APPENDIX B

Rosemount Well Field Study

Prepared for
City of Rosemount

October 2005

BARR

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Rosemount Well Field Study

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1.0 Introduction

The City of Rosemount, Minnesota is in the midst of a comprehensive water system planning effort. As part of the process, the City is planning the ultimate build out of its water system. Barr Engineering is assisting in this effort by conducting a groundwater flow modeling study to identify and evaluate future well fields.

This technical memorandum summarizes the results of the well field study conducted for the City under subcontract to WSB & Associates. The objectives of the well field study include:

(1) Evaluate where to locate new municipal water supply wells,

(2) Estimate how many wells are required to meet projected water demand,

(3) Estimate required well spacing needed to limit interference to acceptable levels

(4) Evaluate the technical feasibility of installing additional wells into the Jordan Sandstone aquifer,

(5) Evaluate the regulatory feasibility of installing additional wells into the Jordan Sandstone aquifer by estimating the impact of the new wells on surrounding wells and natural resources,

(6) Review known contaminant releases in the area and provide general input regarding how the proposed wells may be impacted by those releases.

The report will provide a brief discussion of the **Background** of the project followed by a section describing the **Groundwater Modeling** effort which will include discussion of the **Baseline Condition** used for comparison purposes. This will be followed by the actual **Well Field Evaluation,** which will be broken down into **Evaluation of Long Term Pumping** and **Impact on the Aquifer Source** which discusses allowable aquifer draw down as compared to what is predicted. Next the report will cover **Potential for Well Interference** with nearby existing wells which will be of particular interest to the Minnesota Department of Natural Resources (DNR) and may have significant implications on certain wells field locations, **Known Contaminant Release**, a section on **Evaluating Short Term Peak Pumping**, and a **Conclusion.**

2.0 Background

The City of Rosemount has seen a significant increase in development recently as have many metro area communities. The City is primarily residential and commercial along its western edge where all of it water system infrastructure, is currently concentrated. The Flint Hills Resources refinery (formerly Koch) is located along the City's north eastern edge and is a significant presence that affects water system planning. An additional feature affecting potential well locations in the City is the large tract of University of Minnesota property located in the southern part of the City. All of these were taken into account while preparing this study.

Until recently, the City operated six (6) municipal water supply wells including Well 3 (unique number 211999), Well 7 (unique number 112212), Well 8 (unique number 509060), Well 9 (unique number 554248), Rural Well 1 (unique number 457167, referred to as RW1), and Rural Well 2 (unique number 474335, referred to as RW2). In response to the growth noted above the City recently put Well 12 into service and will be putting Well 14 into service in the near future. All existing and proposed wells pump from the Jordan Sandstone aquifer. Well locations are shown on Figure 1. It is also our understanding that the City plans to remove Well 3 from service in the near future. Therefore, Well 3 was not including in the groundwater modeling done for this study.

The City's current permit with the Department of Natural Resources allows for an annual groundwater appropriation of 788 million gallons per year (MGY). Projections provided by WSB & Associates on behalf of the City (Table 1) indicate that at ultimate build-out the Rosemount municipal water system will provide an average off 12.78 million gallons per day (MGD) which translates to approximately 4.7 billion gallons per year (BGY). The projections also indicate that the ultimate peak day requirement will be 31.95 MGD. To meet these increased demands the City will need to appropriate additional water either from new wells or other sources.

The Minnesota Department of Natural Resources (MDNR) is responsible for managing the State's groundwater resources. John Greer of Barr Engineering spoke with Pat Lynch, MDNR Area Hydrologist for Dakota County, on July 14 regarding the City's planning efforts. Mr. Lynch was not aware of any water quantity issues or concerns at this time that could negatively impact the City's plans to expand the municipal water supply. Mr. Lynch did say that the MDNR prefers to increase groundwater appropriations incrementally and that they will look at a water supplier's conservation efforts when reviewing an application for an increased appropriation.

3.0 Groundwater Modeling

Barr Engineering evaluated three (3) proposed well field locations identified by WSB: two in the western portion of Rosemount and one in the eastern portion of Rosemount. Locations of these proposed well fields are shown on Figure 2. They are called Well Field One which is the southwest most field located near Well #12, Well Field Two which is located near Well #14 in the north central part of the City and Well Field Three which is the east most well field.

A MODFLOW finite difference model based on the Scott and Dakota Counties groundwater model prepared for the Minnesota Department of Health by Barr Engineering (Barr, 1999; 2001) was used to evaluate pumping from the Rosemount municipal wells in the Jordan Sandstone aquifer. This MODFLOW model does not include any aquifers below the Jordan Sandstone. Barr Engineering made modifications to the Scott and Dakota Counties groundwater model for this study in order to more accurately simulate the variation of bedrock surface topography and variations in aquifer hydraulic properties in the vicinity of Rosemount. The modeling pre- and post-processing package Ground Water Vistas (Rumbaugh and Rumbaugh, 2003) was used to facilitate preparation of the changes to the MODFLOW model and to process the modeling results.

In some areas of the Minneapolis-St. Paul metropolitan area, the Jordan Sandstone aquifer and the overlying Prairie du Chien Group aquifer are well connected hydraulically. Where these aquifers are hydraulically well connected pumping from a municipal water supply well in the Jordan Sandstone will have a measurable, and potentially significant, affect on the piezometric surface in the Prairie du Chien Group aquifer in the vicinity of the municipal well. Results of a pumping test conducted as part of the Rosemount wellhead protection area delineation work suggest that there is some leakage from the Prairie du Chien (Barr, 2002) into the Jordan Sandstone. There are private water supply wells in the vicinity of Rosemount that are completed in the Prairie du Chien Group aquifer. Since there is some leakage between the Prairie du Chien Group and Jordan Sandstone aquifers, the possibility that pumping in the Rosemount municipal wells could affect water levels in the private wells in the Prairie du Chien Group aquifer must be evaluated.

There are uncertainties associated with using the MODFLOW model to predict future drawdown. These uncertainties include regional hydraulic head fluctuations, unknown pumping in nearby Jordan Sandstone aquifer wells, and well inefficiency. In order to account for these uncertainties, a safety factor was used in the evaluation of modeling results. The safety factor is an attempt to minimize the chances of the piezometric head in the Jordan Sandstone aquifer being drawn below the top of the aquifer if one of the modeled scenarios were to be implemented. A safety factor of 30 to 50 feet has been used in light of the transmissivity of the Jordan Sandstone aquifer. This safety factor also allows for variations in weather conditions such as a prolonged drought or additional drawdown from new pumping sources not included in this model.

4.0 Baseline Condition

In order to discuss drawdown created by the pumping of a proposed well a baseline condition must be determined. In this case baseline means the assumed static water level in each of the aquifers evaluated. This is significant because groundwater levels at a given location vary throughout any given year and from year to year because of a number of items including precipitation, and when it occurs, pumping from the aquifer and when it occurs, hot spells and when they occur. For the purposed of predicting drawdown in this project the baseline is assumed to be 2003 conditions, which is the last complete year for which data is available for surrounding pumping conditions. A related assumption is that the baseline condition did not cause problematic interference with nearby wells.

It follows then that the drawdown predicted by groundwater modeling in this report will be noted from the baseline piezometric conditions. For the Rosemount well field study, the baseline piezometric condition for the Jordan Sandstone aquifer is based on historically measured groundwater levels in nearby wells and the City's current permitted annual appropriation of 788 MGY. The baseline piezometric condition for the Jordan Sandstone was generated by first assigning a pumping rate of 50-gpm (approximately 26.3 MGY) each to Wells RW1 and RW2 and subtracting the total volume pumped by Wells RW1 and RW2 from the annual appropriation and then evenly distributing the remaining volume (approximately 762 MGY) among Wells 7, 8, 9, 12, and 14. For the baseline case, therefore, an average annual pumping rate of 280-gallons per minute (gpm) was applied to Wells 7, 8, 9, 12, and 14. Pumping rates for high capacity pumping wells in the area around Rosemount are assumed to be the 2003 water usage listed in the DNR's State Water Use Database (SWUDs) converted to a pumping rate. The hydraulic head distribution in the Prairie du Chien Group and Jordan Sandstone aquifers produced by the MODFLOW model under the baseline pumping conditions is shown on Figures 2 and 3 respectively. These head distributions were used as the initial or base line conditions to which all future pumping conditions will be compared.

5.0 Evaluation of Well Fields

As noted above three well fields were evaluated in this report. Well Field 1 is in the vicinity of Well 12 and the while Well Field 2 is in the vicinity of Well 14 (Figure 4). Well Field 3 is in the southeastern corner of Rosemount (Figures 4). For this evaluation, four wells (including Well 12) were placed in the Well Field1, seven wells (including Well 14) were placed in the Well Field 2, and eight wells were placed in Well Field 3 (Figure 4). Wells were sited no closer than 1,700 feet apart in Well Field 3 and no closer than 2,600 feet in Well Fields 1 and 2.

A preliminary evaluation of the western and eastern well fields was done by distributing projected 2020 pumping evenly among the existing and proposed wells and running the groundwater model in steady state mode. This represents the annual average impact the proposed wells will have on groundwater levels as compared to baseline conditions. Pumping from the municipal wells in the western and eastern portions of Rosemount were modeled separately. This was done to quickly identify any major problems (e.g., significant localized aquifer deficiencies or well interference) that would indicate that changes to either well or well field locations would be necessary. No problems were identified in the preliminary evaluation. Since this preliminary work did not include interaction of all the proposed wells it is not presented here. Results of the preliminary evaluation are available upon request.

