4 Identification of Pollutants, Sources and Causes

4.1 Nonpoint Sources

The purpose of a WMP is to address the issue of nonpoint source pollution. Therefore the discussion of causes in relation to *E.coli*, sediment and DO, is centered on nonpoint source pollution. The Watershed planning effort is aware that permitted point sources can contribute; however, it is not the focus of this plan to address permitted point sources.

4.2 Primary Pollutant

Once the watershed monitoring revealed that *E.coli* concentrations were exceeding the water quality standard in Columbia Creek, Skinner Extension Drain and Silver Creek subwatersheds, the investigation turned to possible sources. To begin determining how to reduce the *E.coli* impairment it was important to investigate where the *E.coli* is originating from along, with why it is impairing the above mentioned subwatersheds. Investigations were conducted to identify possible sources of *E.coli*. Field investigations included an agricultural practices survey to assess tillage practices, livestock estimates, livestock access to surface water and current management practices. The use of the Streamlining Spatial Datasets Related to Septic System Failure Case Study, and Time of Sale or Transfer Program results, aided in verifying the sources and causes of *E.coli* contamination. The Steering Committee also provided input on the sources and causes of *E.coli* throughout the project. Identifying the sources and causes of *E.coli* will guide the implementation efforts and best management practices needed to achieve water quality standards.

4.2.1 Primary Pollutant Sources and Causes

4.2.1.1 Methodology

4.2.1.1.1 Agricultural Practices and Tillage Survey

Data on the agricultural tillage practices, grazing, and livestock observations were inventoried in eight subwatersheds with high agricultural land use (Columbia Creek, Skinner Extension Drain, Silver Creek, Sandstone Creek, Frayer Creek, Winchell and Union Drain, Cryderman Lake, and Sebewa Creek). ECD recruited and trained volunteers to conduct the agricultural practices survey. A datasheet for the agricultural practices survey, which primarily focused on the livestock inventory, is included in Appendix 10. Volunteers drove every road throughout each of the subwatersheds and recorded locations and characteristics of observed livestock facilities, including resource concerns. Resource concerns are defined as degraded natural resources (such as eroded stream banks) or landscape features that increase the risk of transporting pollution (i.e.; flooded area in the middle of a pasture). In the same subwatersheds, volunteers recorded information on tillage practices. ECD reviewed aerial imagery from Bing Maps (Microsoft Corporation, 2012) to further assess locations of livestock facilities that are not visible from the road.

The tillage survey was conducted to review current tillage practices and identify areas that may potentially be contributing to sediment, nutrient, pathogen, and bacteria loading in the stream. The crop residue was recorded as an overall percentage for the subwatershed. The categories used were: No till (>30% residue) Reduced till (15-30%) and Conventional till (<15%) residue remaining on the field.

4.2.1.1.2 High Impact Targeting (HIT) Modeling

Sedimentation is a water quality concern for the Watershed. It is contributing to the following water quality designated use not being met, other indigenous aquatic life and wildlife. To address this water quality concern in the WMP, the HIT Model was used.

The HIT Model projects estimates for the rate that sedimentation is occurring on agricultural lands. Estimates are projected based on a combination of computer modeling and geographical information systems technology. The intent of the HIT Model is to provide calculated estimates for subwatersheds that can then be used to help determine where to implement best management practices.

As part of the watershed inventory process, ECD used the HIT Model to determine the extent at which sedimentation is a problem for the watershed and to aid in the prioritization process of subwatersheds. The HIT Model provided annual estimates for sediment delivery for each subwatershed.

4.2.1.1.3 Septic Systems

Time of Sale or Transfer Program (TOST)

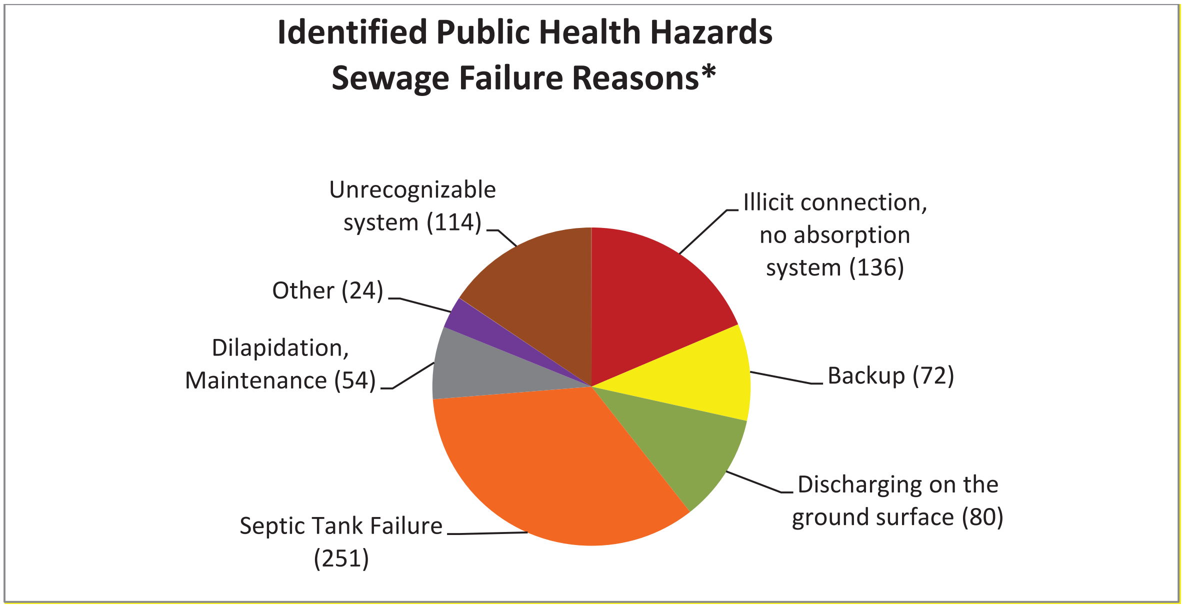
The Watershed is covered by four health departments: Ingham, Barry-Eaton, Ionia and Mid-Michigan Health Department (includes Clinton County). Ingham and Barry-Eaton District Health Departments (BEDHD) are the only two with a TOST program. A TOST program requires the inspection and evaluation of septic systems and/or wells before any residential home property is transferred. Through this program hazards are identified and corrected on sites served by a well and/or sewage system. Ingham County established a program in 2006 and Eaton County established a program in 2007.

County Health Departments that have a TOST program are able to get a grasp as to the potential extent of failing septics. It is considered a progressive public health management practice to have in place.

Through the established TOST programs valuable information has been collected that can be used to further understand the extent of septic systems and water quality within the Watershed.

