6.0 CITY OF CARVER

The City of Carver has a long-standing rural community with a historic downtown; however, development has been occurring with the expansion of the Twin Cities Metro area. Located within the bluffs of the Minnesota River Valley, Carver has a considerable amount of topographic relief. A significant portion of Carver drains to the Spring Creek system, characterized by steep slopes and ravines (Bolton & Menk, Inc., 2018).

The 2008 Inventory identified 101 gullies in Carver; three sites were removed from the Project because they were outside the District's boundary; two were considered not applicable (**Figure 40**). Of the remaining 96 points, 30 appeared to be pipe outfall locations.

There were 143 site surveys collected in 2020, including 11 locations that were determined not applicable because features relevant to the study were not observed. The remaining 132 points were all confirmed to be either a gully, pipe outfall, or both (**Figure 41**).

6.1 Previous Restoration Efforts

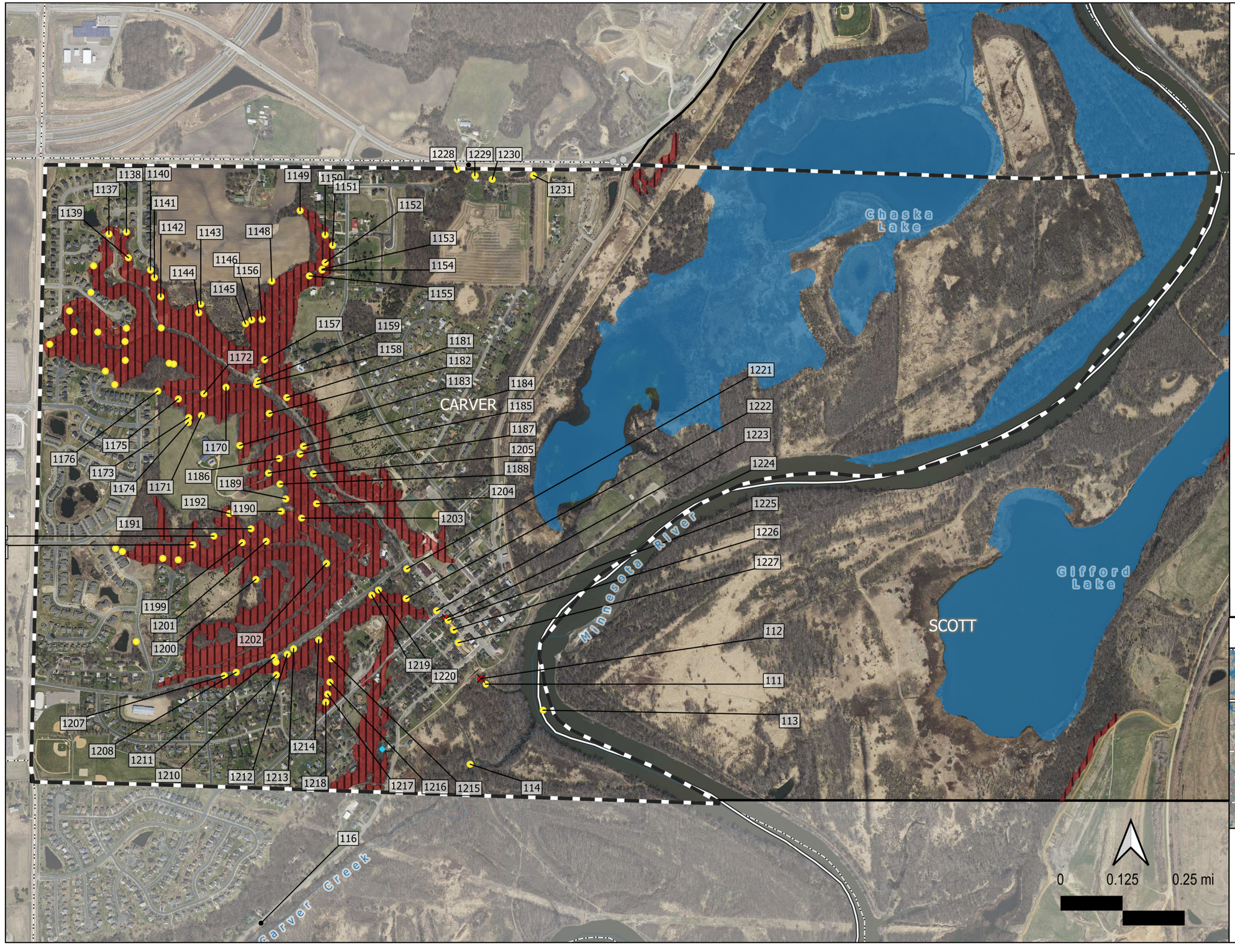
Carver recognizes the challenges the community faces because of erosion in creeks and the steep slopes characteristic of the Minnesota River bluffs. As part of Carver's 2018 local surface water plan, several gully erosion issues were identified, and corrective actions were proposed to prevent sediment from entering Spring Creek. These locations include general erosion concerns with the Spring Creek watershed, the 6th Street ditch erosion, and a ravine stabilization project at 4th Street and Elm Drive to repair active gully erosion, scheduled for 2020 or later (Bolton & Menk, Inc., 2018).

The LMRWD is also in the process of finalizing a conceptual plan for stabilizing bank erosion at 112 5th Street and 420 Broadway Street, along Spring Creek, in downtown Carver.

6.2 Field Survey Discussion

Gullies either formed along the Minnesota River floodplains or back in the wooded areas behind residences, where groundwater-fed streams cut into the soil. Very few resident interactions occurred during this phase of the Project. The field team encountered several severe gullies that were inaccessible due to unstable banks, which created a challenge for accurately assessing and photographing the entire length of the gully system.

Figure 40: Carver 2008 Inventory Locations



LEGEND

2008 Gully Inventory Waypoints

- Inside LMRWD
- Outside LMRWD Boundary
- Non-Applicable Points
- Outside Carver
- MnDNR Spring Inventory
- Calcareous Fens
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- High Value Resource Area Overlay District
- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

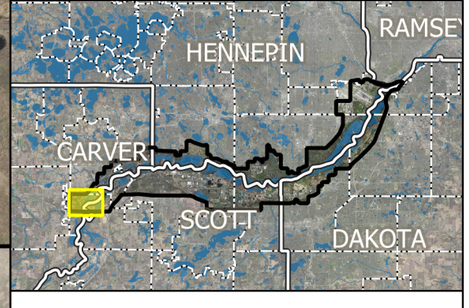


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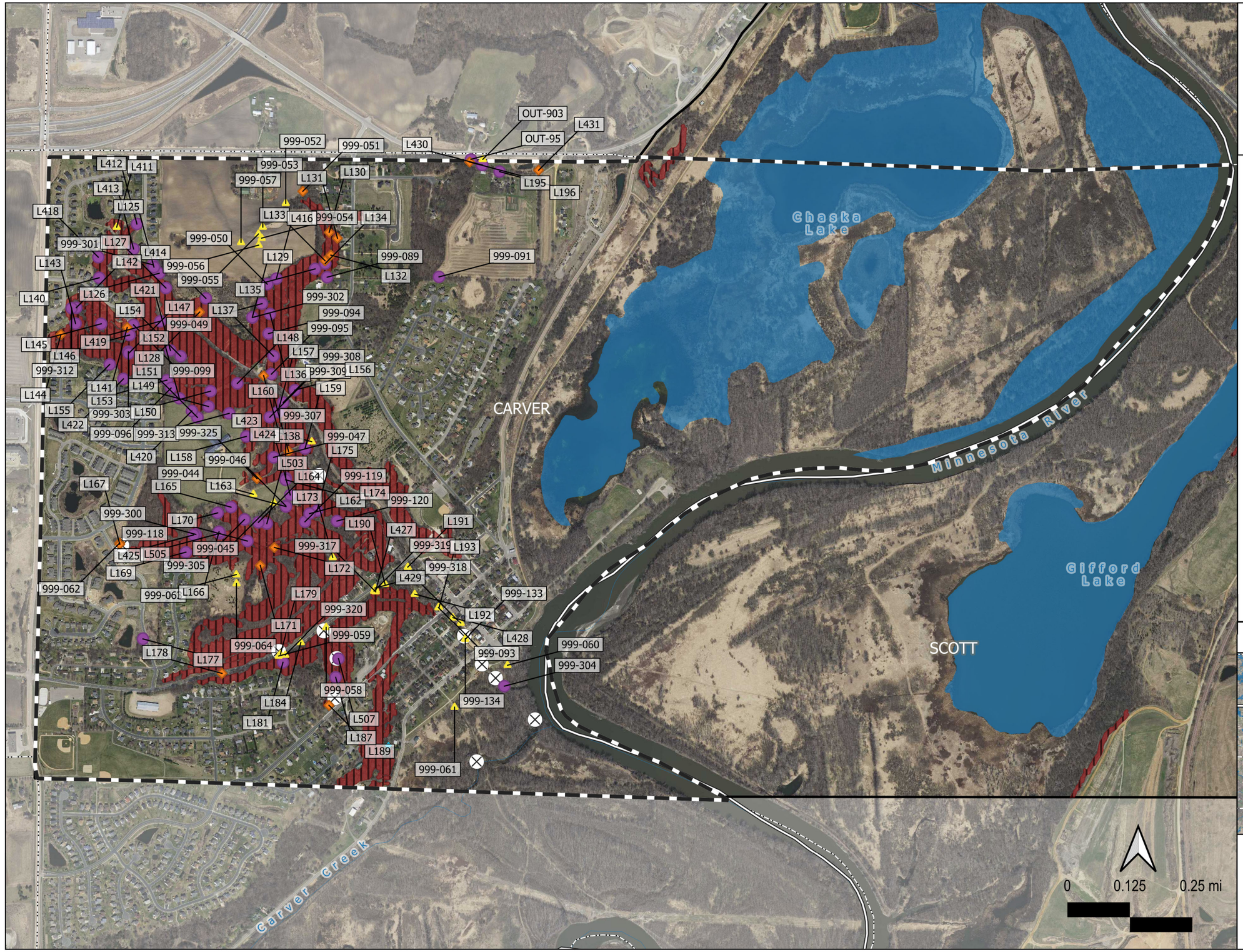
Figure 41: Carver 2020 Survey Locations



LEGEND

- 2020 Pipe Outfall Surveys
- 2020 Combination Surveys
- 2020 Gully Surveys
- 2020 Inaccessible Waypoints
- 2020 Non-Applicable Waypoints
- MnDNR Spring Inventory
- Calcareous Fens
- Public Waters
- Public Waterbodies

