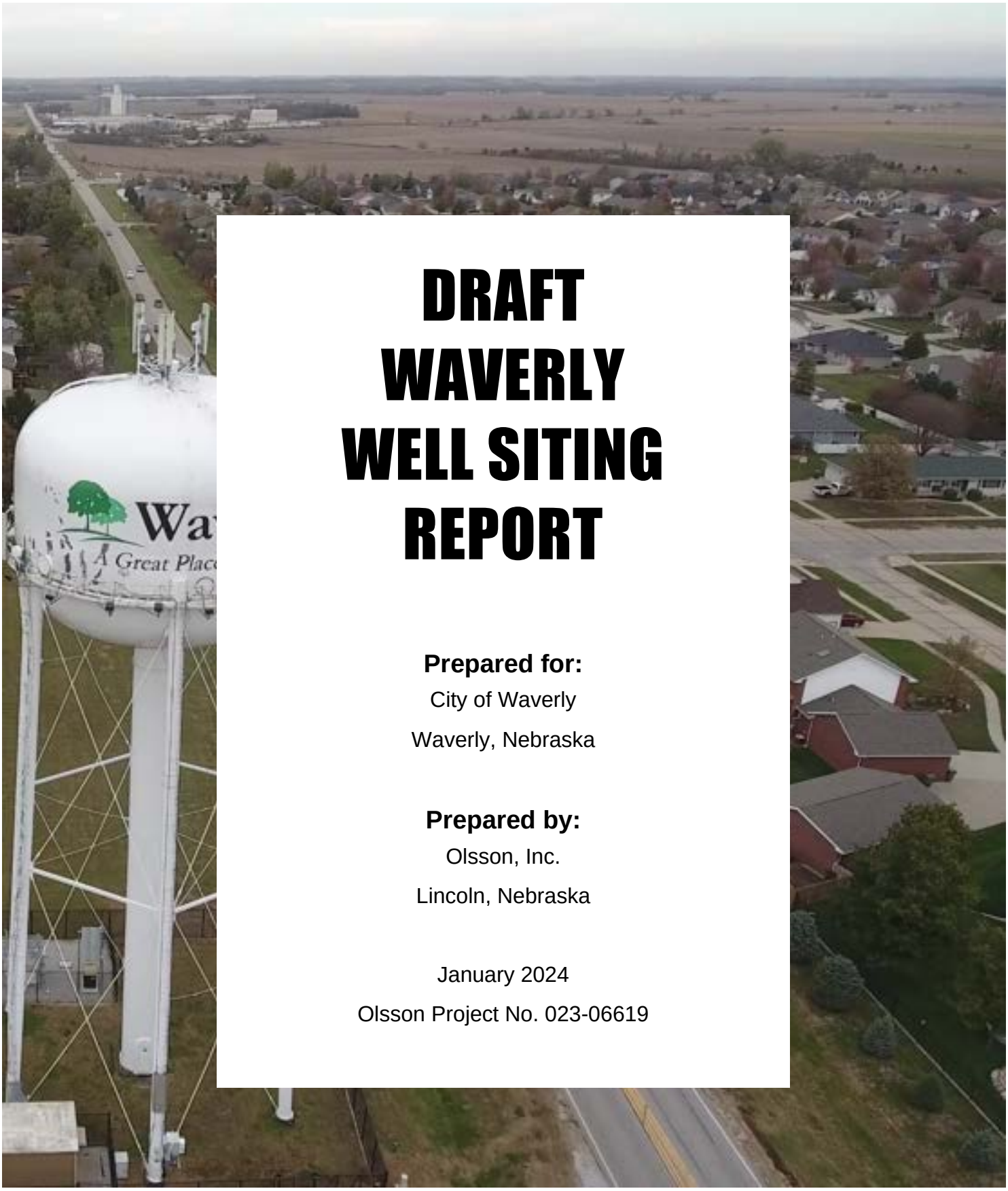

DRAFT WAVERLY WELL SITING REPORT

Prepared for:

City of Waverly

Waverly, Nebraska

Prepared by:

Olsson, Inc.

Lincoln, Nebraska

January 2024

Olsson Project No. 023-06619

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SUMMARY

The City of Waverly (Waverly) has experienced recent water level declines in their municipal wellfield. A previous report by Olsson in 2023 titled “Waverly Wellfield Hydrogeologic Analysis Report” outlined recommendations for the alteration of the well constructions and pumping regimes of Waverly’s existing municipal wells to reduce the likelihood of the pumping water level reaching the shutoff levels at these wells. With this potential threat to the water supply, Olsson’s team investigated four potential locations for the expansion of Waverly’s water supply infrastructure, prioritized, and proposed multiple test holes in each area. The four areas investigated in this report are: the Existing Wellfield Area, the Camp Creek Area, the Salt Creek Area, and the Confluence Area of Salt, Rock, and Camp Creeks.

With the available hydrogeologic data gleaned from borehole logs from NDNR’s Registered Well Database, aerial electromagnetic (AEM) data, and available water level monitoring information recommendations for proposed test holes and potential groundwater sources are identified. These recommendations and propositions do not use other considerations in the evaluation such as water quality, potential costs, and jurisdictional limitations. Two general approaches to expanding Waverly’s water supply are explored in this report, the siting of proposed test holes within Waverly’s Existing Wellfield Area and the siting of proposed test holes outside of the Existing Wellfield Area. There is more information available in the Existing Wellfield Area that leads to a more comprehensive evaluation and proposition of test holes. The water level declines observed at Waverly’s existing municipal well, described in Olsson’s previous Hydrogeologic Analysis Report would also affect the water table at the proposed test hole locations within the Existing Wellfield Area. Of the three areas outside of the Existing Wellfield Area, it is the opinion of the Olsson team that the Salt Creek Area should be the highest priority to be explored with proposed test holes. In decreasing order of prioritization, the Camp Creek Area would the next recommendation and the final recommendation would be the Confluence Area. These recommendations are based on the spatial distribution of available hydrogeologic data that point towards areas of high transmissivity. This estimation of transmissivity is based on the lithology of the boreholes in the area and the water levels that have been measured in the area. As mentioned previously, this report is aimed at the siting of proposed test holes which will provide more hydrogeologic information in these areas, not the establishment of a municipal well. If the lithology of the proposed test holes matches that of the targeted borehole logs, then the well’s water production can be tested by pumping tests, and the results of those tests will provide more information on the well’s effectiveness as a municipal well. An examination of water quality concerns of the Study Area show nitrate concentrations exceeding the USEPA’s maximum contaminant load of 10.0 mg/L of nitrate for safe drinking water nearest the ‘A’ priority test hole in the Camp Creek Area. This should be considered for future development of test

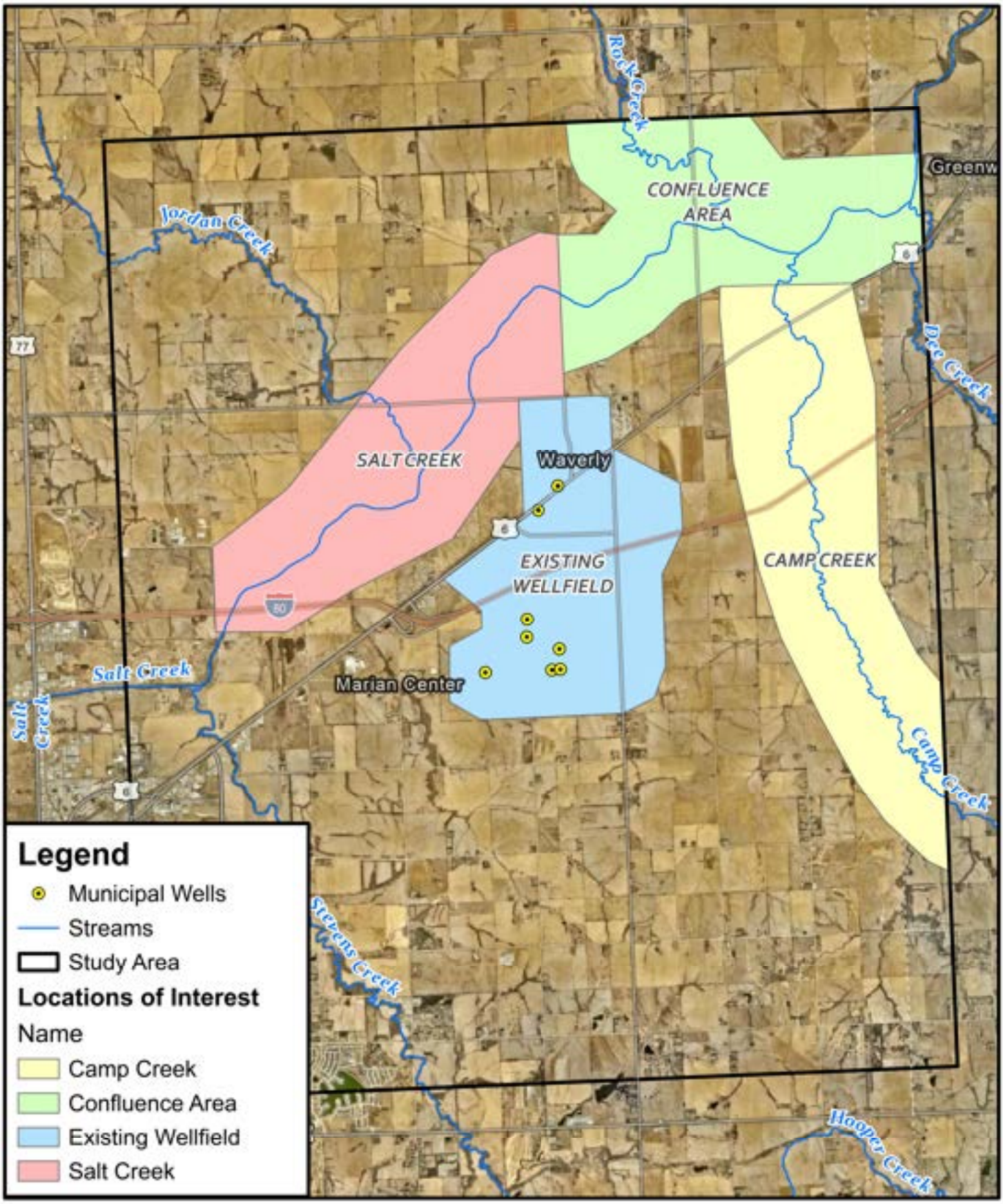
holes. Nitrate contamination is a complex issue; one in which concentrations of nitrate can vary greatly over short spatial distances. Moreover, proposed test hole locations may have nitrate concentrations that differ greatly compared to the measured samples nearby.

1. INTRODUCTION

The well siting recommendations in this report were completed by Olsson under contract with the City of Waverly, Nebraska. This document was prepared solely for the City of Waverly, Nebraska in accordance with the contract between the City of Waverly, Nebraska and Olsson dated November 30th, 2023. This document is only intended to be relied upon by the City of Waverly, Nebraska personnel that will use this analysis for consideration when estimating the longevity of the local groundwater system. All data, drawings, documents, or information contained in this report have been prepared exclusively for the City of Waverly, Nebraska and may not be relied upon by any other person or entity without the prior written consent by the City of Waverly, Nebraska.

This report was initiated to further assess the hydrogeological resources in the existing well field, the Camp Creek area, the Salt Creek area, and the area near the confluence of Salt, Rock, and Camp Creeks. Therefore, the primary objective of this well siting memo are to assess the groundwater resources in these areas with the intent of locating potential groundwater resources and propose potential test well locations. This well siting memo will cover the existing data, not already specified in the Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023), detail findings for each of the four areas, and propose potential test well locations within these areas. The proposed siting of test holes outside of the Existing Wellfield Area are based on hydrogeologic characteristics that affect water quantity including the lithology, water use, and water levels in the area and regulatory setbacks from active wells. The proposed test hole locations outside the Existing Wellfield Area do not consider water quality, potential costs, existing water distribution infrastructure, or legal jurisdiction to establish a well in that location.

The four locations of interest are delineated **Figure 1**: the existing wellfield, the Camp Creek area, the Salt Creek area, and the confluence area of Salt, Rock, and Camp Creek. Within these general locations, areas of noteworthy hydrogeologic characteristics will be identified and justified in the following sections. The same study area shall be used as was done previously in the Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023).



olsson

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1 INCH = 1.5 MILES

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Nebraska FIPS 2600 Feet

LOCATIONS OF INTEREST

WELL SITING MEMO
WAVERLY, NE

FIGURE

1

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2. EXISTING WELLFIELD

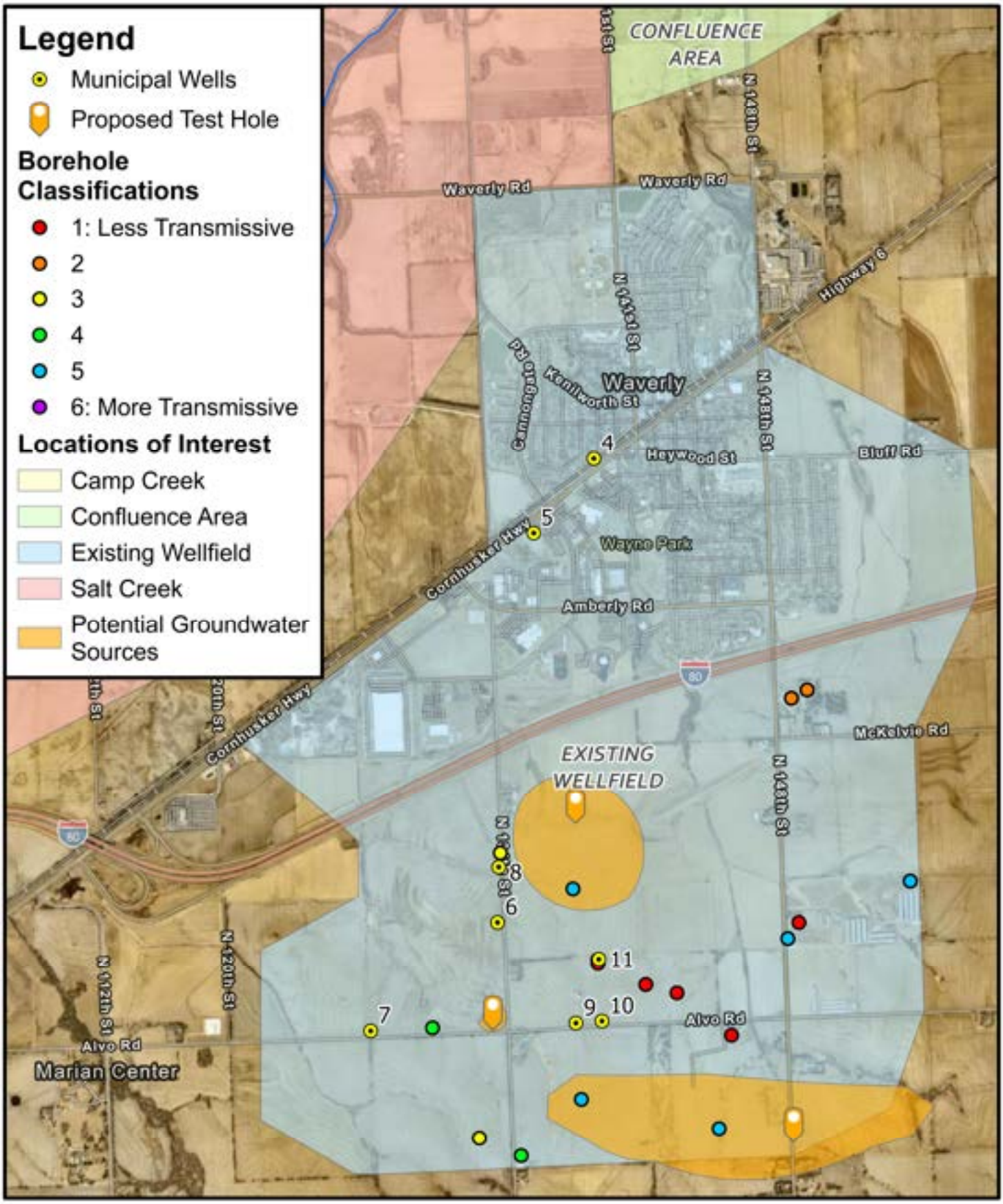
The data covering Waverly's existing wellfield was explored in detail in the Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). This memo builds on the understanding of the hydrogeologic resource at Waverly's wellfield established in the Hydrogeologic Analysis Report (Olsson, 2023). The following sections detail three areas with noteworthy hydrogeologic characteristics near the existing wellfield. These three noteworthy areas are identified in **Figure 2**. It should be noted that this area is focused on the south end of Waverly's wellfield and the areas near Waverly's existing water distribution infrastructure north of Interstate-80 are detailed in **Sections 3-5.**

2.1 Current Water Extraction

In the existing wellfield area there are seven active municipal wells. The extraction rates from these seven municipal wells are detailed in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). Including these seven municipal wells, there are other active extraction wells that are making use of the hydrogeologic resource in this area, such as irrigation and domestic wells; all active registered wells are detailed in **Table 1**. The details of **Table 1** are not listed to quantify the amount of water being extracted from the aquifer in this area, but to provide a generalized metric to interpret the existing withdrawals on the aquifer in the area.

Table 1. Active Registered Wells in Existing Wellfield Area

Well Type	Number of Active Wells
Municipal	7
Irrigation	6
Domestic	10
Ground Heat Exchange	7
Monitoring/ Observation	9
Commercial/ Industrial	2
Livestock	2
Other	2
Total	45



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1 INCH = 0.5 MILES

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Nebraska FIPS 2600 Feet

BOREHOLE CLASSIFICATIONS IN EXISTING WELLFIELD

WELL SITING MEMO
WAVERLY, NE

FIGURE

2

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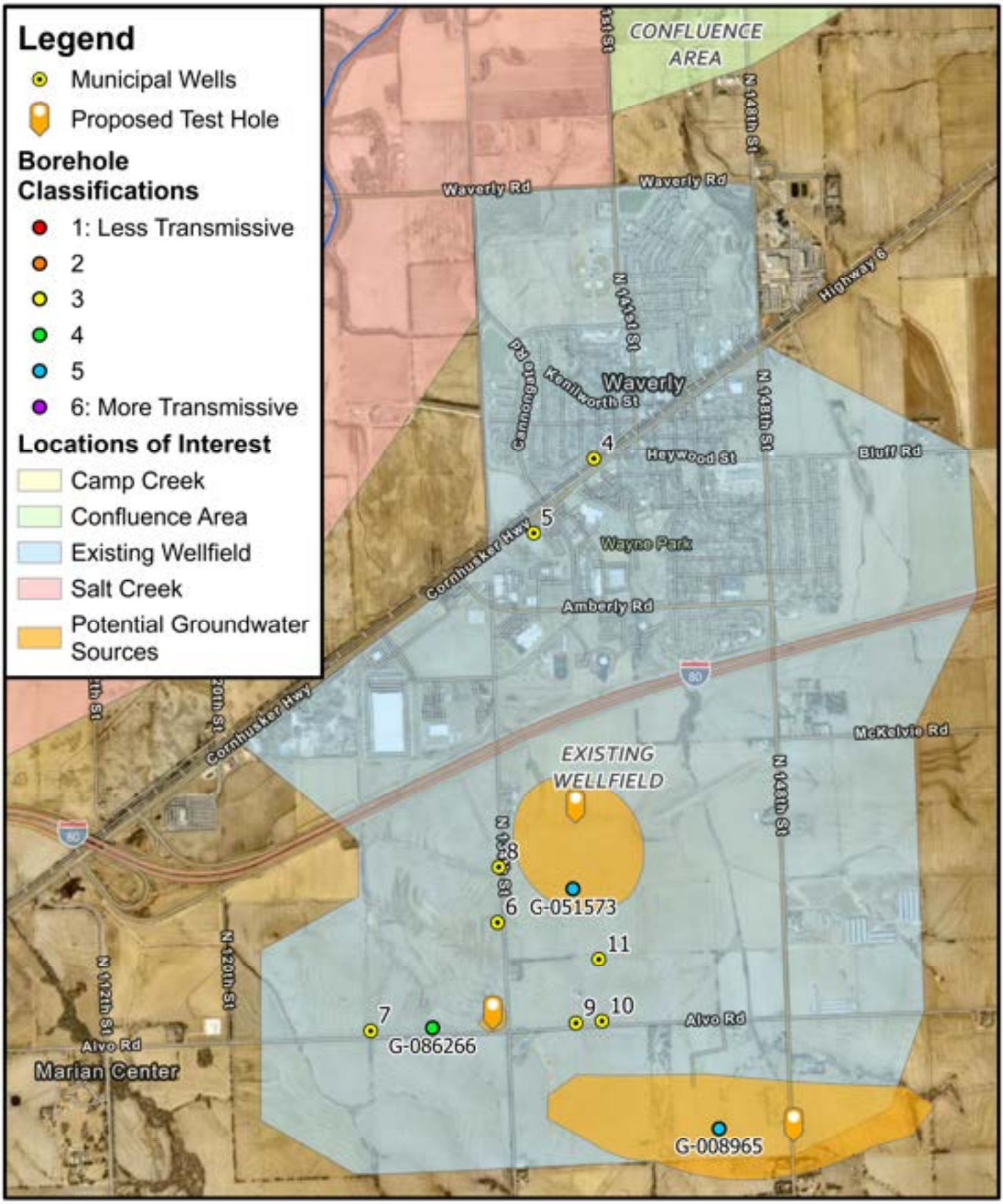
2.2 Borehole Analysis

Borehole logs from the NDNR Registered Well Database were evaluated to create a subjective transmissivity estimate for each well. The first step in this process involved the selection of wells throughout the location of interest, in this case the Existing Wellfield, to provide ample data coverage across the area. Next, the borehole logs of the selected wells were individually assigned a relative transmissivity estimate based on the hydrogeologic properties of the listed materials and intervals described in the borehole log from the NDNR Registered Well Database. A well's subjective transmissivity estimate was assigned a value between 1 through 6; a value of 1 being less transmissive (e.g. a borehole log that has large intervals of less transmissive materials and confining layers like dense clay and shale layers, with little to no intervals of more transmissive materials like course-grained sand) and a value of 6 being more transmissive (e.g. a well with an 80' interval of highly transmissive materials coarse sand & gravels with little to no intervals of less transmissive materials like dense clays).

The locations of the borehole logs that were evaluated in the Existing Wellfield Area are displayed in **Figure 2** with their associated ratings. The borehole transmissivity classifications throughout this memo are, in part, used to delineate potential groundwater sources, as shown in **Figure 2**. The areas delineated as potential groundwater sources are areas in which the lithology suggests a highly transmissive area. The water table is present throughout the study area; therefore these delineated areas should not be interpreted as the only areas where the water table is present. Two of the potential groundwater sources within the Existing Wellfield Area are identified as such, partially, due to the borehole classifications of the nearby wells. The final step in the process of evaluating borehole logs was to identify existing wells that have transmissive lithologies that should be targeted for proposed test holes. These wells within the Existing Wellfield Area are identified in **Figure 3**. The well diagrams for these wells can be found in **Appendix A**. Beginning in the west, G-086266, the closest well to the proposed test hole at the corner of Alvo Rd. and N 134th St. has a about a 45' to 50' interval of sandstone, similar to Waverly's domestic Well 7 and 10. This area will be explained in greater depth under **Section 2.3**. G-051573, the closest well to the northernmost proposed test hole, has sandstone intervals beginning at a depth of 20' and continuing to about 170', with a few layers of fine grained material. This location was selected for its seemingly high transmissive borehole log and its proximity to municipal Well 8, which is one of the existing municipal wells that is not immediately threatened by lowering water levels in the area (Olsson, 2023). Lastly, G-008965, the closest well to the southeastern proposed test hole in the Existing Wellfield Area, has a nearly 80' interval of sandstone down to a depth of 147'.



