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Clearwater River BMP Siting – Draft Report

Prepared for:

Clearwater River Watershed District

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WATERSHED DISTRICT

WENCK
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Table of Contents

1.0 Purpose and Scope

There are currently eight lakes located along the Clearwater River Chain of Lakes that are impaired for nutrients. The Upper Clearwater River, between County Ditch #20 North and Lake Betsy (Figure 1), is impaired for bacteria and dissolved oxygen (DO). Additionally, monitored total suspended sediment (TSS) and phosphorus concentrations in the Upper Clearwater River are high and occasionally exceed state water quality standards. Total Maximum Daily Load (TMDL) studies and implementation plans for the impaired lakes and river reaches in the Upper Clearwater Watershed were completed in 2009. Since the completion of the TMDL studies, the Clearwater River Watershed District (CRWD) has implemented several water quality improvement projects in the Upper Clearwater River Watershed. These projects include:

- Kingston Wetland Restoration
- targeted, variable rate fertilizer application
- stream bank protection and stabilization projects
- Kimball Stormwater Retrofit Phase I & Phase II
- various agricultural best management practices (BMPs)

Despite the work and projects already completed in the Upper Clearwater River Watershed, further nutrient, sediment and bacteria load reductions are needed to meet state water quality standards and TMDL goals. The CRWD has identified landscape agricultural practices and in-stream erosion due to altered hydrology as the primary sources of sediment, phosphorus, and bacteria to the Upper Clearwater River. The CRWD's comprehensive plan identified the direct tributary areas between Clear Lake and Lake Betsy as a high-priority implementation area with respect to restoration and surface water protection in the Upper Clearwater River Watershed.

In 2015, the CRWD received a Clean Water Partnership (CWP) grant to identify and implement agricultural BMPs and/or other projects to reduce sediment, phosphorus, and bacteria loads to the Upper Clearwater River. Through this project, the CRWD updated the existing 2008 field reconnaissance of high priority sediment and bacteria sources through desktop review/analysis and field visits. Sites with the highest potential export were prioritized for implementation projects. Combinations of agricultural BMPs and/or stream stabilization techniques are recommended to reduce sediment, phosphorus, and bacteria loads to the Clearwater River.

This report presents the results of the desktop analysis, site visits, and BMP identification and prioritization portion of the CWP grant. This information is intended to help provide the CRWD staff and Board with the necessary information to decide which BMPs they would like to pursue for the implementation phase of the project.

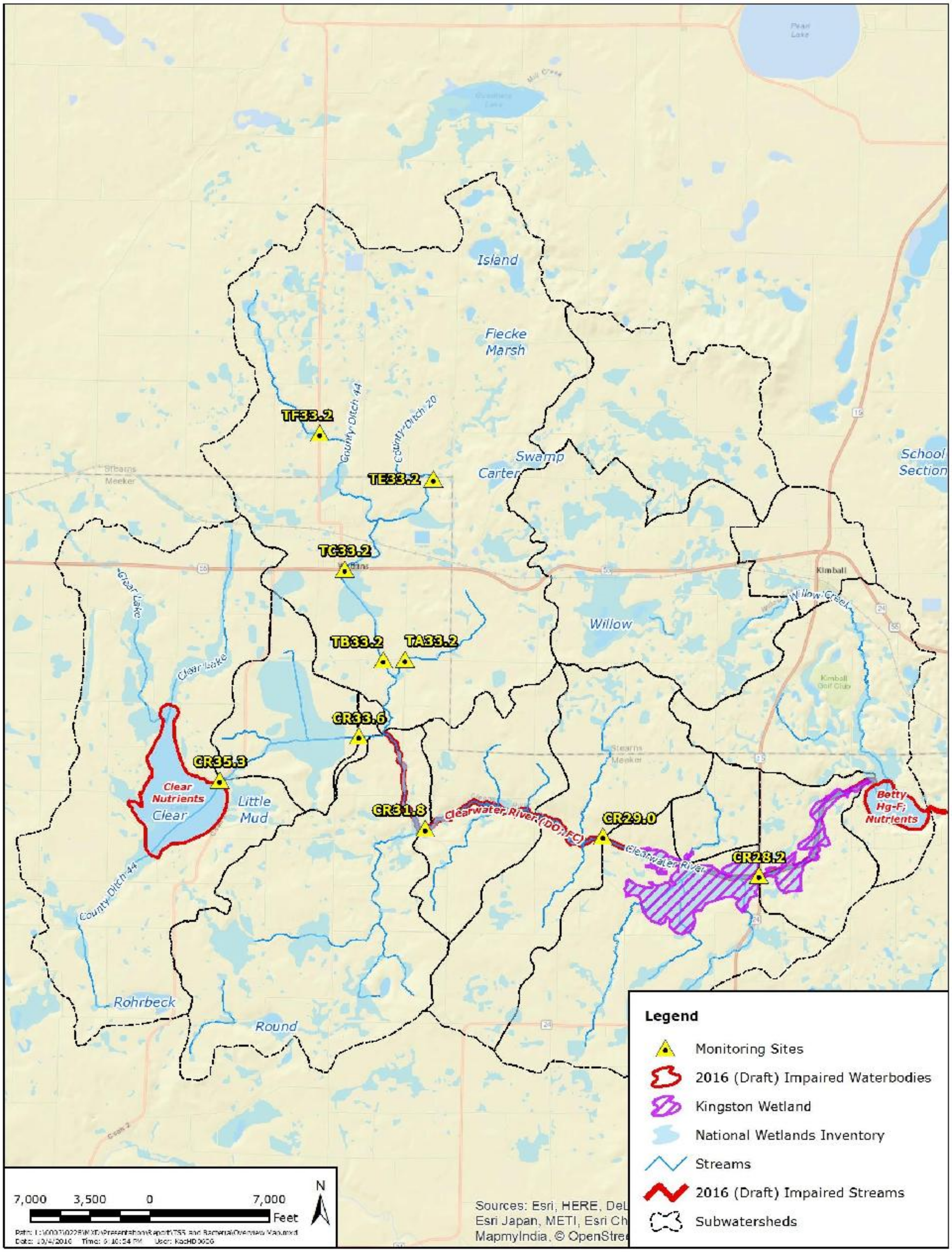

Figure 1. Upper Clearwater River Watershed.

2.0 Water Quality Summary

2.1 TSS DATA

CRWD staff has collected TSS data at several monitoring stations throughout the Upper Clearwater River Watershed. Stations CR29.0 and CR28.2 are the two long-term routine monitoring stations in the upper watershed. CR29.0 is located upstream of the Kingston Wetland, while CR28.2 is located at the downstream end of the wetland (Figure 1). TSS data has also been collected at two other mainstem stations (CR33.6 and CR31.8) and two tributary stations (TB33.2 and TC33.2) along County Ditch #20 North. TSS data from all stations is summarized in Table 1 and presented as box plots in Figure 2. Figure 3 shows TSS concentrations since 2005 by flow regime at station CR29.0. The data shows high TSS levels typically occur during high flow conditions and the biggest increase in TSS occurs between stations CR31.8 and CR29.0. This suggests BMP implementation efforts should focus on this stretch of the Upper Clearwater River Watershed.

Table 1. TSS monitoring in the Upper Clearwater River Watershed (2005-2015)

Station	Samples Collected	Average TSS [mg/L]	Samples >30 mg/L	Percent >30 mg/L
CR33.6	8	12	1	13%
CR31.8	10	47	2	20%
CR29.0	64	35	30	47%
CR28.2	100	12	10	10%
TB33.2	27	8	1	4%
TC33.2	22	12	1	5%

2.2 BACTERIA DATA

CRWD staff has collected *E. coli* data at several monitoring stations throughout the Upper Clearwater River Watershed. Three *E. coli* longitudinal surveys were performed during the summer of 2016 to determine potential sources and locations of high bacteria levels in the upper watershed (Figure 4). Results of these surveys indicate *E. coli* levels are low coming out of Clear Lake (station CR35.3) and usually above the standard at all other monitoring stations in the watershed. The largest increases in *E. coli* concentration along the mainstem Clearwater River occurs between CR33.6 and CR29.0. County Ditch #20 North *E. coli* concentrations are consistently high and are a significant source of bacteria to the mainstem Clearwater River. *E. coli* concentrations at the two County Ditch #20 North and the three ditch tributary monitoring stations did not show any spatial patterns between stations during the three longitudinal surveys. Figure 5 presents *E. coli* concentrations by season and flow regime at station CR29.0. This data shows *E. coli* is high and above state standards during all seasons and flow conditions.

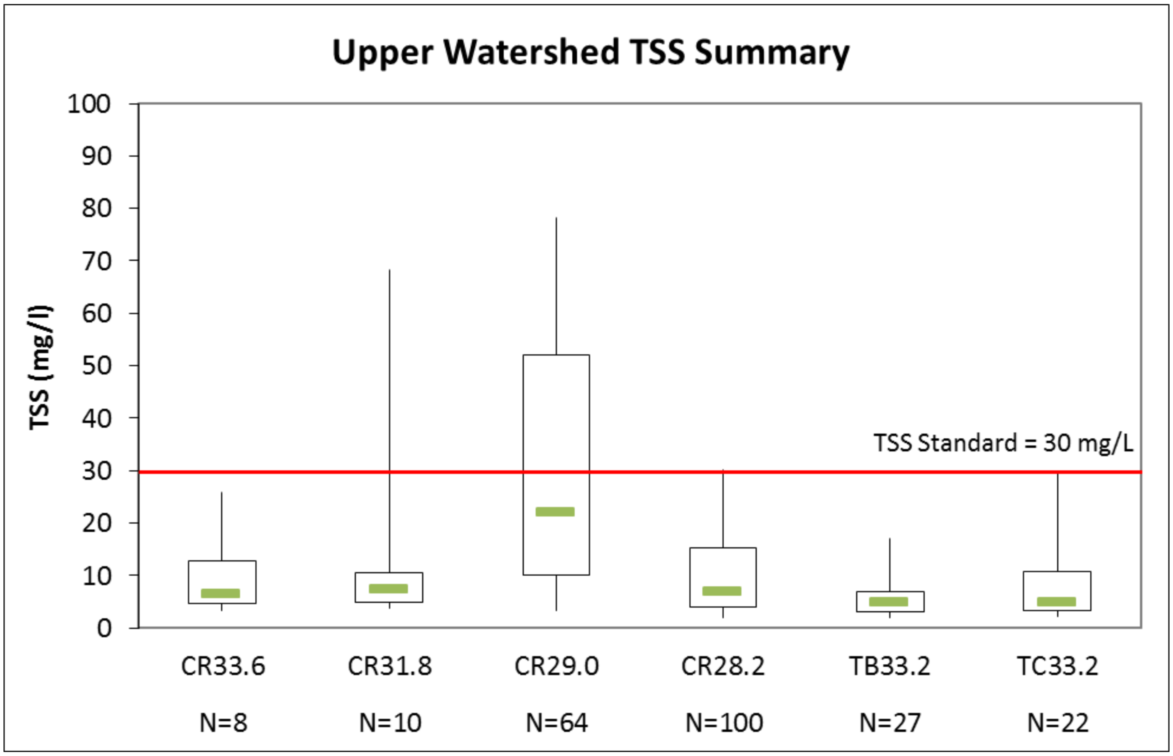

Figure 2. Upper Clearwater River TSS data by site (2005-2015)

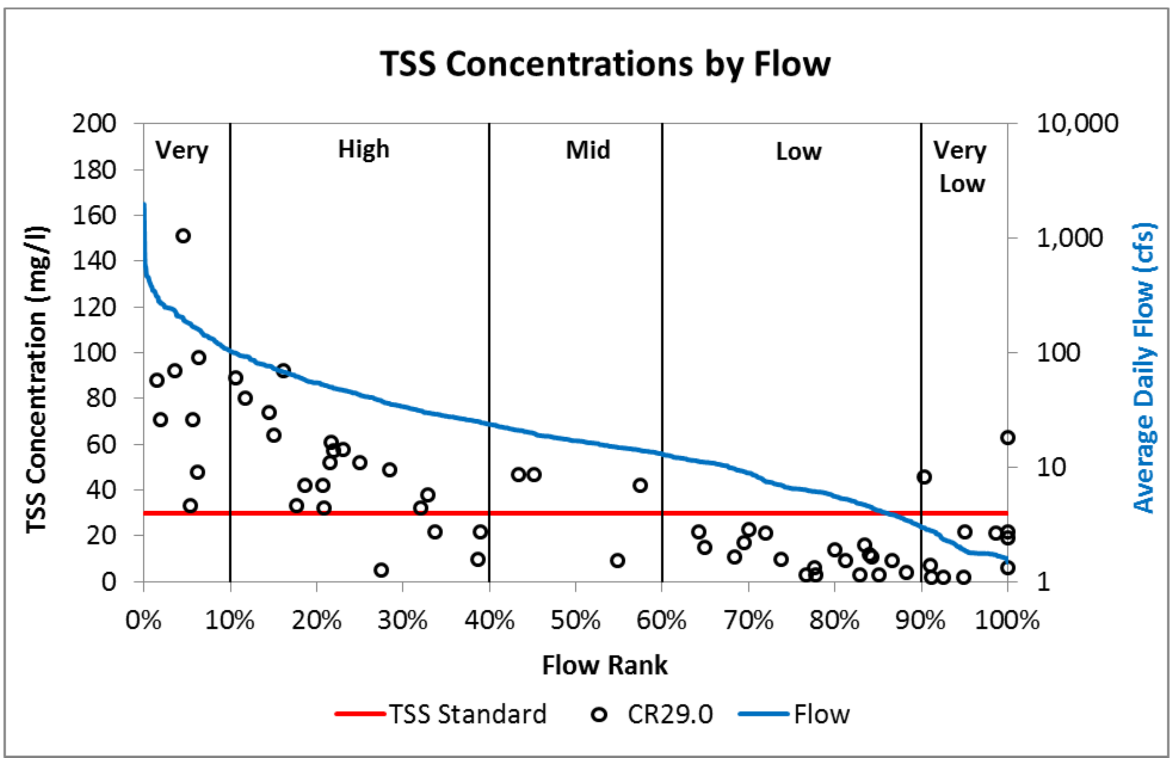

Figure 3. TSS data for station CR29.0 by flow regime (2005-2015)

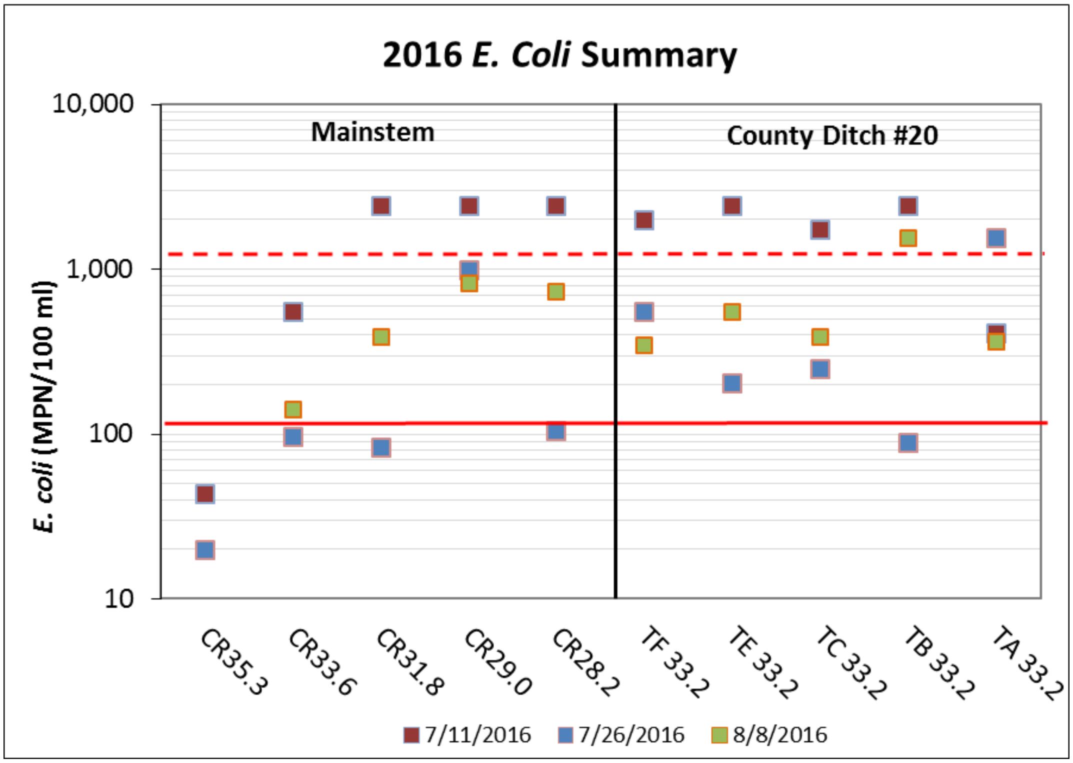

Figure 4. 2016 Clearwater River *E. coli* longitudinal surveys.

