Hewitt Groundwater Data Summary

A data summary for the Village of Hewitt, Wood County, Wisconsin

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Background

Groundwater introduction

Groundwater is water contained underground in pore spaces and fractures in sediment and rock. The *water table* is the undulating surface of the saturated zone; pore spaces and fractures are completely filled with water below this surface. The water table is an important feature of the groundwater system because its slope determines the direction of groundwater flow and where groundwater contributes to the flow in springs, streams, and rivers. Like surface water, groundwater flow is gravity-driven, moving from high water elevation towards low water elevation.

Groundwater *recharge* is water that has soaked into (infiltrated) the ground, and moved through pores and fractures in soil and rock to the water table. Recharge maintains the supply of fresh water that flows through the groundwater system to wells, streams, springs, and wetlands. Not all precipitation becomes groundwater recharge—some of it runs off the land surface to streams or storm sewers, some evaporates, and some is taken up by plants. Recharge is greatest in the spring and fall because the ground is not frozen and because plants are not using large amounts of water. Important factors that affect recharge include land cover (forest, row crop, pasture, commercial or residential area, etc.), soil type, vegetation, and rainfall timing and intensity. For example, infiltration rates are higher in sandy soil than in clayey soil or pavement.

The ease with which water flows through rock or sediment depends on the *hydraulic conductivity* of that material. A well in an aquifer with high hydraulic conductivity can be pumped at a higher rate without pumping the well dry. Hydraulic conductivity is controlled by the connectedness of pore spaces, so materials with large, well-connected pores or pervasive fractures transmit water more easily.

Purpose of Project

This study was requested and funded by the Village of Hewitt, and was completed between July and November of 2011. The purpose of this study was to collect information on Hewitt's groundwater resource and evaluate the sustainability of the current rate of water use, considering the village's growth trend. Local officials and planners requested information about local groundwater resources, including potential well yields, groundwater sustainability, and groundwater flow directions. The study area is approximately 3 miles by 3 miles, centered on the Village of Hewitt (Plate 1).

Hydrogeology of Wood County

Hewitt is located in northwestern Wood County, Wisconsin. The bedrock geology of Wood County consists primarily of Precambrian-aged metamorphic and igneous rocks. The rock itself has very low hydraulic conductivity, but the upper portion (approximately the top 10 to 30 feet) is highly weathered, and numerous fractures allow groundwater flow. Some of the larger fractures extend deeper into the rock, but become less common with depth (Batten, 1989). The bedrock underlying Hewitt is identified by well drillers as granite, an igneous rock, and the upper portion is often reported as "broken", "weathered", or "soft". In the southwestern half of the county, Cambrian sandstone is commonly found above the Precambrian bedrock. While Cambrian sandstone is occasionally encountered in boreholes in and around the Village of Hewitt, it does not form a continuous layer.

Due to topography of the land surface and bedrock surface, bedrock is approximately 30 to 80 feet below the ground surface in the Village of Hewitt.

Surficial sediments in the northern two-thirds of Wood County (including Hewitt) consist of clay-rich soils and hillslope deposits formed by weathering of the bedrock, as well as some glacial sediment (Batten, 1989).

The combination of clay-rich soils over crystalline bedrock makes groundwater in the vicinity of Hewitt scarce in comparison to other parts of Wisconsin.

Village of Hewitt Maps

The main product of this study is a series of maps (Plates 1- 5) depicting various aspects of the hydrogeology of the Village and immediate surrounding area. These maps are primarily based on well construction reports produced by water well drillers and submitted to the Wisconsin Department of Natural Resources. For this project, three hundred twenty-three well construction reports were located by address and plotted on a map using Geographic Information System (GIS) software. In these reports, well drillers record the total depth of each well, the depth of the geologic layers encountered while drilling, and the depth to water in the well. This information was used to generate generalized maps of depth to bedrock (Plate 2) and depth to groundwater (Plate 4). By using land surface elevation data (Plate 1), maps of bedrock elevation (Plate 3) and water table elevation (Plate 5) were also created.

Depth to bedrock (Plate 2) across the study area varies from 10 ft to 85 ft, with depths inside the Village boundary ranging from 25 ft on the eastern side to 85 ft on the western side. Bedrock elevation (Plate 3) ranges from 1150 ft to 1220 ft above sea level. Bedrock elevation is the lowest in the western portion of the Village. Depth to groundwater (Plate 4) within the

Village is generally between 13 and 20 feet. Water table elevation (Plate 5) in the Village ranges from 1230 ft in the northeast to 1210 ft in the southwestern portion.

