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Salt Creek Watershed Management Plan

Porter County, Indiana

June 17, 2008

Communities working together

Assessing water quality

Protecting Salt Creek

Coordinated by: Save the Dunes Conservation Fund
Funded by: Indiana Department of Environmental Management

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1.0 INTRODUCTION

1.1 Project Summary

The United States has more than 3.5 million miles (56 million kilometers) of rivers and streams that, along with closely associated flood plain and upland areas, comprise corridors of great social, cultural, and environmental value. Increases in human population and industrial, commercial, and residential development place heavy demands on wetlands, streams, rivers, and lakes. These demands result in degradation of water quality, loss of habitat for fish and wildlife, and decreased recreational and aesthetic value. Coastal areas are especially vulnerable to development pressure and are currently ten times as densely populated as inland areas (Lake Michigan Coastal Program (LMCP), 2007).

Northwestern Indiana's Lake Michigan watershed is one of the most industrialized and populated areas in the state, and Porter County's population is projected to increase by 12% by 2030 (Indiana Business Research Center (IBRC), 2008). In recent years local, state, and federal agencies, as well as many private organizations and individuals, have focused effort on restoring water quality, floodwater storage functions, biological integrity, and recreational benefits to rivers and streams within the Calumet Region, including Salt Creek. These efforts include work completed by municipalities within the watershed, local governments, Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), the National Park Service- Indiana Dunes National Lakeshore (INDU), Northwest Indiana Steelheaders, Northwestern Indiana Regional Planning Commission (NIRPC), Save the Dunes Council and Conservation Fund, Soil and Water Conservation Districts (SWCDs), United States Fish and Wildlife Service (USFWS), United States Geological Service (USGS), United States Army Corps of Engineers (USACE), and many others.

Watershed management is an effective way to cross traditional boundaries and bring people in region together to effectively manage land, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land. The Salt Creek Watershed Management Plan (SCWMP) is the framework for the restoration and management efforts within the Salt Creek watershed and is consistent with other efforts underway in the Calumet Region. This plan builds on work that has already been done by the entities acknowledged above and others. It furthers the efforts by identifying priorities and management needs. Some sections of the Salt Creek *Escherichia coli (E. coli)* Total Maximum Daily Load *(*TMDL) (WittmanHydro Planning Associates ((WHPA), 2004) have been incorporated into the SCWMP. NIRPC's *Watershed Management Framework Plan for Lake, Porter, and LaPorte Counties* (NIRPC, 2005) and IDNR-LMCP's *Indiana Coastal Nonpoint Pollution Control Program 6217 Document* (2005) were also used to prepare this plan.

In 2006 Save the Dunes Conservation Fund (SDCF) was contracted by IDEM to develop a watershed management plan to address the nonpoint source pollution problem in Salt Creek. SDCF coordinated the development of the SCWMP, which addresses the nonpoint sources identified in the TMDL, concerns raised by the public and Salt Creek Committee Members, and other problems identified by water quality data acquired during the planning process. Development of the SCWMP was a community driven process and involved a diverse group of local citizens, experts, organizations, and community leaders.

The SCWMP addresses nonpoint sources of pollution by documenting current water quality and biological integrity and making recommendations for improving water quality. It also includes recommendations for point sources from the TMDL. In addition to covering pollution prevention and remediation, the recommendations include implementation and restoration activities. This plan addresses the improvement of water quality in Salt Creek and its tributaries and is the framework to achieve the following vision developed by public participants and Committee Members: *A healthy Salt Creek watershed that protects and improves Lake Michigan water quality, provides recreation for surrounding communities, and helps maintain a strong economic base and an excellent quality of life.*

To reduce the identified stressors in the Salt Creek watershed and address other concerns identified by the Salt Creek Committee Members and stakeholders, the group developed the following goals:

- Goal 1: Reduce nitrate by 65%, phosphorus by 66%, and sediment loading 33% by 2028.
- Goal 2: Reduce pathogen (*E. coli*) concentrations by 86% by 2028.
- Goal 3: Improve stakeholder and public involvement.
- Goal 4: Improve biotic communities so that the density and diversity of EPT (*Ephemeroptera, Plecoptera, Trichoptera*) taxa improves by one scoring metric level.

The SCWMP identifies activities, responsibilities, partners, potential funding sources, and general timeframes for meeting these goals. Specific implementation plans will be developed as implementation funding is available.

Copies of the SCWMP were provided to the distribution list (Appendix A). The plan can be downloaded from www.savedunes.org. To request a copy of the plan, please contact Christine Livingston at:

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Phone 219-879-3564
Fax 219-872-4875

1.2 Watershed Partnerships

Early in the Salt Creek watershed management planning process, the following three committees were formed: Steering, Technical Advisory, and Outreach (Appendix B). The Steering Committee met biannually to guide development of the plan and coordinate related efforts. The Technical Advisory Committee met quarterly to plan watershed management efforts and provide technical input. The Outreach Committee met bimonthly to coordinate volunteer activities and community outreach and encourage public participation. The Salt Creek Committee Members include representatives from all municipalities within the watershed, IDEM, IDNR, INDU, Natural Resources Conservation Service (NRCS), NIRPC, the Northwest Indiana Steelheaders, the Porter County Convention, Recreation, and Visitor Commission (PCCRVC), the Porter County Plan Commission, the Porter County Surveyor's Office, United States Environmental Protection Agency (USEPA), USFWS, Valparaiso and Purdue Universities, developers, and other organizations.

The Committee Members assisted in preparation of maps, gave presentations at public meetings, helped gather and interpret existing data and reports, and provided input based on their vast and varied experience and knowledge of the Salt Creek watershed. The Salt Creek Watershed Group developed the following mission statement: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed and will develop strategies that conserve, protect, and enhance the natural resources of the watershed.* The continued efforts of Committee Members and stakeholders are needed to implement this plan and ensure success in achieving their vision for the watershed.

The plan was developed by the Steering, Technical Advisory, and Outreach Committees and the general public. Salt Creek Committee Members are listed in Appendix B. In addition to Salt Creek Committee Members, many other stakeholders were identified during development of the SCWMP. Individuals who attended Steering Committee Meetings and workshops or contacted SDCF to indicate interest in the watershed project were added to the Salt Creek Watershed Group list. This broader list received e-mail notifications of upcoming meetings and the status of the SCWMP. SDCF coordinated public and committee meetings and related events and provided technical and administrative support. Further support and technical assistance were provided to the Watershed Group by IDEM and USEPA. Section 2.8- Endangered Species was contributed by Liz McCloskey of the USFWS, Section 2.9- Exotic and Invasive Species was contributed by John Ervin of IDNR, Section 2.10.2- Cultural and Recreational Resources was contributed by Lorelei Weimer of the PCCRVC, and the description of the Indiana Salmonid Stocking Program in Section 3.6.5- Potential Unverified and Other Sources was contributed by Joe Exl of IDNR-LMCP. Craig Shillinglaw created several maps of the watershed, including the subwatershed maps shown in Figures 2-6 of this plan. Information was obtained from the *E. coli* Task Force, IDEM, IDNR, INDU, USFWS, local parks departments, and municipalities within the watershed on past and current water sampling sites as described in Section 3- Water Quality.

1.3 Public Participation

The general public was invited to attend all quarterly Technical Advisory Committee and Outreach Committee Meetings to encourage citizen participation in the development of the SCWMP. During meetings the group developed mission and vision statements, offered input on sampling site locations, listed and prioritized concerns, and set goals. Draft plans were posted to the SDCF website and hard copies were provided at public meetings. Public participants provided feedback on the plan's content.

On May 16, 2006 SDCF hosted a conference to inform participants about watershed management planning and implementation. The workshop was made possible by partnerships with Conservation Technology Information Center (CTIC), IDEM, IDNR- LMCP, NRCS, Porter County Plan Commission, Porter County Surveyor's Office, SDCF, and USEPA- Region V. Subject matter specialists and practitioners shared technical information, watershed expertise, and case studies. The conference, entitled *Watershed Based Planning: Developing a Framework for Managing the Salt Creek Watershed*, was held at the Porter County

Administration Center in Valparaiso, Indiana. The event was an important step in raising awareness, overcoming barriers, and forming a collaboration of diverse community members concerned with the Salt Creek watershed. The workshop binder cover page and agenda are shown in Appendix C and Appendix D, respectively. A summary of the workshop is available online at http://www.savedunes.org.

Outreach to encourage citizen participation was conducted through the production and distribution of an informative brochure (Appendix E), press release distribution and newspaper articles in local papers (Appendix F), e-mail notification, newsletter articles in various regional newsletters, presentations at various meetings, and a web page (www.savedunes.org).

2.0 PHYSICAL DESCRIPTION OF THE WATERSHED

2.1 Watershed Location

The Salt Creek watershed is located in Porter County, Indiana within the Lake Michigan water watershed. It extends from south of the City of Valparaiso to the Little Calumet River in the City of Portage (Figure 1) and includes the following land uses: agricultural, forest, grassland, residential, commercial, industrial, and recreational. Residential communities include most of the City of Valparaiso, the southeastern portion of the City of Portage, the unincorporated Village of South Haven, the southern portion of the Town of Burns Harbor, and small portions of the Towns of Chesterton and Porter. With 49,573 acres (20,062 hectares) the Salt Creek watershed covers 19% of Porter County.

The Salt Creek watershed (Hydrologic Unit Code (HUC) - 04040001050) is a subwatershed of the Little Calumet-Galien watershed (HUC - 04040001). It is bordered on the south by the Cobb Ditch Sievers-Creek watershed (HUC - 07120001090100) and the Ahlgrim Ditch watershed (HUC - 07120001090120) and on the southeast by the Cook Ditch watershed (HUC - 07120001090080) and the Crooked Creek-Flint Lake watershed (HUC - 07120001090060) all of which are subwatersheds of the Kankakee River watershed (HUC - 07120001). The Salt Creek watershed is bordered to the west by the Deep River-Deer Creek watershed (HUC - 04040001030050), the Duck Creek watershed (HUC - 04040001040010), and the Burns Ditch-Willow Creek watershed (HUC - 04040001040030), to the north by the Burns Ditch Outlet watershed (HUC - 04040001060040), and to the northeast by the Sand/Coffee Creeks watershed (HUC - 04040001060030) all of which are subwatersheds of the Little Calumet-Galien watershed (HUC - 04040001) and within the Lake Michigan water watershed (Figure 1).

It is important to note that due to changes in drainage and hydrology, the official USGS watershed delineation of Salt Creek does not reflect the actual boundary of the watershed in certain areas. For example, Loomis Lake and Spectacle Lake in the City of Valparaiso naturally drained through Damon Run into Salt Creek (Pilz, 2006). Due to concerns over nearby Flint Lake's ability to maintain a constant level and a dependable source of water for the City of Valparaiso, water from Loomis Lake and Spectacle Lake were diverted into Flint Lake. In 1924 the City of Valparaiso water utility constructed Proffitt's Dam on Loomis Lake's outlet and connected the Lake to Flint Lake via a 24-inch (67-centimeter) drainage tile. Loomis Lake and Spectacle Lake now drain through Flint Lake and to the Kankakee River rather than into Salt Creek. Aditionally, although the official USGS delineation indicates that Silver Lake is within the Salt Creek watershed, Silver Lake also drains into Flint Lake and the Kankakee River watershed. The Porter Cove subdivision in the Town of Porter and the area bounded by 100 North, Pearson Road, and 23rd Street in the Town of Chesterton have been redirected and now flow north to the Little Calumet River through Peterson Ditch (Wiseman, 2007).

The official delineation of the Salt Creek watershed still includes Loomis Lake and Spectacle Lake, which now drain into the adjacent Kankakee River watershed and sections of Chesterton and Porter that now drain to Peterson Ditch. Several of the maps in this document reflect the official USGS watershed delineation, which does not reflect the Valparaiso Lakes and Peterson Ditch modifications. The actual and official boundaries of the Salt Creek watershed are shown in Figure 1.

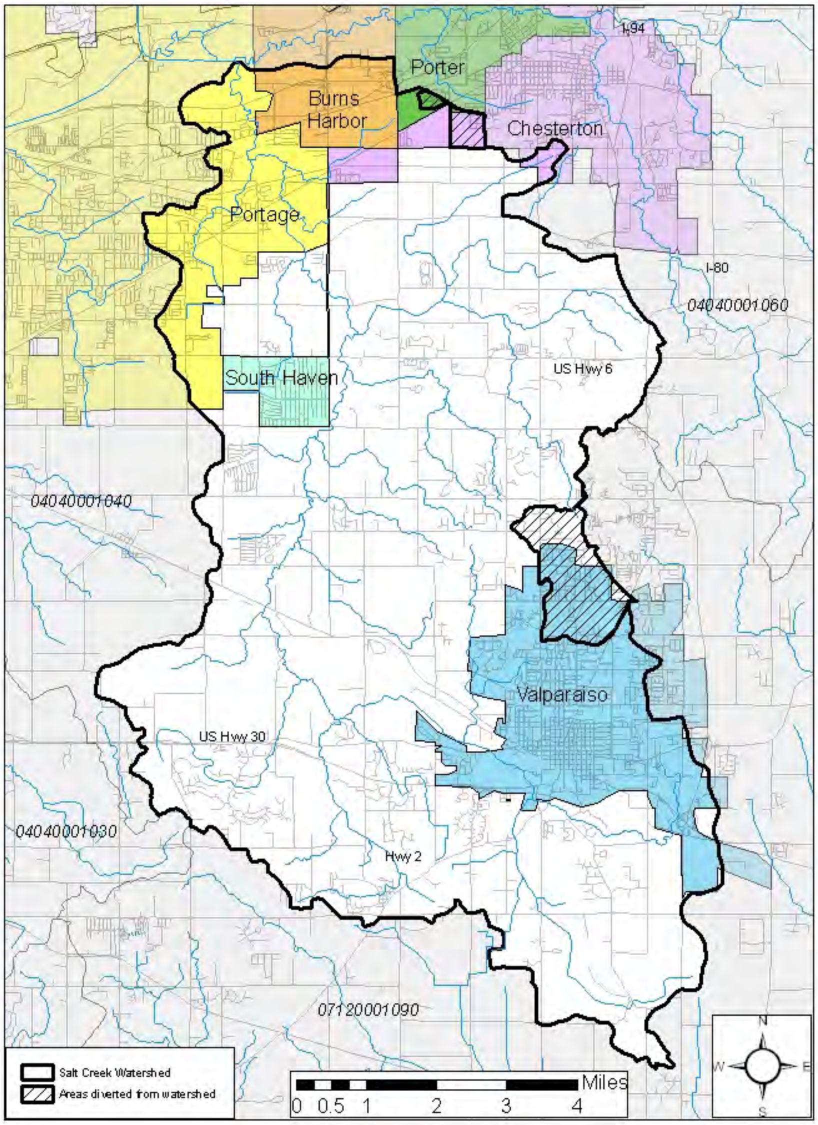

Figure 1. Actual and official boundaries of the Salt Creek watershed (Source: See Appendix R)

2.2 Subwatersheds

The Salt Creek watershed contains the following five 14 digit HUC subwatersheds: Squirrel Creek (HUC - 04040001050050) (Figure 2), Damon Run (HUC - 04040001050040) (Figure 3), Sager's Lake (HUC - 04040001050010) (Figure 4), Clark Ditch (HUC - 04040001050020) (Figure 5), and Pepper Creek (HUC - 04040001050030) (Figure 6).

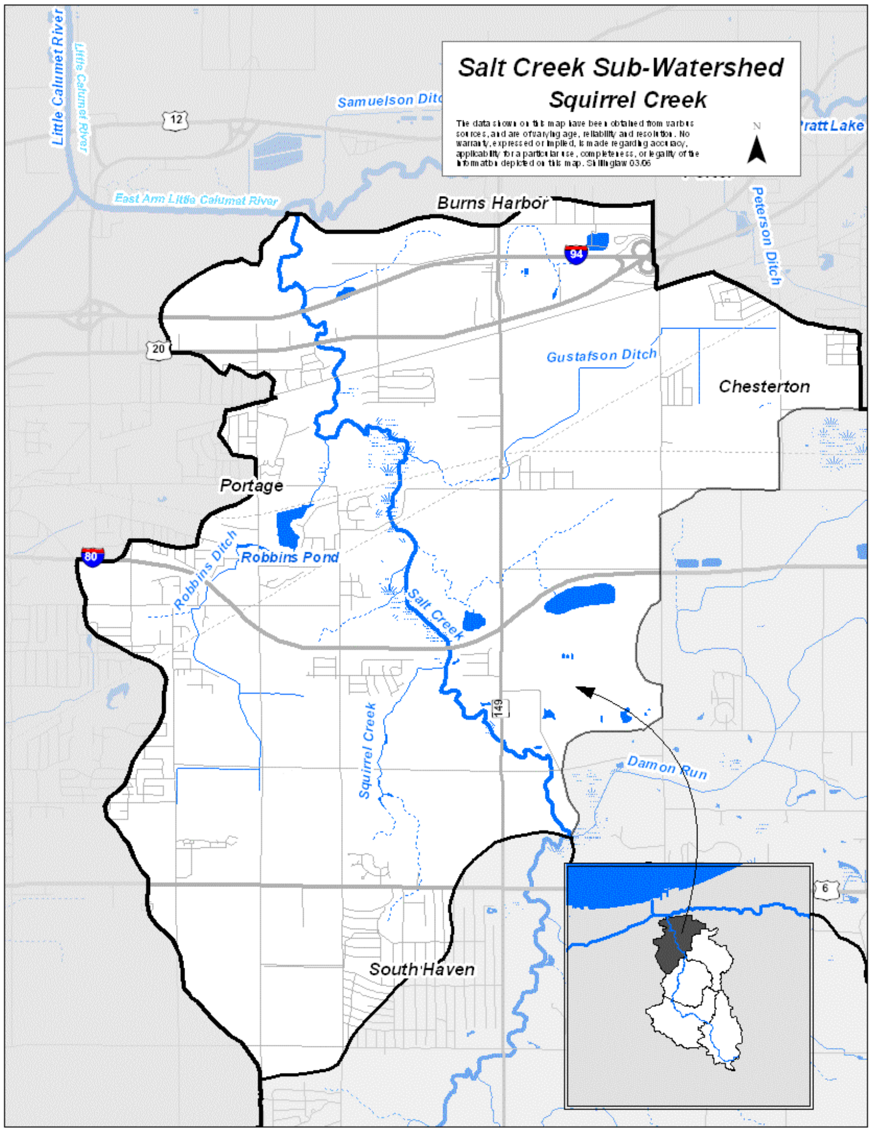

Figure 2. Squirrel Creek subwatershed (Source: See Appendix R)

The Squirrel Creek subwatershed (Figure 2), the northernmost subwatershed of Salt Creek, encompasses 9,337 acres (3,779 hectares) south of Salt Creek's outflow into the Little Calumet River. Land cover in the Squirrel Creek subwatershed is 38% developed, 25% cultivated crops, 23% forest, 10% grassland/herbaceous, 1% pasture/hay, and 3% other (Figure 25)(USGS, 2001). See Section 2.10- Land Use for information on land cover classifications. Urban areas include parts of Burns Harbor, Chesterton, Portage, and South Haven. Waterbodies include Robbin's Ditch, Robbin's Pond, and Gustafson Ditch. Sampling sites 11 (Figure 45), 12 (Figure 14), 14 (Figure 48), and 16 (Figure 50) are within the Squirrel Creek subwatershed. Squirrel Creek, Gustafson Ditch, and an unnamed tributary within the Squirrel Creek subwatershed are impaired for *E. coli* (Figure 29).

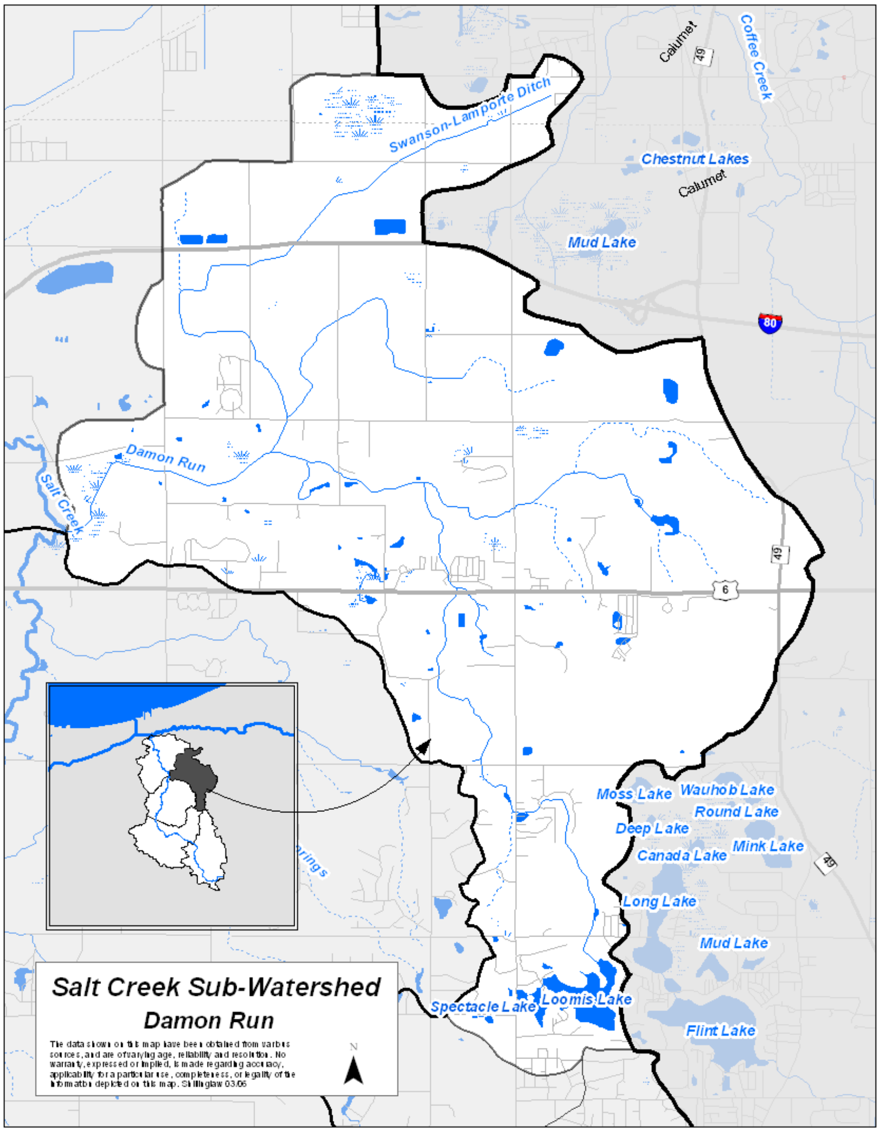

Figure 3. Damon Run subwatershed (Source: See Appendix R)

The Damon Run subwatershed (Figure 3) encompasses 7,646 acres (3,094 hectares) in the northeastern section of the Salt Creek watershed. Prior to the diversion of waters from Spectacle Lake and Loomis Lake, these waterbodies were within the Damon Run subwatershed. Land cover in the Damon Run subwatershed is 37% forest, 17% cultivated crops, 17% grassland/herbaceous, 15% developed, 11% pasture/hay, and 3% other (Figure 25)(USGS, 2001). See Section 2.10- Land Use for information on land cover classifications. National Pollutant Discharge Elimination System (NPDES) permitted facilities in the subwatershed include the Forest Oaks Wastewater Treatment Plant, Liberty Farm Mobile Home Park, Liberty School, Sands Mobile Home Park, and Whispering Sands (Figure 63). Sampling site 13 (Figure 15) is located within the Damon Run subwatershed. Damon Run and the Swanson-Lamporte Ditch are impaired for *E. coli* (Figure 29).

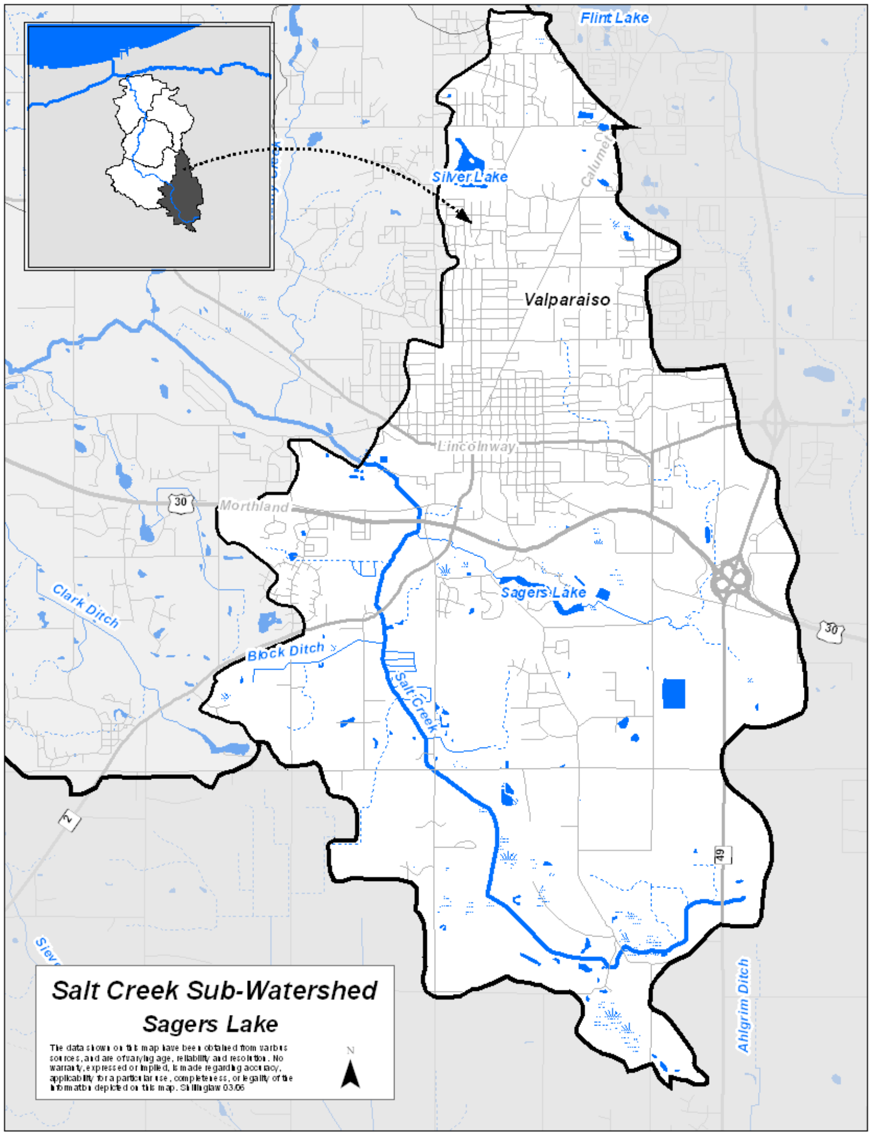

Figure 4. Sager's Lake subwatershed (Source: See Appendix R)

The Sager's Lake subwatershed (Figure 4) encompasses 10,556 acres (4,272 hectares) in the southeastern portion of the watershed and contains the headwaters of Salt Creek. A large portion of Valparaiso is within this watershed. Land cover in the Sager's Lake subwatershed is 43% developed, 21% forest, 16% cultivated crops, 9% grassland/herbaceous, 9% pasture/hay, and 2% other (Figure 25)(USGS, 2001). See Section 2.10- Land Use for information on land cover classifications. Sampling sites 4 (Figure 38), 5 (Figure 39), and 6 (Figure 40) are within the Sager's Lake subwatershed. Contrary to the official USGS boundary of the watershed, Silver Lake is not within the Salt Creek watershed.

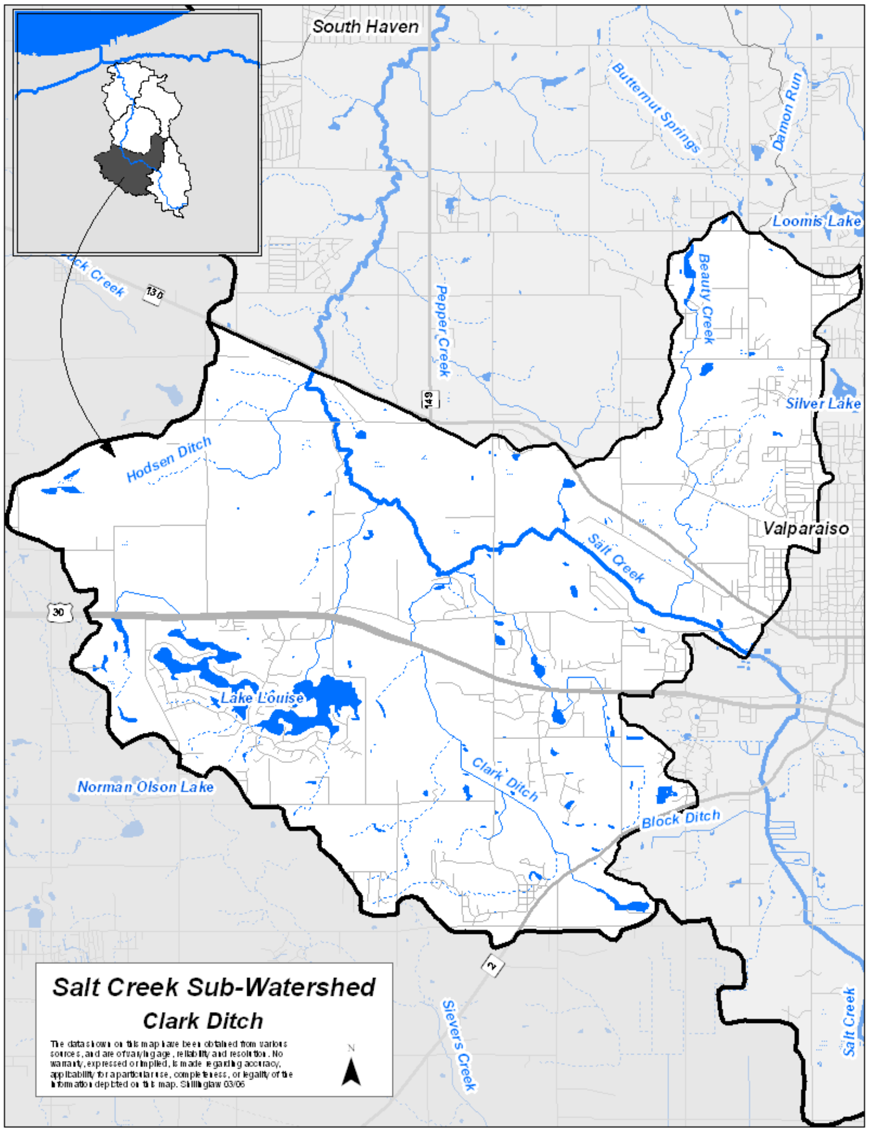

Figure 5. Clark Ditch subwatershed (Source: See Appendix R)

The Clark Ditch subwatershed (Figure 5) encompasses 12,739 acres (5,155 hectares) in the southwestern portion of the Salt Creek watershed and includes the western portion of Valparaiso and the residential communities of Shorewood Forest and Aberdeen. NPDES permitted facilities in the subwatershed include Nature Works Conservancy District, Shorewood Forest, Stop N Shop Gas Station, and the Valparaiso Municipal Wastewater Treatment Plant (Figure 63). Clark Ditch, Beauty Creek, Hodsen Ditch, and Lake Louise are located within the Clark Ditch subwatershed. Land cover in the Clark Ditch subwatershed is 31% forest, 22% developed, 17% cultivated crops, 13% grassland/herbaceous, 13% pasture/hay, and 4% other (Figure 25)(USGS, 2001). See Section 2.10- Land Use for information on land cover classifications. Sampling sites 1 (Figure 35), 2 (Figure 36), 3 (Figure 37), and 7 (Figure 41) are within the subwatershed. Clark Ditch, Hodsen Ditch, the Lake Louise Outlet, and an unnamed tributary are listed as impaired for *E. coli* (Figure 29).

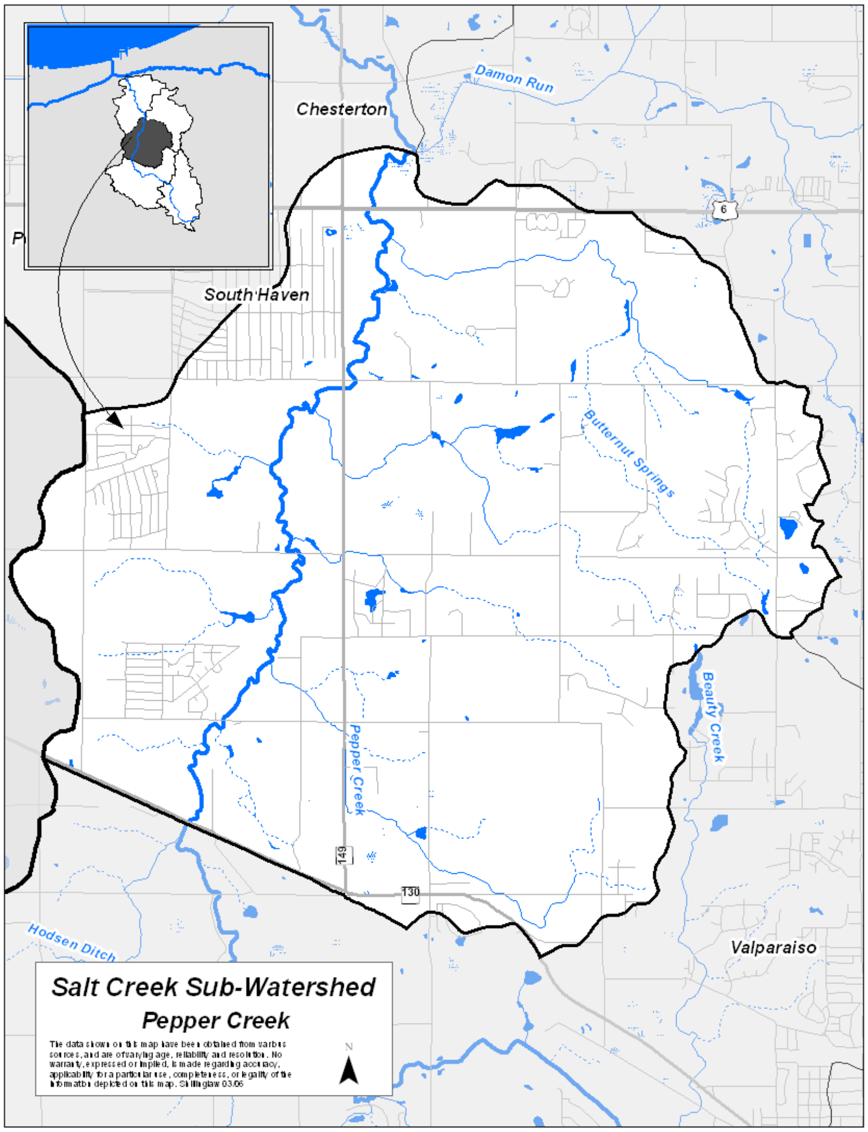

Figure 6. Pepper Creek subwatershed (Source: See Appendix R)

The Pepper Creek subwatershed (Figure 6) encompasses 9,292 acres (3,760 hectares) in the western central portion of the Salt Creek watershed. The watershed includes the southern portion of South Haven and residential areas south of South Haven. Land cover in the Pepper Creek subwatershed is 31% forest, 27% cultivated crops, 21% developed, 11% grassland/ herbaceous, 7% pasture/hay, and 3% other (Figure 24, Figure 25)(USGS, 2001). See Section 2.10- Land Use for information on land cover classifications. NPDES permitted facilities in the subwatershed include Mallard's Point, Twin Creeks Conservancy District, and a Speedway Gas Station (Figure 63). Sampling sites 8 (Figure 42) and 15 (Figure 49) are within the Pepper Creek subwatershed. The mainstem of Salt Creek is listed as impaired for biotic communities within the Pepper Creek subwatershed (Figure 29).