5.1 Evaluation of Long Term Pumping

In order to evaluate the affect of long term pumping from existing and proposed Rosemount municipal wells the projected ultimate water demand (Table 1) was used. Since plans call for wells RW1 and RW2 to be used sparingly, if at all, in the future the pumping rates for these two wells was fixed at 50-gpm each. Based on the projected ultimate water demand provided by WSB, and accounting for the assumed pumping from wells RW1 and RW2, a pumping rate of 392-gpm was assigned to each of the 14 existing and proposed wells in the western part of Rosemount and a pumping rate of 411-gpm was assigned to each of the proposed wells in the eastern part of Rosemount. The model was then run in steady state mode.

5.2 Impact on Aquifer Source

As indicated on Figures 5 and 6, the model predicts a maximum drawdown of approximately 27 feet in the Prairie du Chien Group aquifer and approximately 40 feet in the Jordan Sandstone aquifer under the ultimate water demand pumping scenario. Note that these are modeled water levels in the aquifers not the level in the pumped wells which would be lower yet depending on well efficiencies. There is 50 feet of available drawdown in the Prairie du Chien Group and 186 feet in the Jordan Sandstone aquifers. This includes a safety factor as discussed above meaning that even if you were to draw down the entire 50 feet of available drawdown in the Prairie du Chien the water level is still 30 to 50 feet above the top of the aquifer. Note that available drawdown is defined as the amount of drawn down available in the aquifer before the water level would drop below the top of the water bearing unit in which the measurement is made. When the predicted drawdown modeled is less than the available drawdown the modeled condition is acceptable. If the predicted drawdown exceeded what was available there is a possibility that the DNR would intervene to protect the affected resource aquifer.

The predicted drawdowns in the two aquifers are less than the available drawdowns. Thus, from the standpoint of stress on the aquifers, the model indicates that pumping to meet Rosemount's projected ultimate water demand likely would not have any long term adverse impact on either the Prairie du Chien Group or Jordan Sandstone aquifers. This means that the DNR would allow the aquifers to be pumped as modeled here without limitations placed on the pumping rates to protect the aquifer itself.

5.3 Potential for Well Interference

The locations of private wells in the vicinity of Rosemount taken from the Minnesota Geological Survey's County Well Index (CWI) are shown on Figures 5 and 6. The symbols are color-coded to indicate the aquifer in which each of the private wells is completed. Based on model results there are private wells completed in the Prairie du Chien Group and Jordan Sandstone aquifers in areas where the model predicts drawdown of more than 10 feet (Figures 5 and 6). This suggests that, depending on pump setting depths, the possibility exists for pumping to meet the City's ultimate water demand may adversely interfere with some private water supply wells in the vicinity of Rosemount. (It should be noted that the possibility of adverse interference with private wells in the vicinity of Rosemount exists under pumping to meet the projected 2020 water demand as well.) Should the MDNR agree with an interference complaint that pumping from the Rosemount municipal wells in the Jordan Sandstone aquifer results in degradation of performance of another owner's well then the City would be required to rectify the situation. The required response could range from lowering of a pump in the private well to drilling a new well for the owner with the work paid for by the City. Thus, potential well interference is something that should be considered as plans for municipal wells are developed.

The model predicts that drawdown from pumping in the existing and proposed Rosemount wells to meet the City's ultimate water demand will extend beyond the city limits into neighboring municipalities including Apple Valley, Coates, Eagan, Hastings, Inver Grove Heights, and Lakeville. These cities operate municipal water supply wells that pump from the Jordan Sandstone aquifer. Thus, it is possible that pumping in the Rosemount wells may adversely affect wells in one or more of these communities (and vice versa). Therefore, it is recommended that the City of Rosemount maintain communication channels with the neighboring communities regarding water use and plans for expansion of the municipal water systems with the goal of ensuring that all the municipalities can meet their water demands in the future.

5.4 Known Contaminant Release Sites

The locations of known contaminant release sites including leaking underground storage tanks (LUSTs) and non-storage tank release sites in the vicinity of Rosemount available from MPCA files are shown on Figure 13. No further remedial action is planned at some of these sites. Groundwater contamination (not necessarily in the Prairie du Chien Group or Jordan Sandstone aquifers) may have been or may still be associated with some of these release sites (this could include residual contaminant levels associated with sites where no further remedial action is planned). Historical boundaries of groundwater contaminant plumes (generally in or above the Prairie du Chien Group aquifer) from industrial properties in the northeastern portion of Rosemount as well as from a source on property owned by the University of Minnesota in the southern portion of Rosemount are also shown on Figure 13.

Under the ultimate water demand pumping scenario, the groundwater model was used to identify the areas from which groundwater is predicted to flow to existing or proposed Rosemount municipal wells in 10 years or less. These predicted 10-year groundwater time of travel zones, or 10-year capture zones, are shown on Figure 13. While the predicted 10-year capture zones do not intersect the historical groundwater contaminant plume boundaries they do encompass some of the known contaminant release site locations.

In addition to this a meeting was held with the MPCA to discuss Rosemount's planned well field expansions and the potential they may have to impact or be impacted by contaminant releases and groundwater contaminant plumes. Additional information related to that meeting and the resulting proposed course of action that the City should take when siting wells in the future is included as Appendix 1 at the end of this report.

5.5 Evaluation of Short Term Peak Pumping

The effect of short term peak pumping from the existing and proposed Rosemount municipal wells was also evaluated. This evaluation was done by running the model in transient mode with three pumping periods to simulate one full year of pumping at ultimate build out pumping rates. The first pumping period represents pumping from January, Day zero, to mid summer, Day 180, at average annual pumping rates. The second pumping period, the peak demand period, represents an 18 day stretch from day 181 to day 199 where all wells are running continuously to meet demand. The third pumping period represents the return to normal pumping for the remainder of the year, Day 200 to day 365.

In the second pumping period (i.e., the peak pumping period) wells in the western well fields were assigned a pumping rate of 953-gpm and wells in the eastern well field were assigned a pumping rate of 1027-gpm. These rates are based on the projected ultimate peak day demands provided to Barr Engineering by WSB (Table 1). The length of the peak pumping period was set at 18 days based on information provided by WSB. Wells RW1 and RW2 were assigned a pumping rate of 50-gpm in all three pumping periods.

The results of this modeling exercise are depicted on Figures 7 through 12. Figures 7 - 9 represent the drawdowns predicted in the Prairie du Chien aquifer while Figures 10 – 12 represent drawdowns in the Jordan aquifer. Figures 8 and 11 show the impacts of the peak pumping period. Predicted drawdowns in the Prairie du Chien Group and Jordan Sandstone aquifers at the end of each of the pumping periods are within the predicted available drawdowns in the aquifer. However, the predicted drawdowns do indicate that there would be the possibility of adverse well interference under this ultimate peak pumping scenario.

6.0 Conclusions

Based on the water use projections and other information provided by WSB, the modeling done for this study suggests that it is technically feasible for the City to obtain sufficient water from the Jordan Sandstone aquifer using existing and proposed wells to meet both the projected ultimate average day and peak day water demand. Wells can be sited in proposed Well Fields 1, 2, and 3 as planned by the City. Siting them in these locations does not draw down water levels below the top of the aquifer. Modeling suggested that the ultimate average and peak day demands could be met by siting three additional wells in Well Field 1 near Well 12, six additional wells in Well Field 2 near Well 14 and eight new wells in Well Field 3. Wells should never be sited closer than 1,700 to 1,900 feet apart in Well Field 3 and no closer than 2,600 to 2,800 feet apart in the Well Fields 1 and 2 in order to limit potential localized interference. Wells spaced closer than this may result in unacceptable interference between each other and have negative impacts on well capacity. From a regulatory stand point no conditions were encountered that would make using the Jordan aquifer as a source a significant problem, however, the modeling results did indicate that there is a potential for adverse well interference with private and possibly other municipal wells in the vicinity of Rosemount. The DNR will get involved in well inference complaints and work with you to make sure that corrections are made to the wells that are negatively impacted by those you install. If planned for, the potential interference can be dealt with in the normal course of planning out your water system by adding the impacted properties to your system or modifying their wells as needed. Finally, some of the ten year capture zones for the proposed wells do encompass known release sites. None encompassed the large known contaminant plumes originating in south central or northeast Rosemount. The City should follow the procedures recommended in Appendix 1 each time they site a new well to make sure that potential contamination sources are identified and planned for in the well design and construction process.

7.0 References

Barr Engineering Company (Barr), 1999. Scott-Dakota Counties Groundwater Flow Model. Prepared for the Minnesota Department of Health. October, 1999.

Barr Engineering Company (Barr), 2001. Scott-Dakota Counties Groundwater flow Model Update, prepared for Minnesota Department of Health, March 2001.

Barr Engineering Co. (Barr), 2002. "Wellhead Protection Area Delineations for the City of Rosemount, Minnesota", prepared for the City of Rosemount, Minnesota, April 2002.

Rumbaugh, J.O. and D.B. Rumbaugh, 2003. Guide to Using Groundwater Vistas – Version 4, Environmental Simulations Inc.