The northern area of the Village sits atop a high point in the water table, meaning that groundwater flows away in all directions. Plate 5 shows very generalized groundwater flow directions. Much of the groundwater pumped by wells in Hewitt comes from recharge that originated within the village boundary. Groundwater flow within the Village is to the south/southeast.

Specific capacity and hydraulic conductivity

The *specific capacity* of a well is a simple measure of the well's ability to produce water, and is commonly reported by well drillers on well construction reports. Specific capacity is defined as the well discharge (gallons per minute) divided by the amount of drawdown, or measured water level decline in the well, caused by the pumping. So, for example, a well that produces 20 gallons per minute (gpm) with two feet of drawdown would have a specific capacity of 20/2, or 10 gpm/ft. Based on the 208 construction reports evaluated, the specific capacity of wells in the Village ranges from 0.003 to 9.0 gpm/ft, with an average of 0.19 gpm/ft. These are fairly low-yielding wells, adequate for supplying single-family homes, but probably not adequate for high-capacity irrigation or industrial wells.

Well installation specific capacity test data were also used to estimate the average hydraulic conductivity of the groundwater aquifer in the Hewitt area using a spreadsheet calculation known as TGUESS (Bradbury and Rothschild, 1985). Hydraulic conductivity is a basic measure of the ability of a geologic formation to transmit water. The average estimated hydraulic conductivity of aquifer material penetrated by wells was 1.7 feet/day (standard deviation of 7.7 feet/day). This is consistent with a previous estimate of 0.7 ft/d for the Precambrian aquifer (Batten, 1989), which was calculated using 1,350 well construction reports from Wood County.

A comparison of well depth and hydraulic conductivity (Figure 1) shows decreasing hydraulic conductivity at greater depths. This, too, is consistent with observations by Batten (1989) that most of the water pumped from the Precambrian aquifer comes from the weathered and fractured upper portion.

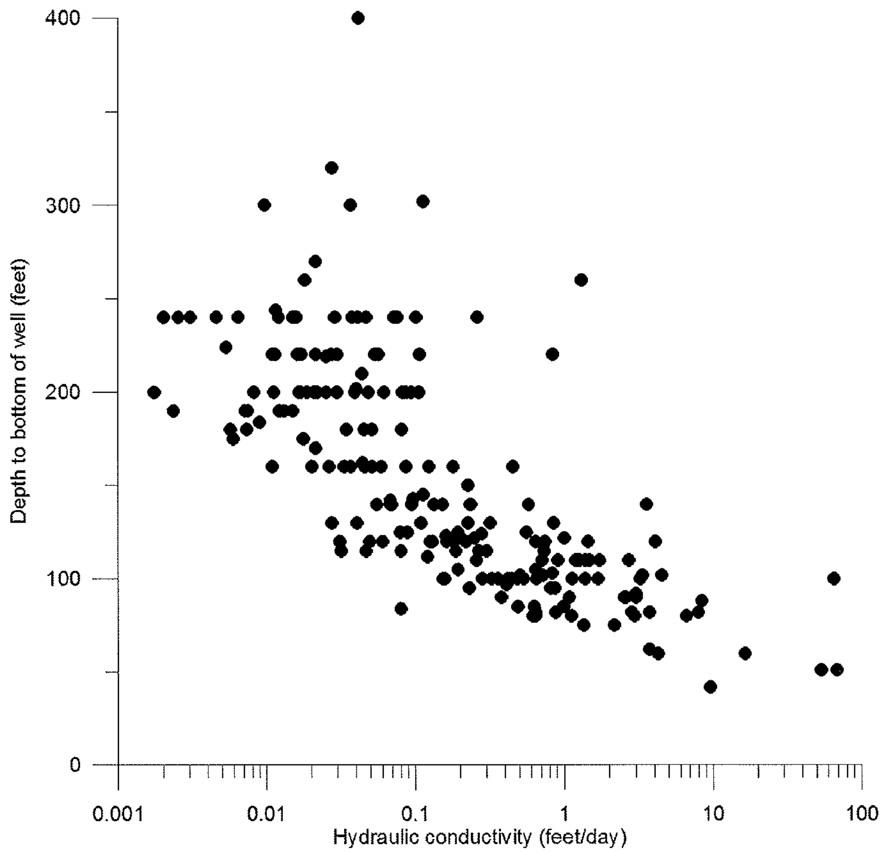


Figure 1- Scatter plot of hydraulic conductivity vs. depth to bottom of well.