2.3 Geology, Topography, and Soils (modified from TMDL)

The topography, surficial geology, soil development, and bedrock geology in the northwestern Indiana region were directly influenced by the advance and retreat of the Lake Michigan lobe of ice during the Wisconsinan glaciation (IDNR, 1994). The bedrock deposits of the watershed are from the Devonian age. These rocks consist of dolomite and limestone overlain by shale (Fenelon et al., 1994). The unconsolidated deposits above the bedrock range from 150-200 feet (46-61 meters) thick in the watershed. The deepest unconsolidated unit is a dense, clay-loam till. In most of the watershed glaciofluvial deposits overlie the clay till. The glaciofluvial deposits consist of sand and gravel interbedded with clay (Fenelon et al., 1994). In the northern portion of the watershed a surficial sand and gravel aquifer unit exists that is primarily recharged directly from precipitation. At higher elevations in the watershed this aquifer is discontinuous, overlain by surficial till, and recharged from the overlying till (Fenelon et al., 1994).

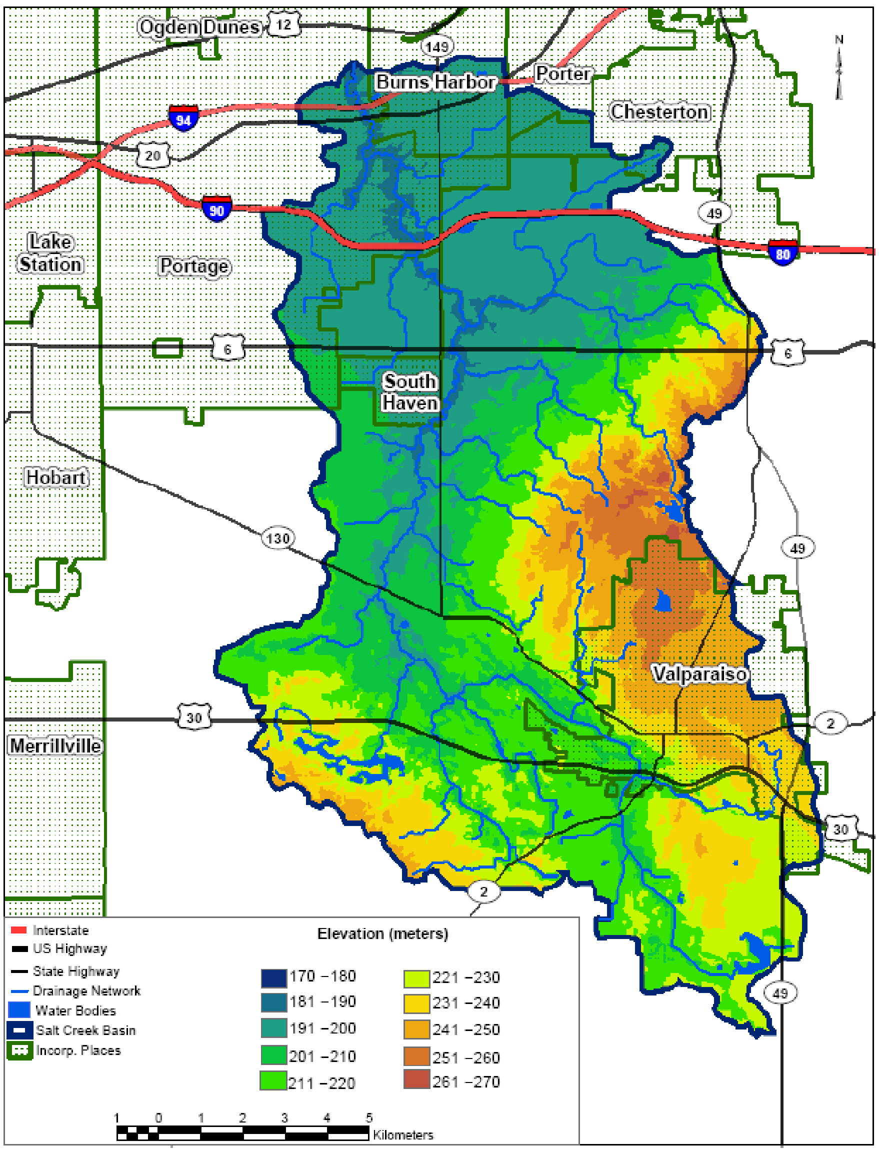

Figure 7. Physiographic relief in the Salt Creek watershed. (WHPA, 2004)

The continuous and discontinuous aquifer systems coincide with the two physiographic regions of the watershed. The two physiographic regions in the Salt Creek watershed are the Calumet Lacustrine Plain and the Valparaiso Morainal Area. The Valparaiso Moraine is characterized by some of the highest elevations in the watershed, ranging from 722-886 feet (220-270 meters) above sea-level in the southern section of the watershed near Valparaiso and Lake Louise (Figure 7). The northern, downstream section of the watershed has the lowest elevation (558-623 feet (170-190 meters) above sea level). Low elevations are characteristic of the Calumet Lacustrine Plain. The surficial geology of northern Indiana follows regional lines similar to topography due to influence of the Wisconsinan glaciation (Figure 8). The watershed consists predominantly of mixed drift (34%), clay-loam to silt-loam till (31%), clay-loam to silt-loam (10%), and lake sand (10%).

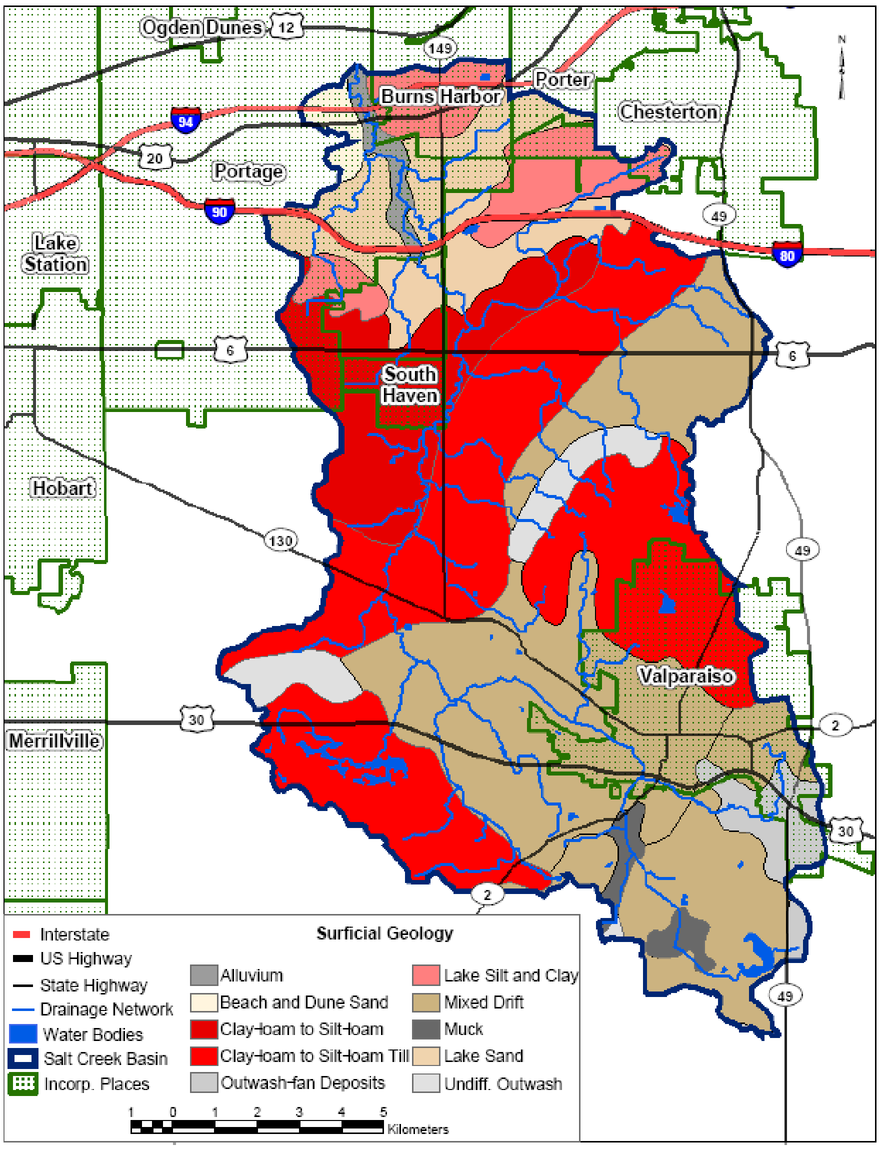

Figure 8. Generalized glacial geology in the Salt Creek watershed (WHPA, 2004)

The watershed is comprised of six soil associations, three of which dominate (Figure 9). The Blount-Glynwood-Morley series is the predominant soil association, occupying 55% of the watershed. These soils are deep or moderately deep to dense till. They are moderately to poorly drained soils "formed in a thin layer of loess and underlying till." The Blount-Glynwood-Morley soils are typically found on ground moraines and end moraines like that of the Salt Creek watershed (U.S. Department of Agriculture (USDA), 2002). The Renssalaer-Darroch-Whitaker soil series, which is associated with 18% of the watershed, consists of deep, poorly and somewhat poorly drained soils. This association corresponds with the low elevations in the northern section of the watershed. The Renssalaer-Darroch-Whitaker soils are "formed in silty and loamy sediments of lake plains, outwash plains, and till plains" (USDA, 2002). The Riddles-Elston-Oshtemo soil series is found in 15% of the watershed. This association consists of very deep, well drained soils "formed in loamy and sandy till" and are found south of Valparaiso and in western portions of the watershed (USDA, 2002).

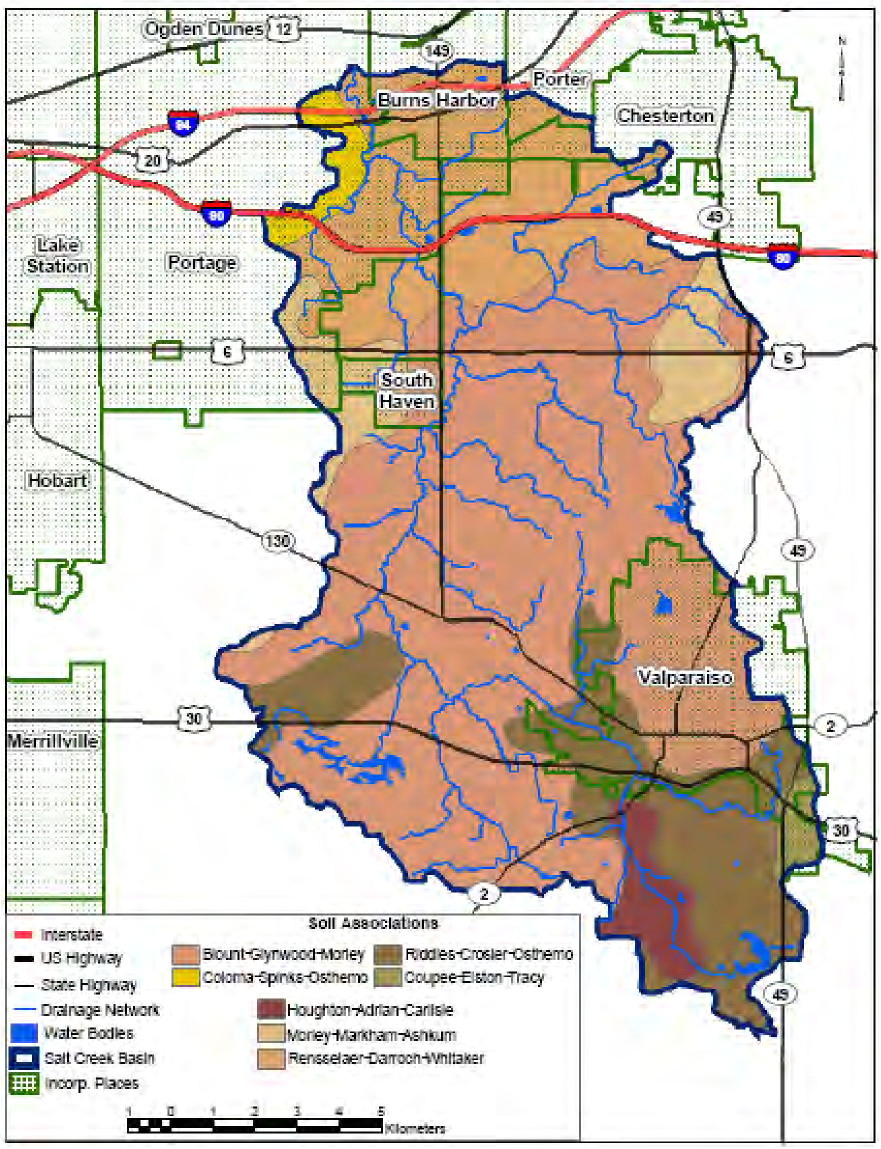

Figure 9. Major soil regions in the Salt Creek watershed (WHPA, 2004)

The NRCS maintains a list of highly erodible soil units for each county based upon the potential of soil units to erode from the land. The classification is based upon an erodibility index for a soil, which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss tolerance (T) value, the maximum annual rate of erosion that could occur without causing a decline in long-term productivity. The NRCS provided the frozen list for Highly Erodible Land (HEL) Soils in Porter County Indiana (Figure 10). Potentially highly erodible soils may or may not be highly erodible depending upon factors such as slope steepness and length. A field investigation would be necessary to determine whether or not potentially highly erodible lands are in fact highly erodible.

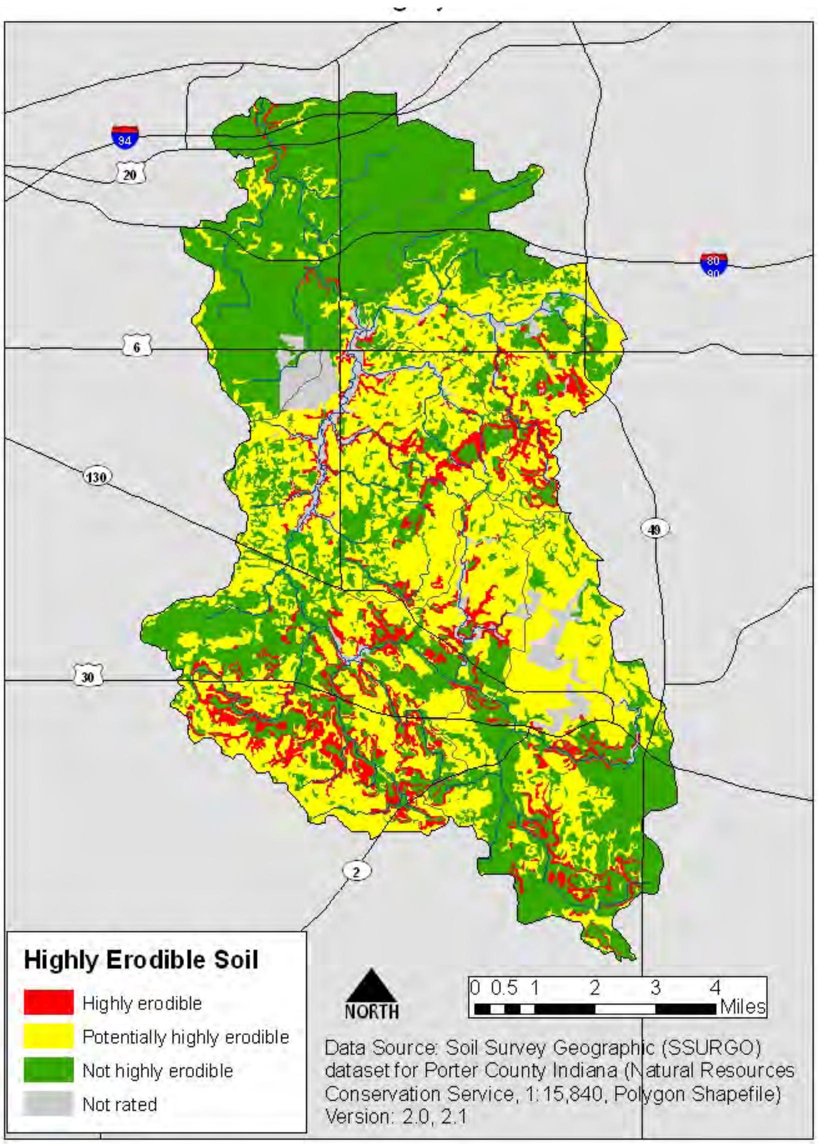

Figure 10. Salt Creek watershed highly erodible land (Source: See Appendix R)

Figure 11 shows the dominant soil hydrologic groups in the Salt Creek watershed. A hydrologic group is a grouping of soils that have similar runoff potential under similar storm and cover conditions. The majority of the soils in the Salt Creek watershed have moderately high runoff potential.

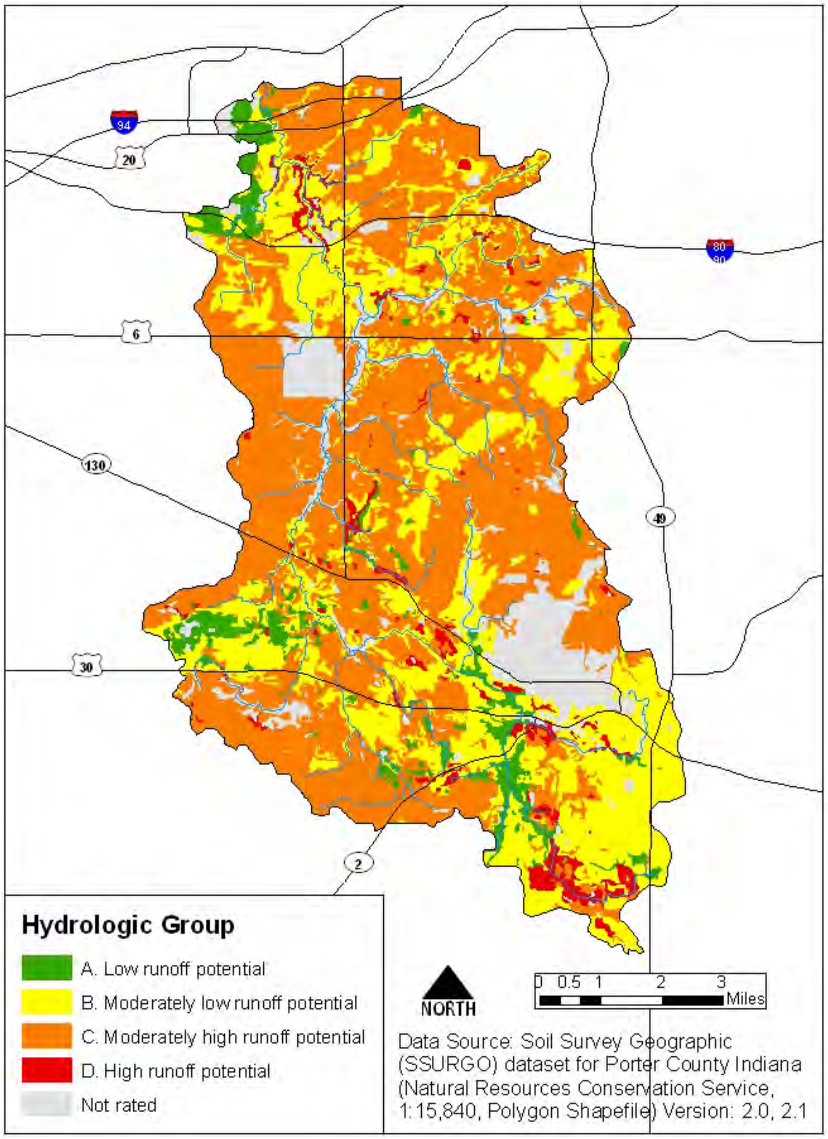

Figure 11. Salt Creek watershed dominant soil hydrologic groups (Source: See Appendix R)

2.4 Climate (from TMDL)

The climate of the Salt Creek region is classified as temperate continental, which describes an area with warm summers and cool winters (IDNR, 1994). The mean monthly temperature in summer, based on records from 1971-2000, ranges from 69 to 73° F (21 to 23 °C). The mean monthly temperature in winter ranges from 22 to 28° F (-5.5 to -2.2 °C) (Figure 12) (Purdue University, 2002). The close proximity of Lake Michigan causes the vicinity to have increased amounts of snowfall in winter. The Salt Creek watershed receives approximately 50 inches (127 centimeters) of snow in an average winter (IDNR, 1994). The average annual precipitation is 40 inches (102 centimeters), with the heaviest rains occurring in the spring and summer months (Figure 12). Approximately 70% of the rainfall is lost to evapotranspiration, leaving about 12 inches (31 centimeters) of surplus for the watershed's surface water and groundwater supply (IDNR, 1994).

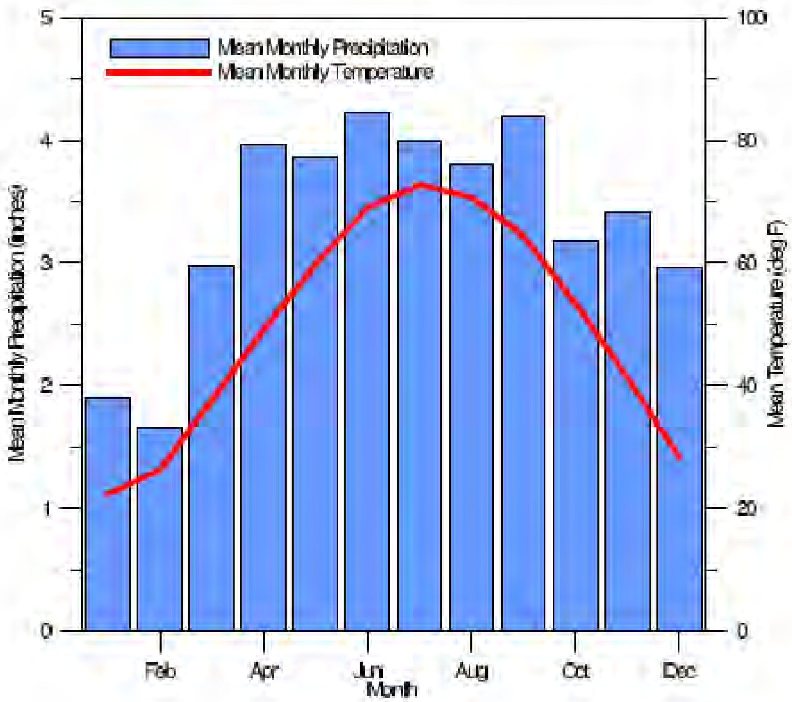

Figure 12. Mean temperature and precipitation in Valparaiso, Indiana, 1961–1990 (WHPA, 2004)

2.5 Hydrology (modified from TMDL)

Stream order is a common stream classification system which helps describe a river's size and watershed area; the greater the stream order, the greater the size and watershed area (Allan, 1995). Using this system, Salt Creek is a fourth order stream. Historically, the USGS maintained a stream gage on Salt Creek near McCool, Indiana (Figure 13) from 1945-1991. A flow-duration curve (Figure 14) was developed with daily values from the period of record. A flow-duration curve shows the percent of time that a specified discharge was equaled or exceeded. From the flow-duration curve, the 20-to-90 percent flow-duration ratio can be calculated to indicate streamflow variability. The 20-to-90-percent flow-duration ratio is a numerical index that describes the slope of the middle portion of the flow-duration curve (IDNR, 1994). It reflects not only flood-attenuating factors, but also the relative component of stream flow due to base flow (IDNR, 1994). The low 20-to-90 percent flow-duration ratio for Salt Creek indicates that the stream has high base flow. This is indicative of the surficial sand and gravel aquifer in the lower region of the watershed. The aquifer absorbs precipitation in the watershed during wet weather, dampening the high flows, but can also release water to the stream in times of dry weather, maintaining high base flow. This enables Salt Creek and other streams which flow through the Valparaiso Moraine to have some of the highest sustained low flows relative to drainage area in the state (IDNR, 1994). The average discharge of Salt Creek is 766 cubic feet per second (cfs)(21.7 cubic meters per second) and the minimum daily discharge is 10 cfs (0.28 cubic meters per second). The lowest 7-day average flow which occurs (on average) once every 10 years (7Q10 flow) is 19 cfs (0.54 cubic meters per second) at the McCool stream gage (Fowler and Wilson, 1996). The mean monthly flows for Salt Creek are shown in Figure 15. The mean flows show a pattern typical to Midwestern streams; flows are highest in March and April and lowest in August and September.

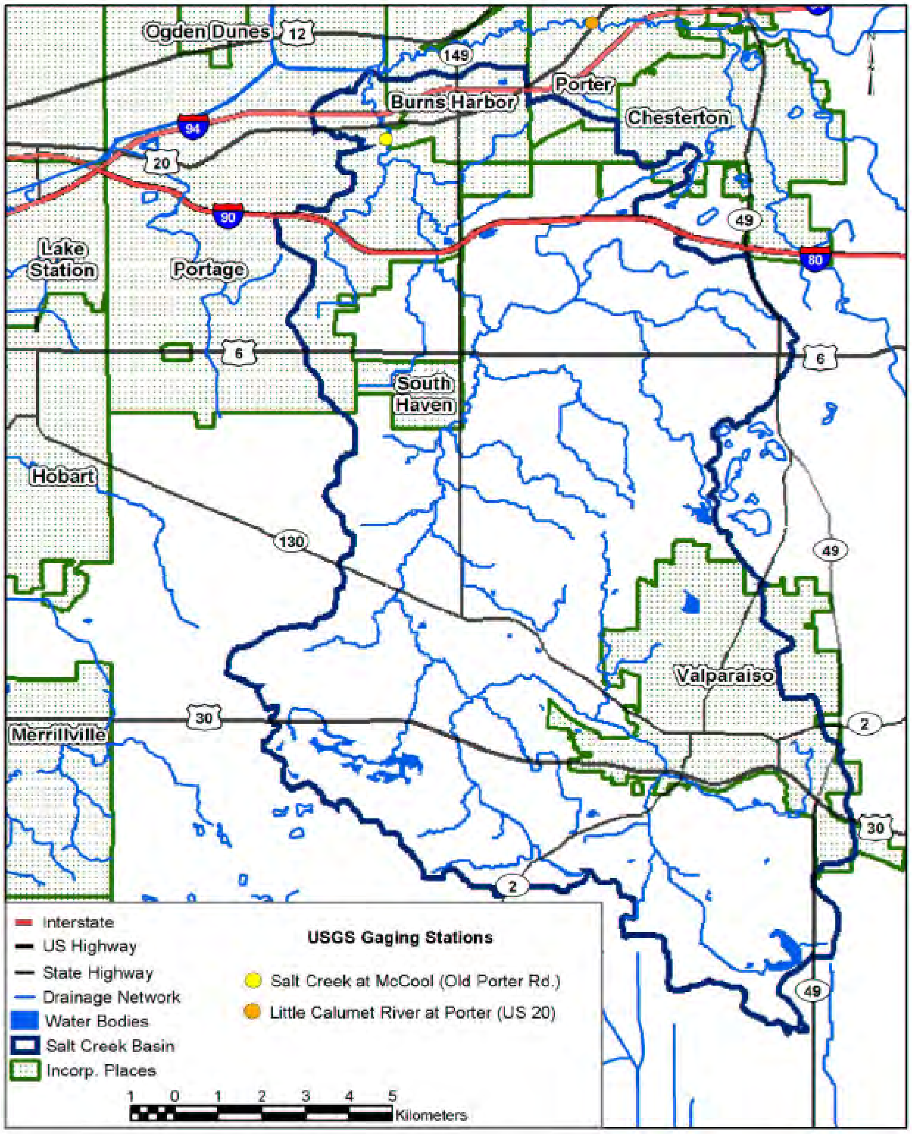

Figure 13. Location of USGS stream gages (WHPA, 2004)

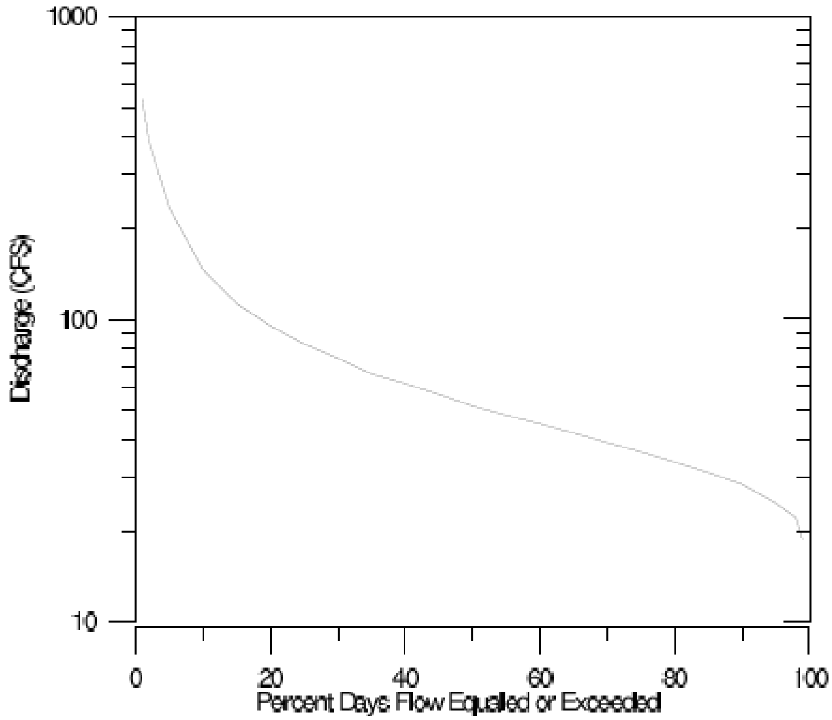

Figure 14. Flow–duration curve for Salt Creek (WHPA, 2004)

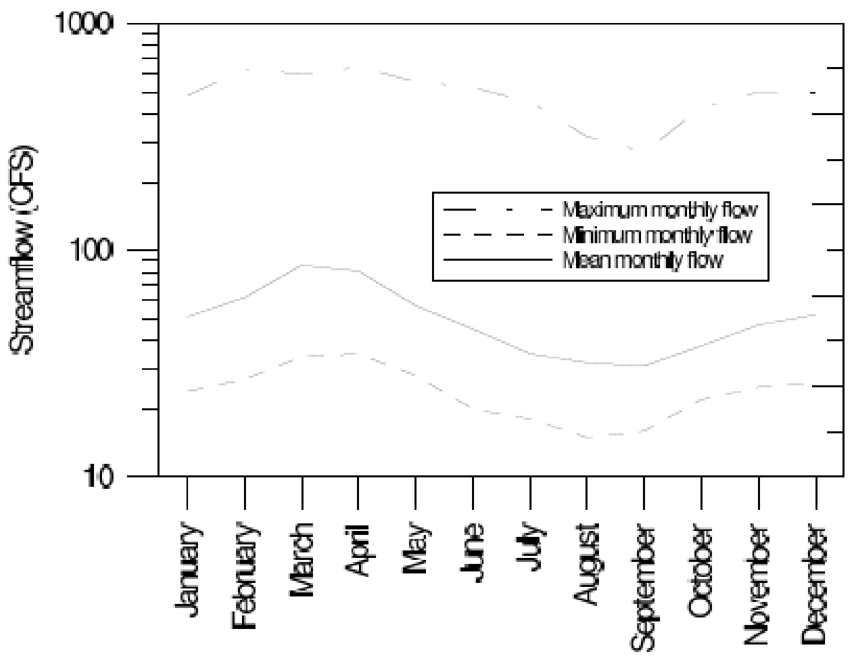

Figure 15. Mean monthly flows in Salt Creek (WHPA, 2004)

It should be noted that if current land use trends continue, impacts from development and other man-made modifications will alter the hydrology of the Salt Creek watershed. As noted previously, the boundary of the watershed has already been altered by manmade modifications in several areas. The Loomis Lake and Silver Lake subwatersheds and sections of the Town of Porter no longer drain to Salt Creek decreasing the area that drains to the Creek. As detailed in Section 2.6- Wetlands, many of the wetlands in the watershed have been drained for agricultural or urban development. As development occurs throughout the watershed, increases in impervious surfaces, ditching, and installation of storm drains alter existing flow patterns. These alterations can disrupt hydrologic function and impact water quality by causing flashy conditions and stream bank erosion and increasing stormwater runoff and flooding.

2.4 Wetlands

It is estimated that 24.1% of Indiana's surface area was covered in wetland before European settlement (State of Indiana, 2007). Indiana ranks fourth in the nation in percentage of wetlands lost, with an estimated 85% of wetlands lost. Much of Indiana's original wetlands were concentrated in northwestern Indiana. Currently, the Salt Creek watershed contains approximately 4,118 acres (1,667 hectares) of wetlands or 8% of the total surface area (USFWS, 2003). Figure 16 shows wetlands, lakes, ponds, streams and other water resources, as defined by USFWS and compiled from the National Wetland Inventory (NWI). Aerial photograph interpretation techniques were used to compile the NWI. The NWI was not intended to produce maps that show exact wetland boundaries comparable to boundaries derived from ground surveys, and boundaries are generalized in most cases. It should be noted that the estimates of the current extent of wetlands in the Salt Creek watershed listed in this section are based upon the NWI (USFWS, 2003). These estimates may not agree with those listed in Section 2.10- Land Use, which are based upon the USGS 2001 Land Cover in Indiana derived from the National Land Cover Database.