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1 INCH = 0.5 MILES

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Nebraska FIPS 2600 Feet

BOREHOLE DIAGRAMS IN EXISTING WELLFIELD

WELL SITING MEMO
WAVERLY, NE

FIGURE

3

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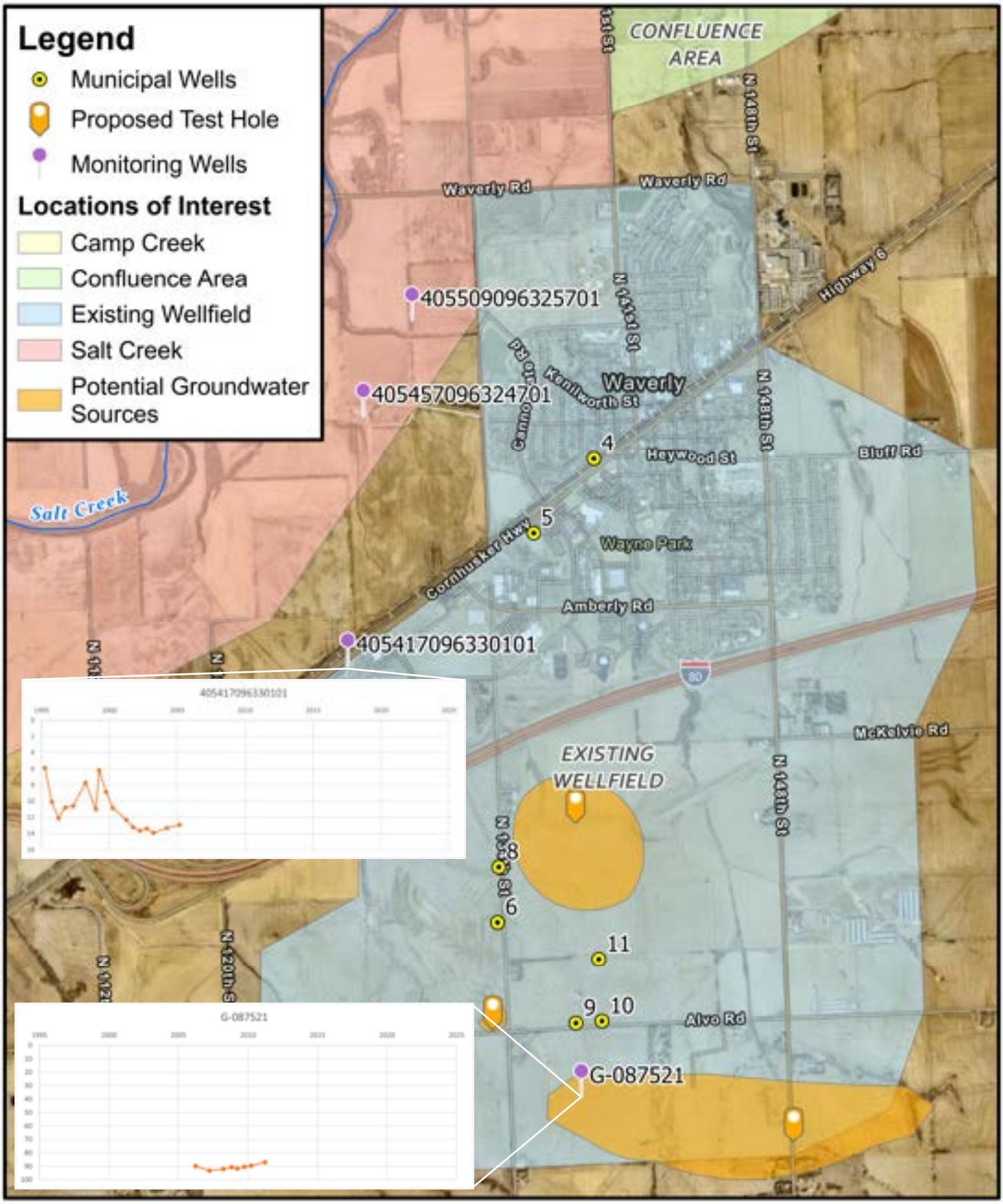
2.3 AEM Analysis

The Existing Wellfield Area has the most available aerial electromagnetic (AEM) data of the four locations of interest in this memo. Therefore, the proposed test hole locations in this area were the most extensively cross-examined between the borehole logs and the AEM resistivity data. Figures of all AEM flight lines in the study area can be found in **Appendix B** of the Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). This memo focuses on the specific flight lines that pertain to the siting of proposed test holes, all flightlines used in these evaluations can be found in **Appendix B** of this memo. The western potential groundwater source in the Existing Wellfield was delineated based on the area having higher resistivity values for a large interval similar to the existing municipal wells nearby. More specifically, the westernmost proposed test hole is sited to target the 70' sand and gravel interval observed in Waverly's municipal Well 7. The figures pertaining to this proposed test hole are along flight lines L143501 and L175001. The siting of the northern proposed test hole was most informed by flight lines L175601 and L176001. This proposed test hole is sited to target a 70' sandstone layer observed in G-051573, as described in **Section 2.2**. Lastly, the southeastern proposed groundwater source was delineated following large sandstone intervals in both G-008965 and G-087521. The AEM data indicates that there is a large area of high resistivity values south along Alvo Rd. beginning east of 134th St. and extending east past 141st St.

2.4 Trends in Groundwater Levels

Groundwater level monitoring in the Existing Wellfield is best observed in the static water level figures of Waverly's municipal wells in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). As discussed in the previous report, water level declines are seen in all the static water levels of Waverly's municipal wells as well as the nearby USGS wells (Olsson, 2023). The monitoring wells within the existing wellfield depicted in **Figure 4**, along with the depth to water measurements since the January 1995. What can be gleaned from the data that was captured at these locations is the relative depths of the water table at its location. G-087521 has its most recent sample dated back to April 2011, and had a depth to water of 87' below ground surface. Waverly's municipal wells have much more detailed and continuous water level monitoring as displayed in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). In that Hydrogeologic Analysis Report it is evident that water levels in the Existing Wellfield Area are experiencing recent declines, and more drastic declines over the past three years. This recent decline in water levels can be expected at the proposed test hole locations in the Existing Wellfield Area. These water level declines may impact a potential municipal wells ability to stay above the shutoff pumping water level as exemplified by Waverly's municipal Well 7 as described in the previous report (Olsson, 2023).The water levels from Waverly's municipal wells provide some insight into the direction of water level trends in the area but does not inform the magnitude of the water level trends in the three proposed areas.



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1 INCH = 0.5 MILES

NAD 1983 StatePlane
Nebraska FIPS 2600 Feet

WATER LEVEL MONITORING LOCATIONS

WELL SITING MEMO
WAVERLY, NE

FIGURE

4

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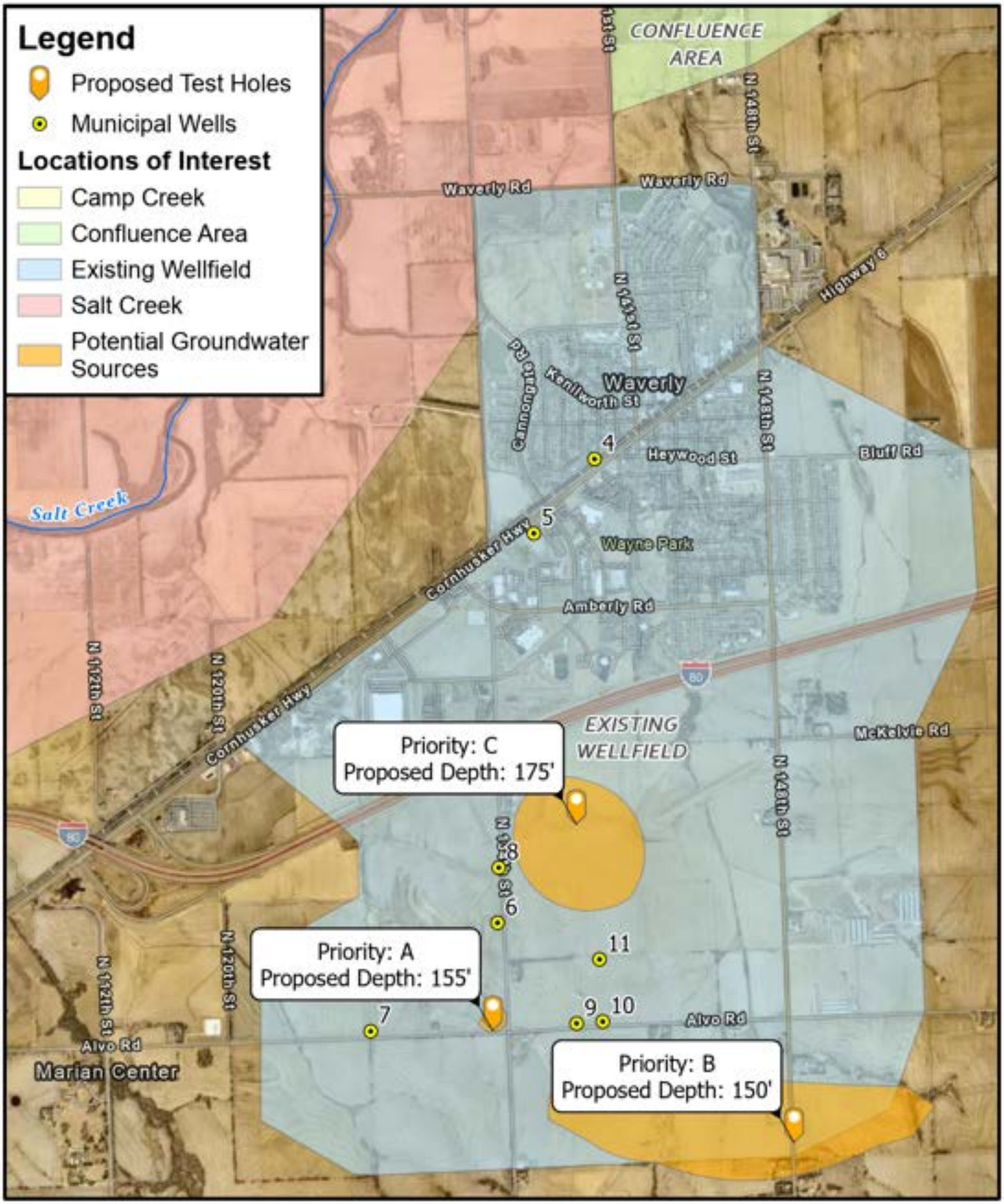
2.5 Recommendations

Within the Existing Wellfield Area, three proposed test holes are identified and are prioritized in terms of which test hole the Olsson team suggests should be targeted prior to other proposed test holes in the area these can be seen in **Figure 5**. In this figure, the priority follows the alphabet in decreasing priority, therefore the proposed test hole labeled with an 'A' would be the highest priority test hole in the area, because the Existing Wellfield Area has three proposed test holes, the lowest priority in the area has a 'C' rating. The proposed test hole with an 'A' priority, located east of Waverly's municipal Well 7. The 'A' priority test hole was sited based on its proximity to the productive lithology of municipal Well 7, the estimated transmissivity of a water table that matches that observed in the municipal wellfield, and the AEM resistivity displaying a large interval of resistive material that could imply a large interval of coarse-grained materials. Secondly, the southernmost proposed test hole was given the 'B' priority because of the transmissive borehole logs nearby and the AEM data showing a large interval of coarse-grained material. Lastly, the 'C' priority well in the existing wellfield area still displays what seems to be a good transmissivity mostly based on the depth of the nearby boreholes and is reinforces by AEM data.



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1 INCH = 0.5 MILES

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Nebraska FIPS 2600 Feet

TEST HOLE PRIORITIZATION IN EXISTING WELLFIELD

WELL SITING MEMO
WAVERLY, NE

FIGURE

5

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3. CAMP CREEK AREA

The Camp Creek Area is located east of the existing wellfield along Camp Creek, from where it enters the study area, north to its confluence with Salt Creek and extending roughly 3/4 of a mile in either direction. This area was not evaluated to the same extent that the Existing Wellfield Area in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). There are limitations to the available data in this area, including the lack of AEM flight lines covering this area. Nonetheless, interpretations of hydrogeologic data that led to the delineation of two potential groundwater sources and the siting of three proposed test holes within the Camp Creek Area, displayed in **Figure 6**, are described in this section.

3.1 Current Water Extraction

Within the Camp Creek Area, there are 25 active registered wells, with further detail in **Table 2**. As mentioned in **Section 2.1**, the details of **Table 2** are not listed to quantify the amount of water being extracted from the aquifer in this area, but to provide a generalized metric to interpret the existing withdrawals on the aquifer in the area. The number of wells in an area can be an indication of the presence of an adequate aquifer resource in the area.

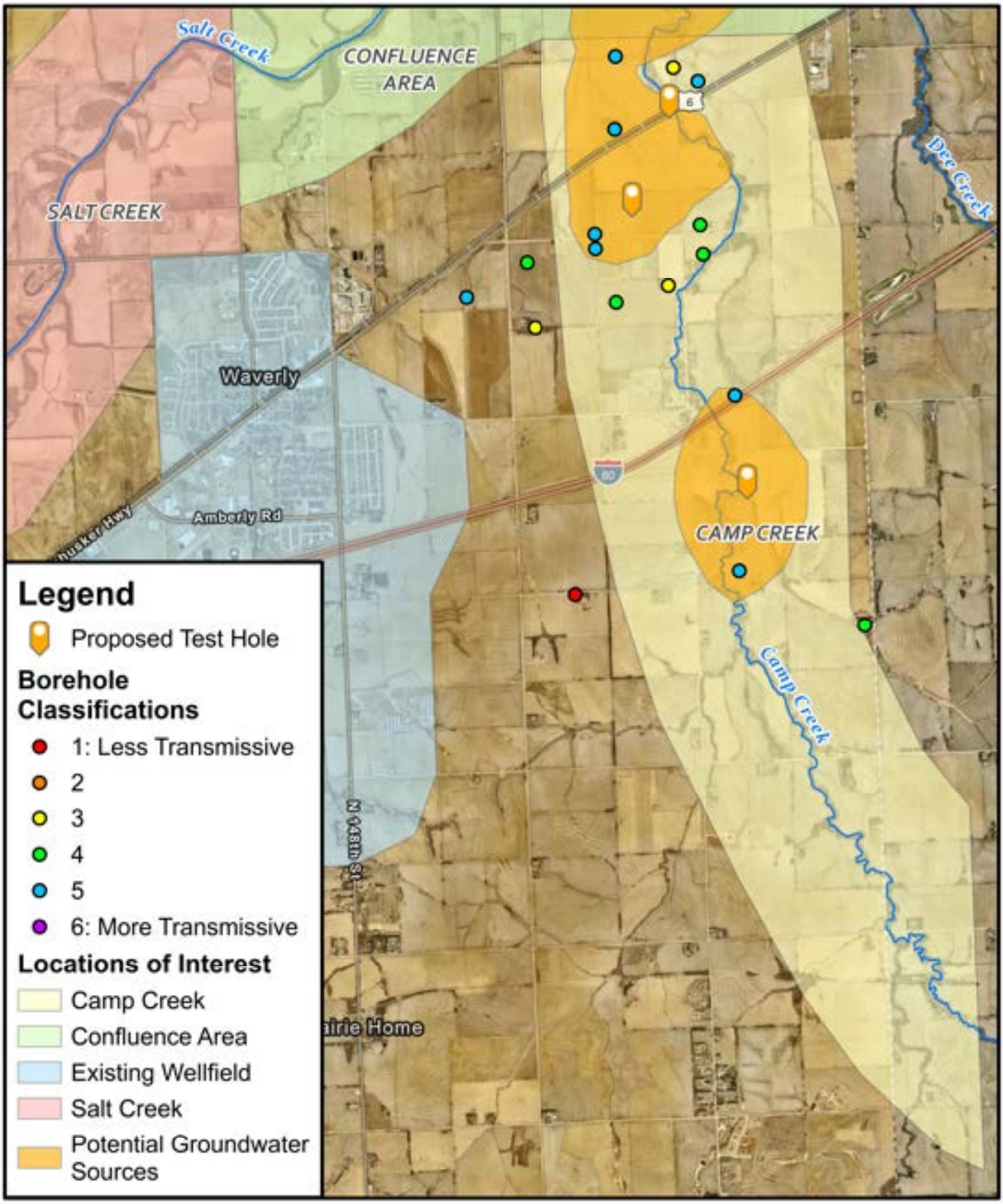
Table 2. Active Registered Wells in the Camp Creek Area

Well Type	Number of Active Wells
Municipal	-
Irrigation	12
Domestic	8
Ground Heat Exchange	1
Monitoring/ Observation	3
Commercial/ Industrial	-
Livestock	-
Other	1
Total	25

3.2 Borehole Analysis

The locations of the borehole logs that were evaluated in the Camp Creek Area are displayed in **Figure 6** with their associated ratings. The borehole classifications within the Camp Creek Area were important in the delineation of the two potential groundwater sources within the area, as other data sources were limited compared to the Exiting Wellfield Area. Overall, there seemed to be more coarse-grained sands and gravels, and sandstones along Camp Creek, and north of McKelvie Rd. There are two areas in which the borehole data alluded to highly transmissive areas, a southern area between McKelvie Rd. and Interstate-80, and N 176th St. and N 190th St.

The second northern area begins at Waverly Rd. and extends north into the Confluence Area, this section will focus on the portion of this area within the Camp Creek Area. Three well



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1 INCH = 0.75 MILES

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BOREHOLE CLASSIFICATIONS IN CAMP CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

6

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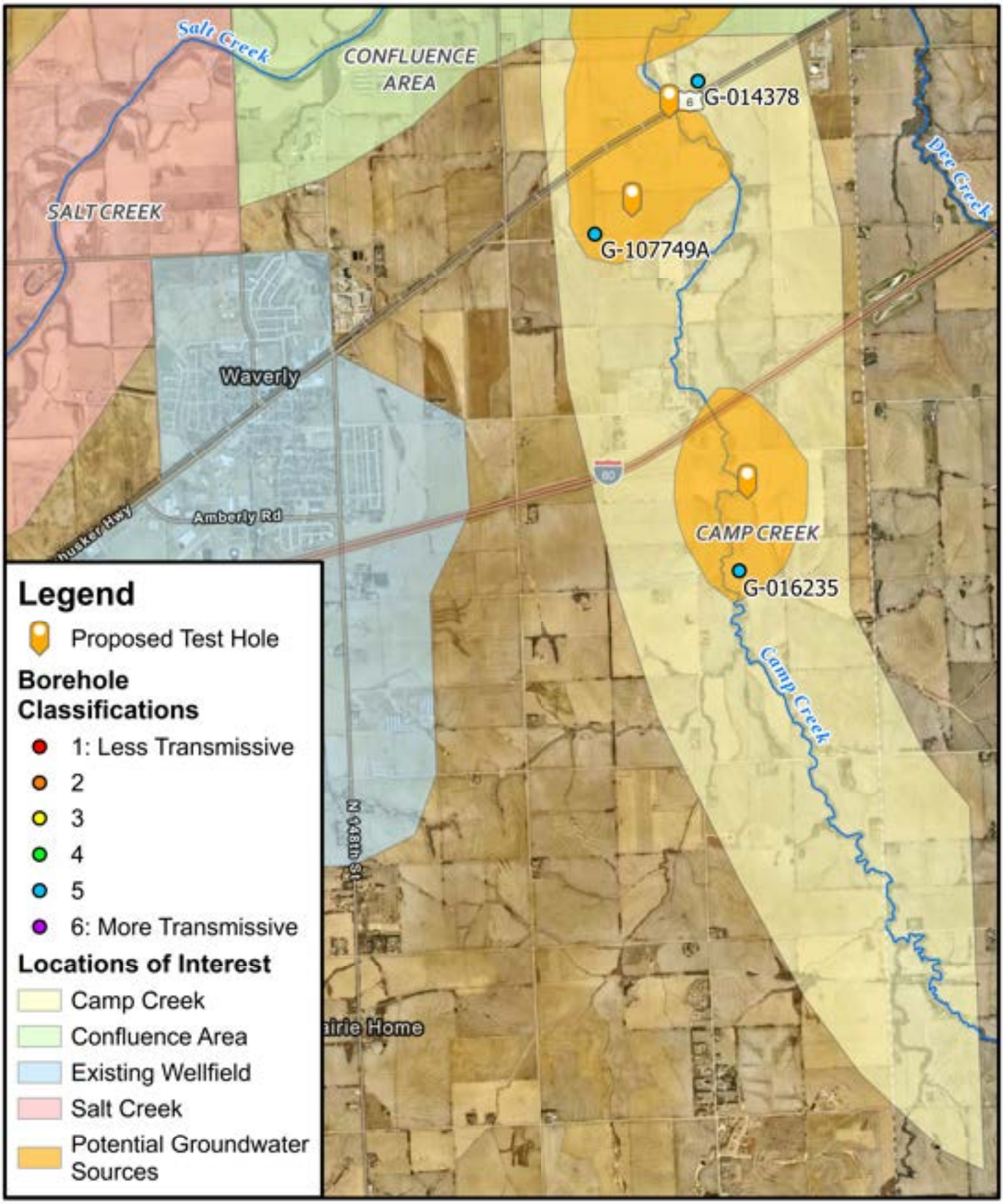
diagrams were selected as representative target lithologies for the three proposed test holes in the Camp Creek Area, these well diagrams can be found in **Appendix A**. Additionally, these wells are called out in **Figure 7**.

Starting in the south and moving north, the southern potential groundwater source was informed by G-016235, which has a 45’ interval of sands and gravels from a depth of 20’ to about 65’. The middle proposed test hole in the Camp Creek Area is proposed to target the 45’ interval of coarse-grained sands with another 20’ of sandstone beneath reaching a depth of 105’, as observed in G-107749A. Lastly, the northernmost proposed test hole should target the 45’ sand and gravel interval that extends to a depth of 91’ which is present in the borehole log for G-014378.

3.3 AEM Analysis

AEM flight lines in the Camp Creek Area were much more limited than those in the Existing Wellfield Area. Regardless, flight lines were used in the siting of all three proposed test holes in this area, and the flight lines provide support for the lithologies represented in the NDNR borehole logs. Flight line L142501 presents the resistivity near G-016235, which was cited in the previous section, and displays that the coarse-grained material may extend deeper than the borehole log displays, additionally, it shows that the east side of Camp Creek in this area has a larger amount of high-resistivity materials than the west side in this upstream portion of Camp Creek. Flight line L300401 is a partial reasoning for the siting of the northern two proposed test holes in the Camp Creek Area; this flight line allows for the targeting of the pair of a 45’ sand and gravel interval and a 20’ sandstone interval found in G-107749A.