From 2007 to 2010, BEDHD identified 602 rural residential sites with sewage failure conditions. Seven reasons have been identified for sewage failure by BEDHD (Figure 14). Of those seven reasons sewage failure is more likely to be attributed to septic tank failure. The two next likeliest reasons are illicit connection-no absorption system and unrecognizable system. Overall the BEDHD has found 26% sewage failure rate of sites being evaluated during their Time of Sale or Transfer Program.

Figure 14. Reasons for sewage failure in the District, as found by the BEDHD (First Three Years, 2007-2010).



*Note: There may be more than one reason for failure on an individual site. Thus there are more total reasons for failure (731) than the total number of sites with sewage failures (602).

Reasons for Sewage Failure Key:

- Illicit Connection/no absorption system refers to sites where there is no absorption system, or raw sewage leaves the septic tank and is connected to a pipe, or other method directing the sewage away to an unapproved location such as a field tile, county drain, river, lake, or other water body.
- Sewage Back up is a condition found where raw sewage is backing up into the home, pressurized above the tank's operating level, or pressurized liquid level above the absorption system's maximum operating level.
- Sewage on the ground is a condition where raw sewage is being deposited directly on the ground surface.
- Septic Tank Failure includes a condition that does not provide proper initial treatment of raw sewage and/or a septic tank that is an imminent safety hazard. This includes tanks with corroded or missing outlet baffles, no sanitary outlet tee, leaking tanks, bottomless tanks, collapsed/cracked septic tanks and/or uncovered/open septic tanks.
- Dilapidation, Maintenance includes systems filled with roots and/or soil, collapsed/broken piping, where present, pump and/or pump controls not functional, and/or excessive solids/scum accumulation in the tank(s).
- Other refers to various unique conditions such as systems located on neighboring property, sites without a septic tank, sites where the septic tank is bypassed and/or portions of the sewage system have been removed.

- Unrecognizable system refers to a —system that is not recognized under any standard, rule or law to provide proper treatment and disposal. Examples include 55 gallon drums, seepage pits or rock piles, debris filled pits, single (graveless) tiles.

Streamlining Spatial Datasets Related to Septic System Failure Case Study

In 2012, graduate students from Michigan State University's Water Policy and Management course (FW868) coordinated with the Eaton Conservation District on a semester-long project that would contribute to the development of a watershed plan for the Middle Grand River. The project specifically focused on consolidation of spatial data sets in order to narrow the scope of understanding local *E. coli* contamination. The focus was on on-site wastewater systems (e.g. septic tanks and drain fields) in the Watershed.

The study identified the Watershed having greater than 12,000 septic systems (Table 16). Of those systems over 1,000 of them are estimated to be located near 75 meters of a river. When investigating potentially how many systems could be in an area more susceptible to failure and water quality impact, it is important to incorporate the quality of soils. Within the Watershed it is estimated that fewer than 400 septic systems are located in areas 75 meters from a river and poorly drained soils. The study resulted in identifying these as Areas of Highest Likely Impact (Figure 15). Skinner Extension Drain, Sandstone Creek and Carrier Creek subwatersheds have the greatest amount of Areas of Highest Likely Impact. This information will help focus priority areas within the subwatersheds and guide implementation efforts. See Appendix 11 for the full report.

Figure 15. Areas of Highest Likely Impact as identified by proximity to Middle Grand River Watershed surface water and zones of non-preferred soils for effective septic system functionality.

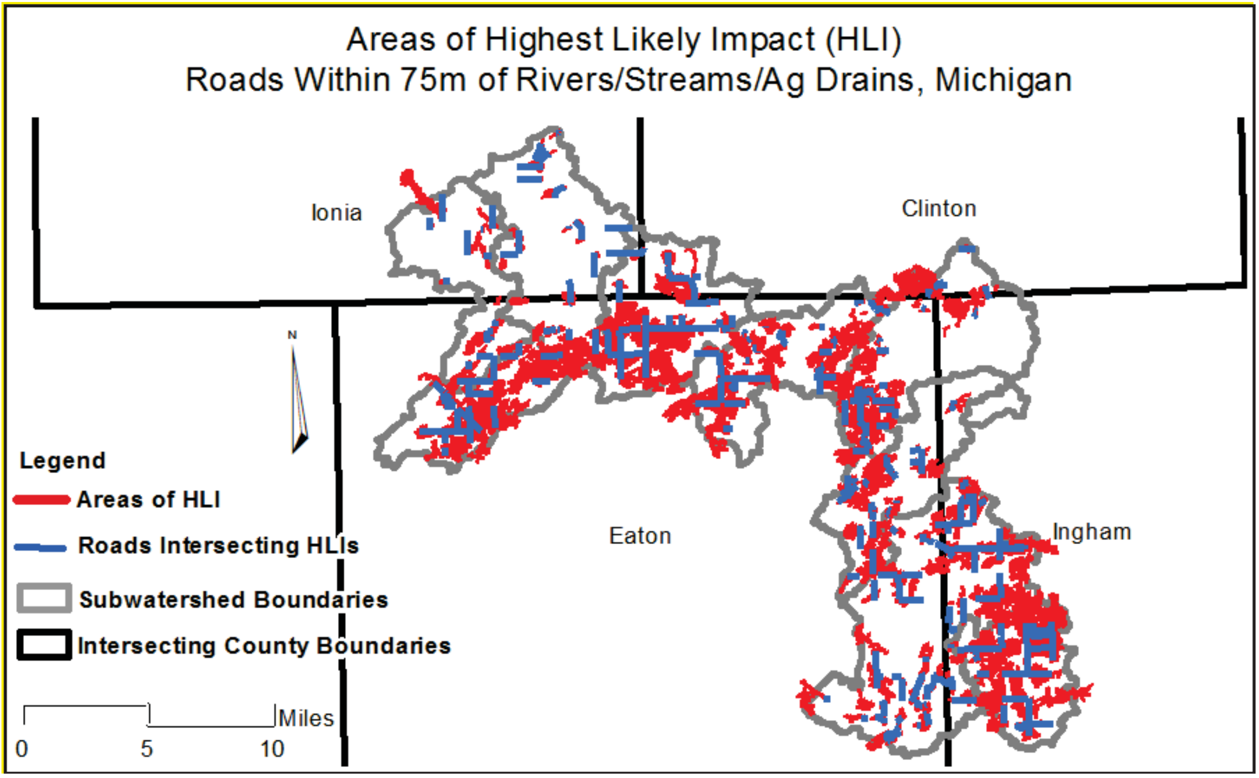


Table 16. Number of road segments within the SteetMap USA (2010) dataset that satisfy proximity and soil type criteria.

