City of Carlos

WELLHEAD PROTECTION PLAN

<u>Part 2:</u>

- **Potential Contaminant Source Inventory**
- **Impacts of Expected Changes to Land and Water Resources**
- **Issues, Problems & Opportunities**
- **Wellhead Protection Plan Goals**
- **Management Strategies**
- **Evaluation Plan**
- **Emergency/Contingency Plan**

July 2019

CLEAN WATER LAND & LEGACY AMENDMENT

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PUBLIC WATER SUPPLY PROFILE

PUBLIC WATER SUPPLY

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PART 2 EXECUTIVE SUMMARY

This portion of the wellhead protection (WHP) plan for the City of Carlos includes:

- the results of the Potential Contaminant Source Inventory,
- the Wellhead Protection Management Strategies,
- the Emergency/Alternative Water Supply Contingency Plan, and
- the Wellhead Protection Program Evaluation Plan.

Part 1 of the wellhead protection plan presented the 1) delineation of the wellhead protection area (WHPA) and the drinking water supply management area (DWSMA) and 2) the vulnerability assessments for the system's wells and the aquifer within the DWSMA. Part 1 of the WHP plan was submitted and approved by the Minnesota Department of Health (MDH). The boundaries of the WHPA and DWSMA are shown in Figure 1.

The vulnerability assessment for the aquifer within the DWSMA was performed using available information and indicates that the aquifer used by the system is considered to be moderately vulnerable to contamination because there appears some likelihood that a small amount of recharge from the surface is occurring. Consequently, the principal potential sources of contamination to the aquifer are other wells that reach or penetrate it, shallow disposal-type wells and storage tanks. This information was presented to the WHP Team during the Second Scoping meeting held with the MDH when the necessary requirements for the content of Part 2 were outlined and discussed in detail.

The vulnerability assessment for the public water supply system's wells indicates that the wells are vulnerable to contamination based on the well construction, because the wells themselves may provide a pathway for contaminants to enter the aquifer used by the public water supplier.

The information and data contained in Chapters 1-4 of this part of the WHP Plan support the approaches taken to address potential contamination sources that have been identified as potentially affecting the aquifer used by the public water supply. The reader is encouraged to concentrate attention on Chapters 1-4 in order to better understand why a particular management strategy is included in Chapter 5.

In Chapter 1, the required data elements indicated by MDH in the Scoping 2 Decision Notice are addressed, as well as the assessment of data elements. Pertinent data elements include information about the geology, water quality, water quantity, land use, and the public utility services. The data elements and information supplied in Part 1 of the WHP Plan are based on the assessment that the aquifer providing drinking water for this system is moderately vulnerable to contamination from land uses, such as other wells that penetrate the same aquifer and land uses that either store liquids in tanks or dispose of liquids below the land surface.

Chapter 2 addresses the possible impacts that changes in the physical environment, land use, and water resources have on the public water supply. Only small changes in land use are expected and likely will not have significant impacts on the aquifer. The City of Carlos has evaluated the support necessary to implement its wellhead protection plan. Limited resources do pose a challenge due to the size of the community and the city will focus efforts on building partnerships with local and state resource agencies to cooperate and collaborate on drinking water protection efforts.

The problems and opportunities concerning land use issues relating to the aquifer, well water, and the DWSMA, and those issues identified at public meetings are addressed in Chapter 3. The moderately vulnerable status of the aquifer and the good quality of water currently produced by the system's wells leaves four major concerns to be addressed by this plan: 1) other wells located within the DWSMA that could become pathways for contamination to enter the aquifer; 2) the pumping effects of high-capacity wells that may alter the boundaries of the delineated WHPA, reduce the hydraulic head in the aquifer, or cause the movement of contamination toward the public water supply wells; 3) underground or above-ground storage tanks that may release contaminants into groundwater and 4) shallow disposal-type wells. No shallow disposal wells or underground tanks were identified, although six domestic wells and two aboveground storage tanks (AST) were identified in the DWSMA. The city will proactively monitor the establishment of other high capacity wells.

The drinking water protection goal that the city would like to achieve with this plan are listed in Chapter 4. In essence, the City would like to, "Promote public health by maintaining a potable drinking water supply for all residents and staff of the City of Carlos through the promotion of activities which protect their aquifer."

The objectives and action plans for managing potential sources of contamination are contained in Chapter 5. Actions aimed toward educating the general public about groundwater and drinking water protection issues, proper well management, and collecting data relevant to wellhead protection planning are the general focus.

Chapter 6 contains a guide to evaluate the implementation of the identified management strategies of Chapter 5. The wellhead protection program implementation efforts for the City of Carlos will be evaluated by the city at a minimum of every 2 ½ years.

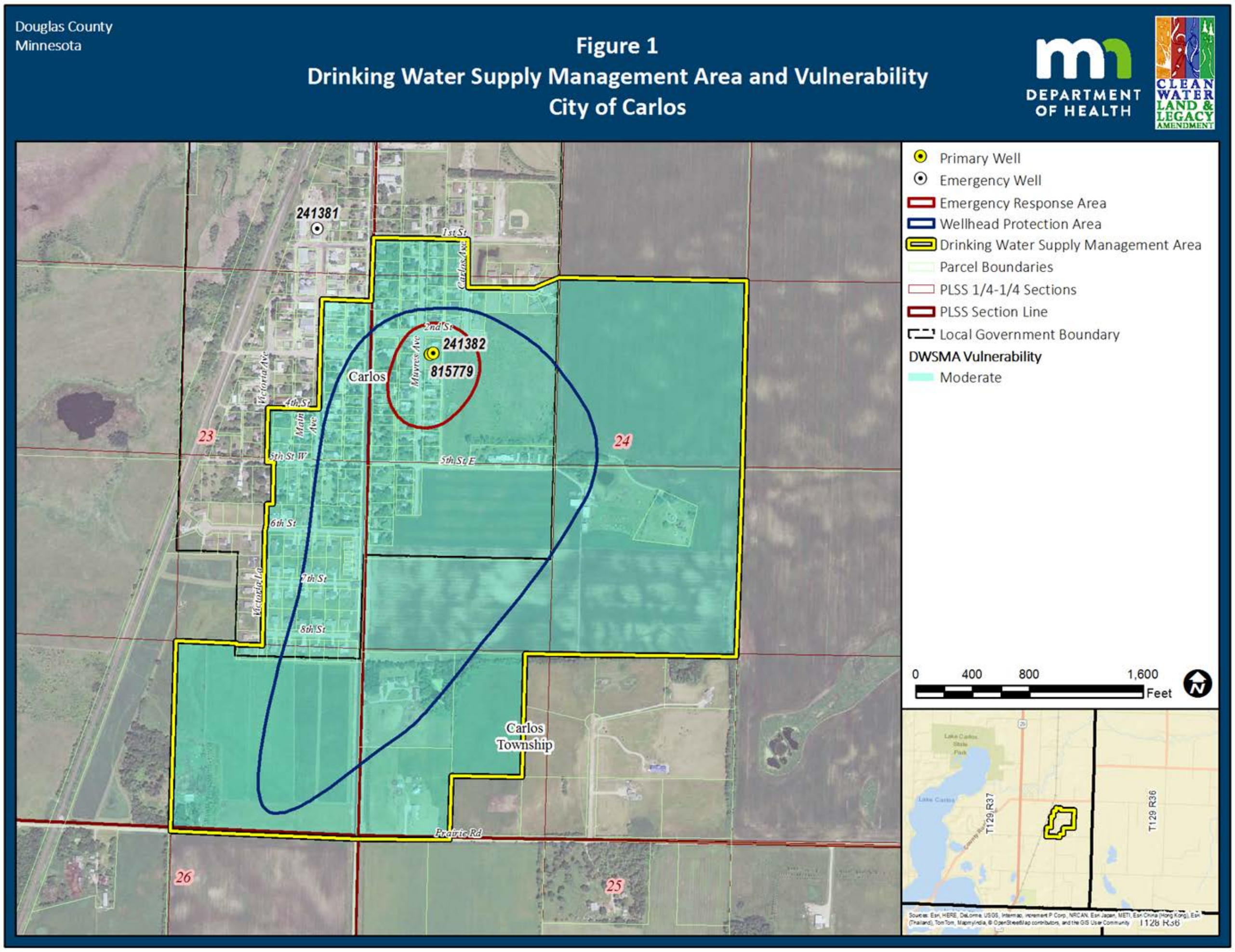
An emergency/contingency plan is included to address the possibility that the water supply system is interrupted due to disruption caused by contamination or mechanical failure. Chapter 7 contains details about the water supply distribution system, emergency contact numbers, equipment listings as well as other information to assist the system in responding quickly and effectively in emergency situations.

Summary of Wellhead Protection Actions

Wellhead Protection Action Item Descriptions	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Public Education and Outreach										
The City will provide a short summary of the new wellhead protection plan amendment in the city's newsletter and direct residents to the city's website for detailed educational materials.	•							•		
Post WHP educational materials on the city website. Many educational/outreach materials are located on the MRWA website dealing with proper well management, water conservation, storage tank management etc…	•									
Potential Contaminant Source Management										
Provide well owners in the DWSMA materials on proper well management.		•					•			
If the City is made aware of any unused wells in the DWSMA, apply for a Douglas to pay the costs associated with sealing them	As Occurs									
If a tank is it needs corrective action, apply for funding to perform any corrective actions, including but not limited to having the tank properly removed. Contingent on grant funding.			•							
Provide storage tank owners information on best management practices for storage tanks.	•									
WHP Team and Manager will update the PCSI map and table.					•					
It is unlikely old muni wells exist, however the city will work with MDH and others to try and find the location of any wells if they do exist.			•							
If any of the old muni wells are found, the city will apply for a Douglas and if successful have the wells sealed.			•	•						
Inform MDH if a Class V well is identified within the DWSMA.	As Occurs									
Land Use Management										
Send Douglas County a map of the DWSMA and letter discussing the importance of WHP. Ask to be notified of any requests for changes in land use or zoning which are located within the DWSMA.	•									
Data Collection										
Work cooperatively with MDH to resample wells for vulnerability parameters as determined by the MDH, provided MDH will cover the costs.						•				
If wells are constructed within two miles of the city or one mile of the DWSMA, their locations should be verified.									•	
Working in cooperation with MDH Hydrologist drill a few well-placed test borings and sample them for the following water quality sampling (chloride, bromide, nitrate). The MDH Hydrologist will help select what parameters to test for. Work will be completed contingent upon receiving grant funds.						•				
Inner Wellhead Management Zone										
Implement measures that are specified in the IWMZ PCSI report.	•	•	•	•	•	•	•	•	•	•
Monitor the 200 ft. radius around the wells to ensure that setback distances for new potential contamination sources are met.	•	•	•	•	•	•	•	•	•	•
Request MDH assistance to update the Inner Wellhead Management Zone Inventory for the public water supply wells.					•					•
Reporting and Evaluation										
Prepare an evaluation of WHP plan implementation efforts every 2 ½ years.			•			•			•	
Summarize all WHP Plan implementation efforts in a report to MDH prior to the Scoping 1 meeting for the WHP Amendment.								•		

Contingency Strategy										
Review the contingency strategy portion of the city’s wellhead protection plan to ensure that it reflects current personnel contact information, changes in the water supply system infrastructure and other needs and concerns.					•					

Figure 1—WHPA and DWSMA Map



CHAPTER ONE

DATA ELEMENTS, ASSESSMENT (4720.5200)

REQUIRED DATA ELEMENTS

Physical Environment Data Elements

Precipitation – This data element does not apply because there is not a direct hydraulic connection between the land surface and surface waters and the aquifer serving this water supply system.

Geology – This data element is required and is presented in detail in the first part of the WHP Plan and thus is only summarized here. The water supply for the city of Carlos is obtained from two primary wells. The geologic condition at the wells identified as Well 2 (241382) and Well 3 (815779) include a cover of clay-rich geologic materials over the aquifer that may retard the vertical movement of contaminants, although it is considered leaky. Water from the aquifer is relatively young based on tritium analysis. Additional information is included in Part 1 and included in this Plan as Exhibit 7. The Part 1 reviewed and considered other existing records of wells and geophysical boreholes. The WHP Team is unaware of any existing surface geophysical studies or new test holes/borings since the development of Part I.

Soils – This data element does not apply because there is not a direct hydraulic connection between the land surface and the aquifer serving this water supply system.

Water Resources – This data element, as defined by the state wellhead rule, does not apply because there is not a direct hydraulic connection between the land surface and the aquifer serving this water supply system.

Land Use Data Elements

Land Use – These data elements include information about parcel boundaries, political boundaries, potential contaminant sources, land use maps and zoning maps. A map showing the political boundaries and land survey map is included as Figure 1. A large portion of the DWSMA boundary extends beyond city limits into Carlos Township in the southern part of the DWSMA. The city does have zoning authority, however outside city limits Carlos must rely on Douglas County and their zoning authority. Currently, the DWSMA is zoned for residential and rural residential by the county and city. The city does not have a comprehensive land use plan. The city's zoning map is in a format which makes it unable to be included in this plan. The parcel boundaries map shows the parcels for the properties located within the DWSMA is included in Exhibit 6 and can also be found on the County website. Carlos Township does not have zoning authority.

Land use within the DWSMA is a mixture of commercial, residential and row crop agriculture. The majority of the land within the DWSMA is agriculture production. A generalized land cover map and table is included as Exhibit 2 in the Appendix.

The Inner Wellhead Management Zone (IWMZ) is a fixed two-hundred foot radius around City wells. The public water supplier is responsible to manage all potential contaminant sources identified within that area. The IWMZ was inventoried for potential contaminant sources for this planning process and no significant issues or potential contaminants were identified.

Due to the moderately vulnerable designation of the DWSMA determined during the Part I WHP planning process, an inventory of other wells, storage tanks, shallow disposal wells, and other potential contaminant sources located within the DWSMA is required, as identified in the Scoping 2 Decision Notice. A listing of potential contaminants inventoried within the DWSMA and a map showing their locations are included in the Appendix as Exhibit 4. At this time no shallow disposal wells (Class V wells) have been identified.

Public Utility Services – Records of well construction and maintenance is used to support the development of Chapter 7 of this plan, which details an emergency plan for this system. These records are kept by city staff at city hall.

The main transportation route and corridor through the DWSMA is County Highway 9, which runs north/south through town (See Figure 1). This is a busy roadway used by residents and commercial vehicles. In assessing the distance from the wells, stormwater runoff routes and time of travel, the WHP Team isn't too concerned about the Highway as a potential threat to their source of drinking water. The stormwater runoff system is in good shape and transported outside the DWSMA and is not a concern to groundwater quality for the city.

The City regularly maintains its sanitary sewer and public water supply system. The City does not have sanitary sewer and public water supply system maps of size to include in the plan. Maps are available and can be viewed at city hall. There are no gas or oil pipelines located within the DWSMA, nor are there any public drainage systems.

As necessary, the city hires a licensed well driller to perform standard maintenance on the city wells. The city has copies of applicable documents at city hall.

Water Quantity Data Elements

Surface Water Quantity – This data element does not apply because there is not a direct hydraulic connection between surface waters and the aquifer serving this water supply system.

Groundwater Quantity – Groundwater levels are adequate for the amounts that the City of Carlos is permitted for under the groundwater appropriations program that is administered by the Minnesota Department of Natural Resources (DNR). Information and discussion regarding the volumes appropriated, the type of use, and aquifer source can be found in Part 1. There are currently no other high-capacity wells within the DWSMA for which well interference complaints with the city's wells have been documented, and no water use conflicts are known to exist. The WHP Team is unaware of any environmental bore holes in the DWSMA.

At this time, there appears to be sufficient groundwater quantity, based upon the existing pumping capacity of well(s) completed in the aquifer used by the system. This data element applies as it relates to future groundwater uses that may influence the ability of the aquifer to yield water to the City. Increased water use may result in a reduction in aquifer yield or increase the likelihood that contaminants of human or natural origin may affect the quality of drinking water.

Water Quality Data Elements

Surface Water Quality – This data element does not apply because there is not a direct hydraulic connection between surface waters and the aquifer serving this water supply system.

Groundwater Quality – These data elements include information about the overall water quality of the aquifer the City of Carlos is using as well as other groundwater quality information generated from groundwater contamination studies.

A general overview of water quality data can be found in the city's Consumer Confidence Report (Exhibit 3) which is provided to residents yearly. At present, none of the contaminants for which the Safe Drinking Water Act has established health-based standards has been found above maximum allowable levels in the city's water supply, nor are any present at one-half of those levels. No other known water quality or chemistry data is known for: 1) bacteriological contamination indicators and inorganic and organic chemicals; 2) water chemistry and isotopic data from wells, springs, or other groundwater sampling points; 3) groundwater tracer studies or reports. The city's wells are considered vulnerable to contamination due to tritium being detected in the well water (Exhibit 7 Table 2). Detectable tritium indicates the presence of young (post-1953) water.

There are two small aboveground tanks (approximately 256 gallons in size) and six private wells located at the various building sites throughout the DWMSA. The WHP Team is unaware of any property audits identifying contamination or existing reports of groundwater tracer studies.

ASSESSMENT OF DATA ELEMENTS

A. Use of the Wells –

The city currently uses Well 2 (241382) and Well 3 (815779) as the primary public water supply wells. The city plans to keep this arrangement into the future.

Wellhead Protection Area Delineation Criteria – See the Part 1 WHP Plan for documentation regarding how the delineation criteria were applied to determine the boundaries of the WHPA. The Part 1 WHP Plan is included as Exhibit 8 in the Appendix.

The Part I WHP Plan also discusses in detail an assessment of the data elements used for delineation purposes. The MDH Hydrologist also proposes several recommendations to improve the data set for future delineation efforts. These recommendations are included as management strategies in Chapter 5 of this plan.

Quality and Quantity of Water Supplying the Public Water Supply Well –
Water quality monitoring results for this public water supply indicate very low levels of contamination from 1) human-origin, such as fuel and fuel break-down products, pesticides, or commercial fertilizer, or 2) naturally-occurring contaminants such as arsenic and boron. At this time, problems with water quality are not an issue since these levels are well below health concern levels. The city of Carlos is currently enjoying water quality that meets the standards set forth in the Federal Safe Drinking Water Act.

No other high capacity wells were identified near the DWSMA during the Part II WHP planning process. At the present time it is expected that the aquifer will yield sufficient quantities of water for the City of Carlos over the life of this plan.

The Land and Groundwater Uses in the DWSMA –
Proactive management of existing wells, unsealed or unused wells, shallow disposal wells, and storage tanks are of concern in the moderately vulnerable aquifer. The management strategies selected and documented in Chapter 5 of this Plan will focus on activities that have the most potential to impact the aquifer this city is using for its drinking water supply.

Table 1 - Potential Contamination Sources and Assigned Risk for the IWMZ

Source Type	Total	Level of Risk
Public Supply Wells	2	L
Buried Sewer Lines	2-3	L
Water Treatment Backwash Basin	1	NA
Storm Water Intakes	2-3	NA

Table 2 - Potential Contamination Sources and Assigned Risk for the Rest of the DWSMA

Potential Source Type	Total Number	Number Within Emergency Response Area and Level of Risk		Number Within Remainder of the DWSMA and Level of Risk	
City Wells	2	2	L	0	NA
Domestic Well	6	0	NA	6	H
Aboveground Storage Tank	2	1	H	1	M

CHAPTER TWO

IMPACT OF CHANGES ON PUBLIC WATER SUPPLY WELL(S) (4720.5220)

I. CHANGES IDENTIFIED IN:

A. Physical Environment -- Large-scale changes in the physical environment within the DWSMA are not anticipated during the 10-year period that the WHP Plan is in effect.

B. Land Use -- Land uses that result in additional water wells in the DWSMA are unlikely, although if one would be drilled they would have little impact on the aquifer unless water demand is increased to the point that 1) additional loss in hydraulic head occurs within the aquifer used by the City, or 2) pumping changes the boundaries of the WHPA. Constructing additional wells into the aquifer may increase the points of entry, alter the WHPA, or draw naturally-occurring or human-caused contaminants towards the City wells. The city doesn't foresee much for residential or business construction within the DWSMA.

Land use inside the Inner Wellhead Management Zone: The land within the 200-foot radius consists primarily of city-owned property and single family residential homes within the IWMZs. Large scale land use changes are not expected to occur during the next 10 years within the IWMZs. Changes in land uses should be closely monitored due to the susceptibility of the aquifer to contamination from some types of activities at the land surface.

B. Surface Water -- There appears to be either no direct, or a limited, hydraulic connection between surface water and the aquifer used by the public water supply system as a drinking water source. Therefore, any changes to the conditions of surface waters will have little or no impact on the quality or quantity of the public water supply. There are no officially recognized FEMA floodplains located within the DWSMA and the city does not feel there are any flooding issues within the DWSMA. The City of Carlos DWSMA is located within the Long Prairie Watershed (HUC8: Long Prairie River 07010108) and the Spruce Creek minor watershed unit (HUC 10s: Spruce Creek-Long Prairie River 0701010802). Spruce Creek and the Long Prairie River flows north and eastward towards the Mississippi River.

D. Groundwater -- The City wells have historically provided groundwater of acceptable quality and quantity. As of the date of Plan approval, the City does not anticipate a large increase in water use or is not aware of any such water use expansions in the DWSMA or immediately adjacent area.