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1 INCH = 0.75 MILES

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BOREHOLE DIAGRAMS IN CAMP CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

7

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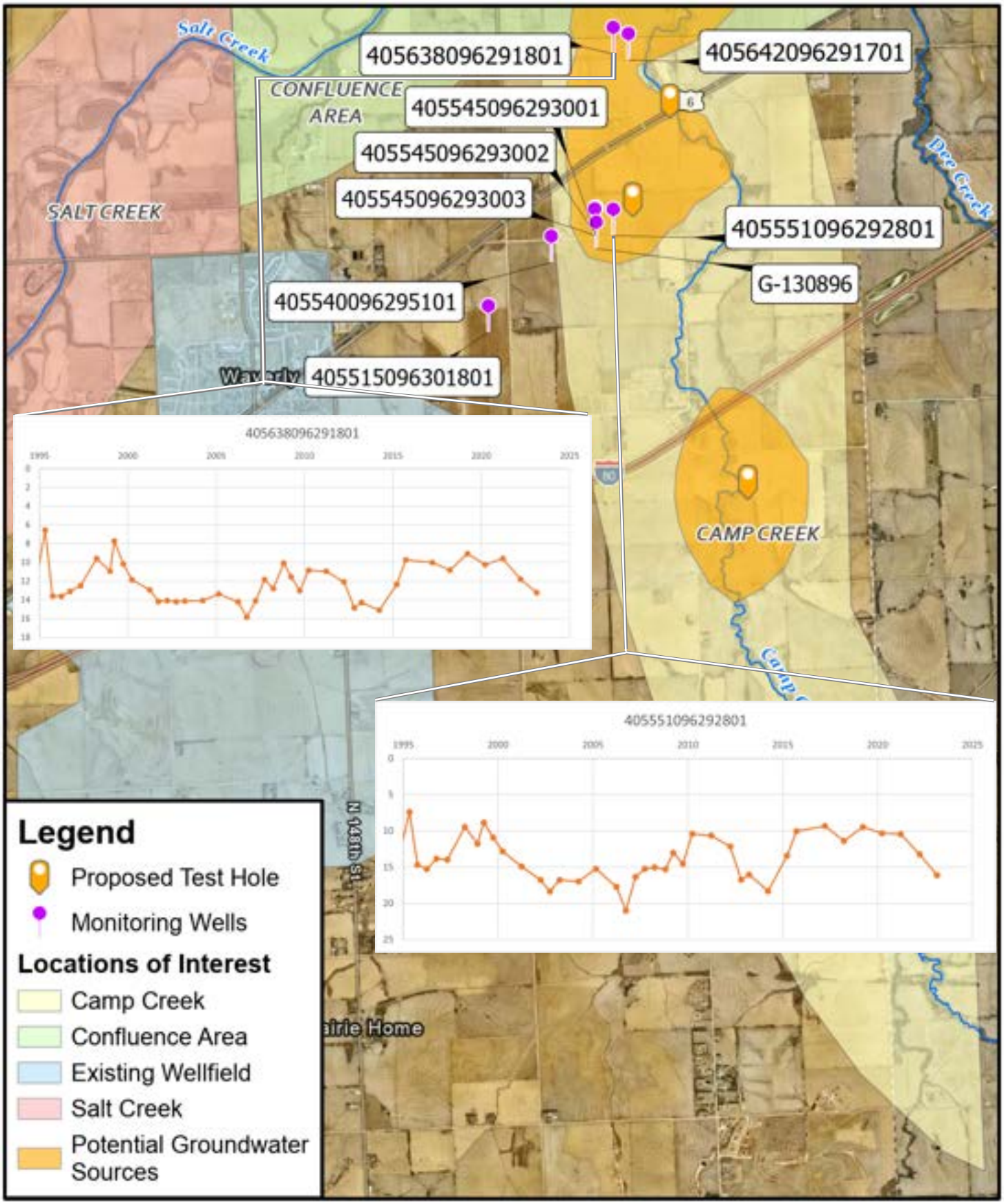
3.4 Trends in Groundwater Levels

Moving from south to north, there is no additional information to inform the water levels at the southernmost proposed test hole. The water levels at this location will presumably be similar to those seen at monitoring well 405638096291801, as this monitoring location is close to Camp Creek, which will have an affect on the water table at this proposed site. As can be seen in **Figure 8**, the water levels at both 405551096292801 and 405638096291801 have seen declines over the past three years, similar to what has been seen at Waverly's municipal wells. Both of the charts in this figure display the depth to water at these locations going back to 1995; the most recent water level measurements remain a few feet above the lowest these sites have been measured at over the 27 year range displayed. These sites were chosen for both the completeness of the dataset and for the proximity to the proposed test hole locations.



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1 INCH = 0.75 MILES

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MONITORING LOCATIONS IN CAMP CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE 8

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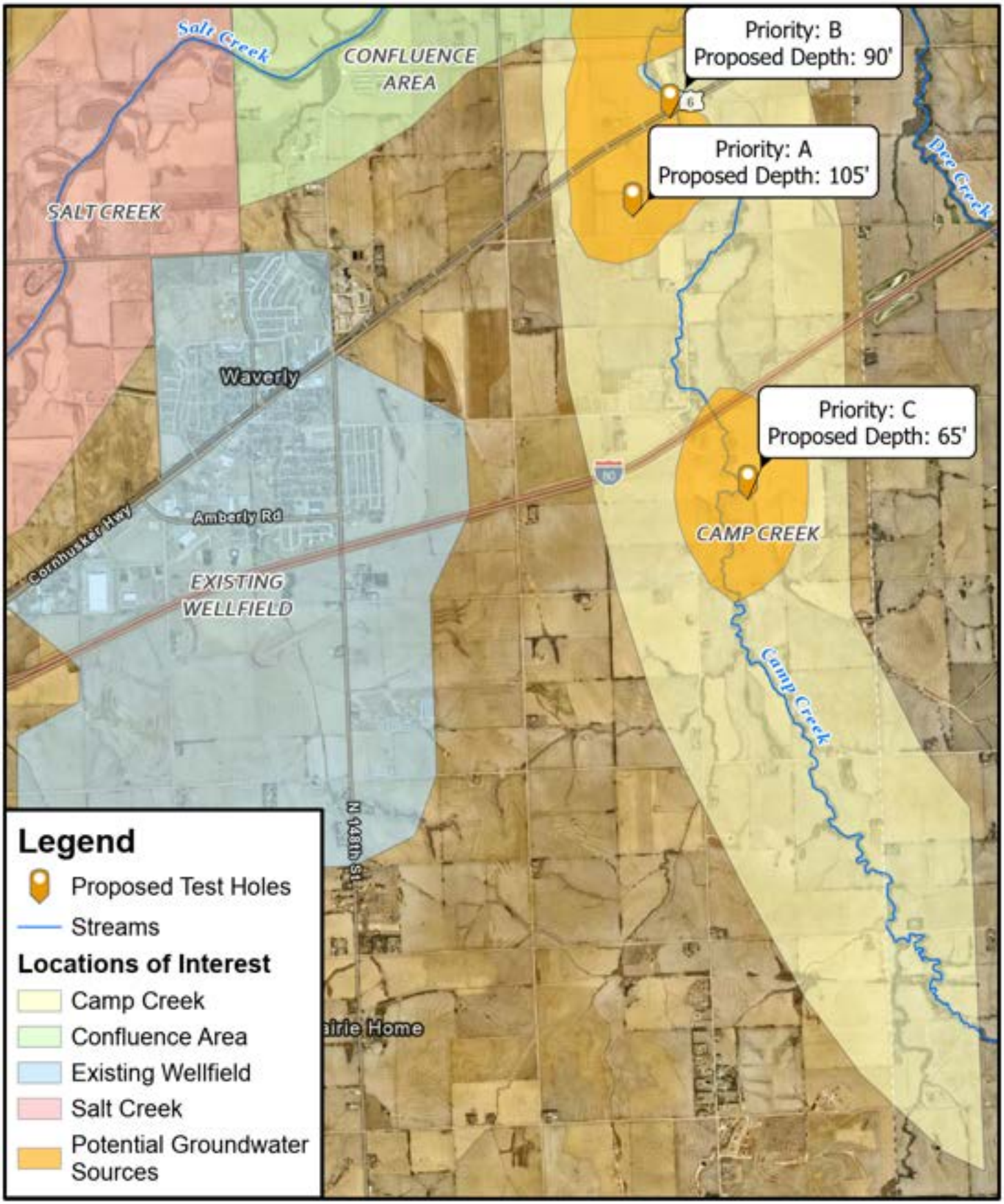
3.5 Recommendations

There are three recommended test holes in the Camp Creek Area, as seen in **Figure 9**, the ratings in this area follow the format as described for the Existing Wellfield Area in **Section 2.5**. The ‘A’ priority well in the Camp Creek Area is located west of Camp Creek and south of U.S. Highway 6. This siting of a proposed test hole is aimed at targeting the lithology seen in nearby borehole logs and the AEM data. Of the three test holes in this area, this well is targeted to be nearest the intersection of a higher water table, borehole logs that have decent depths, and conductive lithologies seen in the borehole logs. The ‘B’ priority well is sited in a similar location as the ‘A’ priority well, only that the borehole logs imply a shorter potential well depth, leading to a less transmissive well. The ‘C’ priority is supported by the AEM data, the borehole logs, and will have a similar water table as Waverly’s municipal wellfield, although the shorter potential depth of this well limits it possible transmissivity, leading it to be the lowest priority test hole of the three in this location.



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1 INCH = 0.75 MILES

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TEST HOLE PRIORITIZATION IN CAMP CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

9

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4. SALT CREEK AREA

The Salt Creek Area is located west and north of the existing wellfield along Salt Creek, from approximately 1 mile away from where the creek enters the study area, following Salt Creek to N 141st St., and extending roughly 3/4 of a mile in either direction of the creek. This area was not evaluated to the same extent that the Existing Wellfield Area in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). There are limitations to the available data in this area, including the lack of AEM flight lines covering this area. Nonetheless, interpretations of hydrogeologic data that led to the delineation of three potential groundwater sources and the siting of four proposed test holes within the Salt Creek Area, displayed in **Figure 10**, are described in this section.

4.1 Current Water Extraction

Within the Salt Creek Area, there are 15 active registered wells, with further detail in **Table 3**. As mentioned previously, the details of **Table 3** are not listed to quantify the amount of water being extracted from the aquifer in this area, but to provide a generalized metric to interpret the existing withdrawals on the aquifer in the area. The number of wells in an area can be an indication of the presence of an adequate aquifer resource in the area.

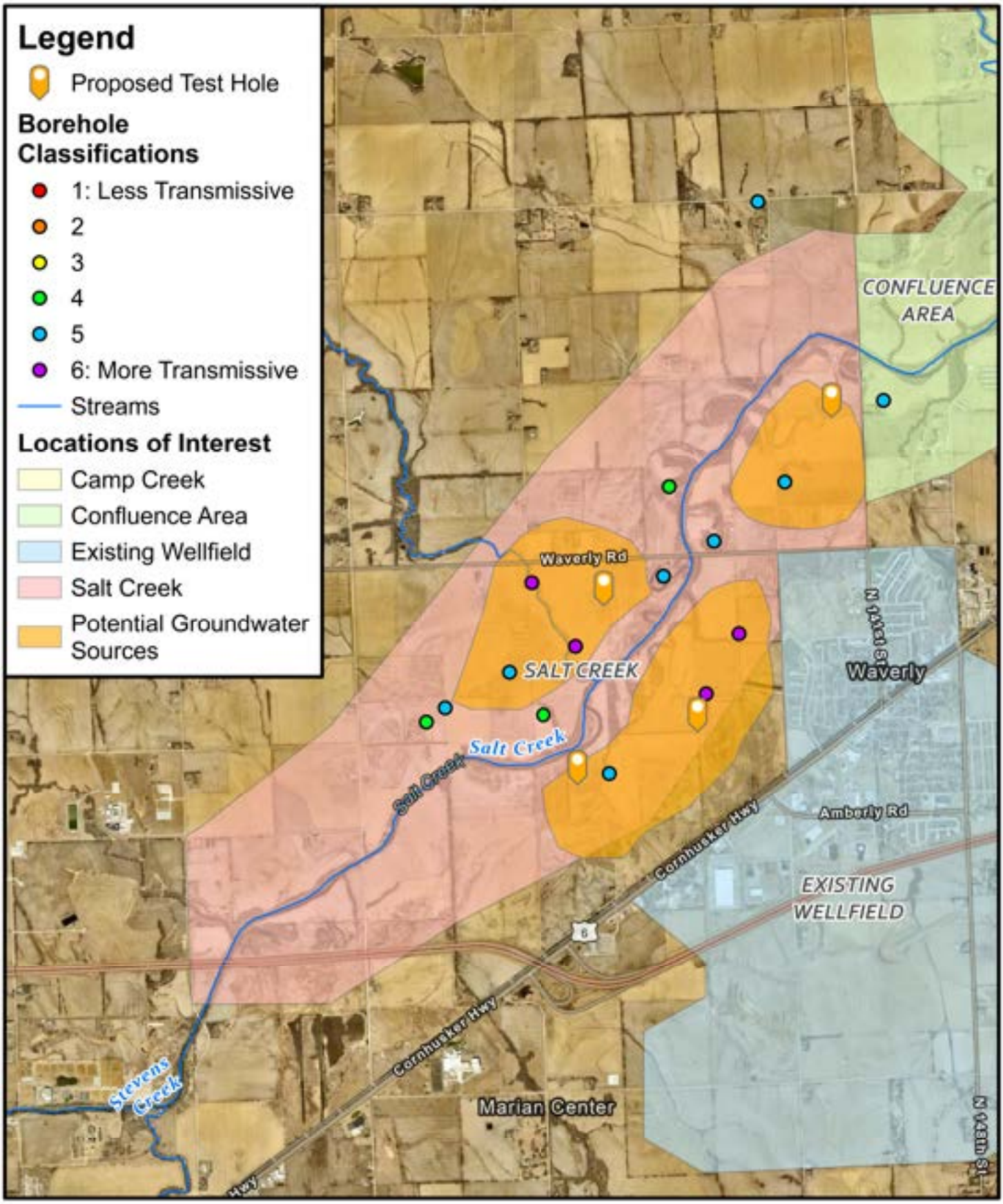
Table 3. Active Registered Wells in the Salt Creek Area

Well Type	Number of Active Wells
Municipal	-
Irrigation	10
Domestic	3
Ground Heat Exchange	1
Monitoring/ Observation	1
Commercial/ Industrial	-
Livestock	-
Other	-
Total	15

4.2 Borehole Analysis

The locations of the borehole logs that were evaluated in the Salt Creek Area are displayed in **Figure 10** with their associated ratings. The borehole classifications within the Salt Creek Area were important in the delineation of all three of the potential groundwater sources within area, as AEM data coverage in this area is limited. Overall, there seemed to be more coarse-grained sands and gravels, and sandstones along Salt Creek, especially on the south side of the creek between N 112th St and N 134th St. The other areas identified as potential groundwater sources

are to the northwest of Salt Creek covering the end of Jordan Creek and just west of N 141st St. Four well diagrams were selected as representative target lithologies for the four proposed test



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1 INCH = 0.75 MILES

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WELL CLASSIFICATIONS IN SALT CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

10

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holes in the Camp Creek Area, these well diagrams can be found in **Appendix A**. Additionally, these wells are called out in **Figure 11**.

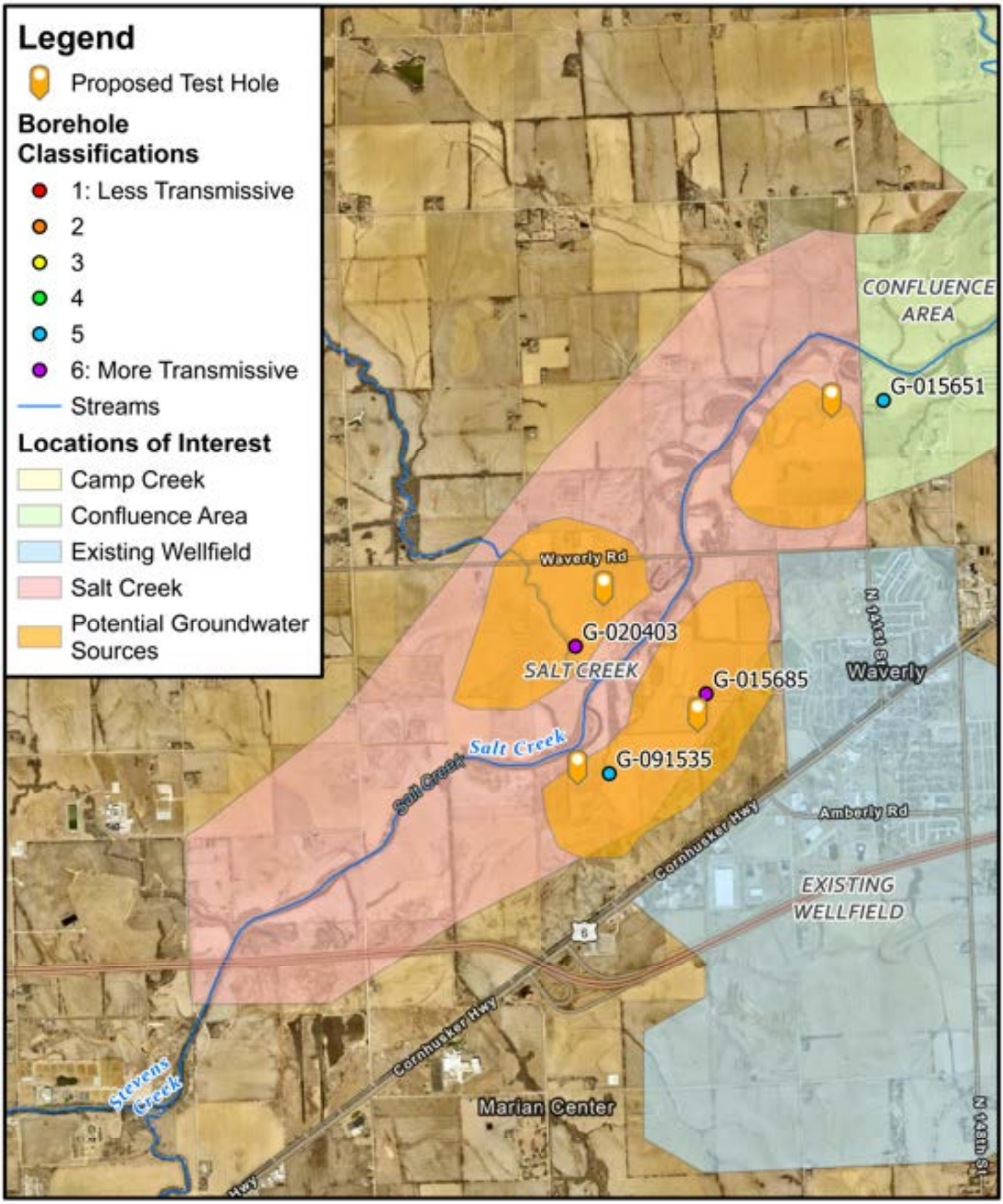
The target lithologies for the proposed test holes in the southernmost potential groundwater source area are an 85' interval of sand and gravels with a few thin layers of clay seen at G-091535 and a 60' interval of sand and gravel observed at G-015685. Moving to the potential groundwater source area covering Jordan Creek to the northwest of Salt Creek, G-020403 has a 40' interval of gravel at a shallower depth than the previous two wells should be targeted at this location. Lastly, G-015651 has sand and gravel intervals that are interbedded with clay layers that extends down to a depth of 90'.

4.3 AEM Analysis

Similarly to the Camp Creek Area, the AEM flight lines in the Salt Creek Area were much more limited than those in the Existing Wellfield Area. This led to the use of only a single flight line to provide support for the lithologies represented in the NDNR borehole logs. Flight line L413700 presents resistivity in the potential groundwater areas covering Jordan Creek and the southernmost area as having high resistivity values and displays that the coarse-grained materials seen in G-019585 and G-015685 may also be present in these two potential groundwater sources where they intersect the flight line. Flight line L413700 strengthened the siting of the two westernmost proposed test holes as there appears to be a thick interval of resistive materials to both the north and south of Salt Creek along this flight line. The figure containing this flight line can be found in **Appendix B**.

4.4 Trends in Groundwater Levels

Two groundwater monitoring wells are located near the two proposed test holes in the potential groundwater source area closest to Cornhusker Hwy., just to the west of Waverly, as seen in **Figure 12**. These two wells have varying temporal availability in the data but monitoring well 405457096324701 shows the decline over the past three years that has been seen in the other locations of interest. Similarly, the most recent measurement is also not the lowest that the water level has been recorded since 1995. Because each of these proposed test holes are located near Salt Creek, it is reasonable to assume that the water levels at each of these proposed test holes would be similar to one another and typically at a shallower depth than the Waverly municipal wells screened in the Dakota Aquifer south of Interstate-80.