	Number of Road Segments	Approx. Number of Septic Systems
Four counties	35,420	50,000+
Watershed	8,248	~12,000
75m of river	969	1,000+
75m + poor soil	499	under 400

4.2.1.1.4 Defining Critical Zones

E.coli data collection throughout the subwatersheds demonstrated widespread exceedances of TBC and PBC. To prioritize the scope of work within the monitored subwatersheds, critical zones were identified.

To determine critical zones, the following questions were asked:

- Did the overall 30 day geomean surpass 3,000 cfu/100mL?

- Was there a spike greater than 1,000 cfu/100mL after rainfall from previous week (linking back to agriculture as an influence)?
- Was there a source identified through bacterial source tracking?
- Does the agriculture practice survey and septic areas of highest likely impact support or disagree with the bacterial source tracking results?

The data from all three sources (ECD, ICHD and Delhi Charter Township) were reviewed based on the questions above. For the upland area to be defined as a critical zone, the monitoring point had to meet one of the above criteria. For example in Columbia Creek subwatershed ECD sites 16, 15, 19 and 6 did not meet one of the critical zone criteria so they were not included. Additionally in Skinner Extension Drain subwatershed Delhi Charter Township site 2 was not included as a critical zone because it did not meet the criteria.

The high, medium, low priorities within the critical areas were based on number of criteria met. For example in Silver Creek subwatershed, Critical Zone 1 met all four criteria and was ranked high priority, while Critical Zone 2 only met three of the criteria and was ranked medium priority.

Future monitoring recommendations were identified and were included in the critical zone tables, and in the long term monitoring strategy (Chapter 9). In the future, *E.coli* data collection in the remaining non-monitored subwatersheds will allow for the creation of critical zones based on results.

4.2.1.2 Results by Subwatershed

4.2.1.2.1 Columbia Creek

Many observations in Columbia Creek included small hobby farms of 1-4 horses and backyard chickens. The highest proportion of resource concerns (8) were found in Columbia Creek. Resource concerns found included erosion, pasture near the river, direct access to surface water and overgrazing (Table 17). Of the subwatersheds monitored for *E.coli* concentrations and BST, Columbia Creek, had the highest livestock density. Columbia Creek had the highest percentage of conservation tillage (no till and reduced till) (62%) (Table 17). As determined by the HIT Model, Columbia Creek has the highest estimate of sedimentation (.090 tons/ac/yr) across the Watershed (Table 17). Since Columbia Creek has the highest percentage of conservation tillage practices, *E.coli* concentrations exceeding the WQS and the highest sedimentation estimate, it will be of the utmost importance to maintain conservation tillage practices in the subwatershed to improve water quality. Fifty-six septic areas of HLI were found in Columbia Creek and should be further investigated for failing septic systems (Table 17). The 8,267 acres of cropland in Columbia Creek could serve as a source of *E.coli* through the application of manure and biosolids as well. Application of manure and biosolids are practices that need to be further evaluated for contribution of *E.coli*.

Table 17. Columbia Creek 2012 Inventory Collection Summary

Subwatershed: Columbia Creek	
2012 Inventory	**Results**
Horses	76
Beef Cattle	49
Dairy Cattle	90
Other Livestock	11
Livestock Density (#/sq. mi.)	12.1
Livestock Farms Near Waterway (200 ft)	4
Resource Concern Observations (# of sites)	Erosion-1, Pasture Near River-2, Direct Access-2, Overgrazed-3
Tillage Practices	NT-35%, RT-27.5%, CT-37.5%
Sedimentation (tons/ac/yr)	.090
Cropland Acres	8,267
Septic Areas of HLI	56

4.2.1.2.1.1 Columbia Creek Critical Zones Linked to Monitoring

As discussed previously in Chapter 3, ECD monitored for *E.coli* in Columbia Creek subwatershed. ECD sites 6, 7, 15, 17, and 19 all exceeded the standard for TBC and PBC 100% of the time in Columbia Creek subwatershed. Of those sites they all had at least two livestock observations located upstream from them. ECD site 16 never exceeded the standard and had the lowest number of livestock observations located upstream. ECD site 18 was the only site in this subwatershed to not have any livestock observations located directly upstream from it; however, this site was monitored for BST and a positive presence for equine and bovine was found (Table 18). ECD site 7 experienced a significant daily geomean spike after rainfall and a positive presence of bovine, equine and human BST, and a livestock population upstream of 136 animals (Table 18).

Table 18. Columbia Creek Critical Zone Factors

ECD *E.coli* and BST Monitoring Sites					
Columbia Creek Critical Zone: 1					
	Location	**Overall 30 day Geomean over 3,000 cfu/100mL**	**Daily Geomean Spike After Rainfall**	**BST Presence**	**Recommendation**
Critical Zone 1	All upland areas between ECD sites 18 and 16	no	yes: ECD site 7	Equine and bovine positive at ECD site 7 & 18	Prioritize agriculture implementation (high priority)
				Human positive at ECD site 7	Prioritize further research and implementation on septics/homes upstream of ECD site 7. Through funding provided by the MDEQ Clean Michigan Initiative, ECD has been awarded a grant to use Environmental K9 Services to track the human presence found at ECD site 7 in 2014. (high priority)
Future Monitoring Recommendation	Future *E.coli* concentration monitoring at ECD sites 6, 7, 17, 18 and 19. No further concentration monitoring recommended for ECD site 16. Specifically ECD sites 15-19 should be further evaluated following rainfall to see if Agricultural is a predominate source. Further BST for human sources is recommended based on land use and documented TOST results and Septic Areas of HLI.				

Critical Zone1 in Columbia Creek is the area where implementation strategies need to be focused to further monitor and engage landowners in voluntary best management practices to improve the water quality.

4.2.1.2.2 Skinner-Extension Drain

Skinner-Extension Drain has a livestock density of 5.175/sq. mi. (Table 19). Beef and dairy cattle are the largest livestock population (Table 19). Two resource concerns were observed in Skinner-Extension Drain, these included a manure pile near the river and direct access to surface water (Table 19). Of the subwatersheds monitored for *E.coli* concentrations and BST, Skinner-Extension Drain had the highest percentage of conventional tillage (52.5%) and the second highest sedimentation estimate (.053 tons/ac/yr) (Table 19). Skinner-Extension Drain has the highest septic areas of HLI across the Watershed (116) and should be further investigated for failing septics. (Table 19). The 17,558 acres of cropland in Skinner-Extension could serve as a source of *E.coli* through the application of manure and biosolids as well. Application of manure and biosolids are practices that need to be further evaluated for contribution of *E.coli*.