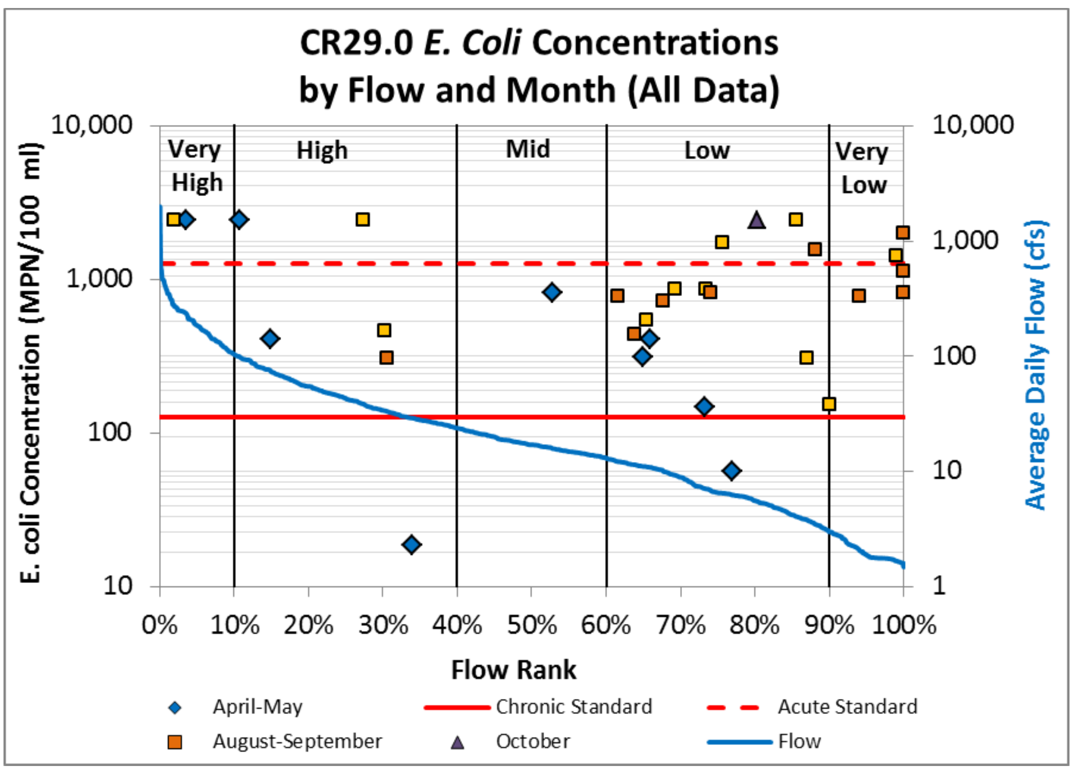

Figure 5. *E. coli* data for station CR29.0 by season and flow regime (2005-2015)

3.0 TSS BMP Identification

This section presents the methodology Wenck and CRWD staff used to identify and prioritize potential BMP projects to address TSS loading in the Upper Clearwater River Watershed. The BMP identification process included a combination of desktop GIS analysis and windshield surveys. Both of these are described below in more detail.

3.1 DESKTOP GIS ANALYSIS

There were several GIS layers and tools used to identify high potential loading areas and BMPs throughout the upper portion of the Clearwater River Watershed. A description of each GIS tools/layer used in this project is provided below.

Light Detection and Ranging (LiDAR)
Light detection and ranging (LiDAR) uses pulses of energy to record elevation values of the landscape. Within a LiDAR point cloud, returns are generated based on the number of objects detected. In areas of high forest canopy multiple returns are created for each penetration of energy. Values are separated into classes and a digital elevation surface is created from the bare earth points.

For this study, Wenck utilized two foot contours derived from a LiDAR DEM to delineate drainage areas for each of the proposed BMPs. Wenck also used LiDAR DEMs to calculate several topographic variables that were used as part of the RUSLE, SPI, Depression Area, and RWI analyses, as described below.

Air Photos
Wenck relied heavily on aerial photographs to determine BMP placement and type. Imagery is readily available through the Minnesota Geospatial (MN GEO) Information Office via a web mapping server. MN GEO provides streaming of Farm Service Administration (FSA) imagery [one-meter resolution] for available years and high resolution imagery collected by participating counties. The 2015 FSA, 2013 Meeker County, and 2015 Stearns county imagery were used to aid in placing BMPs. Stearns County provides imagery through a hosted service on ArcGIS Online.

Revised Universal Soil Loss Equation (RUSLE)
The RUSLE was used to estimate average upland sediment loss throughout the Upper Clearwater River Watershed. RUSLE provides a general assessment of existing soil loss from upland sources using the following factors: rainfall pattern, soil type, topography, land use and land management practices. The general form of the RUSLE has been widely used in predicting field erosion and is calculated according to the following equation:

$$A = R \times K \times LS \times C \times P$$

Where A represents the potential long term average soil loss (tons/acre) and is a function of the rainfall erosivity index (R), soil erodibility factor (K), slope-length gradient factor (LS), crop/vegetation management factor (C) and the conservation/support practice factor (P). RUSLE only predicts soil loss from sheet or rill erosion on a single slope; it does not account for potential losses from gully, wind, or streambank erosion.

For this exercise, it was assumed all agricultural practices are subject to maximum soil loss from fall plow tillage methods, and no BMPs and sediment support practices exist (P-factor = 1.00). Raster layers of each RUSLE factor were constructed in ArcGIS for the Upper Clearwater River Watershed and then multiplied together to estimate the average annual potential soil loss for each grid cell. It is important to note that this RUSLE model is intended to represent the maximum amount of soil loss that could be expected under existing conditions; it is not calibrated to field observations or observed/monitored data. Thus, the model results are intended to provide a first cut in identifying potential field erosion hot spots based on local slope, landuse and soil attributes.

Since RUSLE does not take into account a stream's ability to transport suspended sediment, a sediment delivery ratio (SDR) was used to estimate how much upland soil is delivered to downstream resources of concern such as tributaries, streams, and lakes. The SDR for the Upper Clearwater River Watershed was established using the methodology outlined by the Minnesota Phosphorus Index (UMN Extension, 2006) with equations borrowed from RUSLE2. Since the primary focus of this study is to reduce sediment loading to the Upper Clearwater River, the SDR applied to each RUSLE grid cell was calculated based on distance to the main-stem Clearwater River.

Even with the SDR, field sediment delivery to the stream channel is often over-estimated, since the SDR-adjusted RUSLE model does not take into account wetlands, lakes, and other areas of depressional storage. Average annual monitored TSS loads at station CR29.0 were significantly lower when compared to the SDR-adjusted RUSLE sediment loads for the Upper Clearwater River Watershed. Thus, an additional adjustment factor (approx. 0.05) was applied to the SDR so that the RUSLE model more accurately reflects the sediment loads observed in the main-stem Clearwater River.

Stream Power Index (SPI)

The stream power index examines the erosive power of water on the landscape. Although this exercise does not quantify the amount of sediment being eroded from the land, SPI can be used to find high concentration flow paths to identify rill and gully networks. SPI values were calculated using ArcGIS Spatial Analyst extension. After preconditioning the LiDAR-derived DEM, flow direction, flow accumulation and slope percent were derived. The final calculation is based on the Minnesota Department of Agriculture's evaluation of SPI using GIS (Galzki et. al., 2007). The equation as follows:

$$Ln((flow\_accumulation\_grid + .001) * ((slope\_percent\_grid / 100) + .001))$$

Where:
Ln = Natural log; flow_accumulation_grid = number of contributing cells; slope_percent_grid = slope percent; and .001 is added to each cell to avoid zero SPI values. Following calculation of the SPI, values were reclassified into percentiles from the 80^{th} to 95^{th}. Aggregating the data separates values in low lying areas where ponding may occur (see depression analysis below). These values were used in Galzki et. al. (2007) as corresponding with visible erosion pathways.

Depression Area Analysis

Depressions in the Upper Clearwater River Watershed were identified using GIS processing tools from the Agricultural Conservation Practice Framework (ACPF). The Depression analysis uses an unfilled LiDAR DEM, field boundaries created by the FSA, soil attributes from the Soil Survey Geographic Database (SSURGO), and stream reaches created from the

DEM. The DEM is filled and the depth of the depression is extracted. Hydric soils from SSURGO are used as secondary criteria for identifying areas with probability of wetland soils. The final product of the tool shows the ponding area based on water depth and direct contributing area thresholds set by the user. This data was used to aid in identifying areas where potential tile intakes may be located and where BMPs such as alternative tile intake (ATI) and wetland restorations may be appropriate.

Restorable Wetlands Index (RWI)
The RWI was developed by the Natural Resources Institute at the University of Minnesota Duluth. The tool uses a DEM to derive the topographic wetness index (TWI) or compound topographic index (CTI) in finding areas of flow accumulation to a depression area. Drainage classes in the poor and very poor categories are used in determining if the landscape is potentially tile drained. Finally, wetlands in the National Wetland Inventory (NWI) are intersected with the layer and removed since the tract of land is currently classified as a wetland. This layer was used in determining if a wetland restoration was suitable in the BMP derivation process.

3.2 WINDSHIELD SURVEYS

Windshield surveys and site visits were performed by CRWD and Wenck staff in March 2016 to identify potential locations for BMPs in the Upper Clearwater River Watershed. Prior to the windshield surveys, a series of field erosion "heat" maps (mapbooks) were created by Wenck using results of the RUSLE desktop analysis. These maps showed high potential areas of field erosion in the upper watershed that were used by CRWD and Wenck staff to focus and prioritize their time in the field. Results of the RUSLE analysis showed several potential sediment loading hotspots located in the high-sloped areas near the main-stem Clearwater River and the County Ditch #20 North system. As a result, much of the windshield survey was focused in these areas. While in the field, CRWD and Wenck staff collected field notes and marked GIS locations at approximately 39 sites where they observed obvious signs of field erosion and soil loss. The field notes and GIS locations were later compiled and entered into a GIS database by Wenck staff.

3.3 BMPS CONSIDERED

Based on the desktop analysis and windshield surveys, there are four general types of BMPs that are most appropriate to help reduce sediment loading to the upper Clearwater River: gully practices, contour practices, drainage management practices, and in-channel practices. Table 2 presents a suite of potential BMPs that fall within each of the four general BMP categories, along with potential TSS and TP reductions and rough cost estimates for each specific BMP type.

Table 2. Potential BMPs in the Upper Clearwater River Watershed

BMP Type	Potential BMPs	Sediment Reductions	Phosphorus Reductions	General Cost Range
Gully Practices	Water & Sediment Control Basin (WASCOB)	92%[1]	75%[3]	\$100 to \$150 per linear foot[7]
	Grassed Waterway	77%[1]	58%[2]	\$2,000 to \$3,000 per acre[7]
Contour Practices	Contour Buffer Strip	78%[1]	62%[1]	\$1,500 to \$2,000 per acre for

BMP Type	Potential BMPs	Sediment Reductions	Phosphorus Reductions	General Cost Range
				native prairie[7]
	Terrace	NA[5]	65%[8]	$100 to $150 per linear foot[7]
Drainage Mgt. Practices	Alternative Tile Intake (ATI)	80%[1]	66%[4]	$1,200 to $2,000[7]
	Side Inlet	NA[5]	NA[5]	NA[5]
	Wetland Restoration	NA[5]	NA[5]	$12,000 to $17,000 per acre[7]
In-channel Practices	Two-staged Ditch	70%[6]	36%[6]	New construction: $75 to $100; Channel modification: $25 to $40
	Stream Buffer Enhancement	53% to 98%[1]	41% to 93%[1]	$125 to $175 per linear foot

[1] MDA, 2012.
[2] MPCA, 2014.
[3] McKenna, D.
[4] Wilson et al, 1999.
[5] Removal efficiencies are not available or the numbers vary.
[6] Hodaj et al. 2015
[7] University of Minnesota Extension, 2015.
[8] Alabama Cooperative Extension System.

3.4 FINAL BMP DETERMINATION

Wenck reviewed all of the aforementioned GIS layers/tools and field notes to determine which general BMP type would be most appropriate for each of the 39 sites identified during the windshield survey (see Figure 6 and Table 3). In addition to the general BMP type, a specific BMP was proposed for each of the 39 sites. It should be pointed out that the proposed BMP is one of several options available to the landowner (see Table 2 for other BMP options). For example, SPI, LiDAR, and air photo analysis of Site SH-T122-R29-S31 suggests this site has a high potential for gully erosion and that some sort of gully practice would be most appropriate for this site. Table 3 proposes a WASCOB, however other BMP options such as a grassed waterway could be implemented depending on landowner preference, cost, feasibility, specific site conditions, etc..

Once the BMP was selected, each BMP’s upslope contributing area was delineated in GIS using LiDAR, and the RUSLE model was used to estimate each site’s potential soil loss and sediment delivery to the main-stem Clearwater River. Sediment reductions based on BMP performance (Table 2) were then calculated for each site in order to evaluate which BMPs have the biggest potential impact on sediment loading to the Clearwater River. Table 3 also estimates current phosphorus loads and potential phosphorus load reductions to the Clearwater River. The phosphorus loading estimates were calculated based on the long-term average annual observed TP:TSS ratio (approx. 0.003) at CR29.0. BMP volume reduction benefits were not calculated since most of the practices identified fall within the gully, contour, and drainage management BMP categories. Specific BMPs in these categories are designed to decrease soil loss through filtration, rate control, and slowing the flow of water on the landscape. While these practices may have some secondary volume reduction benefits, they are not intended to be designed or considered infiltration and/or long-term water storage practices. The two wetland restorations identified in this study may provide direct water storage and/or volume reductions; however, a more in-depth feasibility study and hydrologic analysis will be needed in order to quantify these benefits.

Table 3 and the figures in Appendix A describe each of the 39 sites evaluated, proposed BMP type, current sediment delivery, and estimated sediment reduction based on BMP type. Each of the 39 sites in Table 3 were ranked and presented in order of potential sediment reduction to the Clearwater River in tons/year (column 10). Sediment reductions were not calculated for six sites listed at the end of Table 3. Proposed BMPs for these sites include large scale stream buffer enhancements, two-staged ditch, side inlet, wetland restorations, and contour farming. A more detailed monitoring and/or feasibility study would need to be performed to estimate potential sediment reductions and other benefits for these BMPs.

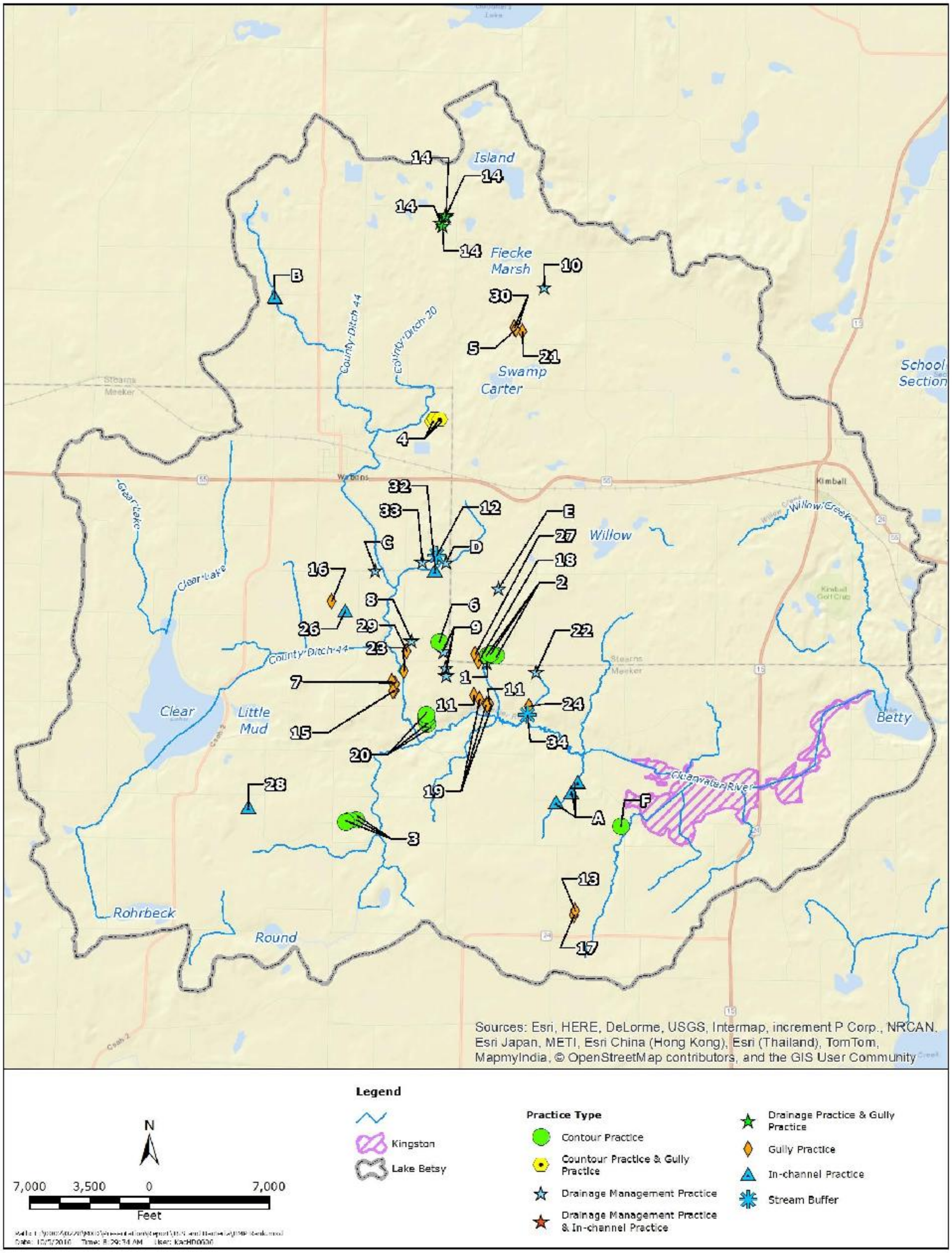

Figure 6. Proposed BMPs in the Upper Clearwater River Watershed.

Table 3. Potential BMPs in the Upper Clearwater River Watershed.