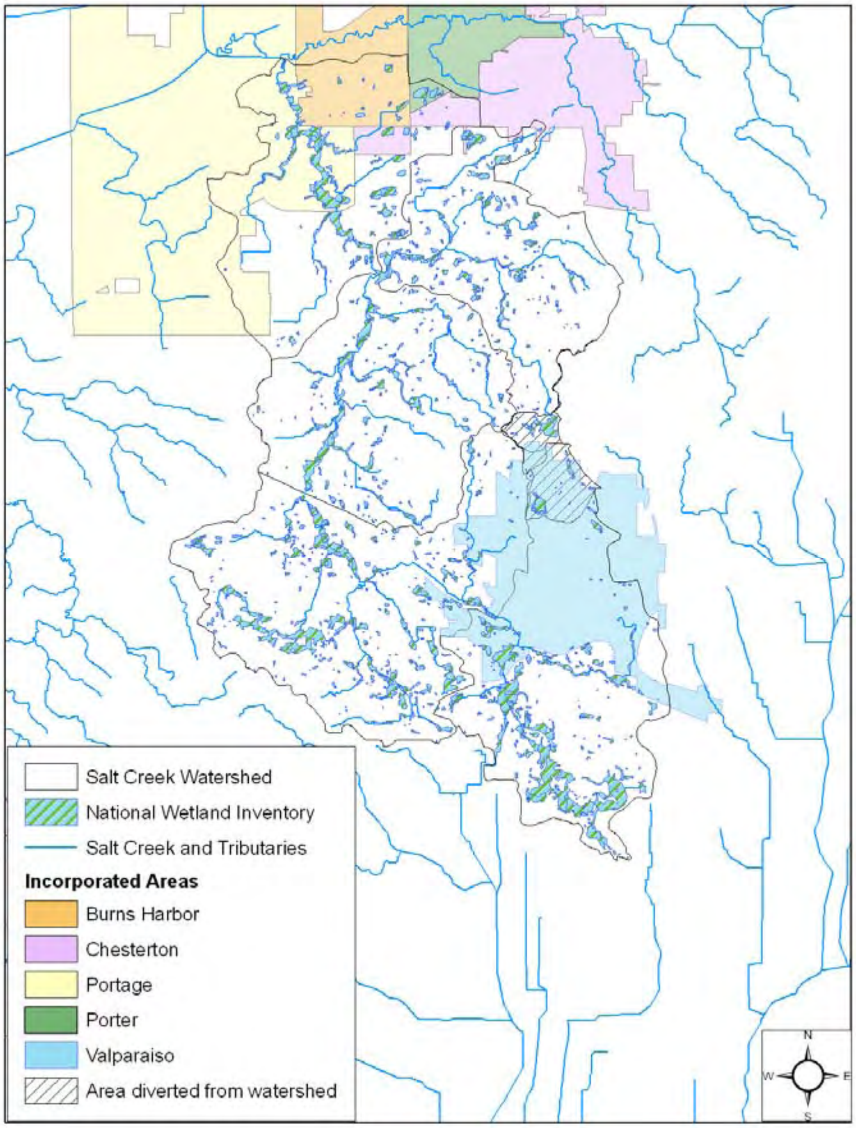

Figure 16. Wetlands in the Salt Creek watershed (Source: See Appendix R)

According to USDA- NRCS soil data, 8,410 acres (3,403 hectares) of the watershed have hydric soils (Figure 17). The acreage of hydric soils provides a rough estimate of the acreage that was likely once wetlands, indicating that approximately 51% of the watershed's wetlands may have been lost.

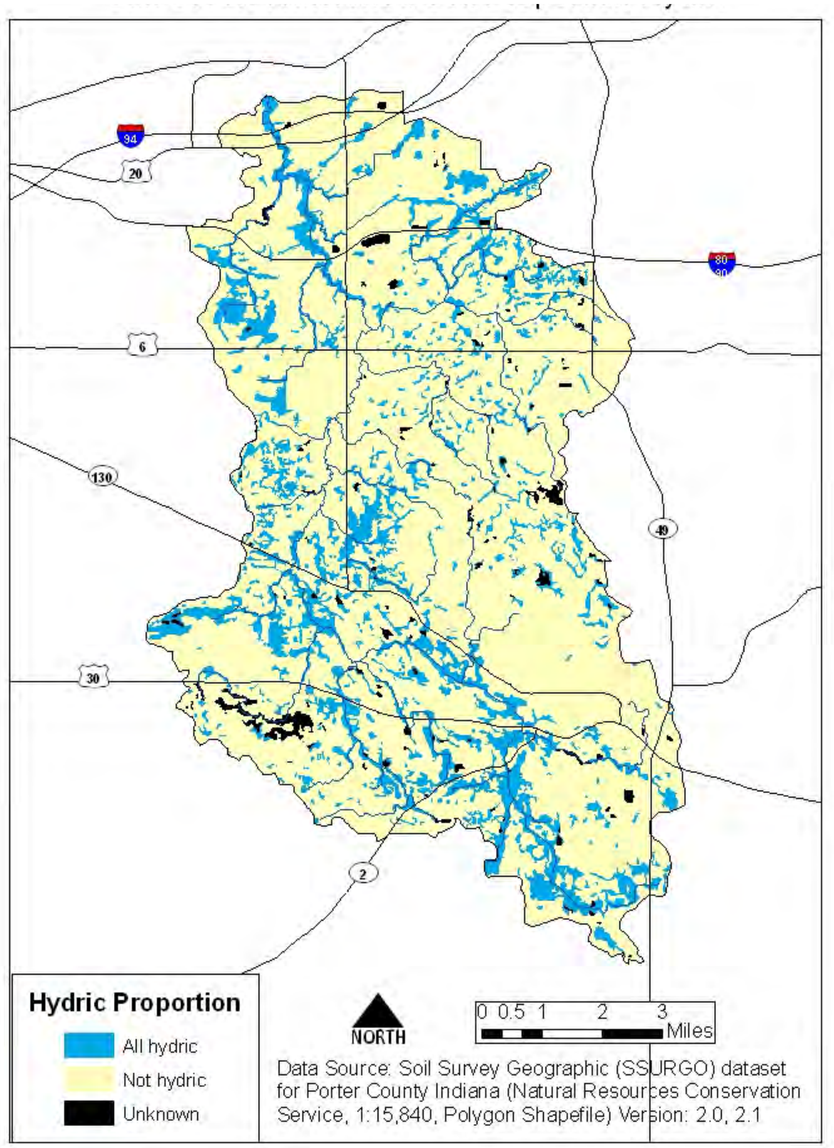

Figure 17. Salt Creek watershed soil hydric ratings (Source: See Appendix R)

The Squirrel Creek subwatershed contains approximately 744 acres (301 hectares) of wetlands or 8% of the total surface area (USFWS, 2003). The largest wetland areas are located along the mainstem of Salt Creek (Figure 18). A large wetland area is preserved in the Portage Parks Department's Imagination Glen.

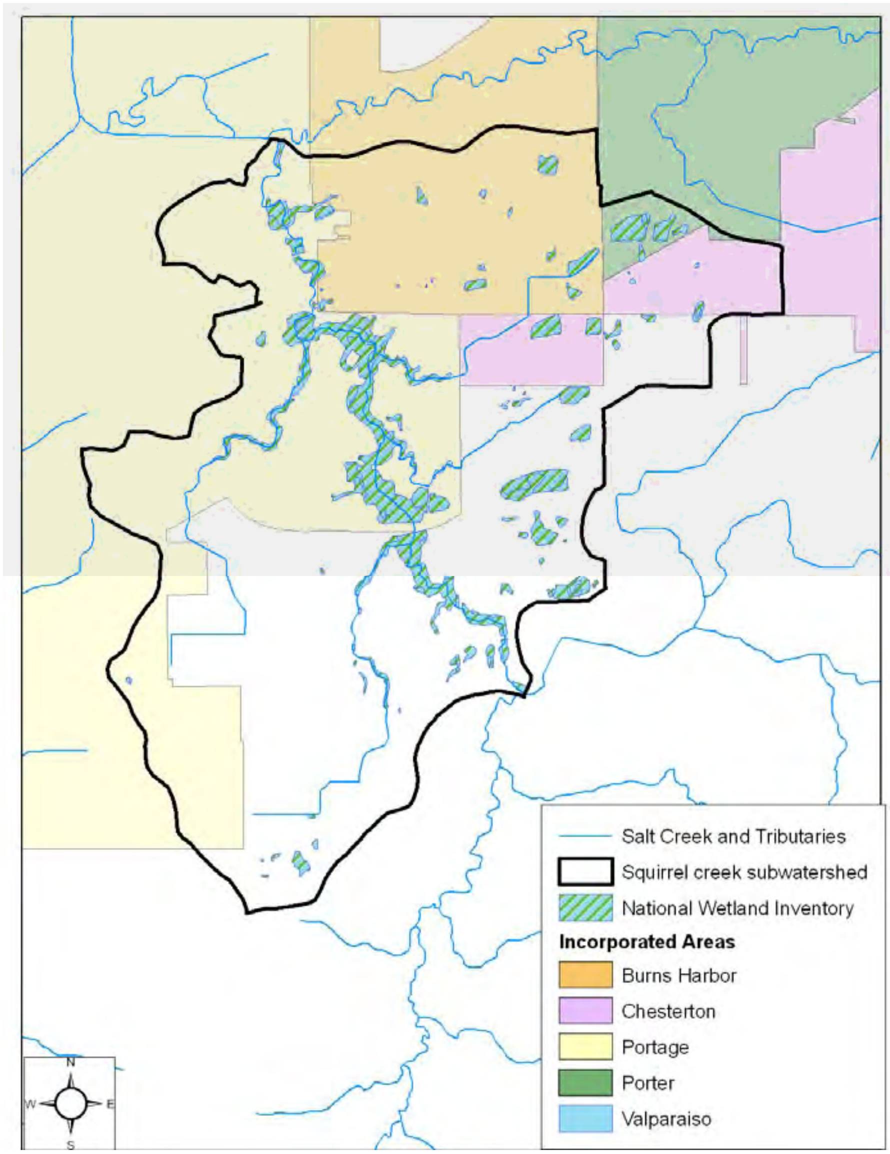

Figure 18. Wetlands in the Squirrel Creek subwatershed (Source: See Appendix R)

The Damon Run subwatershed contains approximately 596 acres (241 hectares) of wetland, or 8% of the total surface area (USFWS, 2003). This is the smallest total acreage of wetland area of all of the five Salt Creek subwatersheds. Large sections of wetlands are located in the area diverted into the Valparaiso Lakes watershed (Figure 19).

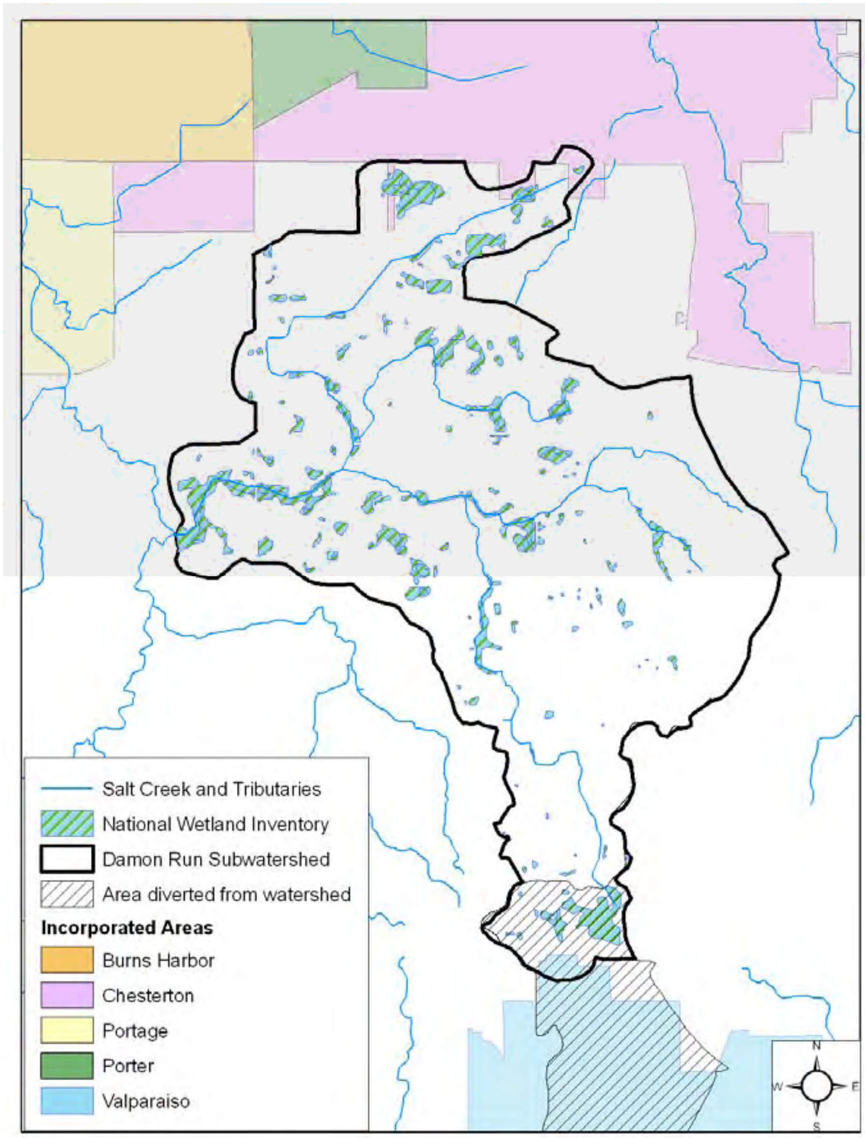

Figure 19. Wetlands in the Damon Run subwatershed (Source: See Appendix R)

The Sager's Lake subwatershed contains approximately 1,202 acres (486 hectares) of wetland, or 11% of the total surface area (USFWS, 2003). This is the largest total acreage and largest percentage of wetland area of all of the five Salt Creek subwatersheds. The majority of the wetlands are located in the headwaters of Salt Creek south of Valparaiso (Figure 20).

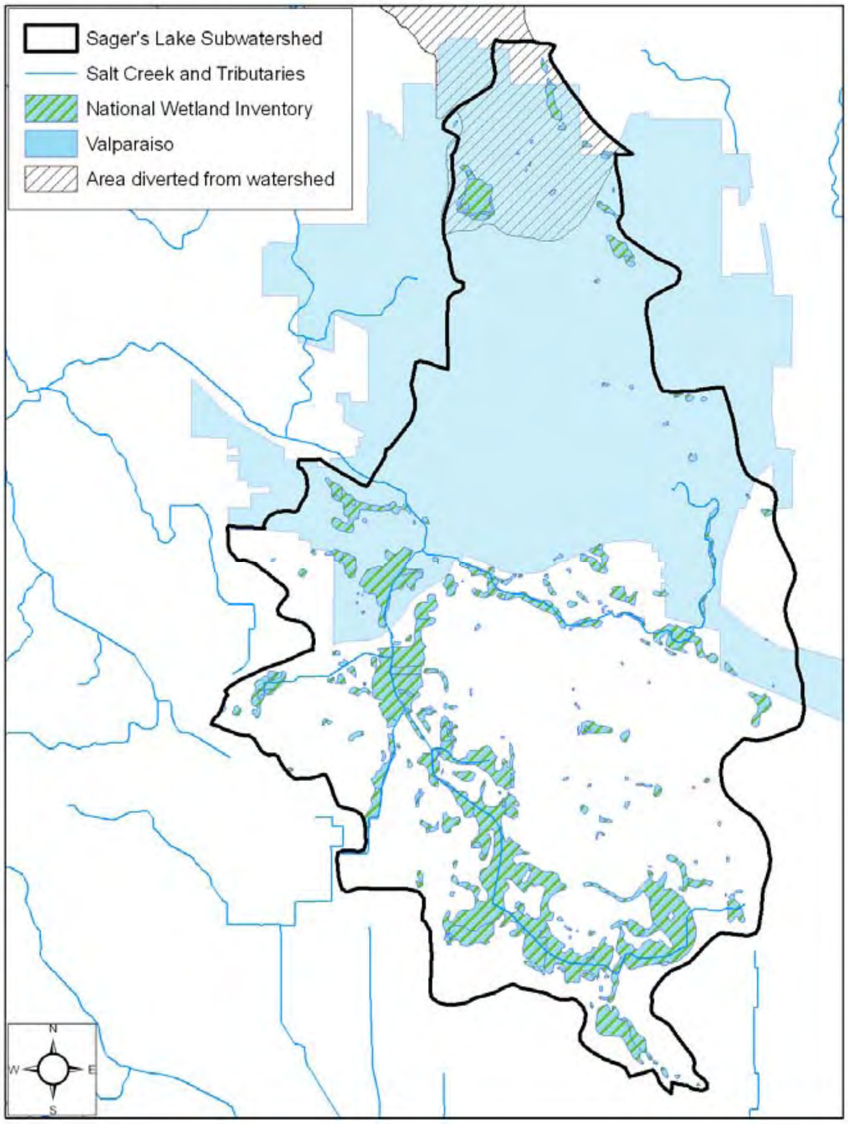

Figure 20. Wetlands in the Sager's Lake subwatershed (Source: See Appendix R)

The Clark Ditch subwatershed contains approximately 1,139 acres (461 hectares) of wetland, or 9% of the total surface area (USFWS, 2003). Lake Louise accounts for the largest wetland listed in the NWI within the Salt Creek watershed. Large sections of wetlands are concentrated along the mainstem of Salt Creek (Figure 21).

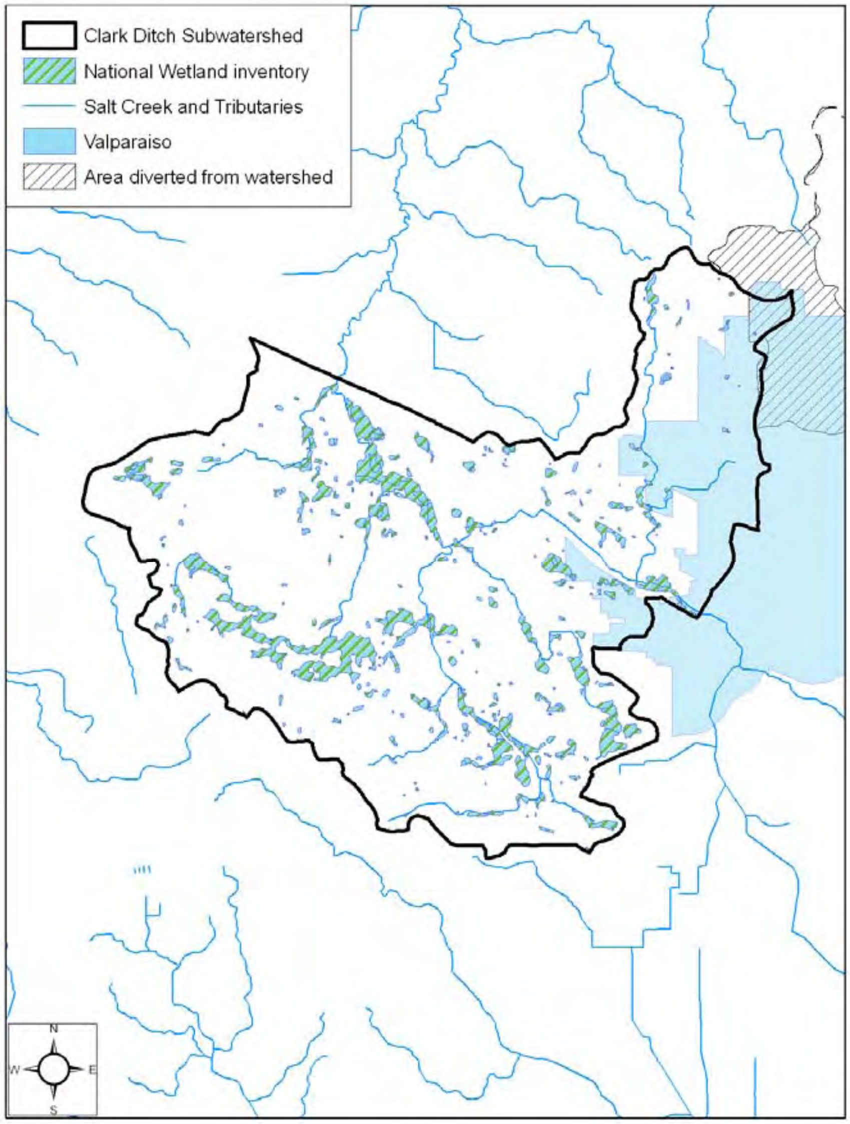

Figure 21. Wetlands in the Clark Ditch subwatershed (Source: See Appendix R)

The Pepper Creek subwatershed contains approximately 607 acres (246 hectares) of wetland, or 7% of the total surface area (USFWS, 2003). This is the smallest percentage of wetland area of all of the five Salt Creek subwatersheds. The largest wetlands are concentrated along the mainstem of Salt Creek (Figure 22).

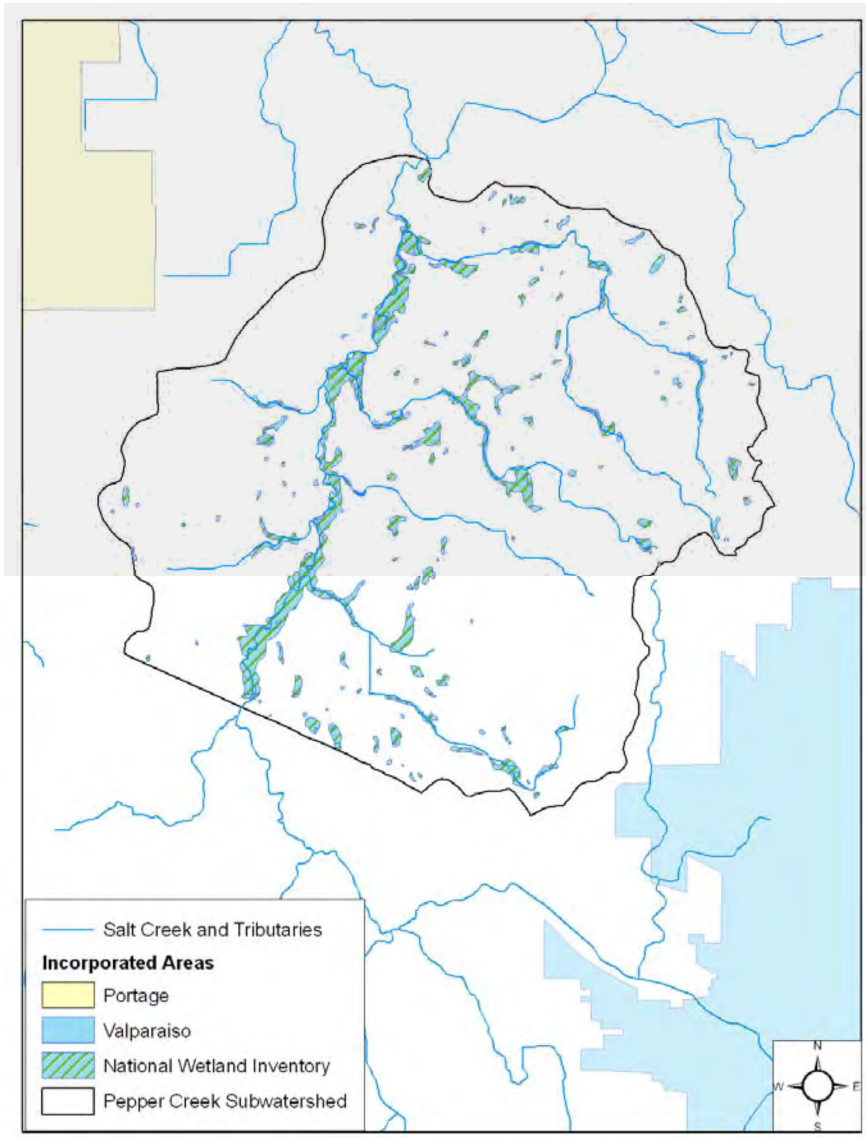

Figure 22. Wetlands in the Pepper Creek subwatershed (Source: See Appendix R)

2.7 Ecoregions

Ecoregions are areas of relative homogeneity in ecological systems and their components. Factors associated with spatial differences in the quality and quantity of ecosystem components, including soils, vegetation, climate, geology, and physiography, are relatively homogeneous within an ecoregion. Ecoregions separate different patterns of human stresses on the environment and different patterns in the existing and attainable quality of environmental resources. They have proven to be an effective aid for inventorying and assessing national and regional environmental resources, setting resource management goals, and developing biological criteria and water quality standards.

The approach used to compile ecoregion maps is based on the premise that ecological regions can be identified by analyzing the patterns and composition of biotic (living) and abiotic (non-living) phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.

The relative importance of each factor varies from one ecological region to another, regardless of the hierarchical level. Because of possible confusion with other meanings of terms for different levels of ecological regions, a Roman numeral classification scheme has been adopted for this effort. Level I is the coarsest level, dividing North America into 15 ecological regions. At Level II, the continent is subdivided into 52 classes, and at Level III the continental United States contains 98 ecoregions. Level IV ecological regions are further subdivisions of Level III units. The exact number of ecological regions at each hierarchical level is still changing slightly as the framework undergoes development at the international, national, and local levels.

The northern portion of the Salt Creek watershed is located in Level IV region 54b, the Chicago Lake Plain (Figure 23). A small section of the watershed near the Town of Porter is located in Level IV region 56d, the Michigan Lake Plain. The central portion of the watershed is located in Level IV region 54a, the Illinois/Indiana Prairie. The headwaters of the Creek in the southeast corner are located in Level IV region 56b, the Elkhart Till Plain. Regions 54b, 56d, 54a, and 56b are subdivisions of the Level III Southern Michigan/Northern Indiana Drift Plains (USGS, 2003).

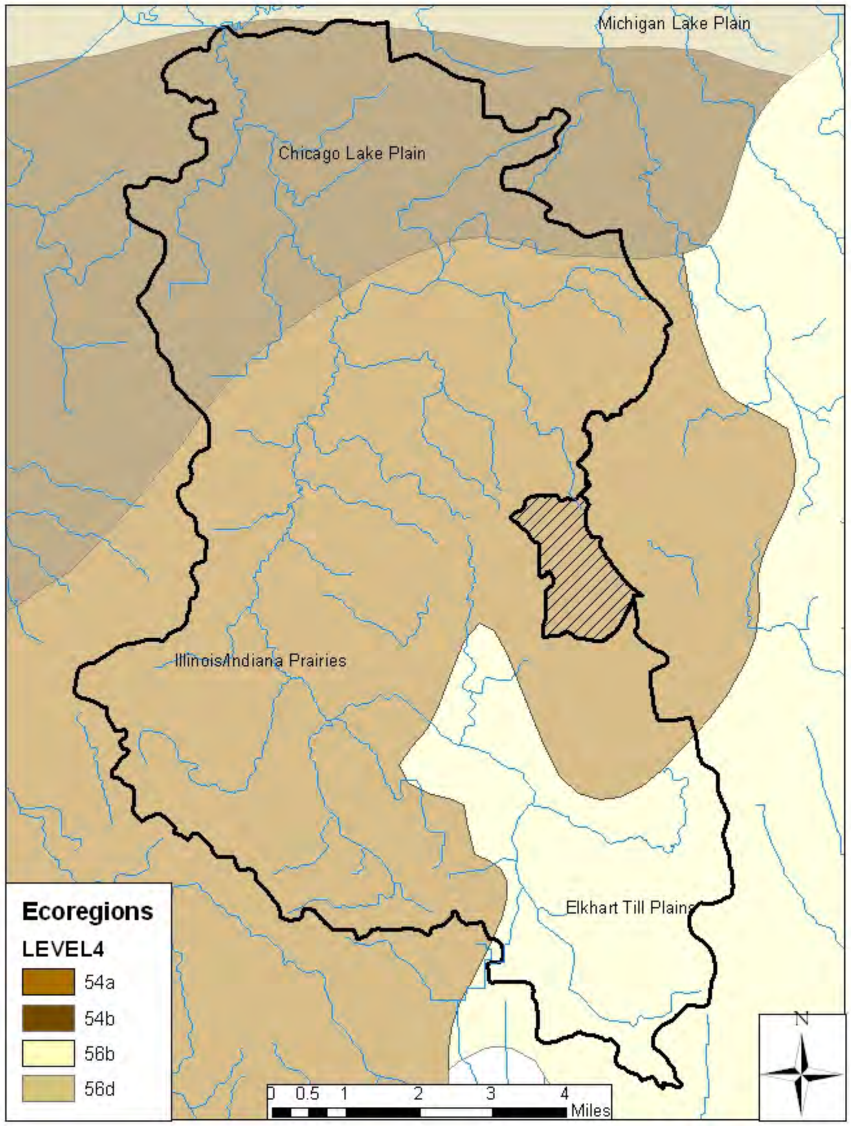

Figure 23. Salt Creek ecoregions (Source: See Appendix R)

2.8 Endangered Species

The Salt Creek watershed is within the range of the federally endangered Bald Eagle (*Haliaeetus leucocephalus*) and Indiana Bat (*Myotis sodalis*). An endangered species is a species in danger of extinction throughout all or a significant portion of its range or habitat. Bald Eagles occasionally visit the general area, usually during winter months. They presently do not nest in northern Indiana, but nesting pairs are gradually moving north from southern Indiana reintroduction sites. For example, in 2006 there were attempts at nesting at Willow Slough Fish and Wildlife Area in Newton County and at Lake Freeman on the Tippecanoe River in White County. There were successful nests along the Wabash River in Cass and Carroll counties. In the future it is possible that the Bald Eagle will nest within the Salt Creek watershed.

Several mist net surveys have been conducted in recent years in the Salt Creek watershed in an attempt to determine whether or not the Indiana Bat is present, but to date (2007) none have been found. Summer habitat for Indiana Bat primarily consists of woodlands, with floodplains and riparian forests being considered the most valuable habitats. Maternity colonies occupy roost sites in forested floodplain or upland habitats and are very loyal to their roosts and nightly foraging areas, which are usually centered over riparian forests. Maternity colonies have been found in both riparian and upland forested areas and on the edge of urban areas (Indianapolis International Airport area), so it is apparent that they will utilize suitable habitat throughout their range. Therefore, the USFWS considers this species to be present within suitable habitats unless proven otherwise. Suitable summer habitat appears to be available within the Salt Creek watershed, so additional mist net surveys are warranted to determine the status of this endangered species.

The Indiana Division of Nature Preserves (IDNP) maintains the Natural Heritage Data Center for the State of Indiana. This is a list of rare species of plants and animals and rare habitat types. A rare species is a species that exists in small numbers and has been determined to need monitoring. It is based upon the observations of many individuals who submit reports to the center. In most cases, the information is not the result of comprehensive field surveys conducted at particular sites. Therefore, rare species may be present at unknown sites that have not been inventoried. IDNP has provided a list of species reported for the Salt Creek watershed (Appendix G). The majority of the species are from Samuelson Fen and related habitats at Imagination Glen Park in Portage. These are unique habitats that have been studied quite well in recent years. Surveys of the 33 acre (13 hectare) fen have found 201 species of plants, the vast majority being native species, including state threatened Great Saint John's-Wort (*Hypericum pyramidatum*) and Smaller Forget-me-not (*Myosotis laxa*), and more than 400 insect species, including the Indiana rare Baltimore Checkerspot Butterfly (*Euphydryas phaeton*) and Sedge Skipper Butterfly (*Euphyes dion*) and state threatened Big Broad-winged Skipper Butterfly (*Poanes viator viator*) and Starry Campion Moth (*Hadena ectypa*). A threatened species is a species that is likely to become endangered in the near future.

Other state listed species of plants and animals have been found at Camp Butternut Springs Girl Scout Camp and at various wetlands and other habitats scattered throughout the watershed. A number of public and private protected areas could harbor rare species and should be surveyed. These include numerous privately-owned Classified Wildlife Habitat Program properties disbursed throughout the watershed and a 130 acre (53 hectare) parcel, unofficially being called Brennan Woods, along Salt Creek which was purchased in 2005 by the Portage Parks and Recreation Foundation utilizing grants received under the Indiana Heritage Trust and the Coastal Zone Management Act of the National Oceanic and Atmospheric Administration (NOAA)'s Office of Ocean and Coastal Resource Management and the IDNR- LMCP. Wetlands, including a fen, in the Salt Creek headwaters should also be investigated further since the uncommon bog species Tamarack (*Larix laricina*) has been observed there. The state threatened Small Cranberry (*Vaccinium oxycoccos*) has been found at another wetland in the Salt Creek headwaters.

Although they are no longer on the Indiana list of endangered species, both the American Badger (*Taxidea taxus*) and Bobcat (*Lynx rufus*) have been found within the Salt Creek watershed in recent years. These two species were on Indiana's original endangered species list established in 1969, but have since improved their populations statewide and were removed from the list in July 2005. They are now protected as non-game species that cannot be hunted or trapped intentionally.

2.9 Exotic and Invasive Species

The purpose of this section of the SCWMP is to identify major invasive species, note their range within the Salt Creek watershed, identify the threatened habitats, suggest whether control measures be implemented, and promote awareness of the situation. An invasive species is a non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. While this section is current as of its writing (July 2007), the situation is continuously changing as species expand, new species are introduced, and efforts are made to control existing invasive species.

Very little of the presettlement vegetation and natural communities of the Salt Creek watershed remain. One of the most troublesome species in the watershed is Reed Canary Grass (*Phalaris arundinacea*). It has invaded much of the sunlit portions of the watershed and has smothered native vegetation. A bog located at the southeastern extreme of the watershed in the headwaters of Salt Creek is particularly dominated by this species. Control of this species with conventional tactics is a virtual impossibility. Discovery and release of biological control will be the only hope to halt this plant.

Cattail (*Typha x glauca*; *Typha angustifolia*) is a serious problem. The complex hybridization of the exotic form has essentially eliminated the native cattail (*Typha latifolia*). The hybrids are extremely virulent and have infested ditches, streams, marshes, and other wetlands. There is currently effort underway to refine conventional control techniques, and small populations appear to be controllable. Further spread of this plant can be somewhat minimized by careful cleaning of equipment when road and ditch crews move from site to site.