Water Budget

A water budget was estimated to evaluate the current rate of groundwater use compared to available groundwater resources. Based on the water table map (Plate 5), the Village is on a groundwater divide, and groundwater flows generally radially outward away from the village. Thus the only source of replenishment to groundwater in the Village is recharge from local precipitation.

Current water use for the Village of Hewitt was estimated using a population size of 790 people and 600 cattle (M. Stueland, personal communication). Average water use was estimated at 53 gallons/day for each human and 35 gallons/day for each bovine (Buchwald, 2009). This equates to approximately 3 million cubic feet/year of water.

Groundwater recharge was estimated using a GIS-based soil-water balance model (described by Dripps and Bradbury, 2007). The model uses daily temperature and precipitation data, along with soil characteristics and land use, to estimate the amount of precipitation that infiltrates to groundwater. Given daily weather data from Marshfield for the years 1981-2010, the model calculated an average annual recharge of 7 inches/year for the Village of Hewitt (approximately 13 million cubic feet/year of water).

Based on this average recharge rate, current water use is equal to approximately 23% of annual groundwater recharge within the Village boundaries. However, it is important to note that some of the remaining 77% contributes to surface water bodies, such as streams and wetlands, and much of this water is removed by evapotranspiration. Annual groundwater recharge can be seen as an upper sustainable limit, but ecosystems may be affected long before water use reaches that amount. In the absence of pumping, groundwater discharges to nearby streams and wetlands, and sustains baseflow. Pumping removes water from the system and reduces baseflow.

A simple computer model of groundwater flow was constructed to help assess the impact of pumping on local groundwater and surface water. The model is based on a modeling code called GFLOW. GFLOW is a two-dimensional, steady-state, analytic element groundwater flow modeling code. It simulates groundwater levels and groundwater discharge based on analytical solutions for pumping wells and surface-water features. For this simple application individual wells were not simulated; instead, water use scenarios of current and doubled water use were simulated by reducing net recharge within the Village in proportion to the increased water use. This approach provides a good approximation of the overall water balance, but does not account for the uneven distribution of wells within the Village boundary, meaning that areas where wells are concentrated could see slightly higher drawdowns. Using this approach, only modest declines in the water table occur under the increased water-use conditions. Simulation of current water use resulted in lowering of the water table up to 2.5 ft with respect to natural (no pumping) conditions. Doubled water use lowered the water table an additional 3 ft.

Drawdown of the water table could reduce streamflow in nearby streams, but model simulations indicated that the impact is likely to be small. The upper reaches of the nearby streams are the most sensitive, as even modest decreases in groundwater discharge to small streams can reduce streamflow by a perceptible fraction. Additional work would be required to predict actual flow reductions in specific streams. However, the model simulations completed for this study do not demonstrate a need for further investigation.

Taken together, the specific capacity analyses, water-table map, and modeling simulations have several implications. First, the hydraulic conductivity of the local aquifer is low, and as a result local well yields are also generally low. The fractured bedrock aquifer can provide sufficient water for wells serving single-family homes or small businesses, but the potential for developing high-capacity wells (defined as wells yielding over 70 gallons per minute) is low. It is possible that higher well yields might be found by locating specific fractured bedrock zones or isolated buried valleys filled with permeable material, but the available data show no such features inside the Village boundaries.

Second, the current groundwater use in the Village is sustainable. Current recharge exceeds water use, and there is no evidence that current water use has caused significant water-table drawdown or significantly impacted flow to local streams and wetlands. Increasing overall water use by a factor of up to 2 would still be sustainable, though obtaining that much groundwater might pose a challenge due to the low-yielding characteristics of local wells.

Third, because it is located nearly on top of a high point, or divide, in the water table, most groundwater used in the Village originates as recharge within the Village itself. Thus, local land use practices, such as maintaining open space and protecting groundwater recharge areas, could have significant benefits to the Village.