Table 19. Skinner-Extension Drain 2012 Inventory Collection Summary

Subwatershed: Skinner-Extension Drain	
2012 Inventory	**Results**
Horses	106
Beef Cattle	113
Dairy Cattle	96
Other Livestock	53
Livestock Density (#/sq. mi.)	5.175
Livestock Farms Near Waterway (200 ft)	10
Resource Concern Observations (# of sites)	Manure Pile Near River-1, Direct Access-1
Tillage Practices	NT-35%, RT-0%, CT-52.5%
Sedimentation (tons/ac/yr)	.053
Cropland Acres	17,558
Septic Areas of HLI	116

4.2.1.2.2.1 Skinner-Extension Drain Critical Zones Linked to Monitoring

Currently, 16 miles of the subwatershed is listed as impaired for failing to meet the TBC designated use due to *E.coli* (*MDEQ TMDL for E.coli in Portions of Red Cedar River and Grand River Watersheds*). As discussed in Chapter 3, Skinner-Extension Drain experienced the highest *E.coli* concentrations of all three subwatersheds monitored. This may be related in part to it also having the highest number of livestock observations located near water (10) along with the highest number of cropland acres (17,558) and septic areas of HLI (116) (Table 20). The livestock population size located upstream in Skinner-Extension Drain does appear to correlate with *E.coli* concentrations exceeding TBC or PBC at monitoring locations. For example, ECD site 10 had an overall 30 day geomean over 3,000 cfu/100mL, experienced a significant daily geomean spike after rainfall and a positive presence of bovine and equine BST, and a livestock population upstream of 23 animals (Table 20). ECD site 5 had an overall 30 day geomean over 3,000 cfu/100mL, experienced a significant daily geomean spike after rainfall and a positive presence of bovine and equine BST, and a livestock population upstream of 51 animals (Table 20).

Table 20. Skinner-Extension Drain Critical Zone Factors

ECD *E.coli* and BST Monitoring Sites					
Skinner-Extension Drain Critical Zones: 6					
	Location	**Overall 30 day Geomean over 3,000 cfu/100mL**	**Daily Geomean Spike After Rainfall**	**BST Presence**	**Recommendation**
Critical Zone 1	All upland area upstream of ECD site 4	no	no	Equine and bovine positive	Prioritize agriculture implementation (medium priority)
Critical Zone 2	All upland area upstream of ECD site B (BST only site)	n/a	n/a	Equine and bovine positive	Prioritize agriculture implementation (low priority)
Critical Zone 3	All upland area upstream of ECD site 5	yes	yes	Equine and bovine positive	Prioritize agriculture implementation (high priority)
Critical Zone 4	All upland area upstream of ECD site 9	no	yes	n/a	Prioritize agriculture implementation upstream of ECD site 12 (medium priority)
Critical Zone 5	All upland area upstream of ECD site 10	yes	yes	Equine and bovine positive	Prioritize agriculture implementation (high priority)
Critical Zone 6	All upland area upstream of ECD site 8	no	no	Equine and bovine positive	Prioritize agriculture implementation (medium priority)
Future Monitoring Recommendation	Future *E.coli* concentration monitoring at ECD sites 1, 4, 5, 8, 9, 10, 11, 12, 13 and 14. Specifically ECDsites 11-14 should be further evaluated following rainfall to see if Agriculture is a predominate source. Further BST for human sources is recommended based on land use and documented TOST results and Septic Areas of HLI.				

Critical Zones 1-6 in Skinner-Extension Drain are where implementation strategies should be focused to further monitor and engage landowners in voluntary best management practices to improve the water quality.

4.2.1.2.3 Silver Creek

Livestock observations in Silver Creek look very different compared to the Watershed as a whole, and the other subwatersheds monitored for *E.coli* concentrations and BST. Only nine horses were observed in Silver Creek and one resource concern (overgrazing) (Table 21). There are significantly less cropland acres in Silver Creek (4,612) (Table 21). When comparing cropland acres and sedimentation estimates across the Watershed and of the subwatersheds monitored, Silver Creek has the lowest acreage and sedimentation with the exception of Carrier Creek which is highly urbanized. In comparison to the subwatersheds monitored, Silver Creek has the second highest amount of Septic Areas of HLI (Table 21). It is highly likely that septic systems contribute to the exceeding *E.coli* concentrations in Silver Creek.

Table 21. Silver Creek 2012 Inventory Collection Summary

Subwatershed: Silver Creek	
2012 Inventory	**Results**
Horses	9
Beef Cattle	0
Dairy Cattle	0
Other Livestock	0
Livestock Density (#/sq. mi.)	0.38
Livestock Farms Near Waterway (200 ft)	2
Resource Concern Observations (# of sites)	Overgrazed-1
Tillage Practices	NT-50%, RT-0%, CT-50%
Sedimentation (tons/ac/yr)	.027
Cropland Acres	4,612
Septic Areas of HLI	64

4.2.1.2.3.1 Silver Creek Critical Zones Linked to Monitoring

Currently, 29 miles of the subwatershed is listed as impaired for failing to meet the TBC designated use and 110 acres are listed as impaired for failing to meet the TBC and PBC designated uses due to *E.coli* (*MDEQ TMDL for E.coli in Portions of Red Cedar River and Grand River Watersheds*). As discussed in Chapter 3, Silver Creek subwatershed is the second highest for TBC (94%) and PBC (67%). Despite the significantly low population of livestock and resource concerns observed in Silver Creek, BST results indicate a positive presence of bovine and equine sources (Table 22). It unclear as to why a presence of bovine was found in Silver Creek unless there is a potential contribution from manure application or cattle were unobservable from the road during the agricultural practice survey. Septic systems are likely a significant contributor given the number of septic areas of HLI reported (64) and the presence of human sources at ECD site 3 (Table 22).

Table 22. Silver Creek Critical Zone Factors

ECD *E.coli* and BST Monitoring Sites					
Silver Creek Critical Zones: 2					
	Location	**Overall 30 day Geomean over 3,000 cfu/100mL**	**Daily Geomean Spike After Rainfall**	**BST Presence**	**Recommendation**
Critical Zone 1	All upland area upstream of ECD site 2	yes: ECD site 20	yes: ECD site 2, 20, and 21	Equine and bovine positive	Prioritize agriculture implementation. Agricultural Practices Survey does not show a large livestock population upstream so land application of manure should be investigated. (high priority)
Critical Zone 2	All upland area upstream of ECD site 3	no	yes	Equine and bovine positive	Prioritize agriculture implementation (medium priority)
				Human positive at ECD site 3	Prioritize further research and implementation on septics/homes upstream of ECD site 3. Through funding provided by the MDEQ Clean Michigan Initiative, ECD has been awarded a grant to use Environmental K9 Services to track the human presence found at ECD site 3 in 2014. (medium priority)
Future Monitoring Recommendation	Future *E.coli* concentration monitoring at ECD sites 2, 3, 20 and 21. Further BST for human sources recommended based on land use and documented TOST results and Septic Areas of HLI.				