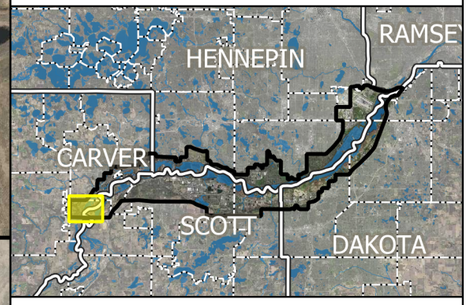
LMRWD Overlay Districts

- High Value Resource Area Overlay District
- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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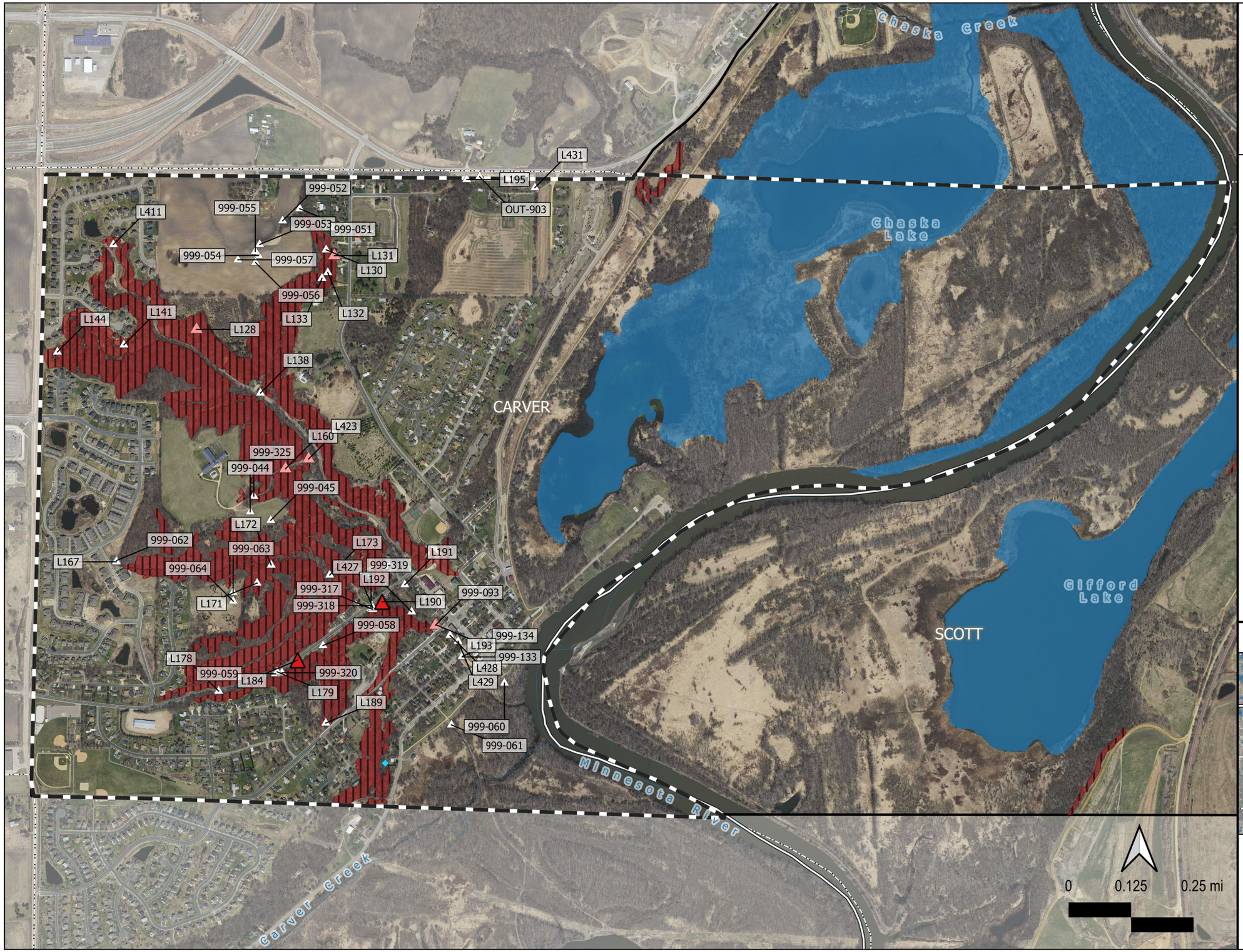
6.3 Findings

Pipes fell into multiple categories, such as large aproned concrete pipes, smaller residential drainage pipes, medium-sized plastic pipes, and medium-sized aproned metal and concrete pipes. Larger pipes around the Carver downtown looked stable, as did many new pipe outfalls feeding into retention ponds near new construction. Other small residential drainage pipes transported water from houses directly into gullies in the forested areas of Carver; these sites appeared more unstable (**Figure 42**).

Carver contained some of the deepest gullies and the highest concentration of high erosion potential sites (**Figure 43**). For particularly long gullies, the team had to complete surveys at multiple locations within the gully system to accurately capture changes. Although drainage pipes contributed to instability, groundwater springs were observed in most locations and many gullies contained groundwater-fed streams with water flowing in the channel. The prevalence of groundwater in Carver was confirmed by the number of observed springs in the MnDNR Spring Inventory. Gullies in Carver branched out and connected at various points, creating branching gully systems, especially along Spring Creek. Many of the heavily eroded gullies consisted of sand, but other substrate types like fine-grained cohesive were present. Boulders and armored stream channels were also prevalent in this area.

Figure 42: Carver 2020 Pipe Outfall Conditions



LEGEND

2020 Pipe Outfalls

- Needs Immediate Attention
- Potential/Future Repair Needed
- Good Condition/No Repair Needed
- MnDNR Spring Inventory
- Calcareous Fens
- Public Waters
- Public Waterbodies

LMRWD Overlay Districts

- High Value Resource Area Overlay District
- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

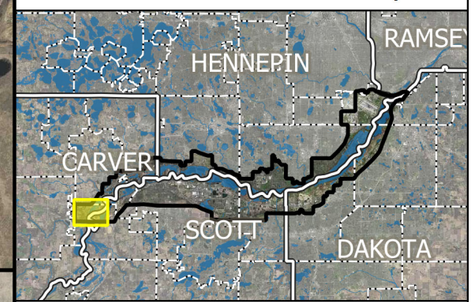


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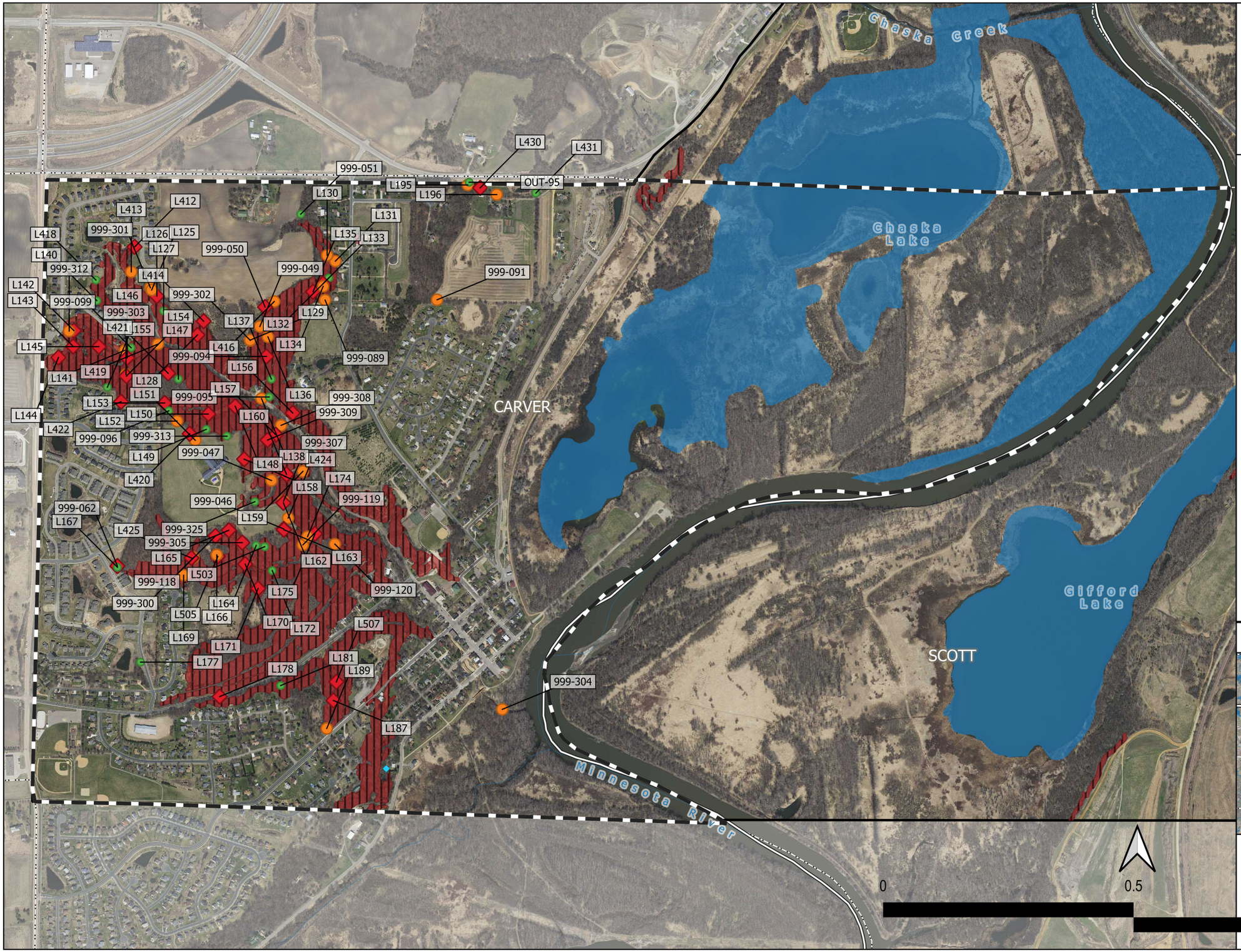
Figure 43: Carver 2020 Gully Conditions



LEGEND

2020 Gully Condition

- High Erosion Potential
- Moderate Erosion Potential
- Good Condition/No Repair Needed
- MnDNR Spring Inventory
- Calcareous Fens
- Public Waters
- Public Waterbodies

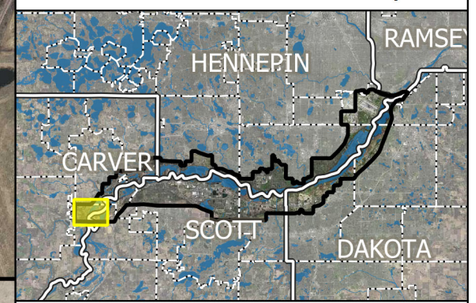
LMRWD Overlay Districts

- High Value Resource Area Overlay District
- Steep Slopes Overlay District [SSOD]

Political Boundaries

- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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6.4 Carver Gully Progression

