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Community Partners	Camp Courageous, Maquoketa River Watershed Management Authority, Iowa DNR, Rebecca Ohrtman Water Quality Consulting L.L.C.

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Potable Water Master Plan

Date: December 10, 2021

Prepared for:
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Section I - Executive Summary

Camp Courageous, located east of Monticello, Iowa, is a year-round recreational camp which serves individuals with special needs and their families. The purpose of this project is to assist Camp Courageous with developing the best short- and long- term strategies for providing high quality potable water to their staff, campers, and families so that they can have the best possible experience. Initial research into solutions to the original scope of this project revealed that improving the water quality of the aquifer would take decades to achieve and would require actions on properties for miles surrounding the camp. While cleaning the aquifer is a worthy long-term goal, more immediate solutions to water quality challenges need to be explored. A team of senior civil and environmental engineering students in the capstone design class at the University of Iowa, worked with Camp Courageous, the Iowa DNR, and Rebecca Ohrtman Water Quality Consulting L.L.C., to amend the scope of work to include a Potable Water Master Plan that explores the best short- and long-term strategies for Camp Courageous. For this plan, Rebecca Ohrtman, Owner of Rebecca Ohrtman Water Quality Consulting L.L.C., served an advisory role to the team, providing guidance and resources to the team. This plan includes recommendations on providing information to the public and farmers within the area, getting the wellhead casings inspected, and options for a centralized water treatment system that could accommodate a growing attendance at the camp.

The primary aquifers serving the camp are currently experiencing concerning levels of nitrate, radium, and iron. Out of seven wells, Camp Courageous currently treats four of their wells with chlorination and two wells with anion exchange to ensure that nitrate levels do not exceed the maximum contaminant limit. Using Safe Drinking Water Information Systems (SDWIS) data, we were able to see nitrate levels in three of the wells at Camp Courageous along with the private well of St. John's Church. There has been a significant increase in nitrate concentrations over the past two decades, and a sharp spike in nitrate concentrations in 2009. David Cwiertny, director of the Center for Health Effects of Environment Contamination at the University of Iowa Engineering, shared with us the Iowa Well Forecasting System and agreed to work with CHEEC (Center for Health Effects of Environmental Contamination) to fund isotope sampling for Camp Courageous. The purpose of isotope analysis was to determine whether the source of the contaminants was biological or chemical. Samples were taken from wells 2, 3, and the St. John's Church well, however, the lab analysis has not been completed as of the date of this report. In the meantime, the team assessed the best treatment and distribution system options for the existing, and future, water demand at Camp Courageous and groundwater contaminants that are currently regulated.

Challenges for this project included identifying possible sources of multiple contaminants and designing for the expansion of Camp Courageous. The client made it clear that we were to establish a holistic solution to meet their long-term potable water needs without exceeding regulatory water standards in the short term. We also had to coordinate with the other 3 teams so that we could help Camp Courageous provide campers with the best possible experience. Our team investigated a range of treatment techniques including point-of-use (POU) and point-of-entry (POE) devices, reverse osmosis, and ionic exchange, as well as various source water protection measures including winter cover crops, bioreactors, perennial vegetation, and other conservation measures.

Some measures may take several years to have an impact, and the size of the impact will be limited without strong participation by area landowners. Nevertheless, we believe these long-term strategies should be pursued.

Based off our understanding of the stratigraphy and current treatment system, the potable water master plan suggests that Camp Courageous begin by getting Well 2 and Camp Courageous 2 inspected to ensure nitrates are not entering through the cased section of each well. The approximate cost of this will be between $350 - $400. A camera may need to be sent down each of the wells to examine the state of the casing which will incur an additional cost.

We also recommend engaging area farmers and local community members to learn more about conservational efforts, incentives, and resources available. This could be done through a brochure, such as the one attached in Appendix A, or a series of informational sessions hosted by Camp Courageous. This report also provides information on installing a centralized treatment system. Although the existing treatment system controls contaminant levels successfully, it may become necessary in the future to remove emerging contaminants that cannot be addressed by the current treatment process. If that becomes the case, it may be more cost effective and efficient to centralize the new water treatment process. Although this would come at a substantial cost, many communities develop a centralized system to facilitate the increasing water demand and handle additional contaminants of concern. We are very grateful for the opportunity to work on this project, and we are pleased to present the following report to Camp Courageous.

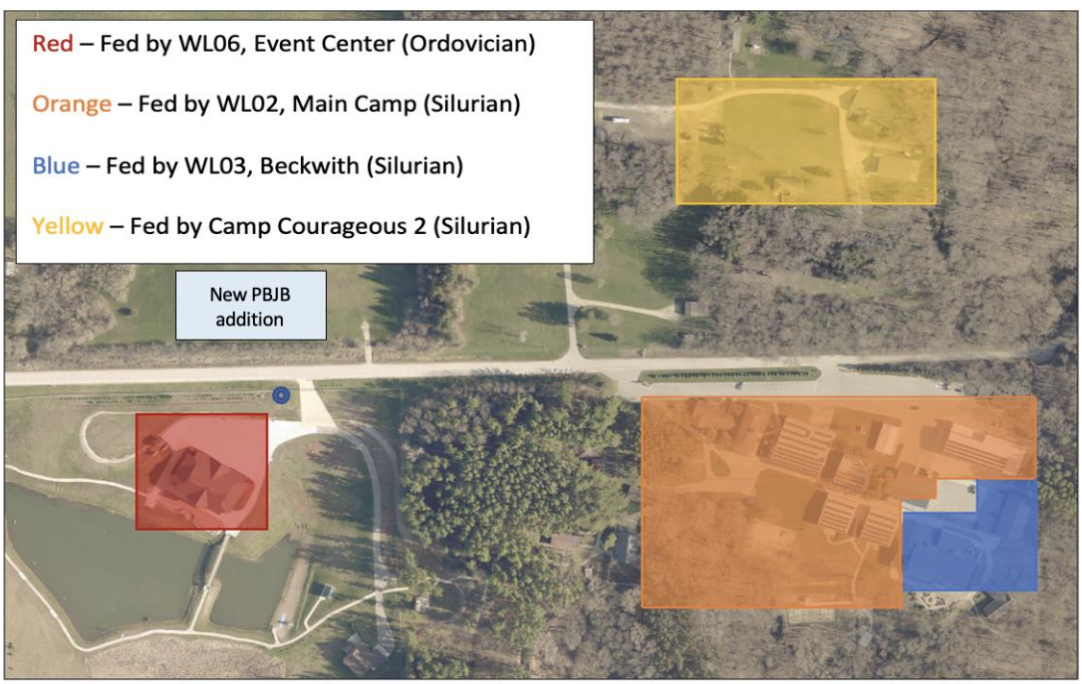

Figure 1.1 Map of well supply to each building; the blue circle represents location of dry hydrant connected to Lake Todd for fire protection

Section II - Organization Qualifications and Experience

University of Iowa
Department of Civil & Environmental Engineering
Iowa City, Iowa

Our engineering team is a group of senior civil and environmental engineering students in the capstone design class at the University of Iowa.

Christian Arnett
Project Manager
Environmental Engineering Major

Madeleine Murphy
Environmental Engineering Major

Mya Wallace
Civil Engineering Major

Our dedicated team members have classroom experience in designing wells, modeling groundwater flow, and planning water and wastewater treatment systems. We have analyzed components of water resources systems, including, water distribution networks, natural and manmade waterways, and storm and sewer management. This experience provides us with the knowledge on appropriate remediation strategies and solutions to improve the groundwater quality.

Section III - Design Services

Project Scope

Camp Courageous, located east of Monticello, Iowa, is a year-round recreational camp which serves individuals with special needs and their families. The original scope of service was to establish a wellhead protection plan that would help prevent pollutants from contaminating the aquifer. This would involve identifying the extent of each capture zone of each well and establishing solutions based off results from pump tests and stratigraphy mapping. Research for this scope revealed that improving the water quality of the aquifer would take decades to achieve and would require actions on properties for miles surrounding the camp. While cleaning the aquifer is a worthy long-term goal, more immediate solutions to water quality challenges need to be explored. The team worked with the client to amend the scope of our work to include a Potable Water Master Plan that explores the best short- and long-term strategies for Camp Courageous.

In creating a comprehensive master plan, the team began by evaluating existing water quality data. We identified the groundwater contaminants of concern in both the Silurian and Ordovician aquifers and compared concentrations to regulated maximum contaminant levels (MCLs). Data from 1997 to 2021 was also compiled and evaluated to determine any correlations or consistencies with land use changes. Potential sources were identified, and samples were taken to perform lab analysis to determine whether the nitrates were coming from a chemical or biological source. Potential sources that were identified were related to specific sources on Camp Courageous' property and existing conditions of the well casings. Other potential sources that were identified that were systemic to the aquifer recharge area. With this understanding the team assessed the best treatment and distribution system options for the existing water demand and regulated contaminants present at Camp Courageous. The future water demand was also estimated and additional contaminants that may be regulated in coming years were also identified and taken into consideration.

The team also evaluated the potential impacts the potable water treatments systems have on the wastewater system and strategies to improve the water quality of the aquifers serving Camp Courageous. Finally, using all this information, short- and long- term recommendations were established for the Camp Courageous potable water system and aquifer quality.