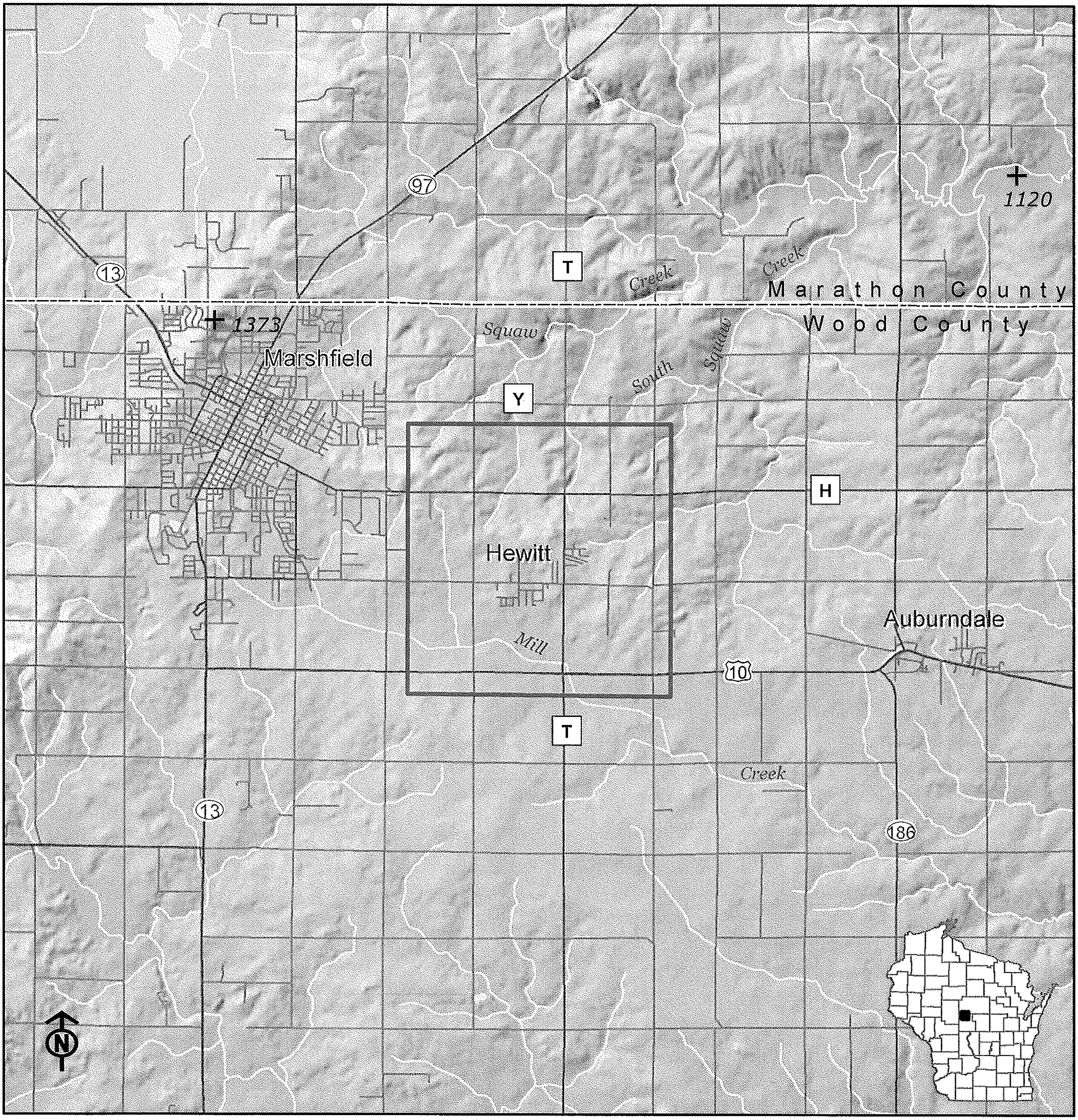
Conclusions

The information collected and simulations performed as a part of this study yield the following conclusions:

- Hewitt sits atop a high point in the water table, so much of the groundwater pumped by wells in Hewitt comes from recharge that originated within the village boundary.
- Hydraulic conductivity tends to decrease with depth, consistent with observations that most flow in the Precambrian aquifer occurs in the weathered and fractured upper portion.
- Wells in Hewitt produce an adequate amount of water for domestic use. However, because the crystalline bedrock beneath Hewitt forms a very low-yielding aquifer, the potential for successful high-capacity wells in or near the Village is low.
- Current groundwater use equals approximately 23% of recharge within the village boundary.
- The current groundwater and water use situation in the Village of Hewitt is sustainable, meaning that current water use is not causing significant declines in groundwater levels or degrading nearby surface water resources. The effect of plausible increases in water use on the elevation of the water table is not expected to be problematic.
- Management of Hewitt's groundwater resource should focus on maintaining current recharge and protecting groundwater quality.