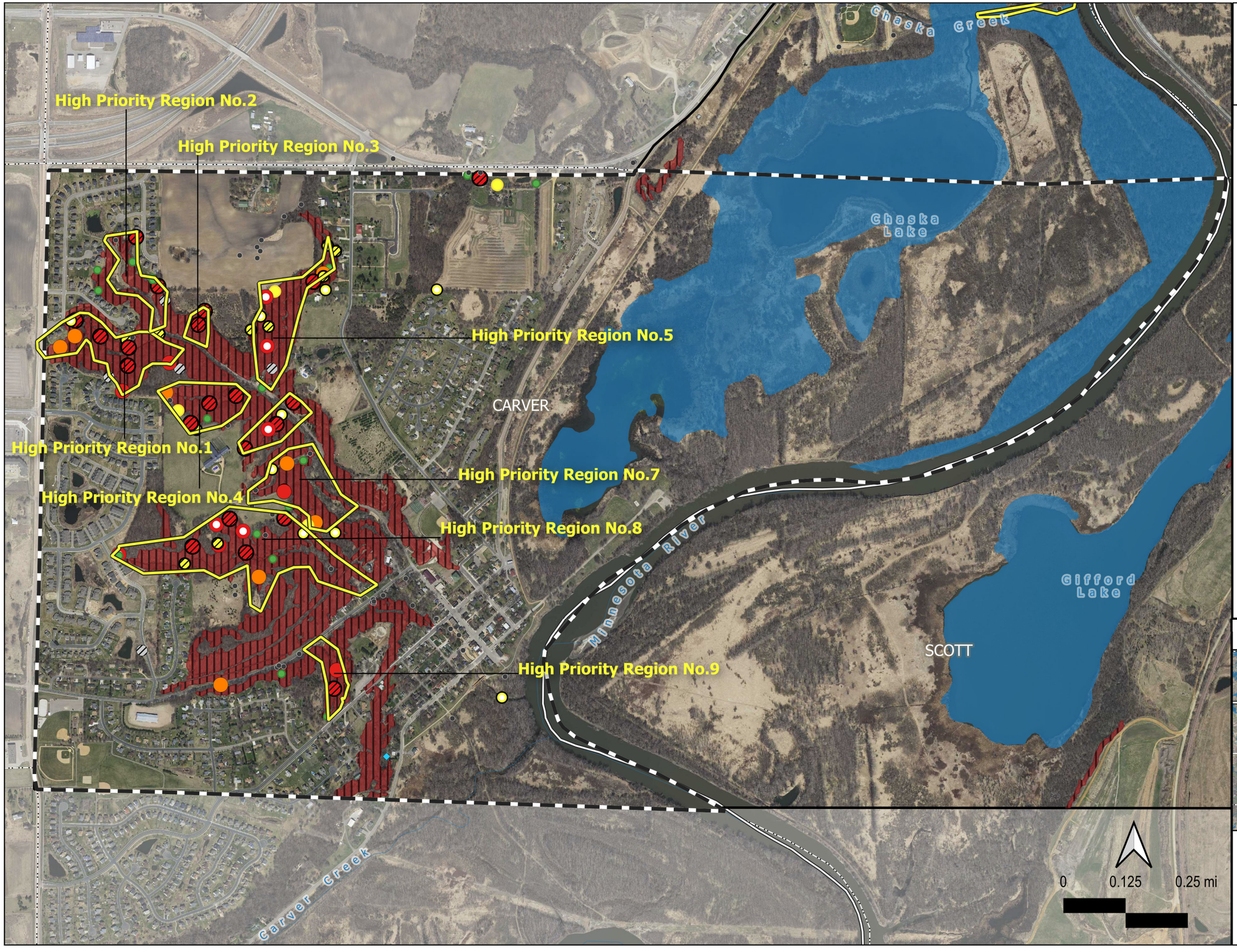
Using the 2008 benchmark data, the severity of erosion potential for most of the gullies in Carver has increased in the 2020 assessments. The total number of gullies has also increased, as has the number of gullies in each erosion potential category since 2008. **Table 6-1** provides an overall summary of the erosion potential within the City of Carver in both 2008 and 2020.

Table 6-1: City of Carver Gully Erosion Potential Summary

	2008 Benchmark Condition	2020 Condition
High Erosion Potential	36	41
Moderate Erosion Potential	21	35
Low Erosion Potential	13	22
	70	**98**

To better assess the erosion progression of an individual site, the change in erosion potential is mapped in **Figure 44**. Priority was placed on sites that increased in severity, going from low to high or moderate erosion potential. In the City of Carver, only 17 sites saw a reduction in erosion potential. The ratings for the sites judged to be less severe in 2020 than in 2008 can likely be attributed to the limited information available from the previous study for ranking determinations. The improved data collected in the 2020 study may have also played a role in the fact that sites were being ranked more appropriately, rather than any significant progressive change that may have occurred.

Figure 44: Carver Erosion Progression and HPRs



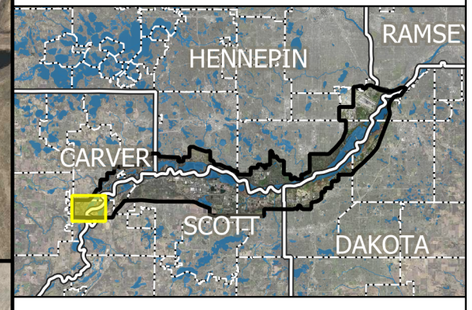
LEGEND

- High Priority Region

Erosion Progression (2008 --> 2020)

- Low --> High
- Moderate --> High
- High --> High
- New Site High
- Low --> Moderate
- Moderate --> Moderate
- New Site Moderate
- Low --> Low
- New Site Low
- Improved
- Non-Gully
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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6.5 Carver High-Priority Sites

In Carver, the high-priority sites are located within the Spring Creek watershed and within the District's Steep Slopes Overlay District. Evidence of groundwater upwellings is documented by the presence of springs, according to the MnDNR Spring Inventory and observation during the site visits.

The high-priority sites within the City of Carver are comprised of nine HPRs and two stand-alone sites shown in **Figure 44**. All the high-priority sites are in the Steep Slopes Overlay District. Each region is primarily grouped around the high erosion potential sites, but there are additional moderate to low priority sites encompassed within each of the regions as well. The rationale for the priority groupings is described below:

- **HPR 1:** All these points are located within Spring Creek's channel and its valley wall, making one large gully system.
- **HPR 2:** These points were grouped because of their geographic proximity to each other, shared access locations, similar characteristics, and shared erosion progression.
- **HPR 3:** This region is one large gully channel containing two waypoints evaluated at different locations in the system.
- **HPR 4:** This region is one large gully system with two head cuts. The system is evaluated as four separate points to document both head cuts and the downstream gully channel fully.
- **HPR 5:** This region is a stream channel with multiple slumps and finger gullies forming along its valley wall. Four high-priority sites make up this HPR, all of which ultimately discharge into the stream channel.
- **HPR 6:** This grouping is due to close proximity, shared access conditions, erosion progression, and characteristics. Three sites comprise one large gully system which truncates at Broadway Street. Across the road, there is one stand-alone site along the parallel hill slope.
- **HPR 7:** This grouping is due to shared characteristics, access conditions, and geographic proximity of all three sites.
- **HPR 8:** This is one large gully system forming a stream channel with sites being located either within the channel or forming offshoot branches on the valley wall of the stream channel.

- **HPR 9:** This is one large gully formed by a pipe outfall discharging and creating a channel. Two high-priority sites make up this region and constitute different points along the channel.

Sites L178 and L430 are not grouped within any of the HPRs because they do not share any geographic proximity or characteristics with other high-priority sites. The two locations are discussed and treated individually.

6.5.1 HPR 1

Currently, HPR 1 is made up of eight sites: L142, L143, L144, L145, L146, L147, L421, and L422 (**Figure 45**). The gully system starts with a pipe outfall discharging and creating a downstream gully, with groundwater upwelling contributing baseflow and forming a stream channel. An additional seep forms a small stream cutting a finger gully on the right bank of the larger gully system, constituting sites L422 and L147. One slump, L421, is formed off the right bank of the stream channel. The mainstream channel is formed by waypoints L142, L143, L144, L145, and L146. The characteristics seen in the main system are a moderate amount of fast-moving water, a medium-deep depth with a wide channel bottom, and a flat slope. Channel armoring is common in the stream channel, but sections of bare soil were observed in the field. The banks were observed to have some-heavy vegetation throughout the reach. The sediment material was found to contain coarse clastic material, mainly being gravel/cobble/boulder sized particles, but portions dominated by sand sized particles were present, nevertheless. The finger gully system on the right bank of the mainstream channel formed a deep, medium-sized, long gully. A moderate amount of fast-moving water formed from groundwater seeps was observed in the channel. Bare soil was common at the head cut, which transitioned to some vegetation being found in the channel closer to its confluence with the mainstream. The gully material was found consistently to be sand in the smaller system. The problem indicators observed for both the mainstream channel and the smaller finger gully system were degradation, loss of bank vegetation, incision, slumping, undercut banks, and leaning trees. The slump on the right bank of the valley wall of the main channel was found to be a deep, medium-sized gully with a steep slope. A small amount of fast-moving water formed from a seep was observed at the time of the visit. The bottom was found to have bare soil, with some vegetation being observed on the banks—mainly small-sized, new vegetation. Degradation, slumping, and leaning trees were the noted problem indicators, with a knickpoint observed at the gully toe above its confluence with the main channel.

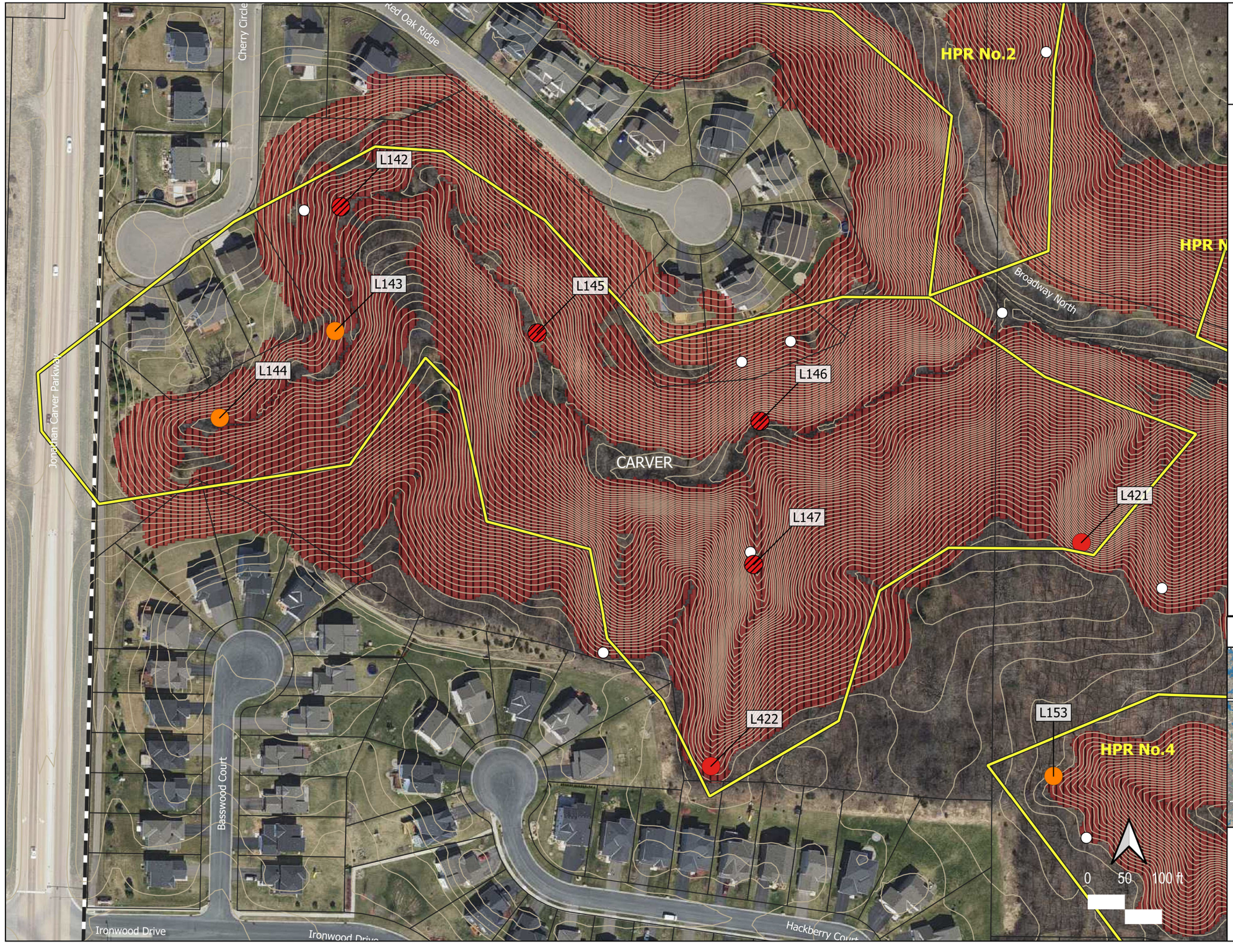
The apparent cause of the mainstream channel was determined to be runoff from both groundwater and unstable drainage features entering the system. Channel incision and slope were both found to be

contributors to the erosion in the downstream portion of the channel. The apparent causes of the slump were groundwater, the steepness of its slope, and channel incision from the stream.