Work Plan

The following table describes the major tasks completed by the team over the project period. Each task is shown in order and duration and is labeled with the team member who took responsibility for leading it. A Gantt chart, Figure 3.1, is provided to graphically convey the information provided within Table 3.1.

Table 3.1: Major tasks completed throughout contract period

Task	Description	Start Date	End Date	Completed by:
1	Compile/graph nitrate data	9-Sep	21-Sep	Group
2	Use ArcMap to identify land uses	15-Sep	21-Sep	Christian
3	Pull well data using IWFoS	20-Sep	6-Oct	Group
4	Feasibility study, Treatment Technique (TT)	1-Oct	10-Oct	Group
5	Well analysis/isotope sampling	8-Oct	10-Nov	Group
6	Feasibility study, Source Water Protection (SWP)	10-Oct	20-Oct	Maddy
7	Develop masterplan	17-Oct	5-Dec	Group
8	Stratigraphy mapping of CC	3-Nov	4-Nov	Group
9	Draft report	5-Nov	19-Nov	Group
10	Comprehensive map of CC	8-Nov	19-Nov	Mya
11	Meeting with Hauser's	8-Nov	9-Nov	Group
12	Informational brochure	10-Nov	19-Nov	Mya
13	Research emerging contaminants	10-Nov	15-Nov	Mya
14	Cost estimates	15-Nov	19-Nov	Mya
15	Final report and presentation	19-Nov	10-Dec	Group

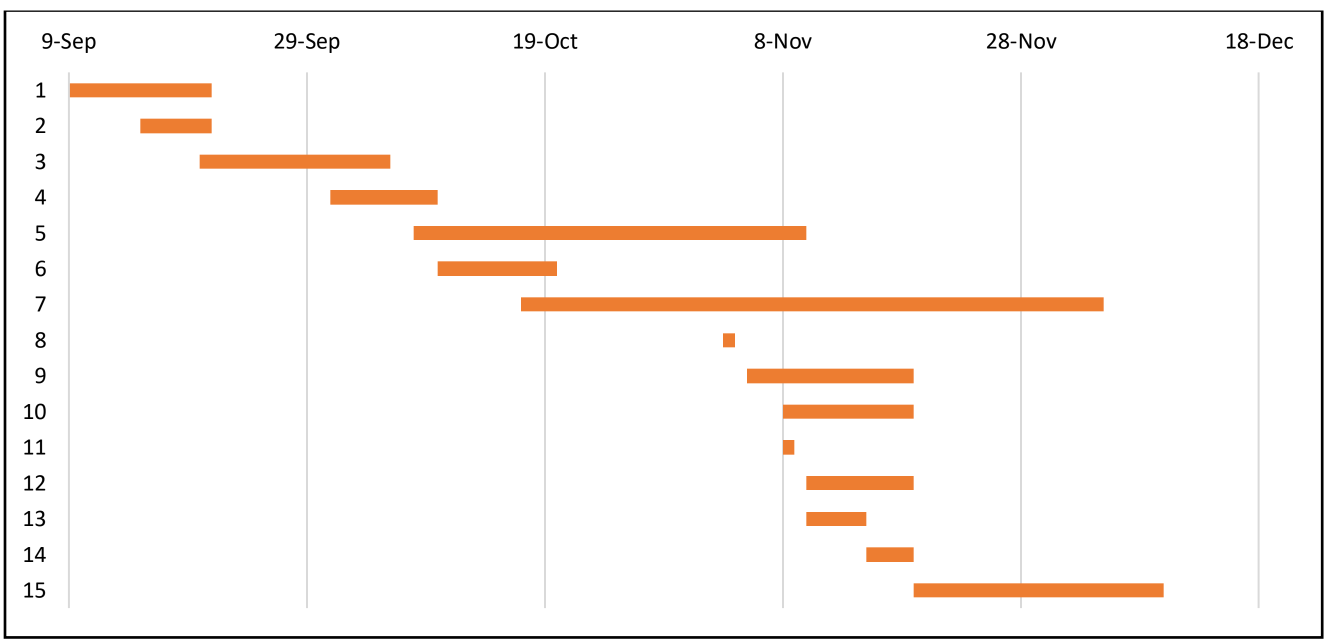

Figure 3.1: Gantt chart for work plan

Section IV - Constraints, Challenges, and Impacts

Constraints

Camp Courageous seeks a holistic solution to meet their long-term potable water needs. This must be done in compliance with regulatory drinking water standards, including but not limited to, SDWA (Safe Drinking Water Act) and the Iowa DNR. Although their current treatment system is successful in reducing nitrate levels in drinking water, the team has been brought on to investigate solutions that could reduce nitrate contamination at the source and prevent it from reaching their wells, thereby reducing treatment costs. The client currently uses anion exchange and approximately 2500 lbs. of salt to treat its water every month. Seeking to be good environmental stewards and to operate most efficiently, Camp Courageous wants to explore ways to reduce the use of salt. Lastly, it appears the recharge area for their aquifer extends far beyond the camp's boundaries. This makes them vulnerable to many activities that are outside their control.

Challenges

This project poses some very complex challenges. In terms of treatment, our primary contaminant of concern is nitrate. However, we must also consider the existence of iron and radium in the deeper well, as well as the potential for emerging contaminants, such as PFAS or "forever chemicals", being treated for in the future. Camp Courageous is classified as a non-transient, non-community public water system. This means that they are only required to sample a handful of analytes from their groundwater system, these include total coliform bacteria, nitrates/nitrites, lead and copper (Iowa DNR, 2021). In the future it may become necessary to remove newly identified or newly regulated contaminants that cannot be addressed by the current treatment process. As regulations get more stringent in the future, it is essential that our design is equipped with clear trigger points that indicate when strategies need to be altered.

We also had to consider the expansion of Camp Courageous in coming years and how our solution would change with a larger population to serve. With the plans that Camp Courageous already has in place, we collaborated with the other project design groups also working to modify the land and water uses on site. For our group specifically, it was important to communicate and coordinate with the storm water design group. While both groups are working on storm water, each has a different perspective. The storm water group are focusing more on the flow of surface water, while we are looking at the storm water that perchlorates down into the groundwater.

Societal Impact within the Community and/or State of Iowa

Nitrate contamination in the groundwater is ubiquitous problem across the Midwest and the state of Iowa. Every year, nitrate, a key component in agricultural fertilizers, flows off the millions of acres of row crops that blanket the Midwest. (Rundquist, 2015) The excess nitrate and other chemicals from farm fields infiltrates groundwater supply where it can remain in soil and water for many months to years. (EPA, 2015) As shown in Figure 4.1 below, eastern, and western Iowa are especially impacted by nitrates compared to central Iowa. Eastern Iowa, where Camp Courageous is located, is in an area of high risk of ground-water contamination. It is important to monitor nitrate in drinking water because it can affect the ability for red blood cells to carry oxygen in the body. High nitrate levels can have significant health effects and can cause methemoglobinemia, a disease that can be potentially fatal in infants.

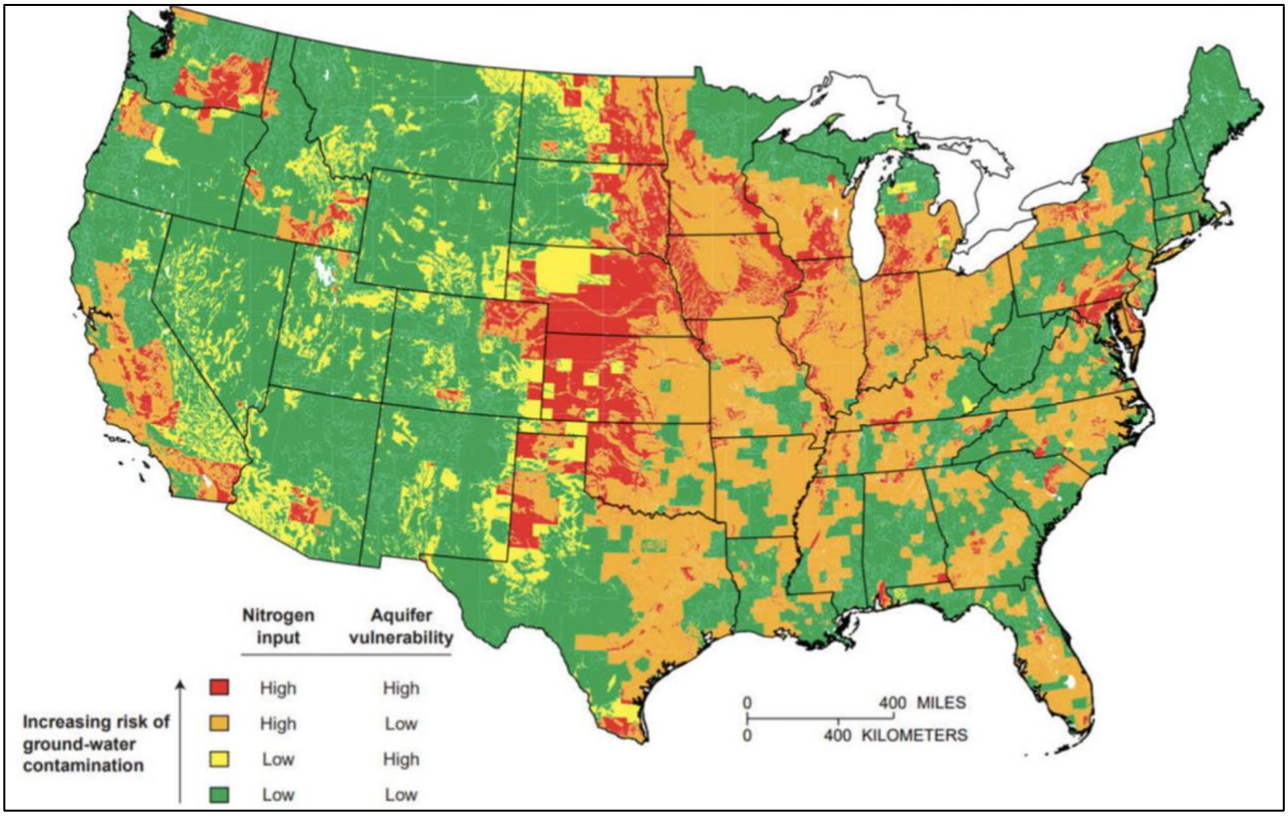

Figure 4.1: Areas of high risk of groundwater nitrogen contamination (USGS, 1999)