II. IMPACT OF CHANGES – List, Describe and Assess Impacts on Aquifer From:

A. Expected Changes Identified Above -

The city anticipates a couple of new homes within the DWSMA, but significant impacts on the aquifer are not expected. Neither surface water nor groundwater changes are expected to impact the aquifer.

C. Influence of Existing Water and Land Government Programs & Regulation -

A number of local and state programs exist that may provide assistance and benefits in managing potential contaminant sources identified in the DWSMA. Following is a brief description of the major programs that have drinking water protection interactions.

The MDH regulates well construction through the Minnesota well code. Code requirements include minimum isolation distances as well as construction criteria designed to protect the well and aquifer. The MDH has a Source Water Protection Douglas program to assist in covering costs associated in the protection of source water. The Minnesota Pollution Control Agency (MPCA) has a tank storage program and has developed Best Management Practices (BMPs) for tank owners to help ensure proper and safe tank operation and maintenance. In addition, the MPCA manages a petroleum remediation program that addresses leaking tanks. This program has direct interaction with MDH staff in determining potential impacts to drinking water sources. The Douglas County Soil and Water Conservation District administers cost share dollars for well sealing. The Douglas County Comprehensive Local Water Management Plan (CLWMP) has identified the protection of groundwater-based drinking water sources as a priority. The WHP Team will coordinate with the County as the CLWMP is updated. The Douglas County Soil and Water Conservation District conducts all water planning activities and at this time no additional local planning for the assessment of impacts on the aquifer are expected at this time.

There may be existing land use ordinances by local governments that could be revised in the future to address new private wells and storage tanks within the DWSMA. However, there is no discussion or intention at this time of requiring additional regulation related to managing wells or storage tanks within the system's DWSMA. The City requires homes and businesses to be connected to sewer and water where the services are provided. The County enforces a zoning ordinance that provides oversight and control to make sure orderly and environmentally appropriate growth occurs within city limits.

C. Administrative, Technical, and Financial Considerations -

The City of Carlos assembled a Wellhead Protection Team early in the process of developing this Plan. Many of the activities during the planning process have been accomplished through the efforts of this group, with assistance from studies provided by other units of government. For the WHP Plan to be effective:

1. The City will need to raise public awareness of the issues affecting the quality or quantity of its drinking water supply through public educational programs.
2. Administrative duties will remain with the Wellhead Protection Manager who will report to the governing authority, coordinate implementation of wellhead protection management implementation measures, and conduct regular meetings.
3. The City has limited funds available for new programs and the implementation of wellhead protection activities. The City plans to utilize other sources of funding or in-kind services to help achieve the goals set forth in this Plan's Chapter 4 and include 1) the Douglas County Soil and Water Conservation District and their well sealing cost-share program; 2) the MDH Douglas program; and 3) the Minnesota Rural Water Association providing technical assistance during the wellhead protection implementation phase.

CHAPTER THREE

ISSUES, PROBLEMS, AND OPPORTUNITIES (4720.5230)

I. LAND USE ISSUES, PROBLEMS, AND OPPORTUNITIES

The WHP Team identified water use and land use issues, problems, and opportunities related to the: aquifer serving the public water supply well, well water, and drinking water supply management area.

The issues, problems, and opportunities were identified by assessing: problems and opportunities discussed at public meetings; data elements described in Chapter One; and the status and adequacy of official controls, plans, and other local, state, and federal programs on water use and land use.

At the beginning of the planning process other Local Units of Government (LUGs) were identified and informed that the system was beginning the wellhead protection planning process. Each unit of government was also sent a copy of the delineated WHPA and DWSMA and vulnerability assessment for the wells and DWSMA. To date, no comments from the LUGs have been received. The general public was also given opportunities to participate in the planning process and to comment at the Public Informational Meeting and Public Hearing. No concerns from the general public have been expressed at this time.

A. The Aquifer – The aquifer used by the city is considered to exhibit a moderate geologic sensitivity because the overlying clay-rich sediments that protect the aquifer are not uniform and may be prone to leakage. The aquifer should be relatively unaffected by land use activities with the exception of other wells that penetrate the same aquifer, storage tanks, shallow disposal wells, or other applicable potential contaminants.

B. The Well Water -- The wellhead protection plan is primarily concerned with other water supply wells, storage tanks and shallow disposal wells located within the moderate portion DWSMA. The potential contaminant source inventory performed by the Wellhead Protection Team identified the types of wells and tanks, as listed in Tables 1 and 2.

The placement of additional high-capacity wells, increased pumping from existing wells, or significant changes in current groundwater appropriations within the DWSMA may have an impact on 1) groundwater availability to all users, 2) increased risk that contamination may enter the part of the aquifer used by the public water supply wells, or 3) change the delineated WHPA and the DWSMA boundaries. At the present time there are not any other high capacity wells, although the City of Carlos will work with the DNR and MDH to become aware of any proposed high-capacity well within the DWSMA.

D. Drinking Water Supply Management Area - The state's Wellhead Protection Rule requires that existing information be utilized in developing the initial WHP Plan. Much of the data collected and utilized to delineate the city's WHPA and DWSMA and to determine the vulnerability of the aquifer to possible contamination comes from small-scale or regional studies. There is a limited amount of subsurface information available to define local groundwater flow conditions and the groundwater chemistry of the aquifer within the DWSMA. The direction of groundwater flow was evaluated to address concerns that the current amount of subsurface information does not permit an unquestioned determination of local groundwater flow conditions toward the system's water supply wells. As a result, delineation of the WHPA represents a composite of capture zones generated by varying aquifer properties, within limits determined by MDH.

A concern expressed by the City is to ensure consistent and long-term management of water wells, environmental bore holes, and observation wells within the DWSMA. The City has limited legal capabilities to regulate well construction and sealing in the DWSMA. Second, changes in land use that increase pumping of the aquifer used by the City well need to be assessed for its possible impacts on water availability and quality. Finally, the City has no regulatory authority over water appropriations and must rely on the State of Minnesota to address issues and concerns related to pumping.

The large portion of the DWSMA lies outside of city limits. The county administers their zoning authority which covers all of the properties outside city limits. The WHP Team assessed the current and future land use changes in the DWSMA and concluded little land use changes are likely.

The City plans to utilize public education opportunities, both existing and proposed, to address potential contamination of the aquifer by other wells, storage tanks, shallow disposal wells, and other contaminant sources. Additionally, the City will work in cooperation with the Douglas County Soil & Water Conservation District to utilize the well sealing cost-share program currently available, and participate in the MDH Douglas program. The WHP Team has identified 6 wells in the DWSMA which are presently being utilized by private residences because city services do not extend to the properties or the wells were there before city water was provided. The City will set high priority on well sealing for wells which might be found later that are unused or not properly maintained. There have been no old municipal wells identified by MDH which the city needs to address.

Further, the City will work with MDH to 1) identify proposed wells that may present groundwater conflict concerns, 2) ensure these wells are properly constructed, and 3) determine whether an alternative aquifer could be used. Six private wells were identified within the DWSMA by the wellhead protection team.

The WHP Team identified two sites with small aboveground gas tanks (two tanks total in the DWMSA). No MPCA regulated tanks were located within the DWMSA. The City will work with the property owners to promote storage tank BMP's. The City will work with MPCA, MDA and MDH to 1) track current and likely future locations of tanks, 2) promote best management practices for all tanks, and 3) provide educational material to tank owners/operators.

Shallow disposal wells (also called Class V Injection Wells) are regulated by the U.S. EPA. No Class V Injection Wells were identified during the potential contaminant source inventory. However, the WHP Team is aware of the drinking water protection issues connected with this type of disposal system and will be monitoring for these types of facilities during the life of the plan. If a Class V Injection Well is identified in the future, the city will inform MDH of it suspected location.

There are no gas lines present within the DWSMA. There are also no maps available of the sanitary sewer, stormwater system or distribution system which can be included in this plan.

There are many tools available to the regulating agencies that may be used to achieve the wellhead protection planning goals identified by the WHP Team. State and local governmental units, such as MDH, Douglas County, and the DNR, regulate:

- ✓ Well construction – MDH;
- ✓ Well sealing – MDH;
- ✓ State groundwater appropriation permits – DNR;
- ✓ Public water supply quality – MDH;
- ✓ Setbacks for specific contaminant sources from a well – MDH and local governments through ordinances and conditional use permitting;
- ✓ Land use controls – Local governments;

- ✓ Tank management program – MPCA, MDA;
- ✓ Shallow disposal wells - U.S. EPA.

The WHP Team recommends that no additional regulations be imposed at this time and are confident that local issues may be adequately addressed through existing processes. These processes include public education, adoption of best management practices for different types of wells, tank maintenance, and communication with landowners in the DWSMA.

One issue identified by the WHP Team concerned whether there are adequate resources to implement wellhead protection activities. The small size of the City and the limited availability of time for staff indicate that it will be a challenge to implement the WHP Plan. The WHP Team will focus its efforts on fostering partnerships to help achieve wellhead protection goals. The MDH and Minnesota Rural Water Association were identified as valuable partners.

CHAPTER FOUR

WELLHEAD PROTECTION GOALS (4720.5240)

Goals define the overall purpose for the WHP plan, as well as the end points for implementing objectives and their corresponding actions. The WHP team identified the following goal after considering the impacts that 1) changing land and water uses have presented to drinking water quality over time and 2) future changes that need to be addressed to protect the community's drinking water:

The goal of the City of Carlos is to promote public health by maintaining a potable drinking water supply for all residents and staff of the City of Carlos through the promotion of activities which protect their aquifer.

CHAPTER FIVE

OBJECTIVES AND PLANS OF ACTION (4720.5250)

Objectives provide the focus for ensuring that the goal of the WHP plan are met and that priority is given to specific actions that support multiple outcomes of plan implementation.

Both the objectives and the wellhead protection measures (actions) that support them are based on assessing 1) the data elements, 2) the potential contaminant source inventory, 3) the impacts that changes in land and water use present and 4) issues, problems, and opportunities referenced to administrative, financial, and technical considerations.

Objectives

The following objectives have been identified to support the goals of the WHP plan for the City of Carlos:

1. Create awareness and general knowledge about the importance of WHP in the City of Carlos.

2. Properly inventory and manage potential contaminant sources to protect the drinking water supply for the City of Carlos.
3. Gather additional information within the DWSMA in order to better understand the size and vulnerability of the DWSMA.
4. Effectively track and report the implementation efforts and wellhead protection plan progress to pertinent governing authorities.
5. Manage the Inner Wellhead Management Zone to prevent contamination of the aquifer near the public supply wells.
6. Effectively prepare the City of Carlos for disruptions to the water distribution system.

WHP Measures and Action Plan

The WHP team has identified WHP measures that will be implemented by the city over the 10-year period that its WHP plan is in effect. The objective that each measure supports is noted as well as 1) the lead party and any cooperators, 2) the anticipated cost for implementing the measure and 3) the year or years in which it will be implemented.

The following categories are used to further clarify the focus that each WHP measure provides, in addition to helping organize the measures listed in the action plan:

1. Public Education and Outreach
2. Potential Contamination Source Management
3. Land Use Management
4. Data Collection
5. Inner Wellhead Management Zone
6. Reporting and Evaluation
7. Water Use and Contingency Strategy

Establishing Priorities

Not all of these measures can be implemented at the same time, so the WHP team assigned a priority to each. A number of factors must be considered when WHP action items are selected and prioritized (part 4720.5250, subpart 3):

- Contamination of the public water supply wells by substances that exceed federal drinking water standards.
- Quantifiable levels of contamination resulting from human activity.
- The location of potential contaminant sources relative to the wells.
- The number of each potential contaminant source identified and the nature of the potential contaminant associated with each source.
- The capability of the geologic material to absorb a contaminant.
- The effectiveness of existing controls.
- The time needed to acquire cooperation from other agencies and cooperators.
- The resources needed, i.e., staff time, legal, financial, and technical resources.

The City of Carlos defines a priority for implementing a WHP measure as an action that protects their drinking water supply from contamination from the potential contaminant source or any other possible threat to the quality or quantity of its drinking water supply. The following table lists each measure that will be implemented over the 10-year period that the city's WHP plan is in effect, including the priority assigned to each measure.

WHP Plan of Action

PUBLIC EDUCATION AND OUTREACH:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#1): The City will provide a short summary of the new wellhead protection plan amendment in the city's newsletter and direct residents to the city's website for detailed educational materials.	1	High	City, MRWA	$400	X							X		
WHP Measure (#2): Post WHP educational materials on the city website. Many educational/outreach materials are located on the MRWA website dealing with proper well management, water conservation, storage tank management etc…	1	High	City, MRWA	Staff Time	X									

POTENTIAL CONTAMINATION SOURCE MANAGEMENT:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#3): Provide well owners in the DWMSA materials on proper well management.	2	High	City, MRWA	$75		X					X			
WHP Measure (#4): If the City is made aware of any unused wells in the DWSMA, apply for a grant to pay the costs associated with sealing them.	2	High	City, MDH, MRWA	Based on bids received	As Occurs									
WHP Measure (#5): If a tank needs corrective action, apply for funding to perform any corrective actions, including but not limited to having the tank properly removed. Contingent on grant funding.	2	High	City, MRWA, MDH	Based on bids received	As Occurs									
WHP Measure (#6): Provide storage tank owners information on best management practices for storage tanks.	2	High	City, MRWA	$100	X									
WHP Measure (#7): WHP Team and Manager will update the PCSI map and table.	2	Medium	City, MRWA	Staff Time					X					
WHP Measure (#8): It is unlikely old muni wells exist however the city will work with MDH and others to try and find the location of any potential wells.	2	Medium	City, MRWA, MDH	Based on bids received			X							
WHP Measure (#9): If any of the old muni wells are found, the city will apply for a grant and if successful have the wells sealed.	2	Medium	City, MRWA, MDH	Based on bids received			X	X						

WHP Measure (#10): Inform MDH if a Class V well is identified within the DWSMA.	2	Low	City, MDH	Staff Time	As Occurs									

LAND USE MANAGEMENT:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#11): Send Douglas County a map of the DWSMA and letter discussing the importance of WHP. Ask to be notified of any requests for changes in land use or zoning which are located within the DWSMA.	1	Low	City, MRWA	Staff Time	X									

<u>DATA COLLECTION</u>:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#12): Re-sample Wells #2 and #3 for vulnerability parameters determined in consultation with MDH (likely tritium, chloride, bromide, nitrate and ammonia); contingent on funding assistance from MDH for sampling and analysis.	3	Medium	City, MDH	Staff Time						X				
WHP Measure (#13): If wells are constructed within two miles of the city or one mile of the DWSMA, their locations should be verified.	3	Medium	City, MDH	Staff Time									X	
WHP Measure (#14): Working in cooperation with MDH Hydrologist drill a few well-placed test borings and sample them for the following water quality sampling (chloride, bromide, nitrate). The MDH Hydrologist will help select what parameters to test for. Work will be completed contingent upon receiving grant funds.	3	Medium	City, MDH	Staff Time					X					

IWMZ MANAGEMENT:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#15): Implement measures that are specified in the IWMZ PCSI report.	5	High	City	Staff Time	X	X	X	X	X	X	X	X	X	X
WHP Measure (#16): Monitor the 200 ft. radius around the wells to ensure that setback distances for new potential contamination sources are met.	5	High	City	Staff Time	X	X	X	X	X	X	X	X	X	X
WHP Measure (#17): Request MDH assistance to update the Inner Wellhead Management Zone Inventory for the public water supply wells.	5	High	City, MDH	Staff Time					X					X

REPORTING AND EVALUATION:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#18): Prepare an evaluation of WHP plan implementation efforts every 2 ½ years.	4	Low	City	Staff Time			X			X			X	
WHP Measure (#19): Summarize all WHP Plan implementation efforts in a report to MDH prior to the Scoping 1 meeting for the WHP Amendment.	4	Low	City, MDH, MRWA	Staff Time								X		

WATER USE AND CONTINGENCY STRATEGY:

Description	Objective	Priority	Responsible Party & Cooperators	Cost	Implementation Time Frame									
					2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
WHP Measure (#20): Review the contingency strategy portion of the city's wellhead protection plan to ensure that it reflects current personnel contact information, changes in the water supply system infrastructure and other needs and concerns.	6	Medium	City, MRWA	Staff Time					X					

These costs are estimates and actual costs will be will be determined prior to completion of measure

CHAPTER SIX
EVALUATION PROGRAM (4720.5270)

The success of the wellhead protection management program must be evaluated in order to determine whether the plan is actually accomplishing what the City of Carlos set out to do. The following activities will be implemented to:

- Track the implementation of the objectives identified in Chapter 5 of this Plan;
- Determine the effectiveness of specific management strategies regarding the protection of the public water supply;
- Identify possible changes to these strategies which may improve their effectiveness; and
- Determine the adequacy of financial resources and staff availability to carry out the management strategies planned for the coming year.

1) The City will continue to cooperate with MDH in the annual monitoring of the water supply to determine whether the management strategies are having a positive effect and to identify water quality problems that may arise which must be addressed.
2) It is recommended that the WHP Team meets on an annual basis, although it will meet a minimum of once every 2 ½ years to review the results of each strategy implemented during the previous plan year(s) and identify and discuss whether modifications are needed for those strategies, and identify strategies for the coming plan year(s).
4) The city will prepare a written report that documents how it has assessed plan implementation and the action items that were carried out. The report will be presented to MDH at the first scoping meeting held with the city to begin amending the WHP plan.

CHAPTER SEVEN

CONTINGENCY PLAN

INDEX

A. PURPOSE

The purpose of this Contingency Plan is to establish, provide and keep updated, certain emergency response procedures and information for the City of Carlos, MN which may become vital in the event of a partial or total loss of public water supply services.

B. PUBLIC WATER SUPPLY CHARACTERISTICS

1. Current Supply Source

City of Carlos	Well Number 2	Well Number 3
Unique Well #	241382	815779
Supply Source	Glacial Drift	Glacial Drift
Well Depth (ft.)	74	84
Well Diameter (in.)	8	8
Well Capacity (gpm)	360	360
Well Production (gpm)	180	180

2. Treatment

The City of Carlos adds chlorine, fluoride and potassium permanganate at their well house.

3. Storage and Distribution

The City has one 50,000 gallon above ground storage tank. The majority of the water distribution system is looped, with the exception of 2 dead ends in the system. The water system contains all necessary valving and piping to isolate various areas of the distribution system during times of repair. The City is working on installing meters on all connections. Flush the distribution system two times a year.

4. Maps/Plans

Maps of the water distribution system and valving are on file at the Carlos City Hall and City Shop. Maps are also available and on file at Bolton and Menck Offices, Willmar, Minnesota.

C. PRIORITY OF WATER USERS DURING WATER SUPPLY EMERGENCY

Table C-1—Water Use Priority Grouping

Priority Group and Rank	Maximum daily use (gpd)	Minimum daily use (gpd)
Residential #1	100,000	30,000
Commercial #2	6,000	3,500

Triggers for implementing water supply reduction/allocation Procedures:

In the event of a major system disruption, failure or an emergency, conservation procedures would be enacted by the Water Operator, City Clerk, Mayor and City Council.

D. ALTERNATIVE WATER SUPPLY OPTIONS

1. Surface water sources and treatment needs. The Long Prairie River flows near the City of Carlos. The Minnesota National Guard may be able to provide emergency treatment of surface water for human consumption. In the event of a significant water disruption emergency such as a catastrophic event, the following procedure is recommended:

1. Contact the County Sheriff (320) 762-8151 or 911 to request assistance from the Minnesota National Guard.
2. Sheriff contacts the MN Nat'l Guard; Division of Emergency Management, State Duty Officer (800) 422-0798; and Community Support Group at (651) 282-4013 to request assistance for the City.
3. The MN National Guard can provide a portable "ROWPU" (Reverse Osmosis Water Purification System) capable of supplying 900 gph or 15gpm.

2. Bottled water supplies, delivery and distribution: Larger quantities of bottled water or distributors in the Carlos area include:

1. Wal-Mart, Alexandria, MN (320) 762-8945
2. Viking Coke, Alexandria, MN (320) 763-6571
3. Alexandria Wholesalers, Alexandria, MN (320) 759-9009
4. H. Boyd Nelson Inc., Alexandria, MN (320) 763-6682

3. System interconnects with other water supplies. The City of Carlos currently has no interconnects with any other high capacity wells within the Carlos area.

4. New well. No other new wells are planned at this time.

5. Emergency or backup wells. The integration and interconnections within the City of Carlos's water supply system allows for the isolation of wells and components of the system while still being able to provide the City with water.

6. Emergency treatment of water system. The City owns a generator which can be used to power the water treatment plant in the case of a power failure.

7. Source Management (blending). The City does not have the ability to blend water generated from the two municipal wells through the interconnections within the water supply distribution system.

8. Other. No other water supply alternatives have been identified by the City of Carlos at this time.

E. INVENTORY OF AVAILABLE EMERGENCY EQUIPMENT AND MATERIALS

Table E-1 contains a list of services, equipment and supplies that are available to the City (system) to respond to a disruption in the water system. It is believed that the items contained in Table E-1 would be adequate to respond to most (if not all) water system emergencies.