In 2008, the previous study found that the mainstream channel was formed by a culvert, with extensive erosion found throughout the channel. Steady water flow was observed at the time of the visit in 2008, and a spring was observed. This gully system was benchmarked predominantly as having high erosion potential, with the upstream portion rated as moderate based on the information available from the previous study. In 2020, the field team confirmed their findings, with seeps observed throughout the channel. The field team observed that extensive and severe erosion were still apparent in the channel, and that the stream has continued to incise and erode. **Figure 46** shows a side-by-side comparison of conditions observed at L145 during each study. **Figure 46a** highlights the depth and magnitude of channel incision along the stream channel seen in 2008. **Figure 46b** highlights the recent slumping and magnitude of channel incision observed in 2020. **Figure 47** is another side by side comparison of conditions observed at L146 during each study. **Figure 47a** shows the channel incision that was noted in 2008. **Figure 47b** shows the channel incision observed in 2020, as well as recent slumping along the left bank. The gully system was rated in 2020 as having high erosion potential throughout the reach, giving evidence of its continued evolution to increased severity and providing the rational for its high priority ranking.

In 2008, the small finger gully system was described as having a head cut with mild erosion near the head cut and spring water in the channel. The system was benchmarked as having a low erosion potential near the head cut and a high erosion potential at the downstream portion of the channel. The team found in 2020 that the gully has progressed to having a more severe erosion potential near the head cut, with steep bank slopes and active signs of erosion and slope movement. The team additionally confirmed the high erosion potential ranking of the downstream portion of the system. The slump was described in 2008 as follows: “bigger gully tip, looks all right.” It was benchmarked as having low erosion potential based on the information available to the team. In 2020, it was determined to have a high erosion potential ranking and was observed to have become more severe, with signs of recent slumping and active erosion. It was additionally observed to be degrading and incising at its toe, a characteristic not noted or described in 2008.

Figure 45: Carver High Priority Region No. 1



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

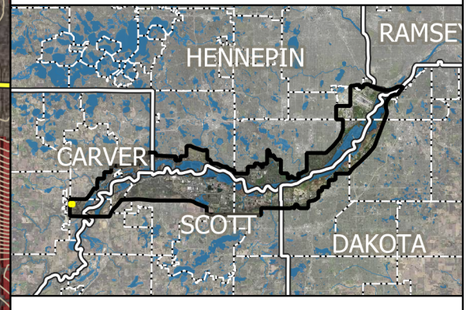


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Figure 46. Photo 'a' is an image taken in 2008 of L145's banks with person for scale; Photo 'b' is an image taken in 2020 of L145's channel and left bank with a person for scale.

Figure 47. Photo 'a' is an image taken in 2008 of L146's channel with a person for scale; Photo 'b' is an image taken in 2020 of L146's channel and left bank with a person for scale.

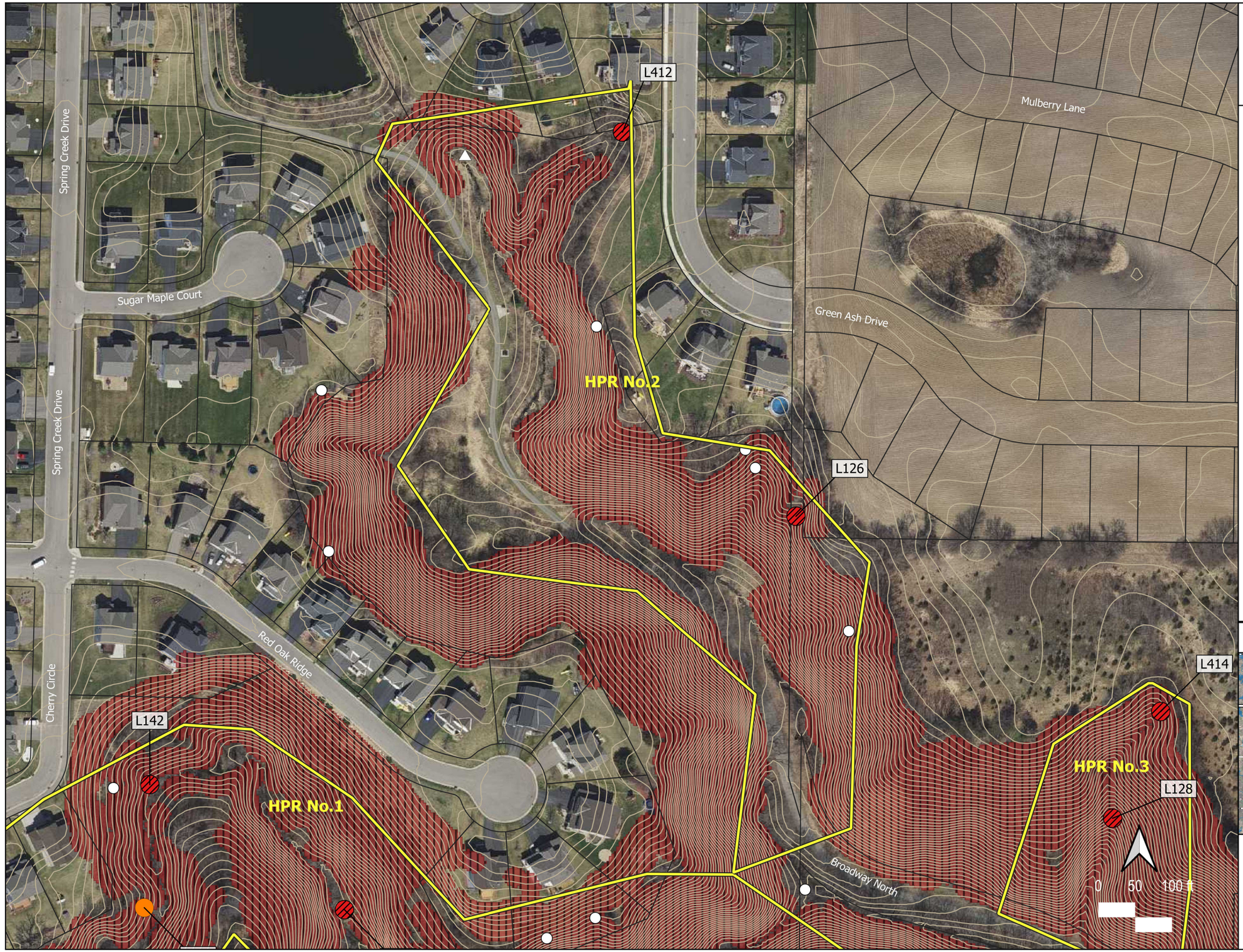
6.5.2 HPR 2

HPR 2 is composed of gullies L126 and L412 (**Figure 48**). Both sites are long, medium-sized gullies with bare soil on their bottoms and some vegetation observed on the banks. Both gullies were found to have steep slopes, and the gully shape ranged from a V- to a U- shape. Sand was the predominant gully material for the region. Incision, slumping, undercut banks, and leaning trees were the common problem indicators in Region 2. Degradation was a less common indicator, being observed only at L412. Additionally, seepage was only observed in L412's channel, creating a low amount of slow-moving water. Both L412 and L126's head cuts were found to be migrating towards the nearby residential properties. A resident expressed concerns to the team about L126's headward erosion.

The apparent causes for the region's high erosion potential were commonly observed to be slope and dense canopy. Uncommonly, groundwater was noted as an apparent cause of gully formation for L412. Additionally, channel incision was noted as an apparent cause for L126 only.

In 2008, the previous study evaluated L126 as a finger gully with undercut banks and exposed banks. They described it as "an old path that channels water" and that it looks "real bad." L126 was benchmarked as having high erosion potential based on the previous survey. The team confirmed this ranking while out in the field, finding evidence of active erosion and channel incision that provided a rationale for its high priority ranking. **Figure 49** details the active erosion observed in both studies. **Figure 49a** shows a similar view taken in 2008, with active erosion and overhanging banks along the head cut area. **Figure 49b** shows an upstream view taken in 2020 of active erosion, with a slump along the head cut area and severely undercut banks along the top of the slump scar. The previous study characterized L412 as a finger gully showing signs of wash out, along with severe downcutting and bank erosion. The gully was benchmarked as having high erosion potential. The team confirmed this ranking in 2020, ranking it as having high erosion potential based on evidence of severe channel incision and degradation.

Figure 48: Carver High Priority Region No. 2



LEGEND

- High Priority Region

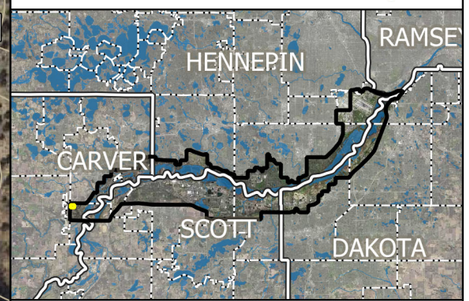
High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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LOWER MINNESOTA RIVER WATERSHED DISTRICT

Figure 49. Photo 'a' is an upstream view of L126's head cut area taken in 2008; Photo 'b' is an upstream view of L126's channel taken in 2020, looking toward the head cut area.