Groundwater Data Summary for the Village of Hewitt
Wood County, Wisconsin

Plate 1
Regional Topography



Base map from ESRI Streetmap dataset (2008), terrain data from Wisconsin Department of Natural Resources and US Geological Survey.

Scale 1:100,000
0 1 2 3
Miles

Study Area Boundary

+ Topographic High and Low Points (in feet above sea level)

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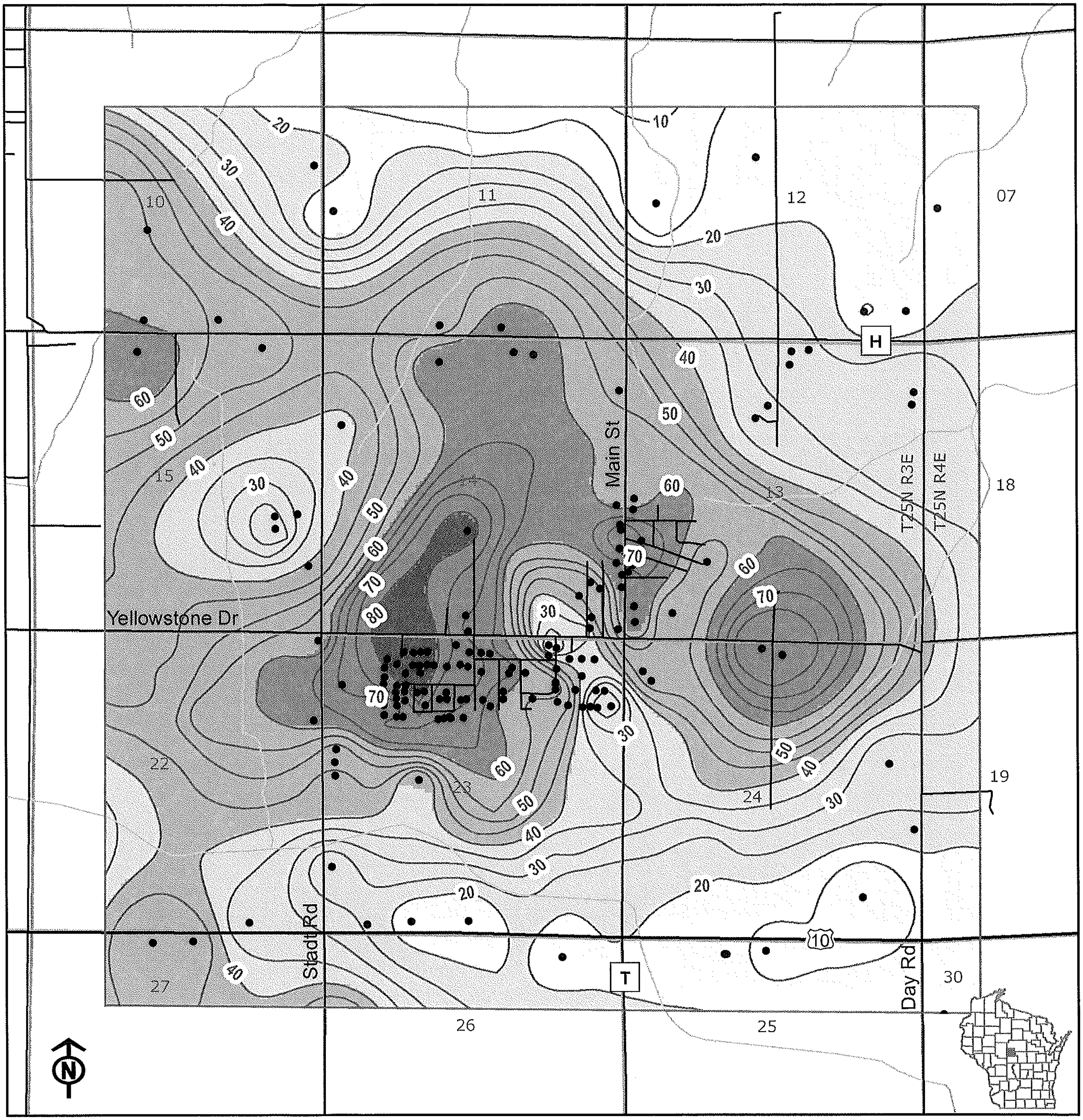
Plate 2
Depth to Bedrock