Critical Zones 1 and 2 in Silver Creek are where implementation strategies should be focused to further monitor and engage landowners in voluntary best management practices to improve the water quality.

4.2.1.2.4 Sandstone Creek

Sandstone Creek has the highest livestock density (20.77/sq. mi.) of the Watershed (Table 23). Only one resource concern (direct access to surface water) was observed (Table 23). Given the high livestock density it would have been expected to observe a higher number of resource concerns or observations near waterways (3) (Table 23). Of the subwatersheds that were not monitored for *E.coli* concentrations or BST, Sandstone Creek has the highest number of septic areas of HLI (81) (Table 23). Sandstone Creek also has the second highest percentage of conventional tillage (70%) observed (Table 23).

Future data collection on *E.coli* concentration is recommended in this subwatershed to track the impact of livestock and human sources. *E.coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 23. Sandstone Creek 2012 Inventory Collection Summary

Subwatershed: Sandstone Creek	
2012 Inventory	**Results**
Horses	180
Beef Cattle	143
Dairy Cattle	0
Other Livestock	6
Livestock Density (#/sq. mi.)	20.77
Livestock Farms Near Waterway (200 ft)	3
Resource Concern Observations (# of sites)	Direct Access-1
Tillage Practices	NT- 25%, RT- 5%, CT- 70%
Sedimentation (tons/ac/yr)	.059
Cropland Acres	9,068
Septic Areas of HLI	81

4.2.1.2.5 Frayer Creek

Frayer Creek has the second highest livestock density (17.1/sq. mi.) of the Watershed (Table 24). Of the subwatersheds that were not monitored for *E.coli* concentrations or BST, Frayer Creek has the highest number of resource concern observations (3) (Table 24). Direct access to surface water was observed at two sites and overgrazing was observed at one site. Frayer Creek has the second highest cropland acreage (12,414) of the subwatersheds not monitored (Table 24). When comparing across the Watershed and with the subwatersheds monitored, Frayer Creek has a significantly lower number of septic areas of HLI (7) (Table 24).

Future data collection on *E.coli* concentration is recommended in this subwatershed to track the impact of livestock and human sources. Given the information at hand, if *E.*coli levels are exceeding the WQS, it would be expected to be more likely a contribution of agricultural sources than human. E.*coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 24. Frayer Creek 2012 Inventory Collection Summary

Subwatershed: Frayer Creek	
2012 Inventory	**Results**
Horses	29
Beef Cattle	77
Dairy Cattle	0
Other Livestock	48
Livestock Density (#/sq. mi.)	17.1
Livestock Farms Near Waterway (200 ft)	2
Resource Concern Observations (# of sites)	Direct Access-2, Overgrazed-1
Tillage Practices	NT- 22.5%, RT- 22.5%, CT- 55%
Sedimentation (tons/ac/yr)	.070
Cropland Acres	12,414
Septic Areas of HLI	7

4.2.1.2.6 Cryderman Lake Drain

Cryderman Lake Drain has the second highest acreage (14,860) of the Watershed (Table 25). Of the subwatersheds that were not monitored for *E.coli* concentrations or BST, Cryderman Lake Drain has the highest cropland acreage. Cryderman Lake Drain has the third highest livestock density (12.92) of the Watershed (Table 25). Across the Watershed, Cryderman Lake Drain has the highest number of livestock observations near a waterway (13), yet only one resource concern was noted (direct access) (Table 25). When assessing the potential for sources outside of livestock for the subwatersheds lacking *E.coli* and BST monitoring, Cryderman Lake Drain, has the third highest number of septic areas of HLI and sedimentation estimate (.077 tons/ac/yr) (Table 25).

Future data collection on *E.coli* concentration is recommended in this subwatershed to track the impact of livestock and human sources. Given the information at hand, if *E.*coli levels are exceeding the WQS, it would be expected to be a mixture of agricultural and human sources. E.*coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 25. Cryderman Lake Drain 2012 Inventory Collection Summary

Subwatershed: Cryderman Lake Drain	
2012 Inventory	**Results**
Horses	28
Beef Cattle	391
Dairy Cattle	165
Other Livestock	6
Livestock Density (#/sq. mi.)	12.92
Livestock Farms Near Waterway (200 ft)	13
Resource Concern Observations (# of sites)	Direct Access-1
Tillage Practices	NT- 25%, RT- 12.5%, CT- 62.5%
Sedimentation (tons/ac/yr)	.077
Cropland Acres	14,860
Septic Areas of HLI	66

4.2.1.2.7 Winchell and Union Drain

Winchell and Union Drain has the highest percentage of conservation tillage (no till and reduced till) (80) of the Watershed (Table 26). Considering the livestock density (5.605) and the number of livestock observations near a waterway (9), it would have been expected to observe at least one resource concern in Winchell Union Drain; however, this was not the case (Table 26). In fact, across the Watershed, Winchell Union Drain was the only subwatershed to have no resource concerns of note (Table 26). Of the subwatersheds that were not monitored for *E.coli* concentrations or BST, Winchell Union Drain had the highest sedimentation estimate (.086 tons/ac/yr) and the third lowest number of septic areas of HLI (22) (Table 26). This subwatershed also ranked as the third lowest in number of septic areas of HLI when comparing the entire Watershed.

Future data collection on *E.coli* concentration is recommended in this subwatershed to track the impact of livestock and human sources. Given the information at hand, if *E.*coli levels are exceeding the WQS, it would be expected to be a mixture of agricultural and human sources. E.*coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 26. Winchell and Union Drain 2012 Inventory Collection Summary

Subwatershed: Winchell and Union Drain	
2012 Inventory	**Results**
Horses	50
Beef Cattle	168
Dairy Cattle	150
Other Livestock	2
Livestock Density (#/sq. mi.)	5.605
Livestock Farms Near Waterway (200 ft)	9
Resource Concern Observations (# of sites)	No resource concerns of note
Tillage Practices	NT-50%, RT-30%, CT-20%
Sedimentation (tons/ac/yr)	.086
Cropland Acres	9,130
Septic Areas of HLI	22

4.2.1.2.8 Sebewa Creek

Sebewa Creek has the lowest percentage of conservation tillage (no till and reduced till) (25) of the Watershed (Table 27). Interestingly, Sebewa Creek has the second highest number of livestock observations near a waterway (11) of the Watershed and three resource concerns were noted due to direct access (Table 27). Of the subwatersheds that were not monitored for *E.coli* concentrations or BST, Sebewa Creek has the second lowest number of septic areas of HLI (19) (this is also true when comparing the entire Watershed) and the second highest sedimentation estimate (.085 tons/ac/yr) (Table 27).