Table E-1–Available Emergency Equipment and Materials

Description	Owner	Telephone	Location	Acquisition Time
Well Repair	Thein Well Drilling	320-796-2111	Spicer, MN	2 Hrs.
Pump Repair	Fortwengler	218-338-2061	Parkers Prairie, MN	1 Hr.
Electrician	Alexandria Electric	320-763-5222	Alexandria, MN	1 Hr.
Plumber	Ellingson Plumbing and Heating	800-595-8645	Alexandria, MN	1 Hr.
Backhoe/ Excavator	Lakes Area Excavating	320-852-7485	Carlos, MN	30 Mins.
Chemical Feed	Hawkins	701-293-9618	Fargo, ND	3 Hrs.
Meter Repair	Core & Main	800-752-8112 (701) 219-7480	Fargo, ND	3 Hrs.
Generator	MNWARN			
Valves	Core & Main	800-752-8112 (701) 219-7480	Fargo, ND	3 Hrs.
Pipe & Fittings	Core & Main	800-752-8112 (701) 219-7480	Fargo, ND	3 Hrs.
Misc. Materials	Alexandria Light and Power	320-763-6501	Alexandria, MN	30 Mins.

F. EMERGENCY IDENTIFICATION PROCEDURES

Table F-1–Emergency Procedural Operations

Incident	Response Procedure & Comments
Identify Disruption	Person identifying disruption contacts City Hall. City Hall contacts Response Personnel Coordinator, City Clerk, and / or Alternate Response Coordinator.
Notify Response Personnel (Coordinator)	Notify Response Personnel Coordinator or Alternate Personnel Coordinator
Identify Incident Direction and Control	Response Personnel Coordinator or Alternate assesses situation and determines incident direction and control, begin solving problem
Identify Internal Communication	Response Personnel Coordinator or Alternate contacts City Hall and City Clerk to inform of situation
Inform Public	Response Coordinator or City Clerk contacts appropriate organizations to inform public of problem
Assess Incident on Continual Basis	Response Personnel Coordinator or Alternate continue to monitor/solve problem
Assess Contamination Disruption	Response Personnel Coordinator or Alternate determines if water supply is contaminated. Monitor/solve problem as needed
Assess Mechanical Disruption	Response Personnel Coordinator or Alternate assesses mechanical disruption. Monitor and solve disruption as needed.
Provide Alternate Water Supply	If needed, alternate water supply is located and provided
Impose Water Use Restrictions	If needed, Water Operator, City Clerk, Mayor and Council may impose water use restrictions.

I. NOTIFICATION PROCEDURES

1. Agency Notification

Table G-1 contains the names and telephone numbers for contacts at various local and state agencies that may be notified in the event of a public water supply system emergency. Based on the nature of the emergency and the information available, various representatives from this listing will be selected by the response coordinator to be part of *the* ***emergency oversight committee*** which will then meet throughout the duration of the emergency to aid in decision-making and positive outcomes.

Table G-1– Agency Emergency Contact Listing

Personnel	Name	Home Telephone	Work Telephone
Water Operator	Jeff Gunderson	320-852-7647	320-815-3478
Mayor/Board Chair	Michael Bous	320-766-4493	
Council Members	Teresa Zwieg	320-852-7741	
Council Members	Ronna Berghoff	320-852-0089	
Council Members	Todd Burgess	320-852-7011	
Council Members	Maria Doucette	320-298-6004	
Response Coordinator	Jeff Gunderson	320-852-7647	320-815-3478
Alt. Response Coordinator	Police Chief		320-852-7920
State Incident Duty Officer	NA		800-422-0798
County Emergency Director	Troy Wolberson	911	320-762-8151
Fire Chief	Jacob Steidl	320-224-7751	911
Sheriff	Troy Wolberson	911	320-762-8151
Police Chief	Ralph Bradley	320-852-7920	320-852-3000
System Operator	Jeff Gunderson	320-852-7647	320-815-3478
Alt. System Operator	Jim Grundei	320-815-1650	
School Principal	Lisa Pikop		320-852-7181
Ambulance	North Ambulance	911	320-762-6160 or 911
Hospital	Douglas Co. Hospital	911	320-762-1151
Power Company	Ottertail Power	NA	800-257-4044
Co. Highway Department	Douglas Co. HWY Dept.		320-762-2999
State Highway Department	Jerry Miller		320-589-7301
Telephone Company	Embarq		800-788-3600
Neighboring Water System	Alexandria Light and Power		320-763-6501
MNWARN			800-367-6792
MRWA Technical Services	Kurt Haakinson	320-808-6272 cell	800-367-6792
MDH District Engineer	Lucas Hoffman		218-332-5147

2. Critical Response Personnel

Table G-2–Critical Response Personnel

Title	Name	Response Assignment
Response Coordinator	Jeff Gunderson	Coordinate actions to address emergency
Alt. Response Coordinator	Police Chief	Coordinate actions to address emergency
Water Operator	Jeff Gunderson	Direct or contact firms to resolve issue
Alt. Water Operator	Jim Grundi	Direct or contact firms to resolve issue
Public Relations	Mayor	Contact media to inform citizens/businesses of emergency
Alt. Public Relations	Fire Chief	Contact media to inform citizens/businesses of emergency
Public Health/Medical	Carlos Fire Dept., First Responders, North Ambulance Service, City & County Police Dept,	Assist City as needed to address emergency
Alt. Public Health/Medical	Miltona Fire Department, Parkers Prairie Ambulance, City & County Police Dept.,	Assist City as needed to address emergency

3. Public Information Plan:

A. Public relations center and primary spokesperson:

Name/Title: Mayor
Address: 109 First Street West, Carlos, MN
Phone: 320-766-4493

Public Information Center Location during Emergency: City Hall

Times Available: City Hall would remain open as needed in the event of an emergency.

Alternate Information Center Location Site: The Carlos Fire Hall would be used as an alternate meeting site.

B. **Information checklist to be conveyed to the public and media:**

1. Name of Water System
2. Contaminant of concern & date
3. Source of contamination
4. Public Health Hazard
5. Steps the public can take
6. Steps the water system is taking
7. Other Information

C. **Media Contacts:**

Media	Name	Telephone	Address
Newspaper	Echo Press	320-763-3133	225 7th Ave E P.O. Box 549 Alexandria, MN 56308
Radio	KIKV 100.7 Radio KXRA 1490 AM	320-762-2154 320-763-3131	604 3rd Ave. West Alexandria, MN 56308 1312 Broadway Alexandria, MN 56308

Public Alert System through Douglas County is another option. The City will hand out materials at homes not registered for the public alert system.

G. MITIGATION AND CONSERVATION PLAN

1. MITIGATION

a. Infrastructure maintenance/upgrades/maps:

The water system is flushed 2 times a year and the systems has 2 deadends. The distribution system is considered to be in good working condition according to City staff.

b. Regular inspection of tower, well, pump house:

All of these items are inspected daily. The well house and chemical rooms have keyed entries and are locked. The water tower is inspected and cleaned annually.

c. Staff emergency training:

City staff receive training annually through the Minnesota Rural Water Association.

d. System security analysis:

All facilities are locked and have keyed entries.

e. Site new backup well:

No new well is planned at this time.

f. System valving to isolate problems:

The water system is adequately valved to isolate problems.

g. Sanitation procedures for construction/repairs:

Shock chlorination is done when needed. All disinfection procedures are performed per State specifications.

2. CONSERVATION

a. Water Meters:

The city is working on installing water meters on all connections.

b. Public Education:

The City of Carlos post their consumer confidence report annually at local businesses in the area.

c. Rate structure:

Water and sewer rates are as follows:

<u>Residential Water:</u> $17 per connection	<u>Commercial Water:</u> $25 per connection
<u>Residential Sewer:</u> $25 per connection	<u>Commercial Sewer:</u> $40 per connection

Exhibit 1: Political Boundaries & Land Survey Map
Exhibit 2: Land Cover Map
Exhibit 3: Consumer Confidence Report
Exhibit 4: PCSI List and Map
Exhibit 5: Zoning & Comprehensive Land Use Map
Exhibit 6: Parcel Boundary Map
Exhibit 7: WHP Plan Part 1
Exhibit 8: Watershed Map

Exhibit 1: Political Boundaries & Land Survey Map

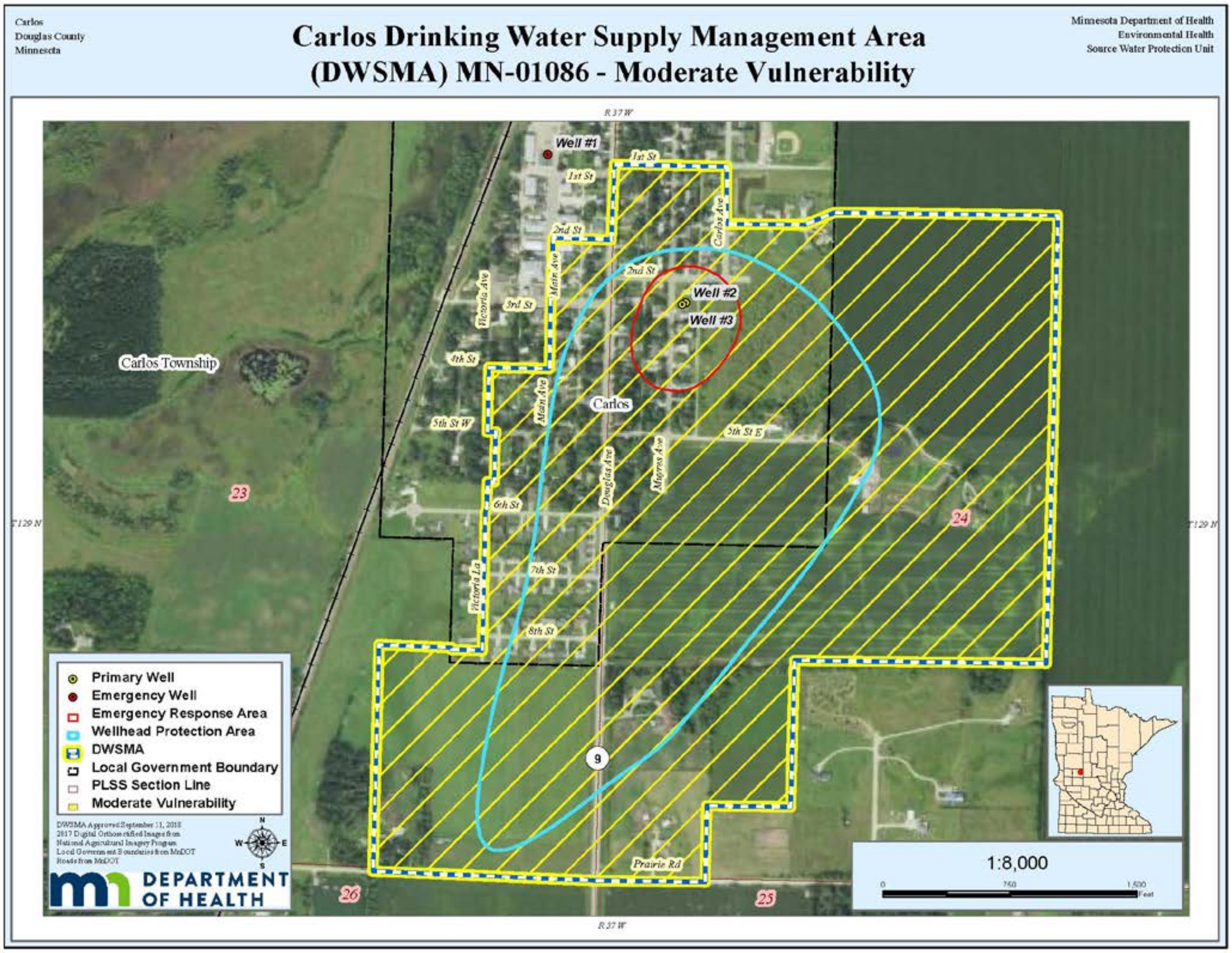
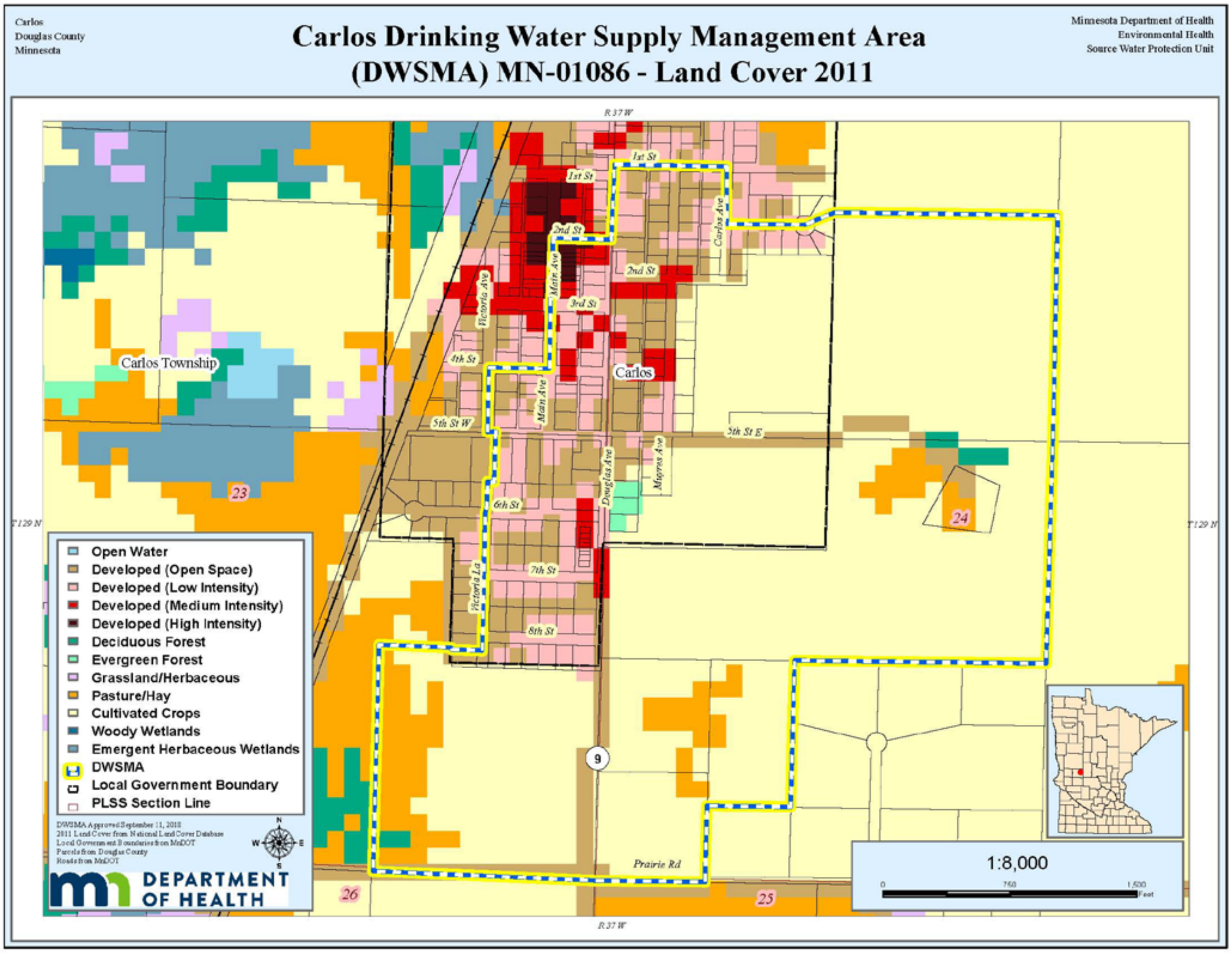


Exhibit 2: Land Cover Map



LAND_COVER	ACRES	PERCENT	YEAR
Developed, Open Space	33.95	12.72	2011
Developed, Low Intensity	25.74	9.64	2011
Developed, Medium Intensity	5.99	2.24	2011
Developed, High Intensity	0.89	0.33	2011
Deciduous Forest	1.55	0.58	2011
Evergreen Forest	1.11	0.42	2011
Pasture/Hay	15.98	5.99	2011
Cultivated Crops	181.74	68.08	2011
Total	266.95	100.00	2011

Exhibit 3: Consumer Confidence Report

Carlos

2017 DRINKING WATER REPORT

Making Safe Drinking Water

Your drinking water comes from a groundwater source: two wells ranging from 74 to 84 feet deep, that draw water from the Quaternary Buried Artesian aquifer.

Carlos works hard to provide you with safe and reliable drinking water that meets federal and state water quality requirements. The purpose of this report is to provide you with information on your drinking water and how to protect our precious water resources.

Contact John Rolf, Clerk-Treasurer, at 320-852-3000 or cityofcarlos@gctel.com if you have questions about Carlos's drinking water. You can also ask for information about how you can take part in decisions that may affect water quality.

The U.S. Environmental Protection Agency sets safe drinking water standards. These standards limit the amounts of specific contaminants allowed in drinking water. This ensures that tap water is safe to drink for most people. The U.S. Food and Drug Administration regulates the amount of certain contaminants in bottled water. Bottled water must provide the same public health protection as public tap water.

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline at 1-800-426-4791.

Carlos Monitoring Results

This report contains our monitoring results from January 1 to December 31, 2017.

We work with the Minnesota Department of Health to test drinking water for more than 100 contaminants. It is not unusual to detect contaminants in small amounts. No water supply is ever completely free of contaminants. Drinking water standards protect Minnesotans from substances that may be harmful to their health.

Learn more by visiting the Minnesota Department of Health's webpage Basics of Monitoring and Testing of Drinking Water in Minnesota (http://www.health.state.mn.us/divs/eh/water/factsheet/com/sampling.html).

How to Read the Water Quality Data Tables

The tables below show the contaminants we found last year or the most recent time we sampled for that contaminant. They also show the levels of those contaminants and the Environmental Protection Agency's limits. Substances that we tested for but did not find are not included in the tables.

We sample for some contaminants less than once a year because their levels in water are not expected to change from year to year. If we found any of these contaminants the last time we sampled for them, we included them in the tables below with the detection date.

We may have done additional monitoring for contaminants that are not included in the Safe Drinking Water Act. To request a copy of these results, call the Minnesota Department of Health at 651-201-4700 or 1-800-818-9318 between 8:00 a.m. and 4:30 p.m., Monday through Friday.

Definitions

- **AL (Action Level)**: The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.
- **EPA:** Environmental Protection Agency
- **MCL (Maximum contaminant level)**: The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
- **MCLG (Maximum contaminant level goal)**: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
- **Level 1 Assessment**: A Level 1 assessment is a study of the water system to identify potential problems and determine (if possible) why total coliform bacteria have been found in our water system.
- **Level 2 Assessment**: A Level 2 assessment is a very detailed study of the water system to identify potential problems and determine (if possible) why an E. coli MCL violation has occurred and/or why total coliform bacteria have been found in our water system on multiple occasions.
- **MRDL (Maximum residual disinfectant level):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **MRDLG (Maximum residual disinfectant level goal)**: The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **NA (Not applicable)**: Does not apply.
- **NTU (Nephelometric Turbidity Units)**: A measure of the cloudiness of the water (turbidity).
- **pCi/l (picocuries per liter)**: A measure of radioactivity.
- **ppb (parts per billion)**: One part per billion in water is like one drop in one billion drops of water, or about one drop in a swimming pool. ppb is the same as micrograms per liter (μg/l).
- **ppm (parts per million)**: One part per million is like one drop in one million drops of water, or about one cup in a swimming pool. ppm is the same as milligrams per liter (mg/l).
- **PWSID**: Public water system identification.
- **TT (Treatment Technique):** A required process intended to reduce the level of a contaminant in drinking water.
- **Variances and Exemptions**: State or EPA permission not to meet an MCL or a treatment technique under certain conditions.

Water Quality Data Tables

LEAD AND COPPER – Tested at customer taps.						
Contaminant (Date, if sampled in previous year)	**EPA's Action Level**	**EPA's Ideal Goal** (MCLG)	**90% of Results Were Less Than**	**Number of Homes with High Levels**	**Violation**	**Typical Sources**
Lead (08/11/17)	90% of homes less than 15 ppb	0 ppb	3.25 ppb	0 out of 5	NO	Corrosion of household plumbing.
Copper (08/11/17)	90% of homes less than 1.3 ppm	0 ppm	0.94 ppm	0 out of 5	NO	Corrosion of household plumbing.

INORGANIC & ORGANIC CONTAMINANTS – Tested in drinking water.

Contaminant (Date, if sampled in previous year)	**EPA's Limit** (MCL)	**EPA's Ideal Goal** (MCLG)	**Highest Average or Highest Single Test Result**	**Range of Detected Test Results**	**Violation**	**Typical Sources**
Barium	2 ppm	2 ppm	0.12 ppm	N/A	NO	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposit.
Ethylbenzene	700 ppb	700 ppb	1.2 ppb	0.00 - 1.20 ppb	NO	Discharge from petroleum refineries.
Xylenes	10 ppm	10 ppm	0.01 ppm	0.00 - 0.01 ppm	NO	Discharge from petroleum factories; Discharge from chemical factories.

CONTAMINANTS RELATED TO DISINFECTION – Tested in drinking water.

Substance (Date, if sampled in previous year)	**EPA's Limit** (MCL or MRDL)	**EPA's Ideal Goal** (MCLG or MRDLG)	**Highest Average or Highest Single Test Result**	**Range of Detected Test Results**	**Violation**	**Typical Sources**
Total Trihalomethanes (TTHMs) (2016)	80 ppb	N/A	7.8 ppb	N/A	NO	By-product of drinking water disinfection.
Total Haloacetic Acids (HAA) (2016)	60 ppb	N/A	2.5 ppb	N/A	NO	By-product of drinking water disinfection.
Total Chlorine	4.0 ppm	4.0 ppm	0.3 ppm	0.20 - 0.56 ppm	NO	Water additive used to control microbes.