There is little Camp Courageous can do to improve the groundwater themselves. Ground water pollution is a problem affecting everyone, leaving no individual in control of the solution for their own well. Everyone needs to be involved in developing the solution. Informing plays a paramount role in raising awareness and keeping groundwater from being contaminated, and Camp Courageous seeks to be a leader in promoting greater water quality by acting as a demonstration site for the Watershed Management Authority (WMA).

Section V - Alternative Solutions Considered

The following information was used to develop the best short- and long- term strategies for providing high quality potable water to their staff, campers, and families at Camp Courageous. Table 5.1 provides information on the seven potable wells that currently exist on the property. Wells 2, 3 and 6 are considered active wells that require monthly operating reports from Camp Courageous water operators since they are available for the public. The CC2 (Camp Courageous 2) well, formally known as Pictured Rocks 2, is active but does not have any available data.

Table 5.1: Summary of Well Information

Well	Activity	Depth	Treatment	Water Quality Challenges	Additional Notes
1	Plugged	Shallow (250 ft)	N/A	-	Drilled 1973
2	Active, public water supply	Shallow (250 ft)	Chlorination and anion exchange	Nitrates	Connected to well 3 Drilled in 1992
3	Active, public water supply	Shallow (356 ft)	Chlorination	Nitrates	Connected to well 2 Drilled in 2009
4	Active	Shallow (335 ft)	N/A	-	Irrigation well
5	Plugged	N/A (0 ft)	N/A	-	Used to fill the lake at CC
6	Active, public water supply	Deep (615 ft)	Chlorination	Radium and iron	Drilled 2017, Event Center Well
CC2	Active, public water supply	Shallow (375 ft)	Chlorination and anion exchange	Nitrates	Previously known as Pictured Rocks 2, drilled in 1960

Using Safe Drinking Water Information Systems data, we were able to create a plot of the nitrate levels in three Camp Courageous wells and a St. John's Church well.

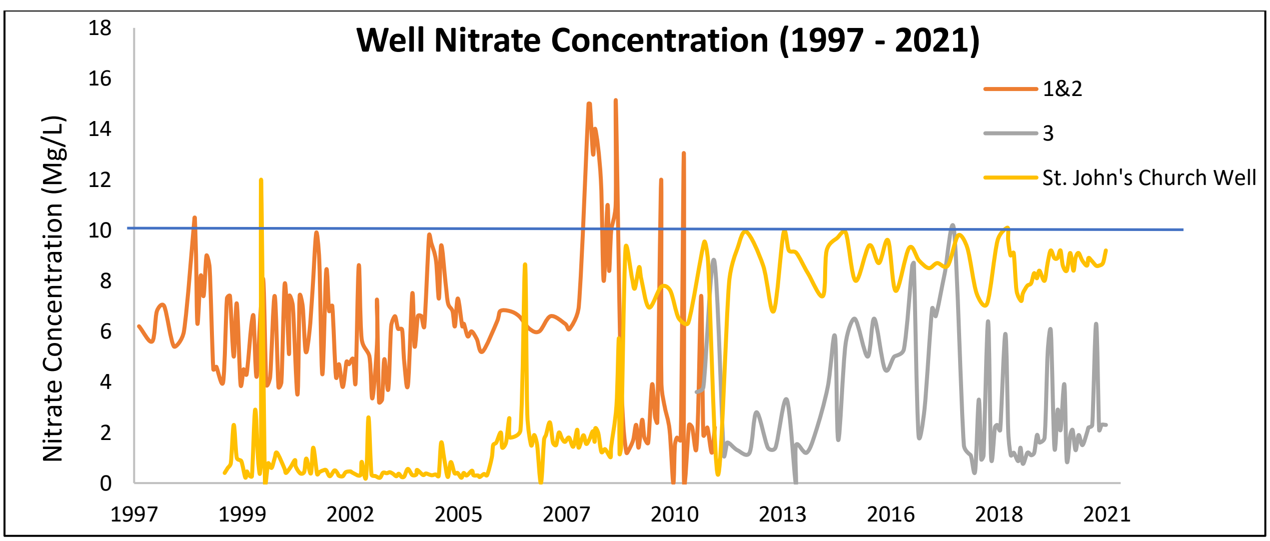

Figure 5.1: Camp Courageous and St. John's Church Well Nitrate Concentration Data 1997 -2021

Figure 5.1 above illustrates the raw nitrate concentrations from 1997 to 2021 in wells 1 and 2, well 3, and a private St. John's Church well, located 2 miles west of Camp Courageous. The blue line indicates the maximum contaminant level (MCL) for nitrate in drinking water. According to the EPA the maximum concentration of nitrate allowed in a public water system in 10 mg/L (EPA, 1998).

The team found significant increases in nitrate concentrations over the past two decades as seen in Figure 5.2 below. Poorly performing septic tanks, feed-lots, and heavily fertilized cropland are all potential sources of concentrated nitrogen and the level of nitrate in the groundwater. Looking at the land use, the team believes it is most likely due to farming practices involving nitrate fertilizer and animal manure.

To get an understanding as to why this may have occurred, we used the program ArcMap to identify land use changes throughout history. We identified the development of Highway 151 east of Monticello in the 1990s, neighborhood growth and the airfield constructed throughout the 1960's. ArcMap also showed farmland development as far back as the 1950s, but there's no clear indicators of what may have caused the increased nitrate contamination.

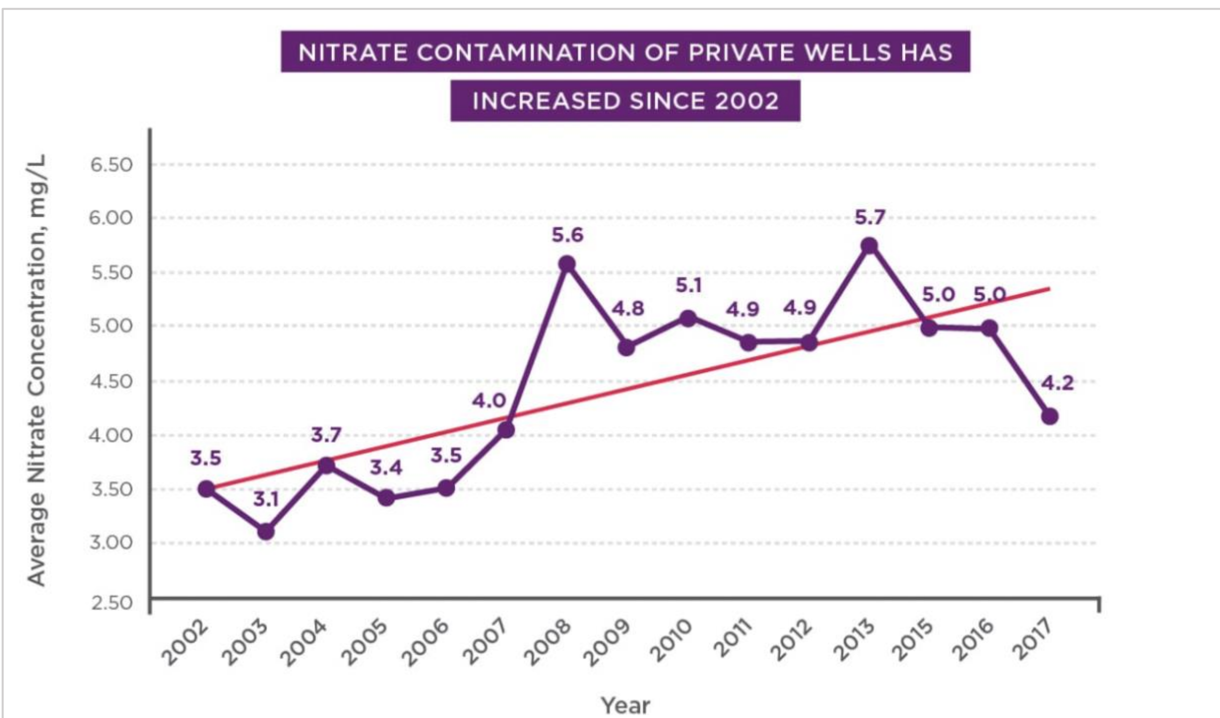

Figure 5.2: Average Nitrate Concentrations from 2002 to 2017 (EWG and IEC, 2018)

We approached David Cwiertny, director of the Center for Health Effects of Environment Contamination at the University of Iowa Engineering, who provided valuable insight into this project. He shared with us the Iowa Well Forecasting System, a tool which gave us access to information on well geology and water quality information across Iowa. He also agreed to work with CHEEC (Center for Health Effects of Environmental Contamination) to fund isotope sampling for Camp Courageous. The purpose of isotope analysis was to determine whether the source of the contaminants was biological or chemical. Chemical results may suggest that there has been excessive fertilization that has seeped nitrogen into groundwater while biological results would indicate contamination from septic tanks or feed lots. Isotope samples were taken on October 8th and sent to the University of Nebraska, Lincoln for analysis. Samples were taken from wells 2 and 3, Camp Courageous 2, and the St. John's Church well, however, the lab analysis has not been completed as of the date of this report. While we wait for the results, we discussed options for both possibilities.

