, Sec 34 and Section of T30, R21, Sec 5
- 18 - 1/4 Section of T30, R21, Sec 5 and 8
- 19 - 1/4 Section of T30, R21, Sec 8
- 20 - 1/2 Section of T30, R21, Sec 8
- 21 - 1/4 Section of T30, R21, Sec 8
- 22 - Section of T30, R21, Sec 7 and 8
- 23 - Section of T30, R21, Sec 7 and 18
- 24 - Section of T30, R21, Sec 18 and Section of T30, R22, Sec 13
- 25 - Section of T30, R21, Sec 18 and 19
- 26 - 1/2 Section of T30, R21, Sec 19
- 27 - Section of T30, R21, Sec 19 and 30
- 28 - Section of T30, R21, Sec 30 and Section of T30, R22, Sec 25



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles, and Ramsey and Washington County Pollution Sensitivity maps (County Atlas Series).
 *: DWSMA geologic sensitivity (L-scores) as determined by MDH using MN CWI data.



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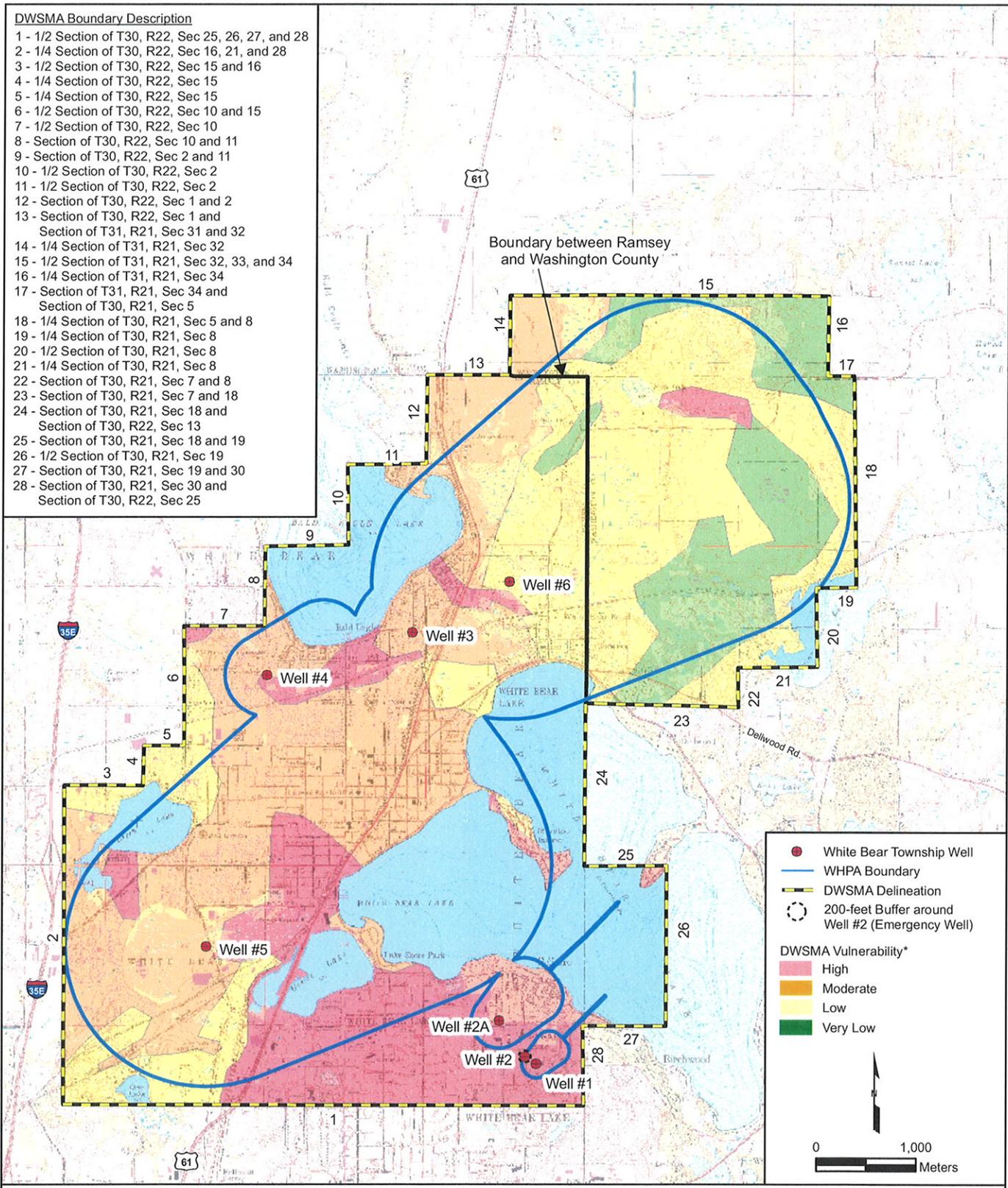
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 WHITE BEAR TOWNSHIP, MINNESOTA