Tables

Table 1

Projected Water Usage for the City Service Area
City of Rosemount, Minnesota

Total of All Well Fields

Year	Projected Total Average Daily Use	Projected Peak Day Demand (2.5xavg.)
	MGD	MGD
2005	2.09	5.23
2006	2.64	6.59
2007	3.19	7.99
2008	3.77	9.41
2009	4.31	10.77
2010	4.85	12.14
2011	5.21	13.02
2012	5.56	13.90
2013	5.91	14.78
2014	6.26	15.66
2015	6.62	16.54
2016	6.85	17.12
2017	7.08	17.70
2018	7.31	18.27
2019	7.54	18.85
2020	7.77	19.43
2021	8.04	20.10
2022	8.31	20.76
2023	8.57	21.43
2024	8.84	22.10
2025	9.11	22.77
Ultimate	*12.78*	*31.95*

Western Well Fields

Year	Projected Total Average Daily Use	Projected Peak Day Demand (2.5xavg.)
	MGD	MGD
2005	1.99	4.97
2006	2.38	5.95
2007	2.79	6.96
2008	3.20	8.01
2009	3.59	8.98
2010	3.99	9.97
2011	4.21	10.52
2012	4.43	11.07
2013	4.65	11.62
2014	4.87	12.17
2015	5.09	12.72
2016	5.09	12.73
2017	5.10	12.75
2018	5.11	12.77
2019	5.11	12.78
2020	5.12	12.80
2021	5.12	12.80
2022	5.12	12.80
2023	5.12	12.80
2024	5.12	12.80
2025	5.12	12.80
Ultimate	*8.05*	*20.12*

Eastern Well Field

Year	Projected Total Average Daily Use	Projected Peak Day Demand (2.5xavg.)
	GPD	MGD
2005	0.10	0.26
2006	0.26	0.64
2007	0.41	1.02
2008	0.56	1.41
2009	0.71	1.79
2010	0.87	2.17
2011	1.00	2.50
2012	1.13	2.83
2013	1.27	3.16
2014	1.40	3.49
2015	1.53	3.83
2016	1.75	4.39
2017	1.98	4.95
2018	2.20	5.51
2019	2.43	6.07
2020	2.65	6.63
2021	2.92	7.30
2022	3.19	7.97
2023	3.45	8.64
2024	3.72	9.31
2025	3.99	9.97
Ultimate	*4.73*	*11.83*

Appendix 1

Approach to Future Well Siting, File Memorandum

BARR

Internal Memorandum

To:	File
From:	Eric Dott, P.G., Senior Hydrogeologist
Subject:	Approach to Future Well Siting
Date:	October 26, 2005
Project:	23/19-927-JCG
c:	John Greer

The purpose of this memorandum is to summarize our recommended approach for evaluating and managing future well sites for potential groundwater contamination concerns, with the objective of managing the City's environmental liability risks and managing health risks. Our recommended approach is based in part on the discussions we had with Minnesota Pollution Control Agency (MPCA) staff from the Voluntary Investigation and Cleanup (VIC) program and the Attorney's General staff.

The primary groundwater contamination concern in the area of focus is the presence of at least one known chlorinated solvent plume emanating from the former University of Minnesota Rosemount Agricultural Research Center, located in south-central Rosemount. The identified plume has been reported by Delta Environmental Consultants, Inc. (2002) to migrate with the regional water table aquifer flow toward the northeast, where it presumably discharges to the Mississippi River. Throughout the eastern portion of the area of focus, the water table is approximately 35 to 75 feet below ground surface within sand and gravel glacial outwash deposits.

Other release sites have been identified in the areas where wells are planned so sources of potential shallow groundwater contamination may be present in the area of focus, however, the information available at this time suggests that the other known sites are likely to be current or former petroleum storage tank sites such as gas stations or individual tank installations (farm stead storage tanks). By the nature of petroleum contamination, such impacts to groundwater tend to be focused at the water table interface and/or are limited to a shallow dissolved-phase plume. Furthermore, petroleum impacts tend to experience significant natural attenuation when conditions are sufficient for microbial and other physical degradation or attenuation processes to occur. Consequently, the type of contamination of significance to locating and designing new water supply wells in this area, is contaminant releases that have the potential to result in a plume migrating significant distances (farther than 0.25 miles) and/or contaminants that might have a tendency to sink through aquifer material (i.e. more dense than water). With these considerations in mind we have developed the following recommended approach for evaluating the potential for significant groundwater contamination to be present or to be within the proposed area of influence.

Based on our discussions with VIC staff, we recommend the following approach to evaluating future water supply well locations:

1. Identify a potential water supply well location with in the area of focus.
2. Perform a Phase I Environmental Assessment of the area of encompassed by a modeled ten year capture zone of the proposed well.
3. If potential sources of contaminated groundwater are present within the ten year capture zone- either relocate the proposed well or evaluate the treatability of the contaminants present- if not treatable then relocate the proposed well;
4. If the suspected contaminant(s) are believed to be treatable and the City is willing to construct and operate such a treatment system- gather groundwater data by installing a small diameter sampling well at the proposed well site.
5. If no detectable contamination is found; proceed with well design.
6. If contamination is detected (i.e. an "identified release") and the City still wants to install a well at this location seek VIC program assistance.
7. Perform a pumping test and include groundwater quality testing at key observation wells and from the pumped well.
8. Using a groundwater flow model of the area, evaluate whether a significant plume is influenced or captured by the proposed pumping.
9. If a groundwater contaminant plume will be intercepted or otherwise affected by the planned well installation- obtain assurances and/or technical review assistance from the VIC program. Note that this assistance is not free and the City will be billed at the hourly VIC rate for MPCA involvement (current rate as of the date of this report is $150/hour).
10. Evaluate the need to mitigate risks or impacts that may be caused by planned water supply extraction- this may include development of an operational contingency plan and possibly a groundwater quality monitoring program for implementation during initial operation of the supply well.
11. If appropriate, obtain a letter of no association from the MPCA. Ultimately, the City will only be able to get a no association letter if contamination is found on the actual site they intend to purchase. If the issue is potential impact to a plume, you should attempt to obtain a letter from them documenting the plan for mitigating the impacts and noting that you are not the party responsible for generating the plume in the first place.

Reference

Delta Environmental Consultants, Inc. 2002. *2001-2002 Groundwater Monitoring Results: University of Minnesota Rosemount Research Center, Rosemount, Minnesota*. Prepared for Mr. David Douglas, MPCA, February 28, 2002.