While nitrate levels are monitored daily, bacteria is measured monthly at Camp Courageous. Although bacteria had not been a prominent concern for years, we still proceeded to investigate the septic system as a potential source of the nitrates in the groundwater. Six pit latrines were installed in the 1990's but are rarely used. A map of the property including the locations of the pit latrines is shown in Figure 5.3.

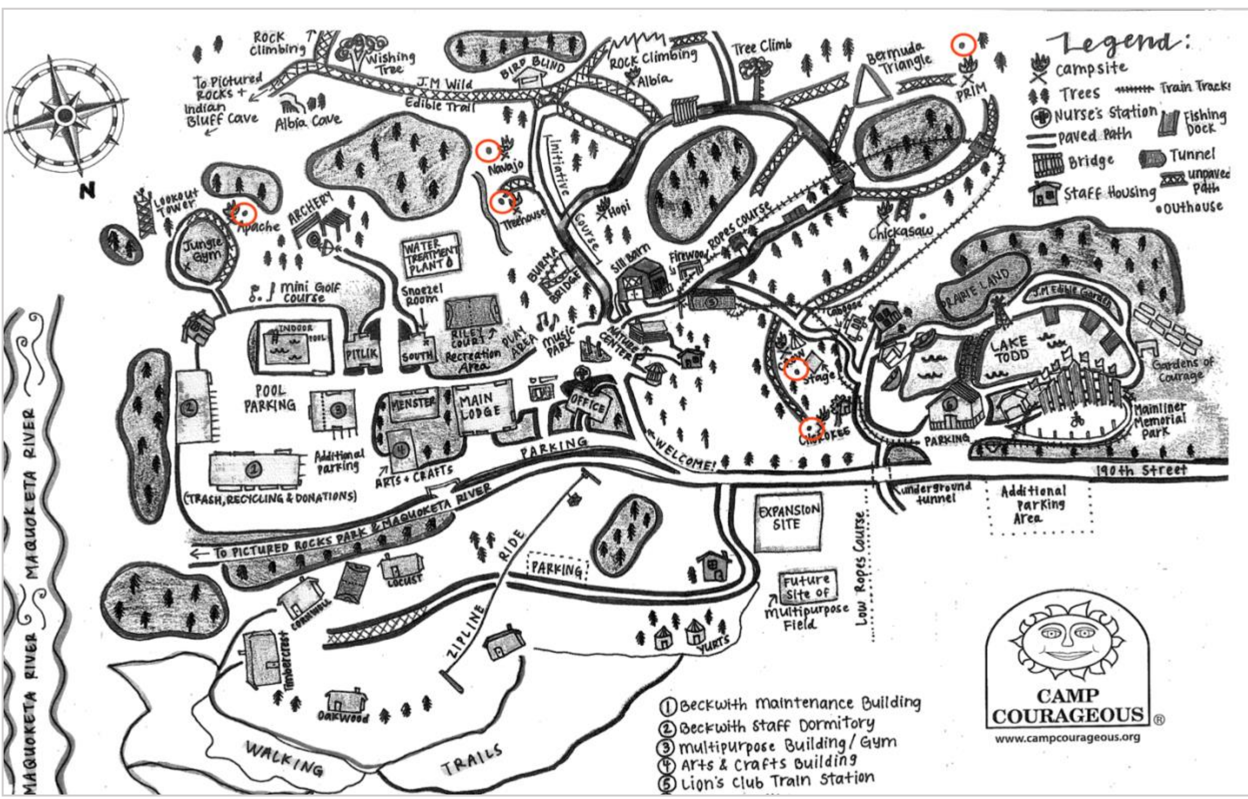

Figure 5.3: Map of Camp Courageous. Pit latrines circled in red

Lastly, Camp Courageous advised that us to consider the future expansion of Camp Courageous in our design considerations. There are upcoming plans to upgrade their cabins, build a gymnasium, and more on the North side of the property, so it is imperative that we design with the potential demands of the camp. Development plans of Camp Courageous are shown below in Figure 5.4

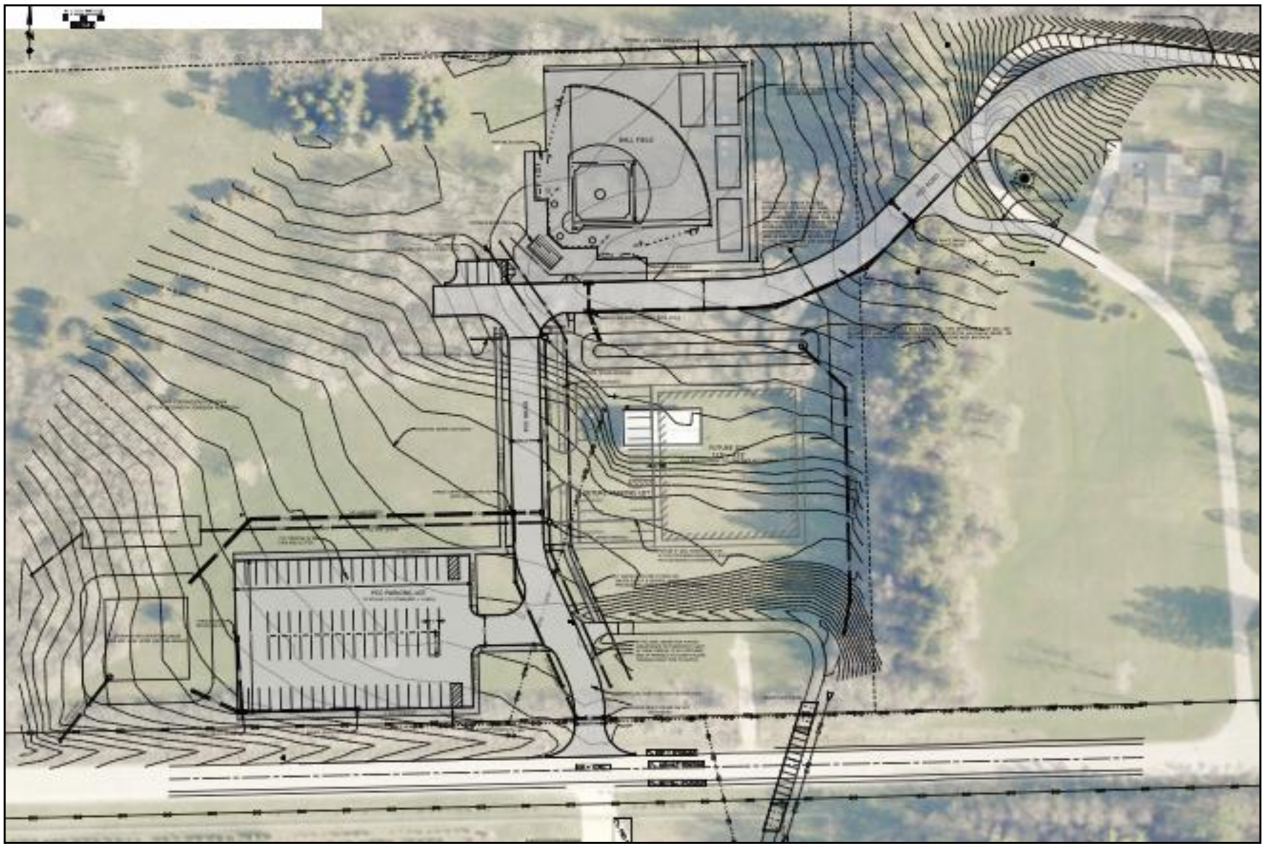

Figure 5.4: Pitlik-Beckwith-Johnson-Bader (PBJB) Addition Site Plan

Our team generated various alternatives to facilitate the removal of nitrate, radium, and iron from Camp Courageous source water. These included both treatment techniques and source water protection strategies that would be feasible for Camp Courageous to implement either as long term, or short-term solutions. Included is a description of each alternative and the advantages/disadvantages that influenced the selection of the preferred alternative.

Treatment Techniques Considered

The following solutions were evaluated as options to facilitate drinking water treatment and reduce the risk of contaminated water entering the public water supply. These solutions aim at protecting drinking water from contamination to improve water quality of potable water and reduce treatment costs.