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olsson

N

0 1 Miles
1 INCH = 0.75 MILES

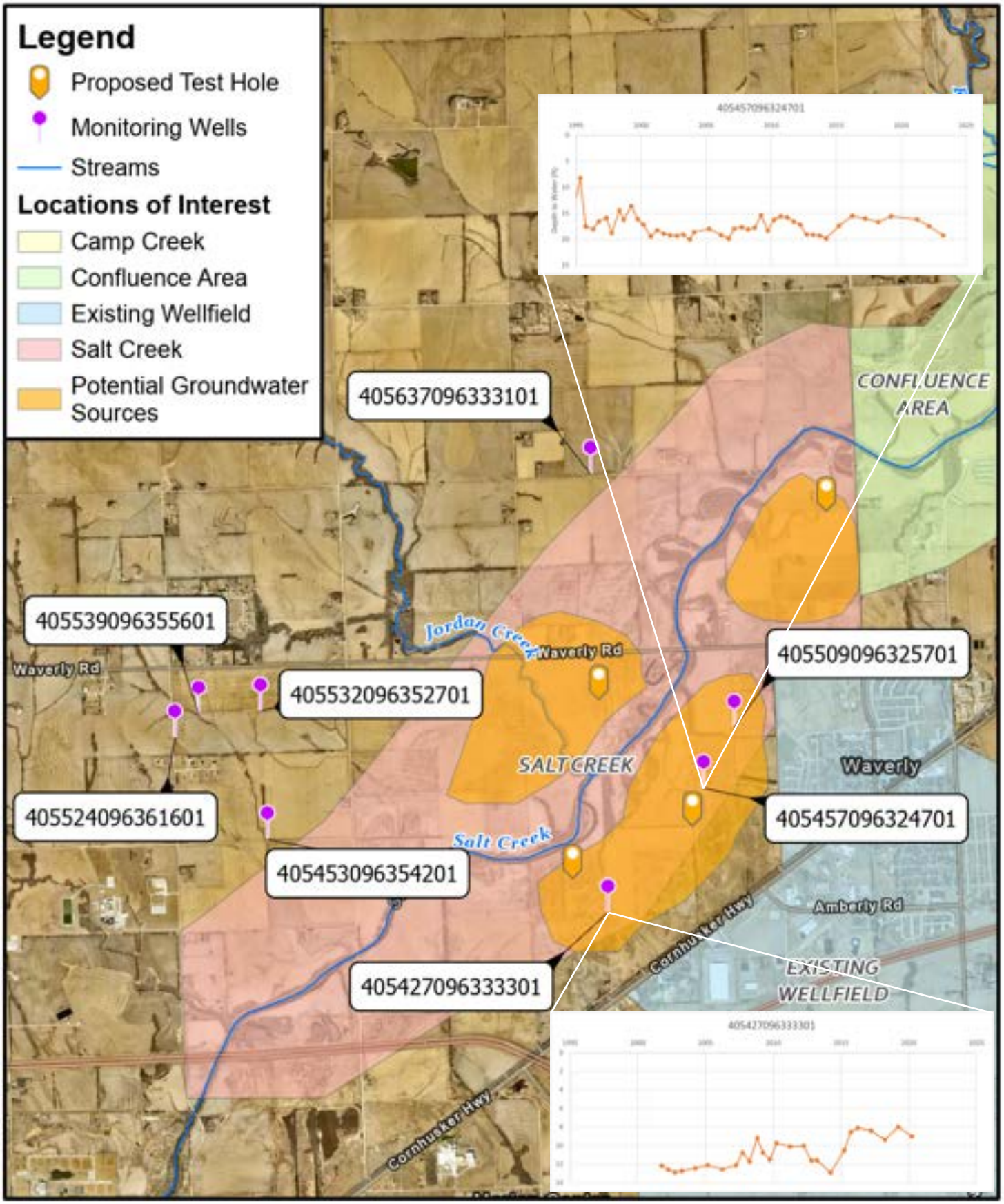
NAD 1983 StatePlane
Nebraska FIPS 2600 Feet

WELL DIAGRAMS IN SALT CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

11



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1 INCH = 0.75 MILES

NAD 1983 StatePlane Nebraska FIPS 2600 Feet

MONITORING LOCATIONS IN SALT CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

12

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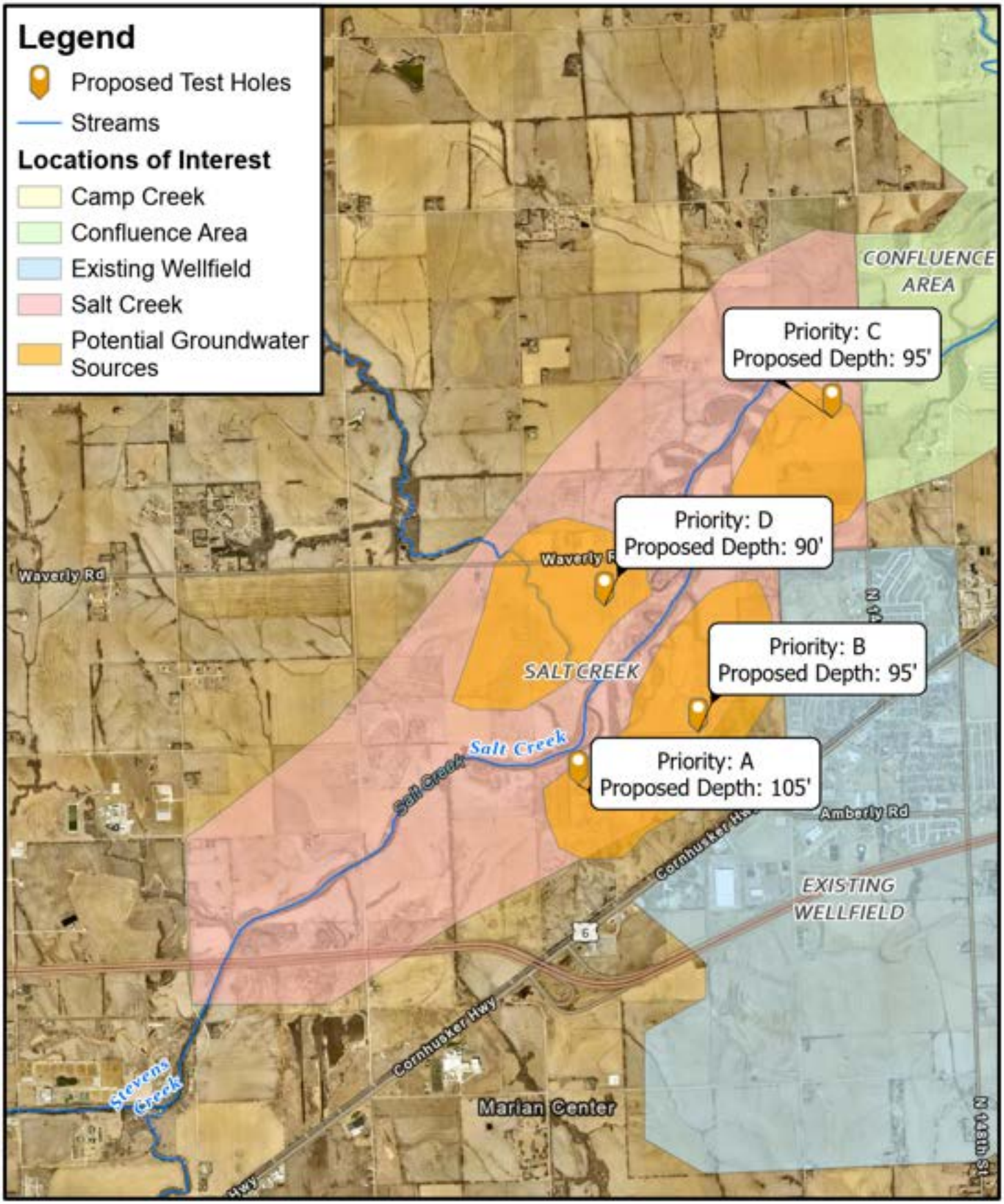
4.5 Recommendations

There are four proposed test holes in the Salt Creek Area, with the ‘A’ priority being the highest priority for a potential test well, and the ‘D’ priority being the lowest in this area, these can be seen in **Figure 13**. The ‘A’ priority well is the southernmost well in the Salt Creek Area and has been identified as the highest priority well because of the apparent transmissivity of the location, a high water table as seen in the monitoring wells nearby, and large intervals of coarse-grained materials seen in both the AEM data and NDNR borehole logs. The ‘B’ priority is very similar to the ‘A’ priority well in this location of interest and is given the ‘B’ priority because of the shorter potential depth of the well compared to the ‘A’ priority well. The ‘C’ priority well in the northeastern portion of the Salt Creek Area has a lithology that does not appear to be as transmissive as the coarse-grained sands and gravels that have been observed near the ‘A’ and ‘B’ priority test hole locations, but presumably has a similar potential depth and water table elevations. Lastly, the ‘D’ priority well in this location appears to have a large interval of coarse-grained materials according to the AEM data, but the borehole logs near this well indicate a thick clay layer above the coarse-grained materials, leading this well to be considered a lower priority than the other three proposed test holes in this area.



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1 INCH = 0.75 MILES

NAD 1983 StatePlane Nebraska FIPS 2600 Feet

TEST HOLE PRIORITIZATION IN SALT CREEK AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

13

5. CONFLUENCE AREA OF SALT, ROCK, AND CAMP CREEKS

The Confluence Area of Salt, Rock, and Camp Creeks, henceforth referred to as the Confluence Area, is aptly located at the confluence of Salt, Rock, and Camp Creeks and is bounded by N 141st St. to the west, Branched Oak Rd. to the north, the city of Greenwood to the east, and is neighbored to the south by the Camp Creek Area. This area was not evaluated to the same extent that the Existing Wellfield Area in the previous Waverly Wellfield Hydrogeologic Analysis Report (Olsson, 2023). There are limitations to the available data in this area, including the lack of AEM flight lines covering this area. Nonetheless, interpretations of hydrogeologic data that led to the delineation of two potential groundwater sources and the siting of three proposed test holes within the Confluence Area, displayed in **Figure 14**, are described in this section.

5.1 Current Water Extraction

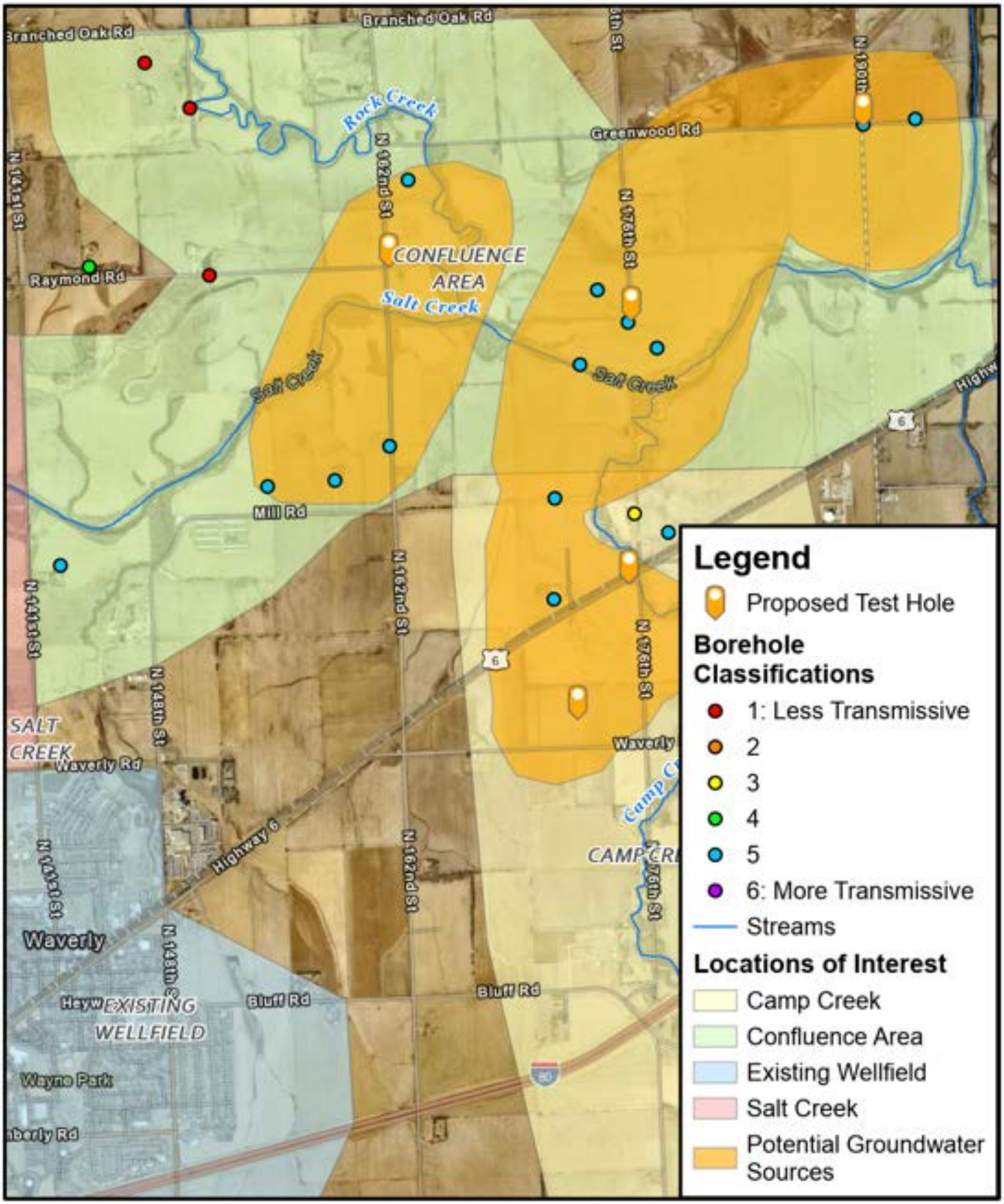
Within the Confluence Area, there are 21 active registered wells, with further detail in **Table 4**. As mentioned previously, the details of **Table 4** are not listed to quantify the amount of water being extracted from the aquifer in this area, but to provide a generalized metric to interpret the existing withdrawals on the aquifer in the area. The number of wells in an area can be an indication of the presence of an adequate aquifer resource in the area.

Table 4. Active Registered Wells in the Confluence Area

Well Type	Number of Active Wells
Municipal	-
Irrigation	12
Domestic	2
Ground Heat Exchange	1
Monitoring/ Observation	5
Commercial/ Industrial	-
Livestock	-
Other	1
Total	21

5.2 Borehole Analysis

The locations of the borehole logs that were evaluated in Confluence Area are displayed in **Figure 14** with their associated ratings. The borehole classifications within the Confluence Area were highly important in the delineation of the two potential groundwater sources within this area, as other data sources were limited. Delineating the potential groundwater sources in this area is somewhat subjective as the boreholes are quite similar across the two areas and into



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0 1 Miles

1 INCH = 0.5 MILES

NAD 1983 StatePlane Nebraska FIPS 2600 Feet

WELL CLASSIFICATIONS IN CONFLUENCE AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

14

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the Camp Creek Area, nonetheless, dividing into separate areas can help to prioritize areas fed by different tributaries to Salt Creek. The western potential groundwater source follows Salt Creek and extends upstream along Rock Creek and the eastern potential groundwater source is shared with the Camp Creek Area and extends downstream following Salt Creek. Three well diagrams were selected as representative target lithologies for the three proposed test holes in the Confluence Area, these well diagrams can be found in **Appendix A**. Additionally, these wells are called out in **Figure 15**.

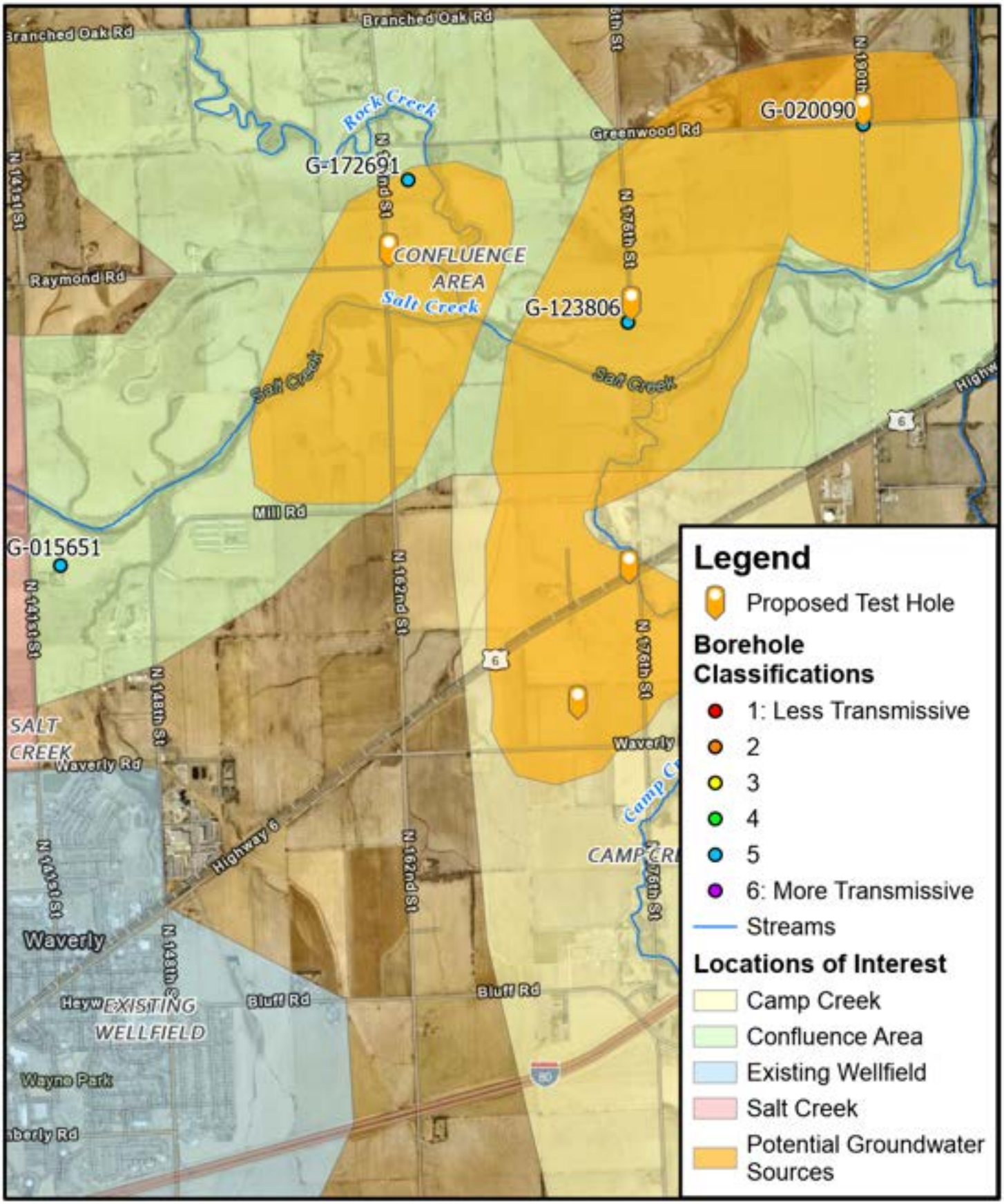
The target lithology for the westernmost proposed test holes in the Confluence Area is a 55' interval of sands, gravels, and sandstones that extend down to a depth of 85' which is observed in G-172691. Moving east, it can be seen in G-123806 that there is a 45' interval of sand and gravels with some clay layers that should be targeted. Lastly, G-020090 has a 40' sand and gravel interval extending down to 78' that sits below a thick clay layer, which could be targeted near this location.

5.3 AEM Analysis

As is the case with all locations of interest outside of the Existing Wellfield Area, the coverage of AEM flight lines in the Confluence Area is limited. This led to the use of only a single flight line to provide support for the lithologies represented in the NDNR borehole logs. Flight line L170401 presents resistivity in the eastern potential groundwater area to the north of Salt Creek as having high resistivity values and what can be interpreted as the coarse-grained materials seen in G-142880, which was a borehole analyzed in **Figure 14**, but is not drawn in a diagram as it was not the closest well to the central proposed test hole location. The figure containing this flight line can be found in **Appendix B**.

5.4 Trends in Groundwater Levels

As has been observed in all of the other locations of interest, the monitoring wells in the Confluence area have observed declines in groundwater levels over the past three years. Additionally, the most recent measurements in the Confluence Area at these two monitoring wells, 405727096305501 and 405722096291801, are not the lowest over the 27 year monitoring period displayed in **Figure 16**. It is unclear whether 405727096305501 is located near a stream or small body of water, but it is presumable that the water table at the westernmost proposed test hole would not be this shallow, but would be more similar to 405722096291801.



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0 1 Miles

1 INCH = 0.5 MILES

NAD 1983 StatePlane Nebraska FIPS 2600 Feet

WELL DIAGRAMS IN CONFLUENCE AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

15

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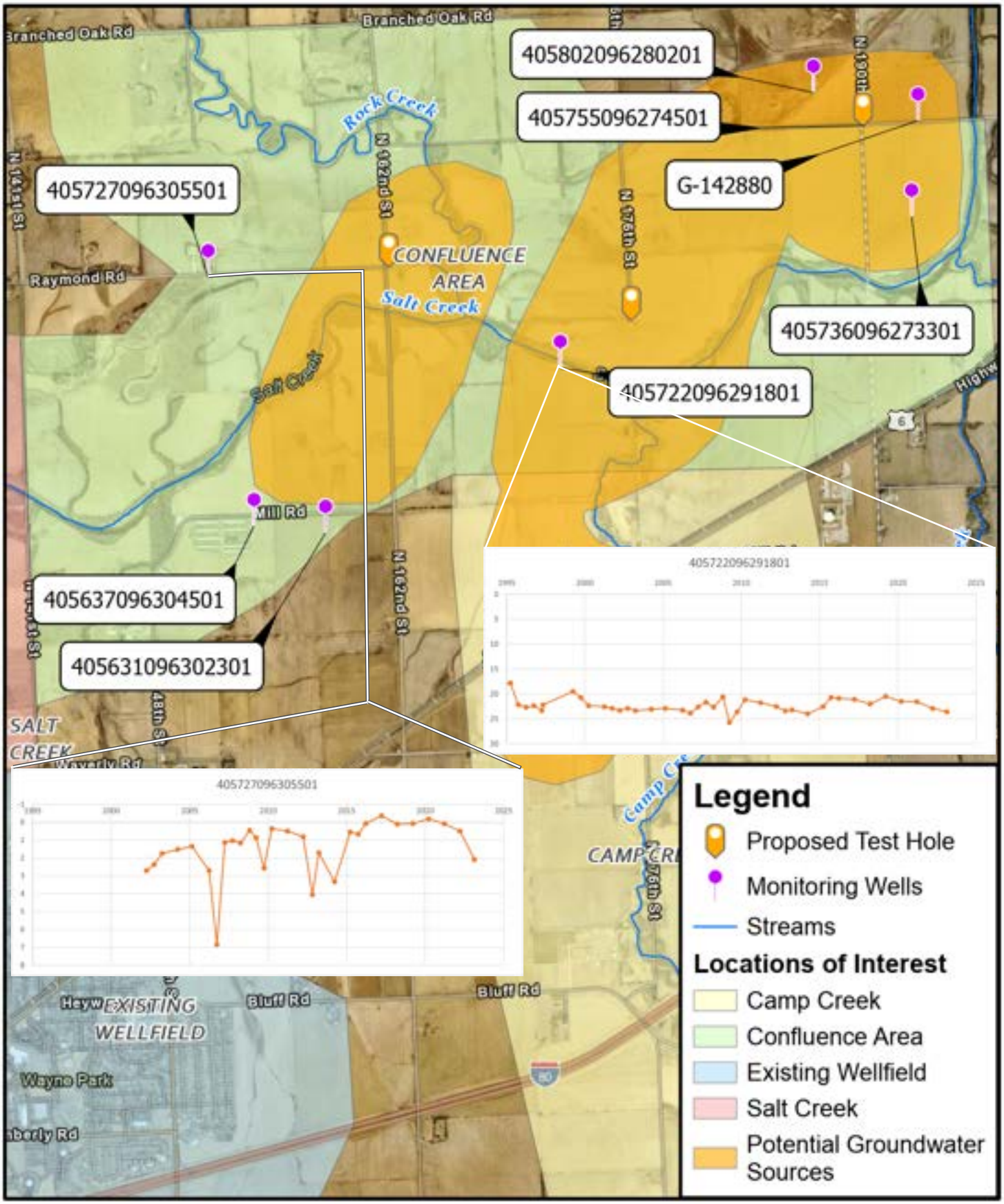

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0 1 Miles

1 INCH = 0.5 MILES

NAD 1983 StatePlane Nebraska FIPS 2600 Feet

MONITORING LOCATIONS IN CONFLUENCE AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