Total HAA refers to HAA5

OTHER SUBSTANCES – Tested in drinking water.

Substance (Date, if sampled in previous year)	**EPA's Limit** (MCL)	**EPA's Ideal Goal** (MCLG)	**Highest Average or Highest Single Test Result**	**Range of Detected Test Results**	**Violation**	**Typical Sources**
Fluoride	4.0 ppm	4.0 ppm	0.71 ppm	0.64 - 0.74 ppm	NO	Erosion of natural deposits; Water additive to promote strong teeth.

Potential Health Effects and Corrective Actions (If Applicable)

Fluoride: Fluoride is nature's cavity fighter, with small amounts present naturally in many drinking water sources. There is an overwhelming weight of credible, peer-reviewed, scientific evidence that fluoridation reduces tooth decay and cavities in children and adults, even when there is availability of fluoride from other sources, such as fluoride toothpaste and mouth rinses. Since studies show that optimal fluoride levels in drinking water benefit public health, municipal community water systems adjust the level of fluoride in the water to a concentration between 0.5 to 1.5 parts per million (ppm), with an optimal fluoridation goal between 0.7 and 1.2 ppm to protect your teeth. Fluoride levels below 2.0 ppm are not expected to increase the risk of a cosmetic condition known as enamel fluorosis.

Some People Are More Vulnerable to Contaminants in Drinking Water

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. The developing fetus and therefore pregnant women may also be more vulnerable to contaminants in drinking water. These people or their caregivers should seek advice about drinking water from their health care providers. EPA/Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbial contaminants are available from the Safe Drinking Water Hotline at 1-800-426-4791.

Learn More about Your Drinking Water

Drinking Water Sources

Minnesota's primary drinking water sources are groundwater and surface water. Groundwater is the water found in aquifers beneath the surface of the land. Groundwater supplies 75 percent of Minnesota's drinking water. Surface water is the water in lakes, rivers, and streams above the surface of the land. Surface water supplies 25 percent of Minnesota's drinking water.

Contaminants can get in drinking water sources from the natural environment and from people's daily activities. There are five main types of contaminants in drinking water sources.

- **Microbial contaminants,** such as viruses, bacteria, and parasites. Sources include sewage treatment plants, septic systems, agricultural livestock operations, pets, and wildlife.
- **Inorganic contaminants** include salts and metals from natural sources (e.g. rock and soil), oil and gas production, mining and farming operations, urban stormwater runoff, and wastewater discharges.
- **Pesticides and herbicides** are chemicals used to reduce or kill unwanted plants and pests. Sources include agriculture, urban stormwater runoff, and commercial and residential properties.
- **Organic chemical contaminants** include synthetic and volatile organic compounds. Sources include industrial processes and petroleum production, gas stations, urban stormwater runoff, and septic systems.
- **Radioactive contaminants** such as radium, thorium, and uranium isotopes come from natural sources (e.g. radon gas from soils and rock), mining operations, and oil and gas production.

The Minnesota Department of Health provides information about your drinking water source(s) in a source water assessment, including:

- How Carlos is protecting your drinking water source(s);
- Nearby threats to your drinking water sources;

- How easily water and pollution can move from the surface of the land into drinking water sources, based on natural geology and the way wells are constructed.

Find your source water assessment at Source Water Assessments (www.health.state.mn.us/divs/eh/water/swp/swa/) or call 651-201-4700 or 1-800-818-9318 between 8:00 a.m. and 4:30 p.m., Monday through Friday.

Lead in Drinking Water

You may be in contact with lead through paint, water, dust, soil, food, hobbies, or your job. Coming in contact with lead can cause serious health problems for everyone. There is no safe level of lead. Babies, children under six years, and pregnant women are at the highest risk.

Lead is rarely in a drinking water source, but it can get in your drinking water as it passes through lead service lines and your household plumbing system. Carlos provides high quality drinking water, but it cannot control the plumbing materials used in private buildings.

Read below to learn how you can protect yourself from lead in drinking water.

1. **Let the water run** for 30-60 seconds before using it for drinking or cooking if the water has not been turned on in over six hours. If you have a lead service line, you may need to let the water run longer. A service line is the underground pipe that brings water from the main water pipe under the street to your home.
   - You can find out if you have a lead service line by contacting your public water system, or you can check by following the steps at: Are your pipes made of lead? Here's a quick way to find out (https://www.mprnews.org/story/2016/06/24/npr-find-lead-pipes-in-your-home).
   - The only way to know if lead has been reduced by letting it run is to check with a test. If letting the water run does not reduce lead, consider other options to reduce your exposure.
2. **Use cold water** for drinking, making food, and making baby formula. Hot water releases more lead from pipes than cold water.
3. **Test your water.** In most cases, letting the water run and using cold water for drinking and cooking should keep lead levels low in your drinking water. If you are still concerned about lead, arrange with a laboratory to test your tap water. Testing your water is important if young children or pregnant women drink your tap water.
   - Contact a Minnesota Department of Health accredited laboratory to get a sample container and instructions on how to submit a sample:
     Environmental Laboratory Accreditation Program
     (https://apps.health.state.mn.us/eldo/public/accreditedlabs/labsearch.seam)
     The Minnesota Department of Health can help you understand your test results.
4. **Treat your water** if a test shows your water has high levels of lead after you let the water run.
   - Read about water treatment units:
     Point-of-Use Water Treatment Units for Lead Reduction
     (http://www.health.state.mn.us/divs/eh/water/factsheet/com/poulead.html)

Learn more:

- Visit Lead in Drinking Water (http://www.health.state.mn.us/divs/eh/water/contaminants/lead.html#Protect)
- Visit Basic Information about Lead in Drinking Water (http://www.epa.gov/safewater/lead)
- Call the EPA Safe Drinking Water Hotline at 1-800-426-4791.To learn about how to reduce your contact with lead from sources other than your drinking water, visit Lead Poisoning Prevention: Common Sources (http://www.health.state.mn.us/divs/eh/lead/sources.html).

Help Protect Our Most Precious Resource – Water

The Value of Water

Drinking water is a precious resource, yet we often take it for granted.

Throughout history, civilizations have risen and fallen based on access to a plentiful, safe water supply. That's still the case today. Water is key to healthy people and healthy communities.

Water is also vital to our economy. We need water for manufacturing, agriculture, energy production, and more. One-fifth of the U.S. economy would come to a stop without a reliable and clean source of water.

Systems are in place to provide you with safe drinking water. The state of Minnesota and local water systems work to protect drinking water sources. For example, we might work to seal an unused well to prevent contamination of the groundwater. We treat water to remove harmful contaminants. And we do extensive testing to ensure the safety of drinking water.

If we detect a problem, we take corrective action and notify the public. Water from a public water system like yours is tested more thoroughly and regulated more closely than water from any other source, including bottled water.

Conservation

Conservation is essential, even in the land of 10,000 lakes. For example, in parts of the metropolitan area, groundwater is being used faster than it can be replaced. Some agricultural regions in Minnesota are vulnerable to drought, which can affect crop yields and municipal water supplies.

We must use our water wisely. Below are some tips to help you and your family conserve – and save money in the process.

- Fix running toilets—they can waste hundreds of gallons of water.
- Turn off the tap while shaving or brushing your teeth.
- Shower instead of bathe. Bathing uses more water than showering, on average.
- Only run full loads of laundry, and set the washing machine to the correct water level.
- Only run the dishwasher when it's full.
- Use water-efficient appliances (look for the WaterSense label).
- Use water-friendly landscaping, such as native plants.
- When you do water your yard, water slowly, deeply, and less frequently. Water early in the morning and close to the ground.
- Learn more
  - Minnesota Pollution Control Agency's Conserving Water webpage (https://www.pca.state.mn.us/living-green/conserving-water)
  - U.S. Environmental Protection Agency's WaterSense webpage (https://www.epa.gov/watersense)

You Can Prevent Pollution

Many of our daily activities contribute to the pollution of Minnesota's surface water and groundwater. You can help protect these drinking water sources by taking the following actions:

- Lawn and property:
  - Limit use of herbicides, pesticides, and fertilizers on your property.
  - Keep soil in place with plants, grass, or rocks.
  - Cover temporary piles of dirt with a tarp or burlap sack.
  - Keep leaves and grass off of streets and sidewalks.
  - Maintain any septic systems, private wells, and storage tanks to prevent leaks. Seal any unused wells.
- Out-of-date medications: Never flush unwanted or out-of-date medications down the toilet or sink. Always take them to a waste disposal or prescription medication drop-off site. More information is available at Managing unwanted medications (www.pca.state.mn.us/living-green/managing-unwanted-medications)
- Hazardous materials: Safety store hazardous materials such as paint, batteries, herbicides, pesticides, and pool chemicals. Dispose of them at a proper waste disposal facility or drop-off event. Do not dump down storm drains, sink or onto your land. Learn more at: Keep hazardous waste out of the garbage (http://www.pca.state.mn.us/featured/keep-hazardous-waste-out-garbage).
- Pet waste: Pick up after your pet and put waste in the trash.
- Trash: Seal trash bags and keep litter out of the street.
- Winter ice removal: Chemicals used to break up the ice are called deicers or anti-icers. They can be harmful to the environment, corrosive to driveways and sidewalks and harmful to plants, pets and humans. Always shovel first, and then only apply deicers/anti-icers lightly if needed. Learn more at 10 smart salting tips to protect Minnesota waters (https://www.pca.state.mn.us/featured/10-smart-salting-tips-protect-minnesota-waters).
- Keep an eye out for car and motor fluids: Seal or repair any fluid leaks that could run off onto streets and into storm drains. Take used motor oil or other fluids to a neighborhood drop-off site.
- Be a water advocate: Spread the word; get involved. There are many groups and individuals working to protect water across Minnesota.

Reduce Backflow at Cross Connections

Bacteria and chemicals can enter the drinking water supply from polluted water sources in a process called backflow. Backflow occurs at connection points between drinking water and non-drinking water supplies (cross connections) due to water pressure differences.

For example, if a person sprays an herbicide with a garden hose, the herbicide could enter the home's plumbing and then enter the drinking water supply. This could happen if the water pressure in the hose is greater than the water pressure in the home's pipes.

Property owners can help prevent backflow. Pay attention to cross connections, such as garden hoses.

The Minnesota Department of Health and American Water Works Association recommend the following:

- Do not submerge hoses in buckets, pools, tubs, or sinks.
- Keep the end of hoses clear of possible contaminants.
- Do not use spray attachments without a backflow prevention device. Attach these devices to threaded faucets. Such devices are inexpensive and available at hardware stores.
- Use a licensed plumber to install backflow prevention devices.
- Maintain air gaps between hose outlets and liquids. An air gap is a vertical space between the water outlet and the flood level of a fixture (e.g. the space between a wall-mounted faucet and the sink rim). It must be at least twice the diameter of the water supply outlet, and at least one inch.
- Commercial property owners should develop a plan for flushing or cleaning water systems to minimize the risk of drawing contaminants into uncontaminated areas.

Home Water Treatment

Most Minnesotans, whether they drink from a public water supply or a private well, have drinking water that does not need treatment for health protection. Water treatment units are best for improving the physical qualities of water—the taste, color, or odor.

No single treatment process can remove all substances in water. If you decide to install a home water treatment unit, choose a unit certified and labeled to reduce or remove the substance of concern. If there is more than one substance you want to remove from your water, you may need to combine several treatment processes into one system.

Even well-designed treatments systems can fail. You should continue to test your drinking water after you install a treatment unit. All home water treatment units need regular maintenance to work correctly. Regular maintenance may include changing filters, disinfecting the unit, or cleaning scale buildup. Always install, clean, and maintain a treatment unit according to the manufacturer's recommendations.

Learn more at Home Water Treatment
(http://www.health.state.mn.us/divs/eh/water/factsheet/com/pou.html).

Beware of Water Treatment Scams

False claims, deceptive sales pitches, or scare tactics have been used by some water treatment companies. Every person has a right to decide what is best for themselves and their family, and you may choose to install additional water treatment to further lower the levels of contaminants of emerging concern, chlorine, and other chemicals in your water. However, you should be cautious about purchasing a water treatment system. If you are considering the purchase of a home water treatment system, please read the Minnesota Department of Health's recommendations online at Warning: Beware of Water Treatment Scams (http://www.health.state.mn.us/divs/eh/water/factsheet/com/beware.html).

The Pros and Cons of Home Water Softening

Water softeners are a water treatment device. They remove water hardness (dissolved calcium and magnesium). The decision to soften your water is a personal choice that can affect your home and the environment. It is important to understand your home's water quality. This will help you decide if a home water softener is necessary and choose the best treatment device(s). Water softeners must be installed and maintained properly to be safe and effective.

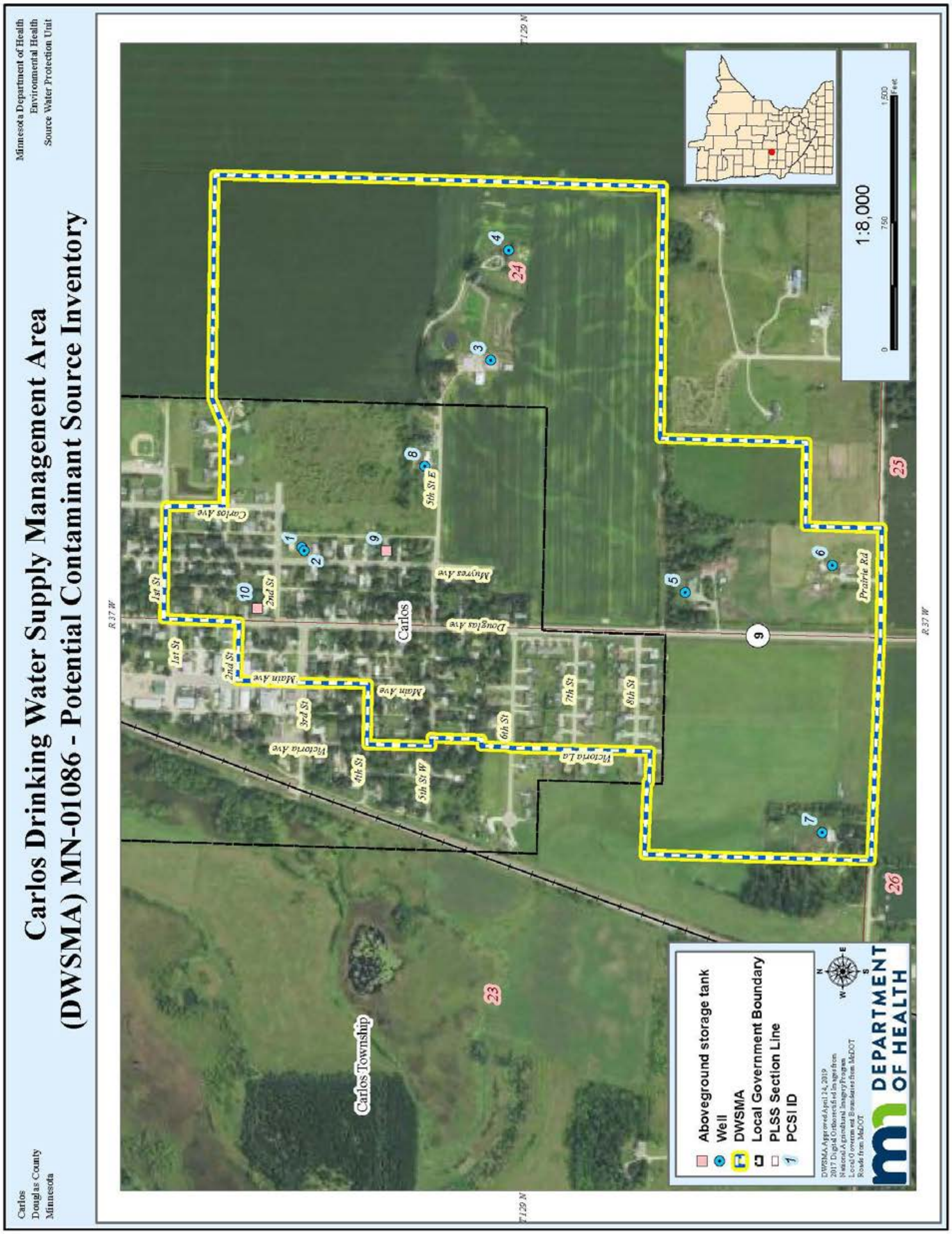
The advantages of home water softening include:

- Prevents build-up of minerals (scale) on the inside of pipes, fixtures, and hot water heaters.
- Lengthens the life of some appliances.
- Reduces or prevents mineral spots on glassware.
- Prevents or reduces soap films and detergent curds in sinks, bathtubs, and washing machines.

The disadvantages of home water softening include:

- Can corrode your pipes. The corroded metal from the pipes can end up in your water.
- Potential health implications from additional sodium from water softening.
- Regular testing of the water and maintenance of the softener is necessary to make sure the softener is working properly.
- Negative impacts to the environment from salt use.
- Water waste: The water used to regenerate the softener beads ends up as waste water.

Exhibit 4: PCSI List and Map



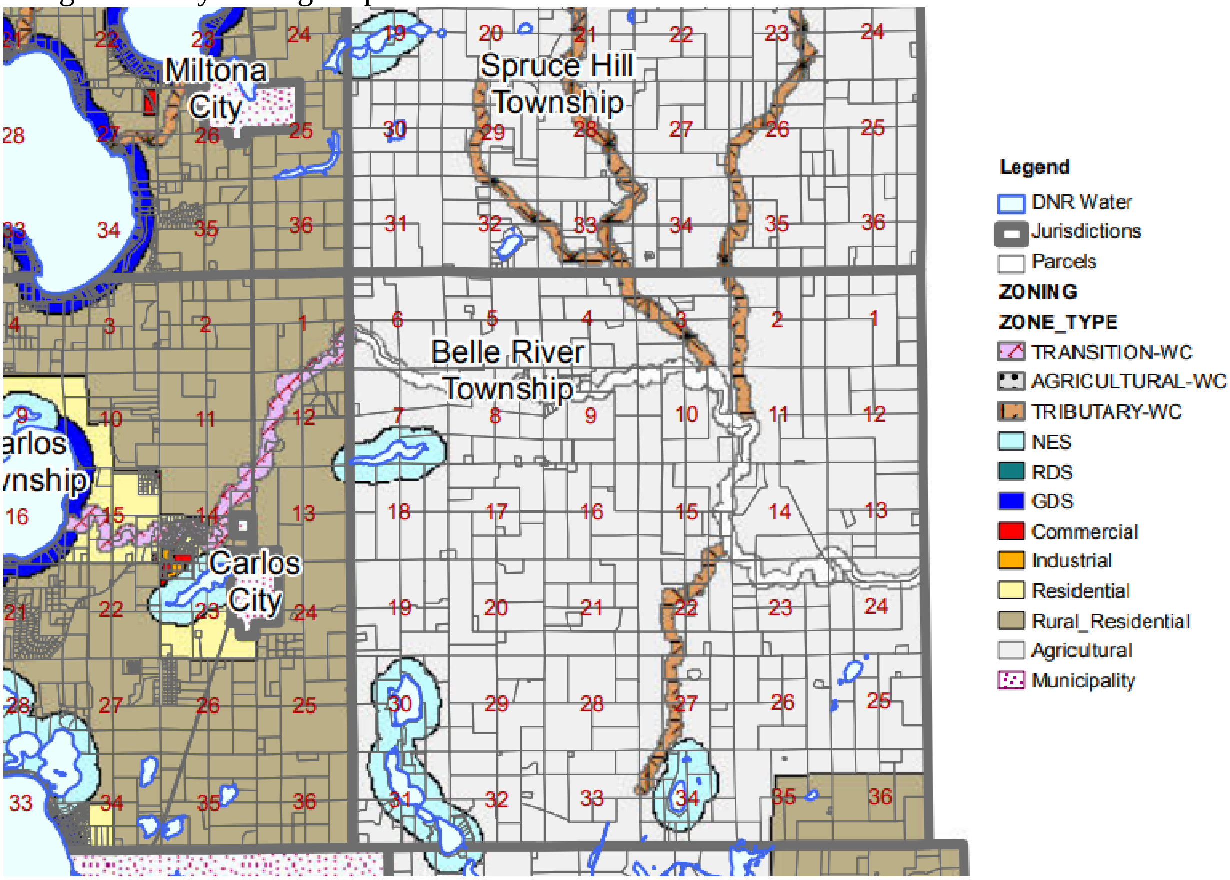
Carlos DWSMA (MN-01086)