Treatment Technique 1: Point-of-Use and Point-of-Entry Filtration

One of our initial short-term solutions was to install a point-of-use (POU) or point-of-entry (POE) filtration system. POU systems treat water right where you use it and can be installed on all faucets, including shower heads, that supply water to the campers and the staff. In Figure 5.5, a POU reverse-osmosis system is shown as example. With approximately 120 faucets and 90 shower heads to account for, this solution was not considered practical. Ongoing maintenance and replacing filters would provide additional work for the staff at Camp and would not provide any additional benefit when compared to the current treatment system. In addition, it was thought that the effect on water pressure that POU filters would have on specific buildings would be a concern. Water pressure may also be a concern for a POE system; however, this was thought to be a more practical system for the water demand.

Figure 5.5: Point of Use device (Applied Membranes , 2020)

Treatment Technique 2: Reverse Osmosis

The team investigated the viability of modifying the current water treatment process from ion exchange to reverse osmosis (RO). Although this process would produce excellent water, it would not eradicate the need for the salt pallets for pretreatment softening. Modifying the system would require significant funding, maintenance, and inspection requirements. Since Camp Courageous' current water treatment is effective with reducing nitrate levels, RO would not provide a necessary improvement in water quality at this time. This treatment is effective at removing most organic compounds, chlorine by products, as well as chemical contaminants (such as metal ions and aqueous salts).

Source Water Protections Considered

The following solutions were evaluated as options to facilitate source water protection and reduce the risk of contaminated water entering the wells. These solutions aim to protect source water from contamination to improve water quality of potable water and reduce treatment costs.

Source Water Protection 1: Denitrifying Bioreactor

One alternative considered was the installment of a wood chip bioreactor on the property line west of Lake Todd. This would be a subsurface trench where wood chips would serve as a substrate for bacteria to denitrify the excessive nutrients leaving the agricultural land. Figure 5.6 shows a schematic of a bioreactor that uses wood chips as its carbon source. This system would be effective at reducing nitrates and has the potential to last 10 - 30 years. This option does require a significant capital cost, up to $8000 with control structures, wood chips, and excavation costs (AgBMPs, 2021). Every 10-15 years, a bioreactor may require maintenance and periodic inspections involving the replacement of control structures and recharging of wood chips, as they decompose with time (IAWA, 2021) (Bowman, 2016). This solution would also require a more in-depth analysis of the land applicability to the bioreactor, such as tile-drainage, size, location, terrain, and more. Due to the hilly terrain, it is suspected that this alternative might be difficult to implement around Camp Courageous as there might not be much space or many drainage tiles around the property.

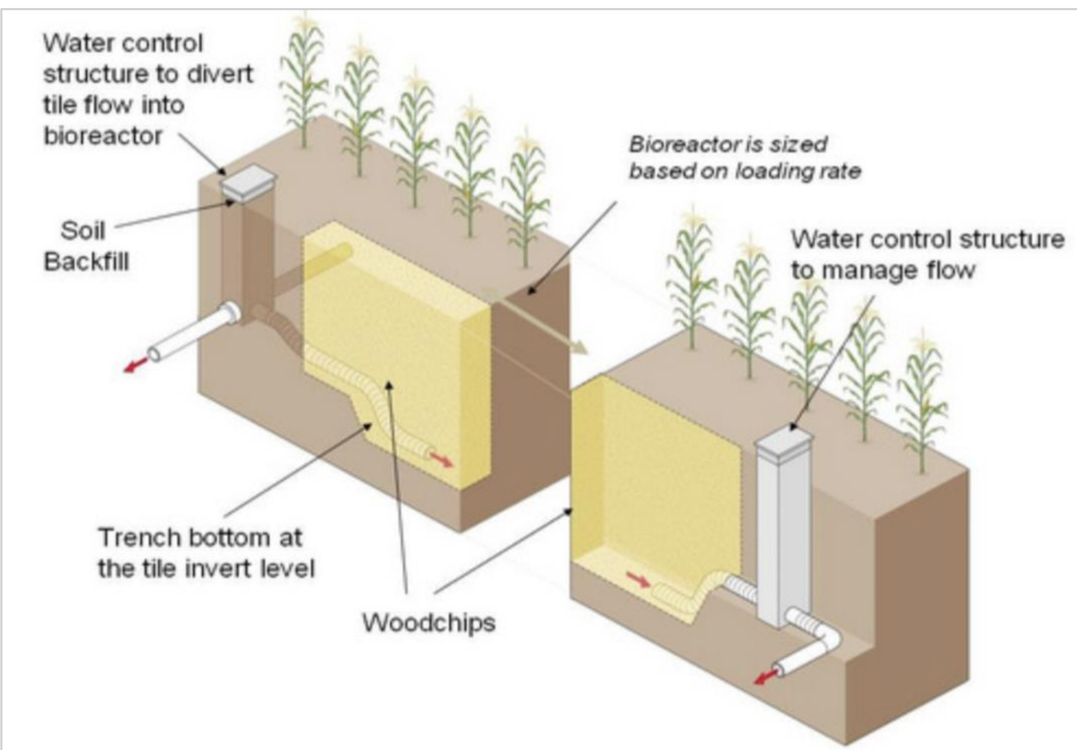

Figure 5.6: Denitrifying woodchip bioreactor (Frankenberger, n.d.)

Source Water Protection 2: Winter Cover Crops

Cover crops successfully reduce nitrate through plant uptake throughout the winter. Small grains, legumes and various species of grass are often used across the Midwest and can also increase soil health, reduce soil erosion, and recycle nutrients after the annual crop growing season. Although there is an estimated cost of $30/acre, many financial incentives exist for farmers who incorporate this management practice. EQIP, the Environmental Quality Incentives Payment program, offers incentive payments through the NRCS up to $57 per acre (SARE Outreach, 2021). This alternative was discussed at length since Camp Courageous currently leases an estimated 200 acres of land to a local farmer for agricultural purposes.

Source Water Protection 3: Saturated Buffers and Perennial Vegetation

Saturated buffers are a relatively new practice for improving water quality and work to reduce nitrate loads by increasing denitrification, increasing plant uptake, and reducing flow towards a water source. A saturated buffer is an area of vegetation between agricultural fields and waterways where the tile outlet distributes water laterally along the buffer before entering a stream or ditch (EPA, n.d.). Figure 5.7 shows a schematic of a conventional tile outlet and after a controlled distributed tile line is installed. A saturated buffer could potentially be installed around the water feature designed by the storm water quality team, however this alternative would require a soils investigation and a site assessment prior to installment. Saturated buffers require minimal maintenance and are simple to install, however it is essential to ensure that there are no adverse impacts to the crop land upstream or the streambank stability.

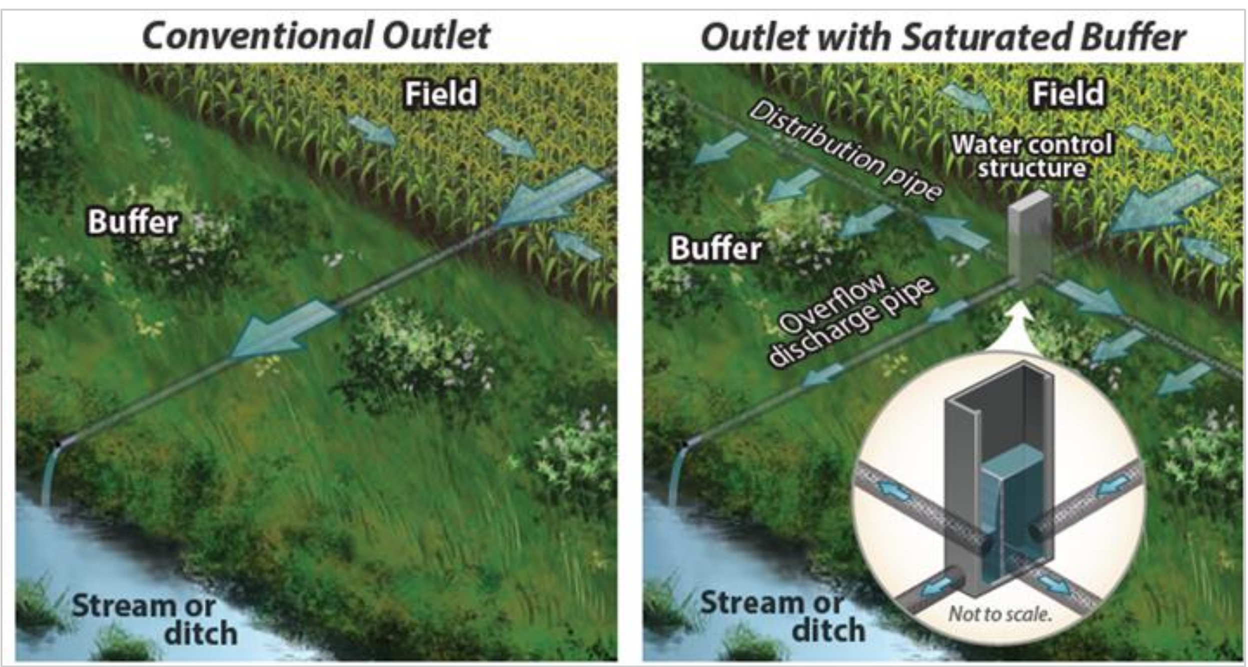

Figure 5.7: Saturated Buffer Illustration (Frankenburger, n.d.)