DWSMA GEOLOGIC SENSITIVITY ASSESSMENT

FILE: G3WBT01U.MXD DATE: 07/17/2007 FIGURE: 14

DWSMA Boundary Description

- 1 - 1/2 Section of T30, R22, Sec 25, 26, 27, and 28
- 2 - 1/4 Section of T30, R22, Sec 16, 21, and 28
- 3 - 1/2 Section of T30, R22, Sec 15 and 16
- 4 - 1/4 Section of T30, R22, Sec 15
- 5 - 1/4 Section of T30, R22, Sec 15
- 6 - 1/2 Section of T30, R22, Sec 10 and 15
- 7 - 1/2 Section of T30, R22, Sec 10
- 8 - Section of T30, R22, Sec 10 and 11
- 9 - Section of T30, R22, Sec 2 and 11
- 10 - 1/2 Section of T30, R22, Sec 2
- 11 - 1/2 Section of T30, R22, Sec 2
- 12 - Section of T30, R22, Sec 1 and 2
- 13 - Section of T30, R22, Sec 1 and Section of T31, R21, Sec 31 and 32
- 14 - 1/4 Section of T31, R21, Sec 32
- 15 - 1/2 Section of T31, R21, Sec 32, 33, and 34
- 16 - 1/4 Section of T31, R21, Sec 34
- 17 - Section of T31, R21, Sec 34 and Section of T30, R21, Sec 5
- 18 - 1/4 Section of T30, R21, Sec 5 and 8
- 19 - 1/4 Section of T30, R21, Sec 8
- 20 - 1/2 Section of T30, R21, Sec 8
- 21 - 1/4 Section of T30, R21, Sec 8
- 22 - Section of T30, R21, Sec 7 and 8
- 23 - Section of T30, R21, Sec 7 and 18
- 24 - Section of T30, R21, Sec 18 and Section of T30, R22, Sec 13
- 25 - Section of T30, R21, Sec 18 and 19
- 26 - 1/2 Section of T30, R21, Sec 19
- 27 - Section of T30, R21, Sec 19 and 30
- 28 - Section of T30, R21, Sec 30 and Section of T30, R22, Sec 25



Source: Centerville, Hugo, White Bear Lake East and White Bear Lake West 7.5-Minute USGS Quadrangles, and Ramsey and Washington County Pollution Sensitivity maps (County Atlas Series).
 *: DWSMA vulnerability as delineated by MDH.



Prepared By:
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 651-490-1405

TKDA / WHITE BEAR TOWNSHIP
 PART I WELLHEAD PROTECTION PLAN
 WHITE BEAR TOWNSHIP, MINNESOTA

DWSMA VULNERABILITY ASSESSMENT

FILE: G3WBT01T.MXD DATE: 07/17/2007 FIGURE: 15

APPENDIX I
RSWCD Draft Report

APPENDIX II

White Bear Township Municipal Well Logs

Unique No. 00226570	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2003/03/11
County Name Ramsey		Entry Date 1991/08/14
Township Name Township Range Dir Section Subsection 30 22 W 25 ABDDCA	Well Depth 445 ft. Depth Completed 445 ft. Date Well Completed 1956/09/00	
Well Name WHITE BEAR TOWNSHIP 1 EASTWOOD MANOR WHITE BEAR LAKE MN	Drilling Method	Drilling Fluid
		Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.
	Use Community Supply (municipal)	
	Casing Drive Shoe? <input type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Diameter Weight(lbs/ft)	
HARDPAN 0 32	20 in. to 39 ft	
PLATTEVILLE 32 52	12 in. to 365 ft	
SHALE 52 57		
ST. PETER SANDROCK 57 172		
SANDROCK & SHALE 172 212		
SHAKOPEE 212 347		
JORDAN 347 445		
	Screen N	Open Hole From 365 ft. to 442 ft.
	Make	Type
	Static Water Level 72 ft. from Land surface	Date 1956/09/00
	PUMPING LEVEL (below land surface)	
	165 ft. after hrs. pumping 627 g.p.m.	
	Well Head Completion	
	Pitless adapter mfr Model	
	Casing Protection <input type="checkbox"/> 12 in. above grade	
	<input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	
	Material From To (ft.) Amount(yds/bags)	
	G 0 365 351 S	
	Nearest Known Source of Contamination	
	ft. direction type	
	Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input type="checkbox"/> Not Installed Date Installed Y	
	Mfr name FAIRBANKS MORSE	
	Model AV 4763 HP 50 Volts 220	
	Drop Pipe Length 196 ft. Capacity 500 g.p.m.	
	Type T	
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
CASING: 020 TO 0039;012 TO 0365.	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
G.W.Q. NO. 0070		
GAMMA LOGGED 1/11/85.		
USGS Quad: White Bear Lake East Elevation 974	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012	
Aquifer: CJDN Ait Id: 84-6120	License Business Name	
	Name of Driller KEMPER, H	