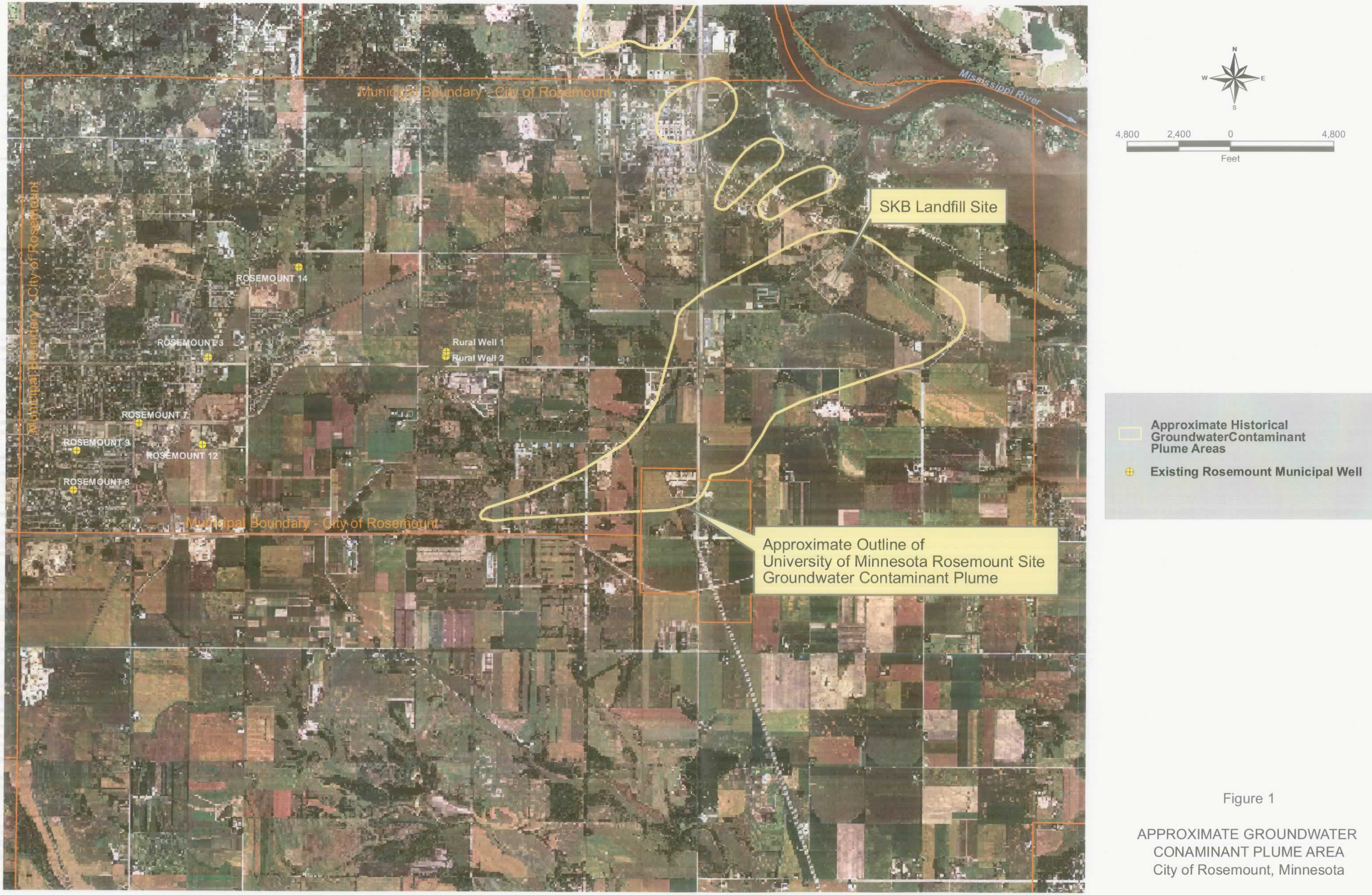


Figure 1

APPROXIMATE GROUNDWATER CONAMINANT PLUME AREA
City of Rosemount, Minnesota

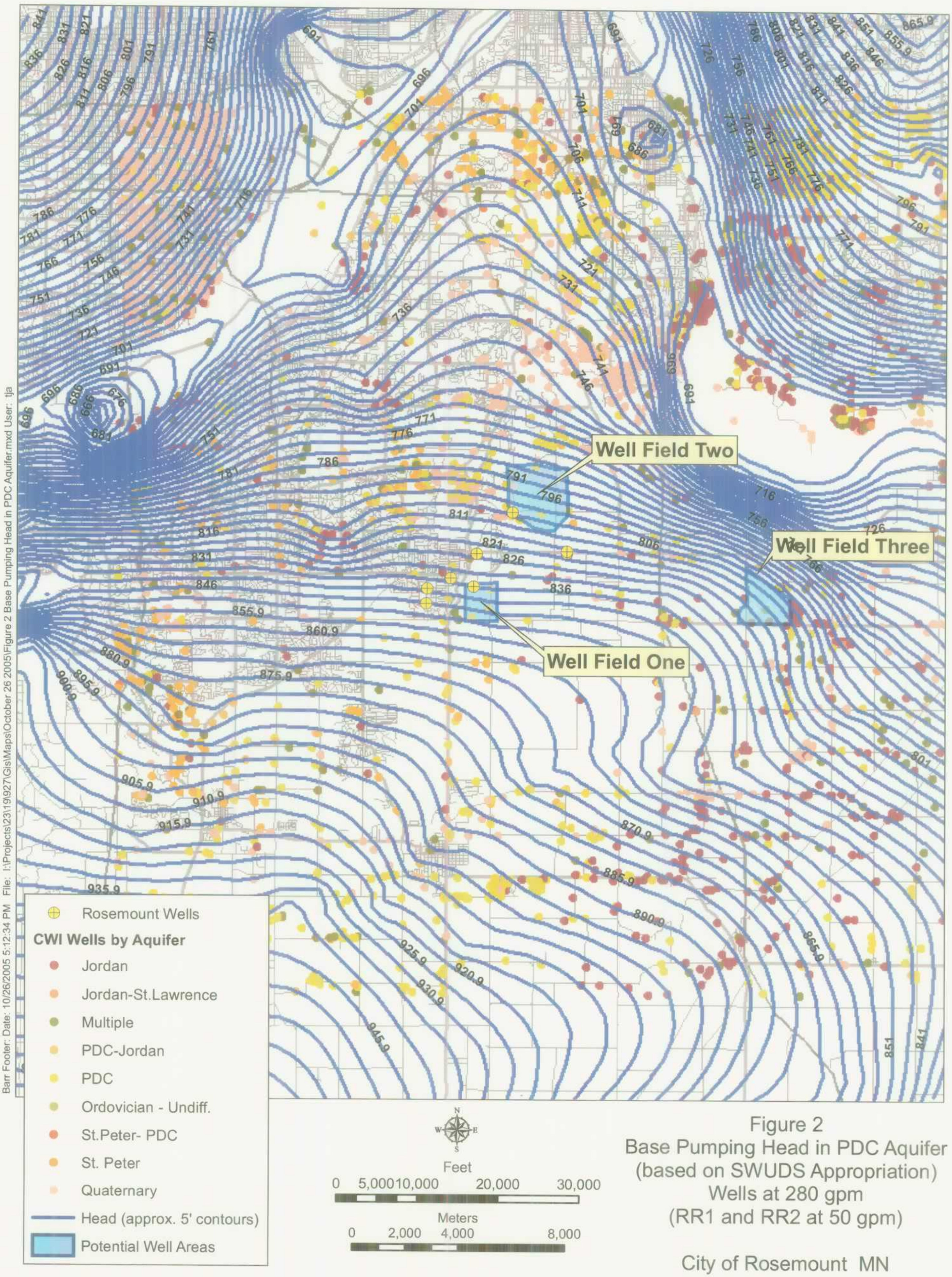


Figure 2
Base Pumping Head in PDC Aquifer
(based on SWUDS Appropriation)
Wells at 280 gpm
(RR1 and RR2 at 50 gpm)

City of Rosemount MN

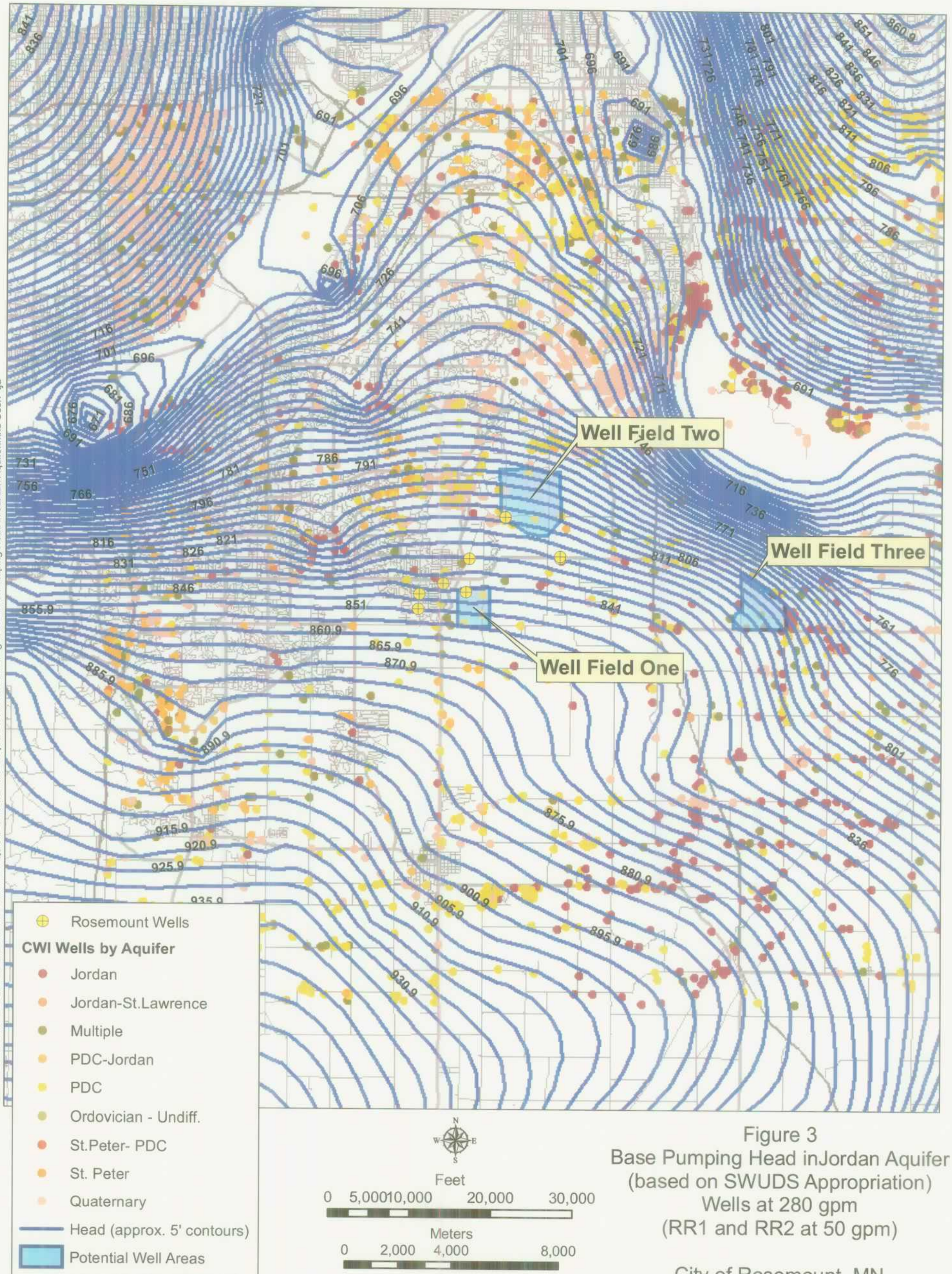


Figure 3
Base Pumping Head inJordan Aquifer
(based on SWUDS Appropriation)
Wells at 280 gpm
(RR1 and RR2 at 50 gpm)