PCSI Report

ID	PIN	NAME	ADDRESS	CITY	ZIP	PCSI	STATUS	MATERIA	PROGRAM ID	TOTAL	COMMENT
1	690189000	Carlos Well #2	109 First St. W.	Carlos	56319	WEL - Well	A - Active	-	241382	1	
2	690189000	Carlos Well #3	109 First St. W.	Carlos	56319	WEL - Well	A - Active	-	815779	1	
3	120857000	Illetschko, Thomas and Sharon	510 Douglas Ave.	Carlos	56319	WEL - Well	A - Active	-		1	
4	120858000	Myrin, Steven	6600 East 5th St. NE	Carlos	56319	WEL - Well	A - Active	-		1	
5	120859100	Steidl, Stacy and Kathy	6951 Co. Rd 9 NE	Carlos	56319	WEL - Well	A - Active	-	636746	1	
6	120859000	Meyers, Lee and Joyce	6115 Prairie Rd NE	Nelson	56355	WEL - Well	A - Active	-	666727	1	
7	120854000	Lien, Gary	5633 Prairie Rd NE	Carlos	56319	WEL - Well	A - Active	-	437706	1	
8	690158000	Daker, Helen	301 East Fifth Street	Carlos	56319	WEL - Well	A - Active	-		1	
9	690191000	Zweig,, Richard and Teresa	310 Muyres Ave.	Carlos	56319	AST - Aboveground storage tank	A - Active	F000 - Fuels, gases & oils (unspecified)		1	
10	690172000	Drexler, Dennis and Violet	110 Douglas Ave.	Carlos	56319	AST - Aboveground storage tank	A - Active	F000 - Fuels, gases & oils (unspecified)		1	

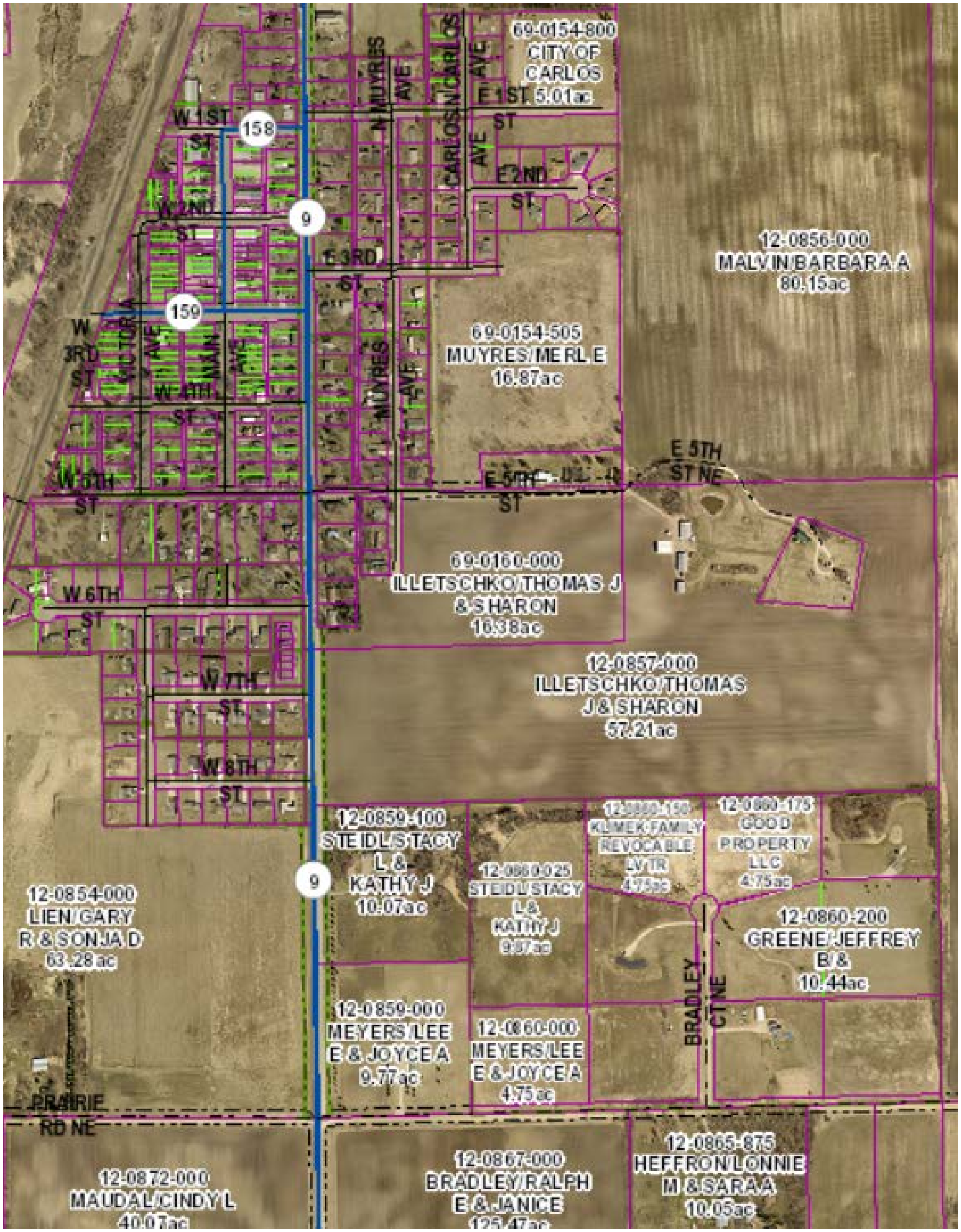
Exhibit 5: Zoning & Comprehensive Land Use Map

Douglas County Zoning Map



*The City does not have a zoning map which can be included in this appendix.

Exhibit 6: Parcel Boundary Map



Detailed parcel information is available at the Douglas County website.
https://www.co.douglas.mn.us/parcel-mapping

Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Carlos

DELINEATIONS – WELLHEAD PROTECTION AREA AND DRINKING WATER SUPPLY MANAGEMENT AREA

VULNERABILITY ASSESSMENTS – WELLS AND DRINKING WATER SUPPLY MANAGEMENT AREA

July 25, 2019

Hydrogeologic Assessment of the Drinking Water Source and Wells for the City of Carlos

Public Water Supply ID: 1210010

City of Carlos
PO Box 276
Carlos, Minnesota 56319-0276
320-852-3000

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I hereby certify that this plan, document or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the laws of the State of Minnesota.

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Printed Name: Trent Farnum License Number: 50326

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Glossary of Terms

Data Element. A specific type of information required by the Minnesota Department of Health to prepare a wellhead protection plan.

Drinking Water Supply Management Area (DWSMA). The area delineated using identifiable land marks that reflects the scientifically calculated wellhead protection area boundaries as closely as possible (Minnesota Rules, part 4720.5100, subpart 13).

Drinking Water Supply Management Area Vulnerability. An assessment of the likelihood that the aquifer within the DWSMA is subject to impact from land and water uses within the wellhead protection area. It is based upon criteria that are specified under Minnesota Rules, part 4720.5210, subpart 3.

Emergency Response Area (ERA). The part of the wellhead protection area that is defined by a one-year time of travel within the aquifer that is used by the public water supply well (Minnesota Rules, part 4720.5250, subpart 3). It is used to set priorities for managing potential contamination sources within the DWSMA.

Inner Wellhead Management Zone (IWMZ). The land that is within 200 feet of a public water supply well (Minnesota Rules, part 4720.5100, subpart 19). The public water supplier must manage the IWMZ to help protect it from sources of pathogen or chemical contamination that may cause an acute health effect.

Wellhead Protection (WHP). A method of preventing well contamination by effectively managing potential contamination sources in all or a portion of the well's recharge area.

Wellhead Protection Area (WHPA). The surface and subsurface area surrounding a well or well field that supplies a public water system, through which contaminants are likely to move toward and reach the well or well field (Minnesota Statutes, section 103I.005, subdivision 24).

Well Vulnerability. An assessment of the likelihood that a well is at risk to human-caused contamination, either due to its construction or indicated by criteria that are specified under Minnesota Rules, part 4720.5550, subpart 2.

Acronyms

CWI - County Well Index

DNR - Minnesota Department of Natural Resources

EPA - United States Environmental Protection Agency

FSA - Farm Security Administration

MDA - Minnesota Department of Agriculture

MDH - Minnesota Department of Health

MGS - Minnesota Geological Survey

MnDOT - Minnesota Department of Transportation

MnGEO - Minnesota Geospatial Information Office

MODFLOW - Three-Dimensional Finite-Difference Groundwater Model

MPCA - Minnesota Pollution Control Agency

NRCS - Natural Resource Conservation Service

SWCD - Soil and Water Conservation District

UMN - University of Minnesota

USDA - United States Department of Agriculture

USGS - United States Geological Survey

Summary

Protection Areas - The recharge area for the wells is known as the wellhead protection area, or WHPA, and represents the area that contributes water to the city's wells within a 10-year time period. The area that contributes water within a one-year time period is known as the emergency response area, or ERA. Practical reasons require the designation of a management area that fully envelops the wellhead protection area, called the drinking water supply management area, or DWSMA. Each of these areas is shown in Figure 1.

Geology and Groundwater Flow – The city of Carlos has two primary wells screened in a sand and gravel aquifer that is buried beneath a layer of clay-rich sediment. Such aquifers are known generically as Quaternary Buried Artesian Aquifers (QBAA). The city's aquifer is between approximately 53 and 84 feet below the ground surface (Table 1). Regionally, groundwater flow is to the north and northeast.

Table 1 - Water Supply Well Information

Local Well ID	Unique Number	Use/ Status	Casing Diameter (inches)	Casing Depth (feet)	Well Depth (feet)	Date Constructed/ Reconstructed	Aquifer	Well Vulnerability
Well #1	241381	Emergency	8	111	138	1957	QBAA	Vulnerable
Well #2	241382	Primary	8	58	74	1974	QBAA	Vulnerable
Well #3	815779	Primary	8	53	84	4/25/2016	QBAA	Vulnerable

Well Vulnerability - The vulnerability of each well has been assessed based on 1) well construction details, especially conformance with standards required by the state well code, 2) the geologic sensitivity of the aquifer, and 3) past monitoring results. Well construction does not meet current State Well Code specifications (Minnesota Rules, part 4725) at Well #1 and Well# 2 because no grouting information is known. If the well was not grouted, it has the potential for acting as a conduit for flow of surface water and contaminants into the buried aquifer. To date, no evidence of this has been identified and it is likely that the cable tool method was used during construction of these wells, which minimizes that risk. Well #3 meets construction standards, meaning the well itself should not provide a pathway for contaminants to enter the aquifer. The city's wells are considered vulnerable to contamination due to tritium being detected in the well water (Table 2). Detectable tritium indicates the presence of young (post-1953) water.

Table 2 - Isotope and Water Quality Results

1) Unique Number (Well Name)	2) Tritium	3) Nitrate (mg/L)	4) Chloride / Bromide Ratio	5) Chloride (mg/L)	6) Bromide (mg/L)	Arsenic (µg/L)
241381 (Well #1)	1.0 (4/18/2000)	-	-	-	-	-
241382 (Well #2)	14.2 (4/10/2006)	<0.05 (4/22/2014)	153	6.13 (8/14/2013)	0.04 (8/14/2013)	<1.00 (8/14/2013)
815779 (Well #3)	6.9 (9/27/2017)	<0.05 (9/27/2017)	184	7.01 (9/27/2017)	0.0381 (9/27/2017)	<1.00 (9/27/2017)

DWSMA Vulnerability -The vulnerability of the city's aquifer throughout the DWSMA is based on the geologic sensitivity ratings of wells and their monitoring data (Table 2). Based on this information MDH has assigned a moderate vulnerability to the DWSMA. This rating suggests that water and contaminants may travel from the land surface to the city's aquifer within a time span of months to years due to the clay-rich sediments that overlie the city's aquifer being susceptible to leakage. Moderately vulnerable aquifers are prone to a variety of contaminant threats, including chemical storage tanks and abandoned wells which can provide conduits for contaminants to quickly reach the city's aquifer.

Water Quality Concerns - At present, none of the contaminants for which the Safe Drinking Water Act has established health-based standards is found above maximum allowable levels in the city's water supply, nor are any present at one-half of those levels.

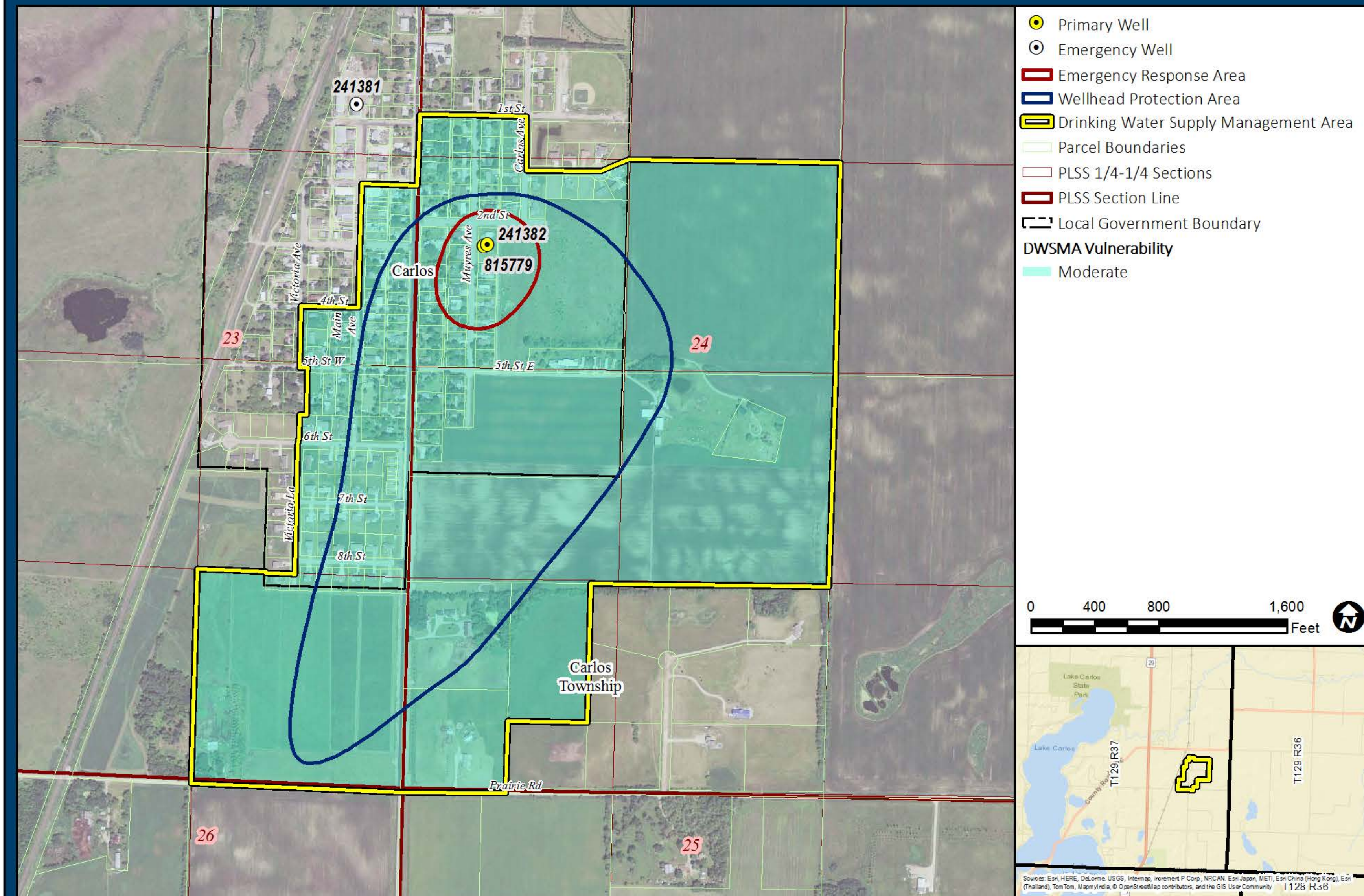
Recommendations - Recommendations have been generated to improve future delineations and vulnerability assessments and should be considered for inclusion as management strategies in the city's wellhead protection plan. These activities include: well locating and water quality monitoring. Further details can be found in the Recommendations section of this report.

Douglas County
Minnesota

Figure 1
Drinking Water Supply Management Area and Vulnerability
City of Carlos

DEPARTMENT OF HEALTH

CLEAN WATER LAND & LEGACY AMENDMENT



Technical Report

Discussion

This document describes the amendments to Part 1 of the wellhead protection (WHP) plan for the city of Carlos (PWSID 1210010). The purpose for amending the plan is to address the changes that have occurred since the plan was last approved, in order to update the WHP measures that are needed to protect public drinking water For example, the locations of the city wells were adjusted for greater accuracy, the pumping volumes of the wells were reapportioned to reflect the new well along with current water use since the first plan was approved, and new irrigation wells were added to the flow model. The amended areas are smaller (Figure 7) due to increased knowledge of the local geology and a better understanding of the local hydrogeology, mainly hydraulic conductivity. The work was performed in accordance with the Minnesota Wellhead Protection Rule, parts 4720.5100 to 4720.5590.

This report presents delineations of the wellhead protection area (WHPA) and drinking water supply management area (DWSMA), and the vulnerability assessments for the public water supply wells and DWSMA. Figure 1 shows the boundaries for the WHPA and the DWSMA. The WHPA is defined by a 10-year time of travel. Figure 1 also shows the emergency response area (ERA), which is defined by a one-year time of travel. Definitions of rule-specific terms used are provided in the "Glossary of Terms."

In addition, this report documents the technical information required to prepare this portion of the WHP plan in accordance with the Minnesota Wellhead Protection Rule. Additional technical information is available from MDH.

Table 1 lists all the wells in the public water supply system. Only wells listed as primary are required to be included in the WHP plan.

Assessment of the Data Elements

MDH staff met with representatives of the city of Carlos on September 27, 2017, for a scoping meeting that identified the data elements required to prepare Part I of the WHP plan. Appendix A presents the assessment of these data elements relative to the present and future implications of planning items specified in Minnesota Rules, part 4720.5210.

General Descriptions

Description of the Water Supply System

The city of Carlos obtains its drinking water supply from two primary wells. Table 1 summarizes general construction information and vulnerability status.

Description of the Hydrogeologic Setting

The city of Carlos is located near the east-central portion of Douglas County. The eastern half of Douglas County is generally characterized by extensive tracts of outwash deposits of sand and gravel (Allison, 1932). Buried sand aquifers exist at depth, such as that used by the city of Carlos, and are separated from the surficial outwash by layers of clay or till. Recharge is commonly by infiltration through these thin, fine-grained layers and surficial sand aquifers to the buried aquifers in the Carlos area (Berg, 2008).

The construction records for the city wells reveal a complex layering of sandy and clayey sediments, with both wells screened in a sand body that is approximately 34 feet thick and which occurs approximately 50 feet below the land surface. These glacial sediments are attributed to the Crow Wing River Group and the Browerville formation (Berg, 2008).

Groundwater flow is generally to the north and northeast towards the Long Prairie River.

A description of the hydrogeologic setting for the aquifer used to supply drinking water is presented in Table 3.

Table 3 - Description of the Local Hydrogeologic Setting

Attribute	Descriptor	Data Source
Aquifer Material	Sand and Gravel	Well Records and the CWI Database
Porosity Type and Value	Primary 20 percent	Fetter, 2001
Aquifer Thickness	Variable: 4 – 96 ft., 34 ft proximal to city wells	Well Records and the CWI Database
Stratigraphic Top Elevation	~1315 ft., AMSL	Well Records and the CWI Database
Stratigraphic Bottom Elevation	~1281 ft., AMSL	Well Records and the CWI Database
Hydraulic Confinement	Confined	Well Records and the CWI Database
Transmissivity	Range of Values: 98 - 16,246 ft^2/day 9,620 ft^2/day at city wells	A range of transmissivity values was used to reflect changes in aquifer composition and thickness as well as uncertainties related to the quality of existing aquifer test data. See Table 4 for the reference value.

Attribute	Descriptor	Data Source
Hydraulic Conductivity	Range of Values: 8 - 282 ft/day 282 ft/day at city wells	The range of values was derived using specific capacity data obtained from well records and/or from additional aquifer test results listed in the "Selected References" section of this report.
Groundwater Flow Field	Groundwater flow is northeasterly, with an approximate compass direction of 10° and gradient of 0.0015 (Figure 2).	Defined by using static water level elevations from well records in the CWI database and documents listed in the "Selected References" section of this report.

The distribution of the aquifer and its stratigraphic relationships with adjacent geologic materials are shown in Figures 3, 4, and 5. They were prepared using well record data contained in the CWI database. The geological maps and studies used to further define local hydrogeologic conditions are provided in the "Selected References" section of this report.

Delineation of the Wellhead Protection Area

Delineation Criteria

The boundaries of the WHPA for the city of Carlos are shown in Figure 1. Table 4 describes how the delineation criteria specified under Minnesota Rules, part 4720.5510, were addressed.

Table 4 - Description of WHPA Delineation Criteria

Criterion	Descriptor	How the Criterion was Addressed
Flow Boundary	Hydrologic Boundary	Long Prairie River, many unnamed creeks within the Headwater Sauk River Watershed and Spruce Creek-Long Prairie River Watershed were added as head boundaries in the flow model.
Flow Boundary	Geologic Boundary	Analysis of specific capacity data suggests the transmissivity of the aquifer system varies with proximity to the city wells. This was simulated in the model by varying the hydraulic conductivity spatially.