Report Copy

Unique No. 00226571	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2002/02/13
County Name Ramsey		Entry Date 1991/08/14
Township Name Township Range Dir Section Subsection 30 22 W 25 ABDCBB	Well Depth 435 ft. Depth Completed 435 ft. Date Well Completed 1961/00/00	
Well Name WHITE BEAR TOWNSHIP 2	Drilling Method	
Contact's Name WHITE BEAR #2 LAKEWOOD & STACKER AV WHITE BEAR LAKE MN	Drilling Fluid	Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.
	Use Community Supply (municipal)	
	Casing Drive Shoe? <input type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Diameter Weight(lbs/ft)	
YELLOW GRAVEL 0 35	12 in. to 45 ft	
DRIFT & SHALE 35 45	8 in. to 375 ft	
LIMESTONE 45 52		
SHALE 52 57		
SANDSTONE 57 211		
LIMESTONE 211 355		
SANDSTONE 355 435		
	Screen N Open Hole From 375 ft. to 435 ft. Make Type	
	Static Water Level 65 ft. from Land surface Date 1961/00/00	
	PUMPING LEVEL (below land surface) ft. after hrs. pumping g.p.m.	
	Well Head Completion Pitless adapter mfr Model Casing Protection <input type="checkbox"/> 12 in. above grade <input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Nearest Known Source of Contamination ft. direction type Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input type="checkbox"/> Not installed Date Installed Mfr name Model HP 0 Volts Drop Pipe Length ft. Capacity g.p.m. Type	
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
CASING: 012 TO 0045;008 TO 0375.	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
USGS Quad: White Bear Lake East Elevation 967 Aquifer: CJDN Alt Id: 84-6120	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. License Business Name Name of Driller	

Report Copy

Unique No. 676446	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2003/10/30															
County Name Ramsey		Entry Date															
Township Name Township Range Dir Section Subsection 30 22 W 24 CDD	Well Depth 420 ft. Depth Completed 420 ft. Date Well Completed 2002/04/25																
Well Name WHITE BEAR TOWNSHIP 2A	Drilling Method Cable Tool																
Well Owner's Name WHITE BEAR TOWNSHIP 4099 BELLAIRE AV WHITE BEAR TOWNSHIP MN 55110	Drilling Fluid Water	Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.															
Contact's Name WHITE BEAR TOWNSHIP 1281 HAMMOND RD WHITE BEAR TOWNSHIP MN 55110	Use Community Supply (municipal)																
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Drive Shoe? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter in. to 420 ft															
SAND/RUBBLE BROW HARD 0 25	Casing Diameter 20 in. to 33 ft Weight(lbs/ft) 78.6																
PLATTEVILLE GRAY HARD 25 30	14 in. to 299 ft 54.6																
GLENWOOD BLU/G MEDIUM 30 35																	
ST. PETER TAN/W SOFT 35 143	Screen N	Open Hole From 299 ft. to 420 ft.															
ST. PETER GRAY HARD 143 197	Make	Type															
SHAKOPEE/ONEOTA PINK HARD 197 330																	
JORDAN TAN MEDIUM 330 410																	
ST. LAWRENCE BLUE HARD 410 420																	
	Static Water Level 55 ft. from	Date 2003/04/21															
	PUMPING LEVEL (below land surface) 109.7 ft. after 4 hrs. pumping 1120 g.p.m.																
	Well Head Completion Pitless adapter mfr Model Casing Protection <input checked="" type="checkbox"/> 12 in. above grade <input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)																
	Grouting Information Well grouted? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No																
	<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Material</th> <th>From</th> <th>To (ft.)</th> <th>Amount(yds/bags)</th> <th></th> </tr> </thead> <tbody> <tr> <td>G</td> <td>0</td> <td>14</td> <td>25</td> <td>S</td> </tr> <tr> <td>G</td> <td>14</td> <td>299</td> <td>63</td> <td>Y</td> </tr> </tbody> </table>	Material	From	To (ft.)	Amount(yds/bags)		G	0	14	25	S	G	14	299	63	Y	
Material	From	To (ft.)	Amount(yds/bags)														
G	0	14	25	S													
G	14	299	63	Y													
	Nearest Known Source of Contamination 140 ft. direction E type SDF Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No																
	Pump <input checked="" type="checkbox"/> Not Installed Date Installed N Mfr name Model HP Volts Drop Pipe Length ft. Capacity g.p.m. Type																
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No																
ELEVATION: 949 FT, MSGS QUAD: C118 COMPLETED WITH TKDA & ASSOCIATES	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No																
USGS Quad: White Bear Lake East Elevation Aquifer: Alt Id: 84-6120	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. <u>71015</u> License Business Name Name of Driller <u>SIGAFOOS, R.</u>																