16

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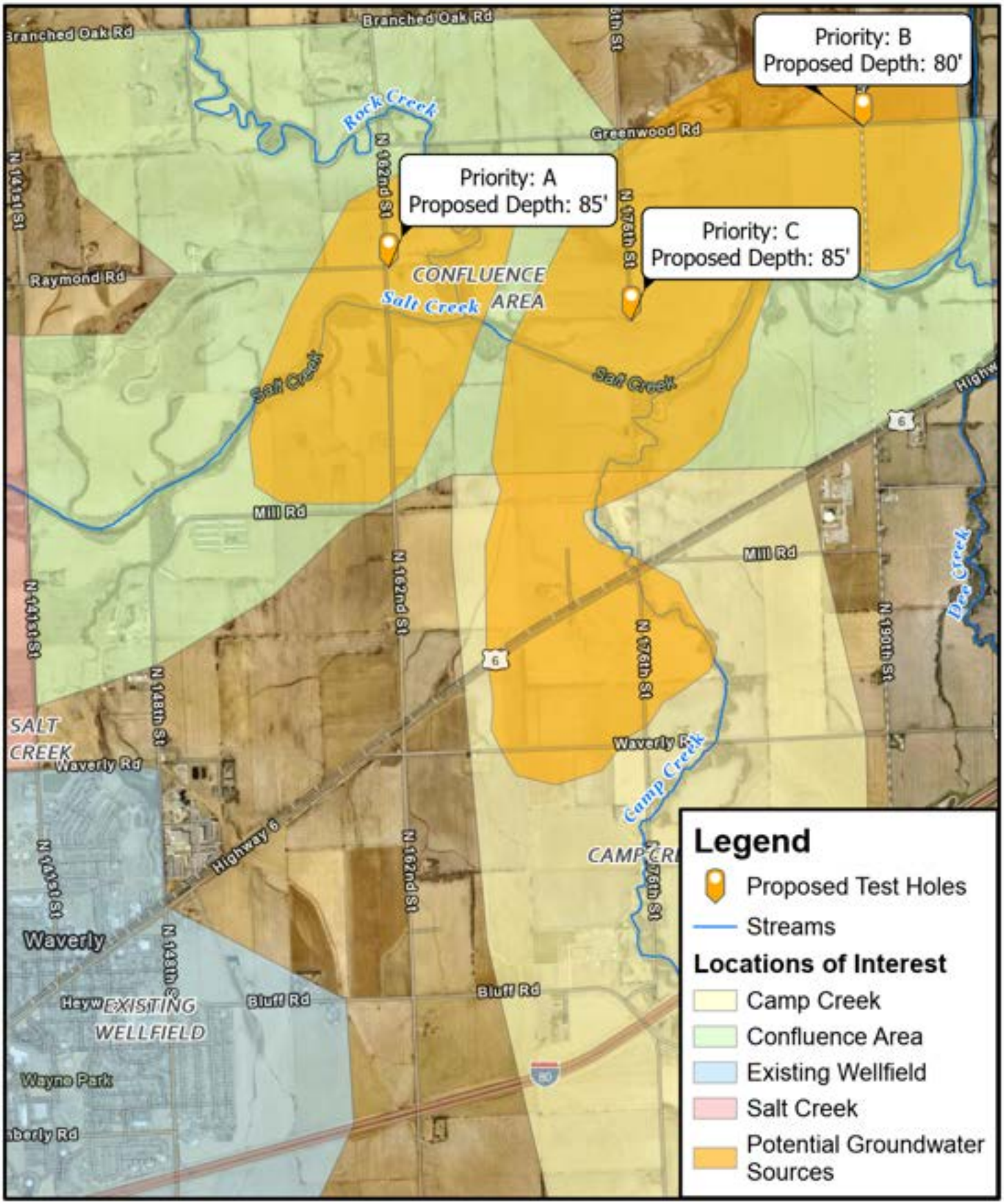
5.5 Recommendations

The Confluence Area has three proposed test holes, the ‘A’ priority test hole being the highest priority and the ‘C' priority test hole being the lowest priority test hole in the area. The westernmost proposed test hole in **Figure 17** is considered the highest priority test hole in this area because the borehole log nearest this well have the highest apparent transmissivity as compared to the other two proposed test holes in this location of interest. The ‘B’ priority test hole in this area matches closely to that of the ‘A’ priority test hole, only with a few more fine-grained intervals observed in the borehole log. Lastly, the ‘C’ priority test hole in this area appears to have the lowest apparent transmissivity of the three proposed test holes because of the increased amount of fine-grained intervals seen in the nearby borehole logs.



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0 1 Miles

1 INCH = 0.5 MILES

NAD 1983 StatePlane
Nebraska FIPS 2600 Feet

WELL CLASSIFICATIONS IN CONFLUENCE AREA

WELL SITING MEMO
WAVERLY, NE

FIGURE

17

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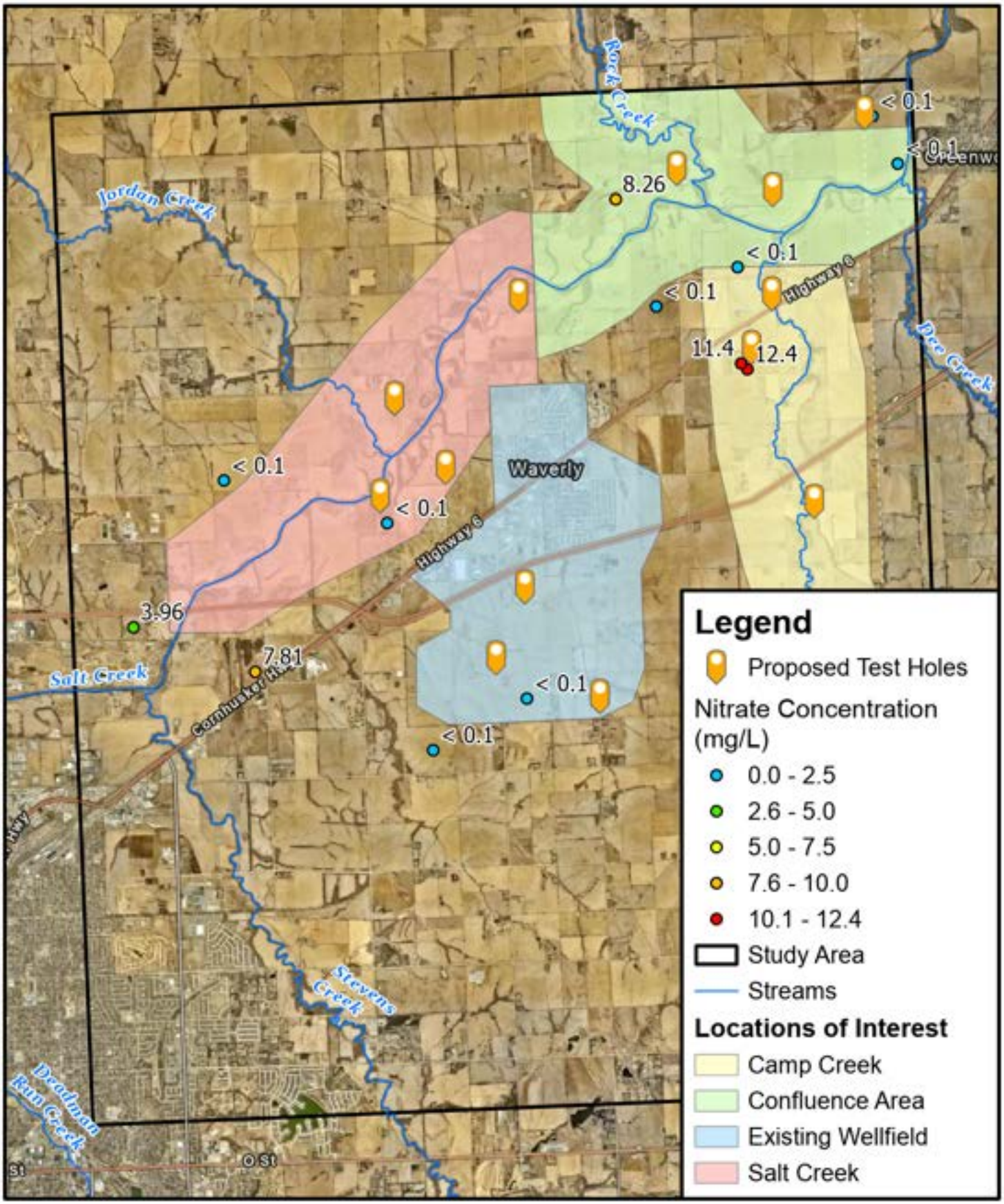
6. WATER QUALITY CONSIDERATIONS

Water quality is an import factor when considering the siting of a proposed test hole that will inform the possible development of a municipal well. The most common groundwater contaminant in Nebraska is nitrate (Nebraska Department of Environment and Energy, 2023). Nitrate concentrations exceeding 1.0 mg/L are indicative of anthropogenic nitrate loading (Dubrovsky et al. 2010). Contamination occurs primarily through leaching of nitrate-nitrogen from applied fertilizer through the soil profile. Sources of nitrate may include runoff or seepage from fertilized agricultural lands, municipal and industrial wastewater, refuse dumps, animal feedlots, septic tanks and private sewage disposal systems, urban drainage, and decaying plant debris.

The Nebraska Department of Environment and Energy maintains a publicly available database of water quality sampling results throughout the entire state, known as the Clearinghouse Database. This database was searched for nitrate-nitrogen as the analyte of focus within the Study Area. The Clearinghouse Database establishes sample locations, where a unique well was sampled and relates any samples or results from that unique well back to the location in the database. The most recent sample within the past five years, after January 1, 2018, were used in the creation of **Figure 18**. As displayed in **Figure 18**, there are two samples displaying nitrate concentrations that exceed the U.S. Environmental Protection Agency's (USEPA) maximum contaminant load (MCL) for safe drinking water of 10.0 mg/L of nitrate. These two samples are taken very near the 'A' priority test hole in the Camp Creek Area.

As the proposed test holes are being implemented with the possibility of furthering the location to a municipal well, the water quality concern of nitrate concentrations exceeding USEPA's MCL for nitrate in drinking water should be adequately considered for the implementation of a proposed test hole. As there is more than one sample very near the 'A' priority test hole that exceeds USEPA's MCL for nitrate in drinking water, it would not be unlikely that similarly high nitrate concentrations would be seen at this proposed test hole location. Nonetheless, nitrate contamination is a complex issue, and a situation in which concentrations can vary greatly with little spatial distance between samples.



olsson

N

0 1 2 Miles

1 INCH = 1.4 MILES

NAD 1983 StatePlane
Nebraska FIPS 2600 Feet

MOST RECENT CLEARINGHOUSE DATA SINCE 2018

WELL SITING MEMO
WAVERLY, NE

FIGURE

18

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7. RECOMMENDATIONS

There are two general options with which Waverly can proceed to address water supply concerns, the first being to expand the existing wellfield infrastructure by exploring additional test holes in the Existing Wellfield Area and the second option being to explore new areas that are not situated directly within Waverly's existing wellfield. Within Waverly's existing wellfield, the infrastructure already exists to integrate a new municipal well into Waverly water distribution system. Additionally, the hydrogeologic, water level, and AEM data is more comprehensive in the Existing Wellfield Area, leading to an increase in the confidence with which proposed test holes may lead to the siting of a productive municipal well. The further development of Waverly's existing wellfield coupled with the recommendations to well construction and operation, listed in the previous Waverly Wellfield Hydrogeologic Analysis Report by Olsson (2023), would provide Waverly the ability to continue to make use of the existing wellfield without exploring the water resources in a different area with less data coverage. Olsson has proposed three test hole locations within the Existing Wellfield Area to target transmissive lithologies with the caution that any new test holes in this area would be subject to the same water level declines that have been seen and recorded at Waverly's municipal wells.

A preface to the second option of exploring new locations to support Waverly's municipal water supply is that the data coverage is inconsistent across the study area and the proposed test holes within the Existing Wellfield Area are informed by more information than those proposed test holes outside the Existing Wellfield Area. The three other locations of interest outside of the Existing Wellfield Area in this report can be ranked generally by the available hydrogeologic data and the water levels shown throughout this report as follows: the first area recommended to be explored as a potential expansion to Waverly's wellfield is the Salt Creek Area, followed by the Camp Creek Area, and lastly, the Confluence Area. This recommendation and the detailed prioritization of the proposed test holes within each location of interest does not consider the potential costs, water quality, nor jurisdictional limitations to acquire the property, these prioritizations solely consider the hydrogeologic data, NDNR borehole logs, and other data specific to water quantity. Considering water quality contaminant results from the NDEE Clearinghouse Database, the only area in which nitrate concentrations exceed the USEPA's MCL for drinking water is near the 'A' priority well in the Camp Creek Area. This water quality concern should be considered by Waverly, as the proposed test holes are being sited to inform potential municipal well locations.

8. REFERENCES

Dubrovsky, N.M., K.R. Burow, G.M. Clark, J.M. Gronberg, P.A. Hamilton, K.J. Hitt, D.K. Mueller, M.D. Munn, B.T. Nolan, L.J. Puckett, M.G. Rupert, T.M. Short, N.E. Spahr, L.A. Sprague, and W.G. Wilber. 2010. The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004. U.S. Geological Survey Circular 1350.

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Olsson. 2023. Water Distribution Study. Prepared for the City of Waverly, Nebraska. August, 2023. 108 p.

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WAVERLY WELL FIELD HYDROGEOLOGIC ASSESSMENT REPORT

City of Waverly, Waverly, Nebraska

January 2024

Olsson Project No. 023-06619

olsson

APPENDIX A

CALLOUT WELL DIAGRAMS

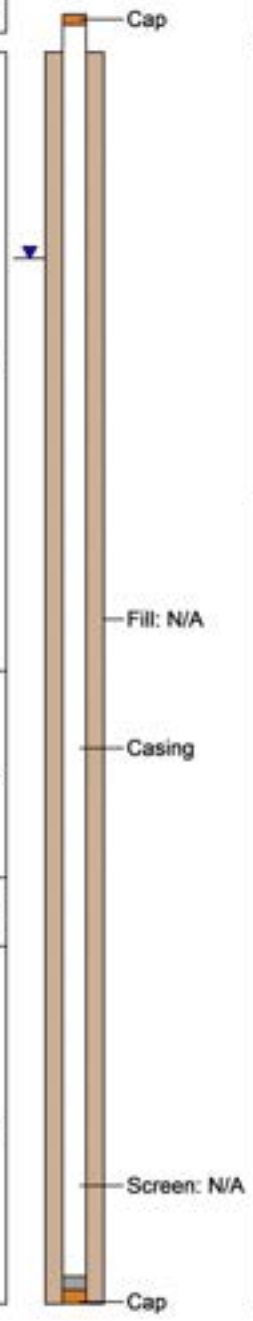
LOG OF BORING G-014378

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			CLAY	CH
40			SAND & GRAVEL	GP
60			CLAY	CH
70			GRAVEL	GP
90				



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 6/7/1957
Hole Diameter	: 36.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: N/A
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: N/A
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 10 ga.
Gravel Pack	: N/A
Grout	: Concrete

NOTES:

Total Well Depth: 91 ft
Static Water Level: 17 ft

LOCATION OF INTEREST:
Camp Creek Area

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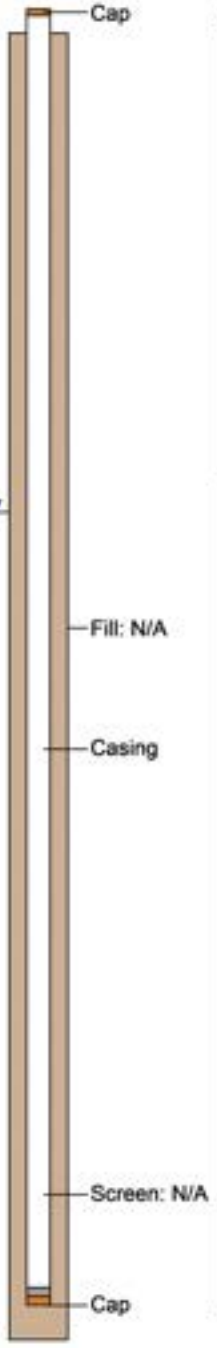
LOG OF BORING G-008965

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil & CLAY	CH
20				
40			CLAY, blue	CH
60			SANDY CLAY, soft	F46
			SANDSTONE, soft to hard	F38
80				
			OCHER, yellow & Iron Pyrites in Layers	F38
100			SHALE, red	SH
			SANDSTONE, medium to coarse grained, light to dark SAND	F38
120				
140				



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 5/18/1957
Hole Diameter	: 32.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 15.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 15.0 in
Joints	: N/A
Opening	: N/A
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 147 ft
Static Water Level: 57 ft

LOCATION OF INTEREST:
Existing Wellfield

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LOG OF BORING G-107794A

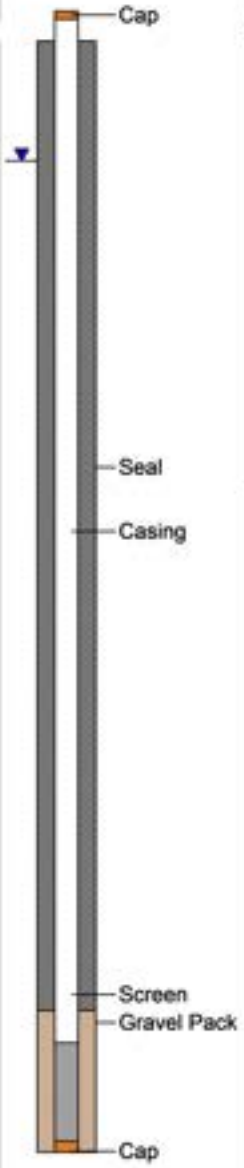
Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil, CLAY, tan & black	CH
20			CLAY, tan & black	CH
			SAND, coarse grained, GRAVEL, fine grained	GP
40			SAND, coarse grained, GRAVEL, coarse grained	GP
			CLAY	CH
			SAND, coarse grained, GRAVEL, medium grained	F46
60			SAND, coarse grained, GRAVEL coarse grained	GP
			SAND, coarse grained, GRAVEL, coarse grained, with CLAY streaks	F38
80			DAKOTA SANDSTONE, red, GRAVEL	F37
			OCHER	F38
100			OCHER, red, GRAVEL	F37
			SHALE, red & white	SH
120				

Well: G-107749A



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 8/24/2000
Hole Diameter	: 9.0 in
Drill. Method	: Rotary
Company Rep.	: Sargent Drilling

WELL CASING

Material	: PVC
Outer Diameter	: 4.5 in
Joints	: Glued

WELL SCREEN

Material	: PVC
Outer Diameter	: 4.5 in
Joints	: Glued
Opening	: 0.018
Gravel Pack	: "B" Pack
Grout	: Chunk Bentonite

NOTES:

Total Well Depth: 102 ft
Static Water Level: 10 ft

LOCATION OF INTEREST:
Camp Creek Area

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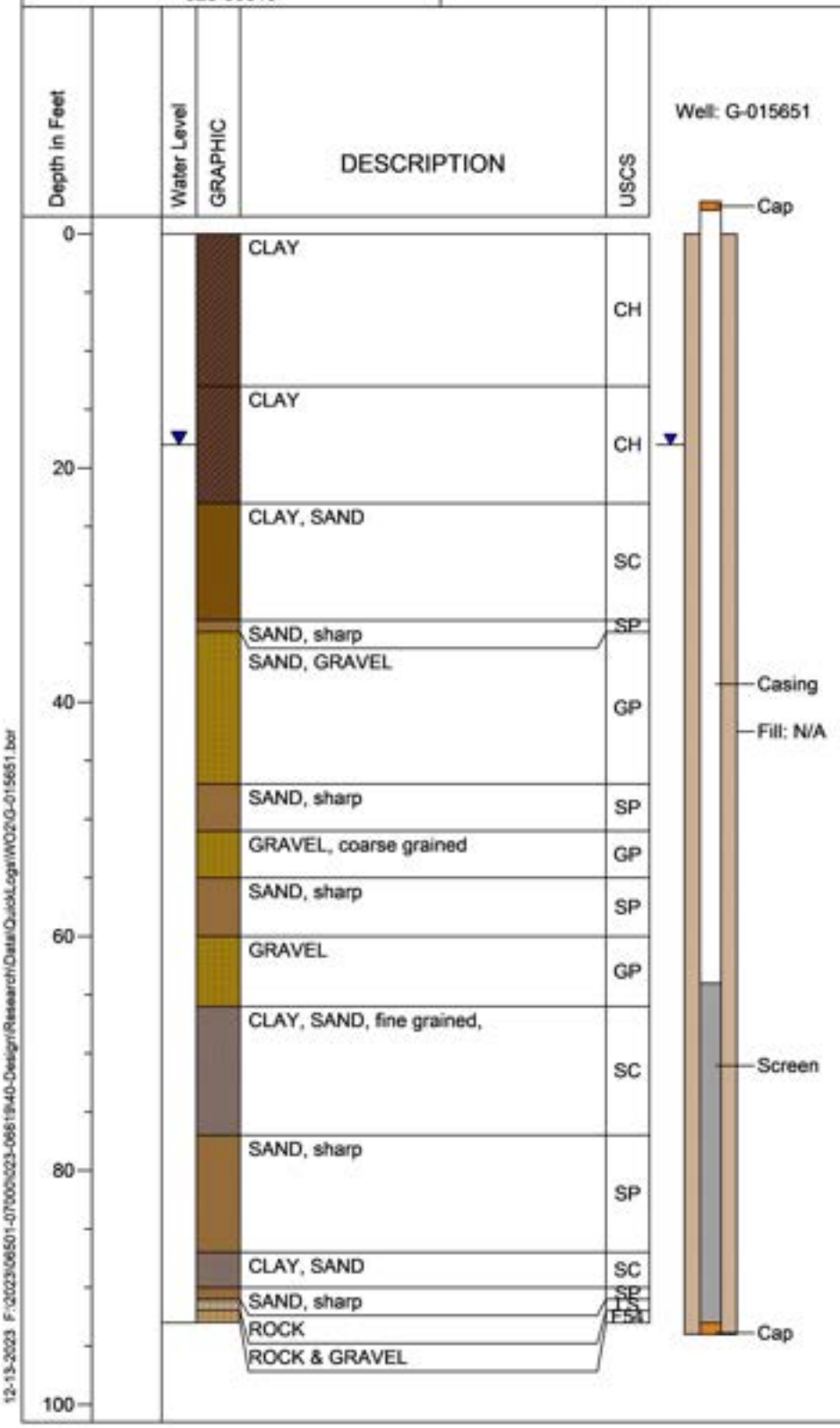
LOG OF BORING G-015651

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 10/10/1954
Hole Diameter	: 36.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 12 ga.
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 94 ft
Static Water Level: 20 ft