Criterion	Descriptor	How the Criterion was Addressed
Flow Boundary	Other High Capacity Wells	The pumping amounts were determined using the same approach used for the public water supply wells. The pumping amounts of these other wells were included in the methods used for the delineation.
Recharge	Modeled Value	During the calibration process it was estimated that approximately three inches of recharge occurs annually to the QBAA used by the city of Carlos. Delin, 2007 estimates approximately 3-5 inches for surficial aquifers in this area.
Daily Volume of Water Pumped	See Table 5	Pumping information was obtained from the DNR, Appropriations Permit Number 1975-1175, and was converted to a daily volume pumped by a well.
Groundwater Flow Field	Groundwater flow is northeasterly, with an approximate compass direction of 10° and gradient of 0.0015 (Figure 2).	The model calibration process addressed the relationship between the calculated versus observed groundwater flow field. Oneka was also used to evaluate the uncertainty of the wells' capture areas based on regional flow, recharge, and local well data.
Aquifer Transmissivity	Reference Value: 9,620 ft^2/day	The aquifer test plan was approved on March 8, 2018, and T was determined from an aquifer test. Uncertainty regarding aquifer transmissivity was addressed as described in the "Addressing Model Uncertainty" section.
Time of Travel	10 years	The public water supplier selected a 10-year time of travel.

Pumping data was obtained from the DNR Permit and Reporting System (MPARS) for the public water supply's Appropriations Permit Number 1975-1175. These values, confirmed by the public water supplier, were used to identify the maximum volume of water pumped annually by each well over the previous five-year period, as shown in Table 5. As Well #3 is new to the system, the maximum five-year total for Well #2 was reapportioned between Well #2 and Well #3 based on the future pumping regime to be used by the city. The maximum daily volume of discharge used as an input parameter in the model was calculated by dividing the greatest annual pumping volume by 365 days.

Table 5 - Annual Volume of Water Discharged from Water Supply Wells

Well Name	Unique Number	2012	2013	2014	2015	2016	5-Year Projection	Pumping Amount Used in Previous Delineation
Well #1	241381	0.010	0.010	0.010	**0.020**	0.002	0.020	0
Well #2	241382	14.468	14.065	12.943	**14.957**	9.391	1.496	20.900
Well #3	815779	-	-	-	-	**3.724**	13.461	0

(Expressed as million gallons. Bolding indicates greatest annual pumping volume.)

In addition to the wells used by the public water supplier, Table 6 shows other high-capacity wells within two miles of the city included in the delineation to account for their pumping impacts on the capture areas for the public water supply wells. Pumping data was obtained from the DNR MPARS database.

Table 6 - Other Permitted High-Capacity Wells

Local Well ID	Unique No.	Permit ID	Use	Max Last 5 Years Pumping	Pumping Amount Used in Previous Delineation
Botzet, Gary	125678	1976-1321	Agricultural Crop Irrigation	0	197
Klimek Family Properties	131628	1977-1621	Agricultural Crop Irrigation	108	0
Botzet, Bruce	132207	1977-1479	Agricultural Crop Irrigation	123	254
Thesing, Eric	214501	1966-0294	Agricultural Crop Irrigation	95	128.6
Steiger, Kenneth	251593	1975-1294	Agricultural Crop Irrigation	332	684

Local Well ID	Unique No.	Permit ID	Use	Max Last 5 Years Pumping	Pumping Amount Used in Previous Delineation
Manthei Golf Inc -	423878	1987-1269	Agricultural Crop Irrigation	73.6	117
Botzet, Gary	591169	1976-1321	Agricultural Crop Irrigation	141	0
Farm Fields Ltd	611606	1999-1099	Agricultural Crop Irrigation	136	187
Malvin, William	775885	2014-1984	Agricultural Crop Irrigation	102	0

(Expressed as million gallons.)

Method Used to Delineate the Wellhead Protection Area

The WHPA for the city of Carlos' wells was determined using the software code MODFLOW (McDonald and Harbaugh, 1988; Harbaugh et al., 2000; Harbaugh, 2005). An additional capture zone calculation was conducted using the stochastic analytical groundwater flow method Oneka (Barnes and Soule, 2002). The resulting WHPA boundaries are a composite of the capture zones calculated from several different model scenarios (Figure 1).

MODFLOW was developed by the United States Geological Survey and is publicly available. The specific software code used for this delineation was MODFLOW-NWT (Niswonger, 2011). The program has been thoroughly documented, is widely used by consultants, government agencies, and researchers and consistently accepted in regulatory proceedings. MODFLOW is also an extremely versatile program capable of simulating groundwater flow in up to three dimensions while offering a variety of boundary condition options, confined or unconfined aquifer conditions and allowing for vertical discretization through the use of layering.

The numerical groundwater model that was constructed consisted of 233 rows, 238 columns, and three layers. The model incorporates a variable areal grid spacing ranging from 1.25 meters near the city's wells to 320 meters at the boundaries of the model domain. Layer tops and bottoms were derived from CWI logs within the model domain. Layer thicknesses vary over the model domain to capture the varying sand and till layering that exists in the area. River head boundaries represent cells where water is flowing both into and out of the aquifer and were used to simulate the many lakes and rivers within the model domain within Layer 1. No flow boundaries are cells where flow cannot occur and are implicitly represented as the boundaries of the model domain and the bottom of Layer 3. Vertical recharge was applied to Layer 1 of the model starting with values published by the U.S Geological Survey (Delin et al., 2007) and then adjusting down until a desired calibration was obtained. Ranges of hydraulic conductivity were first estimated from literature review (Fetter, 2001) and then in Layer 3 were refined with specific capacity data.

Due to the heterogeneity of the unconsolidated sand and till and the lack of contiguous lenses for discretization of hydraulic conductivity zones, site specific data within the model domain was interpolated using the Parameter Estimation (PEST) tool. PEST is a calibration tool developed by John Doherty of Watermark Computing and is most commonly used to estimate aquifer hydraulic conductivity (Doherty, 2010). Typical zonation of hydraulic conductivity introduces zones of different hydraulic conductivity in the model domain at locations where the modeler feels they would do the most good. The parameter zonation process would then be repeated until the fit between model outcomes and field observations was acceptable. Characterization of geologic heterogeneity in the model domain by zones of piecewise uniformity is not in harmony with the nature of the alluvial material, therefore any zonation pattern that is finally decided upon is only defensible on the basis that it is better to employ such a zonation scheme than to ignore geologic heterogeneity altogether. To overcome this problem, the distribution of hydraulic conductivity within the model domain was described by a set of pilot points. The pilot point locations and values in the model domain were derived from specific capacity data at domestic wells and aquifer test data for the city's wells. These values were then smoothed with the geostatistical method of kriging and input into the model. The pilot point method allowed for hydraulic conductivity values to be representative of the city well data proximal to the city well field and then be smoothed further away.

To determine the WHPA, the groundwater flow model was used along with a particle tracking program called MODPATH (Pollock, 2012). MODPATH is used to evaluate advective transport of simulated particles moving through the simulated flow system. A series of 72 particles were launched at each well. A porosity of 20 percent was used and a reverse time of travel was calculated at 10 years.

Oneka was used to assess the probability of impacts that local variations in hydrogeologic conditions may have on a well capture zone. This model treats the aquifer properties and the available water level measurements as variable input parameters. The locations of wells, water levels, and the aquifer geometry were evaluated using information from the CWI database. For the solution, Oneka finds the flow field that best fits the network of water level elevations by varying the values of the aquifer thickness and transmissivity. Oneka then evaluates the probability of the capture of a given point based on the number of times it is included in the capture areas generated by the total number of solutions. The output from the model is a capture zone probability map for the specified time of travel (10 years).

Representative aquifer parameters were used in the base case model scenario. Additional modeling scenarios using MODFLOW and Oneka were then simulated using reasonable estimations of parameters to demonstrate model sensitivity and to reflect uncertainty conditions, which are addressed in the next section. The model parameters for all model runs are listed in Table 7.

The combined output of all model results were composited to create the final WHPA (Figure 1).

Results of Model Calibration and Sensitivity Analysis

Model calibration is a procedure that compares the results of a model based on estimated input values to measured or known values. This procedure can be used to define model validity over a range of input values, or it helps determine the level of confidence with which model results may be used. As a matter of practice, groundwater flow models are usually calibrated using water elevation and/or flux. The sensitivity analysis quantifies the differences in model results produced by the natural variability of a particular parameter. Uncertainty analysis addresses the effects of poor data quality (lack of local detailed information or deficiencies in the data) on the model results. Together, sensitivity and uncertainty analyses are commonly used to evaluate the effects that natural variability and uncertainties in the hydrogeologic data have on the size and shape of the capture zones. In regards to the WHPA delineation, these analyses are used to document that the delineation is optimal, conservative, and protective of public health based on existing information.

Model Calibration

A qualitative evaluation of the calibration can be made by comparing the simulated potentiometric surface (Figure 2) with observed water level targets obtained from the CWI database. Upon review the calibrated flow model generally captures the major features of the groundwater flow system along with the elevation, shape, magnitude, and gradient of the CWI database observed flow field.

A quantitative measure by which to evaluate the success obtained during calibration is to compare the root mean square of the residuals (RMSE) and the maximum observed head difference of the calibration dataset. Thirty-one wells were selected and used in the calibration based on the likelihood that they were completed in the same aquifer used by the city wells. The residual root mean square (RMS) error of the calibration well set was approximately 0.52 meters with a normalized RMSE of 4.4 percent. It is noted that this error is within the calibration target of 10 percent (Waterloo, 2005). The calibration targets (wells) with the greatest residual difference between measured and simulated heads were generally at locations beyond the contribution area to the city wells.

Sensitivity Analysis

Model sensitivity is the amount of change in model results caused by the variation of a particular input parameter. Because of the relative simplicity of this particular MODFLOW model, the direction and extent of the modeled capture zone may be very sensitive to any of the input parameters:

- The **pumping rate** directly affects the volume of the aquifer that contributes water to the well. An increase in pumping rate leads to an equivalent increase in the volume of aquifer and an expanded capture zone, proportional to the porosity of the aquifer materials.

  How Addressed and Results – The modeled pumping rate is based on the largest annual pumping during the last five years of record or anticipated increases in pumping over the next five years, as shown in Table 5, and therefore the sensitivity of the delineation to this parameter is assumed to be minimal when compared with the other parameters discussed below.

- The **direction of groundwater flow** determines the orientation of the capture zone. Variations in the direction of groundwater flow will not affect the size of the capture zone but are important for defining the areas that are contributing water to the well.

  How Addressed and Results – General flow direction was determined based upon static water levels of similarly screened wells in the area of the model. Overall, the sensitivity of the WHPA to the direction of groundwater flow should not be significant, given the current knowledge of the hydraulic head distribution in the aquifer.

- The **hydraulic gradient** (along with aquifer hydraulic conductivity) determines the rate at which water moves through the aquifer materials.

  How Addressed and Results – The flow field shown in Figure 2 provides the basis for determining the extent to which each model run reflects the conceptual understanding of the orientation of the capture area for each well. The regional model has been calibrated to hydraulic heads. The sensitivity of the WHPA to the hydraulic gradient should not be significant given the current knowledge of the hydraulic head distribution in the aquifer.

- The **hydraulic conductivity** influences the size and shape of the capture zone. A decrease in hydraulic conductivity decreases the length of the capture zone and increases the distance to the stagnation point, making the capture zone more circular in shape and centered on the well.

  How Addressed and Results – Initial hydraulic conductivity of the city's aquifer was calculated from specific capacity and aquifer tests conducted throughout the region and geostatistically smoothed across the model domain, with values near the well field reflecting those obtained from the city's wells. Two additional model runs were performed wherein the hydraulic conductivity was decreased/increased by 50 percent to account for the reduced values generally observed for this parameter away from the city well field and the uncertainty in the specific capacity calculation. This resulted in capture zones that were 7.5 percent smaller and 12 percent larger than the initial calibrated case, respectively.

- The **aquifer porosity** influences the size and shape of the capture zone.

  How Addressed and Results – Decreasing the porosity causes a linear, proportional increase in the areal extent of the capture zone. A literature value of 20 percent was used for the delineation and this value was not varied (Fetter, 2001).

- The **aquifer thickness** influences the size and shape of the capture zone.

  How Addressed and Results – Final aquifer thicknesses used in this model were the result of a multi-step statistical analysis. A cross-sectional analysis was done to determine the thicknesses of the aquifer at well points throughout the modeled extent. Layer thicknesses were interpolated between wells and unrealistic values were identified and disposed of at all steps by comparing with adjacent well data, where available, and by using hydrogeologic judgment. As a result, the model layering closely follows the overall stratigraphy through the region. In the area surrounding the city of Carlos's wells, Layer 1 is approximately 18 feet thick representing the unconfined sand, with Layer 2 approximately 35 feet thick representing the clay-rich confining layer, Layer 3 is approximately 34 feet thick representing the sand aquifer the city wells are screened in. The thicknesses vary greatly throughout the model domain but are consistent with CWI records.

Addressing Model Uncertainty

Using computer models to simulate groundwater flow involves representing a complicated natural system in a simplified manner. Local geologic conditions may vary within the capture areas of the public water supply wells, but the amount of existing information needed to accurately define this degree of variability is often not available for portions of the WHPA. In addition, the current capabilities of groundwater flow models may not be sufficient to represent the natural flow system exactly. However, the results are valid within a range defined by the reasonable variation of input parameters for this delineation setting.

The steps employed for this delineation to address model uncertainty were:

1. Pumping Rate – For each well, a maximum historical (five-year) pumping rate or an engineering estimate of future pumping, whichever is greater (Minnesota Rules, part 4720.5510, subpart 4).
2. Aquifer Hydraulic Conductivity – Hydraulic conductivity of the city's aquifer was adjusted plus and minus 50 percent.
3. Probability Analysis – The Oneka Model was used to estimate capture zone probability.

Capture areas were developed for a range of hydraulic conductivities and times of travel of one and 10 years (Figure 6). As the model code uses constant input values for each run, several runs were required to include all variations in input parameters. Table 7 documents the variables used to address MODFLOW uncertainty.

Table 7 - Model Parameters Used in MODFLOW Base Case and Uncertainty Runs

7) File Name	8) Cumulative City Well 9) Discharge (m^3/day)	10) Model Domain Hydraulic Conductivity (m/day)	11) Area Proximal to City Wells Hydraulic Conductivity (m/day)	12) Porosity (%)	13) Remarks
Calibrated Steady State	155	Spatially variable: 3 - 86	86	20	Calibrated Steady State Model used as base scenario
Conductivity-50 Percent	155	Spatially variable: 1.5 – 43	43	20	Calibrated Steady State Model with Kx, Ky and Kz multiplied by 0.5

7) File Name	8) Cumulative City Well 9) Discharge (m^3/day)	10) Model Domain Hydraulic Conductivity (m/day)	11) Area Proximal to City Wells Hydraulic Conductivity (m/day)	12) Porosity (%)	13) Remarks
Conductivity+50 Percent	155	Spatially variable: 4.5 – 129	129	20	Calibrated Steady State Model with Kx, Ky and Kz multiplied by 1.5

The Oneka Model helps to address uncertainties related to aquifer parameters as variations of the flow field. A 10-year capture zone probability map (Figure 6) was generated for the public water supply wells; the values used for the Oneka Model are shown in Table 8. These hydraulic conductivity values represent the 95 percent confidence interval of the geometric mean based on the modeled frequency distribution of specific capacity data from wells within a four-mile range of the city wells. The probability map for the public water supply wells shows that uncertainty of the capture zone increases as the distances from the public water supply wells increase.

Table 8 - Ranges of Values Used for the Oneka Model

14) Well Number	15) File Name	16) Hydraulic Conductivity (meters/day)	17) Thickness (meters)	18) Porosity (%)
Wells 2 & 3	Carlos	11.5 – 15.5	10.3	20

Conjunctive Delineation

The vulnerability of the DWSMA is moderate; therefore, according to current MDH guidance, the need for a conjunctive delineation must be assessed.

Isotopic data from the primary city wells, when analyzed for absolute values of LC Excess does not indicate that well water shows a significant deviation from the Minnesota meteoric water line (Bowen, 2003), indicating the absence of a direct hydraulic connection with evaporated surface waters (Appendix B). Additionally, the WHPA does not intercept any surface water features. As such, a conjunctive delineation was not proven necessary and therefore was not incorporated into the WHPA delineation.

Delineation of the Drinking Water Supply Management Area

The boundaries of the Drinking Water Supply Management Area (DWSMA) were defined by the city of Carlos using the following features (Figure 1):

- Center-lines of highways, streets, roads, or railroad rights-of-ways
- Public Land Survey coordinates
- Property or fence lines

Comparison of Previous and Current WHPA and DWSMA Delineations

The updated WHPA and DWSMA for the city of Carlos are significantly smaller than those generated in 2006 (Figure 7). This reduction stems from a better estimate of the transmissivity and hydraulic conductivity at the city wells. As a result, the WHPA and DWSMA decreased in size.

The following is a brief synopsis of additional technical considerations that changed since the previous plan:

A new groundwater flow model was developed using a different software code. MODFLOW is better able to simulate hydraulic connection of the leaky clay-rich till to the city's aquifer and is also better supported, which increases the likelihood that it can be used for future amendments.

The transmissivity value derived from an aquifer test at Well 423873 located about 2.5 miles south of the city was dismissed in favor of an aquifer test directly conducted at new city Well # 3 (815779).

Recharge was altered from one inch per year – six inches per year to a consistent three inches per year.

Locations of city wells have been adjusted for greater accuracy.

Additional well construction in the area has provided increased knowledge of local geology.

The amount of water pumped by the city wells has decreased since the original delineation. In addition, the array of nearby irrigation wells and their pumping volumes changed since the 2006 delineation (Table 6).

Vulnerability Assessments

The Part I wellhead protection plan includes the vulnerability assessments for the city of Carlos's wells and DWSMA. These vulnerability assessments are used to help define potential contamination sources within the DWSMA and select appropriate measures for reducing the risk that they present to the public water supply.

Assessment of Well Vulnerability

The vulnerability assessments for each well used by the city of Carlos are listed in Table 1 and are based upon the following conditions:

1. Well construction meets current State Well Code specifications (Minnesota Rules, part 4725) at Well #3, meaning that the well itself should not provide a pathway for contaminants to enter the aquifer used by the public water supplier.
2. Well construction does not meet current State Well Code specifications (Minnesota Rules, part 4725) at Well #2 because no grouting information is known. If the well was not grouted, it has the potential for acting as a conduit for flow of surface water and contaminants into the buried aquifer. To date, no evidence of this has been identified and it is likely that the cable tool method was used during construction of this well, which minimizes that risk.
3. The geologic conditions at the well site include a cover of clay-rich geologic materials over the aquifer, however it is not sufficient to prevent the vertical movement of contaminants.
4. None of the human-caused contaminants regulated under the federal Safe Drinking Water Act have been detected at levels indicating that the well itself serves to draw contaminants into the aquifer as a result of pumping.
5. Water samples were collected from Well #2 (241382), and Well #3 (815779) in 2006, 2013, 2014, and 2017 and were analyzed for tritium, nitrate, chloride and bromide (Table 2). Tritium was detected in the samples, confirming the vulnerable nature of the wells (Alexander and Alexander, 1989). However, the chloride and bromide data show no evidence of human-impact to the city's water quality (Mullaney et. al., 2009).

Assessment of Drinking Water Supply Management Area Vulnerability

The vulnerability of the DWSMA is shown in Figure 1 and is based upon the following information:

1. Isotopic and water chemistry data from wells located within the DWSMA indicate the aquifer contains water that has detectable levels of tritium.
2. Review of the geologic logs contained in the CWI database, geological maps, and reports indicate that the aquifer exhibits a moderate to low geologic sensitivity throughout the DWSMA. The clay-rich sediment that overlies the aquifer appears to vary in thickness and composition but appears to be present throughout the area and serves to isolate the city's aquifer from the direct vertical recharge of surface water.

Therefore, given the information currently available, it is prudent to assign a moderate vulnerability rating to the DWSMA, in accordance with the Minnesota Wellhead Protection Rule (parts 4720.5100 to 4720.5590).

Recommendations

The following recommendations have been generated to inform the next amendment of the city of Carlos's Wellhead Protection Plan.

1. Well Locating: This delineation is based on very little well data. If wells are constructed within two miles of the city or one mile of the DWSMA, their locations should be verified. This information may allow a better understanding of the extent and thickness

of the city's aquifer and the overlying confining unit, and could result in a more refined WHPA in the future.

2. Water Quality Monitoring: Re-sample Wells #2 and #3 (or whatever primary wells exist at that time) during year six of plan implementation for vulnerability parameters determined in consultation with MDH (likely tritium, chloride, bromide, nitrate and ammonia); contingent on funding assistance from MDH for sampling and analysis. The city may need to collect the samples and ship them to MDH. This information will be used to update our understanding of the vulnerability of the city's wells and aquifer to contamination risk.
3. Test Drilling and Water Quality Analysis: There is uncertainty about the thickness and composition of the confining unit that overlies the city's aquifer that affects our confidence in the assessment of DWSMA vulnerability. Construction of a few well-placed test borings along with water quality sampling (chloride, bromide, nitrate) could help address these issues and could be funded via a Source Water Protection grant. Before proceeding down this avenue, the public water supplier should discuss the feasibility of this type of study with the MDH hydrologist to determine whether beneficial bore hole locations might also align with willing property owners.

Selected References

Alexander, S.C., and Alexander, E.C., Jr. (1989), *Residence times of Minnesota groundwaters*, University of Minnesota, Minneapolis, Minn., 22 p.

Allison, I. S., (1932), *Geology and water resources of northwestern Minnesota*, Minnesota Geological Survey Bulletin 22, Minneapolis, Minn., 245 p.

Barnes, R.J., and Soule, R.G. (2002), *Oneka: A simple analytical element model for stochastic capture zone delineation,* St. Paul, Minn., 8 p., draft paper.