Report Copy

Unique No. 00224679	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2004/01/06
County Name Ramsey		Entry Date 1991/08/14
Township Name Township Range Dir Section Subsection 30 22 W 11 DAAABC	Well Depth 372 ft. Depth Completed 372 ft. Date Well Completed 1975/00/00	
Well Name WHITE BEAR TOWNSHIP 3	Drilling Method	
Contact's Name TOWN OF WHITE BEAR EAST ST. & PARK AVE WHITE BEAR LAKE MN	Drilling Fluid	Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.
	Use Community Supply (municipal)	
	Casing Drive Shoe? <input type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Diameter Weight(lbs/ft)	
WET MUCK LIGHT 0 10	30 in. to 151 ft	
CLAY & STONES GRAY 10 40	24 in. to 200 ft	
GRAVEL & STONES GRAY 40 70		
GRAVEL BROW 70 94		
SAND RED 94 95		
SANDY DK. BR 95 105		
SAND BROW 105 135		
STONE 135 150		
STONES & BROKEN SHAKO LIGHT 150 151	Screen N	Open Hole From 200 ft. to 372 ft.
SHAKOPEE TAN 151 185	Make	Type
SHAKOPEE DIRTY LT. TA 185 195		
SHAKOPEE LIGHT V.HARD 195 225		
SHAKOPEE PINK V.HARD 225 270		
SHAKOPEE TAN 270 275		
SHAKOPEE TAN 275 280		
SHAKOPEE PINK 280 282		
JORDAN WHITE SOFT 282 305		
JORDAN FINE PINK 305 320		
JORDAN COARSE WHITE 320 325		
ST. LAWRENCE SHALE WHITE 325 340		
SANDSTONE PINK HARD 340 350		
SANDSTONE PNK/G HARD 350 372		
	Static Water Level 15 ft. from Land surface Date 1975/00/00	
	PUMPING LEVEL (below land surface) 64 ft. after hrs. pumping 2000 g.p.m.	
	Well Head Completion Pitless adapter mfr Model Casing Protection <input type="checkbox"/> 12 in. above grade <input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Nearest Known Source of Contamination ft. direction type Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input type="checkbox"/> Not Installed Date Installed Mfr name Model HP 0 Volts Drop Pipe Length ft. Capacity g.p.m. Type	
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
M.G.S. NO. 1143	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
USGS Quad: White Bear Lake West Elevation 923	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. <u>02015</u>	
Aquifer: OPCJ Alt Id: 84-6120	License Business Name	
	Name of Driller <u>SIGAFOOS, G.</u>	

Report Copy

Unique No. 00226572	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2002/02/13
County Name Ramsey		Entry Date 1991/08/14
Township Name Township Range Dir Section Subsection 30 22 W 11 CBBCC	Well Depth 408 ft. Depth Completed 408 ft. Date Well Completed 1976/06/07	
Well Name WHITE BEAR TOWNSHIP 4	Drilling Method	
Contact's Name TOWN OF WHITE BEAR WHITE BEAR LAKE MN	Drilling Fluid	Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.
	Use Community Supply (municipal)	
	Casing Drive Shoe? <input type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Diameter Weight(lbs/ft)	
DRIFT 0 149	30 in. to 166 ft	
SAND ROCK & GRAVEL 149 165	24 in. to 263 ft	
SANDROCK 165 186		
SHAKOPEE 186 311		
JORDAN 311 400		
JORDAN & SHALE 400 408		
	Screen N	Open Hole From 263 ft. to 408 ft.
	Make	Type
	Static Water Level 32 ft. from Land surface	Date 1976/06/07
	PUMPING LEVEL (below land surface) 86 ft. after hrs. pumping 700 g.p.m.	
	Well Head Completion Pitless adapter mfr Model Casing Protection <input type="checkbox"/> 12 in. above grade <input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Material From To (ft.) Amount(yds/bags) G 0 325 250 S	
	Nearest Known Source of Contamination ft. direction type Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input type="checkbox"/> Not Installed Date Installed Mfr name Model HP 0 Volts Drop Pipe Length ft. Capacity g.p.m. Type	
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
M.G.S. NO. 1101 MEAD PARK - STILLWATER AVENUE	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
USGS Quad: White Bear Lake West Elevation 940 Aquifer: MTPL Alt id: 84-6120	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012 License Business Name Name of Driller O'BRIEN, F	