Future data collection on *E.coli* concentration is recommended in this subwatershed to track the impact of livestock and human sources. Given the information at hand, if *E*.coli levels are exceeding the WQS, it would be expected to be a mixture of agricultural and human sources. E.*coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 27. Sebewa Creek 2012 Inventory Collection Summary

Subwatershed: Sebewa Creek	
2012 Inventory	**Results**
Horses	41
Beef Cattle	111
Dairy Cattle	0
Other Livestock	16
Livestock Density (#/sq. mi.)	7.615
Livestock Farms Near Waterway (200 ft)	11
Resource Concern Observations (# of sites)	Direct Access-3
Tillage Practices	NT- 25%, RT- 0%, CT- 75%
Sedimentation (tons/ac/yr)	.085
Cropland Acres	11,192
Septic Areas of HLI	19

4.2.1.2.9 Carrier Creek

Carrier Creek is a highly urbanized subwatershed which is why; it has the lowest cropland acres (3,580) of the Watershed (Table 28). The agricultural practice survey and tillage estimates were not conducted in this subwatershed due to the land use. The highly urban nature of Carrier Creek is also why it has the lowest sedimentation estimate (.013 tons/ac/yr) of the Watershed (Table 28). The HIT Model focuses on agricultural land use to generate the sedimentation estimate. Carrier Creek does have the third highest septic areas of HLI (75) of the Watershed (Table 28).

As discussed in Chapter 3, the Red Cedar makes up roughly 31% of the flow in the Grand River and is therefore a significant contributor of *E. coli* to the Middle Grand River Watershed (*MDEQ TMDL for E.coli in Portions of Red Cedar River and Grand River Watersheds*). This is significant for Carrier Creek because the confluence of the Red Cedar and the Grand River comes together in this subwatershed. Currently, 10 miles of the subwatershed is listed as impaired for failing to meet the TBC and PBC designated uses due to *E.coli* (*MDEQ TMDL for E.coli in Portions of Red Cedar River and Grand River Watersheds*). The Carrier Creek subwatershed is also listed as impaired (8.67 miles) for failing to meet the warmwater fishery and other indigenous aquatic life and wildlife designated uses due to TSS (*Draft: MDEQ TMDL for Dissolved Oxygen in the Grand River, Red Cedar River and Tributaries)*.

Based on the land use of Carrier Creek, future data collection on *E.coli* concentration is recommended to track the impact of canine and human sources. Given the urban land use and human population size, exceeding *E.*coli levels, would be expected to be more likely connected with human sources and potentially canine sources. E.*coli* data collection will also allow for the creation of critical zones based on monitoring in this subwatershed.

Table 28. Carrier Creek 2012 Inventory Collection Summary

Subwatershed: Carrier Creek	
2012 Inventory	**Results**
Horses	no data
Beef Cattle	no data
Dairy Cattle	no data
Other Livestock	no data
Livestock Density (#/sq. mi.)	no data
Livestock Farms Near Waterway (200 ft)	no data
Resource Concern Observations (# of sites)	no data
Tillage Practices	no data
Sedimentation (tons/ac/yr)	.013
Cropland Acres	3,580
Septic Areas of HLI	75

4.2.2 Primary Pollutant Watershed Summary

Based on the data, the executive committee ranked Agriculture sources as highest priority, followed by human, and then other (pet, wildlife). Agriculture sources (bovine and equine) were found at all 10 sites tested (one site had low concentration and was not processed at lab per QAPP). Human sources were found at two of the 11 sites. Based on this information, the executive committee feels that the most impact will be made by addressing agricultural sources. **Both** human and agricultural sources of E.coli are a threat to human health. While the committee recognizes the human sewage public health risk, the data showed a much higher prevalence of agricultural sources.

4.2.2.1 Agriculture

Livestock Sources

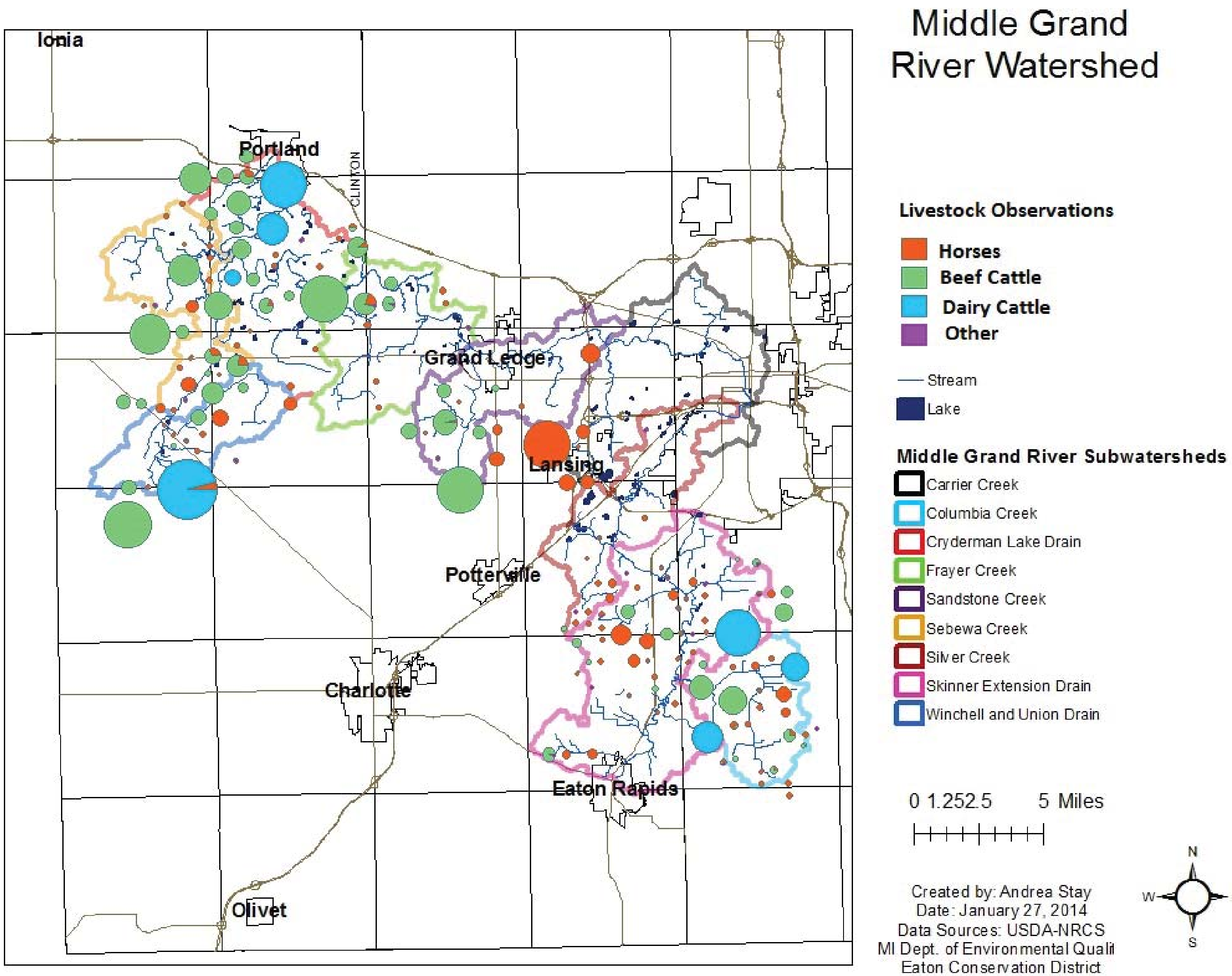
Livestock are a direct source of *E. coli*. As determined by our Agricultural Practices Survey, a majority of the farms are considered small livestock farming operations (having less than or equal to 100 head of livestock) with multiple species (Figure 16). For dairy farms, there were a total of seven farms, with an average of 71 head of cattle. Sixty farms had beef cattle, with an average of 18 head per farm. There were 114 farms with horses that averaged four horses per site. Other livestock populations in this Watershed consist of chickens (11), goats (25), sheep (89), alpacas (14), donkey (1) and pigs (2). The Watershed had a mix of feeding lots and open pasture, with many farms having both present on site. Throughout the Watershed, there were 42 feeding/holding areas, 84 pasture/grazing areas, and 48 sites that had both lots and pasture present.