LOCATION OF INTEREST:
Salt Creek Area

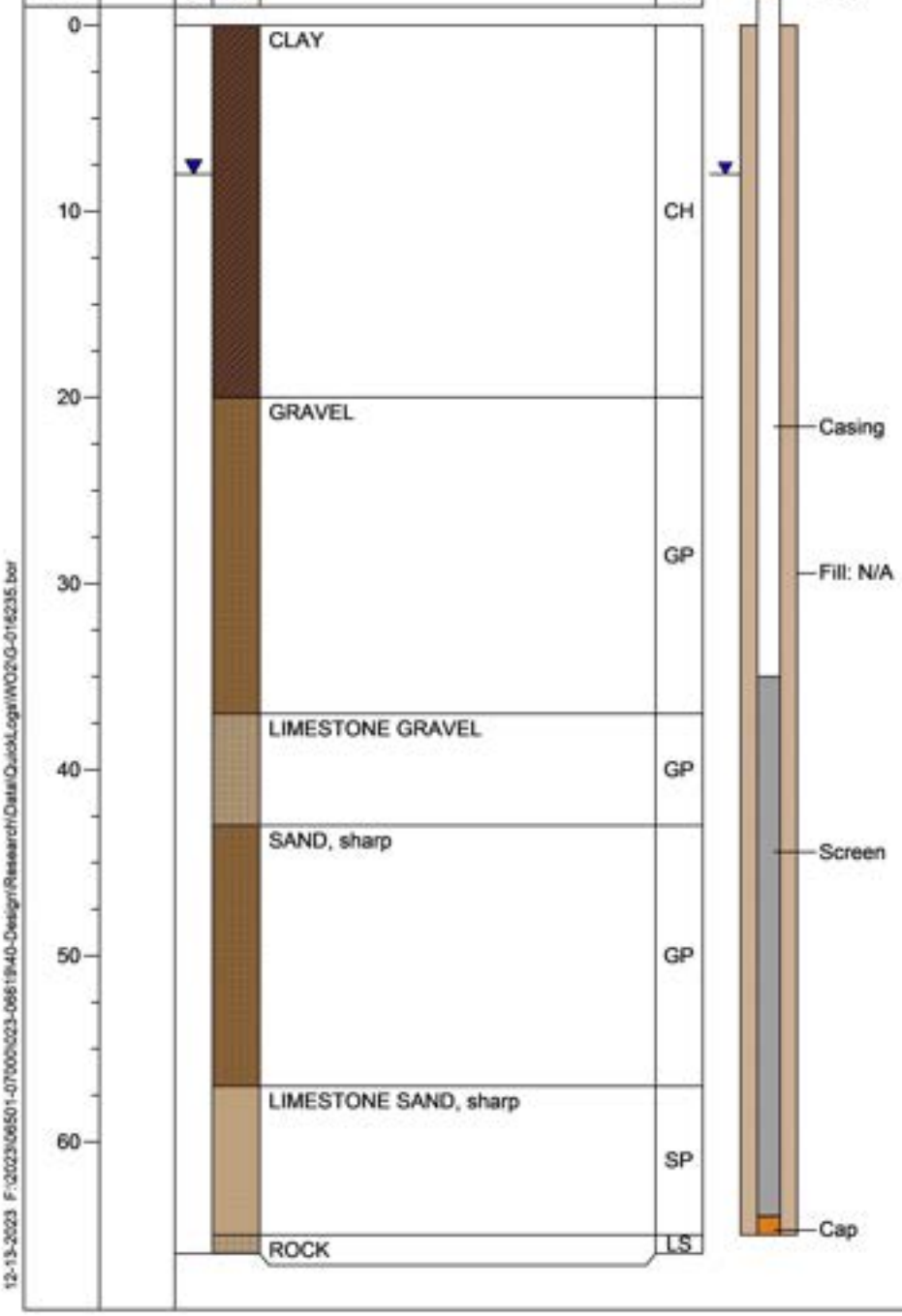
12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-015651.bor

LOG OF BORING G-016235

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 10/15/1954
Hole Diameter	: 36.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 12 ga.
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 65 ft
Static Water Level: 10 ft

LOCATION OF INTEREST:
Camp Creek Area

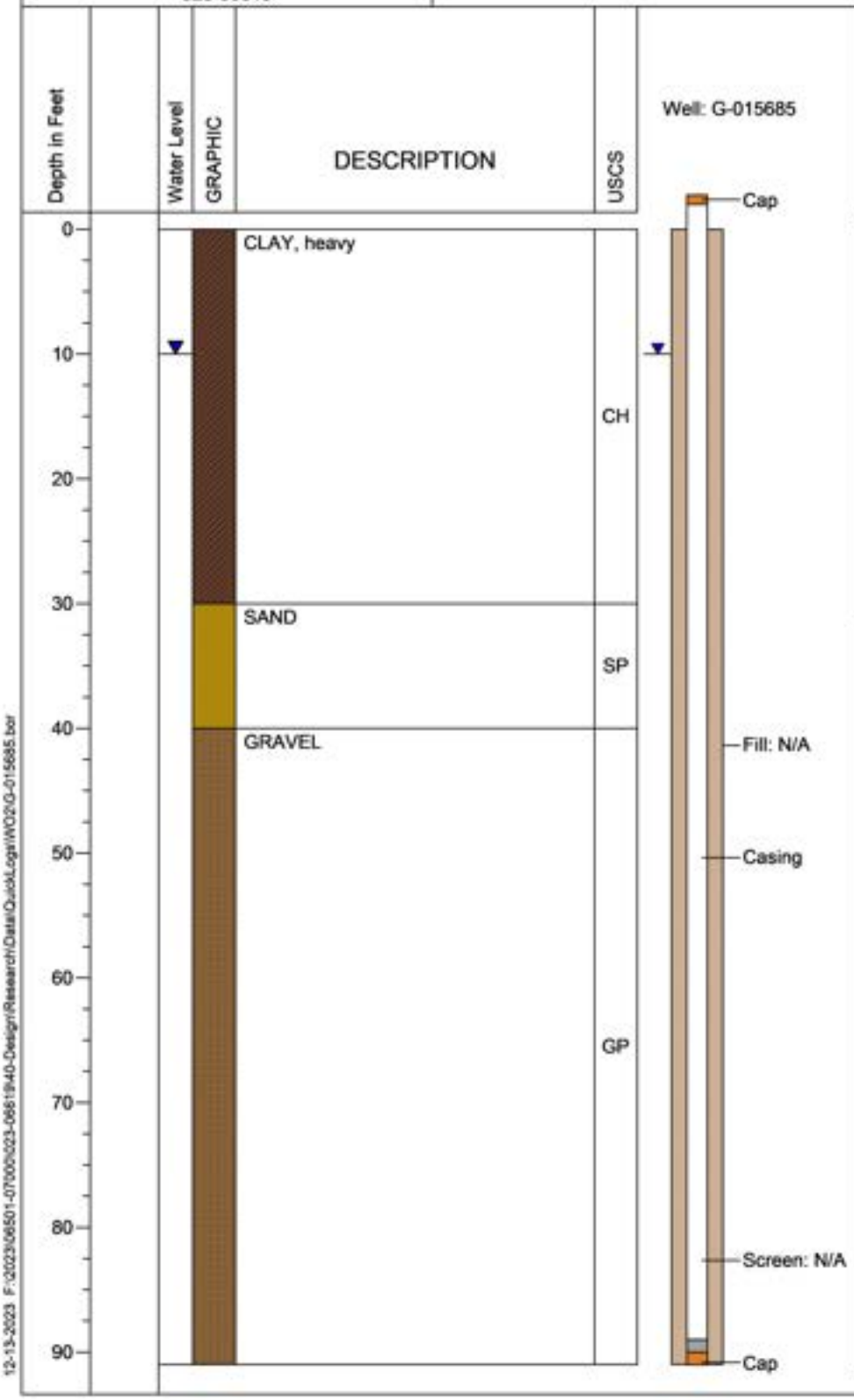
12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-016235.bor

LOG OF BORING G-015685

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 7/15/1949
Hole Diameter	: 32.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 12 ga.
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 91 ft
Static Water Level: 12 ft

LOCATION OF INTEREST:
Salt Creek Area

12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-015685.bor

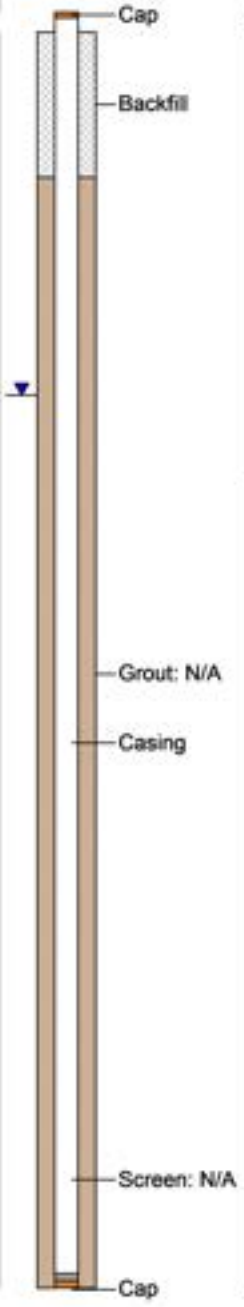
LOG OF BORING G-051573

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil	F44
			CLAY	CH
20			SANDSTONE, red	SS
40			SANDSTONE, white	SS
60			SANDSTONE, red	SS
			SHALE, gray	SH
80			SANDSTONE, coarse, streak of iron ore	F37
100			CLAY, gray and yellow	CH
120			SANDSTONE, coarse, red	F37
			CLAY, gray	CH
140			SANDSTONE, white	SS
160				
180				



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 8/24/1976
Hole Diameter	: 30.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: PVC
Outer Diameter	: 15.0 in
Joints	: Welded/Screwed

WELL SCREEN

Material	: N/A
Outer Diameter	: 15.0 in
Joints	: N/A
Opening	: N/A
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 173 ft
Static Water Level: 52 ft

LOCATION OF INTEREST:
Existing Wellfield

12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-051573.bor

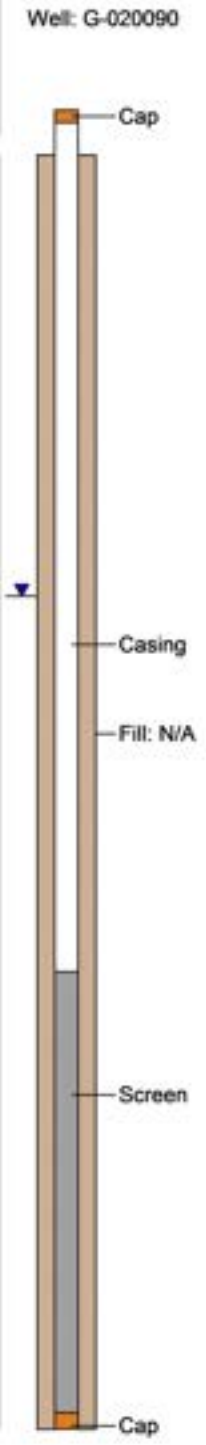
LOG OF BORING G-020090

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil	F44
			CLAY, yellow	CH
30			SAND	SP
40			GRAVEL	GP
80				



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/12/1957
Hole Diameter	: 36.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 10 ga.
Gravel Pack	: N/A
Grout	: Concrete

NOTES:

Total Well Depth: 78 ft
Static Water Level: 29 ft

LOCATION OF INTEREST:
Confluence Area

12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-020090.bor

LOG OF BORING G-091535

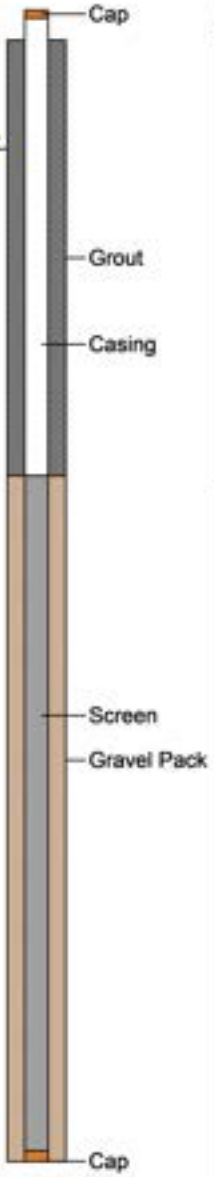
Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil	F44
10	▼		CLAY	CH
20			SAND, fine grained, with CLAY layers	SC
30			SAND, fine to medium grained, traces of TILL, with thin CLAY layers	SC
40			SAND, fine to medium grained, with CLAY layers	SC
50				
60			SAND, coarse grained, GRAVEL, fine grained	GP
70				
80			GRAVEL, fine grained, SAND, coarse grained	GP
90			SAND, fine grained, with hard layers	F38
100			LIMESTONE	LS
110				
120				

Well: G-091535



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 5/191997
Hole Diameter	: 12.0 in
Drill. Method	: Rotary
Company Rep.	: Sargent Irrigation Co.

WELL CASING

Material	: PVC
Outer Diameter	: 4.5 in
Joints	: Glued

WELL SCREEN

Material	: PVC
Outer Diameter	: 4.5 in
Joints	: Glued
Opening	: 0.032 in
Gravel Pack	: N/A
Grout	: Concrete

NOTES:

Total Well Depth: 103 ft
Static Water Level: 12 ft

LOCATION OF INTEREST:
Salt Creek Area

12-14-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-091535.bor

LOG OF BORING G-086266

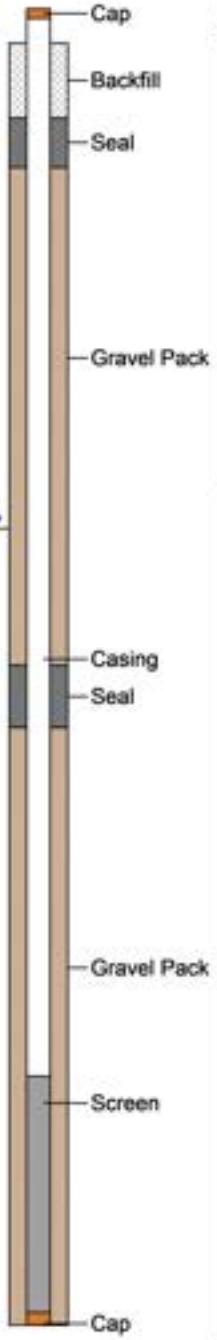
Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	DESCRIPTION	USCS
0	Topsoil	F44
	CLAY, brown & yellow	CH
20	CLAY, silty tan	CH
40	CLAY, dark gray	CH
	CLAY, brown	CH
	CLAY, yellow	CH
	SANDY CLAY, yellow	F46
	SANDSTONE, fine grained, yellow	F38
	IRONSTONE	SS
60	SANDSTONE, fine grained, hard, brown	F38
	SANDSTONE, fine grained, tan & yellow	F38
	SANDSTONE, fine grained, orange	F38
	IRONSTONE, SANDSTONE, medium grained, yellow	F38
80	SANDSTONE, fine to medium grianed, yellow	F38
	SANDSTONE, fine to medium grained, orange	F38
100	SANDSTONE, fine to medium grained, light orange	F38
	LIMESTONE	LS

Well: G-086266



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 7/20/1995
Hole Diameter	: 9.0 in
Drill. Method	: Rotary
Company Rep.	: N/A

WELL CASING

Material	: PVC
Outer Diameter	: 1.0 in
Joints	: Glued

WELL SCREEN

Material	: PVC
Outer Diameter	: 1.0 in
Joints	: Glued
Opening	: 0.013
Gravel Pack	: N/A
Grout	: N/A

NOTES:

Total Well Depth: 103 ft
Static Water Level: 52 ft

LOCATION OF INTEREST:
Existing Wellfield

12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-086266.bor

LOG OF BORING G-123806

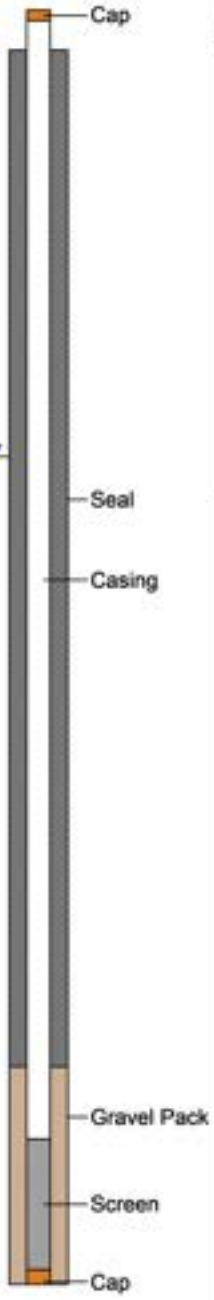
Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0			Topsoil	FILL
			CLAY, brown	CH
			CLAY, dark brown	CH
20			CLAY, brown, gritty	CH
			SAND	SP
			CLAY, dark gray	CH
			SAND, coarse grained, gray	SP
			CLAY, blue	CH
40			SAND, coarse grained, gray GRAVEL, medium grained	GP
			CLAY, gray	CH
			SAND, coarse grained, gray, GRAVEL coarse grained	GP
60			CLAY, gray	CH
			SAND, medium grained, gray	SP
			SAND, medium grained, gray, GRAVEL	GP
80			LIMESTONE	LS

Well: G-123806



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 9/29/2003
Hole Diameter	: 9.0 in
Drill. Method	: Rotary
Company Rep.	: Earnest Drilling

WELL CASING

Material	: PVC
Outer Diameter	: 4.5 in
Joints	: Glued

WELL SCREEN

Material	: Monoflex
Outer Diameter	: 4.5 in
Joints	: Glued
Opening	: 0.025
Gravel Pack	: 1220 Bag Sand
Grout	: Easy Seal Grout

NOTES:

Total Well Depth: 85 ft
Static Water Level: 30 ft

LOCATION OF INTEREST:
Confluence Area

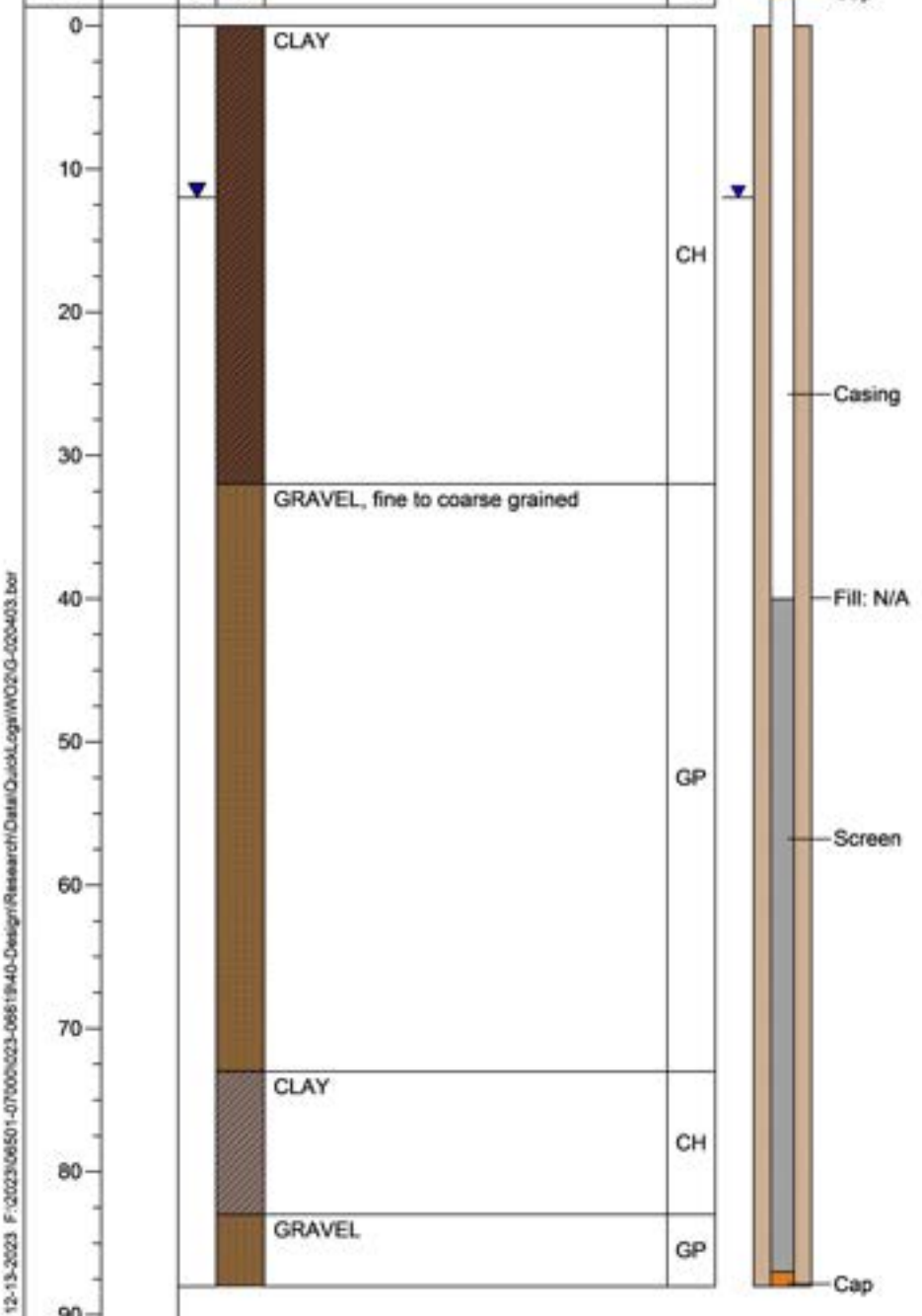
12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-123806.bor

LOG OF BORING G-020403

Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 7/28/1959
Hole Diameter	: 36.0 in
Drill. Method	: N/A
Company Rep.	: N/A

WELL CASING

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A

WELL SCREEN

Material	: Steel
Outer Diameter	: 18.0 in
Joints	: N/A
Opening	: 10 ga.
Gravel Pack	: N/A
Grout	: Concrete

NOTES:

Total Well Depth: 88 ft
Static Water Level: 14 ft

LOCATION OF INTEREST:
Salt Creek Area

12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-020403.bor

LOG OF BORING G-172691

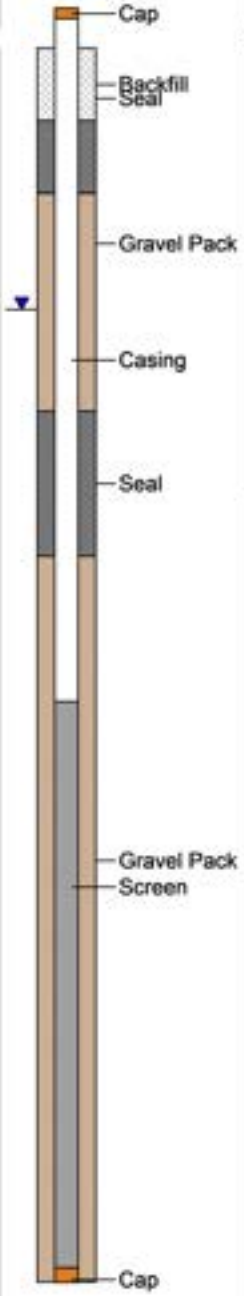
Well Siting Memo
Waverly, NE
Lancaster County

December 2023

023-06619

Depth in Feet	Water Level	GRAPHIC	DESCRIPTION	USCS
0	▼		Topsoil, CLAY, gray, loose	CH
20			CLAY, gray, dense/stiff	CH
			SAND, fine to medium grained, blue GRAVEL, fine grained	GP
40			CLAY, gray, dense/stiff	CH
			SAND, tan, fine to medium grained, with CLAY strip	SP
			SAND, tan, fine to medium grained, loose	SP
60			SANDSTONE, tan, fine to medium grained, loose	F38
			SAND, tan, fine to medium grained, loose, GRAVEL, fine to medium grained	GP
80			SHALE, brown, hard	SH