Rank[1]	Site ID[2]	BMP Type[3]	Proposed BMP[4]	Drainage Area to BMP [Acres]	BMP Distance to Main-stem Clearwater River [miles]	Current Sediment Erosion On Site[5] [tons/yr]	Current Sediment Delivery to Clearwater River[6] [tons/yr]	Current Phosphorus Delivery to Clearwater River[7] [lbs/yr]	BMP Sediment Reduction to Clearwater River[8] [tons/yr]	BMP Phosphorus Reduction to Clearwater River[8] [lbs/yr]
1	SH-T121-R29-S18-1	Drainage Management	ATIs and/or sedimentation basin	146.6	0.57	957	8.6	51.4	6.9	34.0
2	SH-T121-R29-S18-2	Contour	Contour Buffer	88.1	0.64	645	5.8	34.9	4.5	21.7
3	SESE-T121-R30-S26-1	Contour	Contour Buffer	83.8	1.11	565	4.6	27.7	3.6	17.2
4	NE-T121-R30-S1	Countour and/or Gully	Contour Buffer Strip and/or Gully BMPs	44.7	2.54	555	3.9	23.2	3.3	15.9
5	SH-T122-R29-S31	Gully	Wascob	44.0	3.54	435	2.8	17.1	2.6	12.8
6	SESE-T121-R30-S13-1	Contour	Contour Buffer	34.2	0.49	286	2.9	17.4	2.3	10.8
7	NW-T121-R30-S24-1	Gully	Grassed Waterway	20.8	0.09	242	2.9	17.6	2.3	10.2
8	WH-SE-T121-R30-S13-1	Contour	Contour Buffer	18.5	0.23	228	2.5	14.9	1.9	9.2
9	NENE-T121-R30-S24-1	Drainage Management	ATI	45.1	0.42	224	2.3	13.8	1.8	9.1
10	SH-T122-R29-S30-1	Drainage Management	ATI	92.1	3.69	352	2.3	13.6	1.8	9.0
11	SENW-T121-R29-S19-2	Gully	Wascob	13.2	0.12	128	1.5	9.2	1.4	6.9
12	SE-T121-R30-S12-1	In-channel	Stream Buffer	45.5	1.14	189	1.5	9.2	1.2	6.1
13	NESW-T121-R29-S32-1	Gully	Wascob	18.9	1.73	159	1.2	7.3	1.1	5.5
14	NENE-T122-R30-S25-1	Drainage & Gully	ATI & Grassed Waterway	26.1	4.71	199	1.2	7.3	1.0	4.5
15	SENW-T121-R30-S24-1	Gully	Grassed Waterway	6.1	2.45	94	1.2	7.1	0.9	4.1
16	SWNE-T121-R30-S14-1	Gully	Grassed Waterway	25.6	0.52	111	1.1	6.5	0.8	3.7
17	SESW-T121-R29-S32-1	Gully	Wascob	15.1	1.78	120	0.9	5.4	0.8	4.0
18	SESW-T121-R29-S18-2	Gully	Wascob	9.0	0.57	93	0.9	5.2	0.8	3.9
19	SENW-T121-R29-S19-1	Gully	Wascob	8.8	0.11	68	0.8	5.1	0.8	3.8
20	SE-T121-R30-S24-1	Contour and/or Gully	Contour Buffer and/or Gully BMPs	13.4	0.12	78	0.9	5.7	0.7	3.5
21	SENE-T122-R29-S31-1	Gully	Grassed Waterway	25.7	3.60	137	0.9	5.4	0.7	3.1
22	NWNW-T121-R29-S20-1	Drainage Management	ATI	28.1	3.60	85	0.8	4.9	0.7	3.3
23	NWNE-T121-R30-S24-1	Gully	Wascob	9.0	0.56	52	0.7	4.2	0.6	3.2
24	SENE-T121-R29-S19	Gully	Wascob	3.3	0.03	55	0.6	3.9	0.6	2.9
25	EH-T121-R30-S14-1	In-channel	Stream Buffer	2.6	0.16	4	0.8	4.7	0.6	3.2
26	EH-T121-R30-S14-1	In-channel	Stream Buffer	47.8	0.39	77	0.8	4.7	0.6	3.2
27	SESW-T121-R29-S18-1	Gully	Wascob	5.9	0.39	66	0.6	3.6	0.6	2.7
28	NESE-T121-R30-S27-1	In-channel	Stream Buffer	15.6	0.65	87	0.7	4.2	0.5	2.8
29	SWSE-T121-R30-S13-1	Gully	Grassed Waterway	4.5	1.27	48	0.6	3.6	0.5	2.1

Rank[1]	Site ID[2]	BMP Type[3]	Proposed BMP[4]	Drainage Area to BMP [Acres]	BMP Distance to Main-stem Clearwater River [miles]	Current Sediment Erosion On Site[5] [tons/yr]	Current Sediment Delivery to Clearwater River[6] [tons/yr]	Current Phosphorus Delivery to Clearwater River[7] [lbs/yr]	BMP Sediment Reduction to Clearwater River[8] [tons/yr]	BMP Phosphorus Reduction to Clearwater River[8] [lbs/yr]
30	SWNE-T122-R29-S31-1	Gully	Grassed Waterway & Wascob	7.3	0.12	68	0.4	2.7	0.4	1.8
31	SWSE-T121-R30-S12-1	In-channel	Stream Buffer	2.0	3.68	8	0.5	3.0	0.4	2.0
32	SWSE-T121-R30-S12-1	In-channel	Stream Buffer	13.9	1.13	57	0.5	3.0	0.4	2.0
33	SWSE-T121-R30-S12-2	Drainage Management	ATI	9.7	1.00	43	0.4	2.2	0.3	1.5
34	NESE-T121-R29-S19	In-channel	Stream Buffer	2.7	1.01	22	0.3	2.0	0.2	1.3
A	NESE-T121-R29-S19-1	In-channel	Stream Buffer	1.0	0.43	-	-	-	-	-
B	NW-T122-R30-S35-1	In-channel	Two Stage Ditch	45.9	3.93	-	-	-	-	
C	SWSW-T121-R30-S12-1	Drainage Management	Side Inlet	4.8	0.84	20	0.2	1.0	-	-
D	SESE-T121-R30-S12-1	Drainage Management	Wetland Restoration	661.4	1.13	2,341	17.7	106.2	-	-
E	NE-T121-R29-S18-1	Drainage Management	Wetland Restoration	147.3	1.35	1,223	9.7	58.4	-	-
F	SESE-T121-R29-S29-1	Contour	Contour Farming	2.8	0.71	69	0.6	3.8	-	-

[1] Rank based on BMP's estimated sediment reduction to Clearwater River
[2] Site ID naming convention: ¼ Section – Township – Range – Section – BMP# at given site
[3] BMP type determined based on GIS layer/tool analysis (see section 3.1)
[4] Proposed BMP selected by Wenck staff in order to estimate potential reductions. Other BMP options based on general BMP type are presented in Table 2
[5] Calculated using RUSLE (no SDR applied)
[6] Calculated using RUSLE (with SDR applied)
[7] Calculated based on TP:TSS ratio measured at station CR29.0
[8] Calculated using general BMP reductions presented in Table 2

4.0 Bacteria BMP Identification

Below is a general summary and description of the potential sources of bacteria in the Upper Clearwater River Watershed.

4.1 FEEDLOT FACILITIES

Livestock can contribute bacteria to the river through runoff from feedlot facilities and cropland with surface applied manure. According to the Meeker and Stearns County feedlot database, there are approximately 61 active feedlot facilities with over 8,705 livestock animal units throughout the Upper Clearwater River Watershed (Figure 7). A majority of the livestock operations throughout the watershed are cattle, however there are swine operations located near the City of Watkins. There are 14 feedlots located within 1,000 feet of a lake or 300 feet of a stream or river, an area generally defined as shoreland. Eleven of the feedlots in shoreland areas have open lots. Open lots present a potential pollution hazard if the runoff from the open lots is not treated prior to reaching surface water. Manure from all feedlots in the upper watershed is typically applied as fertilizer to agricultural fields and is discussed below.

4.2 MANURE

Manure is a by-product of animal production and large numbers of animals create large quantities of manure. This manure is usually stockpiled and then spread over agricultural fields to help fertilize the soil. During this time the manure can be a source of *E. coli* in rivers and streams, especially during precipitation events.

4.3 SSTS

Failing or nonconforming septic systems, or subsurface sewage treatment systems (SSTS) near waterways can also be a source of bacteria to streams, especially during low flow periods when these sources continue to discharge and runoff driven sources are not active. Currently, the exact number and status of SSTSs in the Upper Clearwater River Watershed are unknown. MPCA’s 2012 SSTS Annual Report (MPCA, 2013) includes some general information regarding the performance of SSTSs in the upper watershed. This study provides county annual reports that include estimated failure rates for each county in the state of Minnesota. The MPCA report differentiates between systems that are generally failing and those that are an imminent threat to public health and safety (ITPHS). Generally failing systems are those that do not provide adequate treatment and may contaminate groundwater. For example, a generally failing system may have a functioning, intact tank and soil absorption system, but fails to protect ground water by providing a less than sufficient amount of unsaturated soil between where the sewage is discharged and the ground water or bedrock. Systems considered ITPHS are severely failing or were never designed to provide adequate raw sewage treatment. Examples include SSTSs that discharge directly to surface water bodies such as ditches, streams or lakes. SSTS failure rates for counties in the Upper Clearwater River Watershed are summarized in Table 4. During the TMDL studies optical brightener surveys were conducted in the upper watershed and no optical brighteners were found in surface waters evaluated.

Table 4. SSTS failure rates by county.

County	Generally Failing SSTSs	ITPHS SSTSs
Meeker	15%	22%
Stearns	2%	10%

4.4 URBAN RUNOFF

There are currently no MS4s located in the Upper Clearwater River Watershed. There are also no communities likely to become subject to MS4 permit requirements in the near future. There is, however, one non-MS4 community (City of Watkins) located in the upper watershed study area. This urban area may contribute bacteria to surface waters through mismanaged pet waste, wildlife (particularly geese and other waterfowl) congregating in stormwater ponds/wetlands/stream corridors, and poorly buffered areas near streams.

4.5 NATURAL REPRODUCTION

It has been suggested that *E. coli* bacteria has the capability to reproduce naturally in water and sediment and therefore should be taken into account when identifying bacteria sources. Two Minnesota studies describe the presence and growth of "naturalized" or "indigenous" strains of *E. coli* in watershed soils (Ishii et al. 2006), and ditch sediment and water (Sadowsky et al. 2010). The latter study, supported with Clean Water Land and Legacy funding, was conducted in the Seven Mile Creek watershed, an agricultural landscape in southwest Minnesota. DNA fingerprinting of *E. coli* from sediment and water samples collected in Seven Mile Creek from 2008-2010 resulted in the identification of 1,568 isolates comprised of 452 different *E. coli* strains. Of these strains, 63.5% were represented by a single isolate, suggesting new or transient sources of E. coli. The remaining 36.5% of strains were represented by multiple isolates, suggesting persistence of specific *E. coli*. Discussions with the primary author of the Seven Mile Creek study suggest that while 36% might be used as a rough indicator of "background" levels of bacteria at this site during the study period, this percentage is not directly transferable to the concentration and count data of *E. coli* used in water quality standards and TMDLs. Additionally, because the study is not definitive as to the ultimate origins of this bacteria, it would not be appropriate to consider it as "natural" background. Finally, the author cautioned about extrapolating results from the Seven Mile Creek watershed to other watersheds without further studies.

4.6 RECOMMENDATIONS

All of the BMPs identified in Section 3 of this report are intended to reduce runoff, soil erosion, and sediment loads to the Clearwater River and therefore should also result in bacteria load reductions. Local feedlot officers, SWCDs, and the CRWD should continue to educate and work with producers to construct livestock access control points, develop manure management plans, and implement responsible manure spreading and pasture management throughout the watershed. Based on the *E. coli* monitoring data presented in Section 2.2, implementation should focus on riparian areas in the County Ditch #20 North subwatershed and the mainstem Clearwater River between CR33.6 and CR29.0. Below is a list of potential livestock BMPs that should be considered throughout the upper watershed. Refer to the Agricultural BMP Handbook for Minnesota (MDA, 2012) for descriptions of each of these BMPs along with discussion of their water quality benefits, design/implementation considerations, and cost information.

- Livestock Exclusion/Fencing
- Waste storage facilities
- Rotational grazing
- Feedlot runoff controls
- Feedlot/wastewater filter strips
- Clean runoff water diversion

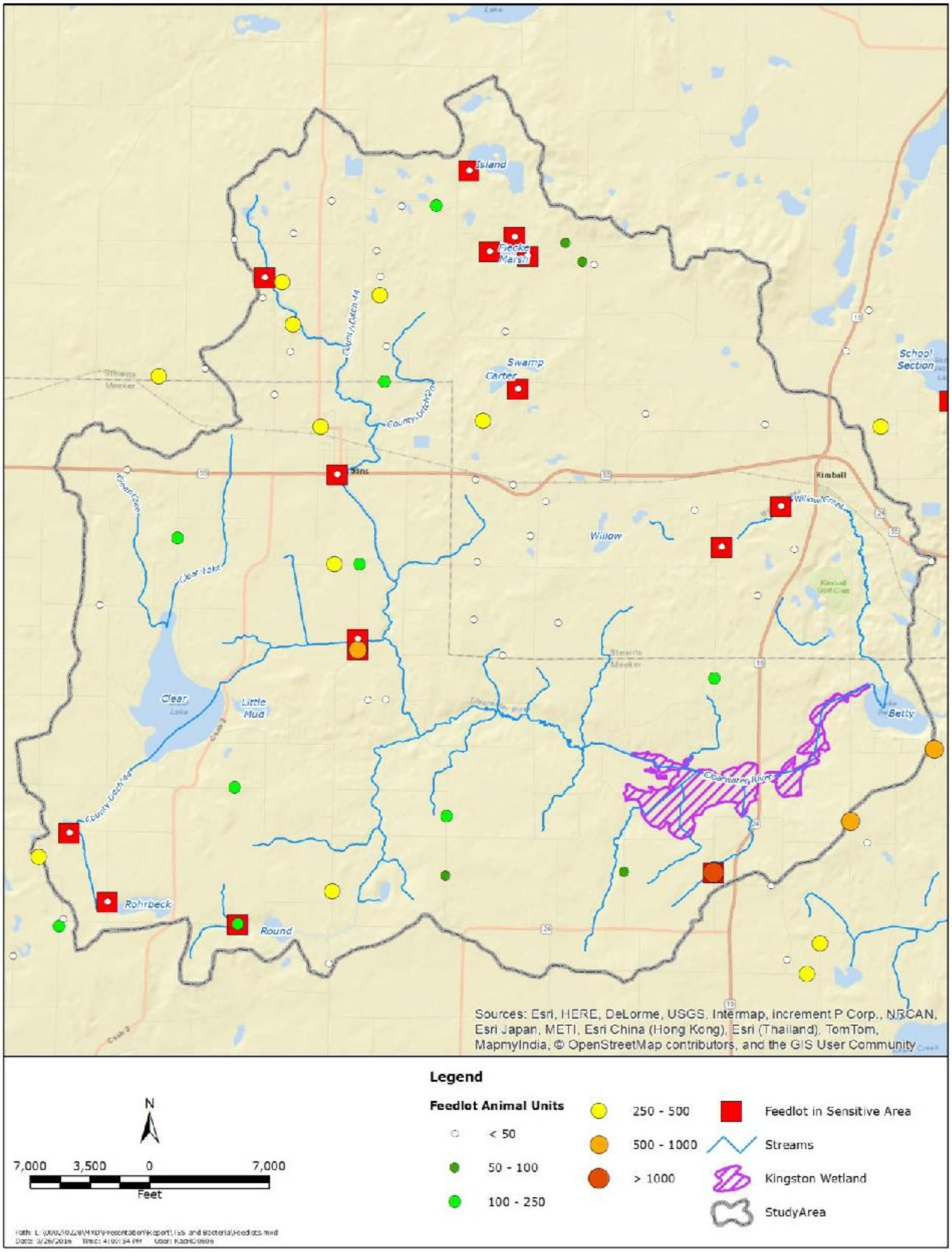

Figure 7. Feedlots in the Upper Clearwater River Watershed.

5.0 Final Recommendations

Wenck recommends that CRWD staff review the proposed BMPs listed in Table 3 to identify which practices they wish to pursue for final design and construction, and then begin contacting land owners to find willing parties for implementation.