Agriculture practice survey data collected in the non-TMDL reaches (Cryderman Lake Drain, Winchell Union Drain, Sandstone Creek, Sebewa Creek and Frayer Creek subwatersheds) documented the highest density of livestock of the Watershed and are a potential source of *E.coli*.

Livestock Causes

Known pollutant causes found through the Watershed inventory include, poor pasture management, livestock access to surface water, overland runoff and/or setbacks at holding facilities and improper manure management and storage.

Figure 16. Livestock Observed in the Watershed



Cropland Sources (where manure is applied)

There are 90,681 acres of cropland in the Watershed. In addition to livestock operations as a source of *E.coli*, manure and biosolid application to crop fields is an additional potential source.

As of 2013, Natural Resource Conservation Services field offices in the Watershed have seen a rising trend in farming operations purchasing poultry (chicken and turkey) manure from sources outside of the Watershed and applying to fields. The extent and impact of this source is currently unknown and further investigation is recommended.

Cropland Causes (where manure is applied)

Artificial drainage such as farm tiles can accelerate the transfer of nutrients and *E. coli* into the surface water and are a potential pollutant cause. Tillage practices such as conventional till can lead to increased runoff. Given the agricultural practice survey findings, tillage practices are a suspected pollutant cause. Other potential pollutant causes include; overland runoff, incorporation of the manure, rate at which manure is applied, and type of livestock that the manure is coming from.

4.2.2.2 Human

Septic System Sources

The collected monitoring data and supporting information provided by partners indicate that septic systems are a source of *E.coli*. Source tracking results identified two of the ten sites with a presence of human sewage. Based on dry weather *E.*coli results, soil types, and age of homes, it is likely that septic systems are contributing higher levels than currently documented. The Septic System Failure Case Study and the Time of Sale or Transfer Program results further support the identification of failing septic systems as a source.

Septic System Causes

Potential pollutant causes attributed to septic systems include; improper maintenance, failing system, and lack of system.

4.2.2.3 Other Sources to Consider

Pet Waste

Pet waste was identified as having a potential impact. Especially in more densely populated areas with higher connectivity to surface water through storm drains.

According to the American Veterinary Medical Association Pet Ownership Calculator, in the Watershed there are approximately 29,365 dogs and 18,353 dog owning households. The Food and Drug Administration estimates dogs produce .75 pounds of waste per day. Using both calculations it can be estimated that 22,023.75 pounds of dog waste are produced each day and over 8 million pounds of waste per year in the Watershed.

Bacterial source tracking did not include pet sources during data collection. They are indicated as a potential source until monitoring data or inspections can verify if they are a source of pollutant.

Pet Waste Causes

Suspected pollutant cause attributed to pet waste is failing to dispose of waste properly.

Wildlife

Wildlife prevalence was not surveyed or used as a bacterial source indicator during data collection. Steering committee partners did not identify wildlife as a priority source during the inventory process. Strategies to reduce wildlife input are limited in scope and practice.

Wildlife Causes

Potential pollutant causes attributed to wildlife include; overpopulation and access to surface water.

4.3 Secondary Pollutants

The data collected by MDEQ during the development of the TMDLs (Biota and DO) and the biological surveys revealed that sediment and low DO are impairing water quality within certain areas of the Watershed. Sediment has been found to be impacting Carrier Creek subwatershed, Sebewa Creek and Picket Drain. Low DO has been found to be impacting Carrier Creek subwatershed.

Macroinvertebrate data collected by ECD found evidence of sedimentation in Columbia Creek, Skinner Extension Drain, Sandstone, Cryderman Lake Drain and Winchell Union Drain subwatersheds. Results from the HIT model indicate high sedimentation rates in all subwatersheds except for Carrier Creek and Silver Creek.

Total suspended solids were identified in the DO TMDL as the major cause of low DO. Potential sources identified in support of the TMDLs include: construction, cropland, livestock, streambanks, rill and gully erosion, septic systems, stormwater, petwaste and fertilizers. Potential causes attributed to each source were also identified in support of the TMDLs.

- ***Construction***
  Potential causes related to sediment and DO are lack of silt fencing and/or management practices in place, bare soil and/or sparse vegetation after completion of a project and lack of low development practices in place.

- ***Cropland***
  Tillage practices, lack of buffers and drainage network are potential causes related to sediment.

- ***Livestock***
  Uncontrolled livestock access and lack of buffer and/or setbacks at holding facilities are potential causes related to sediment.

- ***Streambanks***

Altered morphology and hydrology and lack of vegetation are potential causes related to sediment.

- ***Rill &Gully Erosion***

Concentrated flow from roadside ditches and agricultural land are potential causes related to sediment.

- ***Septic Systems***

Potential causes related to DO are improper maintenance, failing system and lack of system.

- ***Stormwater***

Impervious surfaces such as parking lots, driveways, etc., turfgrass lawns, lack of buffer and/or vegetation such as mature trees and native plants are potential causes related to DO.