Report Copy

Unique No. 00151596	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2002/02/13
County Name Ramsey		Entry Date 1991/08/14
Township Name Township Range Dir Section Subsection 30 22 W 22 DBABBB	Well Depth 412 ft. Depth Completed 412 ft. Date Well Completed 1987/03/25	
Well Name WHITE BEAR TOWNSHIP 5	Drilling Method Cable Tool	
Well Owner's Name WHITE BEAR TOWNSHIP 5 WHITE BEAR LAKE MN 55110	Drilling Fluid	Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.
Contact's Name CITY OF WHITE BEAR TOWNSHIP 1281 HAMMOND RD WHITE BEAR LAKE MN 55110-	Use Community Supply (municipal)	
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Drive Shoe? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> N	Hole Diameter in. to 154 ft
DIRT 0 4	Casing Diameter 30 in. to 150 ft Weight(lbs/ft)	in. to 412 ft
CLAY BLUE 4 40	24 in. to 199 ft	
GRAVEL + CLAY BLUE 40 61	18 in. to 230 ft	
SAND GRAY 61 72		
SAND + ROCKS GRAY 72 104	Screen N	Open Hole From 230 ft. to 412 ft.
SAND-FINE BROW 104 142	Make	Type
SAND + CLAY BROW 142 147		
SAND BROW 147 157		
CLAY GRAY 157 192	Static Water Level 17 ft. from Land surface Date 1987/03/16	
SANDSTONE GREE 192 199	PUMPING LEVEL (below land surface) 31 ft. after 4 hrs. pumping 2200 g.p.m.	
LIMESTONE BROW 199 335	Well Head Completion	
SANDSTONE PINK 335 357	Pitless adapter mfr Model	
SANDSTONE GRAY 357 411	Casing Protection <input checked="" type="checkbox"/> 12 in. above grade	
SHALE GREE 411 412	<input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	
	Material From To (ft.) Amount(yds/bags)	
	G 0 230 30 Y	
	Nearest Known Source of Contamination	
	100 ft. direction type BOW	
	Well disinfected upon completion? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input checked="" type="checkbox"/> Not Installed Date Installed N	
	Mfr name	
	Model HP Volts	
	Drop Pipe Length ft. Capacity g.p.m.	
	Type	
REMARKS, ELEVATION, SOURCE OF DATA, etc.	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
GAMMA LOGGED 3-23-87. 0-192 DRIFT 192-200 OSTP 200-320 OPDC 320-404	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
M.G.S. NO. 2772.		
WELL LOCATED S. OF HWY 96 AND W. OF OTTER LAKE RD.		
USGS Quad: White Bear Lake West Elevation 921	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012	
Aquifer: MTPL Alt Id: 84-612	License Business Name	
	Name of Driller SITTIG, R	