Perennial vegetation could be planted around water features or along the property line to help reduce farm runoff and increase plant nutrient uptake. Currently, the property boundary is predominantly grass, this could potentially be amended so that the vegetated buffer is most effective. Extensive root systems allow for great nutrient absorption, suggesting that trees such as poplars and willows would be most successful at improving the water quality beneath the surface

Source Water Protection 4: Brochure and Information Sessions

Since there's limited source protection practices that can be implemented on the main campus of Camp Courageous, an informational brochure detailing a handful of conservation practices was suggested to be distributed to farmers who own land surrounding Camp Courageous. If any farmer implemented a conservation practice on their surrounding farmland, it can be expected there to be a long-term benefit to Camp Courageous' groundwater contaminant levels. Encouraging a large-scale effort of surrounding farmland properties is the most viable option in creating change in the environment; change may be seen in years to come once implemented. The brochure features the Source Water Protections 1-3 as conservation practices, in addition to no-till/strip till. The goal of the brochure is to inform farmers of these practices, and to incentivize farmers to implement practices that would benefit their land and pockets. Incentivization includes the potential for better soil, better groundwater, and better crop quality and yields, with the capability of the conservation practice having expenses covered for installation through government and research programs. The brochure can be found in Appendix A.

In addition to the informational brochure, Camp Courageous can be an area advocate by hosting information sessions and workshops from agencies, such as the National Resources Conservation Service (NRCS), Practical Farmers of Iowa, etc. to inform the local public of conservation practices and advantages.

Selection of Alternatives

After analyzing each alternative and gaining an extensive understanding of the current water system at Camp Courageous, the team began work on the comprehensive potable water master plan with both short- and long- term solutions included. This plan includes treatment options that will not only remove current contaminants but will be capable of removing emerging contaminants in the future. This plan also provides information on the existing level of treatment, the stratigraphy beneath the property and an implementation plan with trigger points and an estimated time frame for each component.

Section VI Comprehensive Portable Water Master Plan

This section of the report lays out specific short- and long-term recommendations for the Camp Courageous water system. It begins with background information relative to the water system and then outlines recommendations that we believe are most appropriate for Camp Courageous. In accordance with the Iowa DNR, Camp Courageous is classified as a non-transient non-community public water supply. This means Camp Courageous is responsible for regularly monitoring contaminant levels of the water derived from their wells. Under this classification they are only required to sample a handful of analytes from their groundwater system. This list includes, but is not limited to, nitrates, coliform bacteria, radionuclides, and metals such as iron, lead and copper. The purpose of this master plan is to assist the camp with developing the best short- and long- term strategies for providing high quality potable water to their staff, campers, and families.

Research for the original scope revealed improving the water quality of the aquifer would take decades to achieve and requires actions to be taken on properties surrounding the camp. While cleaning the aquifer is a worthy long-term goal, more immediate solutions to water quality challenges need to be explored. The team worked with the client to amend the scope of our work to include a Potable Water Master Plan that explores the best short- and long-term strategies for Camp Courageous based on the stratigraphy, existing treatment system and plans for future development.

Stratigraphy

To understand the source of the contamination it is imperative to understand the geology beneath Camp Courageous. To do this, the team engaged geologists Matthew Graesch and Amber Sauser from IDNR Water Supply Field Office One to provide insight on the stratigraphy beneath Camp Courageous. The following figure, Figure 6.1, shows a rough description of the stratigraphy beneath Camp Courageous. This map is drawn from east to west from the first gravel road (west of Lake Todd) to the Maquoketa River, with a vertical exaggeration of 3:1. Underneath the surface topography, exists a 20 – 50ft thick layer of till and other wind-blown glacial sediments, shown by the brown spotted layer. Underneath this exists a layer of Silurian rock approximately 250ft thick. Due to the porous nature of the Silurian, this aquifer is extremely susceptible to surface water contamination. Beneath this layer exists a regional aquitard, known as the Maquoketa. This is an impermeable unit which separates the Silurian (orange) and the Ordovician (green and below). It is unlikely that contamination would seep beneath this layer due to the impermeable nature of the aquitard. The Ordovician is separated into three different units shown in green, purple, and blue.

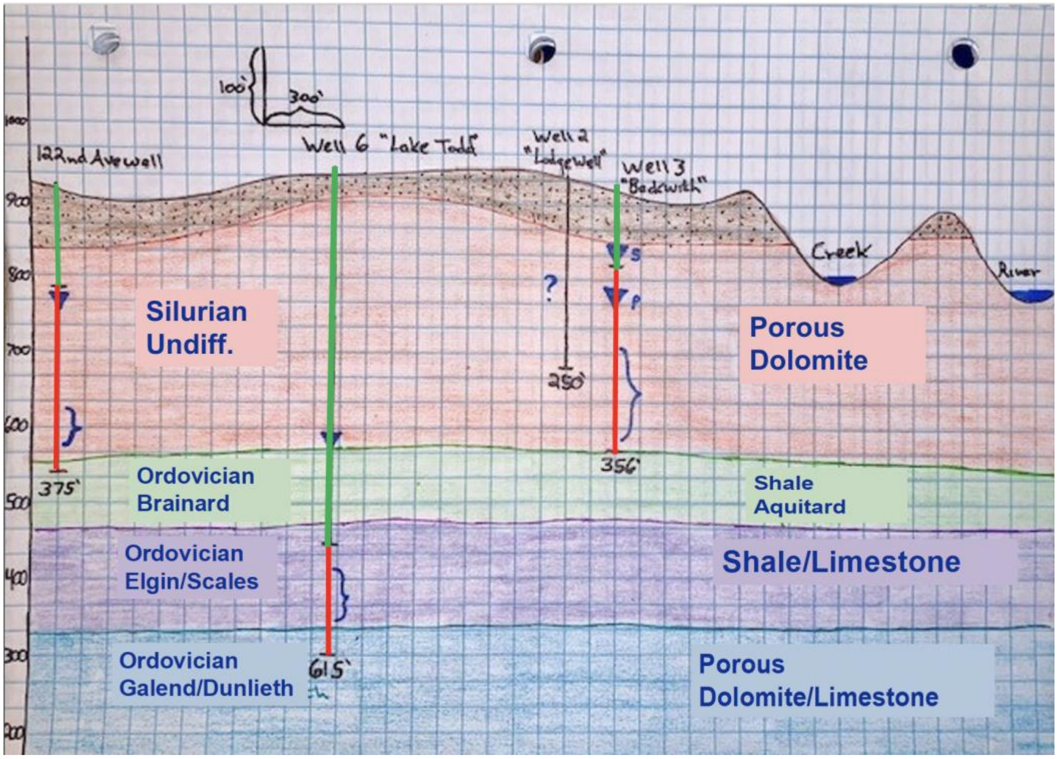

Figure 6.1 Stratigraphy beneath Camp Courageous (Matthew Graesch, 2021)

Four of Camp Courageous' wells are shown on the sketch. The green upper section of each well indicates the cased section of the well while the red portion indicates the screened part of the well that is opened to bare rock where water is drawn. Unless there is a problem with the casing, such as bad grouting or cracked casing, no water should be able to intrude the green section of the well horizontally. The vertical blue bracket towards the bottom of each well shows the major water producing zone, as specified by the well driller, while the blue arow indicates the static water level for each well. The Beckwith well (Well #3), has two arrows to represent the difference in static level and pumping level.

The water quality issues in the shallow wells are highly influenced by land uses within the last decade. As the surficial aquifer is more susceptible to seasonal changes and what is occurring on the surface, we are more likely to see wild fluctuations in contamination levels. This is consistent with the nitrate data obtained and shown in Figure 5.1. Deeper wells, such as well 6 however, have a different set of problems. Although nitrate is not a major concern for well 6, it does have however concerning levels of radium and iron. These water quality issues in deeper wells are more likely to reflect land use changes from ten or more years ago (Mechenich & Shaw, 1996). The water drawn at this depth is much older than the water drawn from a shallow well and has higher levels of naturally occurring radioactivity. Deep wells often experience a greater concentration of dissolved minerals such as calcium, magnesium, and iron. Fortunately, radium, a radioactive metal that occurs naturally in trace amounts in rocks and soils, can be treated using water softening units, such as ion exchange or reverse osmosis, while filtration and water softening can reduce iron levels.

Current Treatment System

The camp currently has high levels of nitrate, radium, and iron in their groundwater. They have seven wells on site; two of which are plugged, and one is used specifically for irrigation and is not connected to the public water supply. Camp Courageous currently treats three of their wells with chlorination and two with anion exchange to ensure that nitrate levels do not exceed the maximum contaminant limit set by the Safe Drinking Water Act. Regular monitoring of these contaminants has prompted Camp Courageous to seek wholistic alternative solutions to improve its water quality. There are four locations where the well water is currently being treated. The following table indicates where, and how much water is treated in each location.