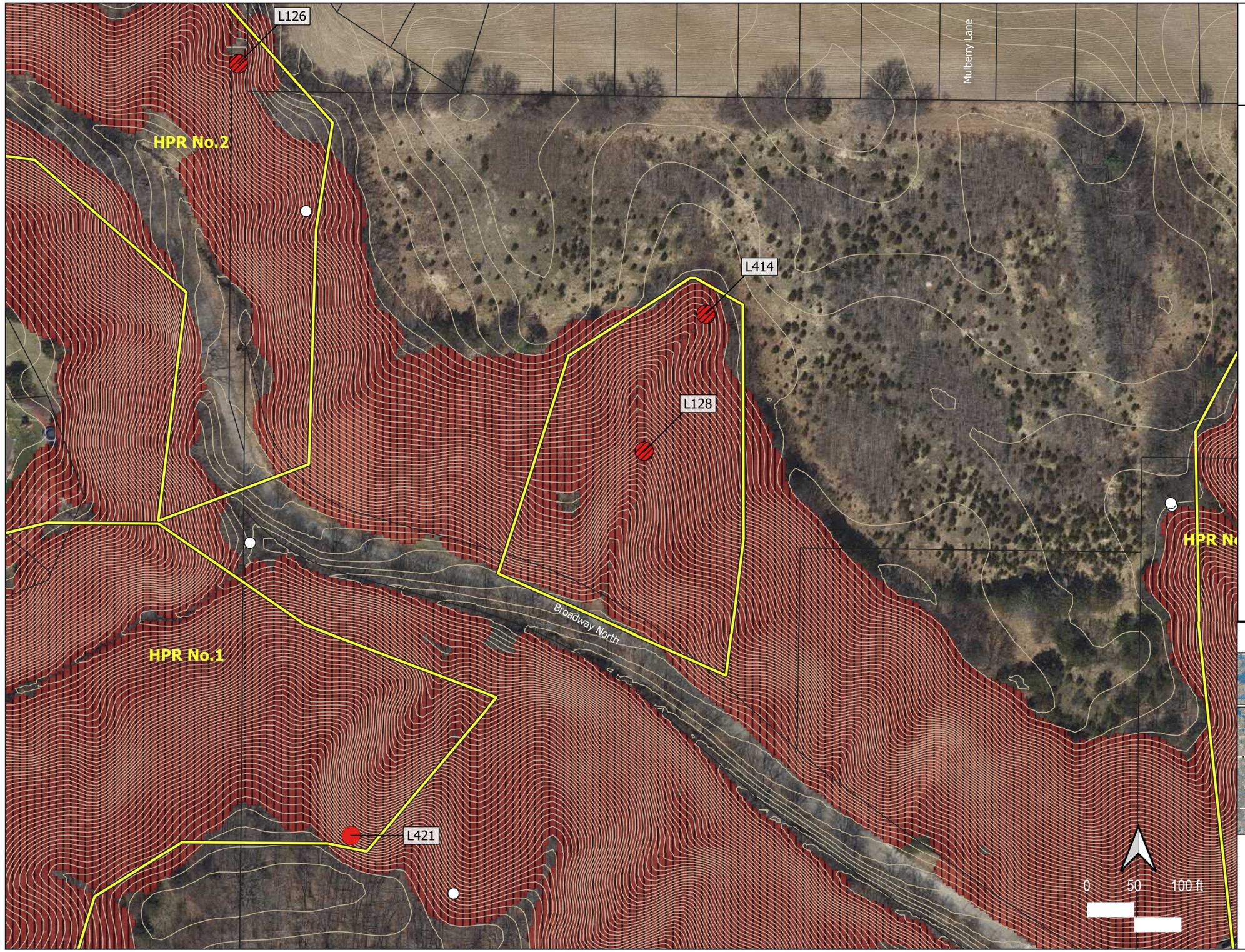
6.5.3 HPR 3

HPR 3 consists of sites L414 and L128 (**Figure 50**). The region forms one gully system, evaluated at the two sites. L414 was evaluated as the head cut of the system and found to be a medium-sized, long gully. L414 was noted to have bare banks and a channel with a steep slope. Sand was the predominant gully material, and no seeps were found at the time of the visit. The head cut was noted in 2020 as not appearing to be severely eroding, but there were large slumps throughout the channel, leading to the high erosion potential ranking. L128 was a deep, narrow, gully culminating at an inlet pipe at its toe. It was found to have bare banks and channel, with a steep slope and sandy material like L414. Conversely it narrowed to a V-shaped channel as compared to the U-shaped channel of the head cut area L128 occupies. A seep was found to begin in L414's channel. It was noted that a large portion of the banks in L414's channel appeared to be easily eroded away or close to slumping off.

Common problem indicators seen in both portions of the channel were degradation, loss of bank vegetation, incision, slumping, overhanging banks, and leaning trees. Apparent causes for L414 or the systems head cut area were not distinct and slope was the only noted cause suspected. Apparent causes for L128 or the downstream portion of the system were listed as groundwater, slope, channel incision, and dense canopy.

In 2008, L414 was described as the top of the gully, with severe bank erosion and a deeply cut channel. L128 was also described in 2008 as "cut deep with bad erosion." Both sites were rated as having high erosion potential during the desktop analysis. In 2020, the field team confirmed the high erosion potential rankings, finding similar signs of degradation, channel incision, and severe erosion. **Figure 51a** shows an image taken in 2008 of L128's channel, showing slumping and channel incision along the banks of the gully. **Figure 51b** shows an upstream view of L128's channel taken in 2020, showing a large knickpoint and its associated downstream degradation. Slumping was additionally observed in the channel downstream of the knickpoint.

Figure 50: Carver High Priority Region No. 3



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

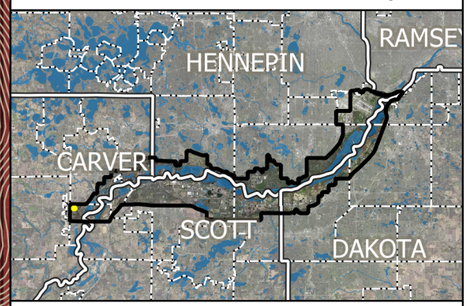


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Figure 51. Photo 'a' is an image of L128's channel and banks taken in 2008; Photo 'b' is an upstream view of L128's channel taken in 2020.

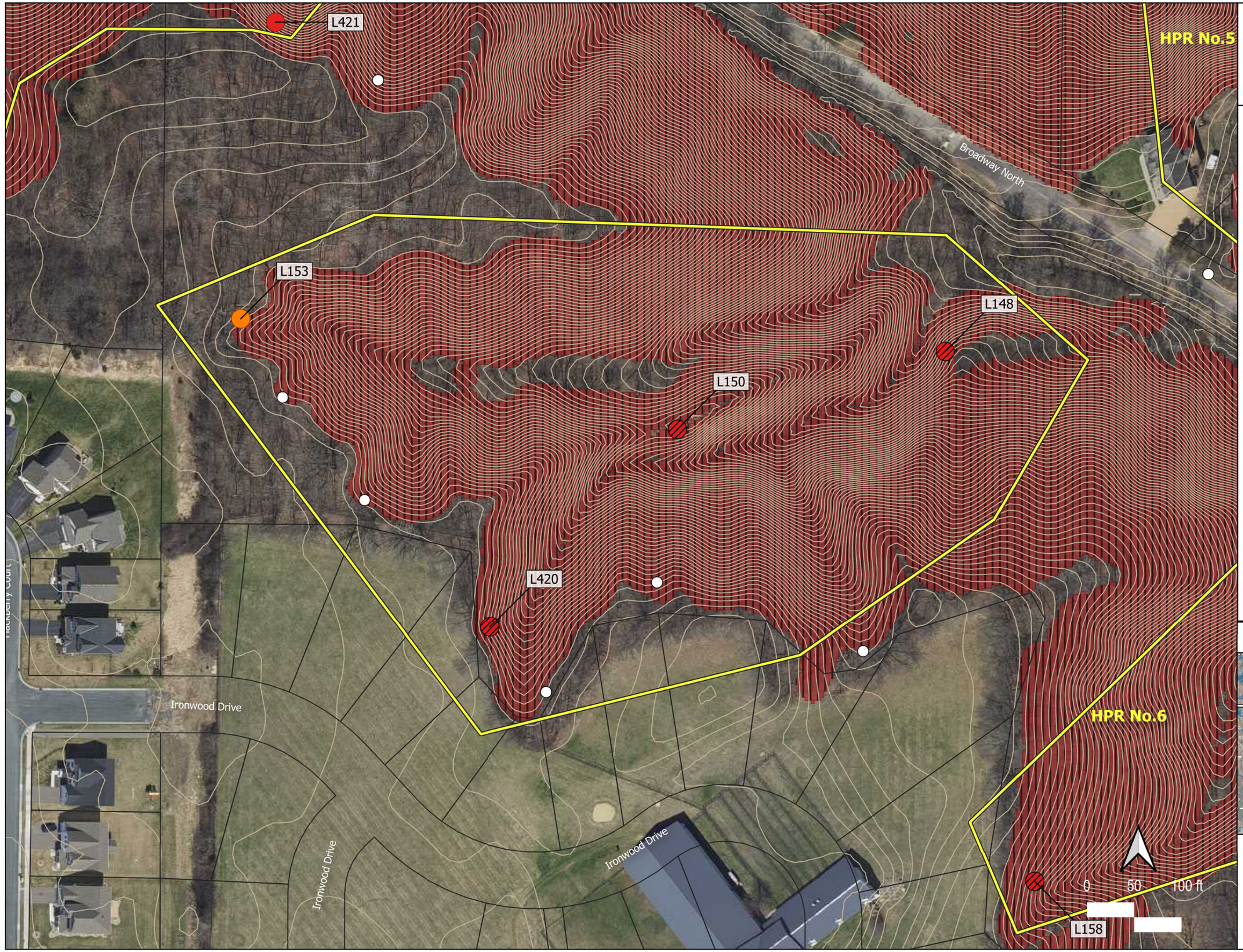
6.5.4 HPR 4

HPR 4 comprises sites L153, L420, L150, and L148 (**Figure 52**). L420 and L153 form 2 head cut areas that connect at a confluence and form a downstream channel, creating the larger gully system. L153 and L420 were found to have differing characteristics. L153 is formed out of two head cuts joining at a confluence and forming a deep and narrow channel. It was found to have a steep slope and to be V-shaped. L420 was found to be a medium-sized gully with a steep slope and trapezoid shape. No seep was observed at the time of the visit at either head cut. The downstream portion of the system comprises L150 and L148. Both sites were deep portions of the channel. Channel width ranged from narrow to medium, and the slope remained steep. Groundwater upwelling was observed at L150, which created a low amount of fast-moving water in the channel. The stream channel truncates before L148's reach, with a dried-up stream channel. A bare channel bottom and banks were common throughout the system with a patch of sparse vegetation forming on the banks near the toe.

Common problem indicators observed throughout the system were degradation, channel incision, undercut banks, slumping, and leaning trees. In the downstream portion of the system, loss of bank vegetation was also observed. The most common apparent cause for the system was slope. Groundwater and channel incision were noted as possible apparent causes for L150, and incision and dense canopy were evaluated for apparent causes of L148. One of the head cuts, L420, had construction occurring behind it. The construction was noted as an apparent cause of the head cut's formation.

In 2008, the study documented extensive erosion at L420, L150, and L148. **Figure 53a** depicts the channel incision and active erosion seen at L148 during the previous study. At L153, the previous study characterized it as a "fingertip that looks good." The desktop analysis rated L420, L150, and L148 as having high erosion potential and L153 as having moderate erosion potential. The field team confirmed the three high ratings in the field, determining evidence of active erosion and slumping that provided the rational for high erosion potential rankings. **Figure 53b** and **Figure 53c** provide examples of the severe slumping, overhanging banks, and channel incision observed throughout the gully system. L153 was determined to be high erosion in the field, due in part to a second head cut forming off the main channel not previously identified in the 2008 study. Fresh bare soil with exposed roots also provided rationale for the site's high priority ranking.

Figure 52: Carver High Priority Region No. 4



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

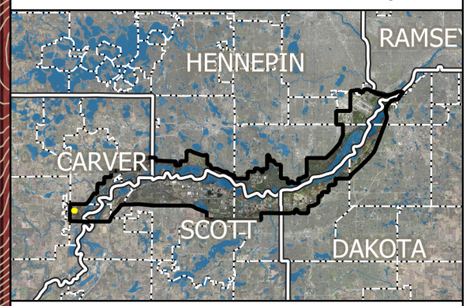


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Figure 53. Photo 'a' is an image of L148's channel and banks taken in 2008; Photo 'b' is an upstream view of L148's channel taken in 2020; and Photo 'c' is an upstream view of L150's channel taken in 2020.