Canada Thistle (*Cirsium arvense*) is a noxious weed that occurs essentially in all sunlit areas of the watershed. This plant is so virulent that very little can be done to control it without biological control.

Purple Loosestrife (*Lythrum salicaria*) was detected in only one wetland in the watershed. This wetland is located on the north bank of Damon Run, northeast of its confluence with Salt Creek. The population is very dense and covers approximately 10 acres (four hectares). The biological control agent *Galerucella spp.* was released along Robbin's Road on the north side of the infestation in June 2007.

Japanese knotweed (*Fallopia japonica*), a new invader to the coastal region, is well established mainly in the southern half of the watershed. It is generally restricted to disturbed roadsides at this time, but it can be expected to expand into floodplains, old fields (abandoned farmland), and woodlands. The plant's proximity to roadsides and its unmistakable appearance will make control possible, if action is taken immediately.

Oriental Bittersweet (*Celastrus orbiculata*) is present and widespread in the watershed. It has the ability to colonize fields, woodlands, floodplains, and essentially all other available habitats. This vine is extremely destructive to not only surface vegetation, but also to the woodland canopy itself. Once established, it climbs trees and competes for sunlight, resulting in tree death. No major infestations were detected in the Salt Creek watershed, but surrounding watersheds are infested.

Garlic Mustard (*Alliaria petiolata*) is present in the watershed. Floodplains and vectoring by foot traffic and wildlife are the major routes of expansion of this weed. Conventional control is difficult, but current research has identified potential biological control insects.

Tree of Heaven (*Ailanthus altissima*) is established and is prevalent around Valparaiso. This weed which is typical of urban areas is present along woodland edges in the eastern portion of the watershed. While no monocultures have been detected, it can be expected to dominate remnant canopies. It produces winged seeds prolifically, which allows it to expand very rapidly. This plant is also allelopathic (chemically inhibits others in its environment in order to gain competitive advantage). This species poses a risk to human health, as there have been cases of heart arrhythmia in individuals after contact with its sap.

Common Reed (*Phragmites australis*) is an aggressive invader throughout the Lake Michigan watershed, and the Salt Creek watershed is no exception. While generally limited to roadside ditches and disturbed shores, it can expand rapidly. The northern portions of the watershed are the most immediately at risk. Existing small populations along U.S. Highway 30 and State Road 130 may be spread by roadside mowing.

Spotted Knapweed (*Centaura maculosa*) is present with a strong population near the gravel quarry located in the southwestern portion of the watershed. Other populations along the railroads have been identified. This plant is allelopathic and produces chemicals that kill soil microflora. It is extremely important to eliminate small populations as they occur. Biological control has been released in the state and is somewhat effective.

Bush Honeysuckle (*Lonicera spp.*) and Autumn Olive (*Eleagnus umbellata*) were introduced simultaneously and planted in the past for their hardiness and as wildlife forage. Birds do, in fact, enjoy the fruits of both plants, but they unfortunately carry the seeds far beyond their existing populations. Large amounts of money and time are being spent throughout the Midwest to control them with relative success. Both species tend to thrive in sunlit areas, but Honeysuckle has the ability to infest woodlands under complete canopies. In the Salt Creek watershed, they are widespread and mostly infest old fields (abandoned farmland) at this time.

Black Locust (*Robinia pseudoacacia*) is another species that was intentionally planted in the past. Firewood cut from this tree produces some of the highest heat values and its propagation in poor soils gave landowners a way to derive production from their land. It is particularly invasive in sandy soils in highly sunlit areas. It very seldom can invade areas with established tree cover, but tends to colonize woodland edges. It occurs sporadically throughout the watershed.

Multiflora Rose (*Rosa multiflora*) is present in every woodland of the watershed. In some areas, it has become the dominant shrub and has excluded most of the ground layer communities. The plant grows unimpeded in shady understories. Conventional control is somewhat effective, but the result in treated areas tends to be bare soil.

<u>Invasive Plants Popular in Landscaping</u>
Another shrubby invader of woodlands, Japanese Barberry (*Berberis thunbergii*), is established in the Salt Creek watershed. While it has not reached the density of Multiflora Rose, it may become a dominant species soon. This plant is popular in residential landscapes. Its dispersion is presumed to be by birds, and it is invading all woodlands. This is a situation in which the public can be integral in reducing the spread of an exotic species, by not planting Japanese Barberry.

Another opportunity for residents of the watershed to help control invasive species is to avoid the popular landscaping plant Burning Bush (*Euonymus alatus*). This plant occurs at very low levels in the eastern portion of the watershed. It is an invader of woodlands and appears to be expanding. Birds are the primary agent for dispersal of seed. Burning Bush is a popular landscape plant due to its striking red fall foliage.

Privet (*Ligustrum vulgare*) has been a popular landscape plant for as long as groomed hedges have existed. The situation is not critical at this time, but can be expected to deteriorate rapidly.

<u>Species Likely to Expand into the Salt Creek Watershed</u>
Surprisingly, the buckthorns (*Frangula alnus, Rhamnu frangula,* and *Rhamnus cathartica*) were not detected in the Salt Creek watershed. However, buckthorn species are present in the county and can be expected to expand. The floodplains and mesic woodlands are the most threatened communities. Control is possible with early detection and response to new populations.

Air Yam (*Diascorea bulbifera*) is another species that was not detected, but is established in adjacent watersheds. This vine is a vigorous climber and often forms deep mats over low vegetation. Established populations have proven to be nearly unstoppable in southern Indiana, yet can be controlled with early detection. Its method for dispersement seems to be by following moving water, but the explanation for isolated introductions is elusive.

While Japanese Stilt Grass (*Microstegium vimineum*), another species from the Orient, has not yet arrived in the watershed, its northward migration through the state has been relatively unimpeded by management efforts. It can be expected to establish in the Salt Creek watershed in as few as five years. The first places this plant will be introduced are high foot-traffic areas such as public access sites and hiking trails.

Other species such as Kudzu, Black Swallowwort, Mugwort, and Giant Hogweed are also present in surrounding counties. These are extremely invasive and will likely reach the Salt Creek watershed soon. Immediate response to these invasions is possible if management crews such as highways and parks receive training in the identification and control methods for these plants.

Future management of the Salt Creek watershed should include not only direct efforts to limit the expansion of exotic species, but also funding and support for research into biological control, and restoration of natural processes such as fire.

2.10 Land Use

2.10.1 Current Land Use and Development Trends (modified from TMDL)

Until the 1800's northwestern Indiana land use consisted of undeveloped wetlands, hardwood forests, or grasslands (IDNR, 1994; WHPA, 2004). In 2001 deciduous forest (28%) and cultivated crops (20%) accounted for the two largest land cover categories in the watershed (Figure 24) (USGS, 2001). The high, medium, and low intensity developed areas accounted for 21% of the watershed combined (Figure 25). The predominant crops grown in the watershed are corn and soybeans (42% and 49%, respectively; Figure 6). Since 1950 corn and soybean acreage has increased 26% and 71%, respectively. In contrast, acreage of wheat and hay dropped 86% and 90%, respectively. Livestock numbers show a general downward trend since 1974, although the data are lacking in more recent years. The number of cattle in the county dropped 59%, from 12,700 in 1975 to 5,200 in 2001. Chicken production decreased 39% from 1974 to 1985 and the number of hogs decreased 17% from 1974 to 1995 (WHPA, 2004).

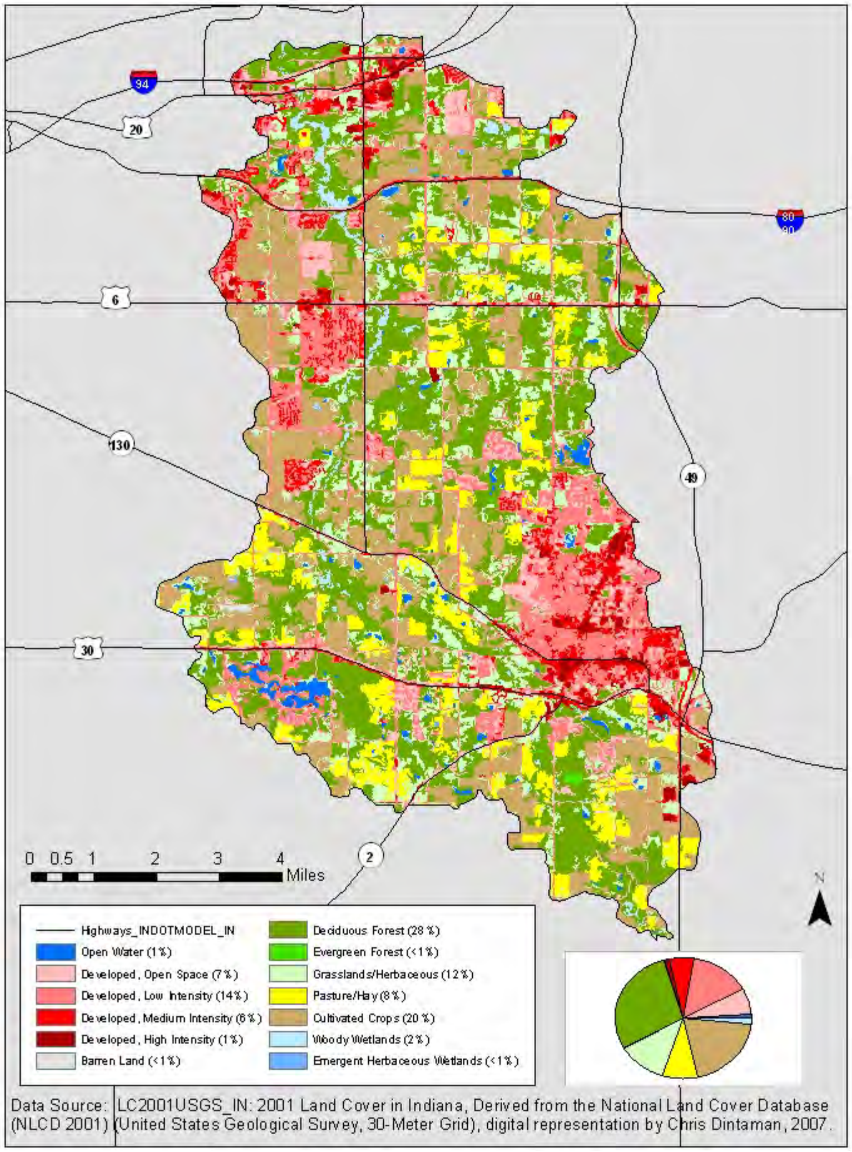

Figure 24. Land cover in the Salt Creek watershed (Source: See Appendix R)

According to the 2001 Land Cover in Indiana derived from the National Land Cover Database, the following land use categories are present in the Salt Creek watershed (USGS, 2001):

- Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.
- Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
- Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.

- Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 to100% of the total cover.
- Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
- Deciduous Forest - Areas dominated by trees generally greater than 16 feet (5 meters) tall and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- Evergreen Forest - Areas dominated by trees generally greater 16 feet (5 meters) and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
- Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
- Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
- Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
- Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
- Emergent Herbaceous Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Figure 25 shows land cover by subwatershed. Land cover categories were grouped into the following five categories: forest (deciduous and evergreen), cultivated crops, grass/herbaceous, developed (open space and high, medium, and low intensity), and other (pasture/hay, emergent herbaceous wetlands, woody wetlands, open water, and barren land). Subwatershed land categories in Section 2.2- Subwatersheds and Section 3.4- Water Quality Data by Sampling Site are grouped in these five categories.

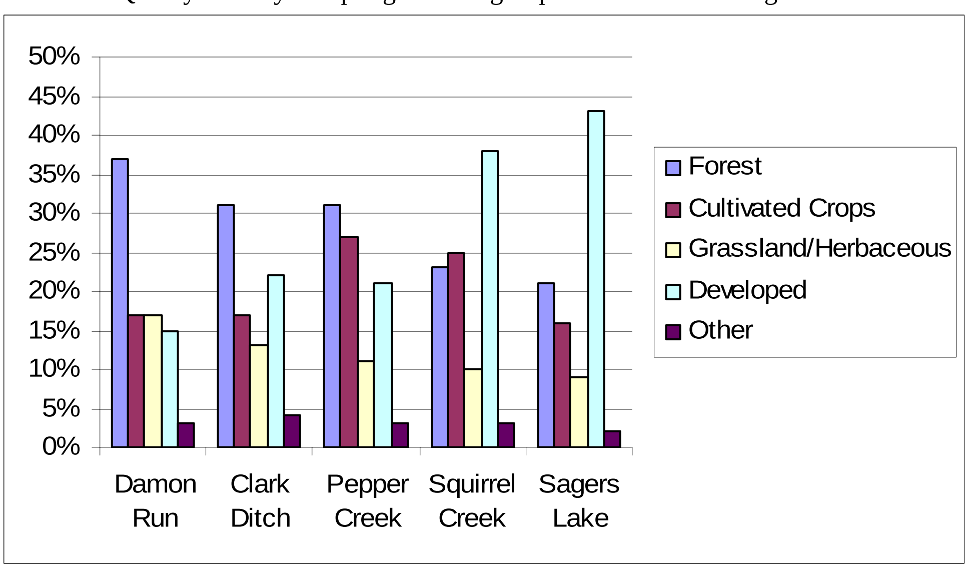

Figure 25. Land cover in the Salt Creek watershed by subwatershed (USGS, 2001)

The majority (70%) of the acreage in Salt Creek's watershed supports only 15% of the population, at a density of less than 500 people per square mile. The average population density is 382.9 people per square mile (IBRC, 2007). The majority of the watershed's population (63%) lives in densities of 1,000 - 10,000 people per square mile. The higher population densities are in and around Valparaiso, South Haven, Portage, and Lake Louise (Figure 26) (WHPA, 2004). As of 2006, Porter County had a population of 160,105 and had grown 13.9% since 1990 (IBRC, 2007). While the City of Portage is the largest city in the watershed with 22.7% (36,300 people) of Porter County's population, only a small portion of the City is within the watershed. The largest urban area within the watershed, Valparaiso, accounts for 18.4% (29,516 people) of Porter County's population, and the majority of Valparaiso is within the watershed. Valparaiso grew 11% between 1990 and 2000 (U.S. Census Bureau, 2006).

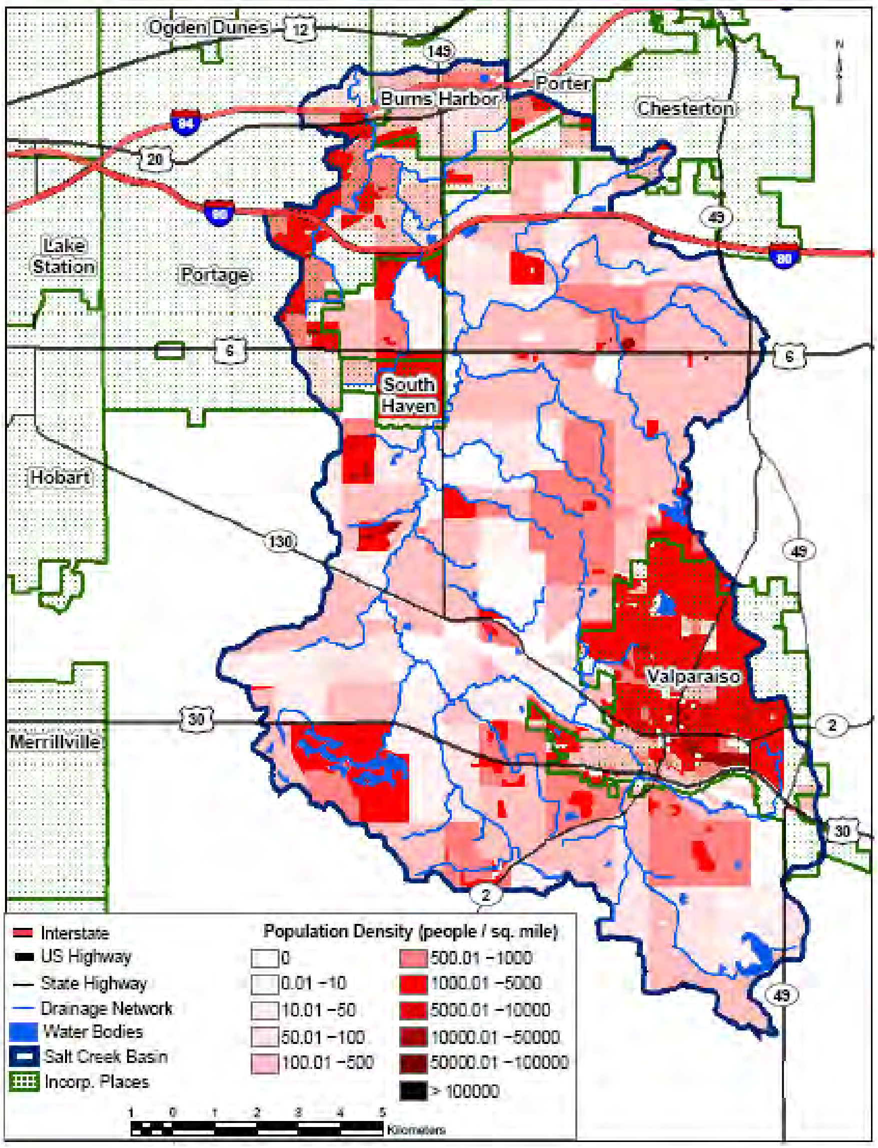

Figure 26. Population density in the Salt Creek watershed (WHPA, 2004)

Appendix Q contains the City of Valparaiso's unincorporated Porter County's zoning maps. The zoning map for unincorporated Porter County indicates areas zoned for low density single family residential land use along the State Road 49 corridor between Chesterton and Valparaiso and to the south and west of

Valparaiso. The map also indicates areas zoned for medium density single family residential land use along the State Road 149 corridor between Portage and Valparaiso. Much of the remaining land in unincorporated Porter County is zoned for rural residential land use (Porter County Surveyor's Office, 2007). Figure 27 shows the change in population density from 1990 to 2000 by civil township. The largest increases in population density occurred in the townships surrounding the Cities of Portage and Valparaiso. The Indiana Business Research Center projects a population of 179,675 in Porter County in 2030, an increase of 12% from 2006 (IBRC, 2008). The total number of housing units in Porter County increased from 57,616 in 2000 to an estimated 64,621 in 2006 (IBRC, 2007). In 2006 1,052 residential building permits were filed in Porter County, of which 926 were single family, 70 were two family, 26 were three and four family, and 30 were five family or more (IBRC, 2007).

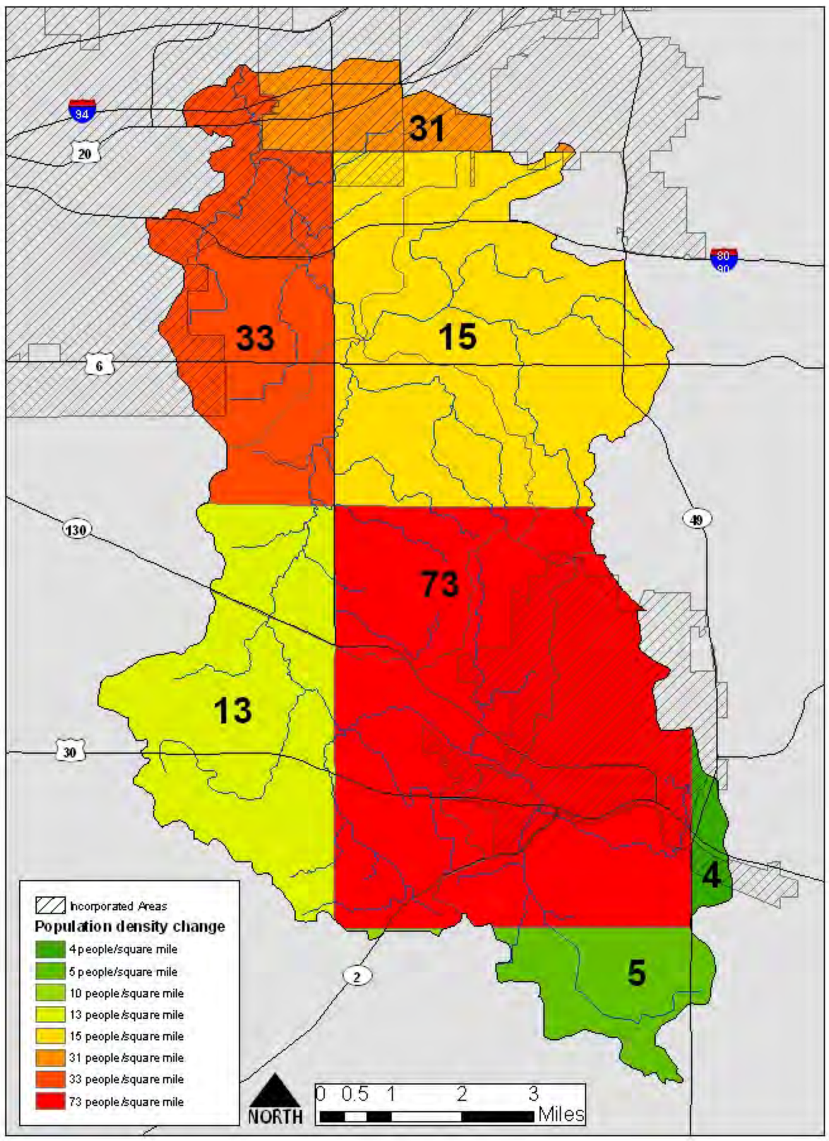

Figure 27. Change in population density, 1990-2000 (Source: See Appendix R)

2.10.2 Cultural and Recreational Resources

Cultural and recreational resources listed in this section include museums, historic landmarks, arts, interpretive and cultural centers, and sites with ecological and/or recreational value. The many festivals and special events that are part of the cultural experience within the Salt Creek watershed are also considered a resource. Festivals that occur within the watershed boundaries are International Music Festival, Kites and Canines, and Winter Lights Festival (Sunset Hill Park), Music under the Stars, Sunday Sounds and Arbor Day Celebration (Taltree Arboretum), Valpo Triathlon (Rogers-Lakewood), Valparaiso Popcorn Festival, Holly Days, and Live Nativity (Downtown Valparaiso), Vale Fine Arts Festival (Rogers-Lakewood), Interwoven Expressions (Aberdeen Manor), and Valparaiso University's Jazz Festival.

Burns Harbor
Lakeland Park, Haglund Road
Features playground equipment, tennis courts, basketball courts, ball fields, picnic shelters, swimming, and fishing.

Chesterton
Brassie Golf Course, 1110 Pearson Road www.thebrassie.com
Natural lakes and wetlands complemented by rolling hills accentuate this 18-hole 16,479 to 21,024 foot (5,493 to 7,008 yard) par 72 golf course.

Liberty Township
The Courts of Northwest Indiana, 127 East U.S. Highway 6 www.thecourtsofnwi.com
The Courts is an exclusively indoor facility that features hardwood basketball courts with electronic scoreboards with team seating, spectator bleachers, and asphalt tennis courts.

Sunset Hill Farm County Park
U.S. Highway 6 and Meridian Road www.porterco.org
This is a 235 acre (95 hectare) park with prairie land and wooded hiking trails. The front of the park is utilized for festivals and events and the back is left natural. Includes four miles (six kilometers) of nature trails, and during the winter offers one continuous marked trail that winds through the park for cross country skiing.

South Haven Area
Haven Hallow Park, 700 North, just west of State Road 149
Haven Hallow Park offers fishing in Salt Creek for chinook and coho salmon, steelhead and brown trout and occasionally northern pike and blue gill.

Unincorporated Porter County
DNR Salt Creek Public Fishing Area
The DNR Salt Creek Public Fishing Area (PFA) was opened in 2005 and includes 75 acres (30 hectares) of hardwood forest and fallow farm fields northwest of Valparaiso. The property provides fishing access to nearly 600 feet (183 meters) of Salt Creek's mainstem. Salt Creek offers excellent trout and salmon fishing, and the PFA protects a section of the Salt Creek watershed. Public parking is located on the north end of the property off County Road 500 North.

DNR Chustak Public Fishing Area
The 76 acre (31 hectare) property and public parking off County Road 600 opened in 2001.

Valparaiso
The Artists' Den, 203 East Jefferson Street
This gallery features oils, watercolors, serigraphs, stone, lithographs, sculptures, glass art, pottery and jewelry by award-winning local, national and international artists.

Bicentennial Park, Burlington Beach Road and Campbell Street www.valparaisoparks.org
Bicentennial Park is a 15.9 acre (6.44 hectare) park that offers newly refurbished playground equipment, tennis courts, and a multi-purpose area with a basketball backstop, softball fields, and open space.

Blythe's Sporting Goods Shooting Range, 2810 Calumet Avenue
Blythe's features a gun and archery range as well as gun rental.

Chicago Street Theater, 154 West Chicago Street www.ctgonline.org
Chicago Street Theater is home of the award-winning Community Theatre Guild, a fixture on the local theater scene for over 50 years, the theater offers live musical and theatrical performances.

The Course at Aberdeen, 245 Tower Road www.golfataberdeen.com
The Course at Aberdeen features 18 holes of challenging championship golf.

Creekside Golf Course and Training Center, 2355 Clifford Rd www.valparaisogolf.com
Creekside features a nine-hole course, a three-hole course, and a year round practice facility with covered tees and lights.

49'er Drive-In Theatre, 675 Calumet Avenue www.49erdrivein.com
This 45 year old landmark is northwestern Indiana's only drive-in theater and one of less than 500 in the entire country. The 49er retains its original look and classic design. Theater patrons can listen to movies through the original working speaker boxes hanging from parking posts or experience digital stereo sound on the radio.

Fairgrounds Park, 704 McCord Road www.valparaisoparks.org
Fairgrounds Park features baseball diamonds, basketball courts, playing fields, playground equipment, restrooms, and the Butterfield Family Pavilion.

Forest Park Golf Course, 1155 Sheffield Drive www.valparaisogolf.com
This is an 18-hole golf course with vistas, woods, flowers, and a layout for players of all abilities.

Forest Park, 775 Harrison Boulevard www.valparaisoparks.org
Forest Park Picnic Area is a 10 acre (4.1 hectare) park with two shelters, a playground, and a large open play area suitable for ballgames, Frisbee, and volleyball.

Foundation Meadows Park, Campbell Street and Bullseye Lake Road www.valparaisoparks.org
The Valparaiso Department of Parks and Recreation is creating a native tree arboretum and restoring upland, mesic, and wetland ecosystems. Only native vegetation will be displayed. Foundation Meadows also features a unique playground called "Butterfly Meadows & Caterpillar Crossing"**.**

Front Porch Music, 505 East Lincolnway www.frontporchmusic.com
This is an intimate 72 seat coffee house where many artists travel to perform concerts.

Glenrose South, 1500 Roosevelt Road www.valparaisoparks.org
Glenrose Park is a 20 acre (8.1 hectare) park that features playground equipment, ball fields, picnic shelters, and restrooms.

Hoosier Bat Company, 4511 East Evans Avenue www.hoosierbat.com
Hoosier Bat Company was created by a former scout for the New York Yankees. They manufacture patented, three-piece, custom-made Hoosier Bats used by major and minor league baseball players. Each year, more than 50,000 custom bats are manufactured for teams such as the White Sox, Mariners, Orioles, Indians, and Brewers.

Inman's Fun and Party Center, 3201 Evans Avenue www.inmansfpc.com
Features bowling, glow bowling, a pro shop, billiards, an arcade, a laser tag arena, a birthday party room, miniature golf, go-karts, bumper boats, and an outdoor pavilion.

Jessee-Pifer Park, Elmhurst and Madison Streets www.valparaisoparks.org
This park features playground equipment, basketball courts, picnic shelters, and restrooms.

Kirchhoff Miller Woods, Roosevelt Road and Institute Street www.valparaisoparks.org
This park features playground equipment, tennis courts, basketball courts, ball fields, picnic shelters, and restrooms.

Memorial Opera House, 104 Indiana Avenue www.memorialoperahouse.com
This landmark was built in 1893 as a memorial to Civil War veterans, and is a treasure for theater and music lovers who delight in the musical and dramatic theatrical productions staged by the Memorial Theatre Company and other acting troupes.

Ogden Gardens, Campbell Street and Harrison Boulevard www.valparaisoparks.org
This 10 acre (four hectare) floral display delights visitors and residents alike. In the center is a wood gazebo with brick pathways. The gardens feature annuals, perennials, rose gardens, shrub beds, and many varieties of trees. Ogden Gardens also has a Japanese garden, which includes a series of trails, streams, bridges, a pond, and a tea house.

Old Jail Museum, 153 South Franklin Street www.oldjailmuseum.org
The Old Jail Museum and Sheriff's home were built in 1860 and 1871 and are maintained as the Porter County Museum. The Sheriff's home is an Italianate brick building that contains rooms of period furniture. The jail is a two-story structure leading to the Sheriff's home. This museum houses the Porter County Historical Society's historical collection.

Pines Family Recreation, 674 North Meridian Road www.valpomall.com/pines
Pines Family Recreation features paintball scenario and speed ball fields, mountain biking (beginner to moderate trails), alpine slide, and winter recreation (skiing, tubing, slide shop).

Rogers-Lakewood Park, Meridian Road (Campbell) www.valparaisoparks.org
Rogers-Lakewood Park is a 122 acre (49.4 hectare) park that features seven picnic shelters, hiking trails, beach, concessions, fishing, boating, swimming, restroom facilities, playgrounds, open space, and Flounder Skate Park, disc golf course, Discovery Teams Course, Discovery Day Camp, and Lakewood Links, which is a two mile (three kilometer) foot/bike path. The Skate Park is a 15,000 square foot (1,393.6 square meter) park that features a street course design with three to six foot ramps, grind rails, jump box and pyramid,

Scuba Tank, 55 South Franklin www.scubatank.com
Conducts dive charters in Lake Michigan where certified divers can scuba dive among shipwrecks, plane wrecks, and break walls.

Taltree Arboretum and Gardens, 450 West 100 North www.taltree.org
Taltree Arboretum and Gardens sits on top of the Valparaiso Moraine and straddles the Salt Creek watershed boundary. It has 300 acres (121 hectare) of woody plant collections, gardens, wetlands, woodlands, and prairies, displaying plants from North America and other parts of the temperate world. More than three miles (five kilometers) of hiking trails allow visitors to experience the natural biodiversity of the landscape. The Joseph E. Meyer Memorial Pavilion is a showcase of natural materials artfully blended into the landscape and the Music in Nature Concert Series and other events are hosted here.

Tower Park, Evans Avenue and Franklin Street www.valparaisoparks.org
This park features playground equipment made entirely from recycled plastic, tennis courts, basketball backboards, and baseball field.

Valparaiso University
Athletics-Recreation Center is VU's main indoor athletic facility, which is a 142,000 square foot (13,192 square meters) building with seating capacity of 5,000.

The Brauer Museum of Art is home to a nationally recognized collection of 19th and 20th century American art. It also houses the largest known collection of works by Junius R. Sloan, a Hudson River School painter who lived and worked in the Midwest. As well as displaying selections from its permanent collection, the Brauer Museum hosts a full schedule of special exhibitions and events.

Center of the Arts is a crossroads for artistic expression, this 100,000 square foot (9,290 square meter) facility features musical, theatrical, and art events throughout the year. Key facilities within the building are the 189 seat theater and Brauer Museum of Art, which houses more than 2,300 works.

Chapel of the Resurrection is one of the largest collegiate chapels in the U.S. It seats more than 2,000 worshipers, has a world-renowned organ, and 94 foot (29 meter) high Mundeloh stained glass windows. Outside the west doors, the Brandt Campanile stands 140 feet (43 meters) tall and sounds out the passing hours.

As the intellectual center of campus, the Christopher Center was designed to bring all campus information services to a single location, while best serving the needs of students. The result is a learning environment that also serves as an important campus social center.

Valparaiso Community Concert, 2727 North Campbell Street (Valparaiso High School)
The Valparaiso Community Concert Association offers a wide variety of live entertainment at Valparaiso High School.

Valparaiso Downtown Commercial District
These historic buildings are roughly bounded by Jefferson, Morgan, Indiana, and Napoleon Streets and are on the National Register of Historic Places. The buildings are now home to many specialty and gift shops as well as restaurants, salons, and other services.

Valplayso, North Glendale Boulevard and Roosevelt Road www.valparaisoparks.org
Valplayso was designed and built in 1994 by the Valparaiso community for the 50th anniversary of the Valparaiso Department of Parks and Recreation. Community participation was incorporated into all phases of the designing and building of Valplayso.

West Side Park, Joliet Road www.valparaisoparks.org
Westside Park is a 15 acre (6.1 hectare) park that features playground equipment, baseball fields, open play areas for football and soccer, and restroom facilities.

Will Park, Morgan Boulevard and Brown Street www.valparaisoparks.org
Will Park is a three acre (1.2 hectare) park with a community-built playground, open shelter, and restrooms.

Zao Island, 1050 Horseprairie Avenue www.zaoisland.net
Zao Island features two 18-hole miniature golf courses, batting cages, go-karts, bumper cars, super slide, live alligators, indoor snack shop, and prize redemption center.

Portage

Duck Creek Golf Course, 638 North 700 West
Duck Creek golf course is an 18-hole course nestled in a beautiful country setting with two ponds.

Imagination Glen Park, 2275 McCool Road www.ci.portage.in.us/parks
This park sits on 256 acres (104 hectares) that house the softball and soccer complexes, the Steel Wheels BMX race track, the 10 mile (16 kilometer) Outback Trail, the Iron Horse Trail, restrooms, concessions, picnic area and shelters, playground area, and a large nature preserve with Salt Creek meandering through the center. Salt Creek provides fishing opportunities for chinook and coho salmon, steelhead and brown trout, and occasionally northern pike and blue gill.

Iron Horse Trail, Willowcreek Road to State Road 149 www.ci.portage.in.us/parks
Plans for Phase I of the Iron Horse Trail Project will include paving the trail from Imagination Glen Park to Hamstrom Road. A unique feature planned is the dual surfacing which provides a hard asphalt surface as well as a softer limestone surface for joggers. Ultimately, the trail will be routed to the new beach front park set to open in 2008. Trail visitors can park at either Woodland Park or Imagination Glen Park and utilize this unpaved trail for walking, jogging, sight-seeing, cross-country skiing, and nature studies.