Table 6.1: Well Name, Location, and Average Water Demand During Peak Season

Well	Location	Average Water Demand (Gal/Day)
WLO2	Lodge Basement	20,000
WLO3	Beckwith Basement	4,000
WLO6	Small Depot by Memorial Park	600
CC2	Locust Cabin Basement	700

The figure below, Figure 6.2, shows which buildings are fed by each well. Camp Courageous 2 (north well) and WL02 (main lodge) are both treated with softening, anion exchange and chlorination, while WL03 (Beckwith) and WL06 (event center) are only treated with softening and chlorination.

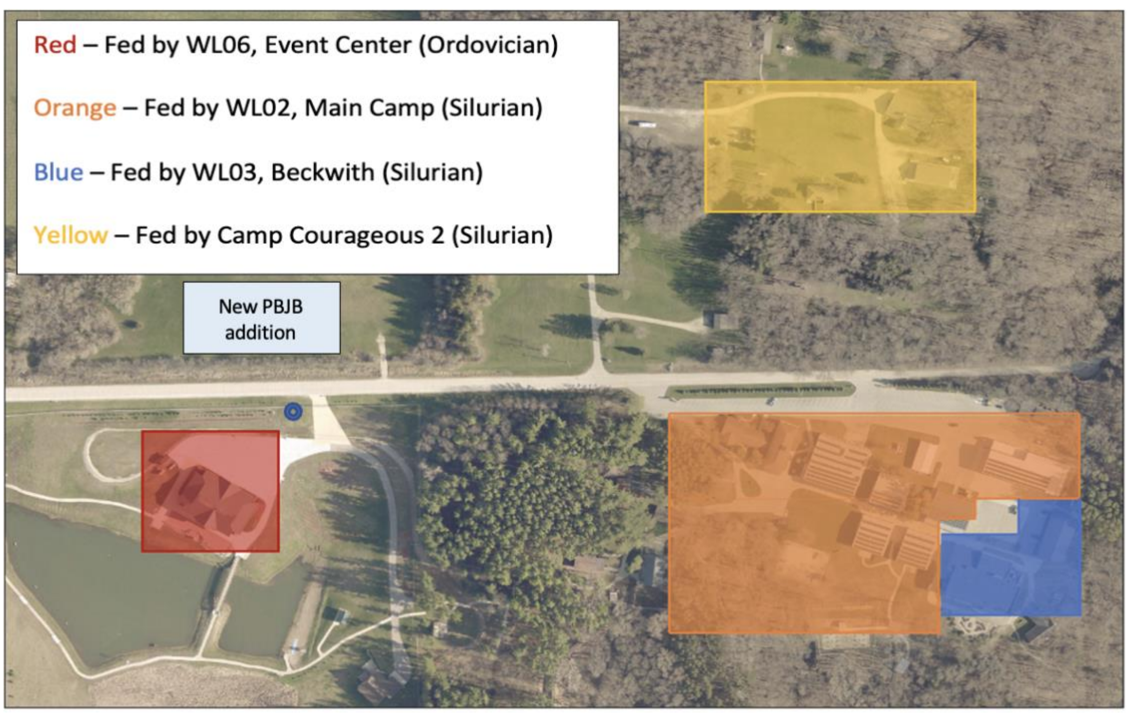

Figure 6.2 Map of well supply to each building; the blue circle represents location of dry hydrant connected to Lake Todd for fire protection

Fire Protection

Camp Courageous has a dry fire hydrant connected to Lake Todd. This is a non-pressurized pipe system that will provide a reliable and accessible water source in the event of a fire on Camp Courageous or nearby property.

Emerging Contaminants

Emerging contaminants are chemicals with historically limited environmental data or found in concentrations generally exceeding original expectations (MidwestGeo, 2020.) Emerging contaminants that have been found in surface water and groundwater are linked to pharmaceuticals, cleaning products, agricultural products and more. (USGS, n.d.). PFAS or "Forever Chemicals", have been a prevalent concern in rural creeks and rivers of Iowa as of 2021, since they are linked to many potential health problems as they bioaccumulate in the body. Researchers have found high levels of PFAS in streams next to agricultural fields and areas of wastewater discharge. There were detectable concentrations of PFAS in the Anamosa Wapsipinicon River, located 11 miles southwest of Camp Courageous, according to a study by the USGS and the Center for Health Effects of Environment Contamination at the University of Iowa. There was no test conducted for the Maquoketa River. (Strong, 2021)

Master Plan Recommendations

The following figure outlines the short- and long- term recommendations most beneficial to Camp Courageous.

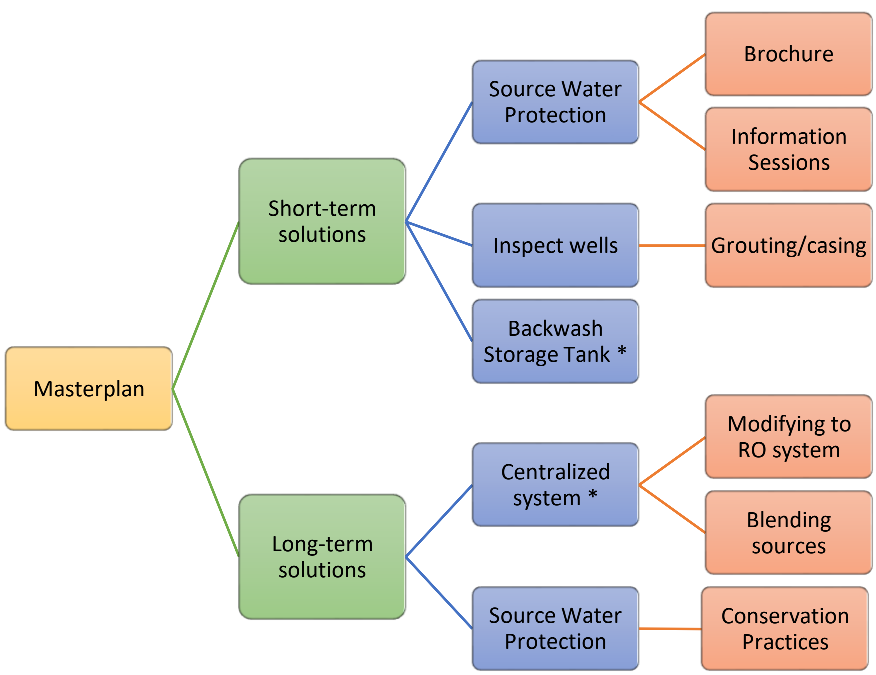

Figure 6.3: Layout of Masterplan. Asterisk (*) denotes trigger point solution

The first thing to note is that Camp Courageous is doing all the right things to treat the existing ground water contaminants. No immediate changes in treatment are recommended. While the raw water nitrates have been around 6 – 8 mg/L, the current treatment system reduces them to about 1.5 mg/L. This eliminates the need for installation of a point of entry or point of use system. However, the team recommends two short term goals that may benefit Camp Courageous in the foreseeable future and a third potential recommendation that would be considered only if warranted by its trigger point.

Short-Term Solutions

1. Well inspection

   The team believes it would be in Camp Courageous' best interest to get the two active shallow wells inspected. Nitrates may be entering the well through a non-grouted or cracked casing, or through the submerged well cap (Iowa State University, 1993). Extending or repairing the well casing may be able to prevent nitrate entering the top of the well casing, however if nitrate is seeping down along the casing on a non-grouted well this creates a more complicated problem. In discussions with Midway Well Service, they estimated it would cost \$350 - \$400 to inspect WL02 and Camp Courageous 2. According to Midway, if problems are noted, the next step would be to pull the pumps and send a camera down the casing which will cost between \$1000 - \$4000. This process will determine the existing condition of the well casing and provide Camp Courageous with steps to proceed.
2. Short-Term Source Water Protection

   Camp Courageous can become an advocate for regional best-practices that can help protect the aquifer. Through hosting informational sessions, Camp Courageous could encourage area farmers to implement greater conservation practices, such as cover crops and saturated buffers, by providing information on financial incentives and resources available that pertain to the area. In addition, an informational brochure exhibiting a handful of these conservation practices was created to inform the farmers in the local area on ways to reduce nitrate runoff. The goal of the brochure is to inform farmers of best-practices if they were not aware of them before, and to incentivize them to implement a practice that benefits their land and pockets. Incentivization includes the potential for better soil, better groundwater, and better crop quality and yields, with the capability of the conservation practice having expenses covered for installation through government and research programs. The brochure can be found in Appendix A.

3. Backwash Storage Tank

   This short-term recommendation should be considered only if Camp Courageous were to start to have problems meeting their daily max dissolved solids limit in their wastewater plant. Backwash storage tanks involves storing the backwash and discharging it over a longer period so that daily limits are not exceeded in the wastewater. The team is aware that one of Camp Courageous concerns with their current water practices is that backwashing the ion exchange systems creates high chlorides concentrations in the wastewater effluent. The team believes that a solution to this issue is backwash storage tanks. The backwash used to clean the ion exchange resin can be used for several purposes. Because the backwash is like a salt brine, it has the potential to be used to salt the parking lots and walkways during the winter. The backwash would need to be tested for its salt percentage and it would need to be optimal for anti-icing (FHA, 1996). This would reduce the need to buy winter salt and reduce costs. The backwash could also be recycled (Satterfield, 2005). The solution can be settled in tanks to remove solids, and the water could be recycled through the ion exchange systems. The solids would be wasted, and this would help Camp Courageous save water.