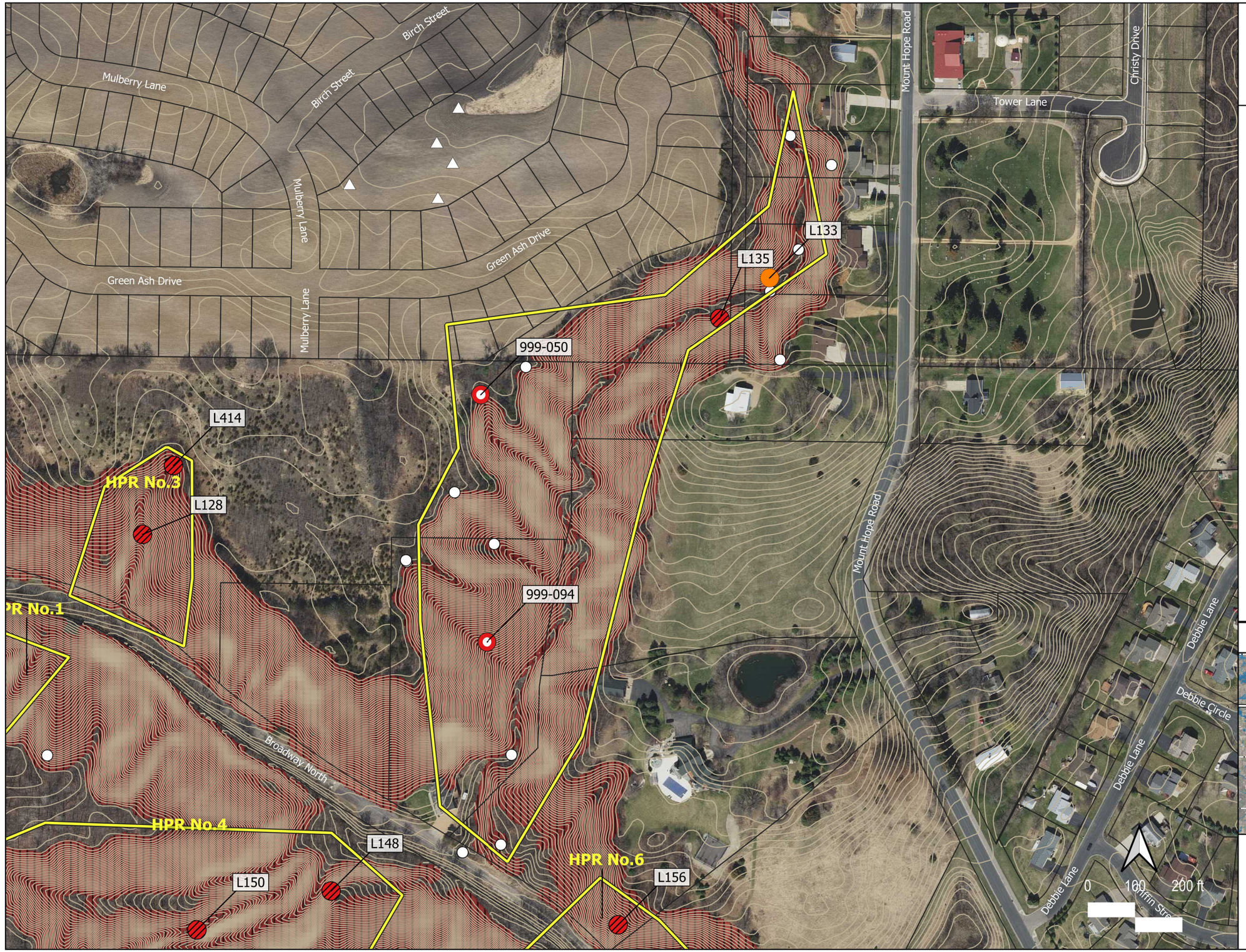
6.5.5 HPR 5

HPR 5 consists of sites L133, L135, and two newly identified sites—999-050 and 999-094 (**Figure 54**). Gullies L133 and L135 were found along the valley wall of a stream channel. Depths were found to be medium, with width ranging from medium to wide. Both gullies were found to be short in length and have both bare banks and channel bottoms. The two sites were found to have steep slopes and sand as the predominant material. L135 was found to be bowl-shaped while L133 was found to be U-shaped. No seep was found to occur in the gullies, but evidence of groundwater upwelling was evident in the stream channel they discharged into. At the head cut of L133, a hanging pipe was found, discharging into the gully channel.

Two newly identified finger gullies form on the right bank of the stream, 999-050 and 999-094. Site 999-050 forms a deep and wide gully that is a medium length. It was found to have a steep slope and is U-shaped. It was observed to have a bare channel bottom, with some vegetation stabilizing its banks. Sand was the predominant gully material, and no seep was observed at the time of the visit. Gully 999-094 is connected to the preexisting waypoint L129 and forms a long finger gully on the valley wall of the stream. The upstream reach of the finger gully, L129, was found to be of moderate erosion potential and is not a high-priority site. Gully 999-094 was found to be a long, medium-sized, narrow gully with both bare banks and channel bottom. It was found to have a steep slope and a V-shape, with fine-grained cohesive sediment as the predominant material. No seep was observed at the time of the visit.

Common problem indicators in the region were channel incision, slumping, undercut banks, and leaning trees. Loss of bank vegetation was less common but observed at 999-094 and L133. The apparent causes of the gully formation in the region were not distinct at all the locations. Slope was the only common and suspected culprit for each gully. An existing pipe outfall with severe outlet erosion was an apparent cause for L133's formation. Channel incision was another apparent cause noted for both L133 and 999-094. Dense canopy was only recorded as an apparent cause for one gully, 999-094.

Figure 54: Carver High Priority Region No. 5



LEGEND

- High Priority Region

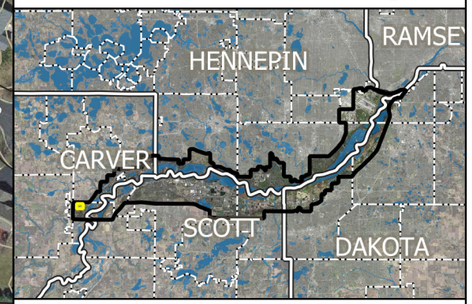
High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map



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In 2008, L133 was noted as a residential drainage pipe. The site was classified as having moderate erosion potential based on the limited information available during the desktop analysis. The team confirmed the presence of a residential runoff drainage pipe causing the gully and found it has significantly eroded since the previous survey. **Figure 55** shows the head cut area of L133. **Figure 55a** depicts the upstream view of L133's channel looking towards the head cut, showing the increased erosion. In comparison, **Figure 55b** shows the same upstream view of L133, taken in 2008. The two photos highlight the increased erosion in the gully channel between the two studies. The team rated it as having high erosion potential in 2020. L135 was evaluated as "bank erosion pretty bad" and as having groundwater upwelling occur and then disappear downstream. The gully was ranked as having high erosion potential during the benchmarking process. The team confirmed the high erosion potential ranking in the field, finding it to be a large slump. The team noted that given its large perimeter of undercut banks and completely bare bottom, there is a high potential for erosion from future precipitation events. **Figure 56** depicts the comparison of the gully between the 2008 and 2020 study. **Figure 56a** is an image of the gully taken in 2008, showing similarly incised and overhanging banks. **Figure 56b** is an upstream view of the incised and overhanging left banks taken in 2020. Sites 999-094 and 999-050 are newly identified points, and as such were not surveyed in 2008 or benchmarked.

Figure 55. Photo 'a' is an upstream view of L133's head cut taken in 2008; Photo 'b' is an upstream view of L133's head cut taken in 2020.

Figure 56. Photo 'a' is an image of L135's channel and banks around the head cut area taken in 2008; Photo 'b' is an upstream view of L135's head cut area and left bank.

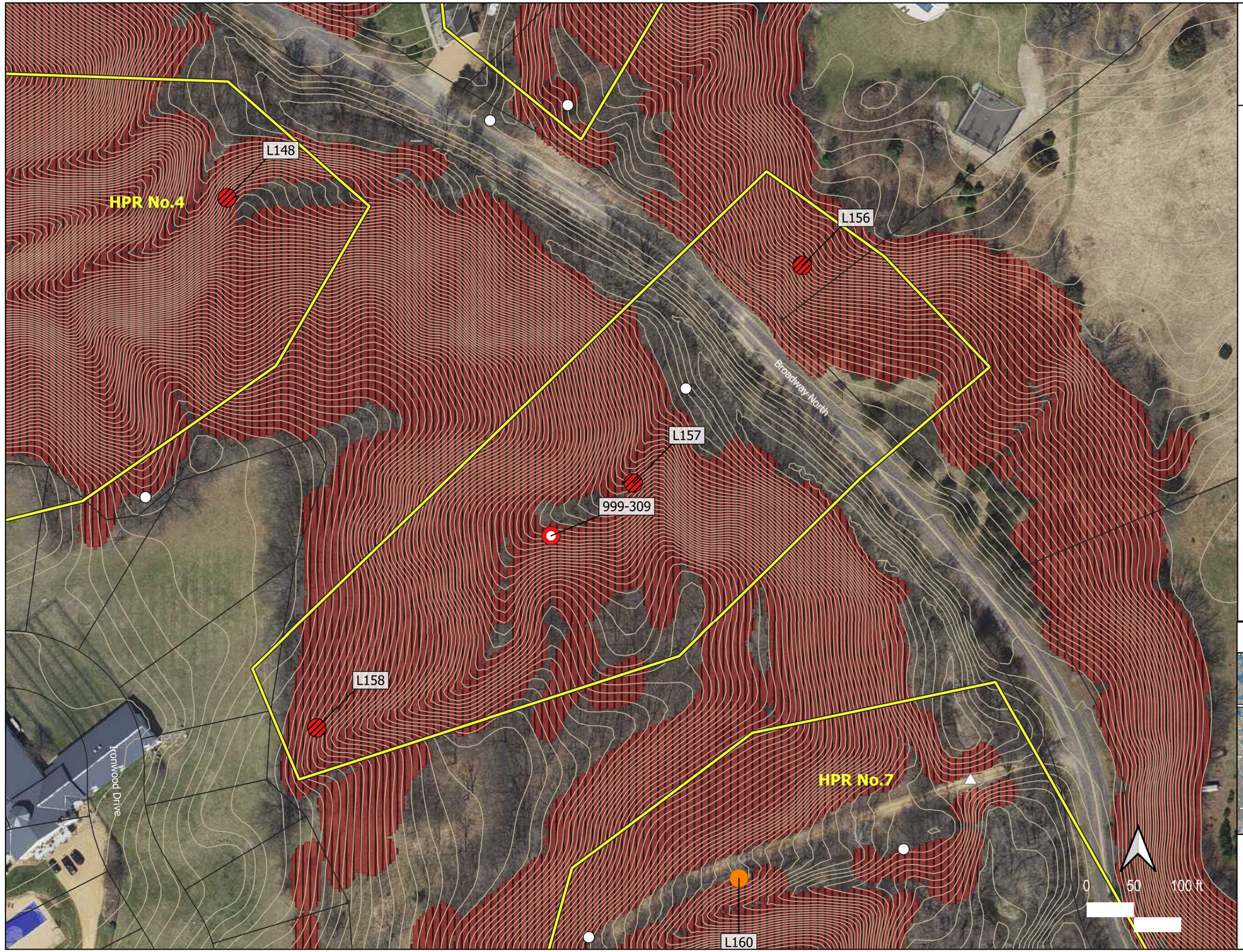
6.5.6 HPR 6

HPR 6 consists of Points L158, L500, L157, and L156 (**Figure 57**). Three sites, L158, L157, and L500, form one gully system, with knickpoints constituting the breaks in the reach where a new point was surveyed. At the head cut, the gully channel was found to be deep but grading into a medium depth further downstream. The gully was found to have a narrow bottom width and a V-shape, with a steep slope. The material for the gully system was found to be fine-grained cohesive sediment. The entire gully system was found to be bare soil, and no seep was observed throughout at the time of the visit. L156 was evaluated as a short, medium-sized narrow gully on the hill slope parallel to the main gully system of this region. Common to the gullies in the region, bare soil, steep slopes, and V-shape were noted for L156. Sand was determined to be the predominant material, and no seep was observed at the time of the visit.