Prairie Duneland Trail, County Line Road to State Road 149 www.ci.portage.in.us/parks
The Portage section of the Prairie Duneland Trail begins at County Line Road (on the west end) just south of U.S. Highway 6 and stretches east for approximately six miles (10 kilometers) through Portage to State Road 149. This paved pedestrian trail is great for all non-motorized recreational activities including walking, running, bicycling, rollerblading, sight-seeing, and bird watching.

Robbinhurst Golf Club and Driving Range, 383 West 875 North www.robbinhurst.com
Golfers of all skill levels enjoy Robbinhurst's 18-hole layout accentuated by mature woodlands and Squirrel Creek.

Steel Wheels BMX Bike Track, State Road 149 www.steelwheelsbmx.com
Indiana's only American Bicycle Association-sanctioned and designed track is the site of statewide and national competitive championship racing for youth and adults. The facility includes a dirt-racing track, concession area, announcing tower, staging area, and finish line.

Indiana Dunes National Lakeshore
A small section of INDU extends into the Salt Creek watershed (Figure 28). This National Park Serviceland encompasses the mainstem of Salt Creek just before the confluence of Salt Creek and the Little Calumet River in Portage. In addition to INDU property, several parks in the Salt Creek watershed are owned and managed by local, municipal, and county parks departments.

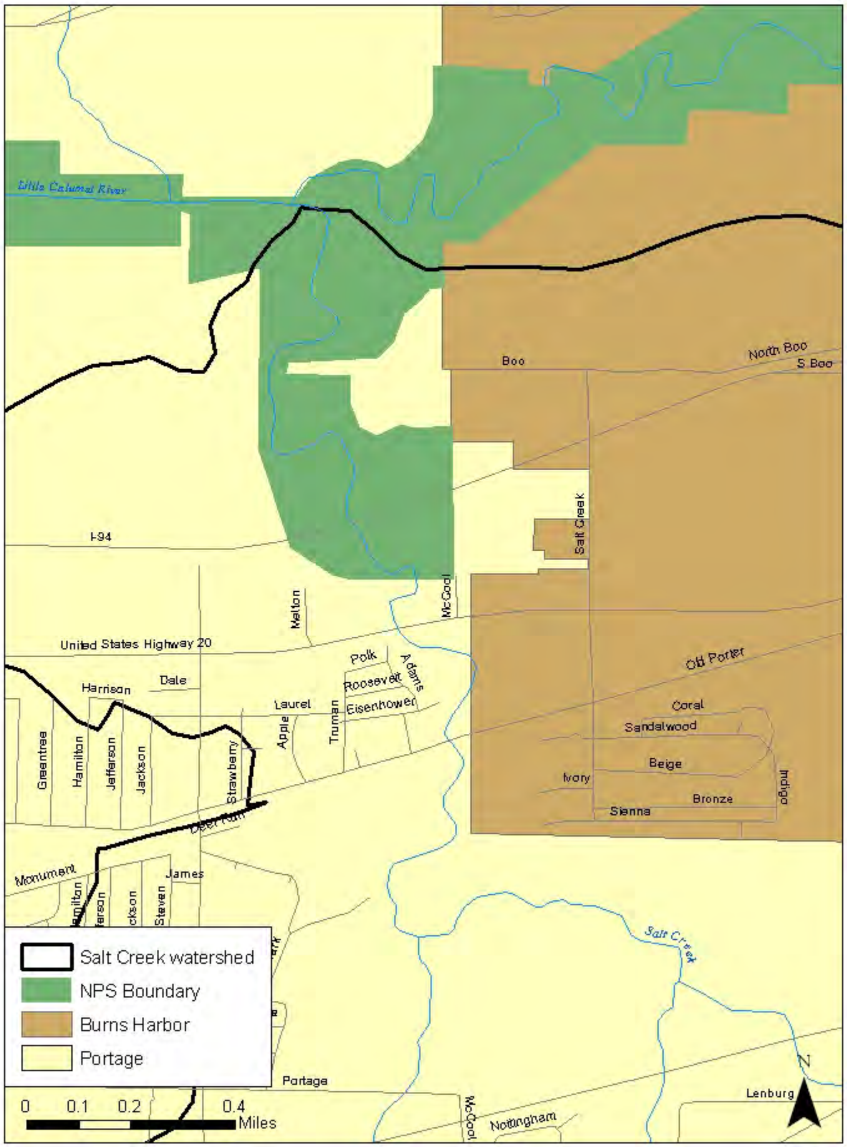

Figure 28. National Park Service property within the Salt Creek watershed (Source: See Appendix R)

2.10.3 History

Before the French explored the area, the Potawatomi inhabited northwestern Indiana. The Iroquois wars in the late 1600s forced the Potawatomi north and west (Schoon, 2003). In the 1670s French explorers Marquette and Joliet encountered Miami villages in northwestern Indiana. The Miami and Potawatomi descended from the Mississippian group. The Missisippian culture was characterized by village life and plant cultivation. A village known as the Fifield Site was excavated by Indiana University in the 1950's. The Fifield Site was located north of U.S. Highway 6 in the Salt Creek valley. This site provided valuable information on the wild game that was hunted in northern Indiana and is thought to have been occupied between 1200 and 1500 AD. After 1701 when the Iroquois wars ended, many Potawatomi returned to the area, and the Miami moved southeast of the area. The Potawatomi Tribe tended to make bark wigwams and hunted and fished in addition to farming (Schoon, 2003). The Potawatomi suffered through the French and Indian War and Revolutionary wars. Some Potawatomi intermarried with European settlers, while others were pushed west to reservations (City of Valparaiso, 2006).

The area that is now Porter County was purchased from the Potawatomi by the United States in October 1832 (City of Valparaiso, 2006). Porter County, which then included the land that is now both Porter and Lake counties, was formed in 1836. The County was named for Commodore David Porter a navy hero from a famous battle near Valparaiso, Chile during the War of 1812 (Porter County, 2006). In 1836 the town of "Portersville" was created as the county seat. The Town's name was changed to Valparaiso in 1837 (City of Valparaiso, 2006). Several mills were constructed on Salt Creek in the 1830s (Shook, 2006). A mill and small settlement was constructed on Damon Run by Sam Olinger in 1836. William Gossett constructed a sawmill on the east bank of Salt Creek in 1836. Lumber from Gossett's Mill was used for several frame buildings in the associated settlement, referred to as the Salt Creek Settlement or Gossettsburgh. The Town of Chesterton was first incorporated under its present name on October 5, 1869 (Chesterton, 2006). The Town of Porter originated in 1858 and has had numerous names including Bailytown, Old Porter, and Hageman. In 1908 it was incorporated with its current name of Porter. Portage was not incorporated as a town until 1958 and then became a city in 1968. Registered historic places within the Salt Creek watershed are listed in Appendix H.

3.0 WATER QUALITY

3.1 Historical Water Quality Data

The Salt Creek watershed has been studied as part of larger studies and independently. IDEM performed the most comprehensive analysis of the Creek's water quality with water chemistry sampling and assessments of the fish and macroinvertebrate communities. IDEM surveys included long-term water chemistry monitoring at fixed sampling stations, periodic assessments as part of the 303(d) rotating watershed study, a biotic community assessment/ intensive survey, and periodic biotic community surveys. A variety of other organizations have also studied Salt Creek, focusing on water chemistry. Additionally, the stream has been examined as part of assessments for other waterbodies, such as the Little Calumet-Galien River and Lake Louise. Appendix I lists the sources for historical water quality data.

Much of the data established that *E. coli* levels are high within Salt Creek. Samples from sites in many parts of the watershed routinely exceeded the Indiana state standard (235 colony forming units (CFU)/100 mL) with concentrations reaching 17,329 CFU/100 mL (in the unnamed tributary at Weblos Trail, site 3 of the current study). The prevalence of high *E. coli* levels led IDEM to include Salt Creek on the 303(d) list of impaired waterbodies in 1998. Since then tributaries to Salt Creek, including Clark Ditch, Gustafson Ditch, Robbin's Ditch, the Lake Louise Outlet, and Damon Run have also been included on the 303(d) list due to high *E. coli* levels (Figure 29).

Salt Creek is designated by IDEM for the following uses: full-body contact recreation, warm-water and cold water aquatic communities, and salmonid fishery. In addition to the IDEM designated uses, the USEPA designates Salt Creek for human health and wildlife. Salt Creek does not currently meet its IDEM designated-use standard for a full body contact recreational stream (Indiana Administrative Code (IAC) 327 2-1.5-5). IDEM identified sections of Salt Creek and its tributaries on the 303(d) list of impaired waters as impaired for excessive *E. coli* concentrations in 1998, 2002, 2004, 2006, 2008 and impaired biotic communities in 2002, 2004, 2006, and 2008 (Figure 29). In 2002 Salt Creek was listed as a Category 5 waterbody, indicating that a Total Maximum Daily Load (TMDL) must be established. In 2004, IDEM completed a TMDL for *E. coli* in Salt Creek (WHPA, 2004). The TMDL report includes a description of the Salt Creek watershed, an inventory of existing water quality data, and the results of source assessment and modeling analysis.

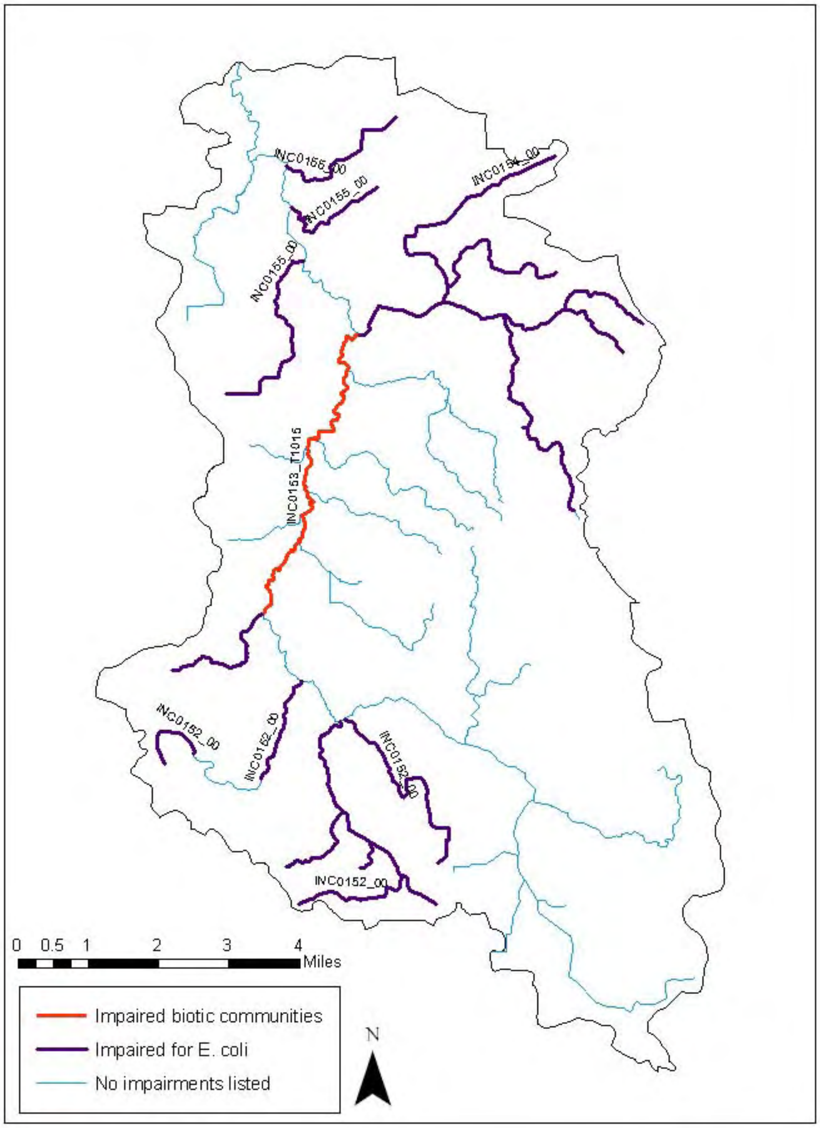

Figure 29. 303(d) impaired streams in the Salt Creek watershed (Source: See Appendix R)

A TMDL represents the maximum capacity of a waterbody to assimilate a pollutant while safely meeting the respective water quality standard. Section 303(d) of the Clean Water Act requires that TMDLs be established for each waterbody in a state that does not meet the water quality standards for the waterbody's designated use. The TMDL for a given waterbody and pollutant is the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels (USEPA, 2001). The sum of the allocations must not result in the exceedance of the water quality standard. In addition, a margin of safety (MOS) must be included in the analysis, either implicitly or explicitly. The MOS accounts for any uncertainty in the relationship between loads and conditions in the receiving water and helps to ensure that the water quality standard is met. These concepts can be expressed conceptually by the equation:

$TMDL = \Sigma WLAs + \Sigma LAs + MOS$

Indiana's water quality standard for recreational waters is set forth in 327 IAC 2-1-6 and 2-1.5-8(e) (2) (IAC, 2008a). The standard reads *"E. coli* bacteria, using membrane filter (MF) shall not exceed one hundred twenty five (125) per one hundred (100) milliliters as a geometric mean based on no less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period." The TMDL was calculated by determining the total percent reduction required to reduce the 100th percentile of the distribution from existing conditions to the target conditions (Figure 30).

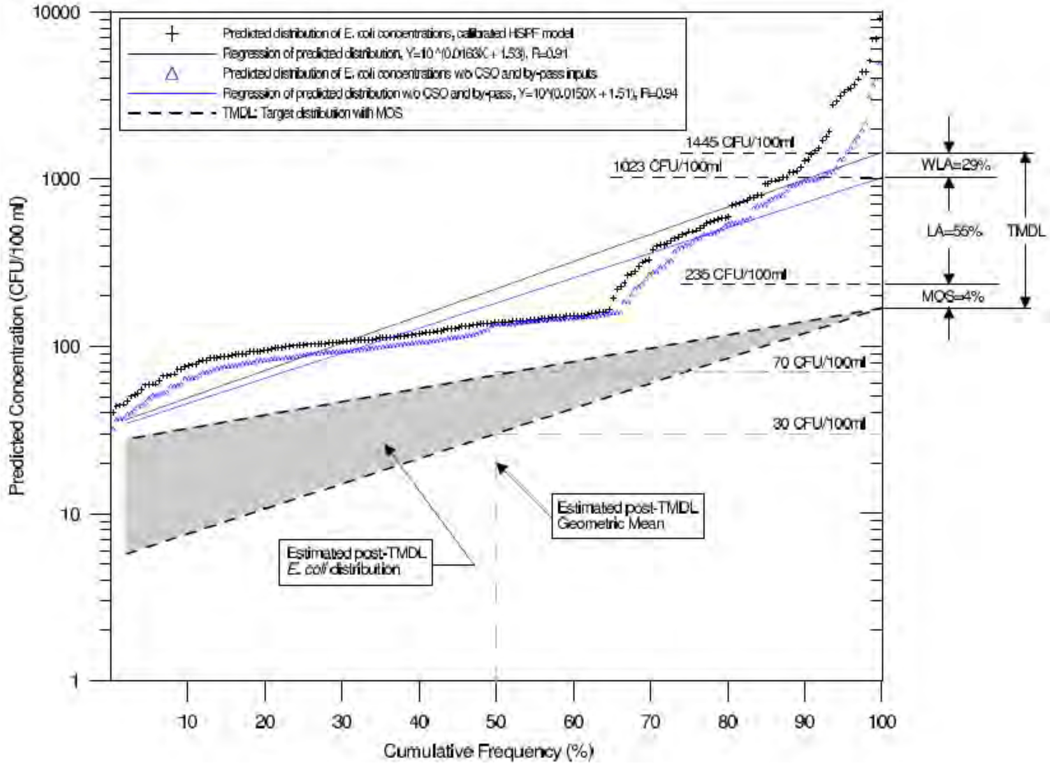

Figure 30. Graphical representation of the statistical method used to calculate the *E. coli* TMDL target and allocations for Salt Creek (WHPA, 2004)

The TMDL elements are summarized in Table 1. Of the total 88% reduction required to meet the target conditions, 29% is the WLA (point source), 55% is assigned to the LA (nonpoint source), and 4% is the MOS. Appendix L contains analysis from the approved TMDL. Appendix J is the verification and calibration information for the HSPF modeling utilized to support the TMDL.

Table 1. Salt Creek TMDL components (WHPA, 2004)

Pollutant	WLA	LA	MOS	TMDL[1]
E. coli	29%	55%	4%	88%

[1]Expressed as reduction required to reduce the 100th percentile of the E. coli distribution to the single-sample standard, with MOS

In 1998, 2002, 2004, and 2006, IDEM listed sections of Salt Creek on the 303(d) list of impaired waterbodies due to impaired biotic communities (Figure 29). Section 3.2- Description of Water Quality Parameters contains detailed scoring criteria for IDEM's biotic assessments. IDEM assesses watersheds on a rotating basis, sampling fish communities and using the Index of Biotic Integrity (IBI) to assess biotic communities in streams. During all sampling events, fish communities were impaired based on IDEM guidelines. In 1990, IDEM sampled six sites in Salt Creek and four sites in tributaries to Salt Creek. IBI scores were generally low, ranging from 14 (where Salt Creek crosses CR 875 N) to 38 (where Sager's Creek crosses Sager Road). Only one site among the ten exhibited an IBI score (38) above the threshold (36) at which IDEM considers streams to be supporting of their aquatic life use designation. In 2006, IDEM assessed the fish community in Salt Creek at 43 sites (Figure 31). IBI scores ranged from 6 to 38, with a geometric mean of 18. Indiana designates streams with an IBI less than 36 as non-supporting of its aquatic life use designation. Concurrently with this fish assessment, IDEM also conducted a comprehensive study to examine the sources of impairment within the watershed (2006 biotic community assessment/intensive survey). This study identified four main contributing factors: contaminants such as dissolved solids, lack of instream habitat, land use in the immediate vicinity, and a fourth factor combining ammonia-nitrogen concentrations and muck/silt accumulation.

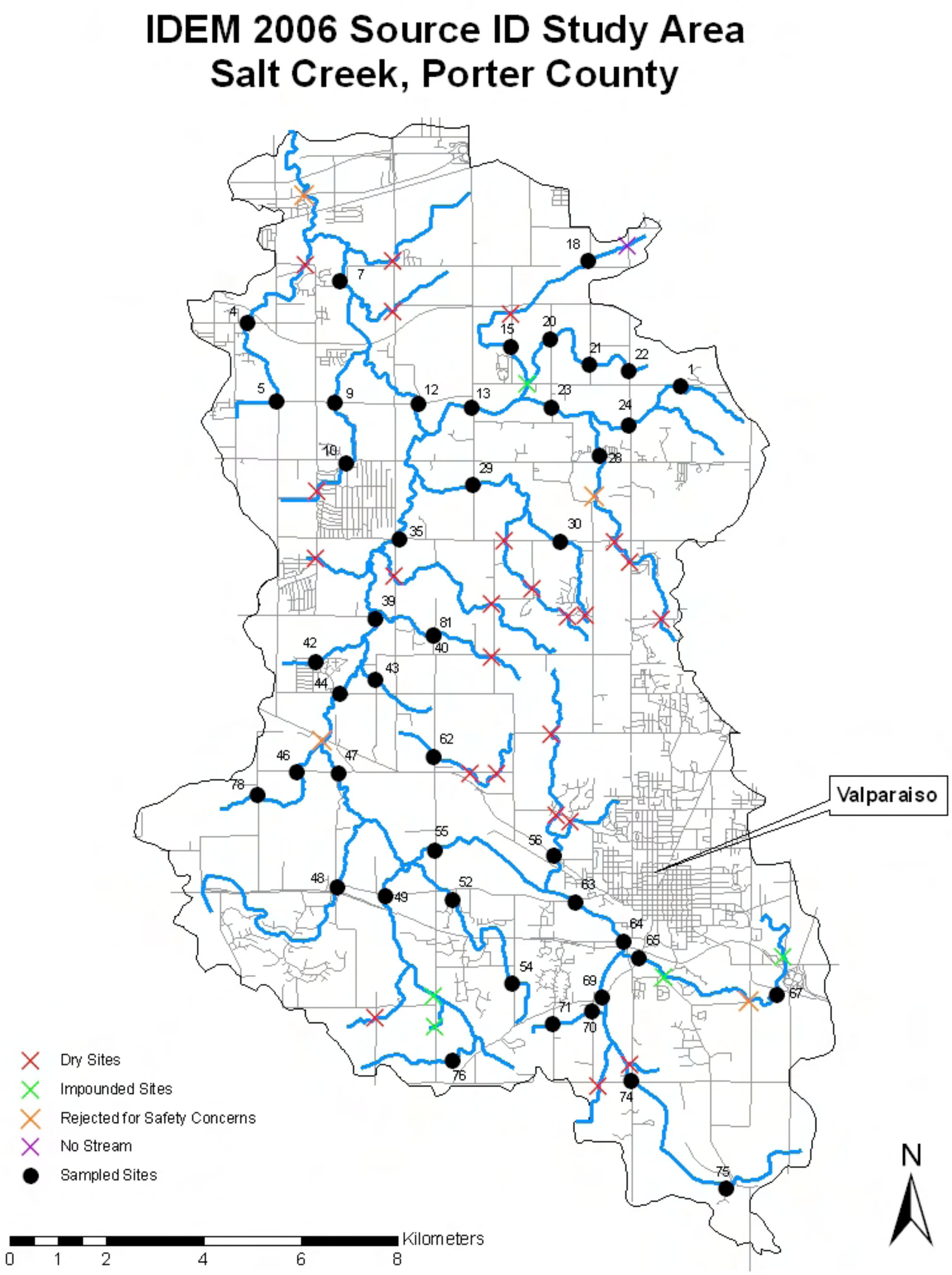

Figure 31. IDEM 2006 biotic community assessment/intensive survey sampling sites (IDEM, 2006b)

Compared to fish community data, macroinvertebrate communities rated higher in biotic assessments, but still exhibited some signs of impairment. In 1990, IDEM sampled macroinvertebrate communities at five sites in the Salt Creek watershed. Macroinvertebrate Index of Biotic Integrity (mIBI) scores ranged from 2.4 to 4.4. None of the scores were below the value (2.2) at which IDEM considers streams to be non-supporting of their aquatic life use designation. However, most scores fell within the ranges indicating moderate or slight impairment, based on IDEM guidelines. IDEM sampled Damon Run again in 2000. The site rated a score of 3.8, which was higher than its 1990 score (2.4). In 2000, Damon Run rated higher in every individual metric except one (EPT Index). EPT taxa are defined as members of the Ephemeroptera, Plecoptera, and Trichoptera (mayfly, stonefly, and caddisfly) families, which are considered to be more pollution intolerant than most other stream-related macroinvertebrates.

In addition, dissolved oxygen (DO) data collected during the 2006 biotic community assessment/ intensive survey suggested high productivity rates throughout the watershed. In August 2006, dissolved oxygen concentrations at eight tributary sampling sites and two mainstem sampling sites did not meet Indiana's water quality standard (5.0 mg/L for tributaries and 6.0 mg/L for the Salt Creek mainstem). Most of the sites (approximately 58%) exhibited low percent dissolved oxygen saturations. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced.

Finally, habitat was generally poor throughout the watershed. IDEM assessed habitat during its macroinvertebrate studies in 1990 and 2000 and during its 2006 biotic community assessment/ intensive survey. Qualitative Habitat Evaluation Index (QHEI) scores in 2000 were relatively high, ranging from 49 (upstream of the Valparaiso Publicly Owned Treatment Works (POTW)) to 88 (downstream of Interstate 94). One score was less than the threshold (51) at which IDEM considers stream habitat to be poor. Habitat scores decreased during subsequent assessments. In 2000, the macroinvertebrate site in Damon Run rated a QHEI score of 61, a ten point decrease compared to its 1990 score (71). A decrease in substrate quality comprised the biggest change between the two sampling events. During the 2006 biotic community assessment/ intensive survey, QHEI scores ranged from 22 to 69, with a geometric mean of 43. Most of the sites (25 of 43 assessed) rated scores lower than the threshold (51) at which Indiana considers stream habitat to be poor. Common limitations for habitat quality included poor substrate, lack of instream cover, and lack of riffle development. Specific findings of historic assessments are included below with results of the current watershed sampling efforts.

3.2 Description of Water Quality Parameters

Because Salt Creek is within the Great Lakes system, water quality standards under Indiana Administrative Code (IAC) 327 IAC 2-1.5 apply. The mainstem of Salt Creek is designated as s salmonid stream (327 IAC 2-1.5-5) for which more stringent water quality standards apply for some parameters. The following is a brief description of the parameters analyzed during the stream sampling efforts:

Temperature
Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Water temperature also governs species composition and activity of aquatic biological communities. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The IAC (327 IAC 2-1.5-8) sets maximum temperatures to protect aquatic life for Indiana streams in the Great Lakes system according to the time of year. For warmwater streams in the Great Lakes system (the tributaries of Salt Creek), temperatures in May should not exceed 80 °F (26.7 °C) and temperatures from June through September should not exceed 90 °F (32.2 °C). Since the mainstem of Salt Creek is designated as a coldwater fishery stream the temperature should not exceed 70 °F (21.1 °C) at any time.

Dissolved Oxygen (DO)
Dissolved oxygen (DO) is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least three to five mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC (327 IAC 2-1.5-8) sets the minimum average DO concentrations at five mg/L per calendar day and no less than four mg/L at any time for Indiana streams in the Great Lakes system. Since the mainstem of Salt Creek is recognized as a coldwater fishery stream, DO should not fall below six mg/L at any time or below seven mg/L in areas where spawning occurs during the spawning season and in areas used for imprinting during the time salmonids are being imprinted. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than

100% saturation) the water with DO. Conversely, DO is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Conductivity

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). During low discharge, conductivity is higher than during high discharge because the water moves more slowly across or through ion containing soils and substrates during base flow. Carbonates and other charged particles (ions) dissolve into the slow-moving water, thereby increasing conductivity measurements.

Rather than setting a conductivity standard, the IAC sets a standard for dissolved solids (750 mg/L). Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 µmhos/cm per mg/L of dissolved solids roughly converts a dissolved solids concentration to specific conductance (Allan, 1995). Thus, converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 µmhos per mg/L yields a specific conductance range of approximately 1,000 to 1,360 µmhos/cm or µS/cm. This report presents conductivity measurements at each site in µmhos/cm.

pH

The pH of water describes the concentration of acidic ions (specifically H+) present in water. Water's pH determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC (327 IAC 2-1.5-8) establishes a range of six to nine pH units for the protection of aquatic life. pH concentrations in excess of nine are considered acceptable when the concentration occurs as daily fluctuations associated with photosynthetic activity.

Nutrients

Scientists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a stream. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy stream. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a stream. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a stream. Scientists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

Nutrients themselves, as well as the primary producers (algae and plants) they feed, can also affect the composition of secondary producer communities such as macroinvertebrates and fish. Changes in secondary producer communities can, in turn, impact the way chemical constituents in the water are processed. This is an additional reason for examining nutrient levels in an aquatic ecosystem.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is a measure of orthophosphate and is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are nitrate-nitrogen (NO_3), ammonium-nitrogen (NH_4^+), and total Kjeldahl nitrogen (TKN). Nitrate is a dissolved form of nitrogen that is commonly found in a rapidly moving stream or anywhere that oxygen is readily available. Because oxygen should be readily available in stream systems, nitrate-nitrogen is often the dominant dissolved form of nitrogen in stream systems. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like SRP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the total organic nitrogen (particulate) and ammonium-nitrogen in the water sample. (Note: TKN was not measured as part of this project; however, it is discussed as a reference point with regard to other collected parameters.)

While the USEPA has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of a stream. (The state, in conjunction with the USEPA, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for streams (USEPA, 2000a). While these are not part of the IAC, they serve as potential target conditions for which watershed managers might aim. The Ohio EPA (OEPA) has also made recommendations for numeric nutrient criteria in streams based on research on Ohio streams (OEPA, 1999). These, too, serve as potential target conditions for those who manage Indiana streams. Other researchers have suggested thresholds for several nutrients in aquatic ecosystems as well (Dodd et al., 1998). Lastly, the IAC requires that drinking waters of the state have a nitrate concentration of less than 10 mg/L, which is the drinking water standard for the state.

Researchers have recommended various thresholds and criteria for nutrients in streams. The USEPA's recommended targets for nutrient levels in streams are fairly low. The agency recommends a target total phosphorus concentration of 0.076 mg/L in streams (USEPA, 2000a). Dodd et al. (1998) suggest the dividing line between moderately (mesotrophic) and highly (eutrophic) productive streams is a total phosphorus concentration of 0.07 mg/L. The OEPA recommended a total phosphorus concentration of 0.08 mg/L in headwater streams to protect the streams' aquatic biotic integrity (OEPA, 1999). (This criterion is for streams classified as Warmwater Habitat, or WWH, meaning the stream is capable of supporting a healthy, diverse warmwater fauna. Streams that cannot support a healthy, diverse community of warmwater fauna due to "irretrievable, extensive, man-induced modification" are classified as Modified Warmwater Habitat (MWH) streams and have a different criterion.) While the entire length of Salt Creek and its tributaries may not fit the WWH definition, 0.08 to 0.1 mg/L is a good goal for the streams. The long term goal of this plan is to meet the total phosphorus target of 0.08 mg/L by 2028 as detailed in Section 4- Goals, Objectives, and Resources. The interim goal of this plan is to meet the total phosphorus target of 0.1 mg/L by 2018 as detailed in Section 4.

The USEPA sets aggressive nitrogen criteria recommendations for streams compared to the OEPA. The USEPA's recommended criteria for nitrate-nitrogen and total Kjeldahl nitrogen concentrations for streams in Aggregate Nutrient Ecoregion VII are 0.633 mg/L and 0.591 mg/L, respectively (USEPA, 2000a). In contrast, the OEPA suggests using nitrate-nitrogen criteria of 1.0 mg/L in WWH wadeable and headwater streams and MWH headwater streams to protect aquatic life. Dodd et al. (1998) suggests the dividing line between moderately and highly productive streams using nitrate-nitrogen concentrations is approximately 1.5 mg/L.

It is important to remember that none of the threshold or recommended concentrations listed above are Indiana standards for water quality. They are presented here to provide a frame of reference for the concentrations found in streams in the Salt Creek watershed. The IAC sets only nitrate-nitrogen and ammonia-nitrogen standards for waterbodies in Indiana. The IAC requires that drinking waters of the state have a nitrate-nitrogen concentration of less than 10 mg/L, which is the drinking water standard for the state. The IAC standard for ammonia-nitrogen depends upon the water's pH and temperature, since both can affect ammonia-nitrogen's toxicity. The draft 2006 303(d) list of impaired waterbodies listing criteria indicates that IDEM will include waterbodies with total phosphorus concentrations greater than 0.3 mg/L on subsequent lists of impaired waterbodies (IDEM, 2006a). The long term goal of this plan is to meet the nitrate target of 1.2 mg/L by 2028 as detailed in Section 4- Goals, Objectives, and Resources. The interim goal of this plan is to meet the nitrate target of 1.5 mg/L by 2018 as detailed in Section 4.

Total Suspended Solids (TSS)

A TSS measurement quantifies all particles suspended and dissolved in water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in water. In general, the concentration of suspended solids is greater in streams during high flow events due to increased overland flow and resuspension of previously settled or attached material. The increased overland flow erodes and carries more soil and other particulates to the stream. The sediment in water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks and poorly managed farm fields.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the stream bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. Few people are enthusiastic about having a picnic near a muddy creek. Pollutants attached to sediment also degrade water quality. In general, TSS concentrations greater than 80 mg/L have been found to be deleterious to aquatic life, although TSS concentrations between 25 and 80 mg/L have been known to reduce fish concentrations (Waters, 1995). The long term goal of this plan is to meet the TSS target of 25 mg/L by 2028 as detailed in Section 4. Goals, Objectives, and Resources. The interim goal of this plan is to meet the TSS target of 80 mg/L by 2018 as detailed in Section 4.

***E. coli* Bacteria**

E. coli is one member of a group of bacteria that comprise the fecal coliform bacteria and is used as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum concentration of *E. coli* at 235 colonies/ 100 mL in any one sample within a 30-day period. For data sets consisting of five equally spaced samples over a 30-day period, the geometric mean must not exceed 125 CFU/ 100mL and not more than one sample shall exceed 576 CFU/ 100 mL. For data sets consisting of 10 or more grab samples where no five of which are equally spaced over a 30-day period mot more than 10% of measurements shall exceed 576 CFU/ 100mL and not more than one sample shall exceed 2,400 CFU/mL

The long term goal of this plan is to meet the *E. coli* standard of 235 mg/L by 2028 as detailed in Section 4- Goals, Objectives, and Resources. The interim goal of this plan is to meet the *E. coli* standard of 576 CFU/ 100mL by 2018 as detailed in Section 4.

Macroinvertebrates

Benthic macroinvertebrates are “aquatic invertebrates that live in the bottom parts of our waters. They make good indicators of watershed health because they live in the water for all or most of their lives, stay in areas suitable for their survival, are easy to collect, differ in their tolerance to amount and types of pollution, are easy to identify in a laboratory, often live for more than one year, have limited mobility, and are indicators of environmental condition (USEPA, 2007).”

The benthic community in the streams was evaluated using IDEM’s macroinvertebrate Index of Biotic Integrity (mIBI). The mIBI is a multi-metric index that combines several aspects of the benthic community composition. As such, it is designed to provide a complete assessment of a creek’s biological integrity. Karr and Dudley (1981) define biological integrity as “the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region”. The mIBI consists of ten metrics (Table 2), which measure the species richness, evenness, composition, and density of the benthic community at a given site. The metrics include family-level HBI (Hilsenhoff’s FBI or family level biotic index; Hilsenhoff, 1988), number of taxa, number of individuals, percent dominant taxa, EPT Index, EPT count, EPT count to total number of individuals, EPT count to Chironomid count, Chironomid count, and total number of individuals to number of squares sorted. A classification score of zero, two, four, six, or eight is assigned to specific ranges for metric values. For example, if the benthic community being assessed supports nine different families, that community would receive a classification score of two for the “Number of Taxa” metric. The mIBI is calculated by averaging the classification scores for the ten metrics. mIBI scores of zero to two indicate the sampling site is severely impaired; scores of two to four indicate the site is moderately impaired; scores of four to six indicate the site is slightly impaired; and scores of six to eight indicate that the site is non-impaired.