City of Rosemount MN

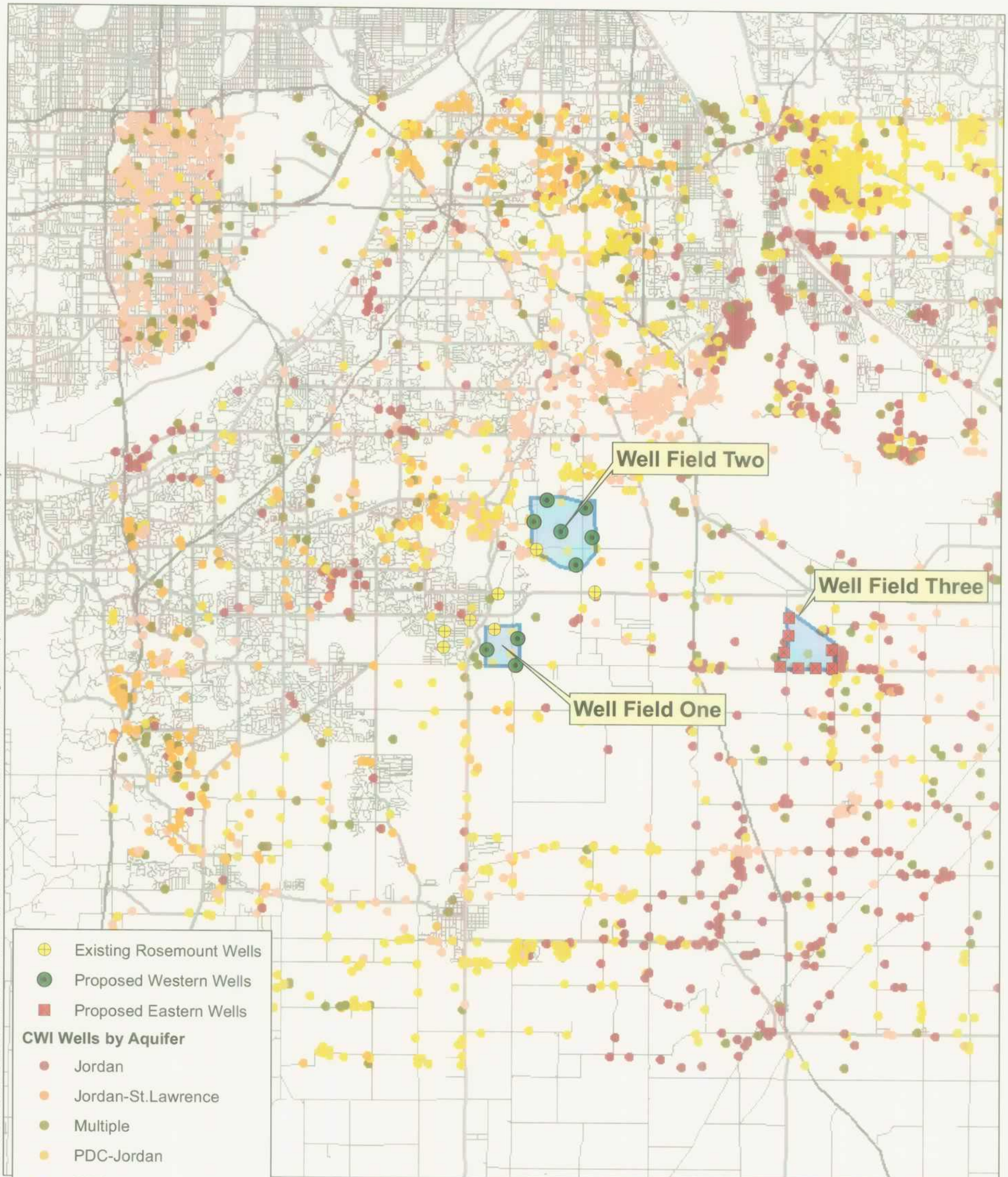


Figure 4
Proposed Well Locations

City of Rosemount MN

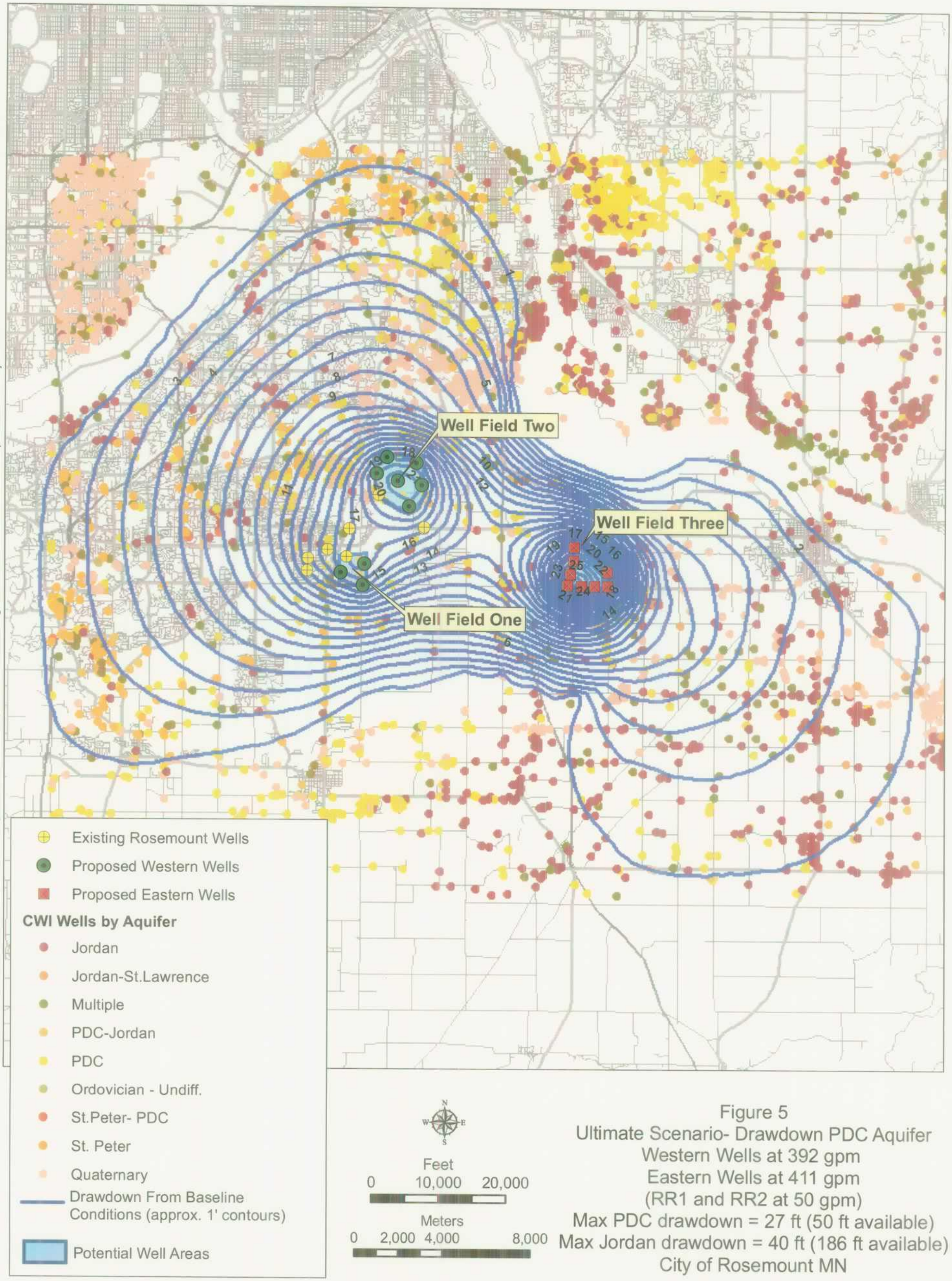


Figure 5
Ultimate Scenario- Drawdown PDC Aquifer
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 27 ft (50 ft available)
Max Jordan drawdown = 40 ft (186 ft available)
City of Rosemount MN

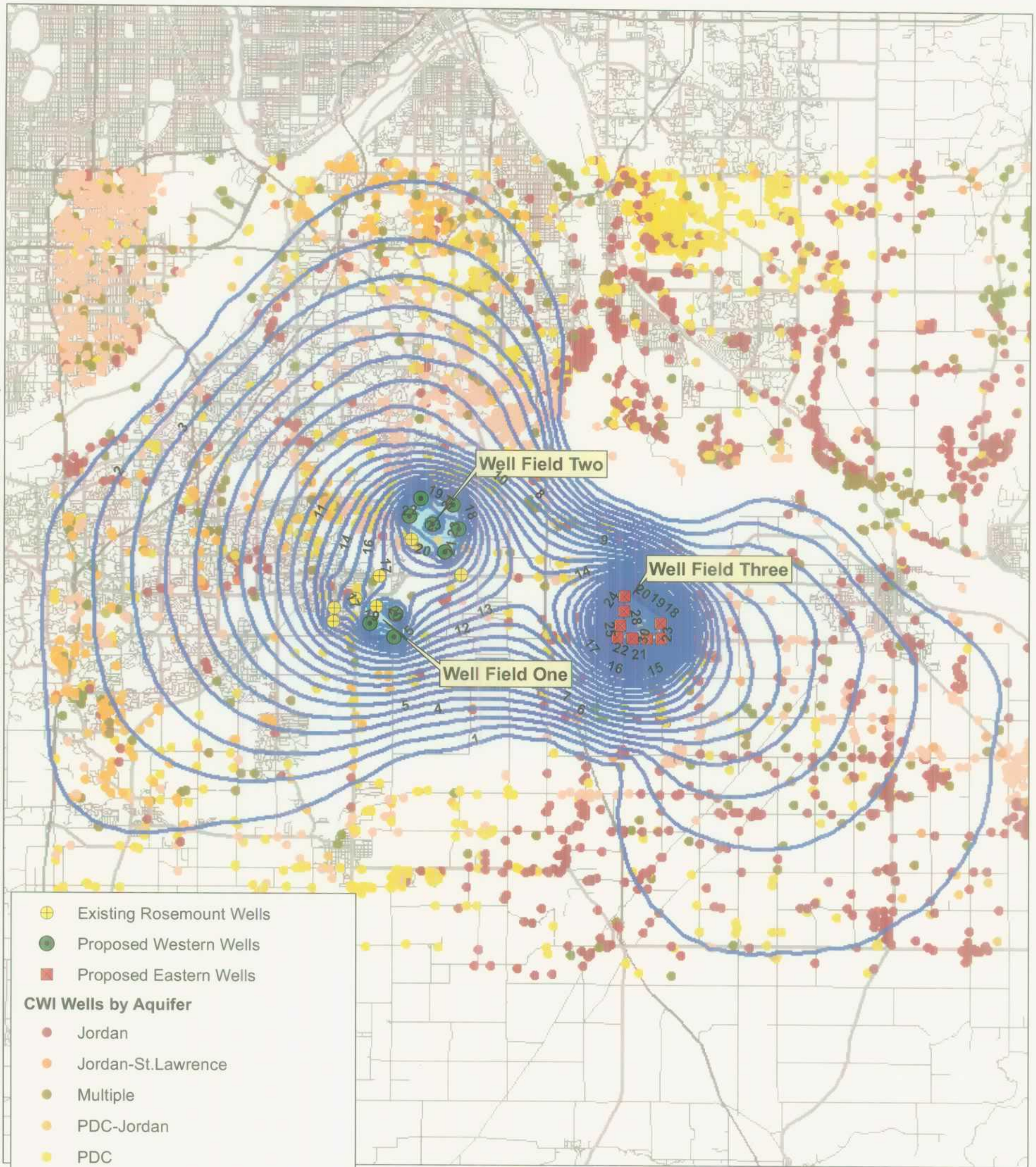


Figure 6
Ultimate Scenario- Drawdown Jordan Aquifer
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 27 ft (50 ft available)
Max Jordan drawdown = 40 ft (186 ft available)
City of Rosemount MN