Problem indicators throughout the region were observed to be degradation, incision, undercut banks, and loss of bank vegetation. The team noted slumping at the head cut and toe of the main gully system, as well as at L156. Apparent causes for gully formation in the region include slope and channel incision, with dense canopy additionally being noted for the main gully system.

In 2008, L156 was noted as being a small finger gully with "deep cut erosion under trees and all up hillside." The gully was benchmarked as having high erosion potential based on the information provided. The team confirmed this ranking during the 2020 study. The main gully system was described in 2008 as being a finger gully with sizeable erosion throughout. Additionally, it was noted to have deep cut erosion at L157 near the gully toe. The system was ranked as having high erosion potential during the desktop analysis. The ranking was confirmed in the 2020 study, with the whole gully system being ranked as having high erosion potential. The team observed a significant increase in erosion and degradation since 2008, further providing a rationale for its high-priority status. **Figure 58** depicts the increased erosion and degradation that has occurred between the two studies. **Figure 58a** is an upstream view of the main gully system channel taken in 2008, showing the channel incision and erosion near L157. **Figure 58b** is the same upstream view taken in 2020, showing the increased channel incision and erosion that has occurred since the previous study, as well as highlighting the channel shape and incision commonly seen throughout the region.

Figure 57: Carver High Priority Region No. 6



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

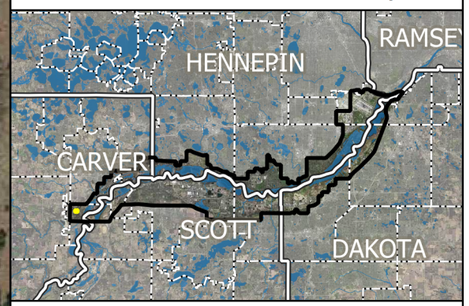


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Figure 58. Photo 'a' is an upstream view of L157's channel taken in 2008; Photo 'b' is an upstream view of L157's channel taken in 2020.

6.5.7 HPR 7

HPR 7 is made up of sites L160, L162, and L175 (**Figure 59**). Gully depth in the region ranges from medium-deep, with the gully bottom width consistently being medium and the gully length consistently long. All gullies in the region were found to be bare, steep, and V-shaped. Sand was the predominant gully material throughout the region. No seep or water was observed in any gully in the region. L160 is formed downstream of a large pipe outfall, which contributes to the gully formation. L175 is connected to an upstream site, L174, which was rated as having moderate erosion potential and not considered a high-priority site. Site L175 was evaluated as the portion of the gully reach where severe erosion begins to occur.

Problem indicators throughout the region were predominantly degradation, slumping and leaning trees; with undercut banks and loss of bank vegetation observed in L162 and L175. Common apparent causes of gully formation in the region include slope and dense canopy, with an unstable drainage feature being listed for L160 as well.

In 2008, L160 was described as “erosion control/tile outlet.” It was rated as having moderate erosion potential during the desktop analysis, based on the limited information provided. Contrary to the previous rating, the field team ranked L160 as having a high erosion potential, evident by the significant downstream erosion observed. Site L162 was described as “minimal erosion along the channel” in 2008; and as such, was rated as having a low erosion potential during the desktop analysis. However, the field team found that it had a high erosion potential due to the fact that the banks and head cut were actively eroding and slumping off; but found it was on the lower end of high potential due to the channel’s stable appearance. Gully L175 was described in 2008 as “the start of severe erosion in the gully” and was benchmarked as having moderate erosion potential based on the image and available information. In 2020, the field team found evident slumping and the head cut pushing back upstream. Additionally, they noted a finger gully forming on L175’s channel. The team in turn rated this gully as having high erosion potential. **Figure 60** shows the gully’s evolution between the two studies. **Figure 60a** is an image taken in 2008 of the gully channel and banks, showing incision and erosion in the channel. **Figure 60b** is an upstream view of the gully taken in 2020, showing the slumping, overhanging banks and active erosion seen at the time of the visit.

Figure 59: Carver High Priority Region No. 7

L158
L160
L162
999-046
L163
L175
305
HPR No.8
Broadway North
0 50 100 ft

LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

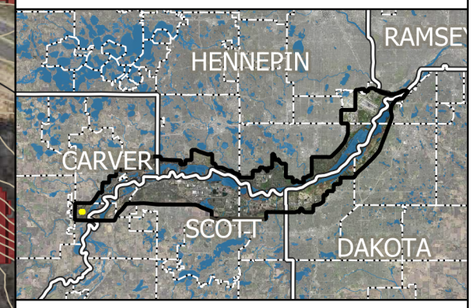

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Figure 60. Photo 'a' is a view of L175's channel and banks taken in 2008; Photo 'b' is an upstream view taken in 2020 of L175's channel and banks.

6.5.8 HPR 8

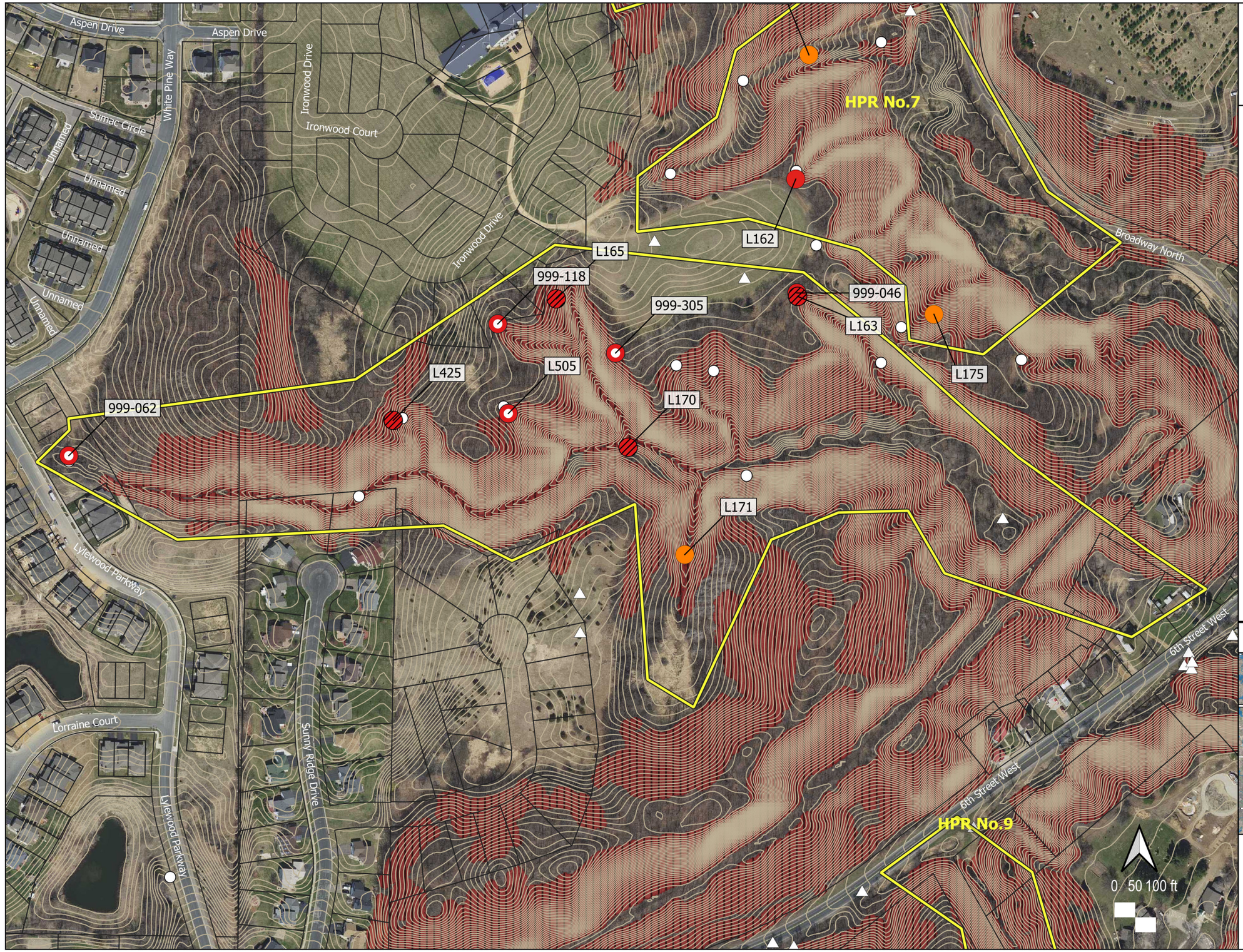
HPR 8 comprises points L128, L426, L163, L165, L500, L170, L171, 999-118, 999-046, and C21 (**Figure 61**). The region is formed from a stream channel, with several finger gullies forming along its valley walls. Gullies in this region are all long and deep, with a range of widths from narrow to wide. Bare soil is common throughout the region, with some sparse patches of vegetation observed. Predominantly, channel slopes in this region are steep, with L163 being the only gully observed to have a flat slope. Gully shapes in the region ranged from V- to U-shaped, with L500 being the only site found to have a trapezoid shape. Seeps were observed along the stream channel in the region but were not found along the gullies carved into the valley walls. Sand was the predominant gully material for the whole region. Water was commonly noted in the gullies; the water level was consistently low at the time of the visits, but the water velocity ranged from standing to fast.

Common problem indicators for the entire region observed were degradation, incision, loss of bank vegetation, slumping, overhanging banks, and leaning trees. Sites L500 and 999-046 were the only sites to not exhibit degradation at the time of the visit. Additionally, C21 showed no signs of loss of bank vegetation when evaluated. Lastly, L426 did not have overhanging banks or leaning trees. A common apparent cause for the whole region was slope. Channel incision was noted for most of the gullies. Two gullies were formed from drainage pipes, L171 and L128, and unstable drainage features were noted as a cause for their formation. Dense canopy was noted for the head cut in L128 as well as in two of the gullies that formed along the valley wall of the stream, 999-118 and 999-046. Lastly, groundwater was noted as an apparent cause for two sites located within the stream channel, L128 and L170.

In 2008, the stream channel was evaluated starting at L128, noting it as the beginning of a long channel. Its evaluation ended with L170, which the survey described as the "end of [an] extremely eroded channel." The desktop analysis rated both L128 and L170 as having high erosion potential based on the images and information provided. The team confirmed these ratings in the field during the 2020 study, finding continued evidence of active erosion, slumping, and incision in the channel. **Figure 62** shows the incision and extreme erosion occurring in L170's channel. **Figure 62a** is an upstream view taken in 2008 showing the severe incision and undercut banks along the right bank. **Figure 62b** is another upstream view taken in 2020 showing the continued severe incision and undercut banks along the right bank. L426 was described as a finger gully with strongly eroded banks in 2008 as shown in **Figure 63a** and was ranked as having moderate erosion potential during the desktop analysis. The team visited the site in 2020 and ranked it as having high erosion potential due to the actively eroding head cut and deeply incised channel observed as shown in **Figure 63b**.