6.0 References

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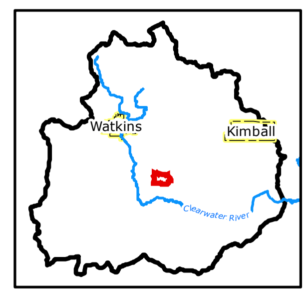
Appendix A

Individual BMP Maps

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
SH-T121-R29-S18-1



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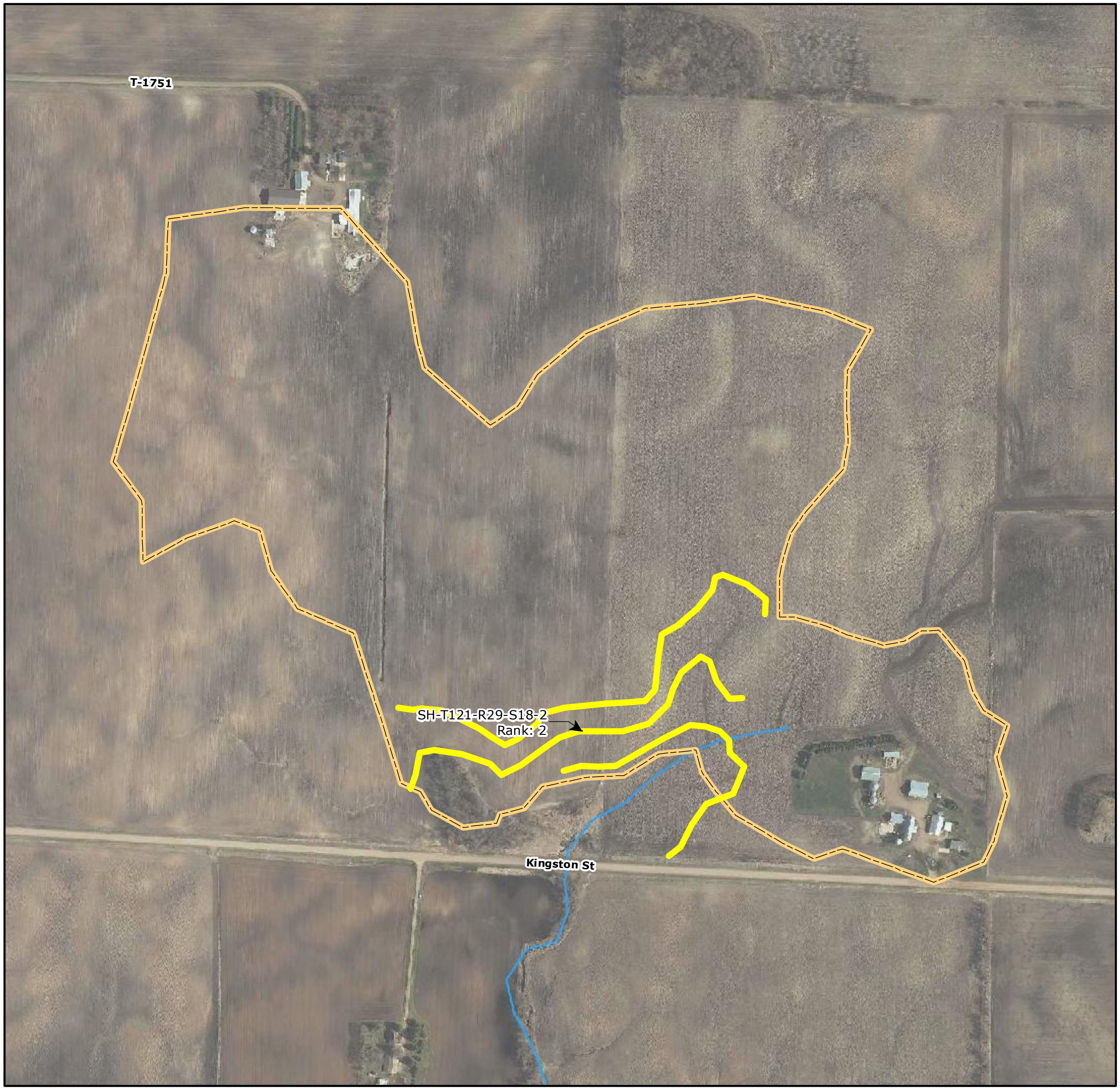
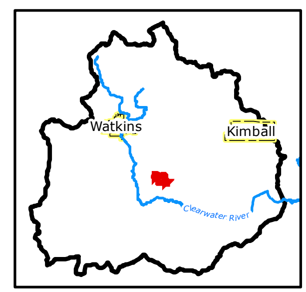


Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Contour Practice
SH-T121-R29-S18-2



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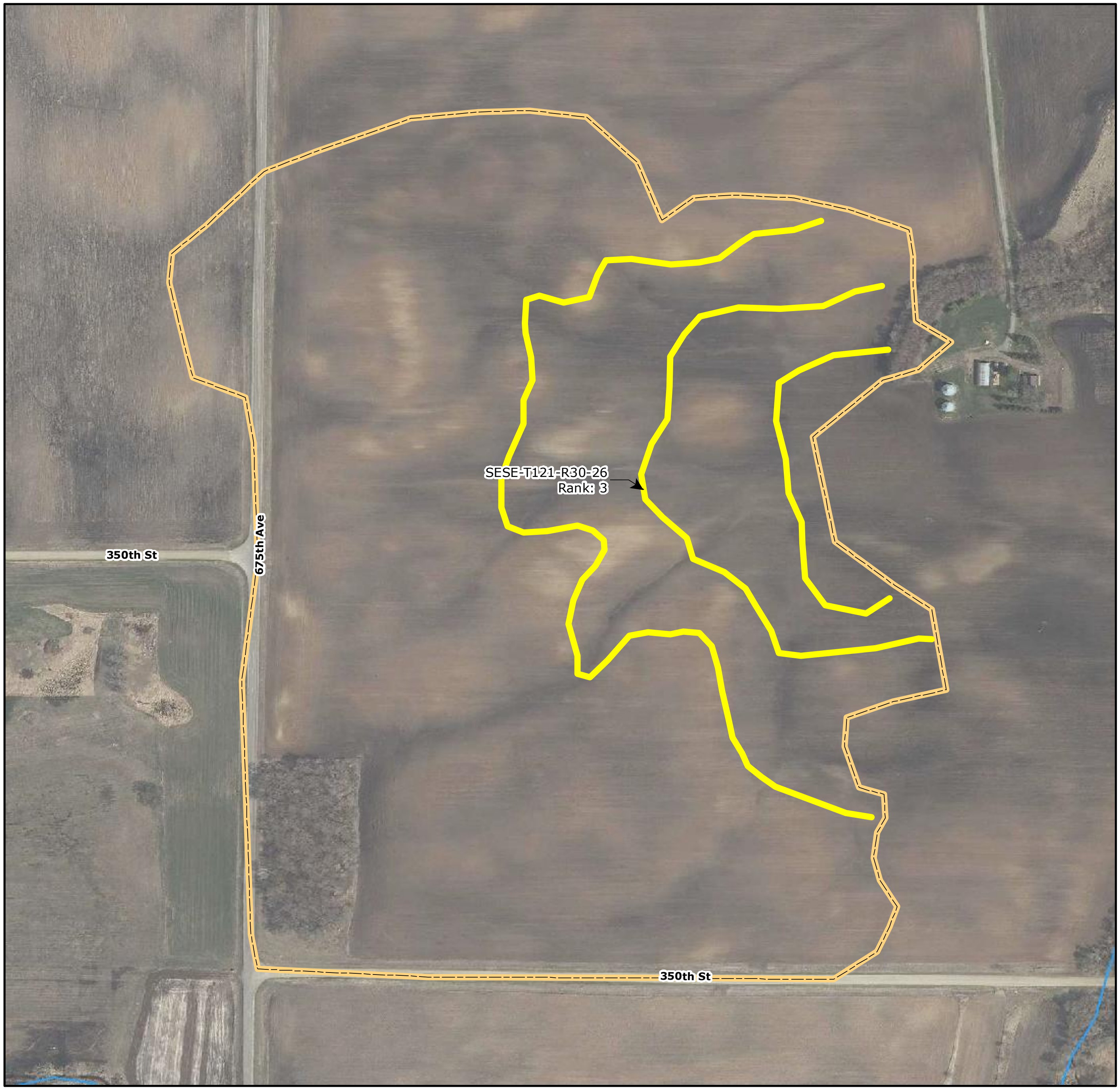

Legend

- Aternative Tile Intake
- Ditch Maintenance
- M Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
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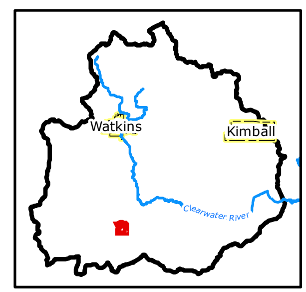

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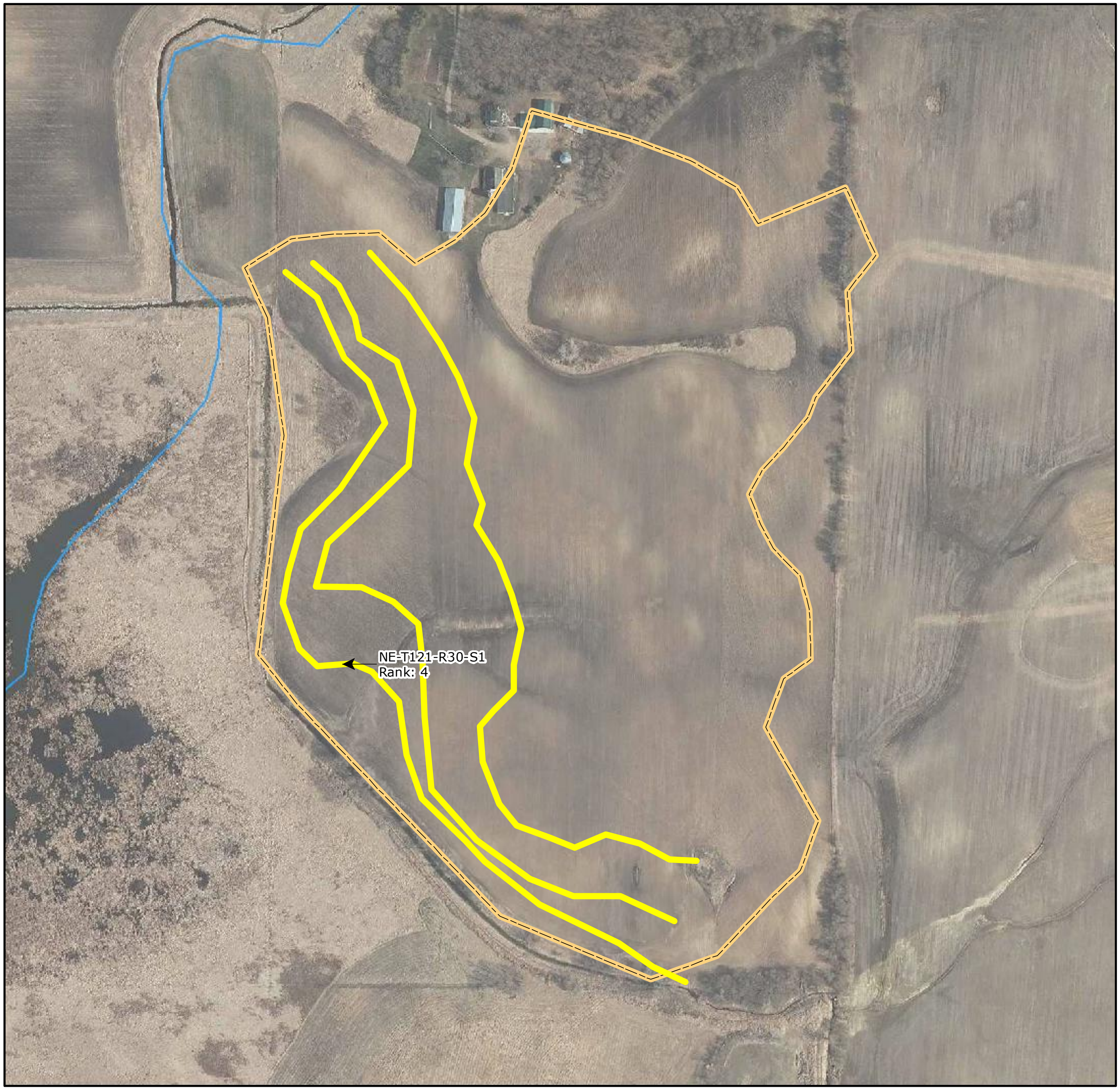
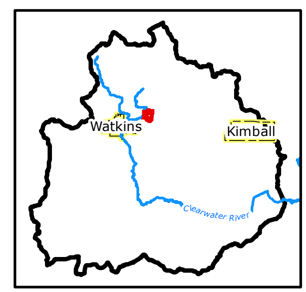


Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Countour Practice & Gully Practice
NE-T121-R30-S1



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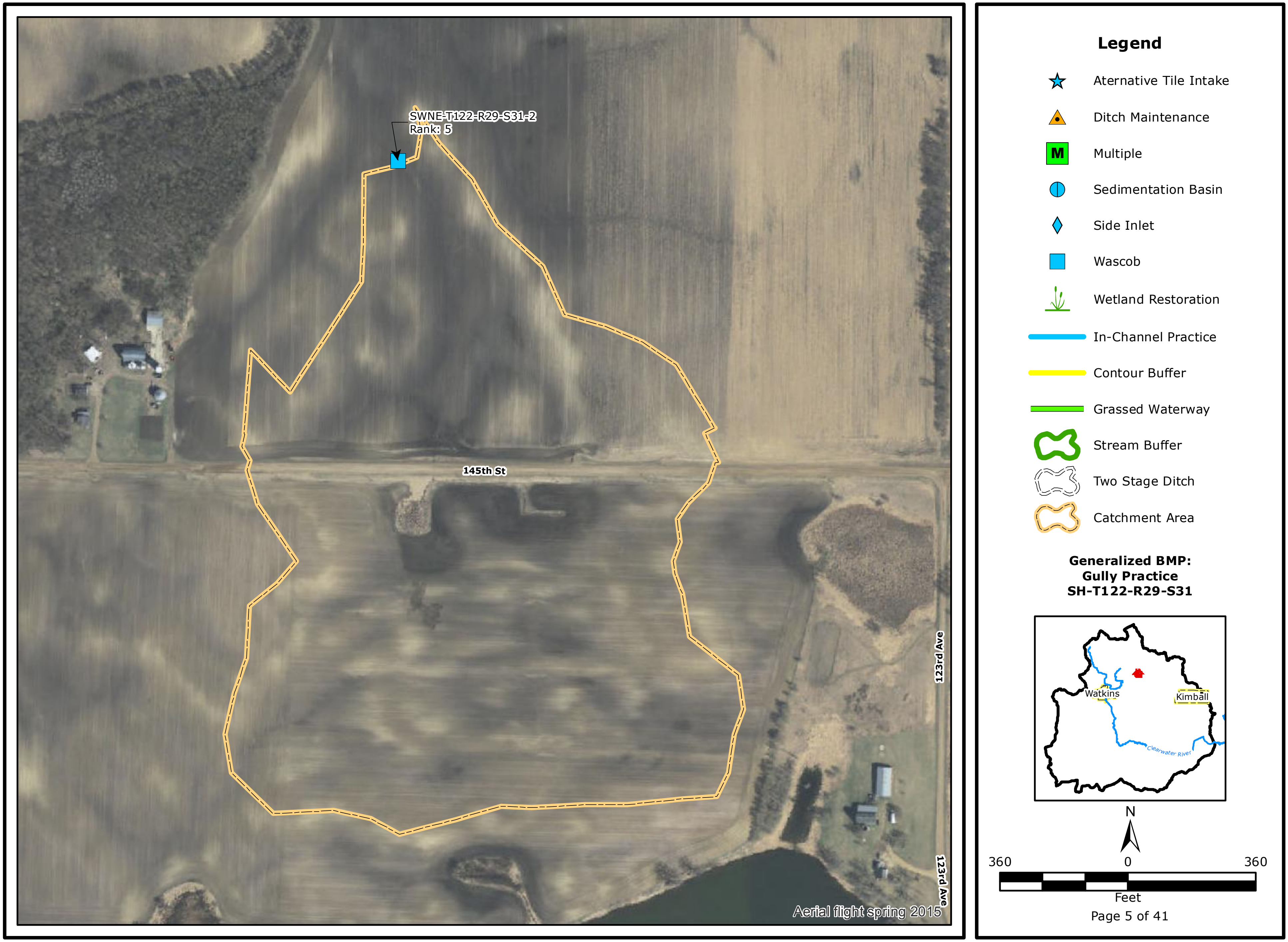
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123rd Ave
123rd Ave
Aerial flight spring 2015
Legend
Aternative Tile Intake
Ditch Maintenance
M
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area
Generalized BMP:
Gully Practice
SH-T122-R29-S31
Watkins
Kimball
Clearwater River
N
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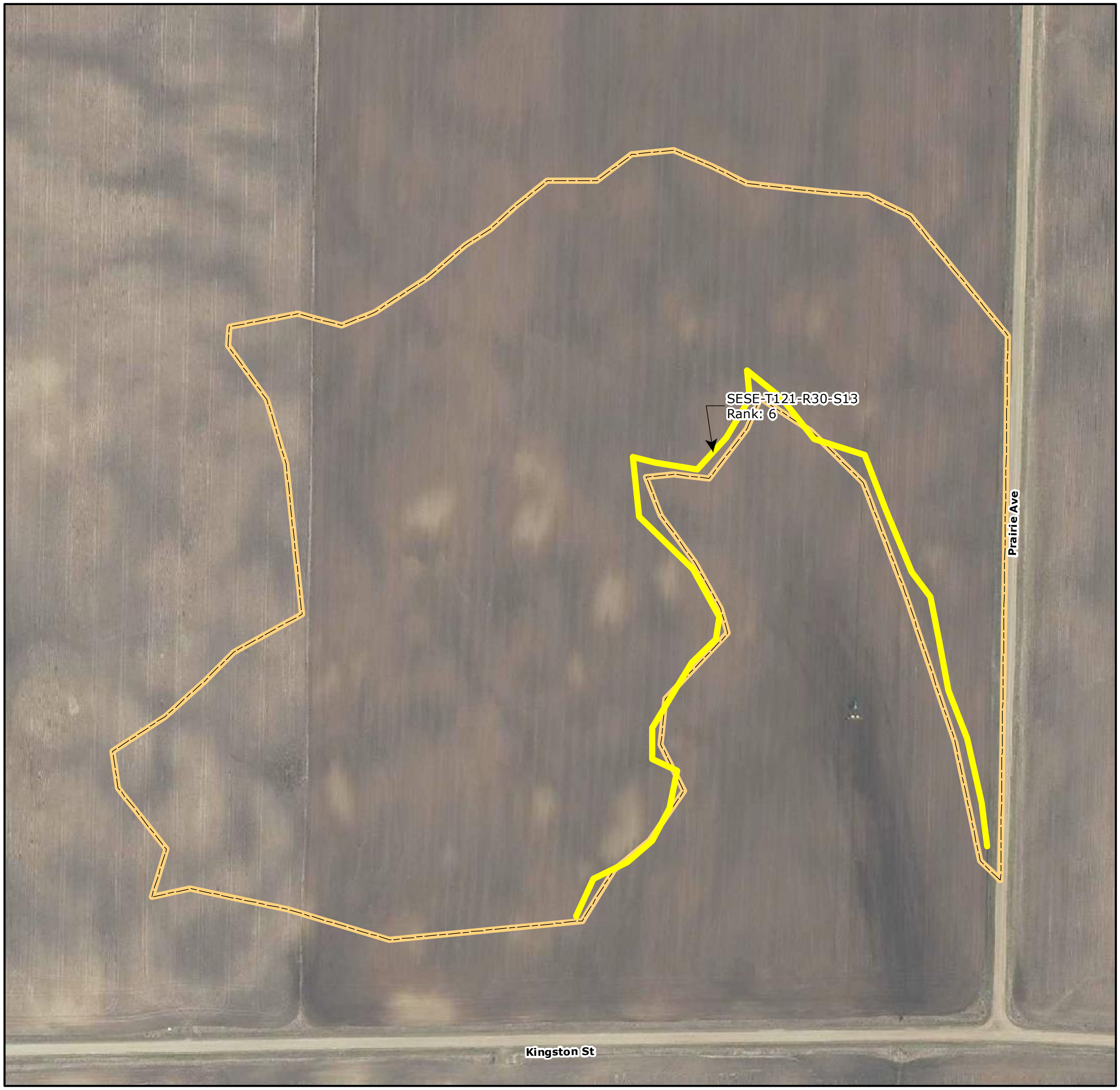
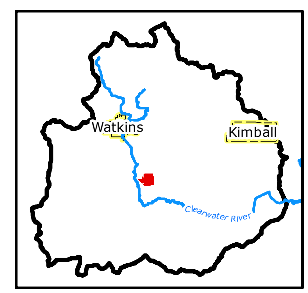
Feet