Report Copy

Unique No. 00596636	MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD <i>Minnesota Statutes Chapter 1031</i>	Update Date 2004/01/06
County Name Ramsey		Entry Date 1998/06/25
Township Name Township Range Dir Section Subsection 30 22 W 12	Well Depth 360 ft. Depth Completed 360 ft. Date Well Completed 1998/05/22	
Well Name WHITE BEAR TOWNSHIP 6	Drilling Method Cable Tool	
Contact's Name WHITE BEAR TOWNSHIP 6 2530 BUFFALO ST MN	Drilling Fluid Water Well Hydrofractured? <input type="checkbox"/> Yes <input type="checkbox"/> No From ft. to ft.	
	Use Community Supply (municipal)	
	Casing Drive Shoe? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> N Hole Diameter 0 in. to 360 ft	
GEOLOGICAL MATERIAL COLOR HARDNESS FROM TO	Casing Diameter Weight(lbs/ft)	
SAND & GRAVEL BROW SOFT 0 19	30 in. to 145 ft	
CLAY GRAY SOFT 19 37	24 in. to 175 ft	
GRAVEL & ROCKS BROW MEDIUM 37 60		
SAND & GRAVEL BROW MEDIUM 60 141		
LIMESTONE TAN HARD 141 272	Screen N Open Hole From 175 ft. to 360 ft.	
SANDROCK WHITE MEDIUM 272 355	Make Type	
SHALE GRY/B MEDIUM 355 360		
	Static Water Level 21 ft. from Land surface Date 1998/04/27	
	PUMPING LEVEL (below land surface) 26 ft. after hrs. pumping 2000 g.p.m.	
	Well Head Completion Pitless adapter mfr Model Casing Protection <input type="checkbox"/> 12 in. above grade <input type="checkbox"/> At-grade(Environmental Wells and Borings ONLY)	
	Grouting Information Well grouted? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Material From To (ft.) Amount(yds/bags) G 0 175 27 Y	
	Nearest Known Source of Contamination 150 ft. direction E type BOW Well disinfected upon completion? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Pump <input checked="" type="checkbox"/> Not Installed Date Installed N Mfr name Model HP 0 Volts Drop Pipe Length ft. Capacity g.p.m. Type	
	Any not in use and not sealed well(s) on property? <input type="checkbox"/> Yes <input type="checkbox"/> No	
	Was a variance granted from the MDH for this Well? <input type="checkbox"/> Yes <input type="checkbox"/> No	
USGS Quad: White Bear Lake East Elevation 928 Aquifer: OPCJ Alt Id: 1620025S06	Well CONTRACTOR CERTIFICATION Lic. Or Reg. No. 62012 License Business Name Name of Driller <u>SAMPSON, J.</u>	

Report Copy

APPENDIX III

Township Well Vulnerability Assessments

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #1

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 226570

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3)	20 points
Low ("L" score of 4 to 7)	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater) Glenwood and basal St. Peter shales present	0 points
TOTAL POINTS	0

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface.	10 points
Each category for which information requested is unknown.	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	0

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet	10 points
201 to 500 feet 365 feet	5 points
>500 feet	0 points
TOTAL POINTS	5

4. Pumping rate - assign the following point values:	
>1000 gallons/minute	20 points
501 to 1000 gallons/minute	10 points
50 to 500 gallons/minute 500 gpm	5 points
<50 gallons/minute	0 points
TOTAL POINTS	5

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million <0.4	0 points
Tritium Results	
>1 TU 3.6 TU, 7/13/1991	Vulnerable
<1 TU	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	Vulnerable

7. Grand total score:	
1. DNR Vulnerability Rating	0
2. Casing Integrity	0
3. Casing Depth	5
4. Pumping Rate	5
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL	Vulnerable due to Tritium > 1 TU 10

Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #2A

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 676446

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3) L2 Glenwood and basal St. Peter shales present	20 points
Low ("L" score of 4 to 7)	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater)	0 points
TOTAL POINTS	20

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface.	10 points
Each category for which information requested is unknown.	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	0

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet	10 points
201 to 500 feet 299 feet	5 points
>500 feet	0 points
TOTAL POINTS	5

4. Pumping rate - assign the following point values:	
>1000 gallons/minute 1120 gpm	20 points
501 to 1000 gallons/minute	10 points
50 to 500 gallons/minute	5 points
<50 gallons/minute	0 points
TOTAL POINTS	20

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million <0.05, 8/16/2004	0 points
Tritium Results	
>1 TU	Vulnerable
<1 TU unknown	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	0

7. Grand total score:	
1. DNR Vulnerability Rating	20
2. Casing Integrity	0
3. Casing Depth	5
4. Pumping Rate	20
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL	Vulnerable 45

Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #3

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 224679

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3) L3	20 points
Low ("L" score of 4 to 7)	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater)	0 points
TOTAL POINTS	20

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface.	10 points
Each category for which information requested is unknown. Casing cement unknown	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	5

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet 200 feet	10 points
201 to 500 feet	5 points
>500 feet	0 points
TOTAL POINTS	10

4. Pumping rate - assign the following point values:	
>1000 gallons/minute 1200 gpm	20 points
501 to 1000 gallons/minute	10 points
50 to 500 gallons/minute	5 points
<50 gallons/minute	0 points
TOTAL POINTS	20

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million <0.05, 9/28/1994	0 points
Tritium Results	
>1 TU	Vulnerable
<1 TU unknown	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	0

7. Grand total score:	
1. DNR Vulnerability Rating	20
2. Casing Integrity	5
3. Casing Depth	10
4. Pumping Rate	20
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL	Vulnerable 55

Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #4

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 226572

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3) L3, based on Well #3 log	20 points
Low ("L" score of 4 to 7)	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater)	0 points
TOTAL POINTS	20

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface. Not all casings extend to grade	10 points
Each category for which information requested is unknown.	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	10

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet	10 points
201 to 500 feet 325 feet	5 points
>500 feet	0 points
TOTAL POINTS	5

4. Pumping rate - assign the following point values:	
>1000 gallons/minute	20 points
501 to 1000 gallons/minute 650 gpm	10 points
50 to 500 gallons/minute	5 points
<50 gallons/minute	0 points
TOTAL POINTS	10

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million <0.05, 9/28/1994	0 points
Tritium Results	
>1 TU	Vulnerable
<1 TU unknown	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	0

7. Grand total score:	
1. DNR Vulnerability Rating	20
2. Casing Integrity	10
3. Casing Depth	5
4. Pumping Rate	10
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL	Vulnerable 45

Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #5

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 151596

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3)	20 points
Low ("L" score of 4 to 7) L6	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater)	0 points
TOTAL POINTS	15

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface.	10 points
Each category for which information requested is unknown.	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	0

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet	10 points
201 to 500 feet 230 feet	5 points
>500 feet	0 points
TOTAL POINTS	5

4. Pumping rate - assign the following point values:	
>1000 gallons/minute 1700 gpm	20 points
501 to 1000 gallons/minute	10 points
50 to 500 gallons/minute	5 points
<50 gallons/minute	0 points
TOTAL POINTS	20

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million 0.69, 4/5/2005	0 points
Tritium Results	
>1 TU	Vulnerable
<1 TU unknown	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	0

7. Grand total score:	
1. DNR Vulnerability Rating	15
2. Casing Integrity	0
3. Casing Depth	5
4. Pumping Rate	20
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL Vulnerable, based on tritium results in nearby wells	40

Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

Vulnerability Assessment Worksheet

Well Name/No. White Bear Township Well #6

Public Water Supplier ID No. 1620025

Minnesota Unique Well No. 596636

1. DNR vulnerability rating - assign the following point values:	
Very High	Vulnerable
High	Vulnerable
Moderate	25 points
Low ("L" score of 1 to 3) L1	20 points
Low ("L" score of 4 to 7)	15 points
Very Low ("L" score of 8 to 11)	10 points
Very Low ("L" score of 12 or greater)	0 points
TOTAL POINTS	20

2. Casing integrity - assign the following point values:	
Each breach of the casing.	20 points
Each casing string not grouted or extending to the land surface.	10 points
Each category for which information requested is unknown.	5 points
Each string of properly installed casing.	0 points
TOTAL POINTS	0

3. Casing depth - assign the following point values:	
<50 feet	20 points
50 to 200 feet 175 feet	10 points
201 to 500 feet	5 points
>500 feet	0 points
TOTAL POINTS	10

4. Pumping rate - assign the following point values:	
>1000 gallons/minute 2000 gpm	20 points
501 to 1000 gallons/minute	10 points
50 to 500 gallons/minute	5 points
<50 gallons/minute	0 points
TOTAL POINTS	20

5. Isolation distance from contamination sources:	
For wells <50 feet deep, assign 10 points to each source located within 100 feet of the well.	
For wells >50 feet deep, assign 10 points to each source located within 50 feet of the well.	
TOTAL POINTS	0