IDEM developed the classification criteria based on five years of wadeable riffle-pool data collected in Indiana. Because the values for some of the metrics can vary depending upon the collection and subsampling methodologies used to survey a stream, it is important to adhere to the collection and subsampling protocol IDEM used when it developed the mIBI. Since the multihabitat approach detailed in the USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, Second Edition

(Barbour et al., 1999) was utilized in this survey to ensure adequate representation of all macroinvertebrate taxa, the mIBI at each site was calculated without the protocol dependent metrics of the mIBI (number of individuals and number of individuals to number of squares sorted). (Protocol dependent methods were defined by Steve Newhouse, IDEM, in personal correspondence.) Eliminating the protocol dependent metrics allows the mIBI scores at sites surveyed using different survey protocols to be compared to mIBI scores at sites sampled using the IDEM recommended protocol.

Table 2. IDEM benthic macroinvertebrate criteria used in evaluation of Indiana pool-riffle streams

	SCORING CRITERIA FOR THE FAMILY LEVEL MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (mIBI) USING PENTASECTION AND CENTRAL TENDENCY ON THE LOGARITHMIC TRANSFORMED DATA DISTRIBUTIONS OF THE 1990-1995 RIFFLE KICK SAMPLES				
	CLASSIFICATION SCORE				
	0	2	4	6	8
Family Level HBI	≥5.63	5.62- 5.06	5.05-4.55	4.54-4.09	≤4.08
Number of taxa	≤7	8-10	11-14	15-17	≥18
Number of individuals	≤79	129-80	212-130	349-213	≥350
Percent dominant taxa	≥61.6	61.5-43.9	43.8-31.2	31.1-22.2	<22.1
EPT index	≤2	3	4-5	6-7	≥8
EPT count	≤19	20-42	43-91	92-194	≥195
EPT count to total number of individuals	≤0.13	0.14-0.29	0.30-0.46	0.47-0.68	≥0.69
EPT count to chironomid count	≤0.88	0.89-2.55	2.56-5.70	5.71-11.65	≥11.66
Chironomid count	≥147	146-55	54-20	19-7	≤6
Total number of individuals to number of squares sorted	≤29	30-71	72-171	172-409	≥410

Where: 0-2 = Severely Impaired, 2-4 = Moderately Impaired, 4-6 = Slightly Impaired, 6-8 = Non-impaired

Although the IAC does not include mIBI scores as numeric criteria for establishing whether streams meet their aquatic life use designation, IDEM may be using mIBI scores to make this determination. (Under state law, all waters of the state, except for those noted as Limited Use in the IAC, must be capable of supporting recreational and aquatic life uses.) In the 2006 303(d) listing methodology, IDEM suggests that those waterbodies with mIBI scores less than 1.4 when using the multi-habitat approach are considered non-supporting for aquatic life use. Similarly, waterbodies with mIBI scores greater than 1.4 when assessed using the multi-habitat approach are considered fully supporting for aquatic life use (IDEM, 2006a). Under federal law, waters that do not meet their designated uses must be placed on the 303(d) list and remediation/restoration plans (TMDL plans) must be developed for these waters.

Habitat

The physical habitat at the sampling sites for each of the streams was evaluated using the Qualitative Habitat Evaluation Index (QHEI). The OEPA developed the QHEI for streams and rivers in Ohio (Rankin 1989, 1995). The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic (flowing water) macrohabitat (OEPA, 1989). While the OEPA originally developed the QHEI to evaluate fish habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general "habitat" health. The QHEI is composed of six metrics including substrate composition, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle-run quality, and map gradient. Observations of stream conditions along a 200 foot (61 meter) reach are recorded on the QHEI datasheet. Each metric is then scored individually then summed to provide the total QHEI score. The QHEI score generally ranges from 20 to 100. It should be noted that the reaches scored during the Salt Creek water quality assessment correspond with the water quality sampling sites. These sites were selected based on their proximity to the stream's outlet to Salt Creek and their ease in accessibility. The QHEI evaluates the characteristics of a 200 foot (61 meter) stream segment as opposed to the characteristics of the entire stream. Therefore, it must be noted that habitat assessed at each reach may not be representative of habitat present throughout the stream system or subwatershed. Rather the QHEI score represents the habitat present within that 200 foot (61 meter) reach.

Substrate type(s) and quality are important factors of habitat quality and the QHEI score is partially based on these characteristics. Sites that have greater substrate diversity receive higher scores as they can provide greater habitat diversity for benthic organisms. The quality of substrate refers to the embeddedness of the benthic zone. Because the rocks (gravel, cobble, and boulder) that comprise a stream's substrate do not fit together perfectly like pieces in a jigsaw puzzle, small pores and crevices exist between the rocks in the stream's substrate. Many stream organisms can colonize these pores and crevices, or microhabitats. In streams that carry high silt loads, the pores and crevices between rock substrate become clogged over time. This clogging, or "embedding", of the stream's substrate eliminates habitat for the stream's biota. Thus, sites with heavy embeddedness and siltation receive lower QHEI scores for the substrate metric.

In-stream cover, another metric of the QHEI, refers to the type(s) and quantity of habitat provided within the stream itself. Examples of in-stream cover include woody logs and debris, aquatic and overhanging vegetation, and root wads extending from the stream banks. The channel morphology metric evaluates the stream's physical development with respect to habitat diversity. Pool and riffle development within the stream reach, the channel sinuosity, and other factors that represent the stability and direct modification of the site comprise this metric score.

A stream's buffer, which includes the riparian zone and floodplain zone, is a vital functional component of riverine ecosystems. It is instrumental in the detention, removal, and assimilation of nutrients. Riparian zones govern the quality of goods and services provided by riverine ecosystems (OEPA, 1999). Riparian zone (the area immediately adjacent to the stream), floodplain zone (the area beyond the riparian zone that may influence the stream though runoff), and bank erosion were examined at each site to evaluate the quality of the buffer zone of the stream, the land use within the floodplain that affects inputs to the waterway, and the extent of erosion in the stream, which can reflect insufficient vegetative stabilization of the stream banks. For the purposes of the QHEI, a riparian zone consists only of forest, shrub, swamp, or woody vegetation. Typically, weedy, herbaceous vegetation has higher runoff potential than woody components and does not represent an acceptable riparian zone type for the QHEI (OEPA, 1989). Streams with grass or other herbaceous vegetation growing in the riparian zone receive low QHEI scores for this metric.

Metric five of the QHEI evaluates the quality of pool/glide and riffle/run habitats in the stream. These zones in a stream, when present, provide diverse habitat and, in turn, can increase habitat quality. The depth of pools within a reach and the stability of riffle substrate are some factors that affect the QHEI score in this metric.

The final QHEI metric evaluates the topographic gradient in a stream reach. This is calculated using topographic data. The score for this metric is based on the premise that both very low and very high gradient streams will have negative effects on habitat quality. Moderate gradient streams receive the highest score, 10, for this metric. The gradient ranges for scoring take into account the varying influence of gradient with stream size.

The QHEI evaluates the characteristics of a 200 foot (61 meter) stream segment as opposed to the characteristics of the entire stream. Therefore, it must be noted that the 200 foot (61 meter) segment is in some cases only representative of a small fraction of the streams/headwaters within the sampling site's subwatershed. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are generally conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (OEPA, 1999). IDEM indicates that higher QHEI scores represents more diverse habitat for colonization by macroinvertebrates. Scores below 51 suggest that poor habitat may be limiting biota within the association stream.

3.3 Sampling Sites and Events

To update historical water quality assessments and supplement on-going and watershed-wide sampling completed by IDEM, the Salt Creek Watershed Group completed water chemistry and physical habitat sampling at 14 stream sites within the Salt Creek watershed. Biological community sampling was completed at 8 of these sites. Water chemistry samples were collected eight times from each of the 14 stream sites (Figure 32, **Error! Reference source not found.**). Sampling sites were selected based upon land use, site accessibility and historic data, including information from IDEM on past and current water sampling sites. The subwatersheds draining to each sampling site are shown in Figure 33. Sampling site 15 is on the mainstem of Salt Creek and encompasses subwatersheds 1-7 (Figure 34). Sampling sites 14 and 16 are on the mainstem of Salt Creek and encompass subwatersheds 1-13. The coordinates of each sampling site are located in Table 3.

Table 3. Locations of stream sampling sites

Site	Sample Type	Stream Name	Northing	Easting
1	Chemistry	Lake Louise Outlet	488456.931	4590817.180
2	Chemistry & Macroinvertebrate	Clark Ditch	489454.004	4590849.288
3	Chemistry	Unnamed tributary at Weblos Trail	490825.103	4590822.367
4	Chemistry	Block Ditch	493721.695	4588583.864
5	Chemistry & Macroinvertebrate	Salt Creek Headwaters (SR2)	493914.086	4588865.241
6	Chemistry	Sager's Lake Outlet	494703.154	4589688.006
7	Chemistry & Macroinvertebrate	Beauty Creek	492991.193	4591681.575
8	Chemistry & Macroinvertebrate	Pepper Creek	489238.334	4595402.327
9	Chemistry & Macroinvertebrate	Unnamed tributary at Mallard's Landing	491284.849	4599384.282
10	Chemistry & Macroinvertebrate	Butternut Springs Outlet	489646.502	4597499.319
11	Chemistry	Squirrel Creek	488465.775	4601083.626
12	Chemistry	Robbin's Ditch	486634.701	4602711.162
13	Chemistry & Macroinvertebrate	Damon Run	491395.036	4600937.863
14	Chemistry & Macroinvertebrate	Salt Creek (Lenburg Road)	488657.246	4603543.697
15	IDEM Fixed Station	Salt Creek (SR130)	488184.878	4594133.898
16	IDEM Fixed Station	Salt Creek (US 20)	487847.107	4605335.589

The Salt Creek supplemental sampling included a range of hydrologic conditions. Six of the sampling events were utilized to characterize "baseflow" or "normal" streamflow conditions, the remaining two events were to characterize storm event runoff. To be considered a storm event sampling had to meet the criteria of either one inch or more of rain in a 24-hour period or rainfall events of greater than 0.75 inch if soils were saturated from previous rainfall. For this analysis, May 16 and June 19, 2007 were considered storm events. Personal observations indicate neither of these events produced the expected runoff/streamflow. The reasons for the lack of streamflow include a combination of the lack of antecedent moisture and low baseflow, and inconsistent weather conditions across the watershed.

The numeric values of the water quality parameters reported in this version of SCWMP reflect the preponderance of base flow samples and are likely not representative of the extent and magnitude of their volume (loadings). Supplemental and historic data were utilized to identify and rank problems and areas relative to each other. The calculated load reductions necessary to meet goals are likely lower than will be necessary to reach watershed wide water quality goals due to the preponderance of base flow data utilized to calculate averages, exceedances, and loadings.

A total of six base flow samples were collected between May 7, 2007 and July 24, 2007. All sampling events represent a snapshot in time, and thus, data resulting from these snapshots should be used for prioritization and comparison between sites where data were collected under similar sampling conditions. If temperature, precipitation, or environmental factors were to change within in the stream during sampling, the data and resultant prioritization may be different than the information presented below. Biological communities in eight of the 14 original stream sites were assessed once in the summer (August 22, 2006) and once in the spring (May 29, 2007). Habitat availability of each reach was assessed once during the study period (August 22, 2006). To ensure comparability to data collected previously by IDEM, SDCF followed similar stream sampling protocols. The stream sampling and the appropriate quality assurance/quality control procedures are referenced in the project's Quality Assurance Project Plan (QAPP). The project QAPP was originally approved by IDEM on August 7, 2006 and amended on April 25, 2007. Appendix M contains the raw data collected during the stream assessments. Appendix N includes the macroinvertebrate communities present within the Salt Creek watershed streams and exhibits the habitat assessment QHEI scores attributed to each reach.

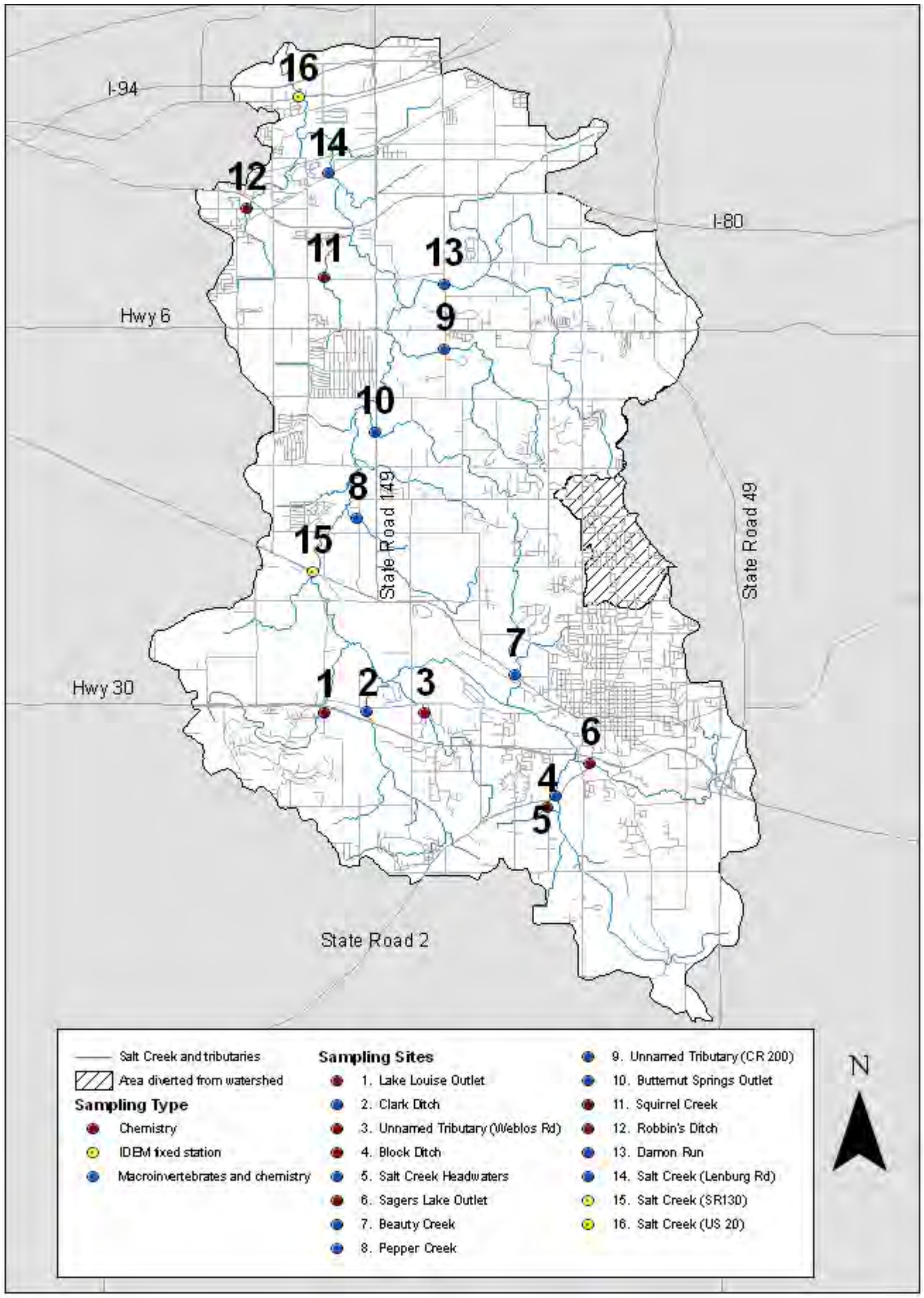

Figure 32. Map of stream sampling sites (Source: See Appendix R)

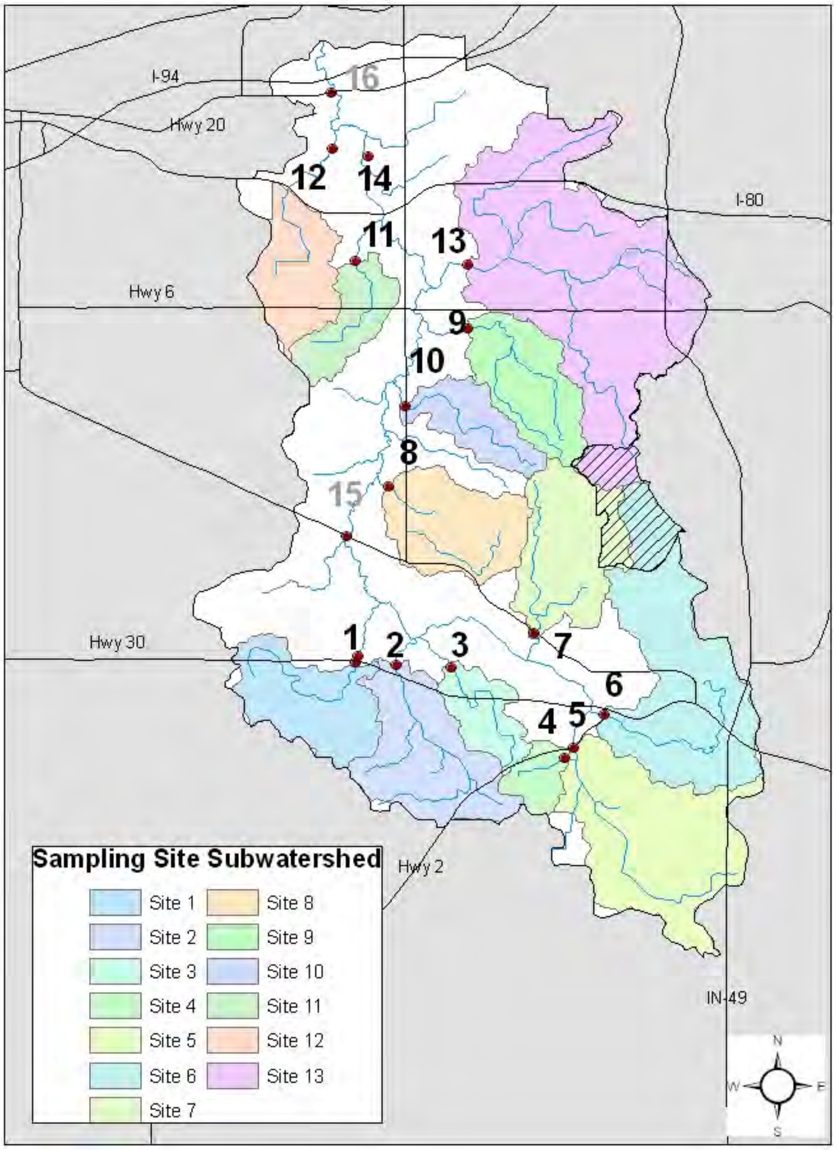

Figure 33. Subwatersheds of sites 1-13 (Source: See Appendix R)

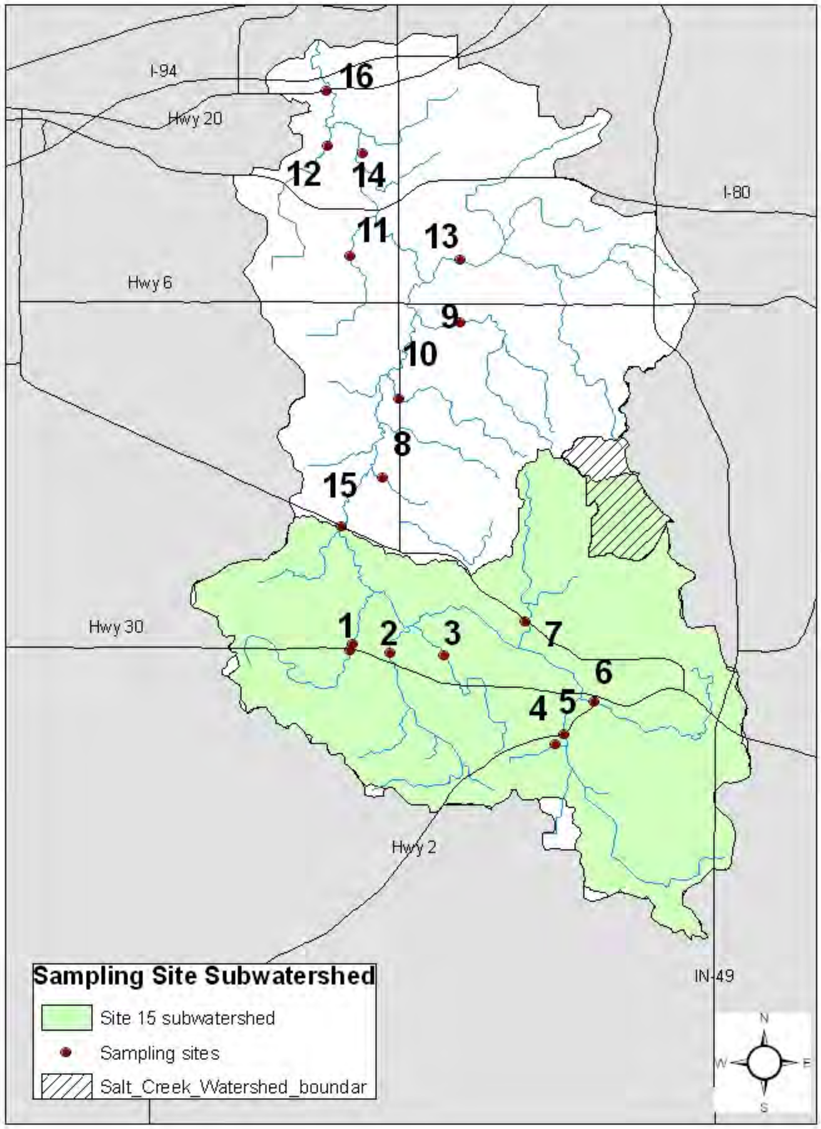

Figure 34. Subwatershed draining to sampling site 15 (Source: See Appendix R)

3.4 Water Quality Data by Sampling Site

The following descriptions provide additional detail about each sampling site, why it was selected, and a summary of the data collected. Salt Creek data are compared to Indiana state water quality standards (IAC, 2008) where available. Suspended solids data were compared to guidelines published in Waters (1995). Otherwise, data were compared to the OEPA standards or recommendations in order to evaluate impairments. Photos of locations were all taken looking upstream. Sampling sites 2, 5, 7, 8, 9, 10, 13, and 14 were selected for benthic macroinvertebrate sampling. When there are revisions to existing Indiana water quality standards or establishment of new ones, the goals of the SCWMP will be evaluated and modified accordingly. Additional water quality or habitat information may be needed to support modification of the watershed management plan's goals.

Site 1: Lake Louise Outlet

Site 1 is located along the outlet stream from Lake Louise within the Salt Creek Headwaters north of U.S. Highway 30 in the Clark Ditch subwatershed (Figure 35). Samples from site 1 reflect water quality in Salt Creek as it leaves Lake Louise before it enters the mainstem of Salt Creek. Site 1 provides information regarding the ability of Lake Louise to assimilate the pollution generated by the Shorewood Forest residential development and the rest of its drainage on Salt Creek water quality. The subwatershed draining to site 1 includes the following land covers: developed (33%), forest (29%), cultivated crops (13%), open water (12%), grassland/herbaceous (7%), pasture/hay (6%), and other (1%). See Section 2.10- Land Use for information on land cover classifications.

Figure 35. Sampling site 1 - Lake Louise Outlet (June, 2006)

Historic water quality in Lake Louise Outlet
IDEM sampled the Lake Louise Outlet during the 2000 Salt Creek Assessment and during the 2006 biotic community assessment/ intensive survey. As with most of the watershed, *E. coli* levels were high in the Lake Louise Outlet. The geometric mean (956 CFU/100 mL) ranked as the second highest among the 16 study sites included in the current study. Likewise, conductivity measurements ranked as the third highest of the sites with a geometric mean of 934 µmhos/cm. None of the conductivity measurements exceeded the Indiana state standard. During 2006, the Lake Louise Outlet exhibited high nutrient concentrations as well. The total phosphorus concentration (0.2 mg/L) ranked among the highest 25% of the 45 sites assessed during the 2006 biotic community assessment/ intensive survey. The nitrate+nitrite concentration (5.7 mg/L) was the highest concentration measured during the biotic community assessment/ intensive survey. Habitat was generally good when assessed in August 2006. The site ranked in the top third of the 43 sites assessed with a QHEI score of 54. This score was higher than the threshold at which Indiana considers habitat to be poor. Instream cover and the lack of pool and riffle development limited habitat quality at the Lake Louise Outlet. Despite the quality of habitat, fish communities were impaired. Four species were collected at the site, with tolerant (97.0%) and omnivorous (90.9%) species dominating the fish community. These characteristics and the low species diversity contributed to an IBI score of 18. This score falls within the "very poor" integrity class for the Central Corn Belt Region (12-22) and is lower than the value (36) at which IDEM considers streams to be non-supporting of their aquatic life use designation. However, this score was typical for sites assessed in the study. It should be noted that there could be unknown impacts on the Salt Creek ecosystem from fish stocking activities. More information on this issue may be found in Section 3.6.5- Potential Unverified and Other Sources, Indiana Salmonid Stocking.

Water quality in Lake Louise Outlet (site 1)
Site 1 exhibited some of the poorest water quality of all tributaries assessed. Average measurements for total phosphorus (0.170 mg/L), ammonia-nitrogen (1.01 mg/L), nitrate-nitrogen (2.32 mg/L), and *E. coli* (2,670 CFU/100 mL) were among the highest measured in the watershed. Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during all sampling events. The average total phosphorus concentration was the second highest among all 14 sites. Orthophosphate concentrations were similarly high. Much of the phosphorus was in the particulate form, with orthophosphate comprising between 7.5 and 44% of total phosphorus concentrations. When standardized with flow, both orthophosphate and total phosphorus loading rates (0.231 kg/d and 0.848 kg/d, respectively) ranked near the median when compared to all sites assessed. Conversely, areal loading rates were among the highest of all sites. Site 1 exhibited the highest average orthophosphate areal loading rate (0.000106 kg/ac/d) and the third highest average total phosphorus areal loading rate (0.000469 kg/ac/d of all tributaries.

Consistent with historic data, average *E. coli* concentrations were among the highest of all sampling sites (2,670 CFU/100 mL). The highest concentration measured during the sampling period was measured at Site 1 (19,000 CFU/100 mL) during the May 16 stormflow event. *E. coli* levels exceeded state standards (235 CFU/100 mL) in four of the eight collected samples. The two highest measured concentrations occurred in early to mid-May, including one storm event. Samples collected in mid-June and early July exceeded the state standard twice but were less than half the concentration measured in earlier samples and were also lower than concentrations at other sites during the same sampling events. Lake Louise's increased residence time in summer and fall likely helps account for this variability in *E. coli*.

Ammonia-nitrogen concentrations were the highest on average of all sites (1.014 mg/L). Ammonia-nitrogen concentrations at site 1 were routinely among the highest observed at all sites for all sampling events. High ammonia-nitrogen concentrations typically indicate high decomposition rates occurring in the stream. Nitrate-nitrogen concentrations were similarly high, exceeding the level at which the OEPA determined streams would support modified warmwater habitat (1.6 mg/L) six times of the nine samples collected. The average nitrate concentration (2.32 mg/L) ranked as the second highest among all sites sampled. When standardized for flow, the Lake Louise Outlet also exhibited the highest average loading (5.44 and 11.7 kg/d, respectively) and the highest and second highest areal loading rates (0.007308 kg/ac/d and 0.002978 kg/ac/d, respectively) of all tributaries for both nitrate and ammonia. For both ammonia and nitrate, loading rates routinely measured more than five times the levels calculated for most other sites during the same sampling event. This suggests that reducing nitrogen loads in the Lake Louise Outlet would also cause measurable decreases in nitrogen concentrations within Salt Creek.

During both base flow and storm flow conditions, none of the samples collected within the Lake Louise Outlet violated the Indiana state standards for temperature, dissolved oxygen, pH, or conductivity. Total suspended solids concentrations measured less than the level (25 mg/L) determined to reduce fish yields (Waters, 1995). Although dissolved oxygen concentrations did not violate Indiana state standards, they were relatively low compared to other sites (fifth lowest) and exhibited signs that decomposition is affecting stream oxygen levels. Low dissolved oxygen levels lend further credence to the idea that decomposition rates are high in the Lake Louise Outlet (previously discussed with the high ammonia-nitrogen concentrations). The stream exhibited undersaturated DO conditions for all sampling events, with saturation levels ranging between 61 and 76%. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen faster than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. As flow through the Lake Louise outlet is relatively slow, it is likely that low saturation results from a combination of both of these factors.

Physical habitat at site 1 was poor. The stream had a QHEI score of 45.5. This score fell below the threshold (51) at which IDEM typically considers stream habitat to be poor. Physical habitat at the site was limited by instream cover, narrow riparian zones, and lack of pool and riffle development. No macroinvertebrate samples were collected by SDCF at site 1.

Site 2: Clark Ditch

Site 2 is located on Clark Ditch at Joliet Road before the ditch enters Salt Creek's mainstem (Figure 36). Samples from site 2 reflect water quality in the southwestern rural residential portion of the watershed. Benthic macroinvertebrates were sampled at site 2. The subwatershed draining to site 2 includes the following land covers: forest (39%), pasture/hay (18%), developed (14%), cultivated crops (13%), grassland/herbaceous (13%), and other (2%). See Section 2.10- Land Use for information on land cover classifications.

Figure 36. Sampling site 2 - Clark Ditch (June, 2006)

Historic water quality in Clark Ditch (site 2)
IDEM sampled Clark Ditch during the 2000 Salt Creek Assessment and during the 2006 biotic community assessment/ intensive survey. *E. coli* levels exceeded the Indiana state standard (235 CFU/100 mL) during all of the five sampling events in 2000. The geometric mean for *E. coli* was 551 CFU/100 mL. Conductivity was relatively high but the geometric mean (826 µmhos/cm) ranked near the middle of the 16 sites included in the study. When assessed in August 2006, nutrient concentrations were low compared to other sites. The total phosphorus concentration ranked near the middle of all 45 sites assessed during the 2006 biotic community assessment/ intensive survey, but was greater than the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L). Concentrations of ammonia-nitrogen (below detection limits) and nitrate+nitrite (0.3 mg/L) both measured below water quality standards. When assessed in August 2006, habitat was poor compared to Indiana guidelines, but was not abnormal compared to other Salt Creek sites. Clark Ditch rated a QHEI score of 45, which ranks near the middle of scores for the 43 assessed sites. The score measured below the value (51) at which IDEM considers habitat to be poor. Instream cover, channel development, riparian zone quality, and lack of pool and riffle development limited habitat quality at Clark Ditch. Fish communities were similarly poor compared to standards. Eight species were collected during the assessment, which rated in the top 25% of all sites assessed. Tolerant (83.8%) and pioneer species (69.4%) dominated the fish community. Pioneer fish species dominate unstable environments affected by anthropogenic stresses and are the first to re-colonize sections of headwater streams after desiccation (Simon, 1991). Overall, the fish community rated poorly with an IBI score of 28. This score falls within the "poor" integrity class for the Central Corn Belt Region (28-34), as designated by Simon (1991). Based on IDEM guidelines, the stream was non-supporting of its aquatic life use designation. Despite the poor score, the site ranked within the top 25% of all 43 sites assessed during the study.

Water Quality in Clark Ditch (site 2)
For most parameters studied, Clark Ditch exhibited relatively good water quality. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana's state water quality standards. These data are consistent with data collected during historic

sampling events. However, total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during six of eight sampling events (0.082 mg/L to 0.191 mg/L). Orthophosphate was similarly high, comprising between 20 and 100% of the total phosphorus concentration. While total phosphorus concentrations did exceed OEPA standards, the average total phosphorus concentration (0.127 mg/L) and loading rate (0.628 kg/d) were relatively low compared to other sites.

E. coli concentrations exceeded the Indiana state standard (235 CFU/100 mL) during seven of the eight sampling events. *E. coli* levels routinely measured at concentrations more than 3.5 times the Indiana state standard, ranging from 150 CFU/100 mL during the May 7 baseflow event to 2,300 CFU/100 mL during the June 5 baseflow event. Measured *E. coli* concentrations increased during May, then remained relatively constant during the rest of the sampling period. As with total phosphorus, *E. coli* concentrations were higher than state standards. However, concentrations were relatively average when compared to other watershed streams.

Suspended solids were the main parameter of concern in Clark Ditch. The average concentration (23 mg/L) ranked as the third highest among all tributaries sampled. Additionally, concentrations exceeded levels found to impair biotic communities (25 mg/L) during four of the eight sampling events. The average loading rate (106 kg/d) for suspended solids ranked fourth highest of all tributaries. This suggests that suspended solids reduction techniques should be the focus when targeting management options for this subwatershed.

Clark Ditch exhibited generally degraded physical habitat. The site rated a QHEI score of 36.5, which places it below the value (51) at which IDEM considers habitat to be poor. Habitat was limited by poor substrate, instream cover, narrow riparian zones, and lack of pool and riffle development. Despite the poor habitat, Clark Ditch exhibited some of the best biological communities of the eight sites assessed. Family-level Hilsenhoff Biotic Index (HBI) scores for Clark Ditch measured 4.31 in August 2006 and 5.50 in May 2007. These scores indicate “fair” to “good” water quality with some organic pollution likely. In August 2006, the stream rated a mIBI score of 5.6, which was the highest score of all eight sites assessed. In May 2007, the stream rated a mIBI score of 3.8. Both mIBI scores were above the level (2.2) at which IDEM considers streams to be non-supporting of their aquatic life use designation. The scores indicated slight and moderate impairment based on IDEM guidelines. A type of caddisfly (Trichoptera family Hydropsychidae) dominated the community (72%) during the August 2006 sampling event. Conversely, caddisflies comprised less than 3% of the community during the May 2007 sampling event. Since caddisflies typically indicate good water quality, their relative scarcity during the May 2007 event compared to the August 2006 sampling event was the primary contributor to the lower mIBI score. However, a lack of other indicators of good water quality suggests that macroinvertebrate communities are moderately impaired in Clark Ditch and that this impairment is likely due to limited habitat present along this reach and elevated total suspended solids and *E. coli* concentrations.

Site 3: Unnamed tributary at Weblos Trail

Site 3 is located on an unnamed tributary of Salt Creek (Figure 37) at Weblos Trail, hereafter referred to as Weblos Trail Tributary. The tributary is a regulated drain. Samples from site 3 reflect water quality in the southern-central rural residential portion of the watershed. Site 3 is surrounded by residential development and has limited protection from impacts because of narrow riparian buffers. The subwatershed draining to site 3 includes the following land covers: forest (32%), developed (27%), grassland/herbaceous (18%), cultivated crops (11%), pasture/hay (10%), and other (3%). See Section 2.10- Land Use for information on land cover classifications.