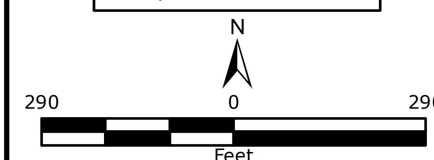


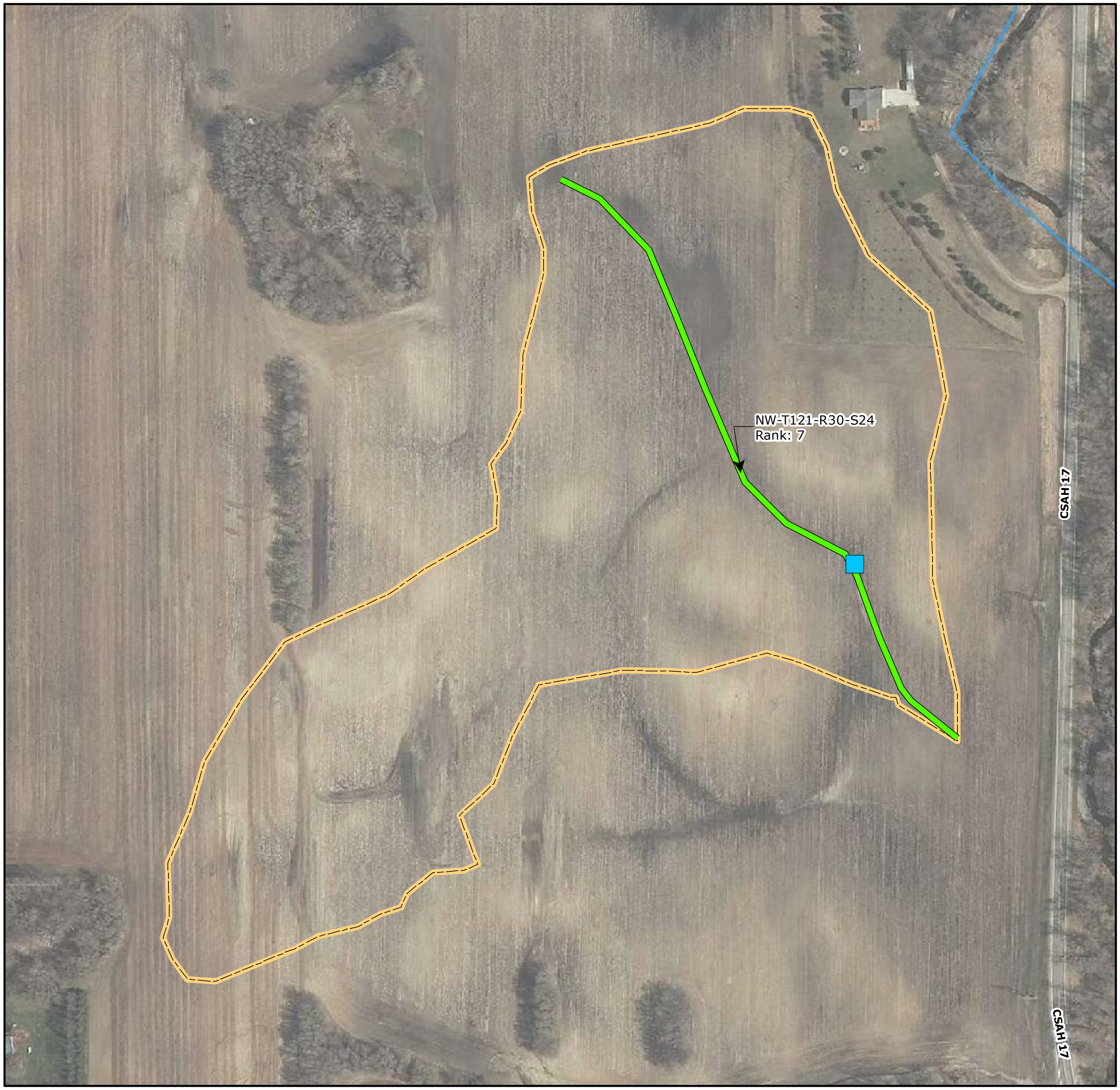
Legend

Aternative Tile Intake
Ditch Maintenance
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area

Generalized BMP:
Contour Practice
SESE-T121-R30-S13-1



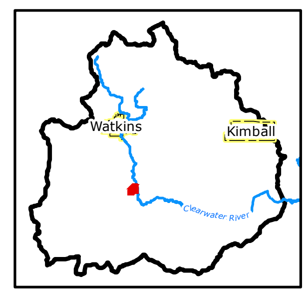




Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
NW-T121-R30-S24-1



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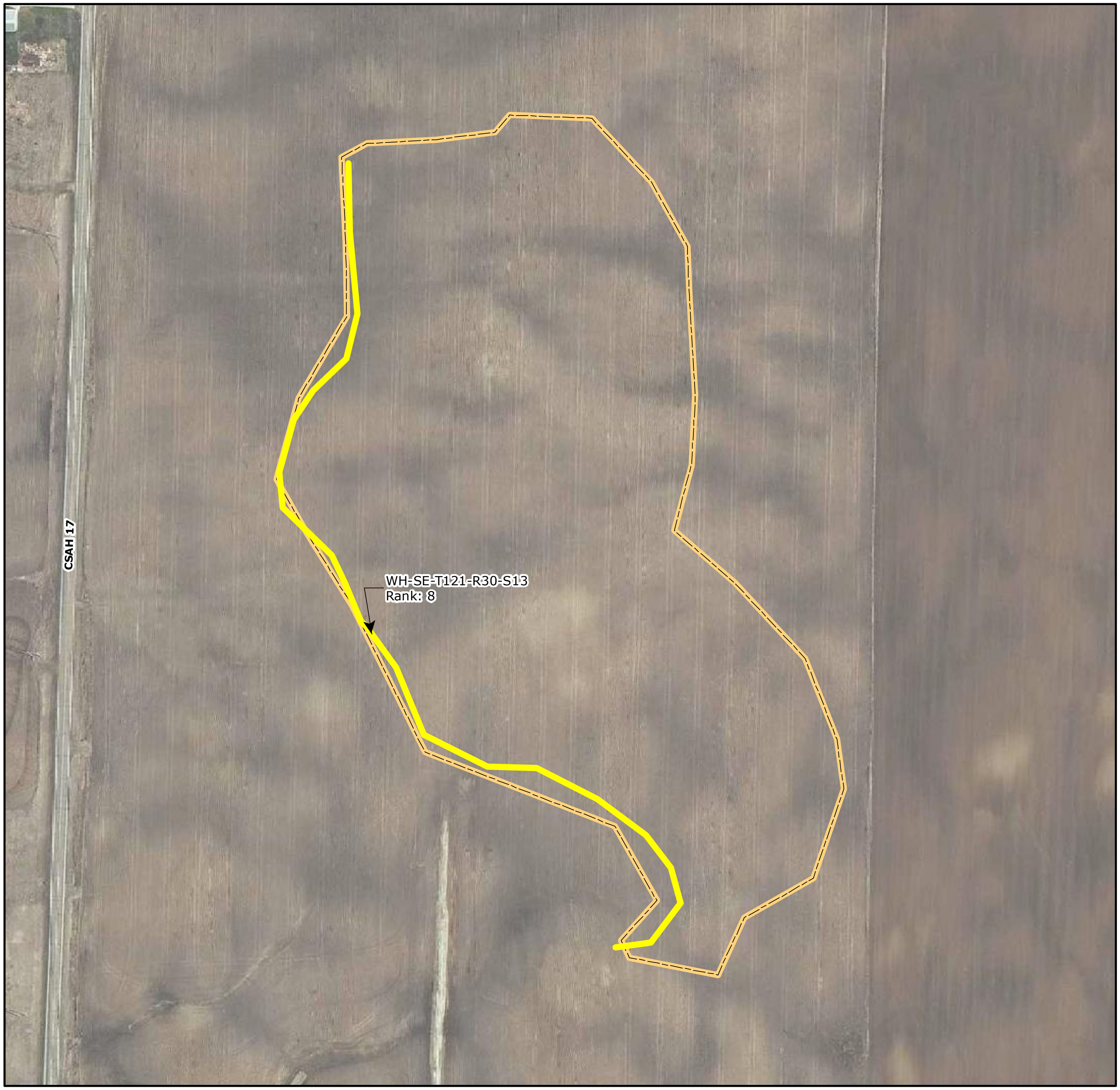
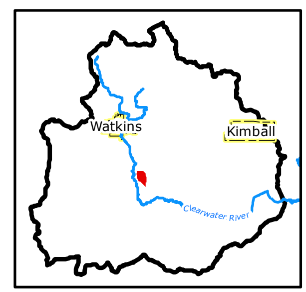


Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Contour Practice
WH-SE-T121-R30-S13-1



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Legend

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- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
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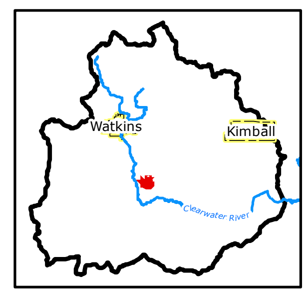
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
NENE-T121-R30-S24-1



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Legend

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- Wetland Restoration
- In-Channel Practice
- Contour Buffer
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- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
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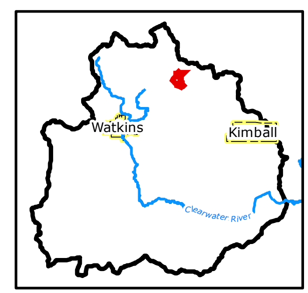
SH-T122-R29-S30-1



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Legend

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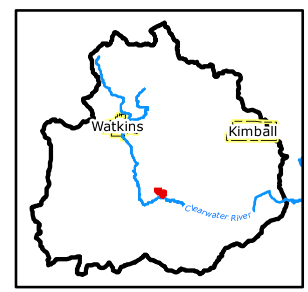
Ditch Maintenance
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area

Generalized BMP:
Gully Practice
SENW-T121-R29-S19-2



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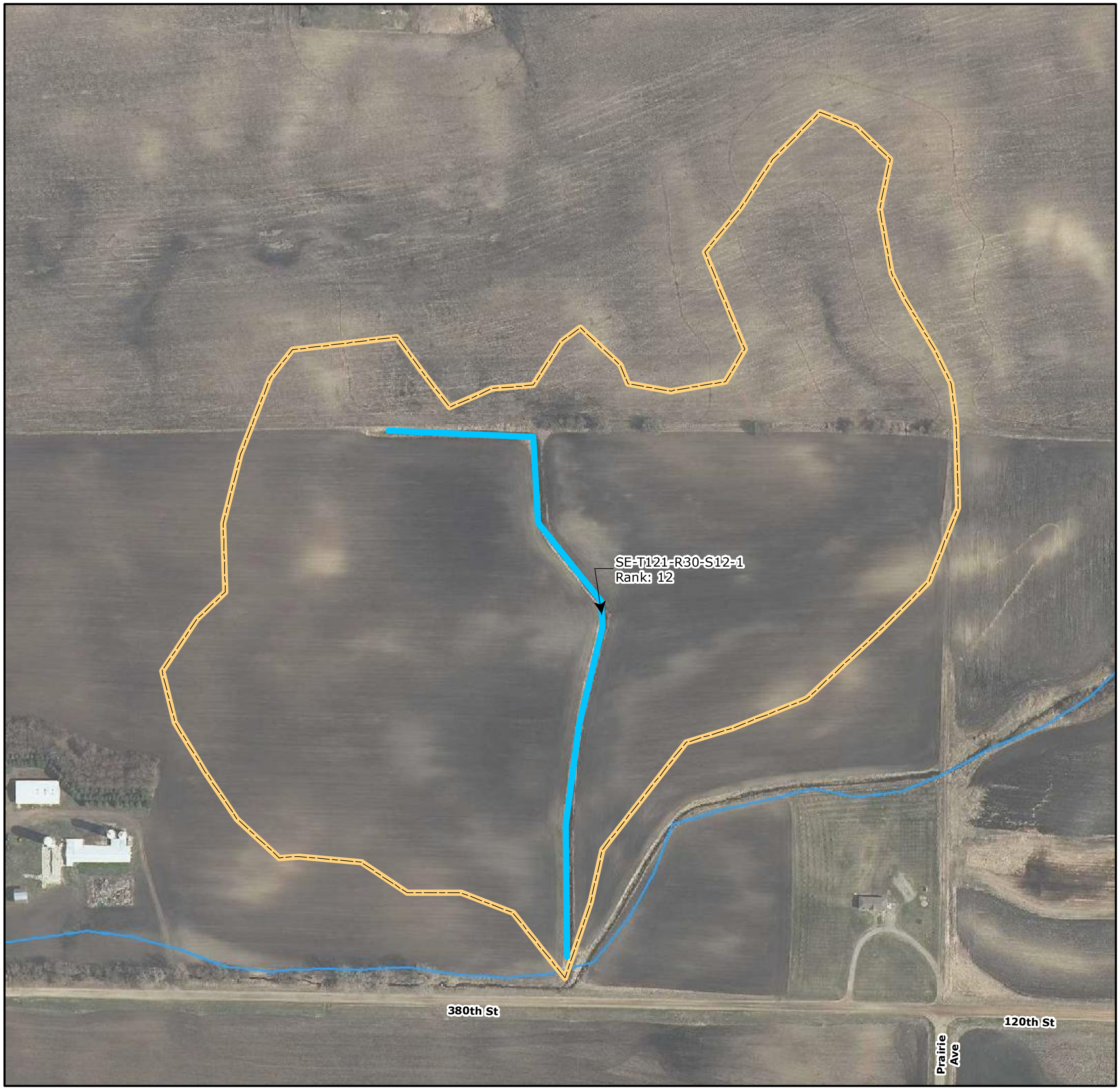

Legend

Aternative Tile Intake

Ditch Maintenance

Multiple

Sedimentation Basin

Side Inlet

Wascob

Wetland Restoration

In-Channel Practice

Contour Buffer

Grassed Waterway

Stream Buffer

Two Stage Ditch

Catchment Area

Generalized BMP:
Stream Buffer
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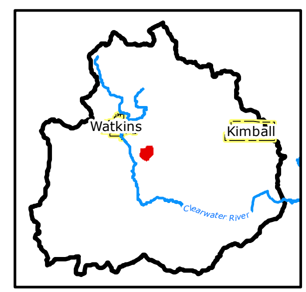

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Legend

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- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
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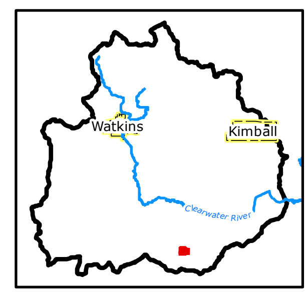

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Legend

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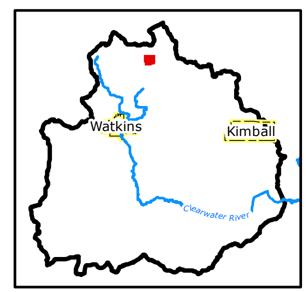
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Practice & Gully Practice
NENE-T122-R30-S25-1