Well: G-172691



Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 5/21/2014
Hole Diameter	: 30.0 in
Drill. Method	: Rotary
Company Rep.	: Sargent Drilling

WELL CASING

Material	: PVC
Outer Diameter	: 16.0 in
Joints	: Glued

WELL SCREEN

Material	: PVC
Outer Diameter	: 16.0 in
Joints	: Glued
Opening	: 0.035
Gravel Pack	: "B" Pack
Grout	: Chunk Bentonite

NOTES:

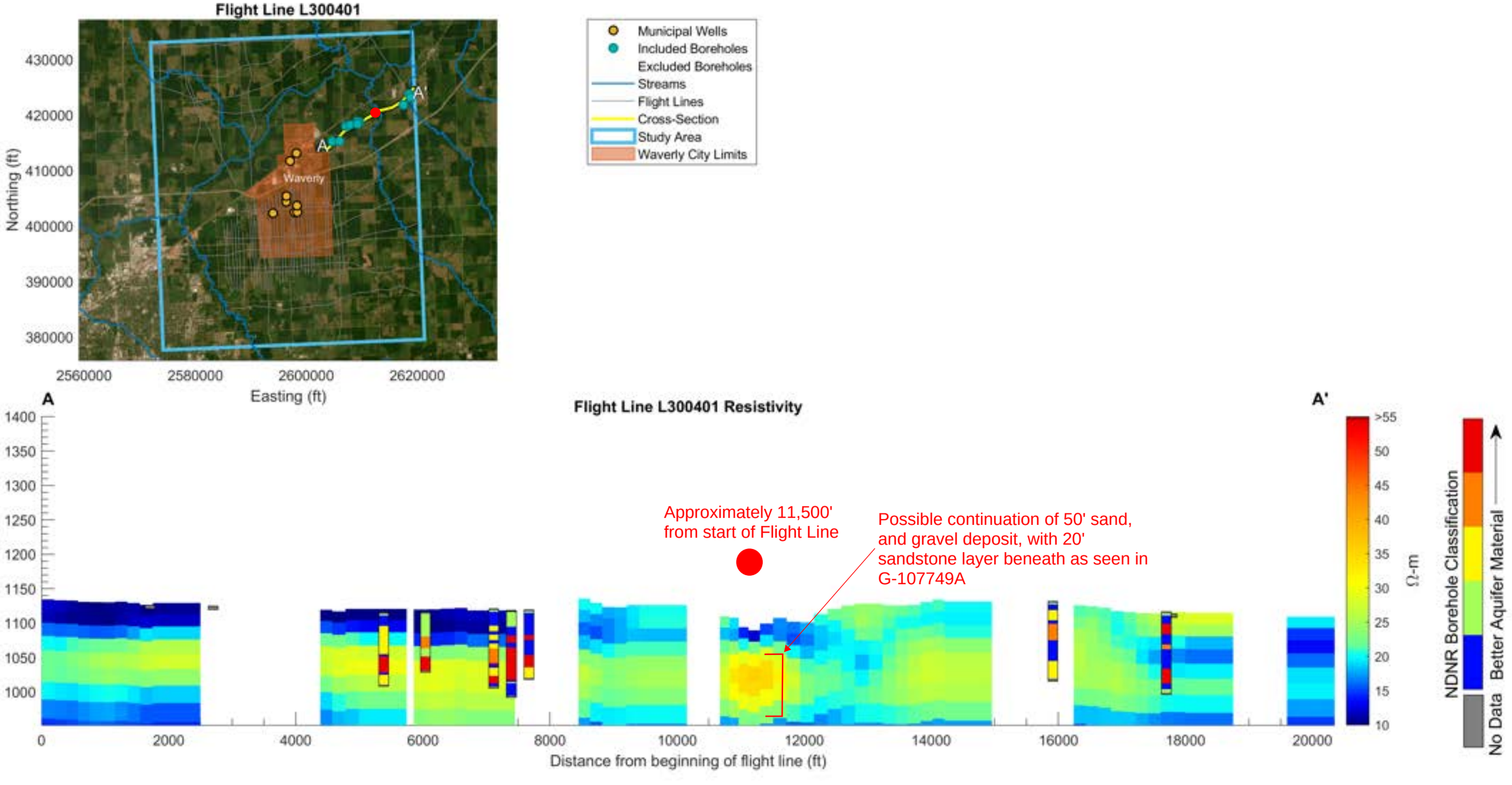
Total Well Depth: 85 ft
Static Water Level: 20 ft

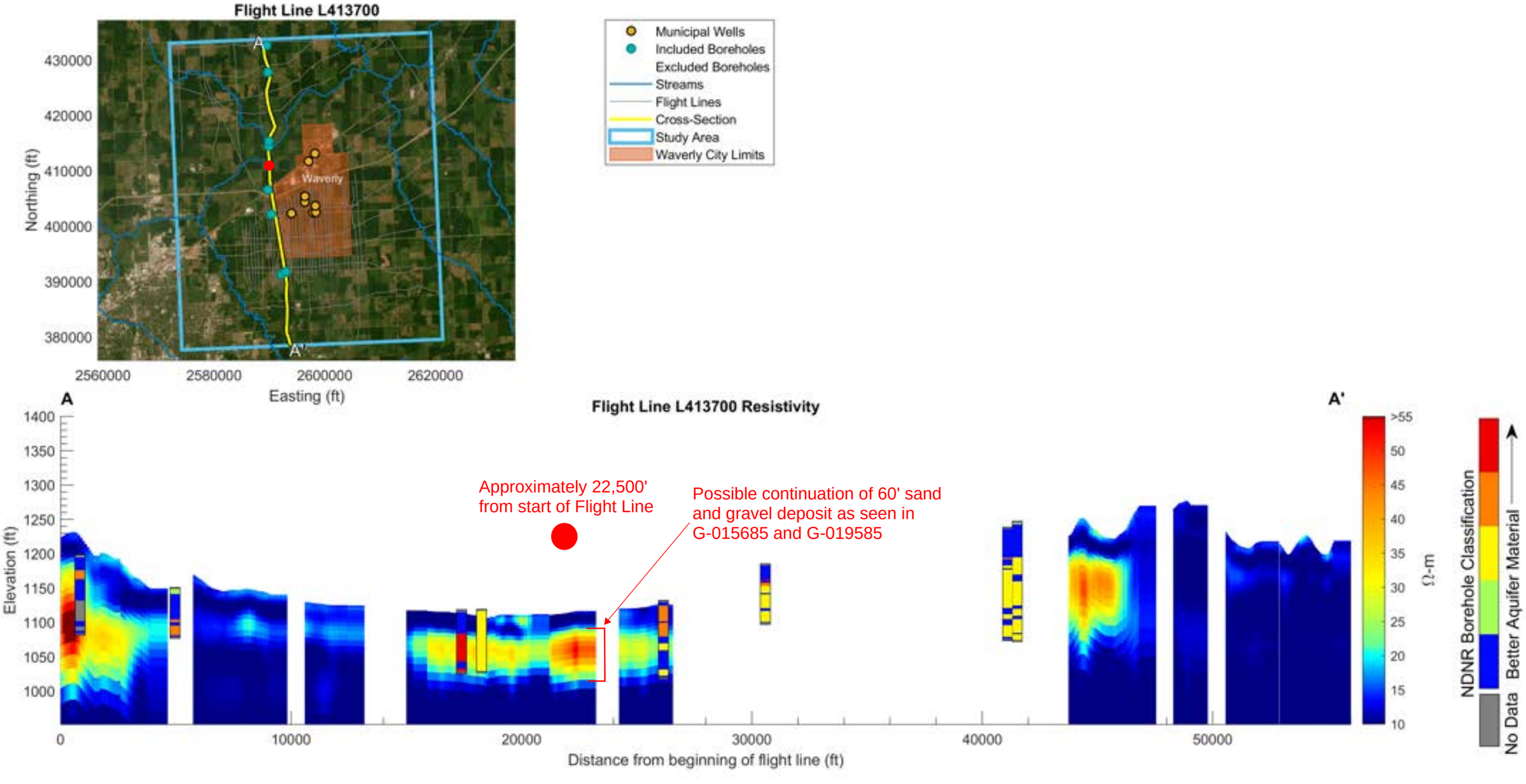
LOCATION OF INTEREST:
Confluence Area

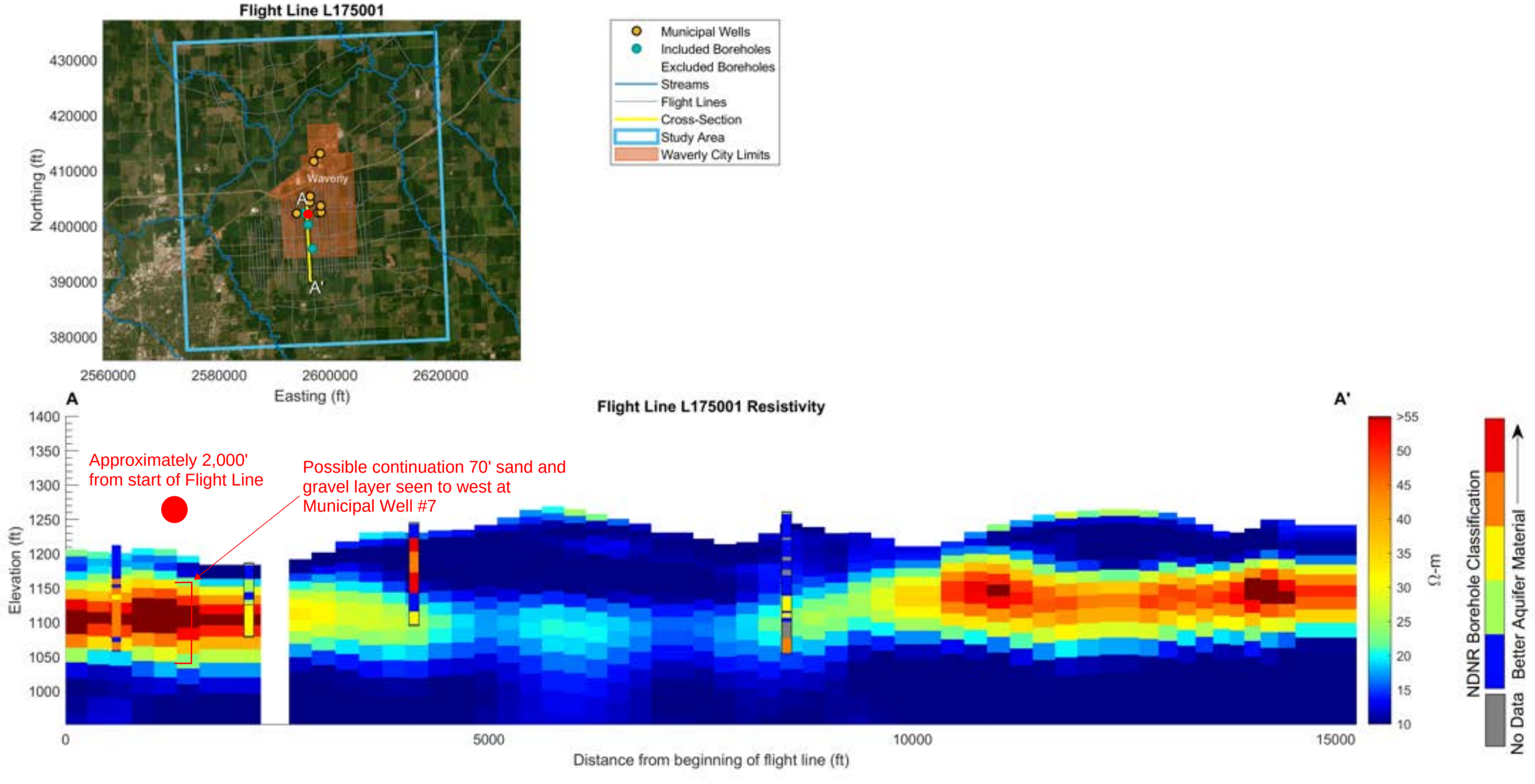
12-13-2023 F:\2023\06501-07000\023-06619\40-Design\Research\Data\QuickLogs\WO2\G-172691.bor

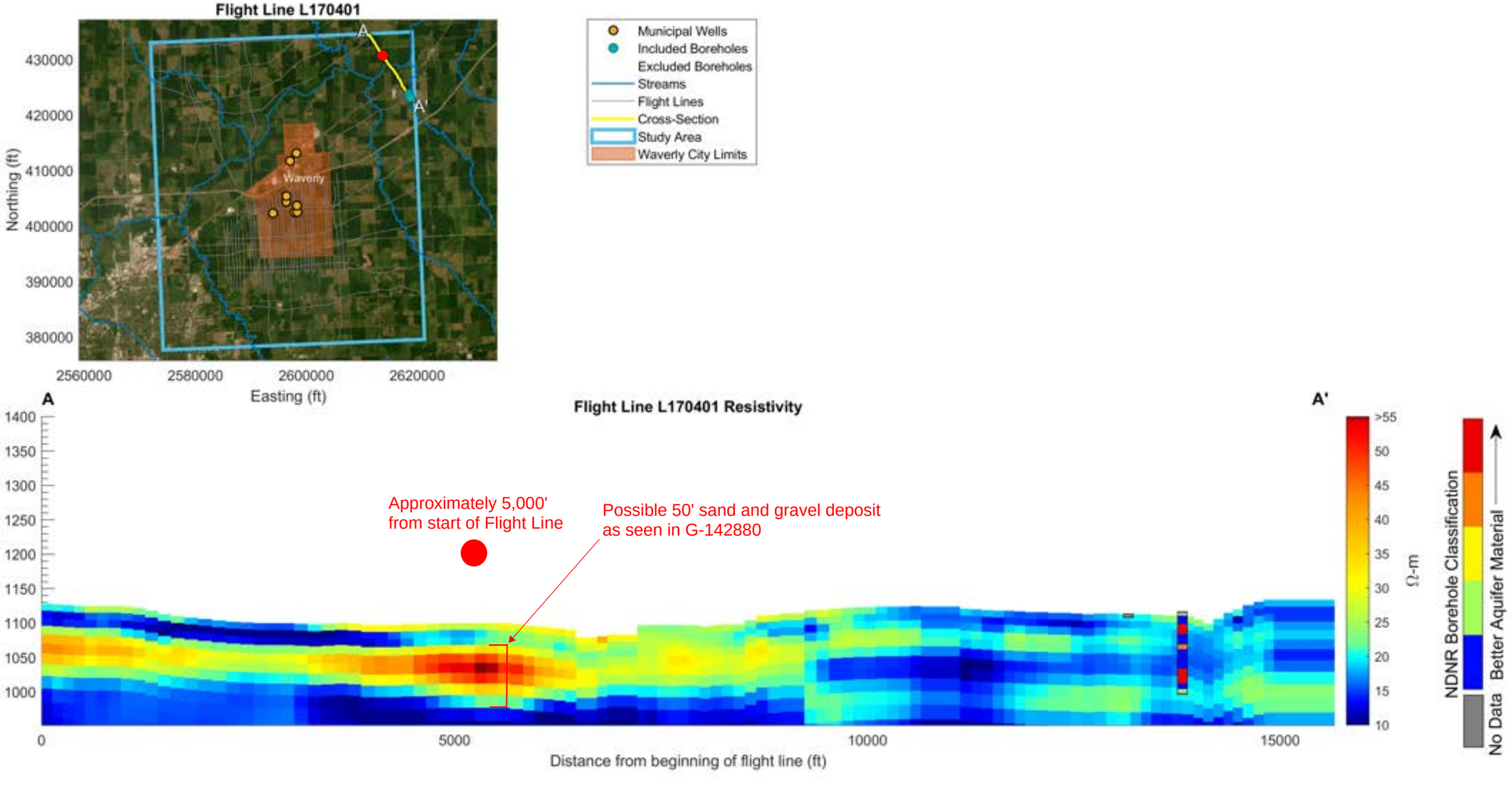
APPENDIX B

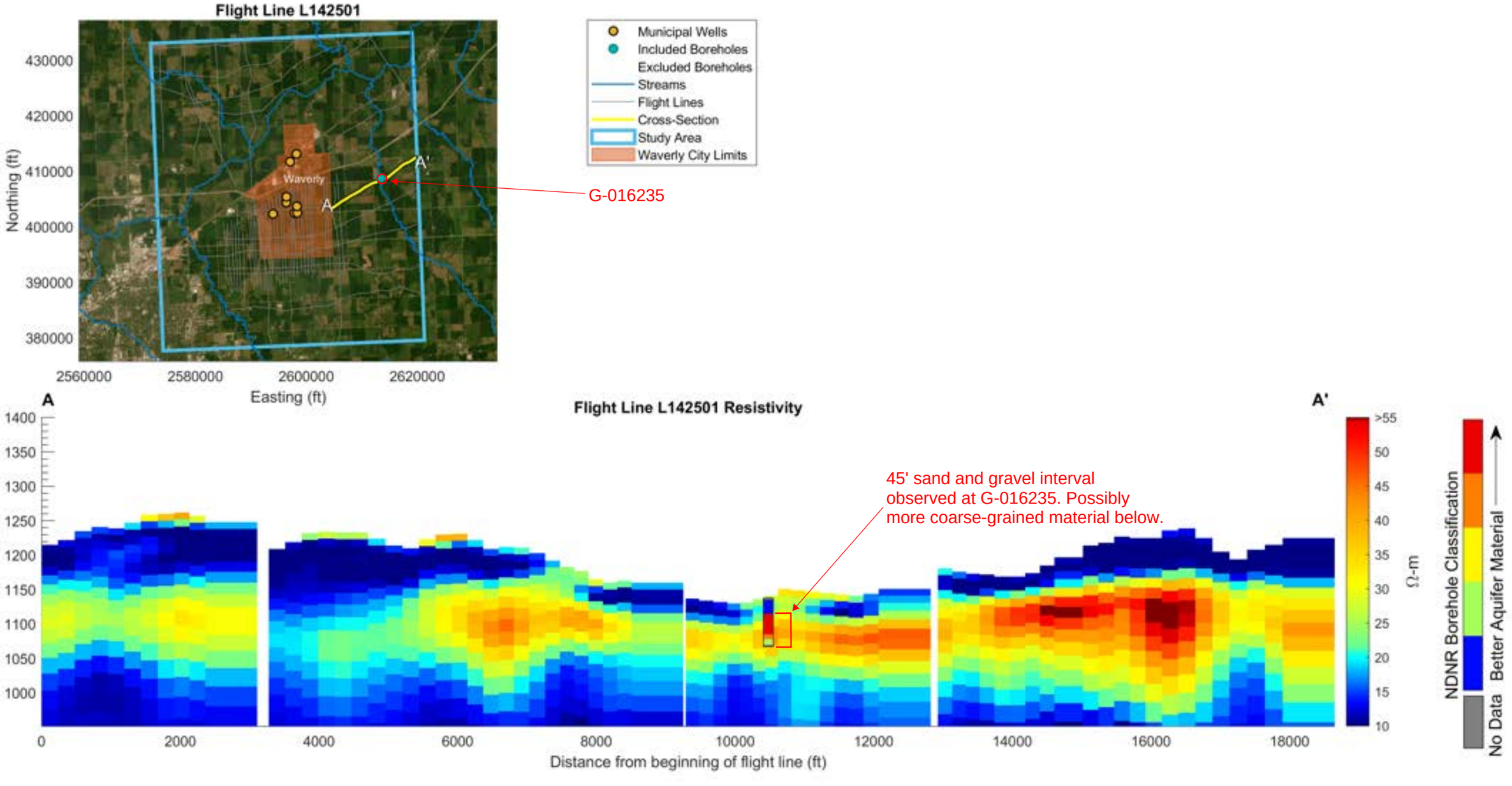
AERIAL ELECTROMAGNETIC DATA EVALUATION FIGURES

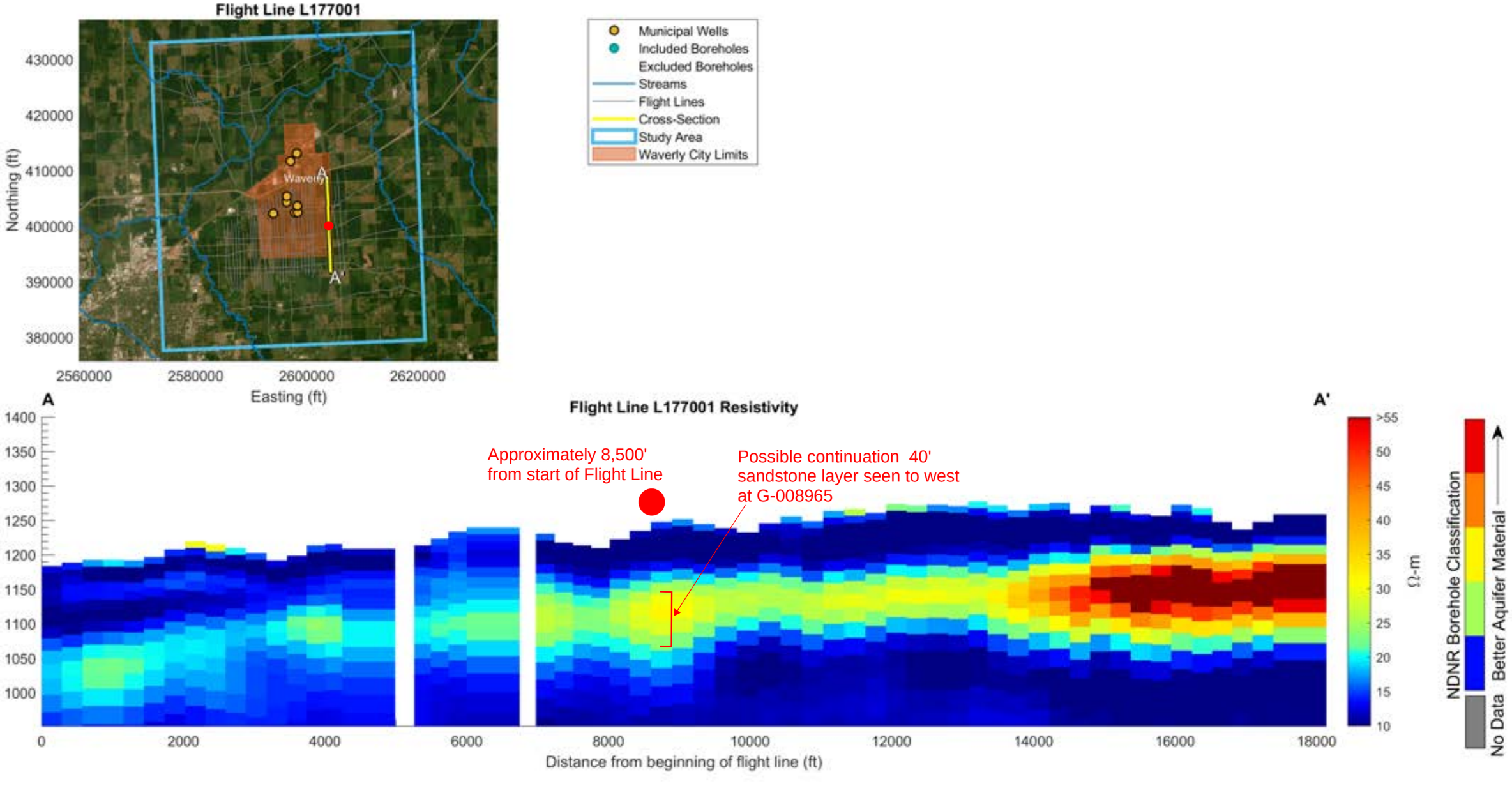

Flight Line L300401
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
A
A'
Waverly
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L300401 Resistivity
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Distance from beginning of flight line (ft)
Approximately 11,500' from start of Flight Line
Possible continuation of 50' sand, and gravel deposit, with 20' sandstone layer beneath as seen in G-107749A
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