- Data Point
- Study Area Boundary
- Public Land Survey Grid

Base map from ESRI Streetmap dataset (2008)

Scale 1:30,000

0 — 1 Miles

Depth to Bedrock (feet)
- 5-foot Contours
- < 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

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Groundwater Data Summary for the Village of Hewitt
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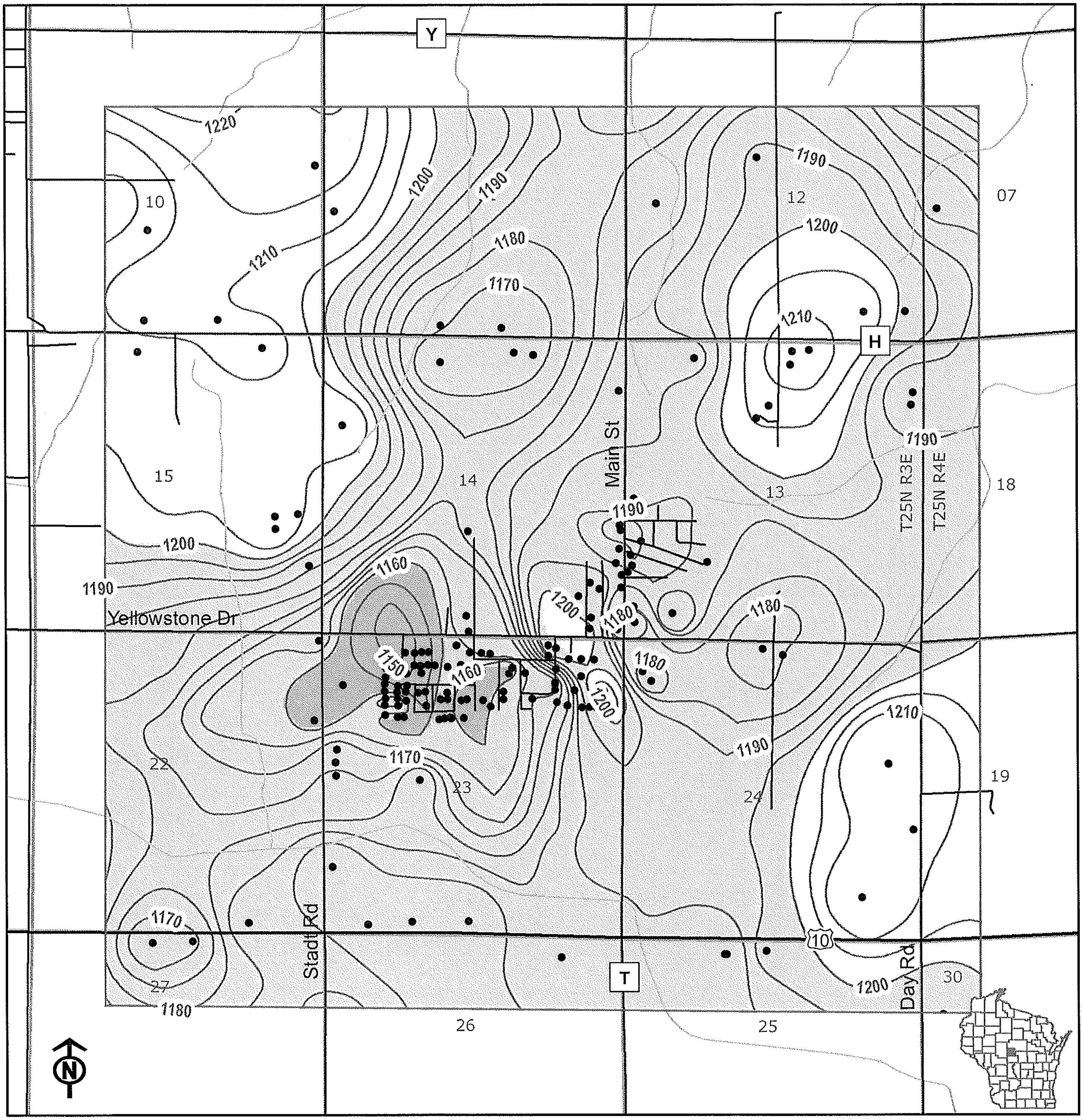
Plate 3
Bedrock Elevation



- Data Point
- Study Area Boundary
- Public Land Survey Grid

Scale 1:30,000

0 — 1 Miles

Bedrock Elevation (feet above sea level)