Figure 37. Sampling site 3 - Weblos Trail Tributary (June, 2006)

Historic water quality in Weblos Trail Tributary (site 3)
IDEM sampled the Weblos Trail Tributary during the 2005 Corvallis *E. coli* assessment and in 2006 during the IDEM biotic community assessment/ intensive survey. *E. coli* levels were among the highest of all samples collected during all studies. All *E. coli* samples collected at site 3 exceeded the Indiana state standard (235 CFU/100 mL). The geometric mean (1,556 CFU/100 mL) ranked as the highest among the 16 study sites included in the study. Conductivity was high (geometric mean of 846 µmhos/cm); however, the geometric mean ranked near the middle of study sites where historic data were available. During the 2006 biotic community assessment/ intensive survey, the Weblos Trail Tributary exhibited the highest total phosphorus concentration (0.97 mg/L) of the 45 biotic community assessment/ intensive survey sites. The total phosphorus level was more than ten times the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L). When assessed in August 2006, habitat was poor when compared to Indiana state guidelines but ranked near the median when compared to other sites. The Weblos Trail Tributary rated a QHEI score of 50. The score was lower than the value (51) at which IDEM considers habitat to be poor, but was within the top half of the 43 biotic community assessment/ intensive survey sites. Riparian zone quality and lack of pool and riffle development limited habitat quality in the Weblos Trail Tributary. Fish communities ranked among the best of all sites assessed in August 2006, but were poor compared with IDEM guidelines. Six species of fish were collected, with tolerant (86.5%) and pioneer (90.4%) species dominating the community. The fish community rated an IBI score of 30, which was within the top 25th percentile of the 43 biotic community assessment/ intensive survey sites. This score falls within the "poor" integrity class for the Central Corn Belt Region (28-34), as designated by Simon (1991). Based on IDEM guidelines, the stream was non-supporting of its aquatic life use designation.

Water Quality in Weblos Trail Tributary (site 3)
For many of the parameters measured, Weblos Trail Tributary exhibited relatively poor water quality. None of the samples collected exceeded Indiana's state water quality standards for temperature, dissolved oxygen, pH, ammonia-nitrogen, or nitrate-nitrogen. Additionally, none of the total suspended solids concentrations exceeded concentrations (25 mg/L) that can cause reduced fish yields. However, dissolved oxygen was low during the eight water quality assessment events. The average dissolved oxygen concentration (6.1 mg/L) was the second lowest of all sites. Undersaturated conditions were measured during all sampling events, with dissolved oxygen values ranging from 52 to 71%. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow is not turbulent enough to entrain sufficient oxygen. Flow is turbulent enough upstream of the sampling point that sufficient oxygen should be present. Therefore, the low dissolved oxygen saturation likely results from decomposition processes. Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L)

during seven of the eight sampling events. Orthophosphate accounted for between 23 and 99% of the total phosphorus concentration. While nutrient concentrations were high within the tributary, concentrations were not atypical for the watershed. The average total phosphorus (0.138 mg/L) and orthophosphorus (0.063 mg/L) concentrations ranked near the median of all sites. Additionally, the loading rates suggest that the stream is not a large source of nutrient loading to Salt Creek. When standardized for flow, the average total phosphorus loading rate (0.137 kg/d) at site 3 ranked as the lowest among all sites sampled. The average areal loading rates ranked as the lowest for nitrate and second lowest for ammonia among all sites sampled (0.000013 and 0.000106 kg/ac/d).

Consistent with historic conductivity data, the average conductivity measurement in Weblos Trail Tributary (970 µmhos/cm) ranked among the highest observed at all sites. Conductivity levels exhibited a general increase over the sampling period. For all samples collected after June 5, 2007, conductivity levels exceeded the Indiana state standard. Indiana maintains a state standard for total dissolved solids of 750 mg/L. This corresponds with conductivities between 1,000 and 1,360 µmhos/cm. The increase in conductivity corresponded with a general decrease in flow. Conductivity is usually driven by the amount of dissolved solids generated by geologic weathering and from other activities typically associated with urban areas. When flow decreases, the same amount of geologic weathering occurs but the amount of water that the solids dissolve in is less, causing concentrations to increase. Therefore, the increase in conductivity measurements is likely due to the decrease in flow and not from an increase in dissolved solids.

E. coli concentrations exceeded the Indiana state standard (235 CFU/100 mL) during seven of the eight sampling events. *E. coli* levels ranged from 100 CFU/100 mL during the May 7 baseflow event to 4,700 CFU/100 mL during the June 5 baseflow event. Concentrations remained fairly constant over the sampling period with little variation between baseflow and stormflow concentrations. Compared to other sites, Weblos Trail Tributary contained average *E. coli* concentrations. Additionally, *E. coli* concentrations are low compared to historic concentrations measured at this site. Historically, this tributary contained some of the highest *E. coli* concentrations measured with the average concentrations measuring one and one-half times the average concentration present during the current sampling period.

Nitrogen concentrations were lower than most other sites sampled in the watershed. Site 3 exhibited the lowest average nitrate-nitrogen concentrations (0.004 mg/L) and the fourth lowest ammonia-nitrogen concentrations (0.115 mg/L). When standardized for flow, average ammonia and nitrate loading rates (0.104 kg/d and 0.006 kg/d, respectively) in Weblos Trail Tributary were the lowest of all sites. Similarly, suspended solids concentrations were uniformly low, measuring less than 13 mg/L for all sampling events. The average suspended solids loading rate (9.419 kg/d) ranked as the lowest and the average areal loading rate (0.009896 kg/ac/d) ranked as second lowest among all sites sampled.

Habitat in Weblos Trail Tributary ranked near the median when compared to all sites. The site rated a QHEI score of 46, which places the site below the value (51) at which IDEM considers habitat to be poor. The site's habitat score was limited by instream cover, narrow riparian zones, low gradient, and a lack of riffles and pools. No macroinvertebrate samples were collected from this stream for this effort.

Site 4: Block Ditch

Site 4 (Figure 38) is located in Block Ditch just south of State Road 2 in the Sager's Lake subwatershed within the Salt Creek Headwaters. Block Ditch is a regulated drain. The subwatershed draining to site 4 includes the following land covers: cultivated crops (40%), forest (17%), pasture/hay (15%), developed (14%), grassland/herbaceous (11%), and other (2%). See Section 2.10- Land Use for information on land cover classifications. Block Ditch flows into the Salt Creek mainstem upstream of sampling site 5, therefore sampling site 4 is within the subwatershed draining to site 5.

Figure 38. Sampling site 4 - Block Ditch (June, 2006)

Historic water quality in Block Ditch (site 4)
IDEM sampled Block Ditch during the 2006 biotic community assessment/ intensive survey. Dissolved oxygen was low at the time of sampling. The stream exhibited undersaturated (<100%) conditions for dissolved oxygen with a percent saturation of 37.7%. The actual oxygen concentration (3.43 mg/L) was less than the concentration (5.0 mg/L) required to sustain aquatic biota. Nutrient concentrations rated among the best of the 16 sites included in the current study. Block Ditch measured total phosphorus and ammonia-nitrogen concentrations below the detection limit and the nitrate+nitrite concentration (0.12 mg/L) measured in the lower half of all 45 biotic community assessment/ intensive survey sites. Habitat was among the poorest assessed during the 2006 biotic community assessment/ intensive survey. The site had a QHEI score of 30. Only four out of the 43 biotic community assessment/ intensive survey sites rated lower QHEI scores than Block Ditch. The score fell below the threshold (51) at which IDEM considers stream habitat to be poor. Poor substrate, instream cover, channel development, riparian zone quality, and lack of pool and riffle development limited habitat quality in Block Ditch. Fish communities were similarly impaired based on IDEM guidelines. Six species were collected in Block Ditch with tolerant (94.1%) and omnivorous (58.8%) species dominating the community. Because of these characteristics, the site rated an IBI score of 20. This score fell within the "very poor" integrity class for the Central Corn Belt Region (12-22), as designated by Simon (1991). Based on IDEM guidelines, the stream was non-supporting of its aquatic life use designation. Although fish communities rated less than guideline values, the IBI score ranked as the median for the 43 sites assessed.

Water Quality in Block Ditch (site 4)
Although temperature, pH, conductivity, ammonia-nitrogen, and nitrate-nitrogen concentrations did not exceed Indiana state standards, Block Ditch exhibited some of the poorest water quality in the Salt Creek watershed. Consistent with historically-collected data, Block Ditch exhibited the lowest average dissolved oxygen levels (5.2 mg/L) among all sites. Five out of eight measurements violated Indiana state standards for dissolved oxygen (daily average of five mg/L) and only one measurement in June and July was sufficient to support aquatic biota. Oxygen saturation levels ranged from 42.1 to 64.4% during the sampling period. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. Flow is slow immediately upstream of the sampling point, suggesting that low saturation results from a combination of both of these factors.

Block Ditch exhibited the highest suspended solids concentrations in the watershed. Suspended solids concentrations exceeded the value (25 mg/L) found to reduce fish yields twice out of the eight sampling events. These two exceedances (120 mg/L during the May 16 stormflow event and 100 mg/L during the

July 5 baseflow event) ranked as the two highest concentrations measured among all sites during all sampling events. All other measurements ranged between 1.8 mg/L during the July 17 baseflow event and 18 mg/L during the July 24 baseflow event. Areal loading rates for suspended solids (0.073597 kg/ac/d) were high, ranking on average as the second highest among all tributaries. Conversely, average loading of suspended solid (38.2 kg/d) ranked as sixth lowest in the watershed. Total loading rates suggest that due to its small subwatershed, Block Ditch is not a large source of sediment to Salt Creek. However, Block Ditch contributes a larger amount of sediment per subwatershed acre than most other subwatersheds.

Large amounts of algae and duckweed were observed at this site. Total phosphorus concentrations were also high in Block Ditch, measuring at or exceeding the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during four of the eight sampling events. The highest concentration (0.740 mg/L) measured during the sampling period was measured at site 4 during the May 16 stormflow event. Orthophosphate accounted for less than 50% of the total phosphorus concentration in Block Ditch for all sampling events. This suggests that much of the phosphorus was present in Block Ditch in the particulate form. The average areal loading rates for total phosphorus (0.000553 kg/ac/d) and ammonia (0.000995 kg/ac/d) measured in Block Ditch ranked as the highest among all tributaries. However, the average total phosphorus loading rate (0.259 kg/d) ranked as third lowest in the watershed. As with suspended solids, this suggests that while total phosphorus concentrations are relatively low within Block Ditch, the Block Ditch subwatershed delivers more total phosphorus and ammonia to Salt Creek per acre than most other subwatersheds.

Conversely, the average *E. coli* concentration in Block Ditch ranked as the second lowest in the watershed (299 CFU/100 mL). Block Ditch also possessed the second fewest number of exceedances of the state standard in the watershed. *E. coli* levels exceeded the Indiana state standard (235 CFU/100 mL) twice during the sampling period: once during stormflow conditions (1,000 CFU/100 mL on June 19) and once during baseflow conditions (560 CFU/100 mL on June 5).

Physical habitat in Block Ditch was among the worst in the watershed. The site rated a QHEI score of 30.5. This score ranked as the second-worst among all sites and fell below the threshold (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, instream cover, lack of pools and riffles, and low gradient. No macroinvertebrate samples were collected for this effort.

Site 5: Salt Creek Headwaters

Site 5 (Figure 39) is located in the headwaters of Salt Creek south of State Road 2. Sampling site 5 is located on a regulated drain. Adjacent to the site are the Porter County Highway Department Facility and the Porter County Animal Control Facility. The subwatershed draining to site 5 includes the following land covers: forest (32%), cultivated crops (27%), pasture/hay (17%), developed (13%), grassland/herbaceous (9%), and other (2%). See Section 2.10- Land Use for information on land cover classifications. Block Ditch flows into the Salt Creek mainstem upstream of sampling site 5, and sampling site 4 is within the subwatershed draining to site 5. Because Site 5 is located on the mainstem of Salt Creek, coldwater fishery water quality standards apply (327 IAC 2-1.5-5).

Figure 39. Sampling site 5 - Salt Creek Headwaters (June, 2006)

Historic water quality in Salt Creek Headwaters (site 5)

IDEM sampled the Salt Creek Headwaters during the 2000 Salt Creek Assessment. Dissolved oxygen was low during most of the sampling events with undersaturated (<100%) conditions typically present. During three of the four sampling events, dissolved oxygen saturation levels measured less than 75%. When streams are less than 100% saturated, decomposition processes may be consuming oxygen faster than it can be replaced or water may not be turbulent enough to entrain sufficient oxygen. Given the relatively constant flow through this stream, turbulent conditions likely occur through much of the stream length, suggesting that decomposition processes are the primary cause for the low DO levels. *E. coli* concentrations exceeded the Indiana state standard (235 CFU/100 mL) during three of the five sampling events. The geometric mean ranked in the lower half of the 16 sites included in the current study. Turbidity levels were among the highest of all sites assessed. The geometric mean for turbidity ranked as the second highest of all sites assessed. On October 25, 2000, turbidity in the stream measured 158 nephelometric turbidity units (NTU), which was higher than the level (20 NTU) designated by Walker (1978) for undesirable changes in aquatic life to occur. Conversely, the geometric mean for conductivity ranked as the lowest of all sites assessed.

Habitat upstream of site 5 was generally poor, ranking in the bottom half of all sites assessed during the biotic community assessment/ intensive survey. The site rated a QHEI score of 34, which was lower than the threshold (51) at which IDEM considers stream habitat to be poor. Habitat was limited by poor substrate, instream cover, and lack of pool and riffle development. Fish communities were also poor upstream of the Salt Creek Headwaters. IDEM sampled the site in 1990 and as part of the 2006 biotic community assessment/ intensive survey. During the 1990 assessment, the site rated an IBI score of 16, which was less than the value at which IDEM considers streams to be supporting of their aquatic life use designation. This score ranked as the second lowest when compared with other watershed sites assessed during the same study. Five species were collected during the 1990 sampling event with tolerant and omnivorous species dominating the community (55.6% for both categories). Conversely, tolerant species were absent from the community and insectivorous species (87.5%) dominated the community during the 2006 biotic community assessment/ intensive survey. However, only three species were collected at the site with pioneer species comprising a majority of the community (75%). Therefore, the site rated an IBI score of 18, which fell in the lower half of all sites assessed. Both the 1990 and the 2006 scores placed the fish community in the “very poor” integrity class for the Central Corn Belt Region (12-22) as designated by Simon (1991). Based on IDEM guidelines, the stream was non-supporting of its aquatic life use designation.

Water Quality in Salt Creek Headwaters (site 5)
Water quality in the Salt Creek Headwaters ranked among the poorest of all sites. While the site did not exceed state standards for temperature, pH, or conductivity; the site exhibited some of the highest nutrients, suspended solids, and *E.coli* levels observed in the watershed. Because the mainstem of Salt Creek is designated as a colwater fishery, DO should not fall below 6 mg/L at any time (327 IAC 2-1.5). DO was below this standard during three events in mid-June and early July at site 5. This is somewhat consistent with historic data where dissolved oxygen concentrations were low, while nutrient and pathogen concentrations were elevated. The average total phosphorus concentration (0.140 mg/L) ranked near the median when compared to all other sites. Total phosphorus concentrations were at or exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during six of the eight sampling events. With the exception of two sampling events, orthophosphate comprised between 16 and 30% of the total phosphorus concentration. This suggests that phosphorus was typically present at this site in its particulate form. Nitrogen concentrations were also normal compared to other sites. The average ammonia-nitrogen concentration (0.14 mg/L) and the average nitrate-nitrogen concentration (0.276 mg/L) ranked near the middle of all tributaries. While nitrogen and phosphorus concentrations were relatively normal when compared with other watershed sites, the Salt Creek Headwaters exhibited some of the highest loading rates and areal loading rates for these parameters in the watershed. Among all tributaries assessed, this site exhibited the second highest average total phosphorus loading rate (1.978 kg/d), the third highest average ammonia loading rate (3.520 kg/d), and the fourth highest average nitrate loading rate (2.143 kg/d). This suggests that, while nitrogen and phosphorus concentrations were not high compared to other sites, the Salt Creek Headwaters is one of the largest sources of nutrients to the Salt Creek.

Suspended solids concentrations exceeded levels shown to cause impairments to biotic communities (25 mg/L) during five of the eight sampling events. TSS concentrations increased during storm events. This is typical of most streams since greater amounts of runoff result in increased overland flow which generally results in stream that carry greater loads of sediment. Additionally, the average loading rate (392 kg/d) and the average areal loading rate (0.077947 kg/ac/d) ranked as the highest among all tributaries assessed. This indicates that Salt Creek Headwaters is the largest single source of suspended solids in the Salt Creek watershed. When data from Block Ditch (site 4), which drains to site 5, are taken into account, the sources of suspended solids become somewhat more apparent. The Block Ditch subwatershed is a large source of suspended sediment to the stream itself contributing more suspended sediment per acre of drainage than other Salt Creek drainages.

E. coli and dissolved oxygen levels were also observed at levels of concern. The average *E. coli* concentration (1,466 CFU/100 mL) was the highest of all sites. Concentrations exceeded the Indiana state standard (235 CFU/100 mL) during all sampling events. Concentrations ranged from 260 CFU/100 mL (during the May 22 baseflow event) to 4,900 CFU/100 mL (during the June 19 stormflow event). The stream was undersaturated with oxygen for all sampling dates, with saturations ranging from 58 to 71%. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. Given the relatively constant flow through this stream, turbulent conditions likely occur through much of the stream length, suggesting that decomposition processes are the primary cause for the low DO levels. Saturations remained relatively constant throughout the sampling period. However, since warmer water can contain lower concentrations of oxygen than colder water, dissolved oxygen concentrations decreased over the sampling period.

Physical habitat scores for the Salt Creek Headwaters fell below IDEM guidelines but were better than scores at most other streams. Salt Creek Headwaters rated a QHEI score of 45, which ranked near the median of all sampling sites. This score fell below the threshold (51) at which IDEM considers habitat to be poor. Habitat was limited by poor substrate, instream cover, narrow riparian zones, and poor pool development. This site was one of only four sites with observed pools and riffles. Likewise, the biological community was better than average in the watershed but still exhibited signs of impairment. Family-level HBI scores measured 4.64 in August 2006 and 5.48 in May 2007. These scores indicate “fair” to “good” water quality with some organic pollution probable. In August 2006, the stream rated a mIBI score of 2.1, placing it below the value (2.2) that IDEM considers supporting of its aquatic life use designation. In May 2007, the stream rated a mIBI score of 4.7, the highest score of the eight sites assessed during the 2007 sampling event. This score indicates slight impairment of the biological community as evaluated by IDEM. Three times as many taxa and individuals were collected during the May 2007 sampling event compared to the August 2006 sampling event. Additionally, families indicative of good water quality (mayflies, stoneflies, and caddisflies) were absent during the August 2006 sampling event but comprised 30% of the community during the May 2007 sampling. The increased density and diversity and presence of families that are acclimated to better quality water accounted for much of the increase in the mIBI score between the two sampling events.

Site 6: Sager's Lake Outlet

Site 6 (Figure 40) is located at the outlet of Sager's Lake south of U.S. Highway 30 before the creek flows under State Road 2 in the Sager's Lake subwatershed. This section of the Sager's Lake Outlet is a regulated drain. Large stones and riprap are present on the banks of the creek. A narrow riparian area is present. Water quality at site 6 reflects urban impacts from a large portion of Valparaiso. The subwatershed draining to site 6 includes the following land covers: developed (67%), forest (11%), cultivated crops (10%), grassland/herbaceous (9%), pasture/hay (2%), and other (2%). See Section 2.10-Land Use for information on land cover classifications.

Figure 40. Sampling site 6 - Sager's Lake Outlet (June, 2006)

Historic water quality in Sager's Lake Outlet (site 6)
IDEM sampled the Sager's Lake Outlet during its 1990 macroinvertebrate survey, 2000 Salt Creek Assessment, and 2006 biotic community assessment/ intensive survey. Water quality was generally good compared to other sites in the watershed. *E. coli* concentrations exceeded the Indiana state standard (235 CFU/100 mL) twice out of five samples collected. However, the geometric mean for the samples ranked in the bottom half when compared to the other sites included in the current study. Conductivity was high but did not exceed state standards. Turbidity was consistently high, exceeding the value (20 NTU) at which undesirable changes in aquatic life occur during three of four sampling events. The geometric mean for turbidity was the highest of the 16 sites. Nutrient concentrations were low compared to other sites and guideline values. Total phosphorus and ammonia-nitrogen concentrations measured below detection limits during the August 2006 biotic community assessment/ intensive survey. The nitrate+nitrite concentration (0.08 mg/L) ranked in the lowest 25% of the 45 biotic community assessment/ intensive survey sites.

Habitat was poor at Sager's Lake Outlet. The site rated a QHEI score of 49, which ranked in the top half of the 43 sites assessed during the biotic community assessment/ intensive survey. The score was lower than the threshold (51) at which IDEM considers stream habitat to be poor. Instream cover and lack of pool and riffle development limit habitat quality at the Sager's Lake Outlet. During 1990, IDEM assessed habitat upstream of site 6 at Sager Road. This site rated a QHEI score of 85, indicating that higher quality habitat may exist elsewhere in the subwatershed.

Biotic communities were better than most other sites in the watershed, but indicated some signs of impairment. Eight species were collected at the Sager's Lake Outlet, which was more species than 75% of the 43 sites assessed during IDEM's biotic community assessment/ intensive survey. Tolerant species comprised a smaller percentage (51.29%) of the community than most other biotic community assessment/ intensive survey sites. Pioneer species (90.5%) dominated the community. The stream rated an IBI score of 23 in 1990 and 32 in August 2006. These scores fell within the "very poor" and "poor" integrity classes for the Central Corn Belt Region, respectively. Both scores fell below the threshold (36) at which IDEM considers streams to be non-supporting of their aquatic life use designation. Despite the poor score compared to state standards, the site ranked as the fourth highest of all sites assessed in August 2006. In 1990, IDEM sampled the fish community upstream of site 6. This site rated an IBI score of 38, placing it in the "fair" integrity class for the Central Corn Belt Region. This again suggests that higher quality habitat and biotic communities exist upstream of the current sampling point.

Water Quality in Sager's Lake Outlet (site 6)
Sager's Lake Outlet exhibited better water quality than most other sites. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana's state water quality standards. Additionally, nutrient concentrations at the site ranked lower than most sites for most parameters measured. *E. coli* concentrations at Sager's Lake Outlet exceeded the Indiana state standard (235 CFU/100 mL) during six of eight sampling events. *E. coli* concentrations ranged from 60 CFU/100 mL during the May 7 baseflow event to 3,100 CFU/100 mL during the June 19 stormflow event. *E. coli* concentrations generally increased during the sampling period with all baseflow concentrations in May measuring below the state standard. Stormflow samples exhibited higher *E. coli* concentrations than those measured in baseflow samples, though exceedances were observed during both wet and dry weather.

The Sager's Lake Outlet contained the third lowest average total phosphorus concentration (0.094 mg/L) in the watershed. However, concentrations were at or exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L)) during five of the eight sampling events. Concentrations generally decreased over the sampling period with concentrations in all samples collected in July falling below the OEPA guidelines. Most of the phosphorus was in the particulate form as orthophosphate comprised between 8 and 50% of the total phosphorus concentrations. Nitrogen levels also ranked among the lowest measured at all sites. The average nitrate-nitrogen concentration (0.112 mg/L) ranked as third lowest and the average ammonia-nitrogen concentration (0.134 mg/L) ranked as fifth lowest among all tributaries assessed. Suspended solid concentrations generally remained below recommended guidelines. Suspended solids concentrations exceeded the level (25 mg/L) that can cause reduced fish yields once during the sampling period (the June 19 stormflow event). While suspended solids, nitrogen, and phosphorus concentrations remained low compared to other sites, loading rates were among the highest of all tributaries. Among all tributaries assessed, the site ranked as fourth highest for average ammonia loading rate (1.31 kg/d), third highest for average total phosphorus loading rate (0.875 kg/d), and third highest for average suspended solids loading rate (148 kg/d). These loading rates would suggest that Sager's Lake Outlet is one of the largest sources of nutrients to Salt Creek, even though concentrations themselves within the stream are already low compared to other sites.

The physical habitat of Sager's Lake Outlet was better than at most other sites. The site rated a QHEI score of 49.25. This score rated as the third highest of all non-fixed station sites but still fell below the threshold (51) at which IDEM considers habitat to be poor. Habitat was limited by poor substrate, instream cover, narrow riparian zones, and poor pool and riffle development. This site was one of only four sites with observed pools and riffles. However, both of these features were poorly developed and will not naturally develop in the sand and muck bottom. No macroinvertebrate samples were collected from this stream during sampling completed for this project.

Site 7: Beauty Creek

Site 7 (Figure 41) is located on Beauty Creek north of State Road 130 in western Valparaiso in the Clark Ditch subwatershed in the headwaters of Salt Creek. Water quality at site 7 reflects impacts from the western portion of Valparaiso. A marine store and Valparaiso's compost facility are located adjacent to the site. The subwatershed draining to site 7 includes the following land covers: developed (45%), forest (29%), grassland/herbaceous (10%), cultivated crops (8%), pasture/hay (7%), and other (2%). See Section 2.10- Land Use for information on land cover classifications.

A rusty water color was noted at site 7. The "rust" is a by-product of iron oxidation reactions that occur within the headwaters of the stream. The iron that provides the substrate upon which oxidation occurs typically originates from the weathering of iron substrates or from the reduction of ferric iron. The presence of a readily-available source of iron allows iron-oxidizing bacteria to persist within the stream. Once these organisms begin to break down the available iron, iron oxide precipitates within the water resulting in the orange iron deposits observed within Beauty Creek. Along severely eroded banks observed within the stream, sediment layers which would typically be covered are exposed to the open air and stream. These areas contain sufficient iron deposits to allow for the oxidation of ferric iron to occur upstream thereby resulting in the deposition of iron oxide throughout the stream system.

Figure 41. Sampling site 7 - Beauty Creek (June, 2006)

Historic water quality in Beauty Creek (site 7)
IDEM sampled Beauty Creek during the 2000 Salt Creek Assessment and the 2006 biotic community assessment/ intensive survey. *E. coli* concentrations were the lowest on average (geometric mean of 59 CFU/100 mL) when compared to other study sites assessed, with no exceedances of the Indiana state standard (235 CFU/100 mL). Conductivity levels were among the highest of all sites. Conductivity levels exceeded the Indiana state standard once (August 27, 2000) during the 2000 sampling period. The geometric mean for conductivity (982 µmhos/cm) was the highest of all sites. Turbidity was lower on average than most other sites, but exhibited periodic high values. The geometric mean (11.0 NTU) ranked as the sixth lowest among the 16 sites included in the current study. However, October 11, 2000 turbidity levels measured 27.2 NTU, which was above the level at which undesirable changes in aquatic life can occur (Walker, 1978). During the 2006 biotic community assessment/ intensive survey, nutrient concentrations were low compared to other sites and guideline values. Total phosphorus and ammonia-nitrogen measured below detection limits. Nitrate+nitrite levels (0.11 mg/L) ranked in the lower half of the 45 sites assessed during the 2006 biotic community assessment/ intensive survey. When assessed in August 2006, physical habitat was generally good in Beauty Creek. The site rated a QHEI score of 57,

which ranked in the highest 25% of the 43 biotic community assessment/ intensive survey sites. The score was higher than the threshold (51) at which IDEM considers habitat to be poor. Scarcity of instream cover and lack of pool and riffle development were the primary limitations for physical habitat along this reach of Beauty Creek. Despite the high quality of physical habitat, fish communities in Beauty Creek were poor compared to state guidelines. Tolerant species comprised a lower percentage (23.53%) of the community than most other sites; however, only three species were collected in Beauty Creek. Therefore, the site rated an IBI score of 18, which was within the lower half of scores measured during the biotic community assessment/ intensive survey but not atypical compared to other biotic community assessment/ intensive survey sites. The score fell within the "very poor" integrity class for the Central Corn Belt Region and was below the threshold (36) at which IDEM considers streams to be non-supporting of their aquatic life use designation.

Water Quality in Beauty Creek (site 7)
Beauty Creek exhibited some of the best water quality in the watershed. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana state water quality standards. The average suspended solids concentration (3.5 mg/L) ranked as the lowest of all sites sampled, and none of the measurements exceeded the level (25 mg/L) at which reduced fish yields can occur. Also consistent with historic *E. coli* data, the average *E. coli* concentration (238 CFU/100 mL) was the lowest of all sites sampled in the watershed. Concentrations exceeded the Indiana state standard (235 CFU/100 mL) once during the eight sampling events, the least number of exceedances of all sampling sites.

Compared to most other sites and consistent with historic data, nutrient concentrations were relatively low. Beauty Creek exhibited the third lowest average total phosphorus concentration (0.093 mg/L) in the watershed. Total phosphorus levels exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during three of the eight sampling events. Two of these three exceedances occurred during stormflow events. Most of the phosphorus was present in the particulate form during all sampling events, with orthophosphate comprising 13 to 57% of the total phosphorus concentration. Nitrogen levels were normal compared to other sites. The average ammonia-nitrogen concentration (0.120 mg/L) and the average nitrate-nitrogen concentration (0.160 mg/L) ranked near the middle of all sites sampled. Loading rates and areal loading rates were similarly low in Beauty Creek compared to other sites. The orthophosphorus and total phosphorus average areal loading rates ranked as the lowest and second lowest of all sites (0.000041 and 0.000157 kg/ac/d). All nitrogen and phosphorus loading and areal loading rates measured less than most other sites sampled in the watershed. This stream also exhibited the second lowest loading rate and the lowest areal loading rate (0.005602 kg/ac/d) for suspended solids in the watershed.

Beauty Creek exhibited the best physical habitat of all sites. The stream rated a QHEI score of 74.25, the highest score of all sites. This score was higher than the threshold (51) at which IDEM considers habitat to be poor. Bank erosion along both sides of the stream provided the only major habitat limitation. Despite the high quality of the physical habitat, biological communities in Beauty Creek were among the worst of all sites assessed. During August 2006, the stream received a mIBI score of 2.1, which tied with two other sites for the second lowest among all eight sites. This score placed the stream below the value (2.2) at which IDEM considers streams supporting of their aquatic life use designation. During May 2007, the stream received a mIBI score of 2.9. This represented the lowest score of all eight sites assessed, but placed it above the value at which IDEM considers streams non-supporting of their aquatic life use designation. Both scores fall within the range indicating moderate impairment, as designated by IDEM. Scuds (Amphipoda, family Gammaridae) dominated the macroinvertebrate community at this site (87.5% of all individuals during August 2006 and 75.7% of all individuals during May 2007), which contributed to the low scores. Family-level HBI scores indicated better biological quality, measuring 4.23 in August 2006 and 3.84 in May 2007. These scores indicated "very good" water quality with possible slight organic pollution. However, these HBI scores may be misleading due to the dominance of scuds, which have a somewhat low tolerance value. The scarcity of other low tolerance groups and the low taxa (family) diversity indicate that the mIBI assessment of moderate impairment likely applies to this site.

Site 8: Pepper Creek

Site 8 (Figure 42) is located on Pepper Creek west of State Road 149 in the Pepper Creek subwatershed. The area surrounding the site is rural residential, with new development occurring. The subwatershed draining to site 8 includes the following land covers: cultivated crops (42%), forest (23%), developed (14%), grassland/herbaceous (10%), pasture/hay (10%). See Section 2.10- Land Use for information on land cover classifications. Benthic macroinvertebrates were sampled at site 8.

Figure 42. Sampling site 8 - Pepper Creek (June, 2006)

Historic water quality in Pepper Creek (site 8)
IDEM sampled Pepper Creek during the 2000 Salt Creek Assessment and the 2006 biotic community assessment/ intensive survey. IDNR sampled the stream in 2003. *E. coli* concentrations were generally low at site 8. Concentrations exceeded the Indiana state standard (235 CFU/100 mL) twice out of five samples collected in 2000. The geometric mean (111 CFU/100 mL) ranked as the third lowest of the 16 sites included in the current study. During the 2003 IDNR assessment, pH measured 9.3, which was higher than the Indiana state standard (6.0-9.0). Algal productivity can increase pH since photosynthesis removes carbon dioxide (a weak acid) from solution. The removal of carbon dioxide results in a decrease in hydrogen ions, which results in higher pH levels. The dissolved oxygen reading from this sampling event indicates undersaturated (<100%) conditions with respect to oxygen. Since high oxygen saturation levels are expected in areas of abundant photosynthetic activity, this would tend to indicate that the high pH was caused by other factors. Physical habitat was good at Pepper Creek when assessed in August 2006. The site rated a QHEI score of 59, tied with two other sites for fourth highest of the 43 sites assessed during the biotic community assessment/ intensive survey. The score was above the threshold (51) at which IDEM considers stream habitat to be poor. Poor substrate and lack of pool and riffle development were the primary limitations for physical habitat. Despite the high quality of physical habitat, the fish community was generally poor in Pepper Creek. Six species were collected at Pepper Creek, with omnivorous and pioneer species comprising a higher percentage (25 and 40%, respectively) of the community than most other sites. The site rated an IBI score of 24, which ranked within the top half of all sites assessed. The score fell within the "poor" integrity class for the Central Corn Belt Region and was below the threshold (36) at which IDEM considers streams to be non-supporting of their aquatic life use designation.

Water Quality in Pepper Creek (site 8)
Pepper Creek exhibited good water quality for all parameters assessed. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana state water quality standards. Additionally, none of the suspended solids concentrations exceeded the level (25 mg/L) at which reduced fish yields can occur. Pepper Creek contained the fourth lowest average total phosphorus concentration (0.107 mg/L) in the watershed. Despite this, total phosphorus concentrations exceeded the

level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during five of the eight sampling events. Concentrations generally decreased during the sampling period with all July samples measuring below the OEPA guidelines. Orthophosphate concentrations were generally low, with dissolved phosphorus comprising 14 to 50% of total phosphorus concentrations. Nitrogen and suspended solids levels were relatively normal compared with other sites. The average nitrate (0.155 mg/L), ammonia (0.143 mg/L), and suspended solids (11 mg/L) concentrations ranked near the middle of all sites sampled. Similarly, loading rates and areal loading rates for total phosphorus, ammonia-nitrogen, nitrate-nitrogen, and suspended solids typically ranked near the median compared with other sites.