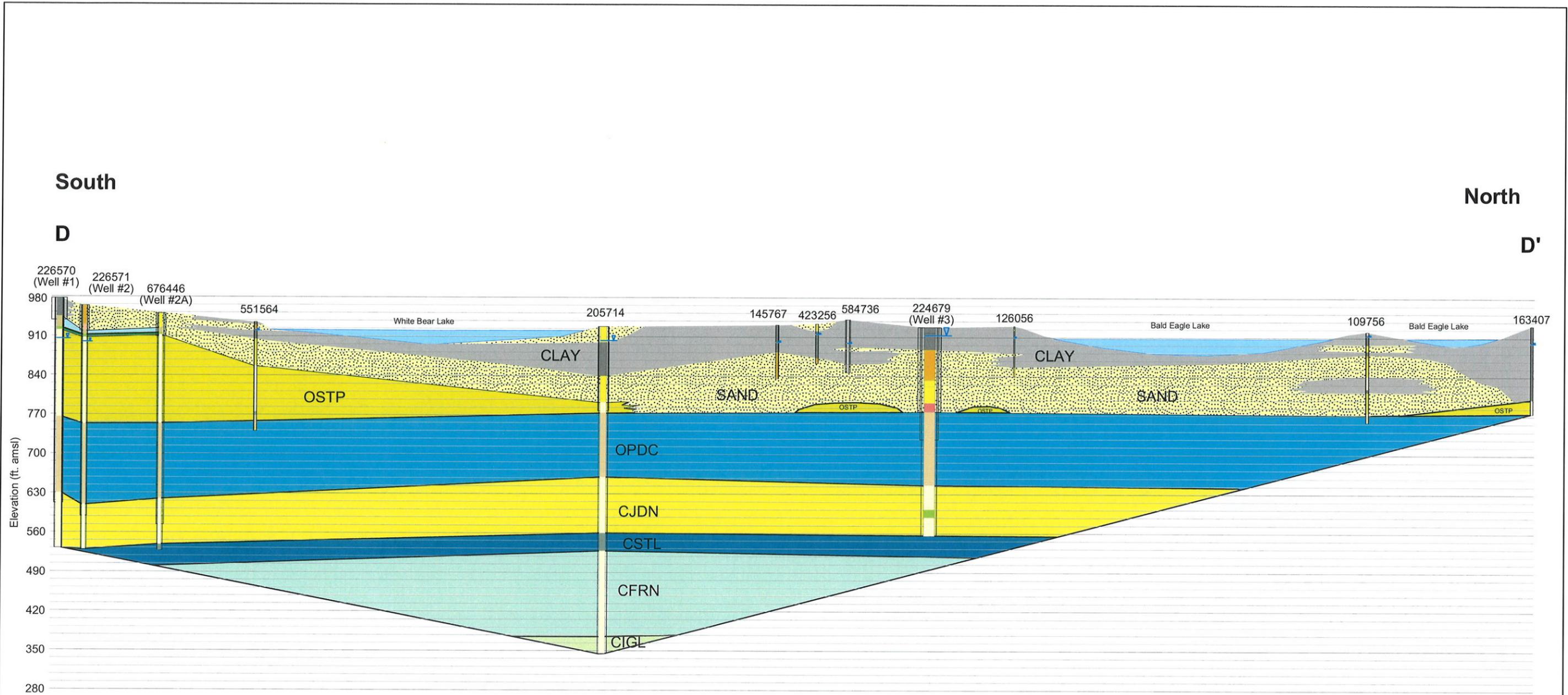
6. Chemical and isotopic information:	
Volatile Organic Compounds Detection	Vulnerable
Synthetic Organic Compounds Detection	Vulnerable
Nitrate-Nitrogen Results	Vulnerable
>10 parts/million	Vulnerable
>3 but ≤10 parts/million	30 points
1 to 3 parts/million	10 points
<1 parts/million <0.05, 4/19/1999	0 points
Tritium Results	
>1 TU 4.8 TU, 6/15/2000	Vulnerable
<1 TU	0 points
¹⁴Carbon Results	
For wells in which the ¹⁴ carbon content of water indicates an age approximation of at least several centuries, subtract 20 points from the score.	
TOTAL POINTS	Vulnerable

7. Grand total score:	
1. DNR Vulnerability Rating	20
2. Casing Integrity	0
3. Casing Depth	10
4. Pumping Rate	20
5. Isolation Distance from Contaminant Sources	0
6. Chemical and Isotopic Information	0
GRAND TOTAL	Vulnerable 50

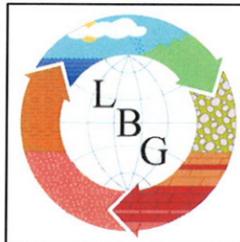
Note: See MDH SWP Vulnerability rating sheet and well log for source data.

- ▶ If the score is 45 or more, the well is considered vulnerable.
- ▶ If the score is between 5 and 40, priority for phasing into the state's WHP program is referenced to population served.
- ▶ If the score is 0 or less, the well is considered not vulnerable.

APPENDIX IV
Geologic Cross-Section D-D'



Source: MN CWI, Bedrock Geology of the Twin Cities Metro Area (Misc Map M-104), and lake bathymetry and elevations from White Bear Lake West and White Bear Lake East USGS 7.5-Minute Quadrangles.



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TKDA/WHITE BEAR TOWNSHIP
PART 1 WELLHEAD PROTECTION PLAN
WHITE BEAR TOWNSHIP, MINNESOTA

GEOLOGIC CROSS-SECTION INCLUDING WHITE BEAR AND BALD EAGLE LAKE

FILE: G3WBTO1S.MXD	DATE: 07/10/2007	FIGURE: AV - 1
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