- 5-foot Contours
- < 1120
- 1120 - 1160
- 1160 - 1200
- > 1200

Base map from ESRI Streetmap dataset (2008)

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Groundwater Data Summary for the Village of Hewitt
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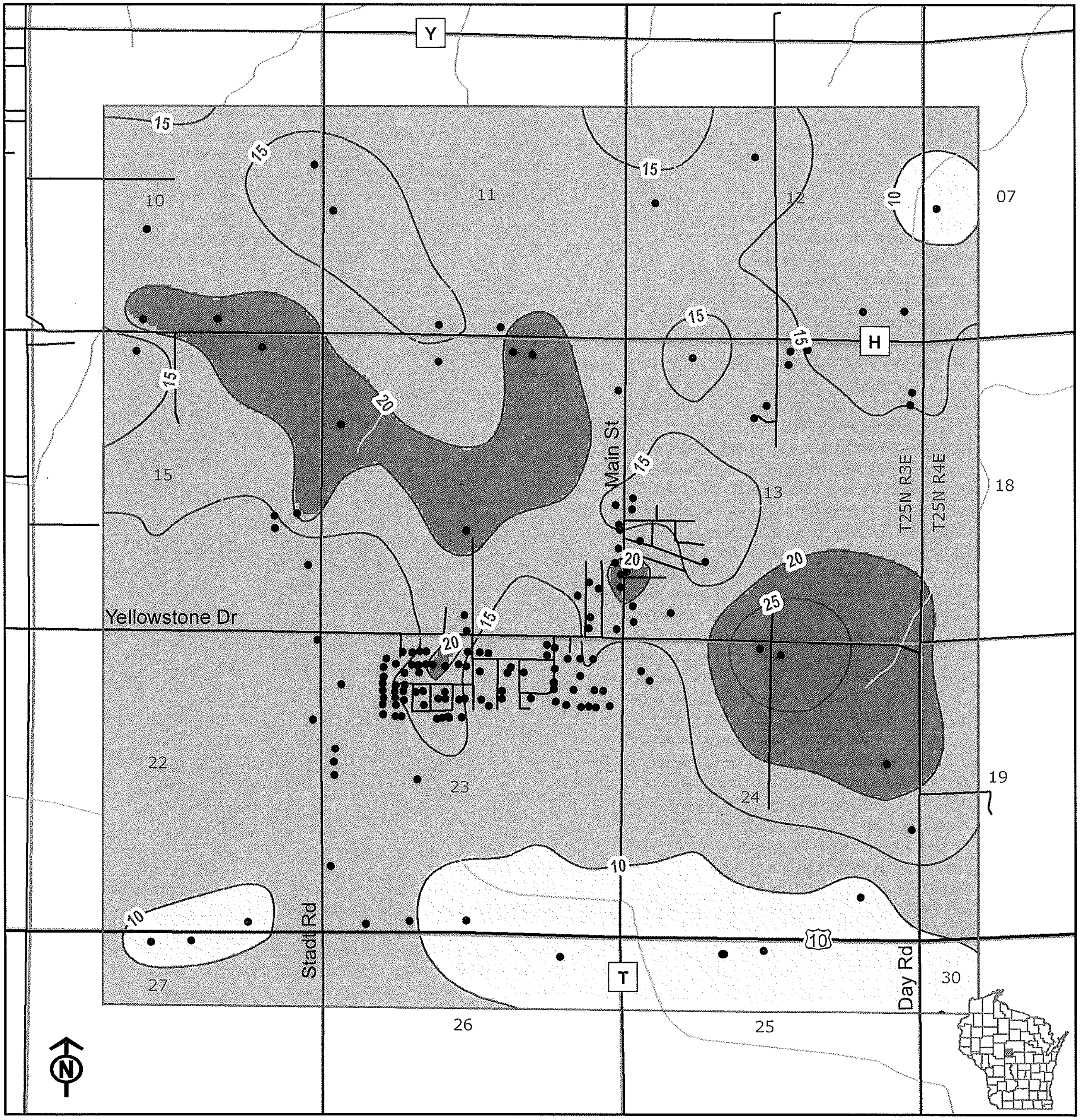
Plate 4
Depth to Water Below Land Surface



• Data Point
Study Area Boundary
Public Land Survey Grid

Base map from ESRI Streetmap dataset (2008)