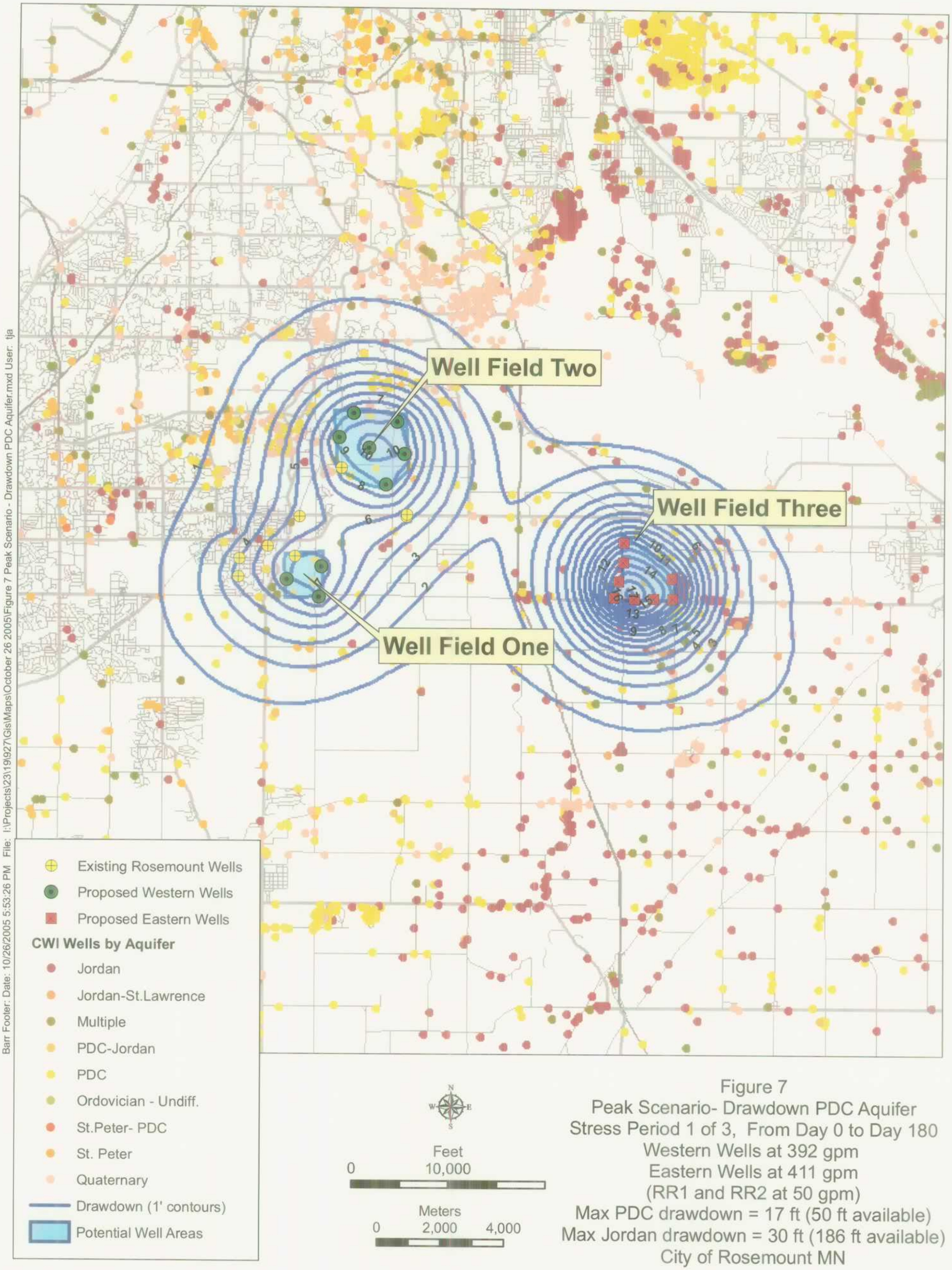


Figure 7
Peak Scenario- Drawdown PDC Aquifer
Stress Period 1 of 3, From Day 0 to Day 180
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 17 ft (50 ft available)
Max Jordan drawdown = 30 ft (186 ft available)
City of Rosemount MN

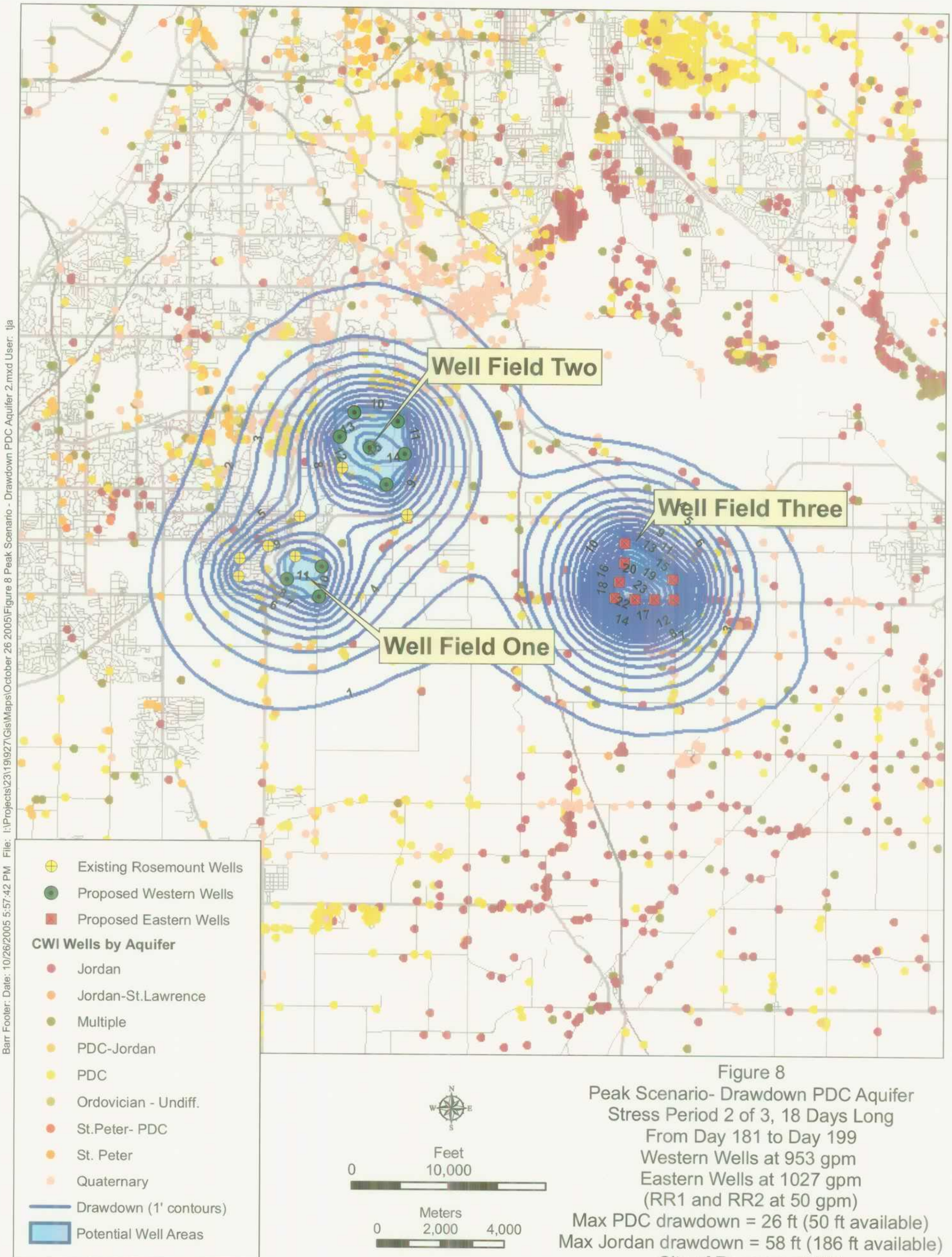


Figure 8
Peak Scenario- Drawdown PDC Aquifer
Stress Period 2 of 3, 18 Days Long
From Day 181 to Day 199
Western Wells at 953 gpm
Eastern Wells at 1027 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 26 ft (50 ft available)
Max Jordan drawdown = 58 ft (186 ft available)
City of Rosemount MN