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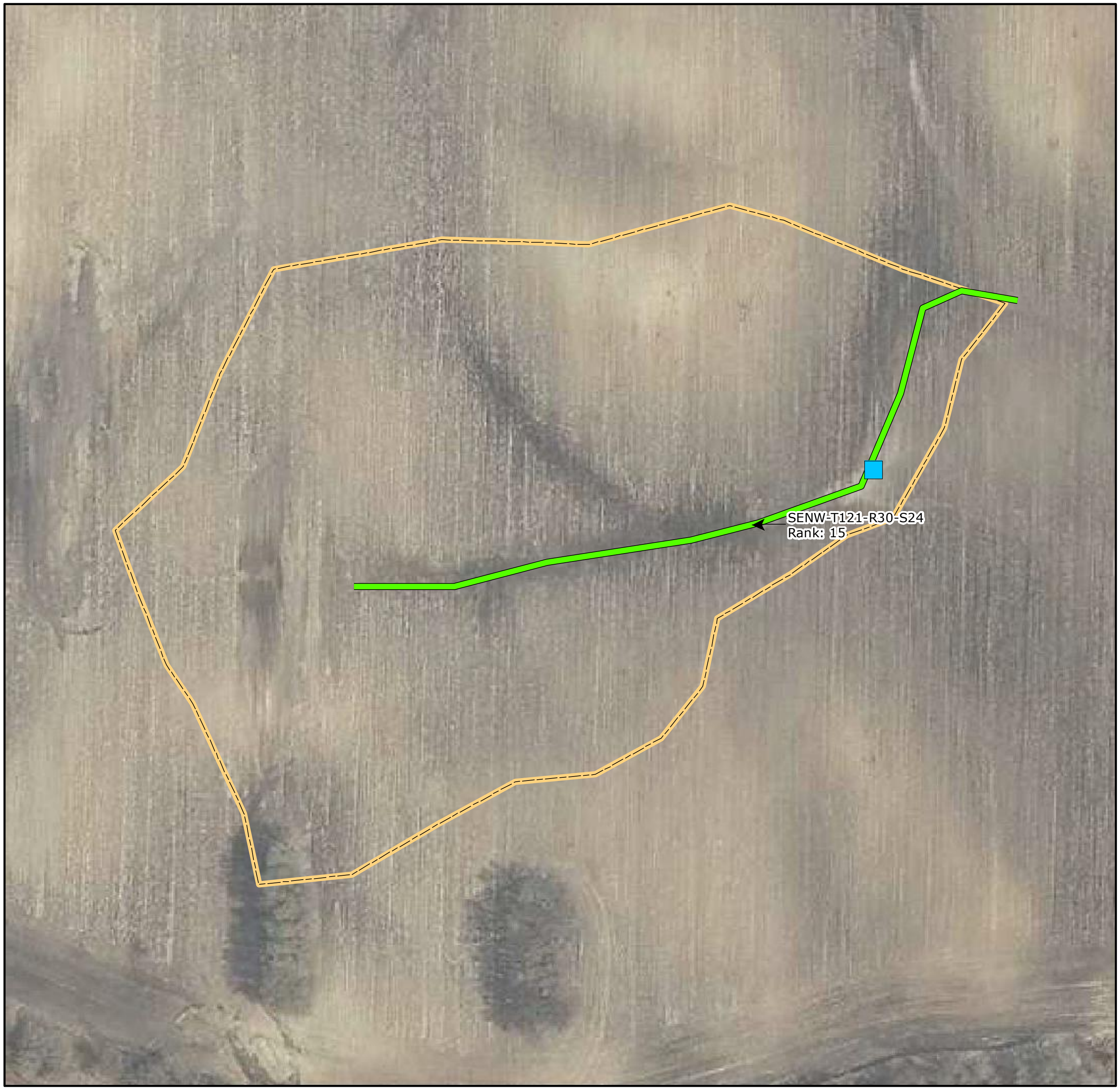

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- Sedimentation Basin
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- Wetland Restoration
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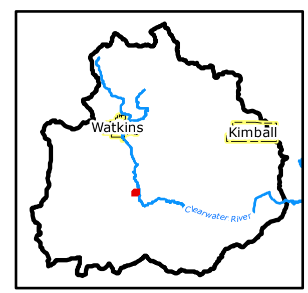
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SENW-T121-R30-S24-1



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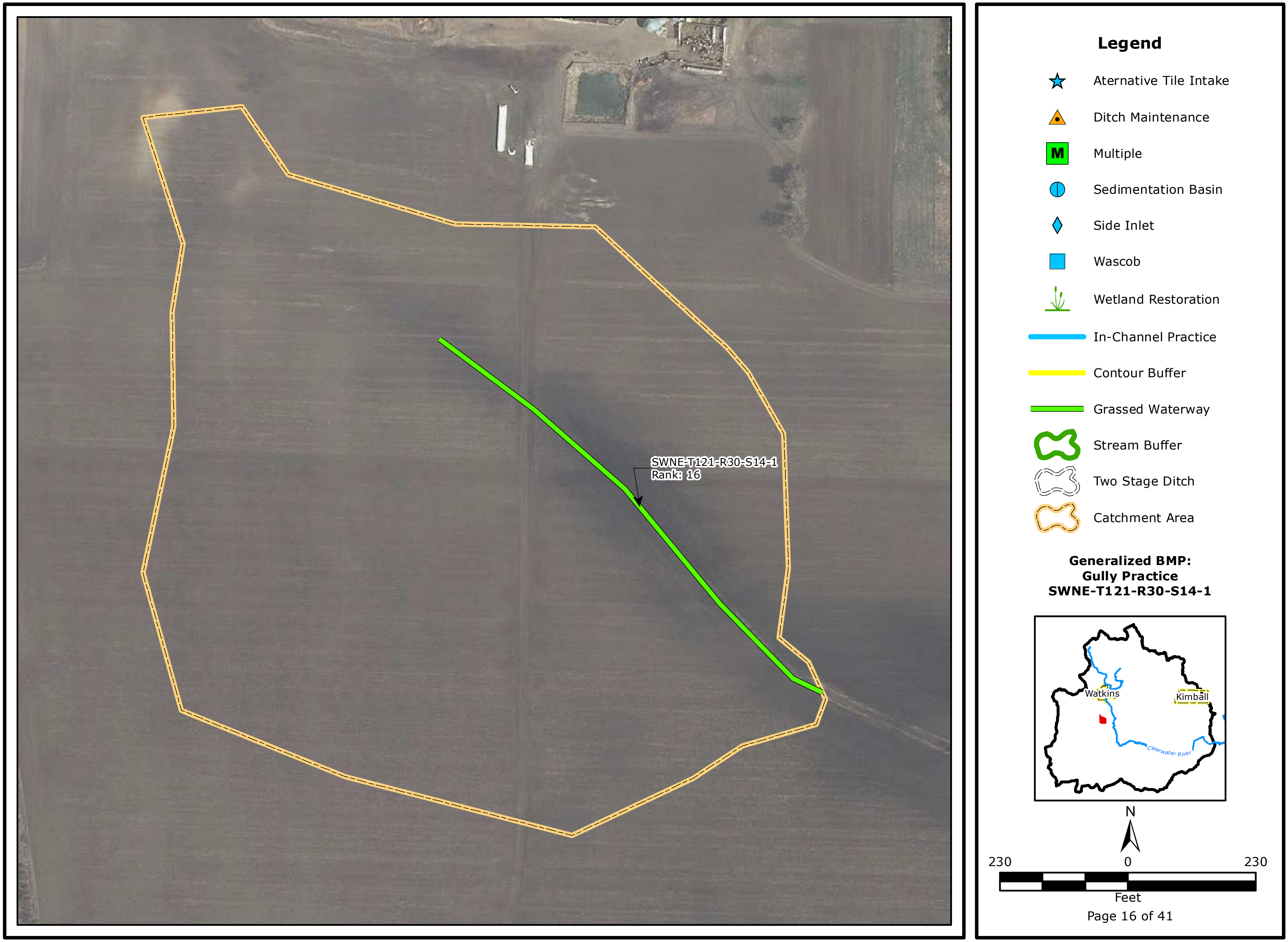
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Aternative Tile Intake
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Sedimentation Basin
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Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area
Generalized BMP:
Gully Practice
SWNE-T121-R30-S14-1
Watkins
Kimball
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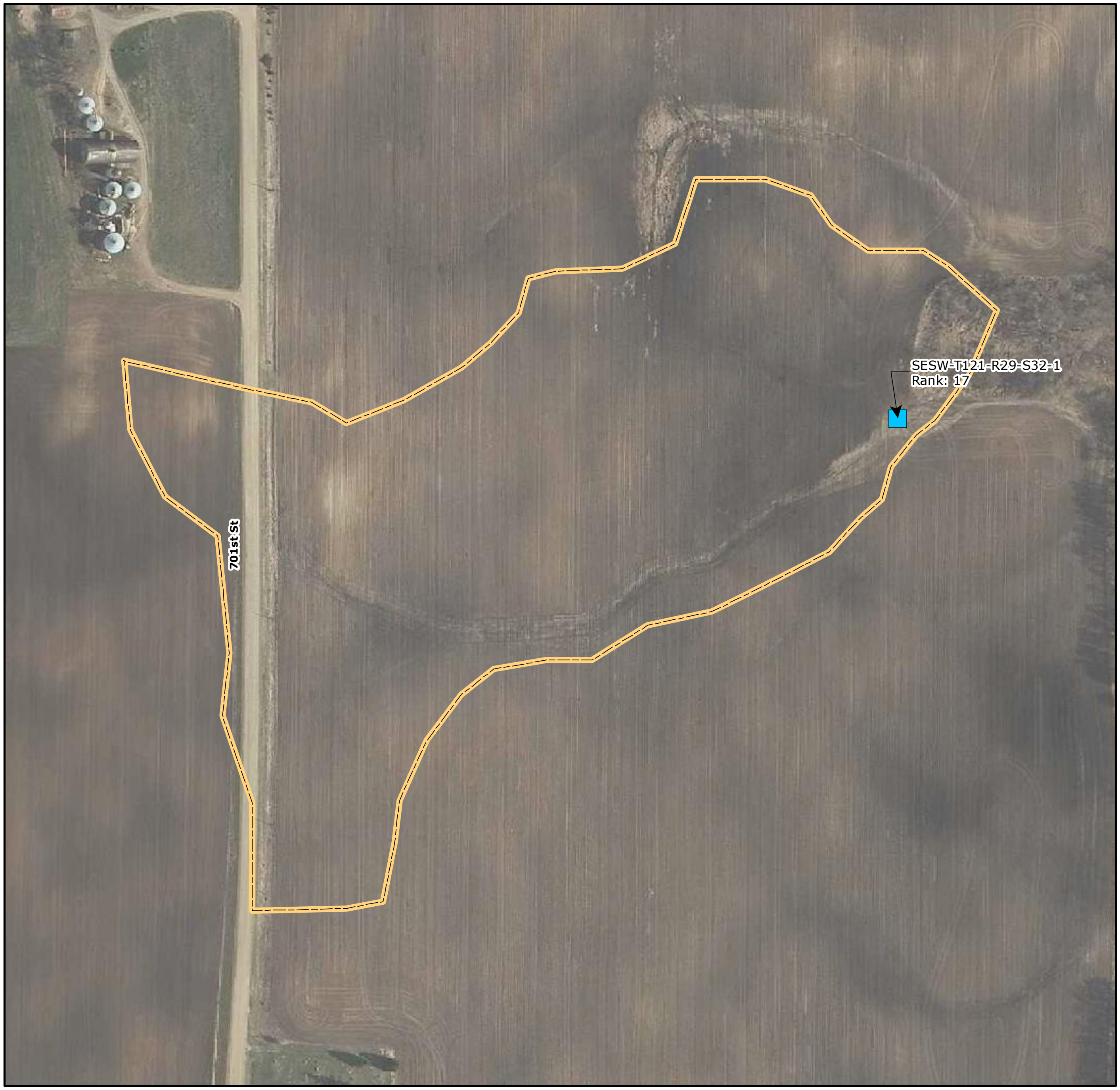

Legend

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- Wetland Restoration
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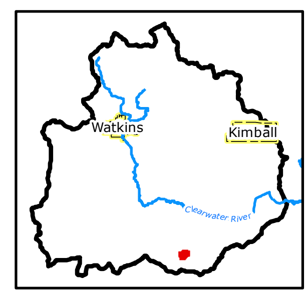
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SESW-T121-R29-S32-1



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Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
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- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
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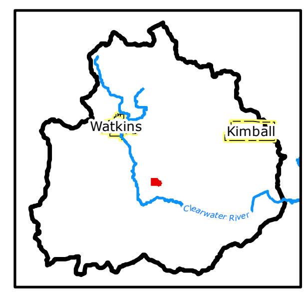
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SESW-T121-R29-S18-2



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Feet

Legend

- Aternative Tile Intake
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- Sedimentation Basin
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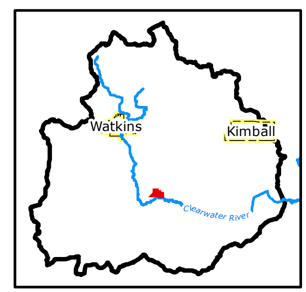
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SENW-T121-R29-S19-1



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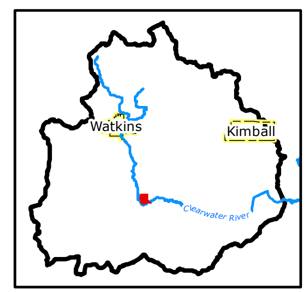
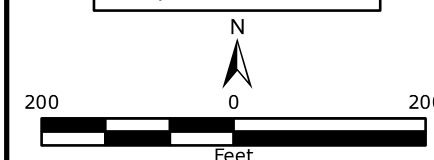
Feet

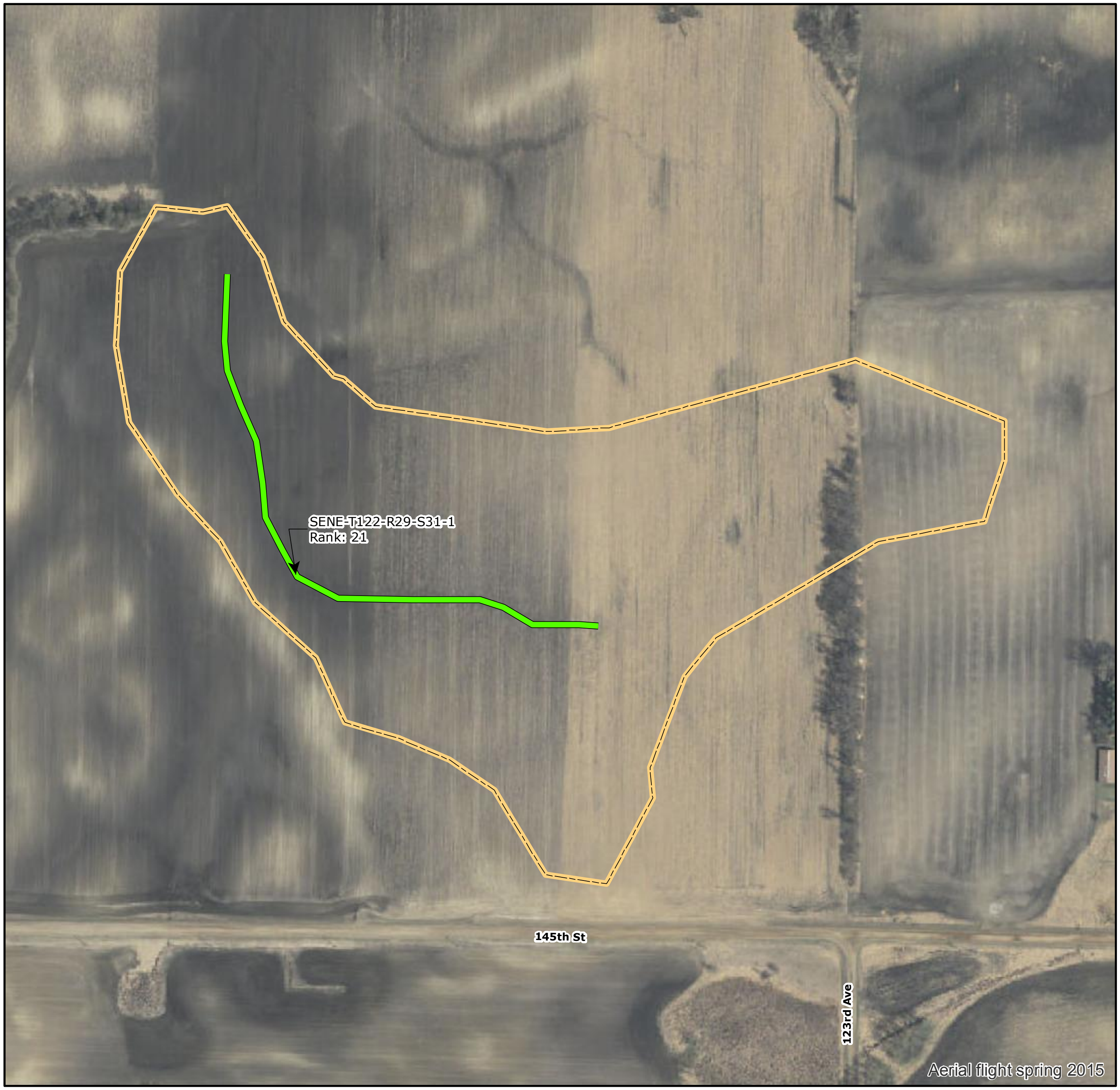
Legend

- Aternative Tile Intake
- Ditch Maintenance
- M Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Contour Practice
SE-T121-R30-S24-1







Legend

Aternative Tile Intake

Ditch Maintenance

Multiple

Sedimentation Basin

Side Inlet

Wascob

Wetland Restoration

In-Channel Practice

Contour Buffer

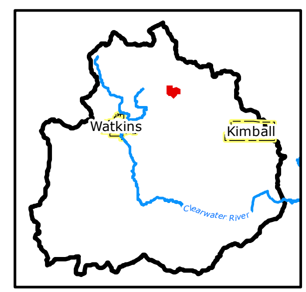
Grassed Waterway

Stream Buffer

Two Stage Ditch

Catchment Area

Generalized BMP:
Gully Practice
SENE-T122-R29-S31-1



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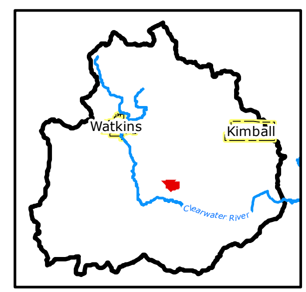
Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
NWNW-T121-R29-S20-1