Scale 1:30,000
0 — 1 Miles

Depth to Water (feet)
5-foot Contours
< 10
10 - 20
> 20

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Groundwater Data Summary for the Village of Hewitt
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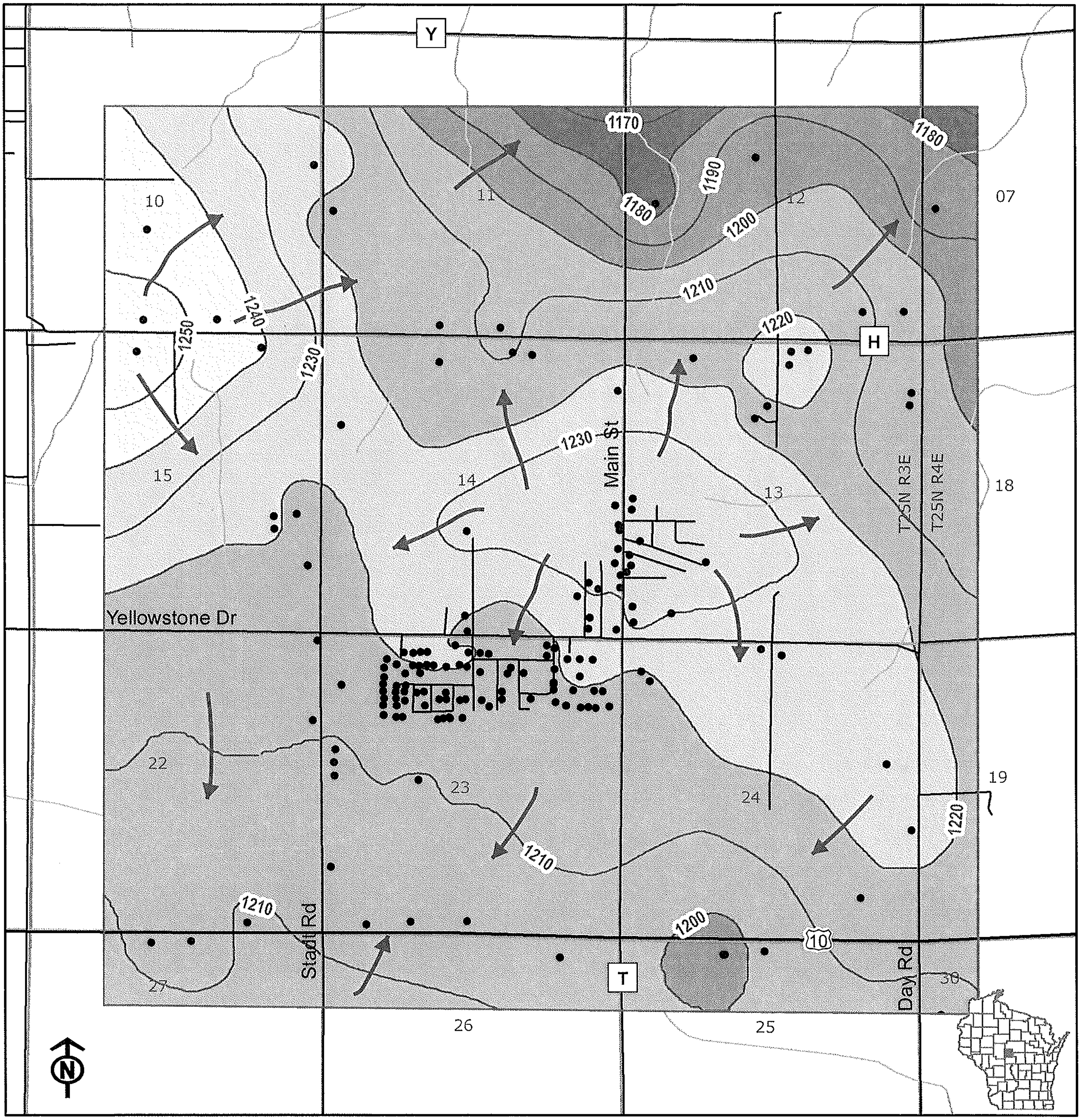
Plate 5
Water Table Elevation



- Data Point
- Study Area Boundary
- Public Land Survey Grid
- Approx. Direction of Groundwater Flow

Scale 1:30,000

0 — 1 Miles

Water Table Elevation (feet above sea level)

- 10-foot contour
- > 1240
- 1220 - 1240
- 1200 - 1220
- 1180 - 1200
- < 1180

Base map from ESRI Streetmap dataset (2008)

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