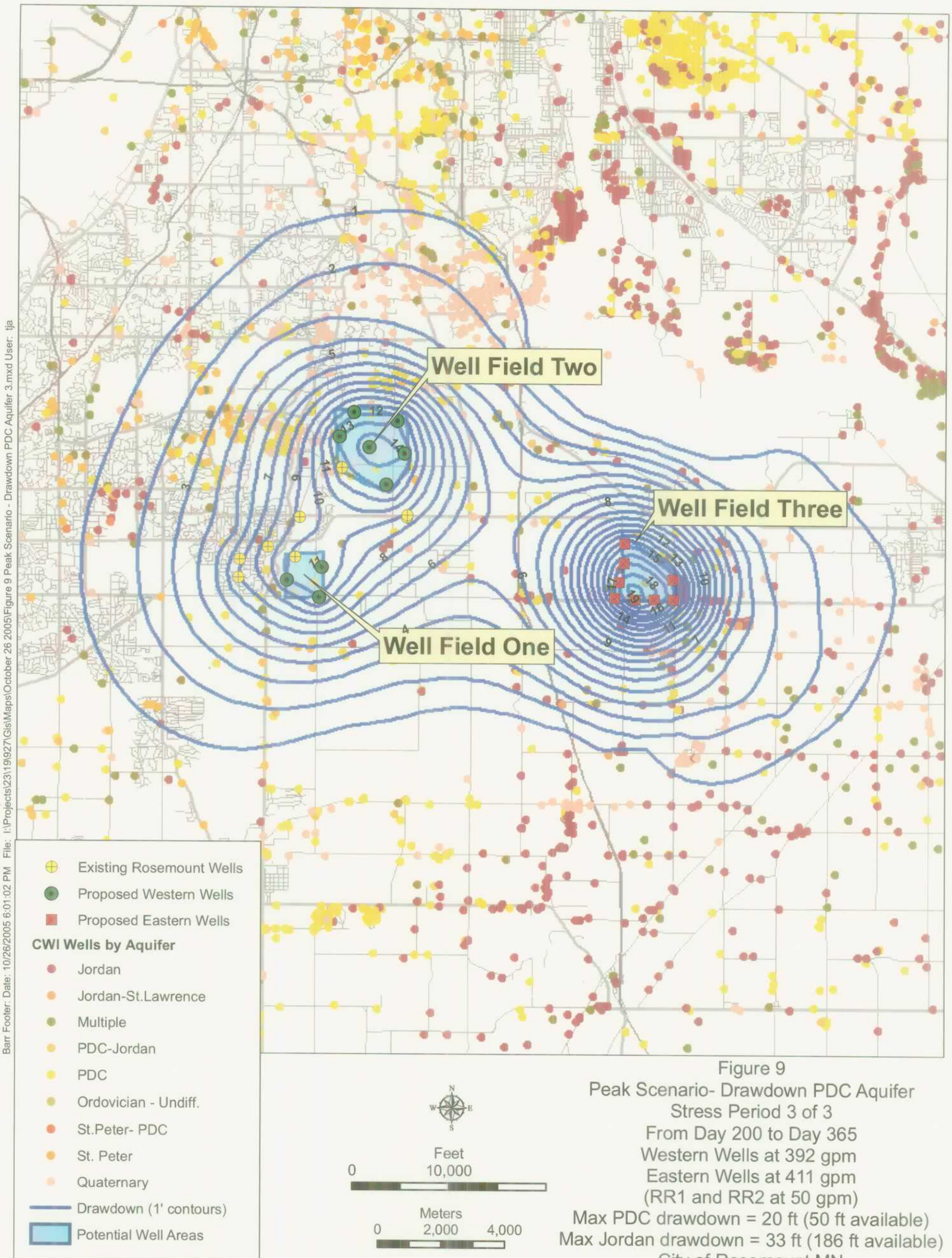


Figure 9
Peak Scenario- Drawdown PDC Aquifer
Stress Period 3 of 3
From Day 200 to Day 365
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 20 ft (50 ft available)
Max Jordan drawdown = 33 ft (186 ft available)
City of Rosemount MN

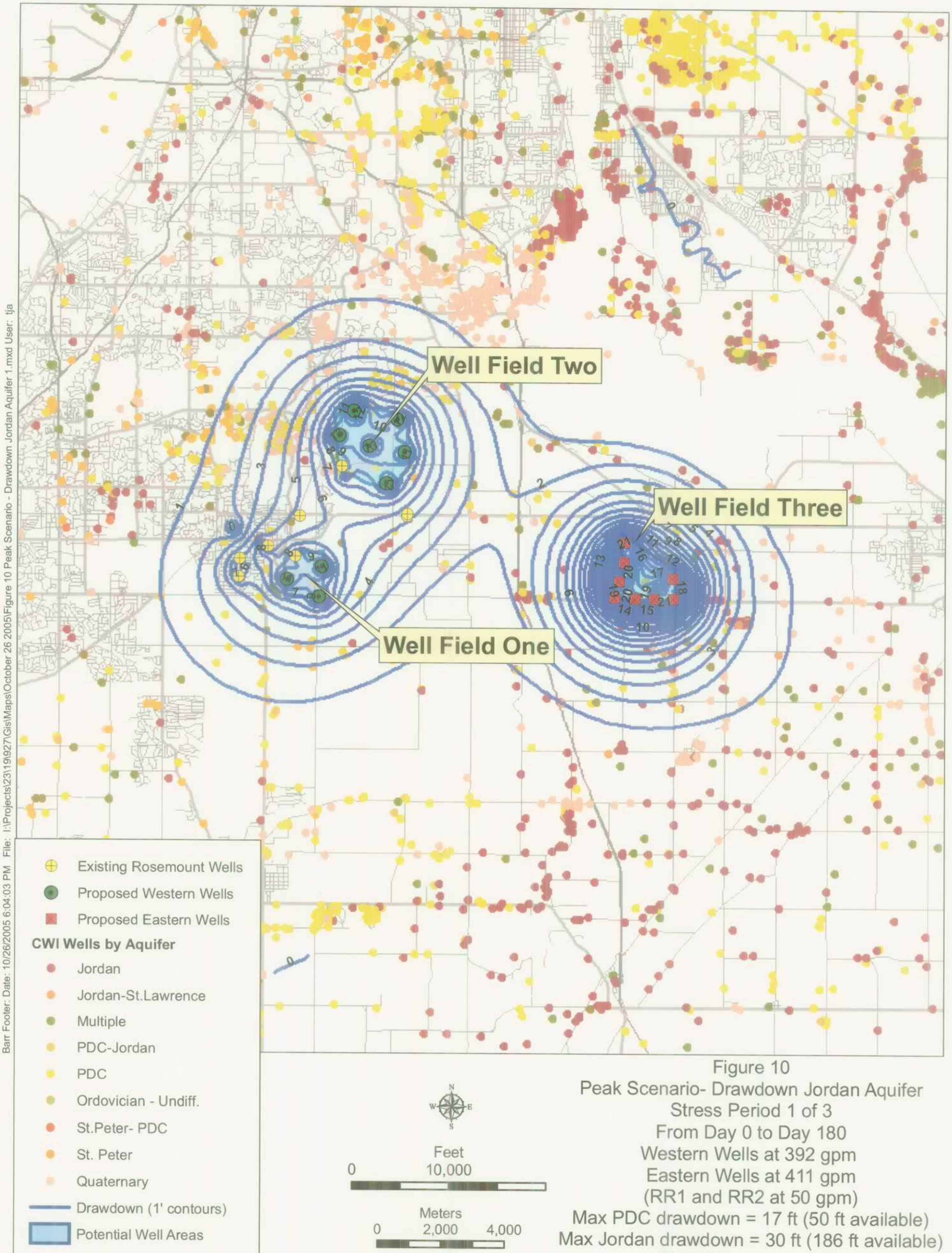
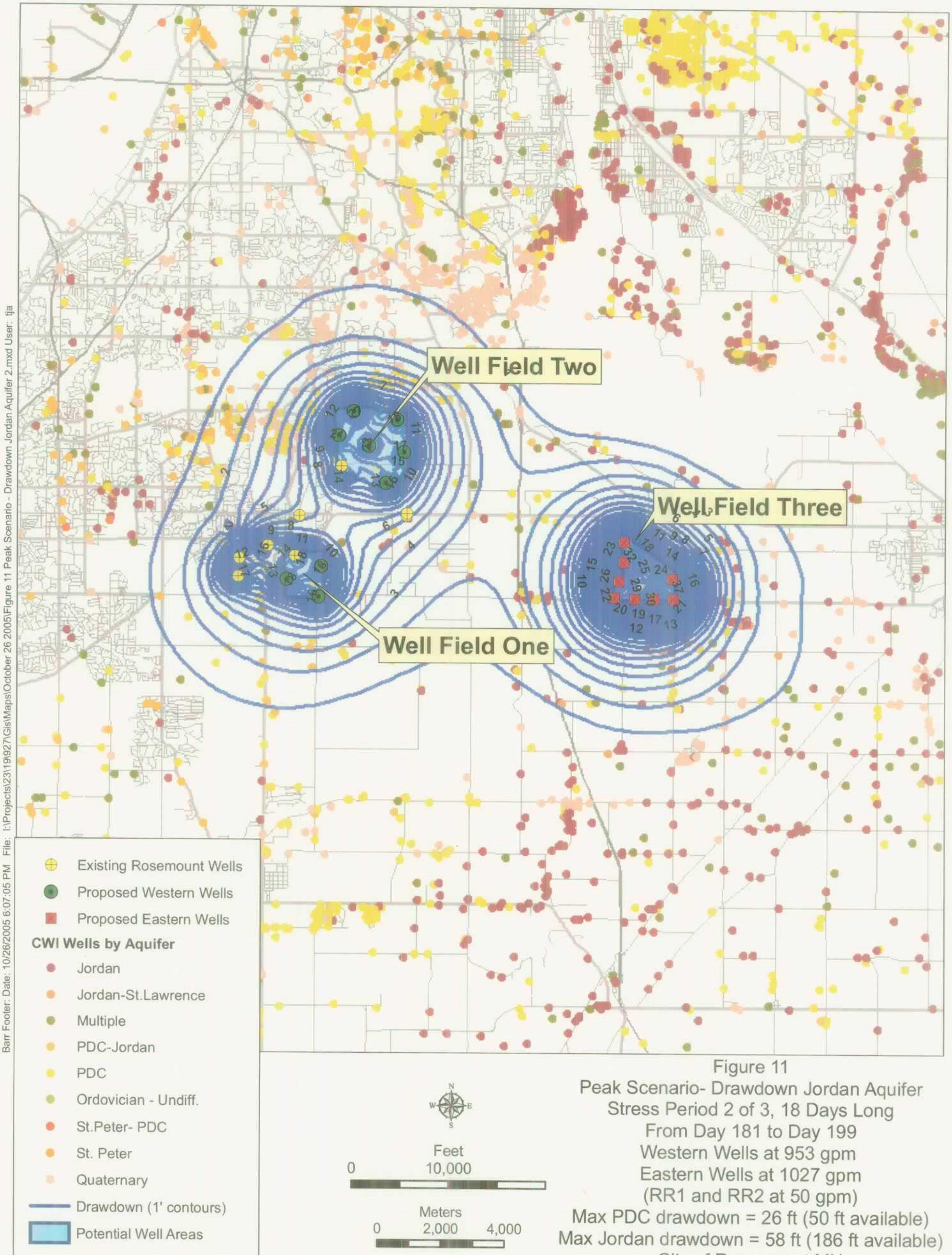