- ***Petwaste***

Failing to dispose of pet waste properly is a potential caused related to DO.

- ***Fertilizers***

Over application and/or improper use of fertilizers is a potential cause related to DO.

4.4 Identification of Pollutants, Sources and Causes Summary

As discussed the primary pollutant for this WMP is *E.coli*. When considering the overall health of the Watershed it is important to include sediment and total suspended solids as secondary pollutants since they have been documented by MDEQ.

Table 29 summarizes the data and information collected during the watershed monitoring and inventory process. The table provides a direct link to understanding the connection between *E.coli*, identified sources (bovine, equine and human), potential causes (failing on-site septics, livestock access to surface water and manure management) and the influence of tillage practices and sedimentation on the movement of *E.coli* throughout the Watershed.

A summary of the pollutants found in the Watershed are identified in Table 30. The table includes the designated uses, pollutants contributing to the degradation of the designated uses, and the known, suspected and potential causes of these pollutants. The pollutants, sources and causes are identified as known (k) if they were documented and measured during any of the monitoring and/or inventory methods. Sources and causes are identified as suspected (s) if indications of them were observed, but the sources or causes were not measured. Land use conducive to serving as a source and cause of the pollutant, but no visual observation or measurements were made qualify as potential (p).

Table 29. Monitoring and Inventory Summary

Subwatershed	*E. coli* Results	Source Tracking Results	Septic Areas of HLI	Livestock Density (#/sq. mi.)	Livestock Observations	Tillage Practices	Sedimentation (tons/ac/yr)
Columbia Creek	Exceeding	Bovine-2, Equine-2, Human-1	56	12.1	Erosion-1, Pasture NR-2, Direct Access-2, Overgrazed-3	NT- 35%, RT- 27.5%, CT- 37.5%	.090
Skinner Extension Drain	Exceeding	Bovine-6, Equine- 6, Human- 0	116	5.175	Manure Pile NR-1, Direct Access-1	NT- 35%, RT- 0%, CT- 52.5%	.053
Silver Creek	Exceeding	Bovine- 2, Equine- 2, Human- 1	64	0.38	Overgrazed-1	NT- 50%, RT- 0%, CT- 50%	.027
Winchell and Union Drain	no data	no data	23	20.77	Direct Access-1	NT- 50%, RT- 30%, CT- 20%	.086
Cryderman Lake Drain	no data	no data	66	17.1	Direct Access-2, Overgrazed-1	NT- 25%, RT- 12.5%, CT- 62.5%	.077
Sandstone	no data	no data	81	12.92	Direct Access-1	NT- 25%, RT- 5%, CT- 70%	.059
Frayer Creek	no data	no data	7	5.605	No resource concerns of note	NT- 22.5%, RT- 22.5%, CT- 55%	.070
Sebewa Creek	no data	no data	19	7.615	Direct Access-3	NT- 25%, RT- 0%, CT- 75%	.085
Carrier Creek	no data	no data	75	no data	no data	no data	.013

Notes:
E.coli results: exceeding water quality standard
Source tracking results: species and # of sites with presence
Septic Areas of HLI: HLI= highest likely impact, # of HLI
Livestock Density: agricultural practice survey
Livestock Observations: observation and # of sites with presence, NR= near river, Direct Access= to surface water
Tillage Practices: agricultural practice survey, NT= No Till, RT= Reduced Till, CT= Conventional Till
Sediment: HIT Model Results

Table 30. Pollutants, Sources and Causes Summary

Designated Use	Pollutant	Sources (in priority order)	Causes (in priority order)
Partial/Total Body Contact Recreation	Pathogens (*E.coli)*(k)	1. Bovine and Equine (k)	1. Uncontrolled livestock access (k)
			2. Poor pasture management (k)
			3. Overland runoff (lack of buffers) &/or setbacks at holding facilities (k)
			4. Lack of manure storage/compost facility (k)
		2. Cropland (where manure is applied) (p)	1. Improper manure application (p)
			2. Overland runoff (lack of buffer &/or cover crops) (p)
			3. Tillage practices (s)
			4. Tiled fields (p)
		3. Septic Systems (k)	1. Lack of system (p)
			2. Failing system (p)
			3. Improper maintenance (p)
		4. Pet Waste (s)	1. Failing to properly dispose of waste (s)
		5. Wildlife (p)	1. Overpopulation (p)
			2. Access to surface water (p)

Table 30. Pollutants, Sources and Causes

Designated Use	Pollutant	Sources (in priority order)	Causes (in priority order)
Other Indigenous Aquatic Life and Wildlife	Sediment (k)	1. Cropland (s)	1. Tillage practices (s)
			2. Overland runoff (lack of buffer) (s)
			3. Drainage network (s)
		2. Livestock (s)	1. Uncontrolled livestock access (p)
			2. Overland runoff (lack of buffer) &/or setbacks at holding facilities (k)
		3. Stormwater (s)	1. Overland runoff attributed to impervious surfaces: parking lots, driveways, etc. (s)
			2. Turfgrass lawns (s)
			3. Overland runoff (lack of buffer and/or vegetation such as mature trees, native plants) (s)
		4. Construction (s)	1. Overland runoff attributed to Lack of silt fencing/management practices in place (p)
			2. Bare soil/sparse vegetation after completion of project (p)
			3. Lack of low impact development practices in place (p)
		5. Streambanks (s)	1. Altered morphology and hydrology (s)
			2. Overland runoff (lack of vegetation) (s)
		6. Rill and gully erosion (s)	1. Concentrated flow from roadside ditch and agricultural land (s)

Table 30. Pollutants, Sources and Causes

Designated Use	Pollutant	Sources	Causes
Warmwater fishery and other indigenous aquatic life and wildlife	TSS (Dissolved Oxygen) (k)	1. Septic Systems (k)	1. Improper maintenance (p)
			2. Failing system (p)
			3. Lack of system (p)
		2. Construction (s)	1. Overland runoff attributed to lack of silt fencing/management practices in place (p)
			2. Bare soil/sparse vegetation after completion of project (p)
			3. Lack of low impact development practices in place (p)
		3. Stormwater (s)	1. Overland runoff attributed to impervious surfaces: parking lots, driveways, etc. (s)
			2. Turfgrass lawns (s)
			3. Overland runoff (lack of buffer and/or vegetation such as mature trees, native plants) (s)
		4. Pet Waste (s)	1. Failing to properly dispose of waste (s)
		5. Fertilizers (p)	1. Over application and/or improper use of fertilizers (p)

Notes:
Known (k): documented and measured during any of the monitoring and/or inventory methods.
Suspected (s): indications or impacts were observed, but not measured.
Potential (p): land use conducive to serving as a source and cause of the pollutant, but no visual observations or measurements were made.