In 2008, L165 was described as an “eroded bank” and rated as having high erosion potential during the desktop analysis based on the available information and image provided. In the field, the team confirmed this ranking during the 2020 study. The team noted the gully appeared to be a severe site, with lots of knickpoints and slumps throughout the channel. Lastly, L163 was described as a “deep channel with severe erosion,” and as such was rated as having high erosion potential during the desktop analysis. The team confirmed this ranking in 2020, noting one large slump with additional significant slumps in the channel, along with multiple knickpoints.

Figure 61: Carver High-Priority Region No. 8



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

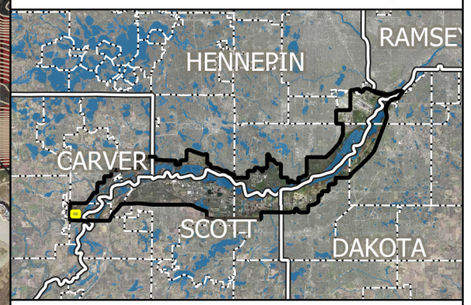


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Figure 62. Photo 'a' is an upstream view of L170's channel taken in 2008; Photo 'b' is another upstream view of L170's channel taken in 2020.

Figure 63. Photo 'a' is an upstream view of L426's channel taken in 2008, Photo 'b' is a downstream view taken in 2020 of L426's channel.

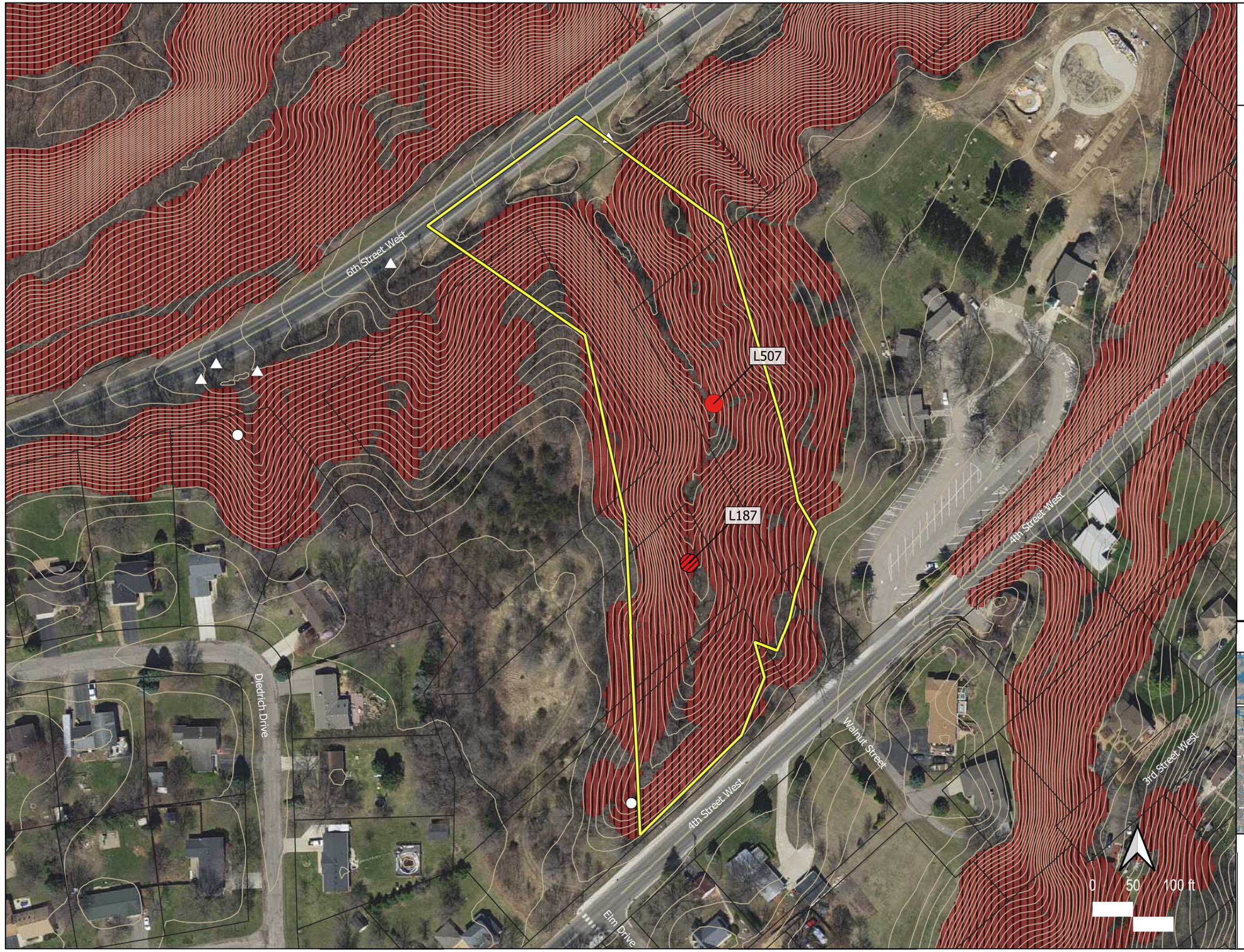
6.5.9 HPR 9

HPR 9 is made up of two sites, L187 and L186, which form one large gully (**Figure 64**). The gully's head cut is formed by a pipe outfall discharge at Site L189. L189 was rated as having moderate erosion potential and is therefore not a high-priority site. It is included in the gully region but not detailed in this section. Both gullies are medium-sized and long, with flat slopes. Channel armoring is common in this region, with some bank vegetation observed throughout. Sand is the predominant gully material in the region. L187 was observed to have a U-shaped channel, whereas L186 was observed to have a V-shaped channel. Seeps were only observed at L186, but no consistent water flow was observed in the gully system.

The problem indicators of the region are degradation, incision, slumping, undercut banks, and leaning trees. New gully head cuts were observed forming within the gully system, and large slumps were seen throughout the region. The apparent causes of L187 were channel incision and an unstable drainage feature. The apparent causes of L186 were an unstable drainage feature, channel incision, groundwater, and a dense canopy.

In 2008, L187 was described as a "washout area." During the desktop analysis, it was determined the site had high erosion potential based on the image and information available. The team in 2020 confirmed this high erosion potential ranking in the field, finding evidence of active erosion throughout the channel and significant slumping. Site L186 was evaluated as a spring at the end of a marsh in 2008 and given a low erosion potential ranking during the desktop analysis, based on the limited information available. The field team determined the site had high erosion potential in 2020, finding evidence of slumping and new head cuts forming from the original channel. Groundwater incision in the channel was additionally noted, providing a rationale for its high erosion potential ranking. **Figure 65** shows the evolution of L186. **Figure 65a** is a downstream image of L186's channel taken in 2008, showing minimal channel incision and erosion. **Figure 65b** is a downstream image of L186's channel taken in 2020, showing severe channel incision, undercut and exposed banks, and erosion in channel.

Figure 64: Carver High-Priority Region No. 9



LEGEND

- High Priority Region

High Priority Sites

- Low --> High
- Moderate --> High
- High --> High
- New Site High

Other 2020 Locations

- Surveyed Gully
- Surveyed Pipe Outfall
- Carver Co. 2-ft Contours
- MnDNR Spring Inventory
- Public Waters
- Public Waterbodies
- High Value Resource Area Overlay District
- Steep Slopes Overlay District
- Carver
- LMRWD Boundary
- Cities, Townships, Unincorporated Areas
- County Boundaries

LMRWD Watershed Location Map

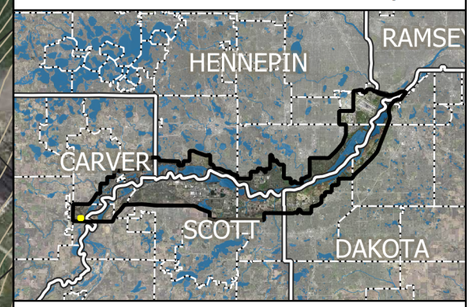


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Figure 65. Photo 'a' is a downstream view of L186's channel taken in 2008; Photo 'b' is a downstream view of L186's channel taken in 2020.

6.5.10 L178

L178 is a stand-alone site and not grouped into any HPR. The gully is formed by a pipe outfall discharging and creating a downstream channel. The gully channel runs parallel to 6th Street. L178 was evaluated as a short, medium-sized, and wide gully. Bare soil was observed in the channel and some vegetation was observed on the banks. The channel slope was noted to be flat, and sand was the predominant gully material. A moderate amount of slow-moving water was observed at the time of the visit, and the gully channel was determined to be U-shaped. No seeps were noted at the time of the visit.

The problem indicators for L178 were loss of bank vegetation, incision, slumping, undercut banks, and leaning trees. The apparent cause of L178 was determined to be channel incision and an unstable drainage feature entering the system. In 2008, L178 was evaluated as a "culvert on side of road." Based on the limited information available, it was determined to be of moderate erosion potential during the 2020 desktop analysis. The field team conversely found it to be of high erosion potential. It was determined as such because it was observed in the field that the right bank was unstable and a large storm coming through the pipe outfall could cause significant erosion and slumping along the bank. **Figure 66** shows a side-by-side comparison of conditions observed at the time of each study. **Figure 66a** shows an image taken in 2008 of the outfall pipe and surrounding channel; the image shows moderate incision and minimal erosion in the downstream channel. **Figure 66b** shows an image of the downstream channel taken in 2020. The image highlights the severe channel incision, active erosion, and unstable right bank.

Figure 66. Photo ‘a’ is an image taken in 2008 of the culvert forming the head cut of L178 and its downstream channel; Photo ’b’ is an image taken in 2020 of L178’s downstream channel, showing significant incision of the channel.

6.5.11 L430

Site L430 is a stand-alone site and not grouped into any HPR. It constitutes a portion of a stream channel near a family farm. One other site is located along the stream channel but was rated as having moderate erosion potential and is not detailed in this section. L430 is a long, medium-sized gully with a steep slope and bare channel bottom. Some vegetation was observed on the banks and the channel shape was evaluated as U-shaped. Sand was the predominant material, although some rock armoring was noted along the banks. Seeps were noted at this site, and in turn, L430 had a low amount of fast-moving water in its channel at the time of the visit. A substantial knickpoint was seen in the channel, causing degradation and incision downstream.

The problem indicators observed at L430 were degradation, loss of bank vegetation, incision, slumping, and overhanging banks. The apparent causes of L430's formation are groundwater, dense canopy, and channel incision. In 2008, the gully was described as an "old foundation" as shown in **Figure 67a**. The 2020 desktop analysis determined this site had high erosion potential, based on the limited information available. In 2020, the team confirmed this ranking in the field. Evidence of significant degradation and incision were observed as shown in **Figure 67b**, providing a rationale for the high erosion potential ranking.

Figure 67. Photo 'a' is an upstream view of L430 highlighting the old foundation inside the channel; Photo 'b' is a downstream view of L430's channel from the knickpoint.