Figure 10
Peak Scenario- Drawdown Jordan Aquifer
Stress Period 1 of 3
From Day 0 to Day 180
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 17 ft (50 ft available)
Max Jordan drawdown = 30 ft (186 ft available)
City of Rosemount MN



Barr Footer: Date: 10/26/2005 6:07:05 PM File: I:\Projects\23\19\927\Gis\Maps\October 26 2005\Figure 11 Peak Scenario - Drawdown Jordan Aquifer 2.mxd User: tja

Figure 11
Peak Scenario- Drawdown Jordan Aquifer
Stress Period 2 of 3, 18 Days Long
From Day 181 to Day 199
Western Wells at 953 gpm
Eastern Wells at 1027 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 26 ft (50 ft available)
Max Jordan drawdown = 58 ft (186 ft available)
City of Rosemount MN

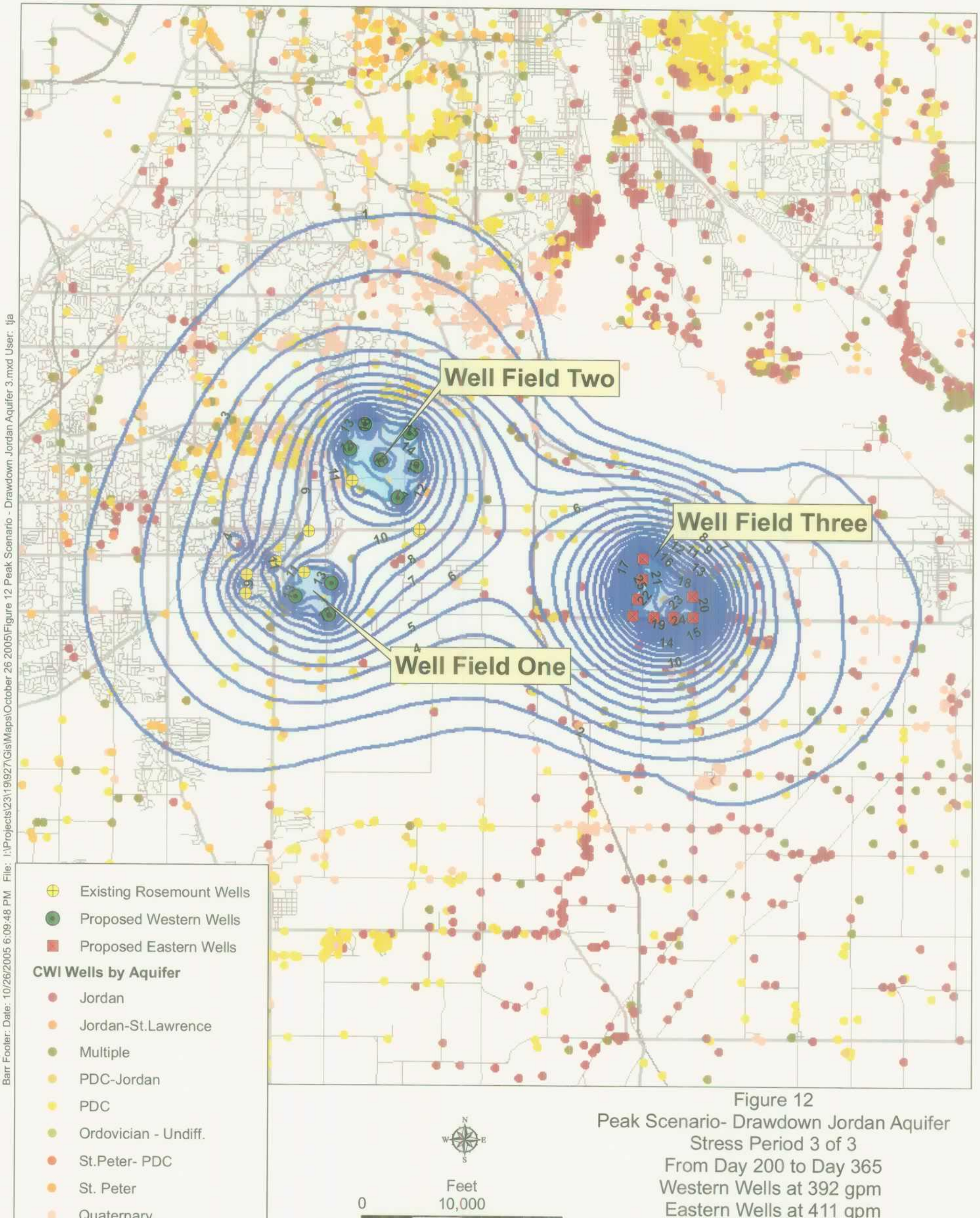


Figure 12
Peak Scenario- Drawdown Jordan Aquifer
Stress Period 3 of 3
From Day 200 to Day 365
Western Wells at 392 gpm
Eastern Wells at 411 gpm
(RR1 and RR2 at 50 gpm)
Max PDC drawdown = 20 ft (50 ft available)
Max Jordan drawdown = 33 ft (186 ft available)
City of Rosemount MN

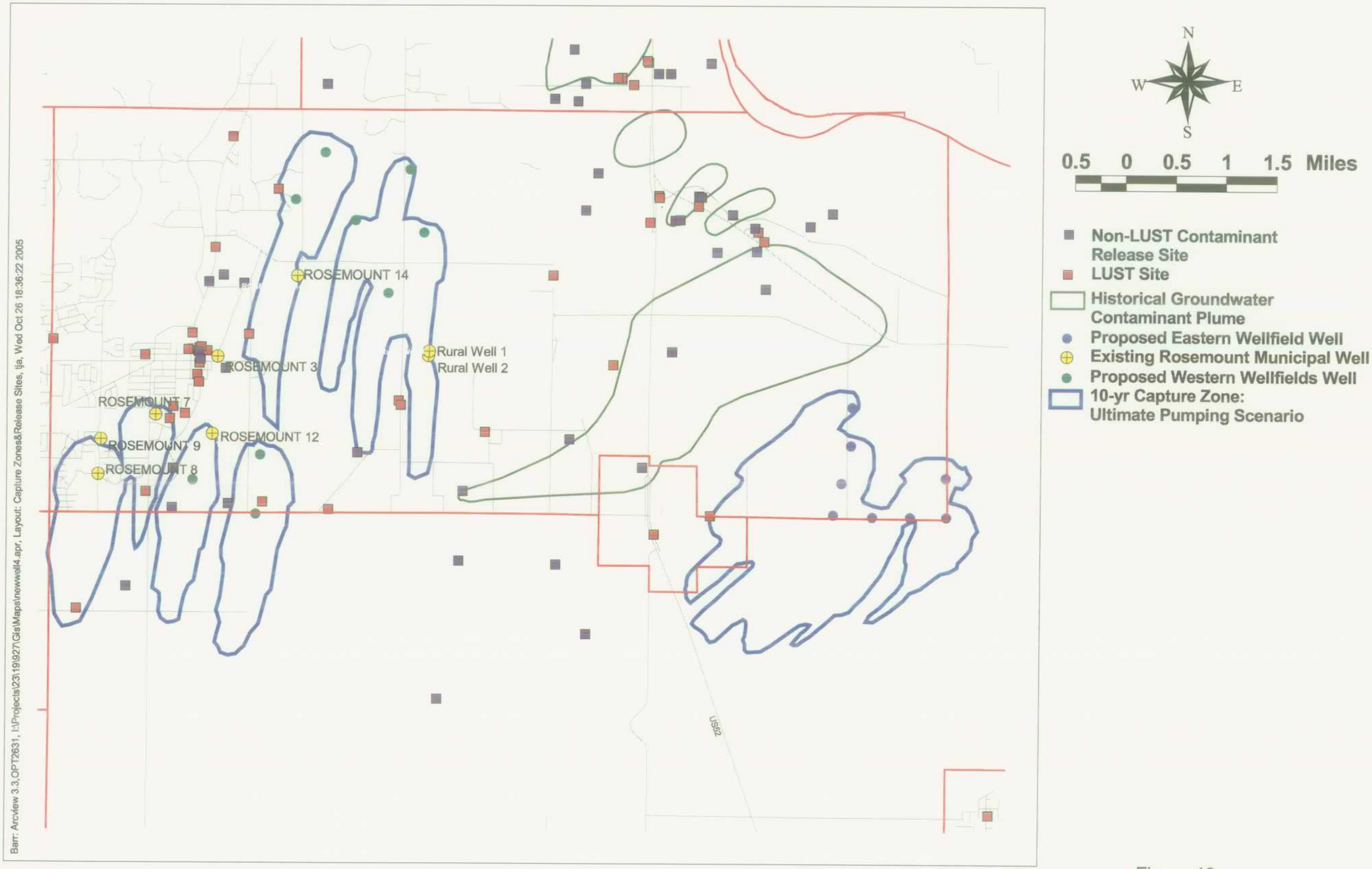


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Figure 13

ULTIMATE PUMPING SCENARIO 10-YR CAPTURE ZONES AND IDENITIFIED CONTAMINANT RELEASE SITES AND GROUNDWATER CONAMINANT PLUMES

City of Rosemount, Minnesota