Berg, J.A. (2008), Traverse-Grant *Regional hydrogeologic assessment* Minnesota Department of Natural Resources, *,* Regional Hydrogeologic Assessments, RHA-6, Part B, Plate 3, St. Paul, Minn., 2 plates, scale 1:200,000.

Bown, G.J., and Revenaugh, J. (2003), *Interpolating the isotopic composition of modern meteoric precipitation*. Water Resources Research 29, 1299, doi:10.129/2003WR002086.

Delin, G.N., Healy, R.W., Lorenz, D.L., and Nimmo, J.R. (2007), *Comparison of local- to regional-scale estimates of ground-water recharge in Minnesota*, Journal of Hydrology, Vol. 334, No. 1-2, p. 231-249.

Doherty, J.E. and Hunt, R.J. (2010) *Approaches to highly parameterized inversion--A guide to using PEST for groundwater-model calibration*, Scientific Investigations Report 2010-5169, U.S. Geological Survey, Reston, Va., 37 p.

Fetter, C.W. (2001), *Applied hydrogeology*, Prentice Hall, Saddle River, N.J., 598 p.

Geologic Sensitivity Project Workgroup (1991), *Criteria and guidelines for assessing geologic sensitivity of ground water resources in Minnesota*, Minnesota Department of Natural Resources, Division of Waters, St. Paul, Minn., 122 p.

Harbaugh, A.W. (2005), *MODFLOW-2005, the U.S. Geological Survey modular groundwater model--the Ground-Water Flow Process*: U.S. Geological Survey Techniques and Methods 6-A16, U.S. Geological Survey, Reston, Va., 253 p.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G. (2000), *MODFLOW-2000, the U.S. Geological Survey modular ground-water model--user guide to modularization concepts and the ground-water flow process*, U.S. Geological Survey, Open-File Report, 00-92, Reston, Va., 121 p.

McDonald, M.G., and Harbaugh, A.W. (1988), *A modular three-dimensional finite-difference ground-water flow model*, Techniques of Water-Resource Investigation, 06-A1, U.S. Geological Survey, 576 p.

Mullaney, J.R., Lorenz, D.L., and Arntson, A.D. (2009), *Chloride in groundwater and surface water in areas underlain by the glacial aquifer system, northern United States,* Scientific Investigations Report, 2009-5086, U.S. Geological Survey, Reston, Va., 41 p.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu. (2011), *MODFLOW-NWT, A Newton Formulation for MODFLOW-2005*: *U.S. Geological Survey Techniques and Methods 6-A37*, U.S. Geological Survey, Reston, Va., 44 p.

Pollock, D.W. (2012), *User guide for MODPATH version 6 – A particle-tracking model for MODFLOW: U.S. Geological Survey Techniques and Methods 6-A41*, U.S. Geological Survey, Reston, Va., 58 p.

Waterloo Hydrogeologic (2005) *Visual MODFLOW V. 4.1 User's Manual*: Waterloo, Ontario.

Figures

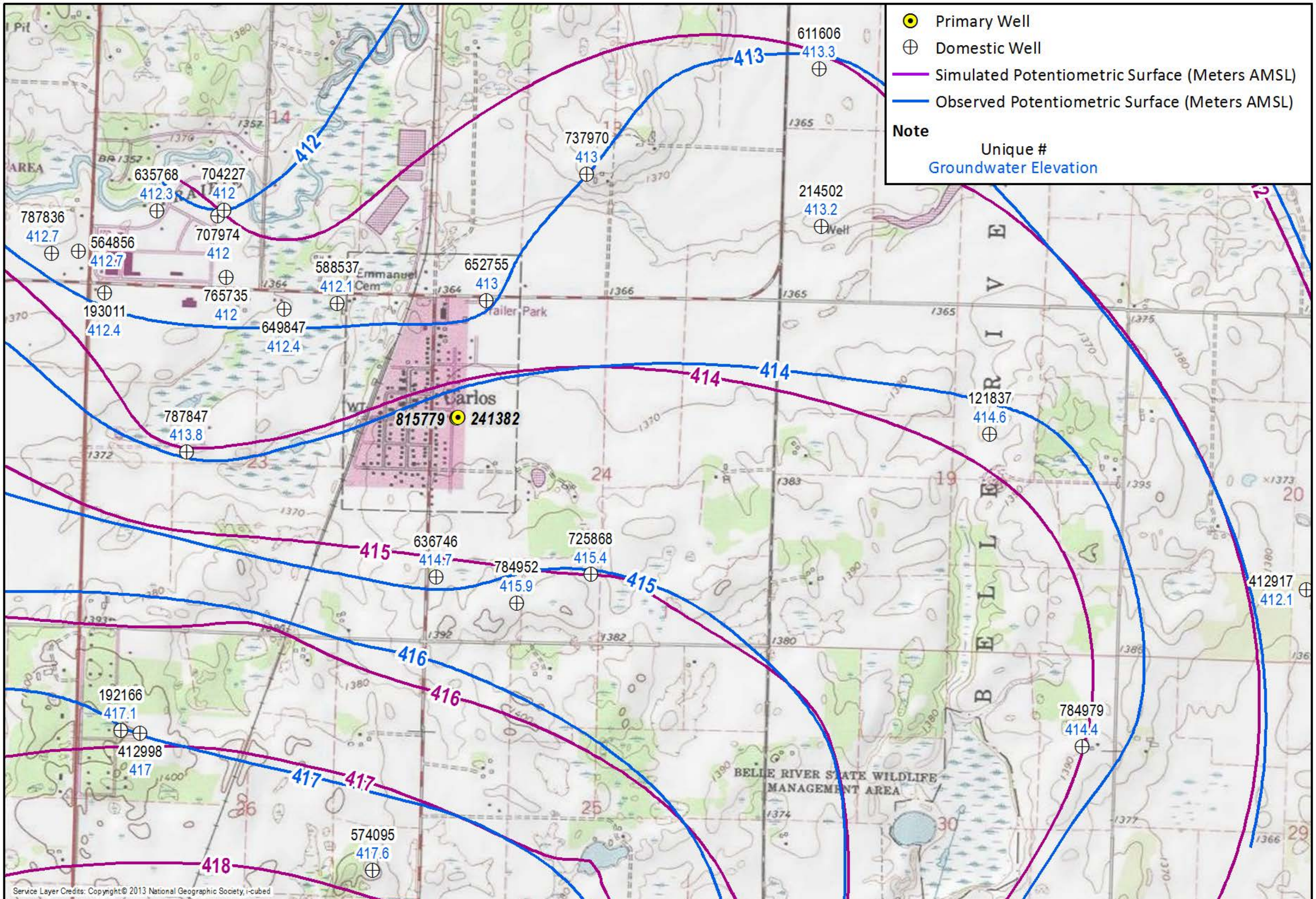


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Figure 2
Simulated and Observed Flow Field
City of Carlos