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Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
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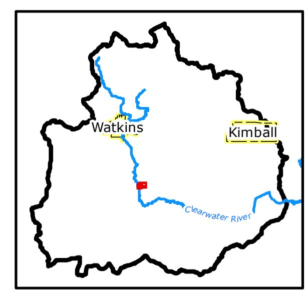
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
NWNE-T121-R30-S24-1



N

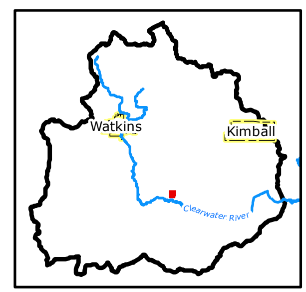
190 0 190

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SENE-T121-R29-S19



N

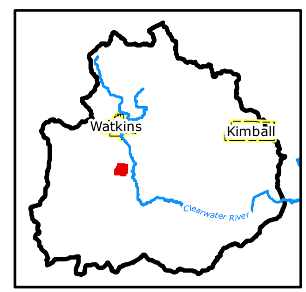
110 0 110

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
In-channel Practice
EH-T121-R30-S14-1



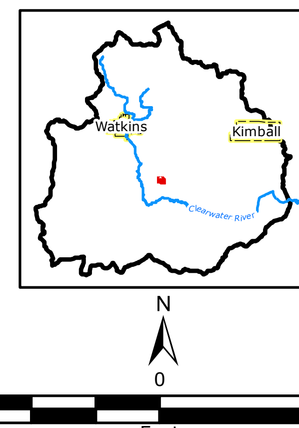
N

325 0 325
Feet

Legend

Aternative Tile Intake
Ditch Maintenance
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area

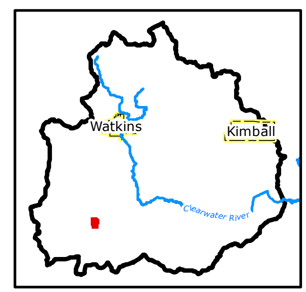
Generalized BMP:
Gully Practice
SESW-T121-R29-S18-1

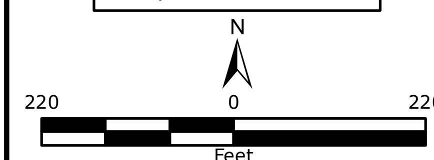


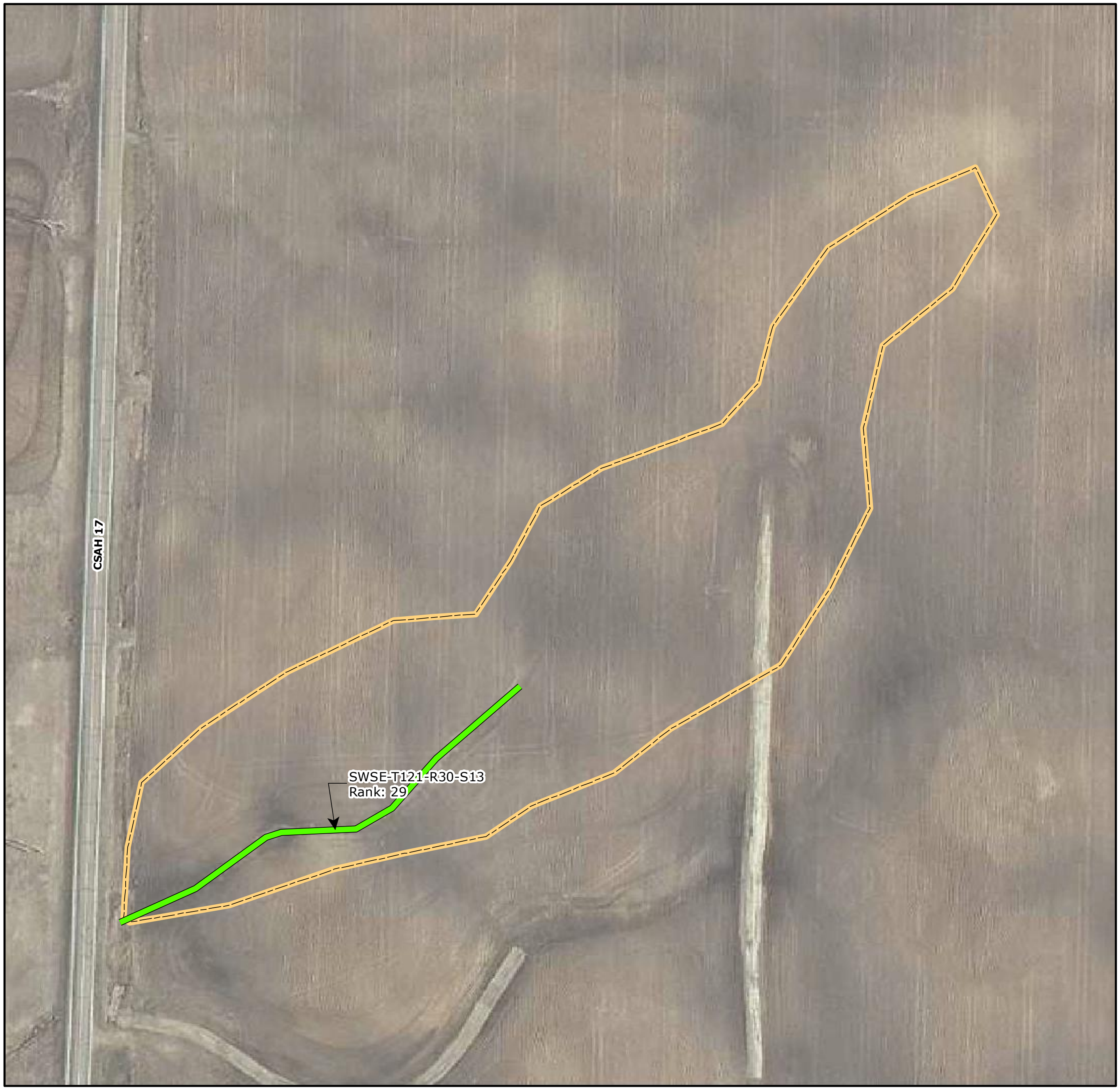
Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
In-channel Practice
NESE-T121-R30-S27-1



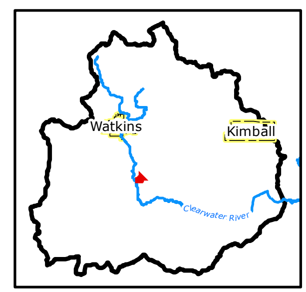




Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Gully Practice
SWSE-T121-R30-S13-1



N

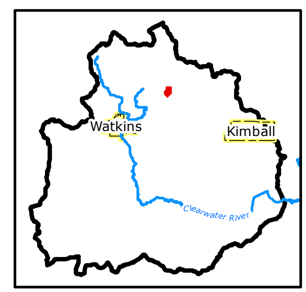
150 0 150

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- M Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

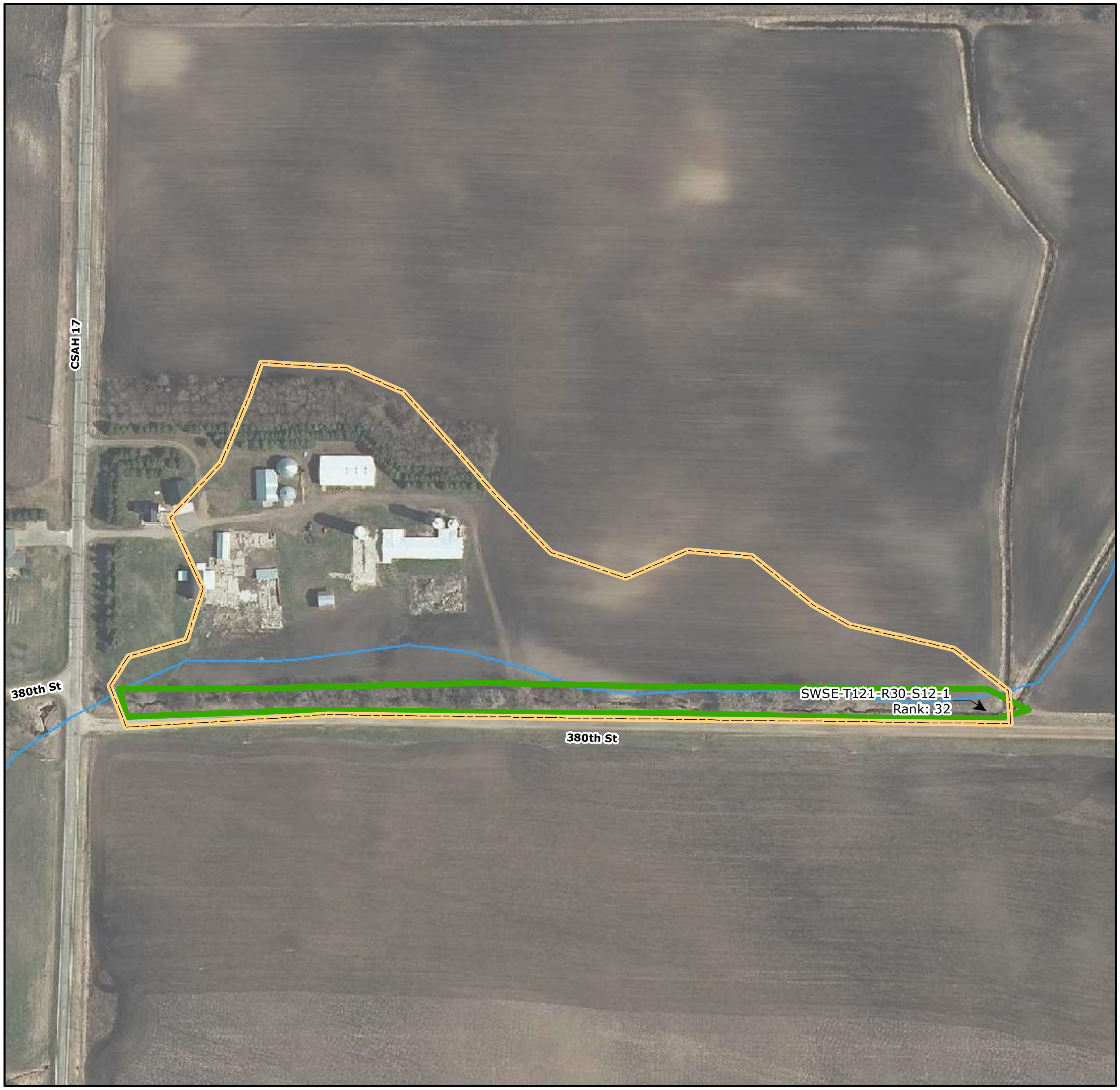
Generalized BMP:
Gully Practice
SWNE-T122-R29-S31-1



N

220 0 220

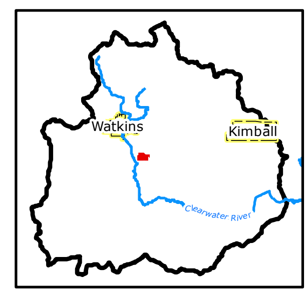
Feet



Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
In-channel Practice
SWSE-T121-R30-S12-1



N

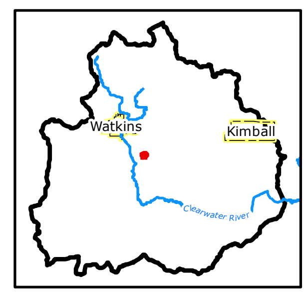
290 0 290

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
SWSE-T121-R30-S12-2



N

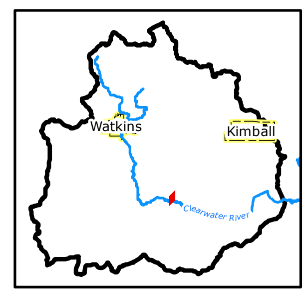
150 0 150

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

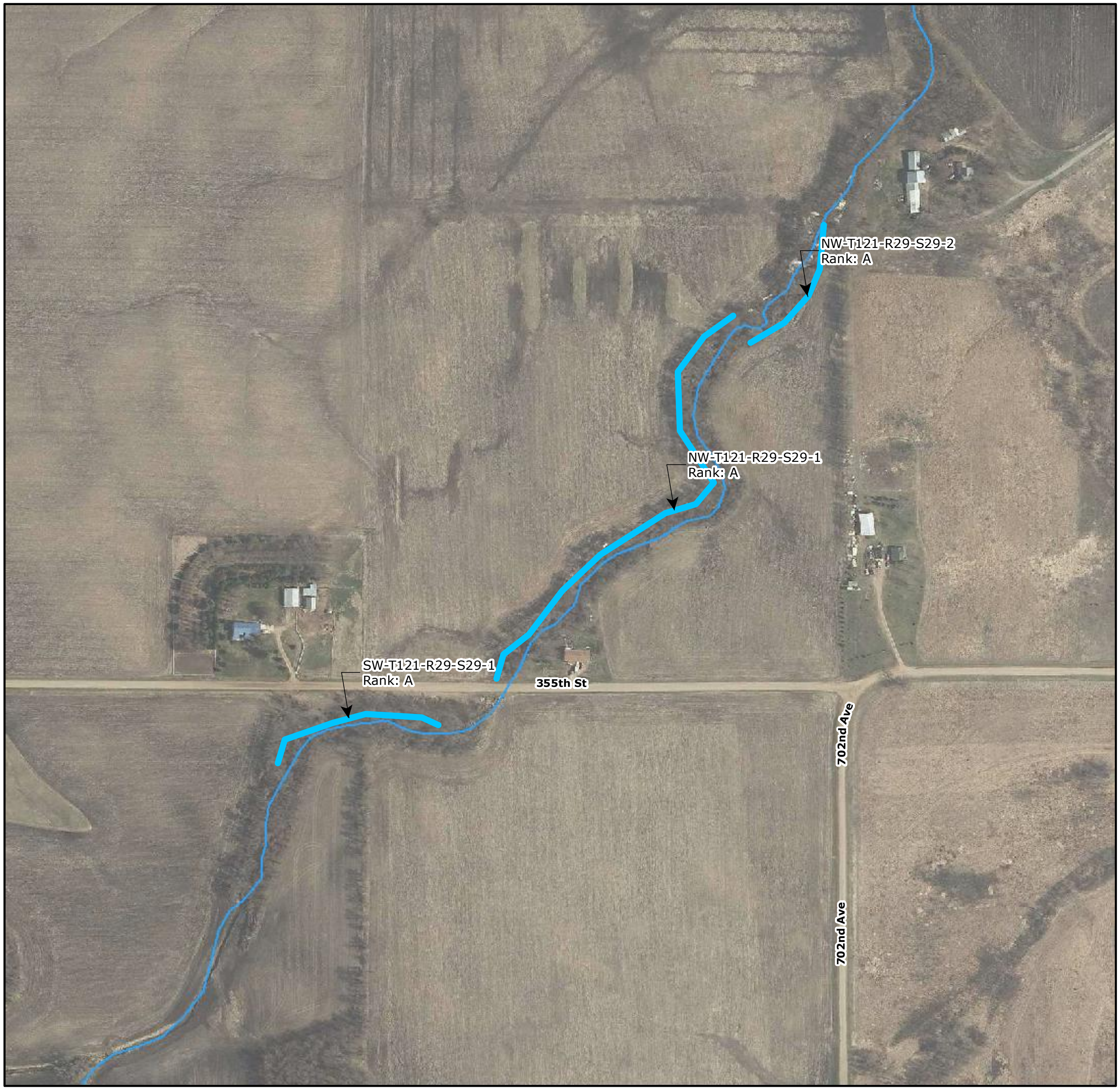
Generalized BMP:
Stream Buffer
NESE-T121-R29-S19