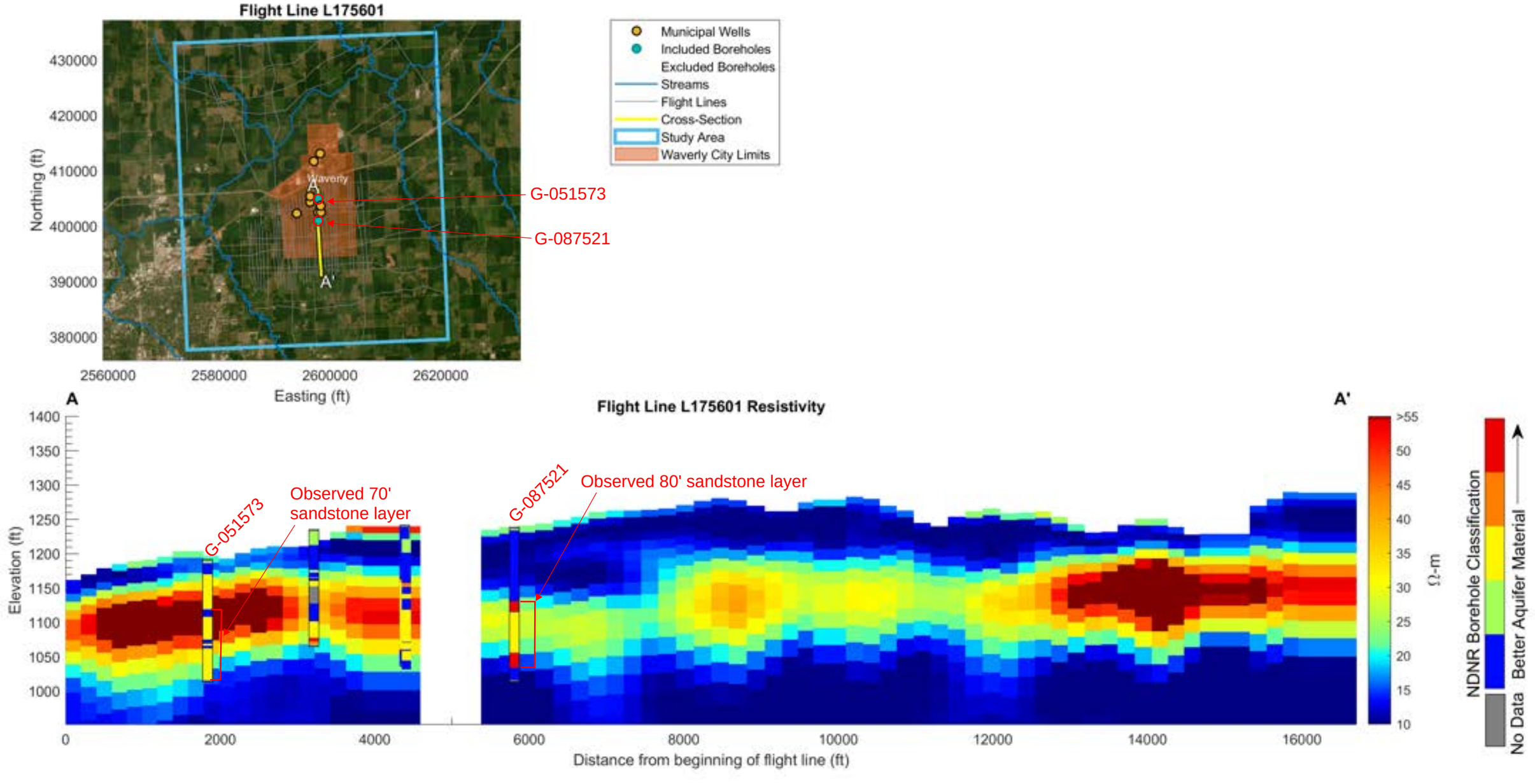

Flight Line L413700
A
A'
Waverly
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L413700 Resistivity
Approximately 22,500'
from start of Flight Line
Possible continuation of 60' sand
and gravel deposit as seen in
G-015685 and G-019585
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
10000
20000
30000
40000
50000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

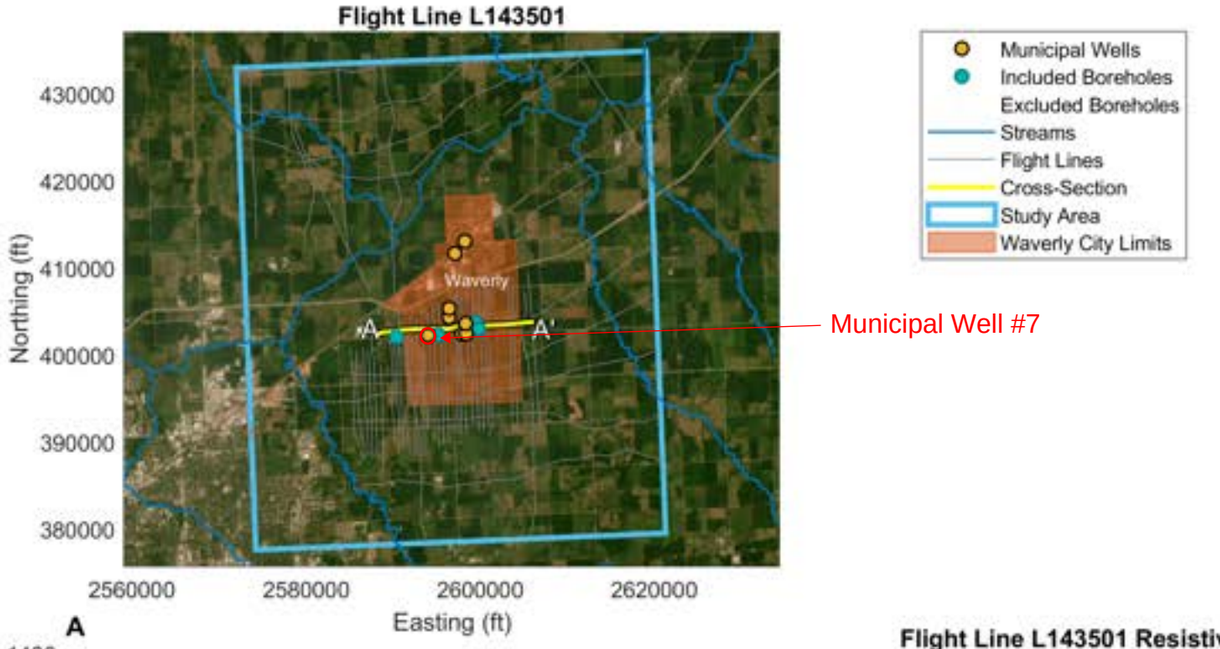

Flight Line L175001
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L175001 Resistivity
A
A'
Approximately 2,000' from start of Flight Line
Possible continuation 70' sand and gravel layer seen to west at Municipal Well #7
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
5000
10000
15000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data


Flight Line L170401
A
A'
Waverly
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
A
A'
Flight Line L170401 Resistivity
Approximately 5,000'
from start of Flight Line
Possible 50' sand and gravel deposit
as seen in G-142880
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
5000
10000
15000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

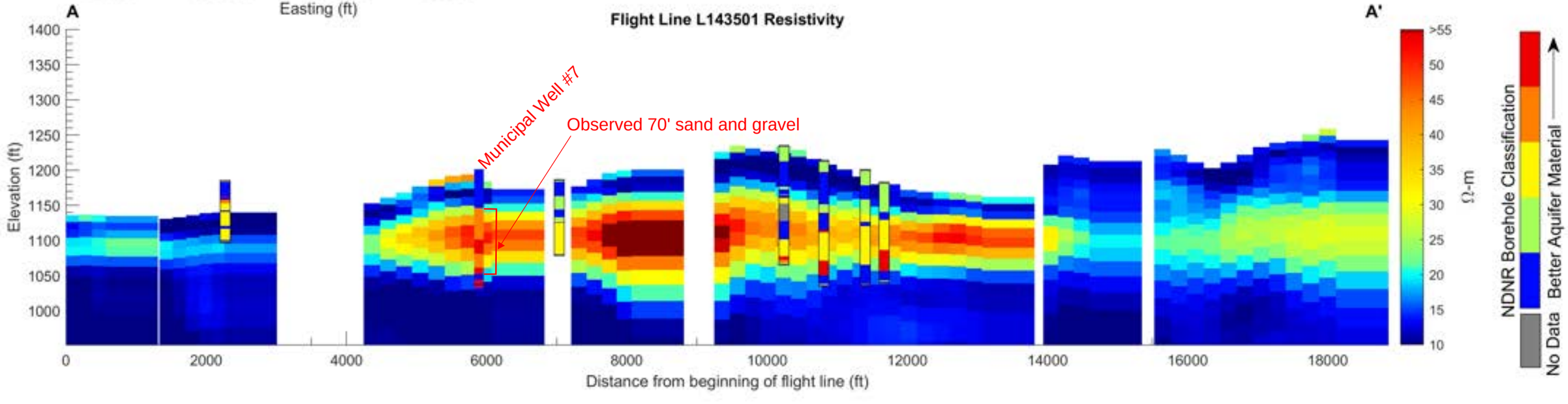

Flight Line L142501
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
G-016235
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L142501 Resistivity
A
A'
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Distance from beginning of flight line (ft)
45' sand and gravel interval observed at G-016235. Possibly more coarse-grained material below.
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

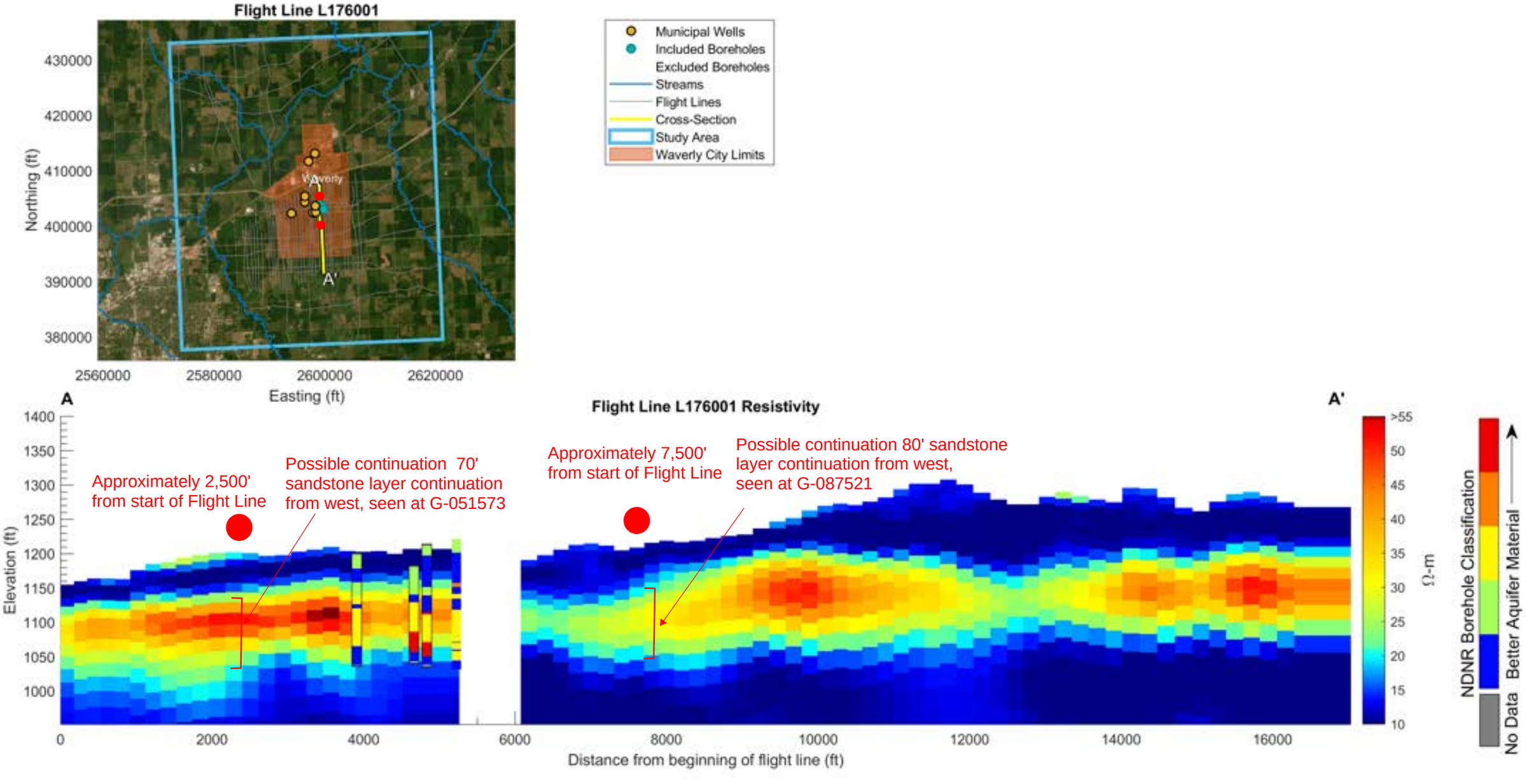

Flight Line L177001
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
A
A'
Flight Line L177001 Resistivity
Approximately 8,500' from start of Flight Line
Possible continuation 40' sandstone layer seen to west at G-008965
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

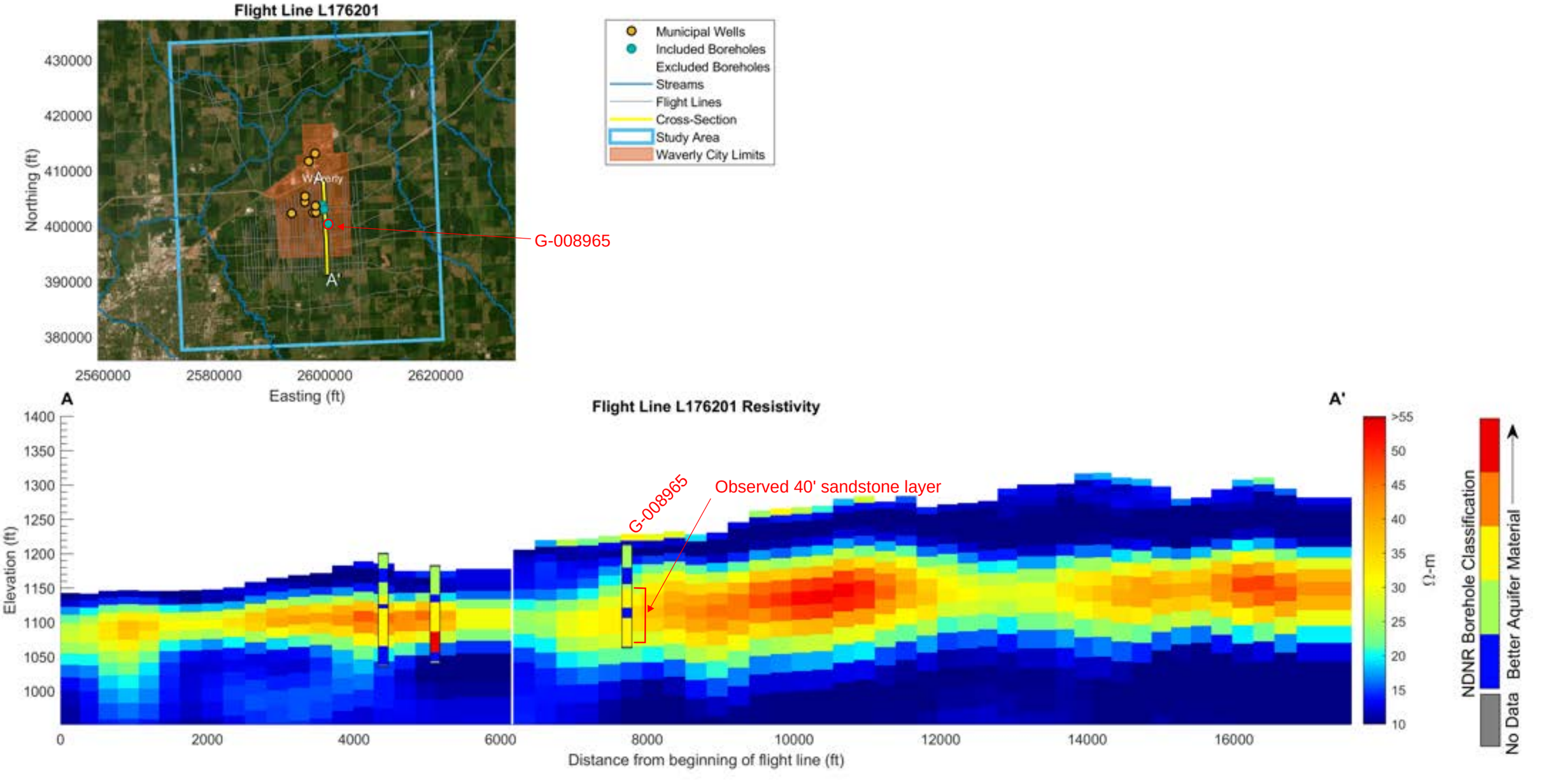

Flight Line L175601
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
G-051573
G-087521
Northing (ft)
Easting (ft)
Flight Line L175601 Resistivity
Observed 70' sandstone layer
Observed 80' sandstone layer
Elevation (ft)
Distance from beginning of flight line (ft)
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data

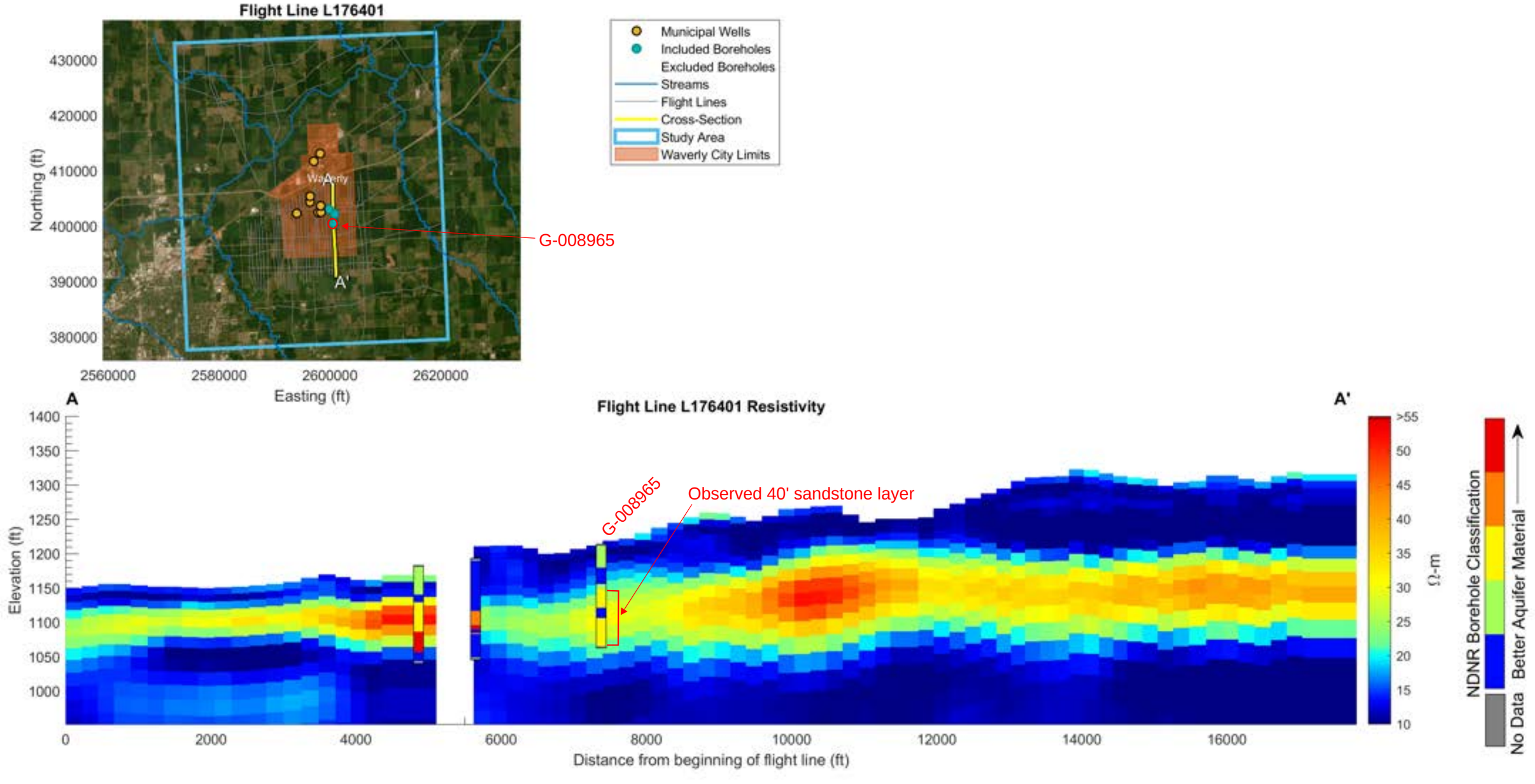


Municipal Well #7




Flight Line L176001
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L176001 Resistivity
A
A'
Approximately 2,500' from start of Flight Line
Possible continuation 70' sandstone layer continuation from west, seen at G-051573
Approximately 7,500' from start of Flight Line
Possible continuation 80' sandstone layer continuation from west, seen at G-087521
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data


Flight Line L176201
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A
A'
G-008965
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
Flight Line L176201 Resistivity
A
A'
G-008965
Observed 40' sandstone layer
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data


Flight Line L176401
Municipal Wells
Included Boreholes
Excluded Boreholes
Streams
Flight Lines
Cross-Section
Study Area
Waverly City Limits
Waverly
A'
G-008965
Northing (ft)
430000
420000
410000
400000
390000
380000
2560000
2580000
2600000
2620000
Easting (ft)
A
A'
Flight Line L176401 Resistivity
G-008965
Observed 40' sandstone layer
Elevation (ft)
1400
1350
1300
1250
1200
1150
1100
1050
1000
0
2000
4000
6000
8000
10000
12000
14000
16000
Distance from beginning of flight line (ft)
>55
50
45
40
35
30
25
20
15
10
Ω-m
NDNR Borehole Classification
Better Aquifer Material
No Data