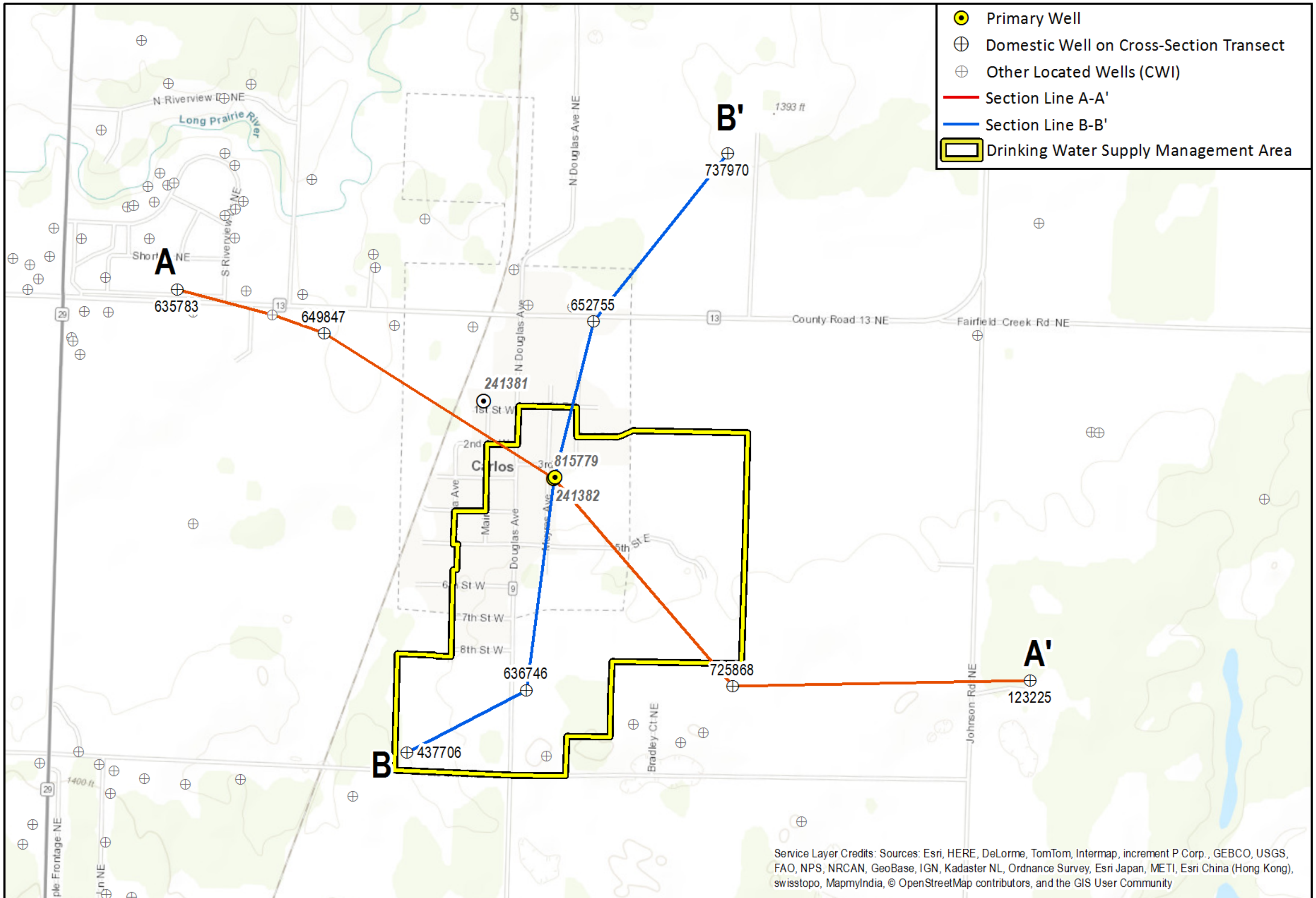


Figure 3
Geologic Cross-Section Locations
City of Carlos

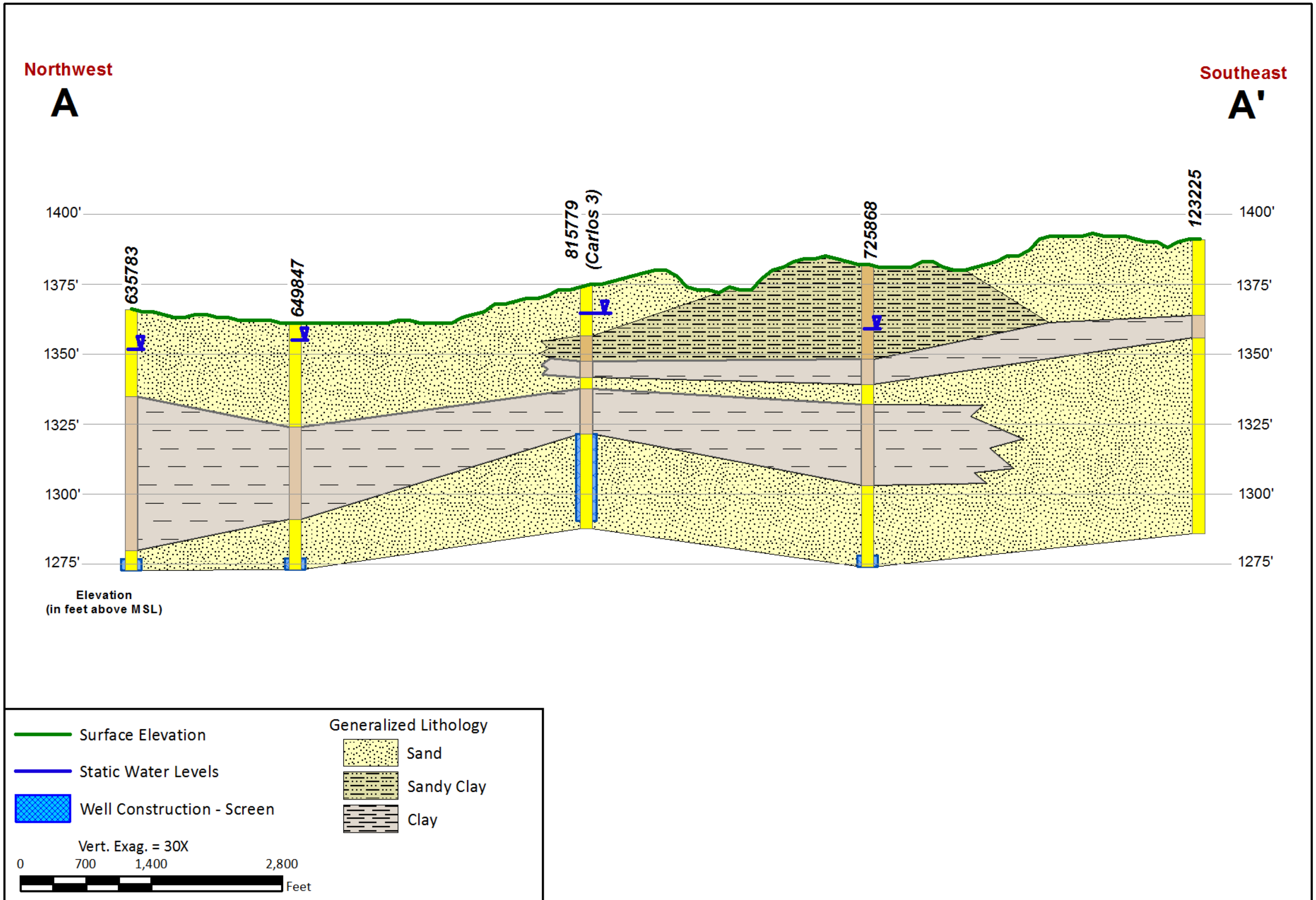


Figure 4
Geologic Cross-Section A-A'
City of Carlos

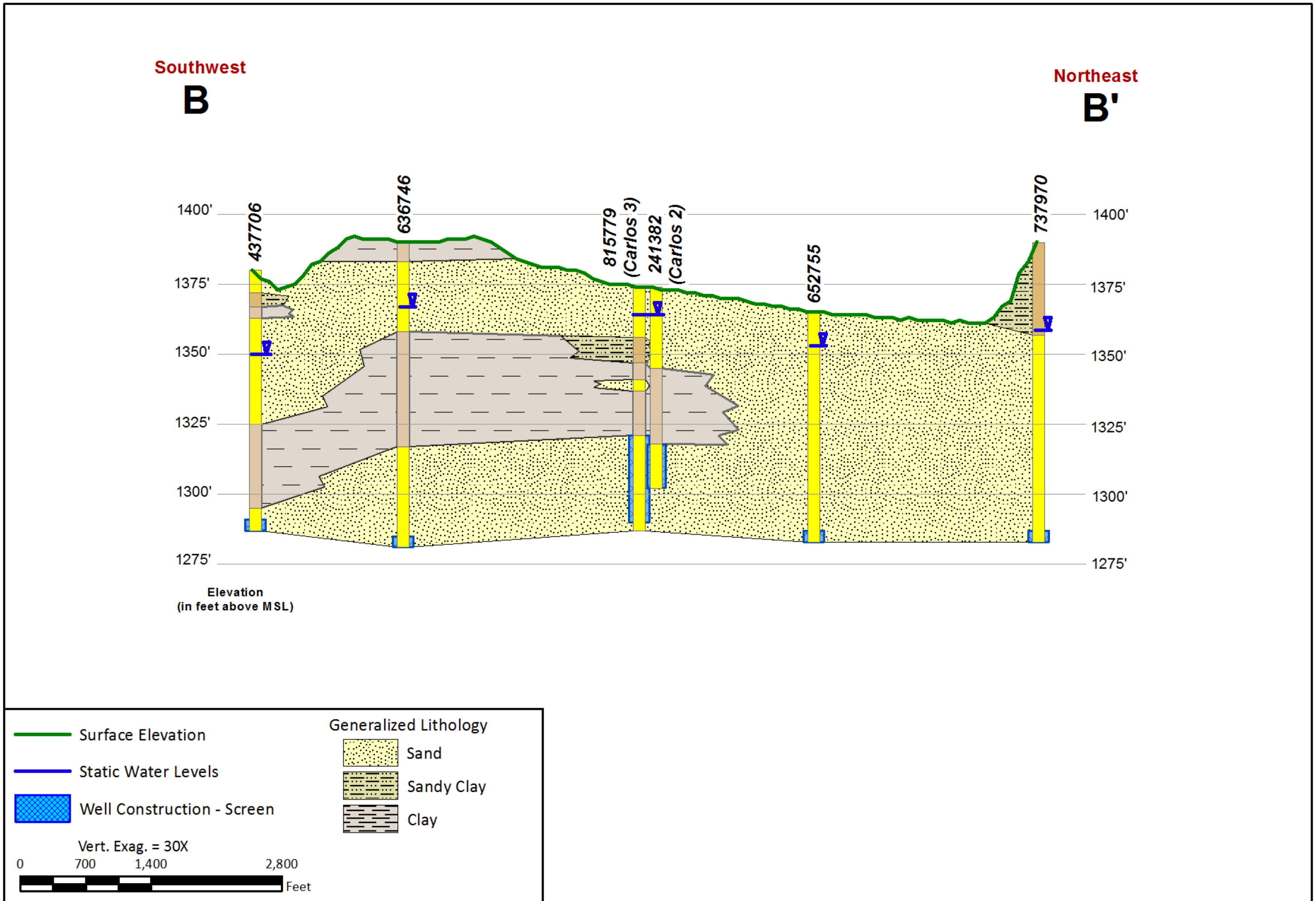


Figure 5
Geologic Cross-Section B-B'
City of Carlos

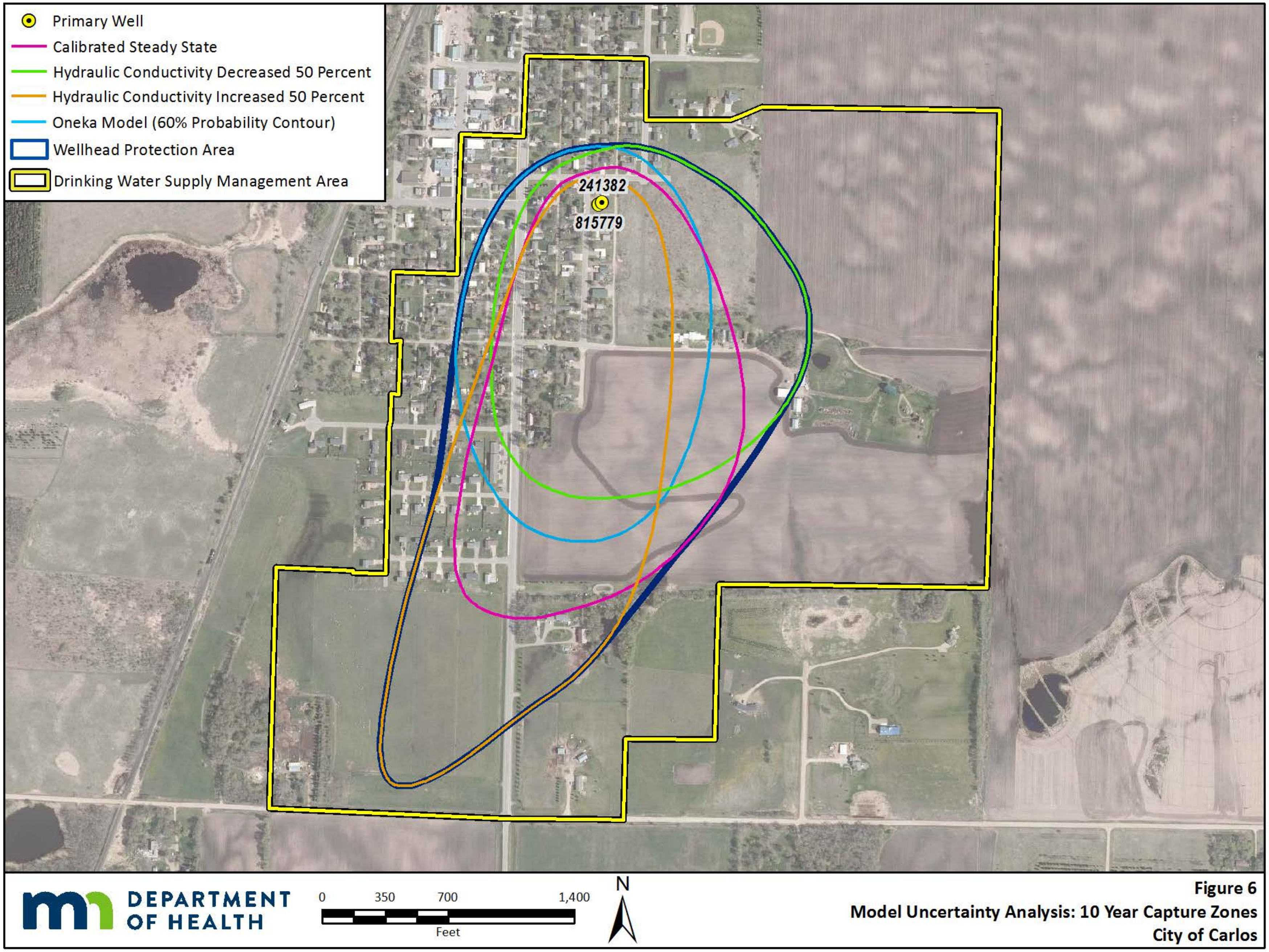


Figure 6
Model Uncertainty Analysis: 10 Year Capture Zones
City of Carlos

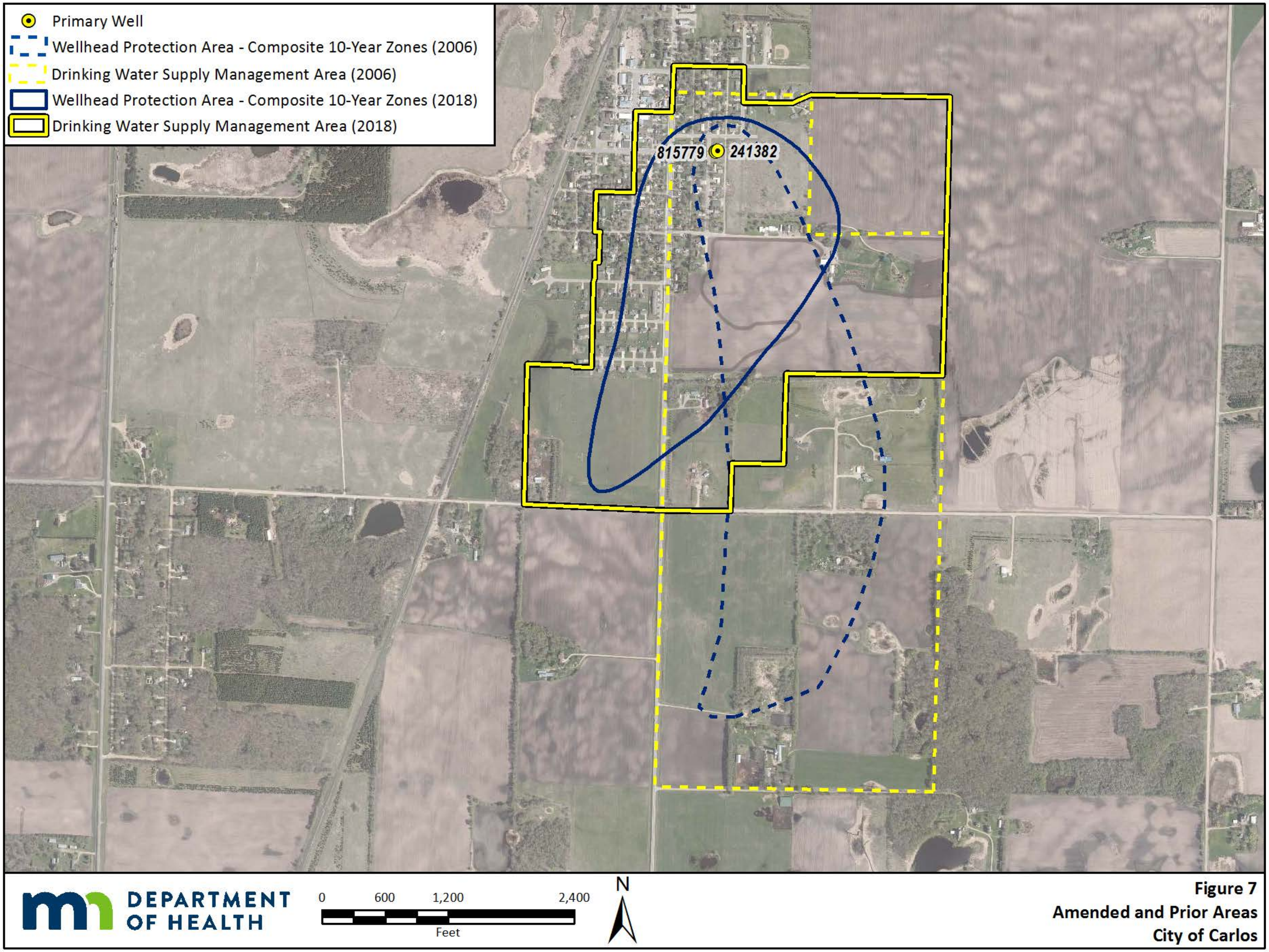


Figure 7
Amended and Prior Areas
City of Carlos

Appendix A: Data Elements Assessment

Data Type	Data Element	Use of the Well(s)	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	Data Source
Climate	Precipitation	H	H	H	H	NOAA, USGS
Geology	Maps and geologic descriptions	M	H	H	H	MGS, DNR
Geology	Subsurface data	M	H	H	H	MGS, MDH, DNR
Geology	Borehole geophysics	M	H	H	H	None Available
Geology	Surface geophysics	L	L	L	L	None Available
Soils	Maps and soil descriptions	L	H	M	L	NRCS
Soils	Eroding lands					
Water Resources	Watershed units	L	H	L	L	MnGEO, DNR
Water Resources	List of public waters	L	H	L	L	MnGEO, DNR
Water Resources	Shoreland classifications					
Water Resources	Wetlands map	L	H	L	L	USFWS
Water Resources	Floodplain map					
Land Use	Parcel boundaries map	L	H	L	L	Douglas County
Land Use	Political boundaries map	L	H	L	L	MnGEO, City
Land Use	Public Land Survey map	L	H	L	L	MnGEO
Land Use	Land use map and inventory					
Land Use	Comprehensive land use map					
Land Use	Zoning map					
Public Utility Services	Transportation routes and corridors	L	L	L	L	MnDOT, MnGEO
Public Utility Services	Storm/sanitary sewers and PWS system map	L	M	L	L	City
Public Utility Services	Oil and gas pipelines map					
Public Utility Services	Public drainage systems map or list	L	H	L	L	MnGEO, DNR
Public Utility Services	Records of well construction, maintenance, and use	H	H	H	H	City, CWI, MDH

Data Type	Data Element	Use of the Well(s)	Delineation Criteria	Quality and Quantity of Well Water	Land and Groundwater Use in DWSMA	Data Source
Surface Water Quantity	Stream flow data	L	H	H	H	DNR, USGS (no relevant data found)
Surface Water Quantity	Ordinary high water mark data	L	H	L	L	DNR (no relevant data found)
Surface Water Quantity	Permitted withdrawals	L	H	L	L	DNR
Surface Water Quantity	Protected levels/flows	L	H	L	L	DNR (no relevant data found)
Surface Water Quantity	Water use conflicts	L	H	L	L	DNR (no relevant data found)
Groundwater Quantity	Permitted withdrawals	H	H	H	H	DNR
Groundwater Quantity	Groundwater use conflicts	H	H	H	H	DNR (no relevant data found)
Groundwater Quantity	Water Levels	H	H	H	H	DNR, (no relevant data found)
Surface Water Quality	Stream and lake water quality management classifications					
Surface Water Quality	Monitoring data summary	L	H	L	L	MDH (no relevant data found)
Groundwater Quality	Monitoring data	H	H	H	H	MDH
Groundwater Quality	Isotopic data	H	H	H	H	MDH
Groundwater Quality	Tracer studies	H	H	H	H	None Available
Groundwater Quality	Contamination site data	M	M	M	M	MPCA (no relevant data found)
Groundwater Quality	Property audit data from contamination sites					
Groundwater Quality	MPCA and MDA spills/release reports	M	M	M	M	MPCA, MDA (no relevant data found)

Definitions Used for Assessing Data Elements

High (H): the data element has a direct impact
Moderate (M): the data element has an indirect or marginal impact
Low (L): the data element has little if any impact
Shaded: the data element was not required by MDH for preparing this delineation
Acronyms used in this report are listed after the Glossary of Terms.

Appendix B

Table 1: ^{18}O Summary Information

ID (link to Table 2)	Number of Samples	Minimum Value	Maximum Value	Mean Value	Coefficient of variation (CV)[1]	Do 1 or more samples show evidence for evaporated surface water? (#)	% of samples showing evidence for evaporated surface water	% evap SW times the mean LC Excess*	% evap SW times the mean LC Excess* rank	Open water (sq.m.) in 1 year Capture Zone	Open water (sq.m.) in 10 year Capture Zone	Primary Groundwater Classification	Most conservative Geologic Sensitivity	Most recent Tritium result
0000241382 (1210010S02)	1	-10.781141	-10.781141	-10.781141	Not calculated	No (0 of 1)	0%	n/a	n/a	n/a/	n/a		L	14.2

(1) - A **highlighted** CV indicates it meets or exceeds the threshold value for high variability of 3% and may indicate rapid or seasonal recharge (http://mdh-app2/pwss_reports/gw_categories_11.pdf).

Table 2: Isotope Analysis

^{18}O	^{2}H	ID (link to Table 1)	Collection Date	LC Excess* (1)	Does the LC Excess* show that the sample is significantly different than the MWL? (2)	Evidence for evaporated surface water? (3)	Estimated Annual Precipitation (Bowen grid for North America for ^{18}O values) (4)	Is the sample ^{18}O value significantly different than the Estimated Annual Precipitation value (Bowen, 2003)? (5)	Precipitation month most closely matching ^{18}O	Precipitation for month most closely matching ^{18}O	Precipitation difference for month most closely matching ^{18}O
-10.781141	-77.296652	0000241382 (1210010S02)	5/22/2017	-0.85285763	No	No	-10.6400	No	April	-10.8651	0.0839

(1) - Bowen GJ, Revenaugh J (2003) Interpolating the isotopic composition of modern meteoric precipitation. Water Resources Research 39, 1299, doi:10.129/2003WR002086

(2) - Absolute values of LC Excess* that are greater than 1 are considered significant deviations from the Minnesota MWL.

(3) - Evidence of evaporated surface water is set to 'Yes' only for those samples where the LC Excess* was both negative and significant, and ^{18}O is heavier than the Estimated Annual Precipitation.

(4) - Landwehr, J.M. and Coplen, T.B. (2004) Line-conditioned excess: A new method for characterizing stable hydrogen and oxygen isotope ratios in hydrologic systems. In Isotopes in Environmental Studies, Edition: 1, Chapter: IAEA-CN-118/56, Publisher: IAEA, pp.132-135. See pp. 99-100 in: http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/36/003/36003223.pdf

(5) - Differences between ^{18}O and Estimated Annual Precipitaion that are greater than 0.4 are considered significantly different.

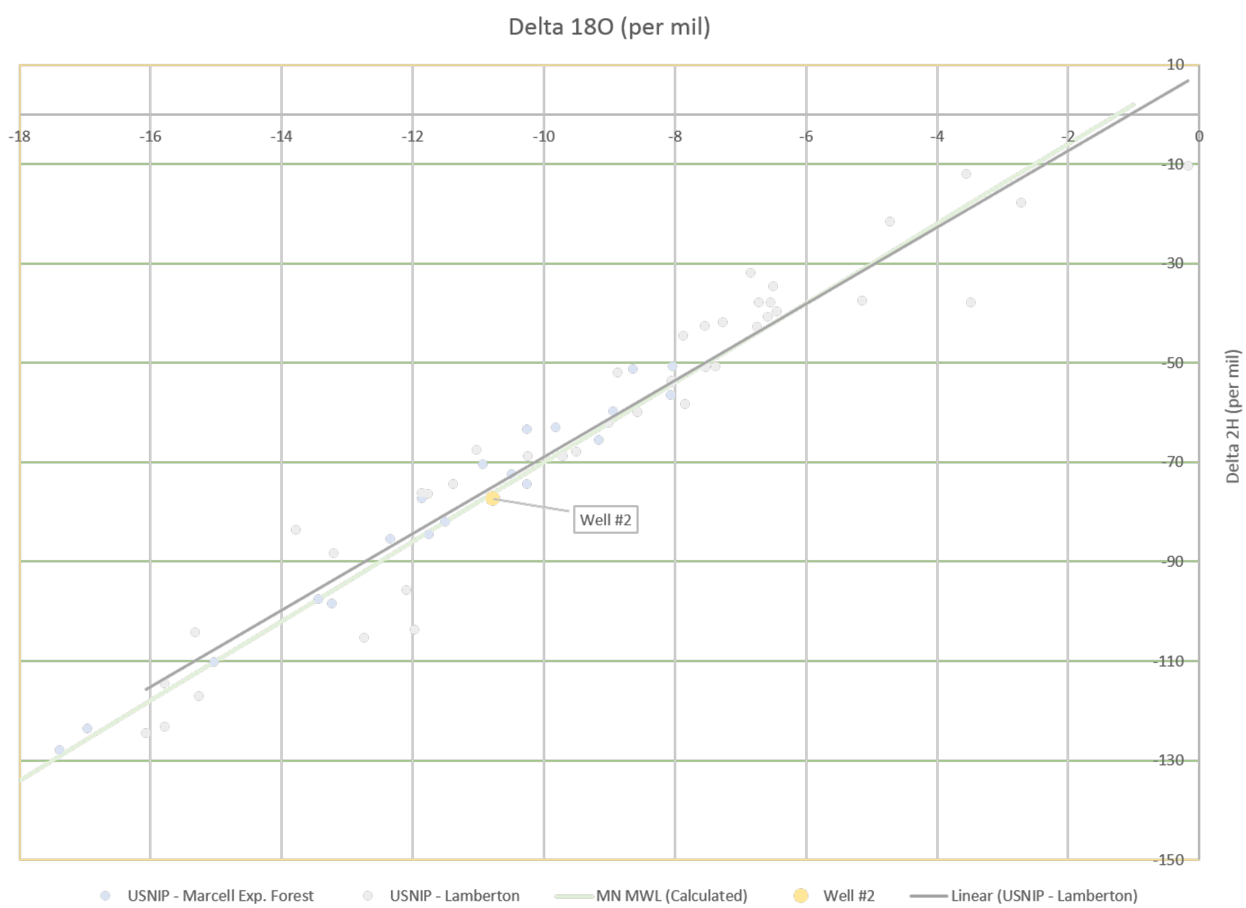
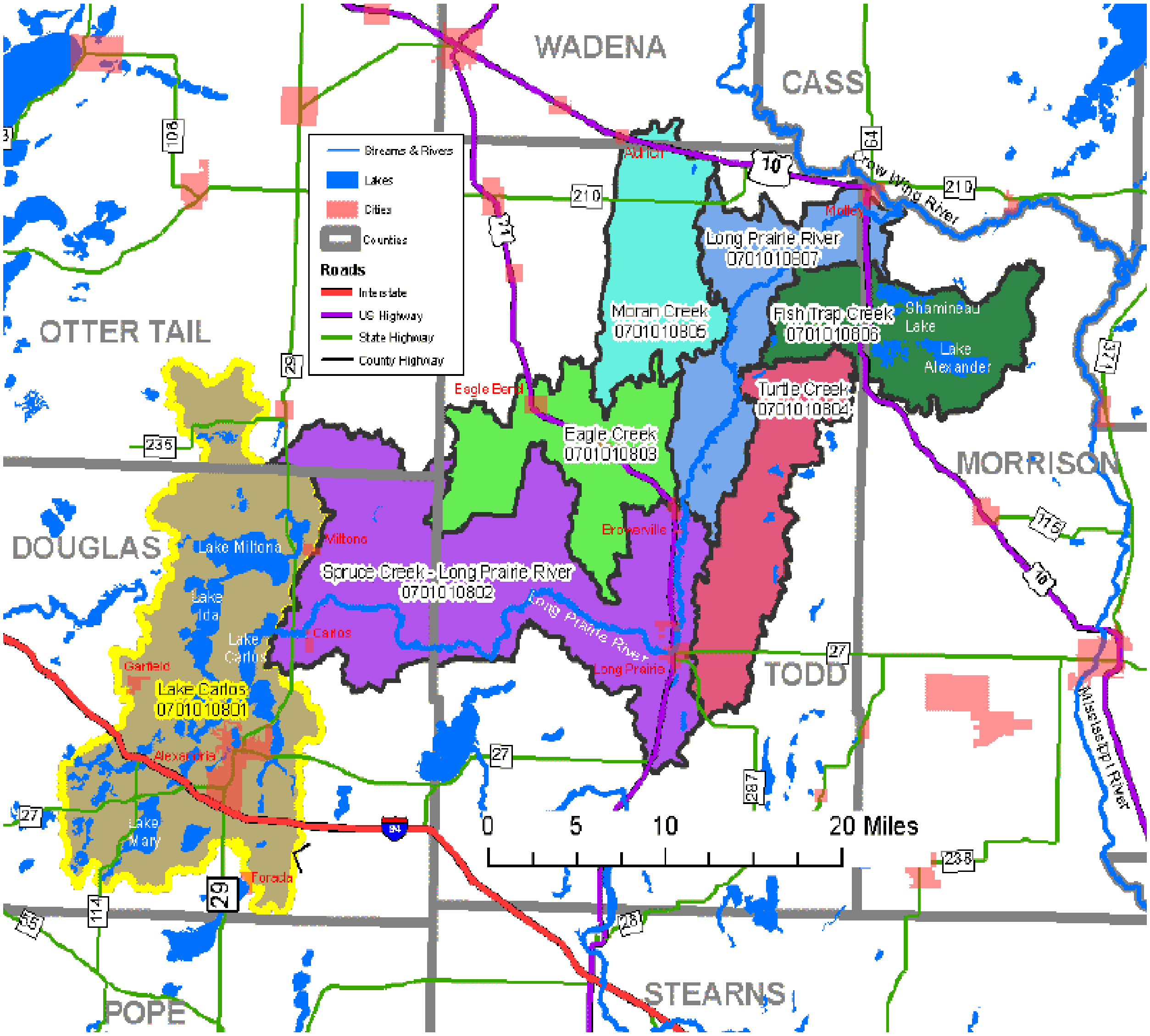
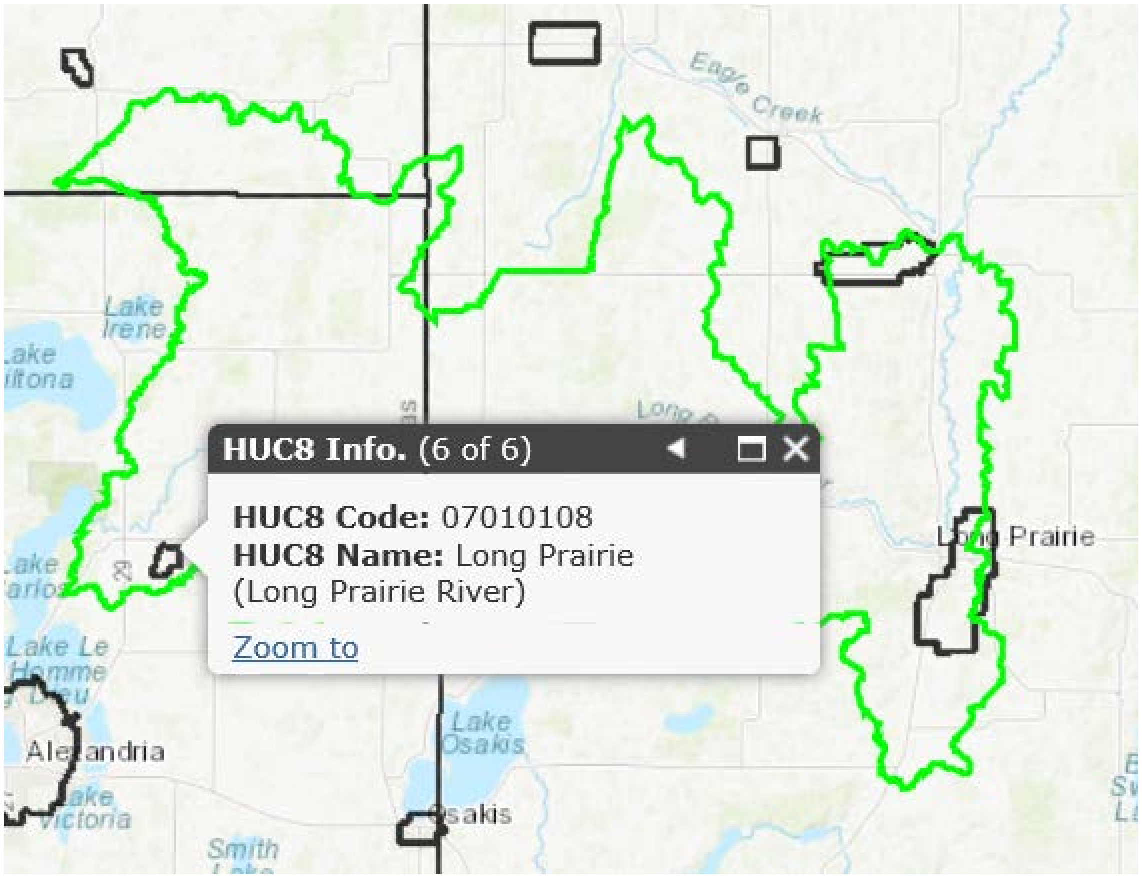


Exhibit 8: Watershed Maps



Long Prairie Watershed Sub-basins. Source MN DNR.



Long Prairie Watershed. Source MDH