N

110 0 110

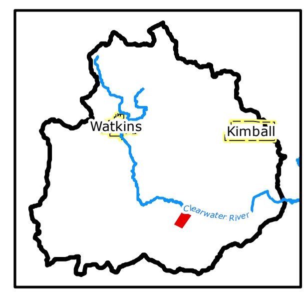
Feet



Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

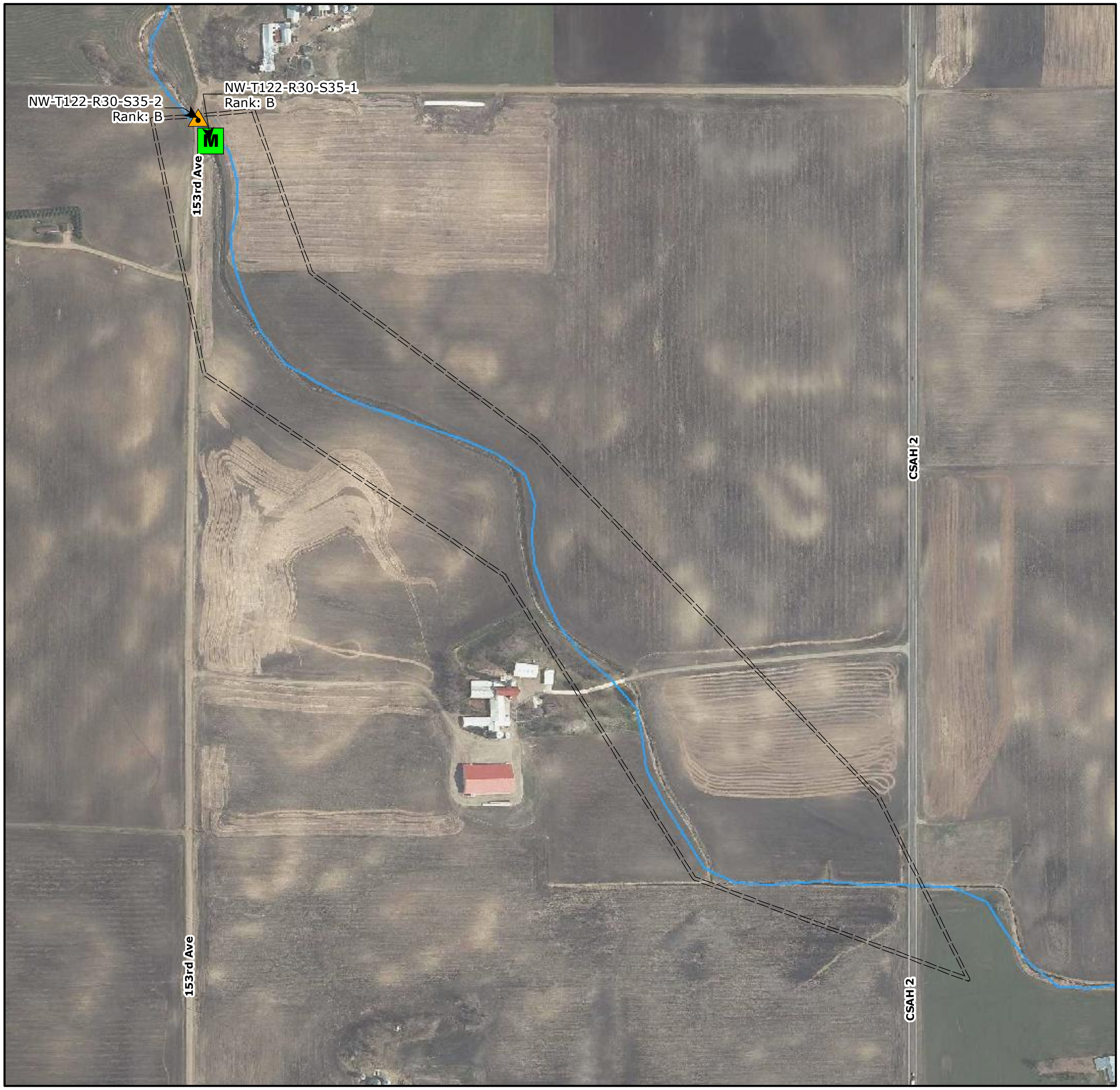
Generalized BMP:
Stream Buffer
NW-T121-R29-S29-1



N

425 0 425

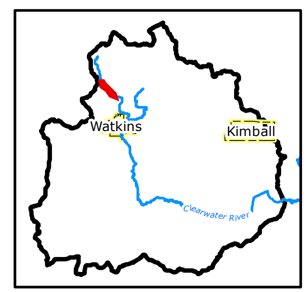
Feet



Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

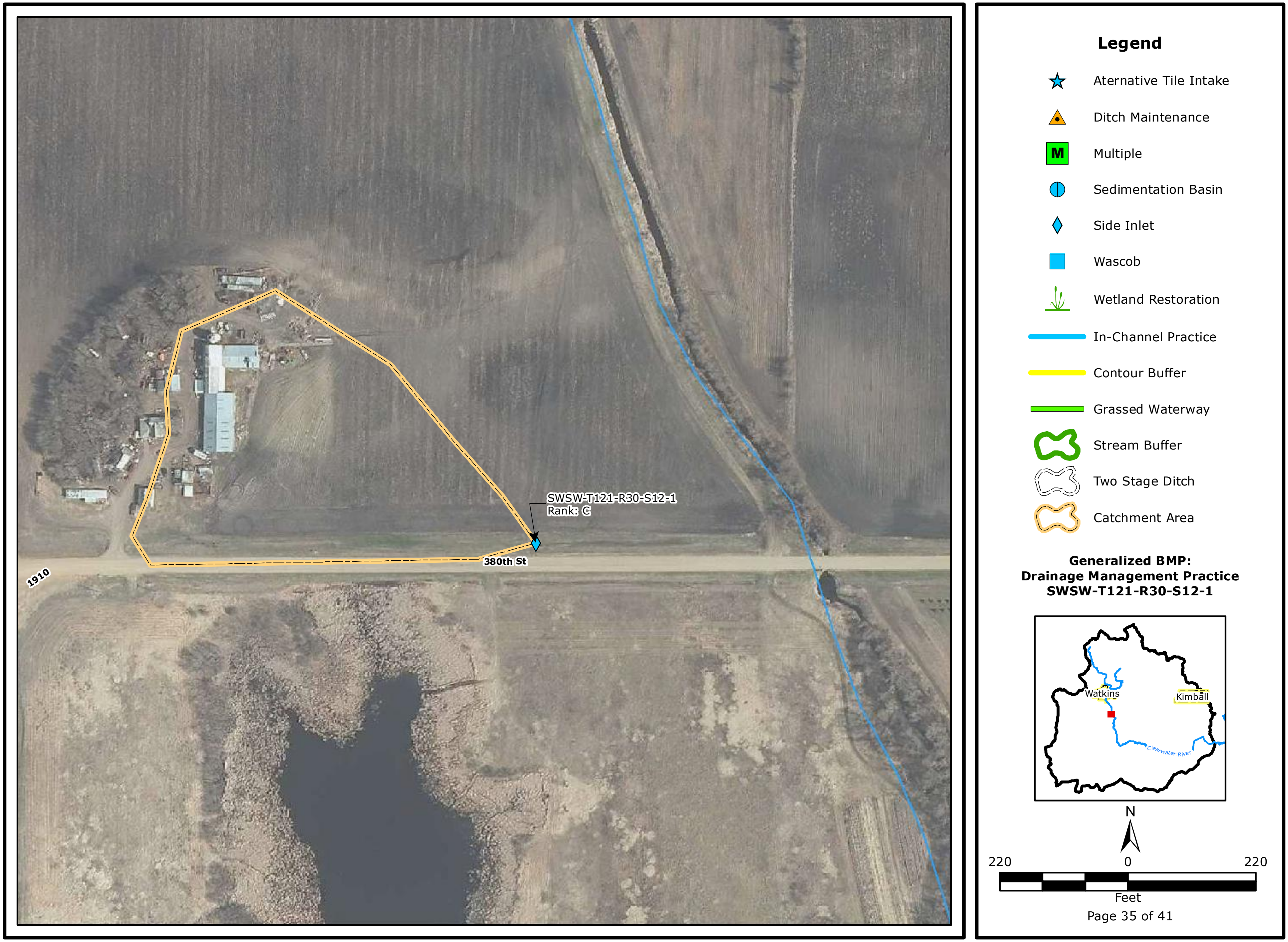
Generalized BMP:
In-channel Practice
NW-T122-R30-S35-1



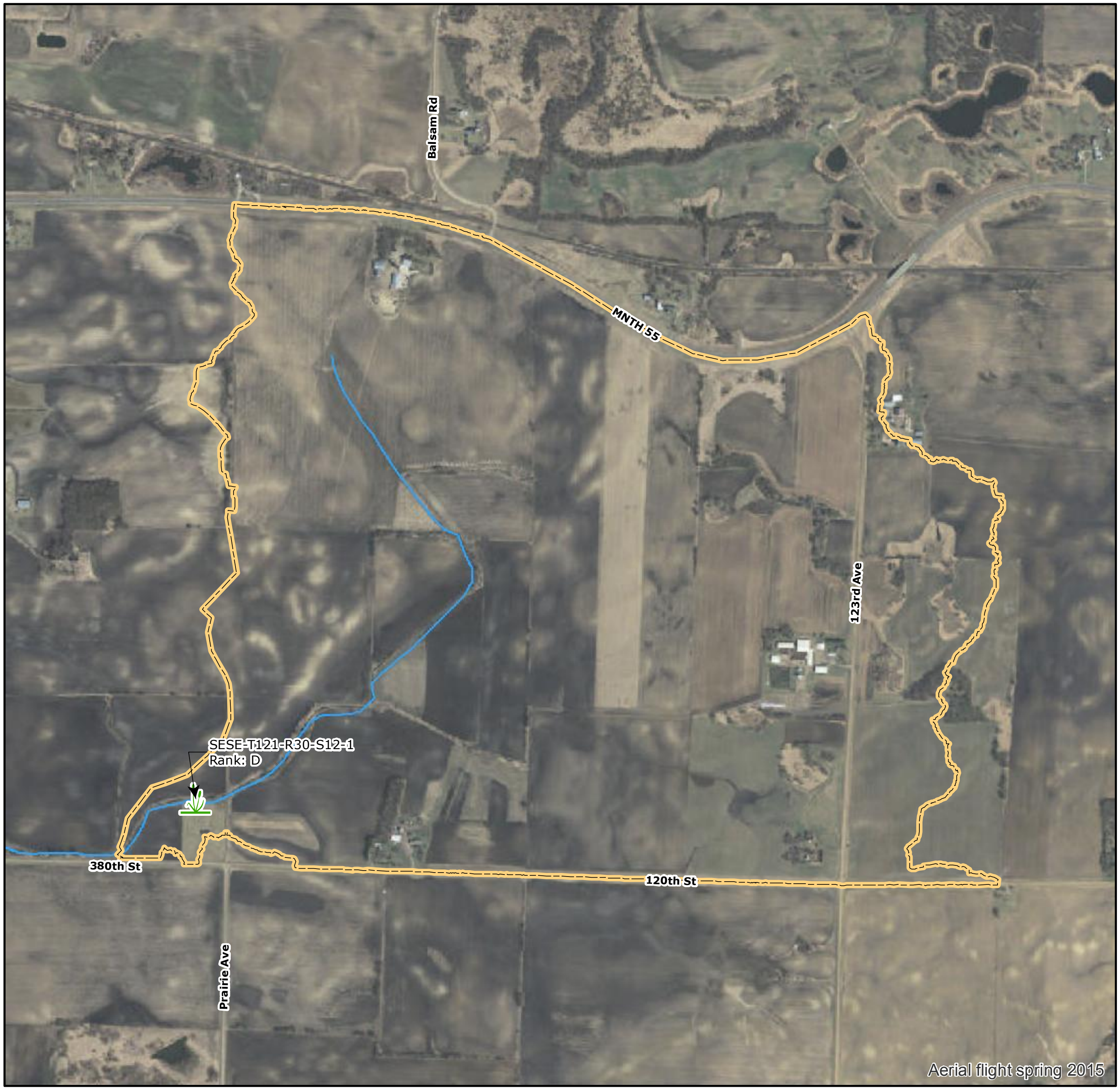
N

560 0 560

Feet



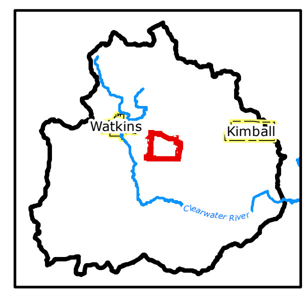
SWSW-T121-R30-S12-1
Rank: C
380th St
1910
Legend
Aternative Tile Intake
Ditch Maintenance
M
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area
Generalized BMP:
Drainage Management Practice
SWSW-T121-R30-S12-1
Watkins
Kimball
Clearwater River
N
220
0
220
Feet



Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
SESE-T121-R30-S12-1



N

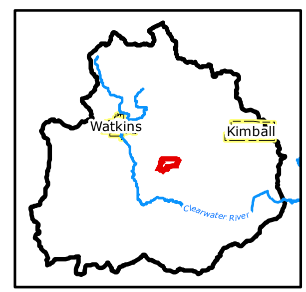
1,200 0 1,200

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Drainage Management Practice
NE-T121-R29-S18-1



N

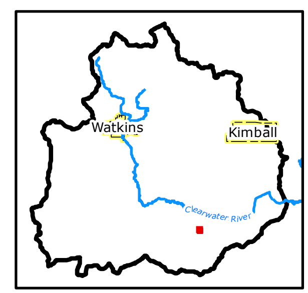
760 0 760

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Contour Practice
SESE-T121-R29-S29-1



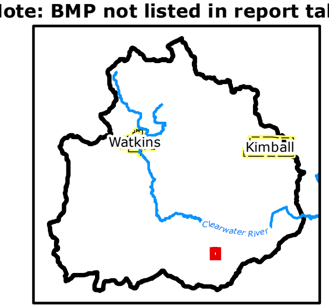
N

80 0 80
Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

Generalized BMP:
Stream Buffer
NENE-T121-R29-S32-1
Note: BMP not listed in report table.



N

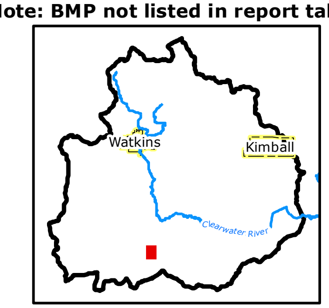
310 0 310

Feet

Legend

- Aternative Tile Intake
- Ditch Maintenance
- Multiple
- Sedimentation Basin
- Side Inlet
- Wascob
- Wetland Restoration
- In-Channel Practice
- Contour Buffer
- Grassed Waterway
- Stream Buffer
- Two Stage Ditch
- Catchment Area

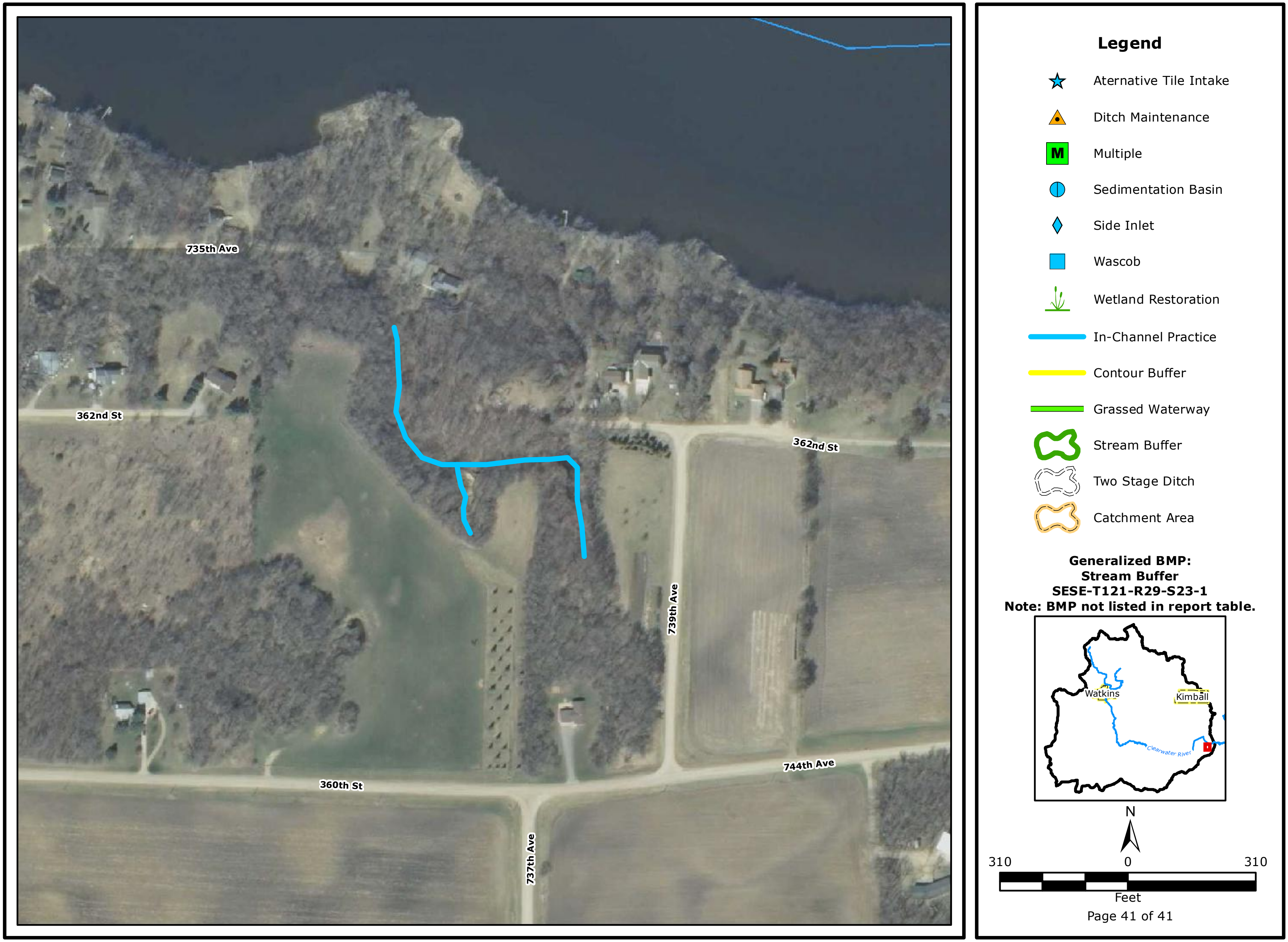
Generalized BMP:
Stream Buffer
NW-T121-R30-S36-1
Note: BMP not listed in report table.



N

310 0 310

Feet



735th Ave
362nd St
362nd St
739th Ave
744th Ave
360th St
737th Ave
Legend
Aternative Tile Intake
Ditch Maintenance
M
Multiple
Sedimentation Basin
Side Inlet
Wascob
Wetland Restoration
In-Channel Practice
Contour Buffer
Grassed Waterway
Stream Buffer
Two Stage Ditch
Catchment Area
Generalized BMP:
Stream Buffer
SESE-T121-R29-S23-1
Note: BMP not listed in report table.
Watkins
Kimball
N
310
0
310
Feet

WENCK ASSOCIATES

Responsive partner.
Exceptional outcomes.

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	Windom	Woodbury	Fort Collins		Mandan	Sheridan
	507-831-2703	651-294-4580	970-223-4705		701-751-3370	307-675-1148
					Dickinson	
					800-472-2232	