Long-Term Solutions

The following recommendations are long-term solutions for both treatment and source water protection.

1. Centralized Water System

   The existing treatment system works well and should be scalable to accommodate growth unless it becomes necessary to remove newly identified or newly regulated contaminants that cannot be addressed by the current treatment process. If that becomes the case, we recommend an analysis be performed to see if it would be cost effective to centralize the new water treatment process. It is not possible to do this analysis at this time because we cannot predict what contaminant, if any, might trigger this change. A centralized system would involve construction raw water lines to transport the water from each well to a central location for treatment. Likewise, a system of water mains would also need to be constructed to transport the treated water out to each of the buildings.

   The team believes this is a feasible long-term option for Camp Courageous' water quality concerns, however it will come at a significant capital cost. One option that could keep contaminant concentrations below threshold limits at a reasonable cost, would be to blend the shallow wells with the deep well. This process would dilute the contaminants in each aquifer so that total contaminant concentrations are minimized. It would require regular monitoring to ensure that blending ratios are optimized and that the treated water quality is within compliance. Other methods for treating the water at the central location are reverse osmosis and ion exchange. Reverse osmosis works to filter out minerals by flowing water under pressure and forcing it though a membrane (University of Missouri, 1998). This treatment technique requires a lot of energy to operate efficiently but produces excellent quality water. Ion exchange with a selective nitrate resin is currently installed as the primary treatment at Camp Courageous and could be used utilized in the centralized system. In this instance, chloride is introduced into the system to remove the nitrate. The nitrate selective resin is then recharged by backwashing with a brine solution and reused. This process can treat large volumes of water, making it advantageous for Camp Courageous and its plans to expand. One potential drawback the team identified was the presence of sulfates in the well water. Unless neutralized before entering the ion exchange unit, the sulfates will reduce the ability for the resin to remove nitrates and may increase the corrosivity of the water (University of Missouri, 1998).

2. Long-Term Source Water Protection

   As discussed earlier, source water protection is an important part of any water quality plan for Camp Courageous and beyond. Boosting conservation efforts to improve ground water quality is imperative across Iowa and the Midwest. In addition to the techniques discussed above, one inexpensive, non-invasive, and versatile treatment technology is the use of plants, such as poplars and willows, to absorb pollutants through their extensive root system. Currently most of the property boundary has a natural grass covering, however, the team believes it would be advantageous to grow plants that are more effective at taking up nitrates and other pollutants present in the groundwater. This edge-of-field practice may include perennials and/or fast growing, hydrophilic trees. Similarly, saturated buffers could be established between agricultural fields and waterways where the tile outlet distributes water laterally along the buffer before entering a stream or ditch. This would require an understanding of the tile drainage system but may be beneficial in the future to reduce the amount of treatment, and associated cost, required of Camp Courageous.

Section VII - Engineer's Cost Estimate

As seen in Figure 6.3, a master plan was developed for Camp Courageous detailing the best approaches for drinking water treatment and source water protection through short- and long-term solutions. The cost of these approaches will vary greatly depending on when they are implemented (e.g., 20 years from now) and by whom, how much water consumption changes with Camp Courageous' expansions, the type of treatment chosen, and to what extent they will carry out these changes (e.g., a centralized treatment in the basement of a building or having its own building.) Due to broad variability with many approaches, a direct number would be difficult to estimate on this report; in Table 7.1 below, dollar signs are used to distinguish relative expenditure for comparing approaches.

Source Water Protection: This would be the least expensive component of the potable water master plan, but if properly executed may reduce, delay, or eliminate some of the long-term recommendations. By serving as a host for informational sessions, Camp Courageous could encourage area farmers to implement greater conservation practices, such as cover crops and saturated buffers, by providing information on financial incentives and resources available that pertain to the area.

Well Inspections: According to Midway Well Service, it would cost approximately between $350 to $400 to inspect the two shallower wells that are currently experiencing high nitrates. Depending on the outcome of this inspection the next step may be to have Gingerich pull the pumps and send a camera down the casing which may incur a higher, more significant cost, somewhere within the range of $1000 and $4000 per well.

Centralized System: The cost of installing a centralized system would involve construction of raw water lines to transport the water from each well to a central location for treatment. Likewise, a system of water mains would also need to be constructed to transport the treated water out to each of the buildings. Reverse osmosis would be the most expensive treatment option to install and maintain, followed by ionic exchange. The least expensive option for treatment would be blending, however, many factors play a role in which system would be most effective. It is not possible to do this analysis at this time because we cannot predict what contaminants, if any, might trigger this change.

Table 7.1: Relative Costs of Masterplan Recommendations

Approaches	Relative Cost
Flyers/ Information Sessions	$ > $100
Well Inspection	$$ > 1,000
Conservation Practices*	$$$ > 5,000
Backwash Storage Tanks	$$$ > 5,000
Centralized System	$$$$$$ > 100,000

*Subsidies can reduce expense if eligible

Appendices

Appendix A: Brochure

Filter Strip

About Conservation Agriculture

What is Conservation Agriculture?

Conservation Agriculture (CA) is a sustainable approach to agricultural production which aims to protect soil from erosion and degradation, improve its quality and biodiversity, contribute to the preservation of natural resources like water and air, while optimizing yields.

Why Conservation Agriculture?

Conservation practices can decrease the levels of water contaminants such as Nitrate, and improve soil, groundwater, and cops.

Nitrates are natural chemicals that are found soil, air, and water. Nitrate levels has been increasing over the past few decades and this is concerning. Excess Nitrates can stem from fertilizer, pesticides, and manure. Nitrates can seep into the groundwater supply and cause health problems in people's well water.

Soil erosion, caused by water and wind detaching and removing topsoil, can lead to infertile lands for crops, water quality issues, and more. CA has the capability of reducing soil erosion and promoting a biodiversity in your soil where your crop will thrive.

Prescribed Grazing of Cover Crops

Conservation Practices and Descriptions

Cover Crops

Crops, including grasses, legumes, and forbs, for seasonal cover and other conservation purposes. Planted prior to grain crop harvest or immediately after harvest, cover crops can reduce erosion, provide winter grazing for livestock, and reduce nutrient loss.

Residue and Tillage Management, No-till/Strip-till/Direct Seed

Managing the amount, orientation and distribution of crop and other plant residue on the soil surface throughout the year, including tillage, nutrient applications and harvesting of residue.

Denitrifying Bioreactor

Denitrifying bioreactors are underground structures filled with wood chips that intercept and treat tile water. They help reduce nitrate levels in water leaving agricultural land

Filter Strips

A strip of dense herbaceous vegetation such as grass, trees or shrubs that filters runoff and removes contaminants before they reach water bodies or water sources, such as wells.

Additional Choices, not limited to:
Field Borders, Wetlands, Prairies, Contour Farming, Ponds, Wetlands, Riparian Forest Buffers, Crop Rotation, Nutrient Management, and more

Benefits of Conservation

Landowner and farm operator decisions can implement CA practices which would benefit them and their soundings.

Better Soil

The importance of soil:

- allows both water and air to move through and get to roots,
- carries a diverse population of microorganisms
- contain an abundance of readily available nutrients

Implementing conservation practices that cause less disturbance to soil through erosion control, reducing compaction, and more, can be seen to improve soil health through the availability of water and maintenance of soil nutrients.

Better Water

Water is essential to our way of life. From drinking, eating, showering, and more. Implementing conservation practices can help filter and reduce contaminants in the groundwater where wells draw water from. Cleaner water can also improve the environment of bio life in and around rivers and streams.

Better Crop

With CA, better soil, and water infiltration lead to a thriving crop with a flourishing ecosystem among its roots. A thriving crop can lead to great yields and more capital in the pocket of the farmer.

More Profit

Aside from the profit of better crop yield, incorporating a practice such as cover crops can show an increase in profits from cost-share payments, crop insurance discounts, reduced labor for those who feed cattle, and more.

Figure A.1: Informational brochure (page 1) tailored to Jones County, Iowa

Wetland on Farm

Cost Assistance

Through conservation planning and financial assistance, local, state, national, and federal agencies are available to help farmers protect their natural resources through funding and cost-sharing.

There are many Farmer-Led research that may provide funding for trials if qualified. This list of sources and program examples is not limited to:

- Practical Farmers of Iowa Cooperators' Program
- Iowa Department of Agriculture & Land Stewardship
- Conservation Stewardship Program (CSP)
- Conservation Innovation Grants (CIG)
- Conservation Reserve Program (CRP)
- The Regional Conservation Partnership Program (RCPP)
- Environmental Quality Incentives Program (EQIP)

Resources

Please consider these resources which provide a lot of information on topics discussed in this brochure.

- National Resources Conservation Service Iowa (NRCS)

  nrcs.usda.gov/wps/portal/nrcs/ia

- Practical Farmers of Iowa

  practicalfarmers.org

- Iowa Department of Agriculture & Land Stewardship

  iowaagriculture.gov/dscwq

Camp Courageous
Monticello, IA

Cropland Conservation Practices

To pursue better quality crop, soil, and drinking water

Figure A.2: Informational brochure (page 2) tailored to Jones County, Iowa

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