The average *E. coli* concentration (546 CFU/100 mL) ranked as the third lowest in the watershed. However, concentrations in Pepper Creek still exceeded the Indiana state standard (235 CFU/100 mL) during six of eight sampling events. *E. coli* levels ranged from 80 CFU/100 mL during the May 22 baseflow event to 1,000 CFU/100 mL during the July 17 baseflow event. *E. coli* concentrations during storm events exhibited increases over baseflow concentrations. However, *E. coli* levels remained consistently above the state standard for all sampling events after June.

Physical habitat in Pepper Creek rated better than average for the watershed, but not above IDEM guidelines. The site rated a QHEI score of 46.5, which placed it below the level (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, instream cover, and poor development of pools and riffles. While instream cover may increase over time, pools and riffles will not naturally develop in the sand and muck bottom stream. Despite the quality of habitat, biological communities were generally poor in Pepper Creek. In August 2006, the stream rated a mIBI score of 2.0, the second lowest of all sites assessed. This score placed the stream below the value (2.2) at which IDEM considers streams to be supporting of their aquatic life use designation. In May 2007, the stream rated a mIBI score of 4.2, the second highest of all sites assessed. Based on IDEM guidelines, these scores fell within the ranges indicating moderate and slight impairment, respectively. Much of the increase in the mIBI score can be attributed to an increase in the number of taxa (families) (13 during May 2007 compared with 4 during August 2006) and the number of pollution-intolerant groups (20% during May 2007 compared with 2% during August 2006) collected. During both sampling events, a small group of taxa dominated the macroinvertebrate community. Scuds (Amphipoda family Gammaridae) comprised 86.4% of the community during the August 2006 sampling event. Likewise, scuds and isopods (Isopopda, family Asillidae) comprised 68.8% of the community. The dominance of the community by these groups suggests that some impairment is limiting diversity at this site. Family-level HBI scores measured 4.40 in August 2006 and 4.55 in May 2007. Both of these scores indicate “good” water quality, with some organic pollution probable. Based on these scores, IDEM would likely consider the stream as supporting of its aquatic life use designation. However, the overall mIBI scores indicate slight impairment based on IDEM guidelines. As the stream possesses relatively good water quality, this impairment is likely due the limited habitat present within this reach of Pepper Creek.

Site 9: Unnamed tributary (Mallard’s Landing)

Site 9 (Figure 43) is an unnamed tributary, hereafter referred to as Mallard’s Landing Tributary, of Salt Creek just east of South Haven in the Pepper Creek subwatershed. The subwatershed draining to site 9 includes the following land covers: forest (44%), grassland/herbaceous (16%), pasture/hay (16%), cultivated crops (13%), developed (10%), and other (2%). See Section 2.10- Land Use for information on land cover classifications. Benthic macroinvertebrates were sampled at site 9.

Figure 43. Sampling site 9 - Mallard's Landing Tributary (June, 2006)

Historic water quality in Mallard's Landing Tributary (site 9)
IDEM sampled the Mallard's Landing Tributary as part of the 2000 Salt Creek Assessment and the 2006 biotic community assessment/ intensive survey. On average, *E. coli* concentrations measured among the highest of all sites. Samples exceeded the Indiana state standard (235 CFU/100 mL) four times during five sampling events. The geometric mean (463 CFU/100 mL) ranked as the fifth highest among the 16 sites included in the current study. Conductivity exceeded the Indiana state standard once during the sampling period. Indiana maintains a water quality standard for total dissolved solids of 750 mg/mL, which roughly corresponds to a conductivity measurement between 1,000 and 1,360 µmhos/cm. Physical habitat was relatively good at Mallard's Landing when assessed in August 2006. The site rated a QHEI score of 58, which ranked in the top 25% of the 43 sites assessed during the biotic community assessment/ intensive survey. This score exceeded the threshold (51) at which IDEM considers stream habitat to be poor. Lack of pool and riffle development was the primary limitation for habitat quality. Fish communities were relatively good compared to other sites. Seven species were collected at the Mallard's Landing Tributary, with tolerant (89.4%) and pioneer (91.8%) species dominating the community. The site rated an IBI score of 34, which tied with one other site for second highest of all sites assessed. The score placed the stream at the bottom of the "fair" integrity class for the Central Corn Belt Region. Based on state guidelines, the IBI score fell below the value (36) at which IDEM considers streams to be non-supporting of their aquatic life use designation.

Water Quality in Mallard's Landing Tributary (site 9)
For many of the parameters measured, the Mallard's Landing Tributary exhibited good water quality compared to most other watershed sites. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana state water quality standards. Average ammonia-nitrogen and nitrate-nitrogen concentrations both ranked below the median for all sites. Only one suspended solid concentration measured higher than the level (25 mg/L) at which reduced fish yields can occur. The only concentration of concern occurred during the May 16 stormflow event when suspended solids concentrations reached 59 mg/L.

Phosphorus and *E. coli* concentrations were similarly low with average concentrations (0.111 mg/L and 861 CFU/100 mL, respectively) less than those measured at most other watershed sites. However, total phosphorus and *E. coli* concentrations still exceeded OEPA and Indiana guidelines. These exceedances are consistent with historic data, where *E. coli* samples measured relatively low on average (463 CFU/100 mL) but were high compared to other watershed streams. Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during five of the eight sampling events. Concentrations generally decreased during the sampling period with the lowest concentrations measured at this site occurring in July. However, July samples still exceeded the OEPA guidelines during two of the three sampling events. Orthophosphate was similarly high, comprising 28 to 100% of total phosphorus concentrations. *E. coli* levels at the Mallard's Landing Tributary ranked near the middle when compared with other sites. However, *E. coli* concentrations exceeded the Indiana state standard (235 CFU/100 mL) during six of the eight sampling events. *E. coli* levels ranged from 0 CFU/100 mL during the July 17 baseflow event to 3,100 CFU/100 mL during the June 19 stormflow event. Exceedances occurred during both stormflow and baseflow events, though stormflow samples typically exceeded concentrations measured in baseflow samples collected both prior to and after stormflow sampling.

Loading rates for all nutrients assessed were among the lowest for all sites. Mallard's Landing Tributary exhibited the second lowest total phosphorus loading rate (0.184 kg/d) in the watershed, the third lowest ammonia-nitrogen (0.233 kg/d) and nitrate-nitrogen (0.355 kg/d) loading rates, and the fourth lowest suspended solids loading rate (22.0 kg/d). Average areal loading rates were similarly low, with the lowest total phosphorus areal load (0.000088 kg/ac/d), second lowest nitrate-nitrogen and orthophosphorus areal loads (0.000172 and 0.000043 kg/ac/d), and third lowest total suspended solids and ammonia (0.010369 and 0.000110 kg/ac/d) areal loads. Both the low relative concentrations and the low loading rates suggest that this tributary should not be the focus to protect and improve water quality to Salt Creek. However, the relatively low concentrations and loading rates suggest that the Mallard's Landing Tributary represents one of the higher quality subwatersheds within the larger Salt Creek watershed. With this in mind, the Mallard's Landing Tributary subwatershed should be considered critical for protection of water quality.

Physical habitat at Mallard's Landing Tributary was better than average for the watershed. The site rated a QHEI score of 58, the third best of all sites. The score was above the value (51) established by IDEM to indicate poor habitat. Physical habitat at the site was limited by poor substrate and lack of riffle development. Despite the quality of habitat, the biological community in the Mallard's Landing tributary was generally poor. In August 2006, the site rated a mIBI score of 2.50, which was second highest of all sites. In May 2007, the site rated a mIBI score of 2.70, the lowest score of all sites assessed. Both scores fell above the cutoff (2.2) established by IDEM as indicating non-attainment of the aquatic life use designation but were within the range established by IDEM as indicating moderate impairment. Family-level HBI scores measured 4.17 in August 2006 and 4.16 in May 2007. Both scores indicated "very good" water quality with possible slight organic pollution. However, these HBI scores may be misleading. A small group of taxa including scuds (Amphipoda family Gammaridae), isopods (Isopoda family Asillidae), and flatworms (Platyhelminthes family Tubellaria) dominated the macroinvertebrate community. Scuds and flatworms have a relatively low tolerance value of four, contributing to the low HBI scores. However, the scarcity of other pollution intolerant taxa and the low diversity at the site suggest that the overall mIBI assessment of moderate impairment is more applicable.

Site 10: Butternut Springs Outlet

Site 10 (Figure 44) is located south of South Haven at the Butternut Spring outlet before the tributary crosses State Road 149 in the Pepper Creek subwatershed. The subwatershed draining to site 10 includes the following land covers: forest (53%), cultivated crops (19%), developed (11%), grassland/herbaceous (11%), pasture/hay (3%), and other (4%). See Section 2.10- Land Use for information on land cover classifications. Benthic macroinvertebrates were sampled at site 10.

Figure 44. Sampling site 10 - Butternut Spring Outlet (June, 2006)

Historic water quality in Butternut Springs Outlet (site 10)
IDEM sampled the Butternut Springs Outlet during the 2000 Salt Creek Assessment. Water quality was relatively good during the 2000 assessment. *E. coli* concentrations were among the lowest of all sites. The geometric mean (187 CFU/100mL) ranked as the fifth lowest of the 16 sites included in the current study. However, concentrations exceeded the Indiana state standard (235 CFU/100 mL) twice during the five sampling events. The geometric mean for conductivity (703 µmhos/cm) and turbidity (5.8 NTU) ranked as the lowest and second lowest, respectively, among all sites. The stream exhibited one turbidity value (46.2 NTU on October 3, 2000) that exceeded the value at which undesirable changes in aquatic life can occur (20 NTU; Walker, 1978). Additionally, pH measurements violated Indiana state standards once during the sampling period (5.9 on October 18, 2000). The decomposition of organic matter can cause pH to decrease in surface water, since decomposition adds carbon dioxide (a weak acid) to the water. Where decomposition rates are high enough to decrease pH, dissolved oxygen saturations would be expected to be low. However, dissolved oxygen at the Butternut Springs Outlet measured 93% saturation at the time of sampling, indicating that other factors were contributing to the low pH during that sampling event. This site was not assessed during the 2006 biotic community assessment/ intensive survey.

Water Quality in Butternut Springs Outlet (site 10)
The Butternut Springs Outlet exhibited relatively good water quality for all parameters measured. None of the temperature, dissolved oxygen, pH, conductivity, ammonia-nitrogen, or nitrate-nitrogen measurements violated Indiana state standards. Additionally, nutrient concentrations ranked among the best in the watershed. The average total phosphorus concentration (0.083 mg/L) at the Butternut Springs Outlet was the lowest of all sites. However, concentrations were still at or exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during five of the eight sampling events with two of these high concentrations occurring during stormflow events. Most of the phosphorus was present in the Butternut Springs Outlet in particulate form with orthophosphorus comprising 15 to 50% of the total phosphorus concentration. Areal phosphorus loading rates were high in the Butternut Springs Outlet. Conversely, phosphorus loading rates ranked near the median when compared to other watershed sites. The site exhibited the second highest orthophosphate and total phosphorus areal loading rates of all tributaries assessed (0.000245 and 0.000475 kg/ac/d). While loading rates suggest that the Butternut Springs Outlet is not among the highest total contributors of phosphorus to Salt Creek, areal loading rates suggest that the subwatershed is contributing a larger amount of phosphorus per acre than other areas in the larger Salt Creek watershed. Nitrogen concentrations were also lower than concentrations present at most other sites. The average ammonia-nitrogen concentration (0.078 mg/L) ranked as the lowest and the average nitrate-nitrogen concentration (0.077 mg/L) ranked as the second lowest of all sampled sites. Ammonia-nitrogen and nitrate-nitrogen loading and areal loading rates also ranked in the bottom half of all

sites' loading rates, suggesting that the Butternut Springs Outlet is not a major source of nitrogen to Salt Creek. *E. coli* levels exceeded the Indiana state standard (235 CFU/100 mL) during six of the eight sampling events; however, concentrations were relatively low when compared with other sampled streams. *E. coli* levels ranged from 120 CFU/100 mL during the May 22 baseflow event to 1,600 CFU/100 mL during the May 16 stormflow event. After May, all samples collected exceeded the state standard, though levels were not as high as those observed at most other sites. *E. coli* levels at site 10 ranked as the third lowest of all sites.

Physical habitat within the 200 foot (61 meter) reach sampled in Butternut Springs Outlet was generally poor. The site rated a QHEI score of 36, which was the fourth lowest habitat score in the watershed. (It should be noted that the 200 foot (61 meter) stream reach assessed during this study may not be representative of the entire Butternut Springs Outlet.) The score was below the level (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, instream cover, narrow riparian zones, and lack of riffle and pool development. Similarly, the biological community at site 10 was also poor. In August 2006, the site rated a mIBI score of 2.10, which was below the value (2.2) at which IDEM considers streams to be non-supporting of their aquatic life use designation. In May 2007, the site rated a mIBI score of 3.60, which was third lowest of sites assessed. This score was above the IDEM state standard for aquatic life use designation but still within the range established by IDEM indicating moderate impairment. The difference in score can be attributed to an increase in number of taxa and the collection of more pollution intolerant taxa (mayflies, stone flies, and caddisflies) during the May 2007 sampling event. During both sampling events, scuds dominated the macroinvertebrate community and intolerant taxa comprised a small percentage of the total sample. Therefore, the assessment of moderate impairment is likely applicable. Family-level HBI scores indicated better conditions, measuring 4.44 in August 2006 and 4.14 in May 2007. These scores indicate "good" to "very good" water quality, with some organic pollution probable to possible slight organic pollution. Based on the water chemistry and habitat data collected within the Butternut Springs outlet, it is likely that the poor habitat present along the sampled reach plays a large role in the limited biological community present in the stream.

Site 11: Squirrel Creek

Site 11 (Figure 45) is located on Squirrel Creek downstream of South Haven in the Squirrel Creek subwatershed at the site of a golf course. Water quality at site 11 reflects impacts from the northwestern portion of the South Haven. The subwatershed draining to site 11 includes the following land covers: developed (48%), cultivated crops (36%), forest (10%), grassland/herbaceous (5%), and other (1%). See Section 2.10- Land Use for information on land cover classifications.

Figure 45. Sampling site 11 - Squirrel Creek (June, 2006)

Historic water quality in Squirrel Creek (site 11)

The Lake Michigan Interagency Task Force on *E. coli* sampled Squirrel Creek during 1997 and 1998 and IDEM sampled the stream during its 2006 biotic community assessment/ intensive survey. *E. coli* concentrations were among the lowest of all sites with historical data. The geometric mean (157 CFU/100 mL) ranked as the fourth lowest among the 16 sites included in the current study. However, concentrations exceeded the Indiana state standard (235 CFU/100 mL) during 13 of the 24 sampling events. Physical habitat was relatively poor in Squirrel Creek when assessed in August 2006. The site rated a QHEI score of 39, which ranked within the lower 50% of the 43 sites assessed during the biotic community assessment/ intensive survey. The score was lower than the value (51) at which IDEM considers stream habitat to be poor. Instream cover, channel development, poor riparian zone quality, and lack of pool and riffle development limited habitat quality in Squirrel Creek. Fish communities were similarly poor compared to other sites. Five species were collected at Squirrel Creek, with tolerant (84.6%) and pioneer (73.1%) species dominating the fish community. The site rated an IBI score of 24. The score was within the top half of all sites assessed but was considered poor when compared to guideline values. The score was less than the value (36) at which IDEM considers streams to be non-supporting of its aquatic life use designation. The score placed the stream in the "poor" integrity class for the Central Corn Belt Region, as designated by Simon (1991).

Water Quality in Squirrel Creek (site 11)

Squirrel Creek exhibited poor water quality for many of the parameters measured. However, none of the temperature, dissolved oxygen, pH, or conductivity measurements violated Indiana state water quality standards. Nonetheless, dissolved oxygen levels indicated high productivity levels in the stream. Dissolved oxygen concentrations were well above Indiana state standards (daily average of five mg/L). Oxygen levels were constant through July with levels at or above 100% saturation. When oxygen levels exceed 100% saturation, photosynthetic processes can be producing oxygen faster than it can escape to the atmosphere. The observed presence of abundant algae within the stream supports this assessment. However, mid-July oxygen levels decreased to nearly half the concentration observed in earlier sampling events with 52.4% saturation. As described above, decomposition processes can decrease stream oxygen levels. This sample occurred during the lowest flow of the sampling period. The decrease in water levels likely reduced the area available for algal growth. Algae growing in these areas would have died and decomposed in the stream, causing the consumption of oxygen.

Nutrient concentrations also indicated the potential for high productivity. Nitrate-nitrogen concentrations exceeded the levels recommended to protect aquatic life during two of the eight sampling events. Both exceedances occurred in the late summer. Concentrations during all other sampling events ranged between a concentration less than lab detection limits (0.0070 mg/L) during the June 19 stormflow event and 0.770 mg/L during the July 5 baseflow event. The average nitrate-nitrogen concentration (1.16 mg/L) was also high compared to other sites, ranking as the third highest on average among all sites. Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during six of the eight sampling events. Compared to other sites, the average total phosphorus concentration in Squirrel Creek (0.159 mg/L) ranked as the fourth highest among all tributaries sampled. Orthophosphate was generally low, comprising 14 to 69% of the total phosphorus concentration. Both total phosphorus and orthophosphate concentrations increased during stormflow events. Despite the high concentrations in Squirrel Creek, loading rates suggest that the stream is not a large source of nutrient loading to Salt Creek. Average loading rates for ammonia, nitrate, total phosphorus, and suspended solids all ranked in the bottom half of all tributaries. When standardized for drainage area, the areal loading rates ranked higher compared to other sites but were still close to the median of all tributaries, with the exception of ammonia, which was the lowest of all sites (0.000076 kg/ac/d).

Conversely, *E. coli* and ammonia concentrations in Squirrel Creek were lower than concentrations present at most other sites. The average *E. coli* concentration (750 CFU/100 mL) ranked as the fifth lowest and the average ammonia-nitrogen concentration (0.107 mg/L) ranked as the second lowest among all sites sampled. Although *E. coli* levels were lower than those at most sites, concentrations in Squirrel Creek still exceeded the Indiana state standard (235 CFU/100 mL) twice during the sampling period. Both exceedances occurred during stormflow events. Baseflow *E. coli* levels ranged from 10 CFU/100 mL to 170 CFU/100 mL. Stormflow concentrations measured more than 13 times baseflow concentrations. This suggests that wet weather events should be the focus when targeting management actions to reduce *E. coli* in this subwatershed.

Physical habitat was poor in Squirrel Creek. The site rated a QHEI score of 35, the third lowest in the watershed. This score fell below the value (51) established by IDEM indicating poor habitat. Habitat quality was limited by poor substrate, instream cover, channelization, bank erosion, and lack of riffle and pool development. This could be attributed to the QHEI assessment being conducted on a section of stream located within a golf course. Squirrel Creek has also not recovered from channelization in this reach, which contributed to the low score. No macroinvertebrate samples were collected from this stream during sampling completed for this project.

Site 12: Robbin's Ditch

Site 12 (Figure 46) is located along Robbin's Ditch in eastern Portage. This section of Robbin's Ditch is a regulated drain. The land use surrounding site 12 is residential with new development currently occurring. A narrow, patchy riparian buffer is present with areas of bare soil. The subwatershed draining to site 12 includes the following land covers: developed (42%), cultivated crops (28%), forest (17%), grassland/herbaceous (10%), pasture/hay (1%), and other (2%). See Section 2.10- Land Use for information on land cover classifications.

Figure 46. Sampling site 12 - Robbin's Ditch (June, 2006)

Historic water quality in Robbin's Ditch (site 12)
IDEM sampled Robbin's Ditch during its 2000 Salt Creek Assessment and the 2006 biotic community assessment/ intensive survey. *E. coli* concentrations were among the lowest of the 16 sites included in the current study. The geometric mean (61 CFU/100 mL) was the second lowest of the 16 sites assessed and none of the five samples exceeded the Indiana state standard (235 CFU/100 mL). Robbin's Ditch exhibited low conductivity levels compared to other sites but had individual measurements above guidelines. The geometric mean for conductivity (742 µmhos/cm) ranked as the third lowest of all sites. However, one measurement out of the five (1,169 µmhos/cm on October 11, 2000) exceeded the Indiana state standard. The geometric mean for turbidity (15.7 NTU) ranked in the top half of the 16 study sites. Measurements exceeded the value (20 NTU) at which undesirable changes in aquatic life can occur twice during the sampling period. When assessed in August 2006, physical habitat in Robbin's Ditch was poor compared to both state guidelines and other sites. The site rated a QHEI score of 30, which ranked in the lowest 25% of the 43 sites assessed during the 2006 biotic community assessment/ intensive survey. Poor substrate,

instream cover, and lack of pool and riffle development all limited habitat quality in Robbin's Ditch. Fish communities were similarly poor. Only two species were collected at Robbin's Ditch, with a majority of individuals being considered tolerant (88.9%) and omnivorous (88.9%). The site rated an IBI score of 14, which was in the lowest 25% of all sites.

Water Quality in Robbin's Ditch (site 12)
Robbin's Ditch exhibited poor water quality for most parameters measured. None of the temperature, or pH measurements violated Indiana state water quality standards. Additionally, none of the suspended solids concentrations exceeded the level (25 mg/L) at which reduced fish yields can occur. However, accumulated sediment was noted in the culvert upstream of the sample site during multiple sampling events. Most of the other parameters measured exceeded Indiana state standards or OEPA guidelines at least once during the sampling period. Dissolved oxygen levels were among the lowest of all sites. The lowest dissolved oxygen concentration (2.4 mg/L) recorded during the project occurred at site 12 during the July 17 baseflow event. Dissolved oxygen concentrations decreased over the sampling period. Early to mid-summer dissolved oxygen levels were in the range typically observed in Indiana streams. In July, however, all three measurements violated the Indiana state standard (daily average of five mg/L) for dissolved oxygen. Saturation levels ranged from 28 to 86% with a similar decrease in saturation over the summer. This decrease can likely be attributed to decomposition processes in the stream. Robbin's Ditch also exhibited the highest average conductivity (1,156 µmhos/cm) of all sites. Indiana maintains a state standard for dissolved solids of 750 mg/L, which corresponds with conductivity levels between 1,000 and 1,360 µmhos/cm. Conductivity levels at site 12 violated the Indiana state standard during six of eight sampling events. Weathering of bedrock and soils contribute naturally to conductivity levels, though other sources such as road salt can add to conductivity levels. Where weathering generates a majority of the conductivity load, conductivity generally decreases with increasing flow since runoff contains lower total dissolved solid concentrations. Conductivity at site 12 did not display this inverse relationship with flow. This suggests that sources besides geologic weathering are contributing to high conductivity measurements in Robbin's Ditch.

E. coli concentrations were among the highest of all sites. The average *E. coli* concentration (1400 CFU/100 mL) in Robbin's Ditch ranked as the third highest in the watershed. *E. coli* levels ranged from 390 CFU/100 mL during the May 22 baseflow event to greater than 12,000 CFU/100 mL during the June 19 stormflow event. Concentrations exceeded the Indiana state standard (235 CFU/100 mL) during all sampling events, though concentrations were typically higher during storm events. Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during all sampling events. Concentrations ranged between 0.120 mg/L during the June 5 baseflow event and 0.230 mg/L during the June 19 stormflow event. The two highest concentrations measured in this stream occurred during the stormflow events. Orthophosphate was high as well, comprising between 30 and 95% of the total phosphorus concentration. Nitrogen levels were similarly high, with the average ammonia-nitrogen concentration (0.214 mg/L) ranking as the third highest and the average nitrate-nitrogen concentration (1.07 mg/L) ranking as the fourth highest among all sites. Nitrate-nitrogen concentrations exceeded OEPA guidelines (1.6 mg/L) during three of the eight sampling events. Loading rates and areal loading rates for all nutrient parameters ranked near the middle when compared with all tributaries. Exceptions occurred for the nitrate areal loading rate (0.002273 kg/ac/d), which ranked third highest.

Physical habitat in Robbin's Ditch was the poorest in the watershed. The site rated a QHEI score of 23, the lowest in the watershed. The score was below the level (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, instream cover, channelization, narrow riparian zones, and lack of poor riffle and pool development. No macroinvertebrate samples were collected from this stream during sampling completed for this project.

Site 13: Damon Run

Site 13 (Figure 47) is located on Damon Run north of U.S. Highway 6 in the north-central section of the watershed. This section of Damon Run is a regulated drain. Water quality data at this site reflects impacts from the northeastern section of the watershed in the Damon Run subwatershed. The site is surrounded by agricultural fields. The subwatershed draining to site 13 includes the following land covers: forest

(32%), developed (27%), grassland/herbaceous (18%), cultivated crops (11%), pasture/hay (10%), and other (3%). See Section 2.10- Land Use for information on land cover classifications. Benthic macroinvertebrates were sampled at site 13.

Figure 47. Sampling site 13 - Damon Run (June, 2006)

Historic water quality in Damon Run (site 13)
IDEM sampled Damon Run during its 1990 and 2000 macroinvertebrate surveys, the 2000 Salt Creek Assessment, and the 2006 biotic community assessment/ intensive survey. IDNR also sampled Damon Run in 2003. *E. coli* concentrations were consistently high, exceeding the Indiana state standard (235 CFU/100 mL) during all sampling events. The geometric mean (738 CFU/100 mL) ranked as the fourth highest of the 16 sites included in the current study. Based on historically-collected *E. coli* data, Damon Run was identified by IDEM and WHPA during completion of the TMDL as one of the priority subwatersheds for *E. coli* concentration reduction. Conductivity measurements were similarly high. The geometric mean ranked as the second highest of the 16 sites. Two of the seven measurements exceeded the Indiana state standard. The geometric mean for turbidity (14.8 NTU) ranked near the middle of all sites. Two of the five measurements exceeded the value (20 NTU) at which undesirable changes in aquatic life can occur. When assessed in August 2006, physical habitat was good in Damon Run compared to other sites. The site rated a QHEI score of 55, which ranked in the top 50% of the 43 sites assessed during the biotic community assessment/ intensive survey. The score exceeded the value (51) at which IDEM considers stream habitat to be poor. Poor substrate and lack of riffle development limited stream habitat. Fish communities were similarly good compared to other sites, but did not meet state standards. The second highest number of fish species (11) of any of the 43 sampled sites was collected at Damon Run. However, tolerant species comprised 57.9% of the sample. The site rated an IBI score of 30, which was tied with two other sites for fifth highest of all 43 sites. However, the score still placed the stream in the "poor" integrity class for the Central Corn Belt Region and was less than the value (36) at which IDEM considers streams to be non-supporting of its aquatic life use designation.

Water Quality in Damon Run (site 13)
Damon Run exhibited moderately poor water quality compared to other streams in the watershed. None of the temperature, dissolved oxygen, pH, or conductivity measurements exceeded Indiana state water quality standards. This is directly opposite the historic findings regarding conductivity, where Damon Run measured among the highest conductivity values for watershed streams. Current dissolved oxygen levels indicated high productivity in the stream. Oxygen levels throughout May were at or above 100% saturation. When oxygen levels exceed 100% saturation, photosynthetic processes can be producing oxygen faster than it can escape to the atmosphere. The average *E. coli* concentration (1,372 CFU/100 mL) in Damon Run ranked as the fourth highest in the watershed. *E. coli* concentrations ranged from 90

CFU/100 mL during the May 7 baseflow event to 4,500 CFU/100 mL during the July 17 baseflow event. Concentrations exceeded the state standard (235 CFU/100 mL) during six of the eight sampling events. Concentrations generally increased over the sampling period, with baseflow concentrations below the state standard in the early summer. All *E. coli* samples collected after May exceeded the state standard. This increase can likely be attributed to a number of factors including, but not limited to seasonal variation in *E. coli* growth and production, concentration of stream flow, or increases in source loading from domestic and wild warm-blooded animal sources. The exact reason for the increase cannot be determined from the current sampling information; however, seasonal increases suggest that concentration of flow and proliferation of production are the likely source of the increase in *E. coli* over time. Concentrations observed during the current sampling are on par with concentrations historically observed within the Damon Run subwatershed. Current data range from 90 CFU/100 mL to 4,500 CFU/100 mL while historic data indicate that concentrations ranged from 240 CFU/100 mL to 1,900 CFU/100 mL. Long-term data suggest that Damon Run remains a priority for controlling *E. coli* loading to Salt Creek; however, current data indicate that other subwatersheds could be of equal or higher priority.

Total phosphorus concentrations exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during five of the eight sampling events. Concentrations generally decreased during the sampling period, with all concentrations collected in July at or below the recommended value. Orthophosphorus typically comprised a small percentage of the total phosphorus concentration. With the exception of two samples, percentages ranged between 22 and 40%. During the June 5 baseflow event and the July 24 baseflow event, dissolved phosphorus concentrations measured higher than during most other sampling events, while total phosphorus concentrations remained at typical levels for this stream. As a result, dissolved phosphorus comprised between 74 and 79% of total phosphorus. Increases in dissolved phosphorus concentrations can result from fertilizer applications and failing septic systems, among other sources. Despite the high values compared to OEPA guidelines, the average total phosphorus concentration (0.119 mg/L) at Damon Run ranked among the lowest 50% of sites sampled. Similarly, the average suspended solids concentration (11.4 mg/L) ranked near the median compared to all other watershed sites. Suspended solids concentrations exceeded the value designated to protect aquatic biota (25 mg/L) only once during the sampling period. Nitrogen levels ranked among the highest in the watershed. The site rated as the fourth highest average ammonia-nitrogen concentration (0.155 mg/L) and the fifth highest average nitrate-nitrogen concentration (0.519 mg/L) among all sites sampled. Nutrient loading rates in Damon Run ranked among the highest in all tributaries. The stream exhibited the highest suspended solids, total phosphorus, and orthophosphorus loading rates (161 kg/d, 2.08 kg/d, and 0.890 kg/d respectively) and the second highest ammonia-nitrogen and nitrate-nitrogen loading rates (2.22 kg/d and 7.29 kg/d, respectively). When standardized for drainage area, the areal loading rates also rated among the top half of sites for most parameters. Specifically, Damon Run exhibited the fourth highest nitrate loading rate (0.000985 kg/ac/d) among all tributaries. All other nutrient areal loading rates calculated for Damon Run rated near the median when compared to other watershed sites.

Damon Run exhibited generally poor physical habitat compared to Indiana standards. The site rated a QHEI score of 39, which was less than the value (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, siltation, instream cover, lack of riffle and pool development, and low gradient. Damon Run also exhibited generally poor biological communities. In August 2006, the site rated a mIBI score of 2.40, which fell in the range at which IDEM considers biological communities to be moderately impaired. In May 2007, the site rated an mIBI score of 4.00. Therefore, the initial assessment of moderate impairment is likely applicable. This score falls on the threshold between moderate and slight impairment, according to IDEM guidelines. Both scores fell above the level (2.2) at which IDEM considers streams to be non-supporting of their aquatic life use designation. Much of the increase in scores between the two sampling events can be attributed to an increase in the number of pollution intolerant taxa (mayflies, stone flies, and caddisflies) and number of intolerant individuals in the May 2007 sampling event compared to the August 2006 sampling event. During the May 2007 sampling event, these taxa still comprised less than 15% of the macroinvertebrate community. Family-level HBI scores measured 5.15 in August 2006 and 4.82 in May 2007. These scores indicate “fair” to “good” water quality with fairly substantial pollution likely. Limited habitat present within the sampling reach and relatively poor water chemistry suggests that both water quality and habitat play relatively equal roles in the relatively poor macroinvertebrate community observed within Damon Run.

Site 14: Salt Creek Mainstem

Site 14 (Figure 48) is located on the mainstem of Salt Creek off Lenburg Road east of Portage. Nearly the entire Salt Creek watershed drains through this site, which is located upstream of IDEM's fixed monitoring station. Because Site 14 is located on the mainstem of Salt Creek, coldwater fishery water quality standards apply (327 IAC 2-1.5-5).

Figure 48. Sampling site 14 - Salt Creek Mainstem (June, 2006)

Historic water quality in Salt Creek (site 14)
None of the historical studies sampled Salt Creek where it crosses Lenburg Road. Water quality is expected to be similar to the fixed station where Salt Creek crosses US 20 (Site 16).

Water Quality in Salt Creek Mainstem (site 14)
Salt Creek exhibited generally poor water quality for many of the parameters measured. Temperature exceeded the Indiana standard for coldwater fishery streams of 70 °F (21.1°C) during two sampling events. However, none of the dissolved oxygen, pH, or conductivity measurements violated Indiana state water quality standards.

The average ammonia-nitrogen concentration (0.115 mg/L) ranked as the third lowest among all sites but all other nutrient parameters in the Salt Creek Mainstem were higher than concentrations measured at most other sites. The Salt Creek Mainstem exhibited the highest average total phosphorus concentration (0.216 mg/L) among all watershed sites. Total phosphorus levels exceeded the level recommended by OEPA to protect aquatic biotic integrity (0.08 mg/L) during all sampling events. Orthophosphorus concentrations were similarly high, accounting for 24 to 92% of the total phosphorus concentration. The average nitrate-nitrogen concentration (3.18 mg/L) at site 14 was the highest among all sites sampled. Nitrate-nitrogen levels ranged between 1.8 mg/L during the May 7 baseflow event and 6.2 mg/L (the highest observed concentration in the watershed) during the July 5 baseflow event. Concentrations exceeded OEPA guidelines (1.6 mg/L) during six of the eight sampling events. The average suspended solids concentration (29 mg/L) in the Salt Creek Mainstem ranked as the third highest among all sites sampled. Suspended solid concentrations exceeded levels found to cause reduced fish yields (25 mg/L) during three of the eight sampling events. Two of these exceedances occurred during storm events. Salt Creek exhibited *E. coli* concentrations above the Indiana state standard of 235 CFU/100 mL during seven of the eight sampling events. *E. coli* concentrations ranged from 100 CFU/100 mL during the May 7 baseflow event to 4,500 CFU/100 mL during the June 19 storm event. Like Damon Run, *E. coli* concentrations generally increased over the sampling period. This increase can likely be attributed to a number of factors including, but not limited to seasonal variation in *E. coli* growth and production, concentration of stream flow, or increases in source loading from domestic and wild warm-blooded animal sources.

The Salt Creek mainstem exhibited poor habitat with similarly low-quality biological communities. The site rated a QHEI score of 44, which fell below the value (51) at which IDEM considers habitat to be poor. Habitat quality was limited by poor substrate, siltation, instream cover, and lack of riffle and pool development. This score fell below the value (51) at which IDEM considers streams to be non-supporting of their aquatic life use designation and within the range designated by IDEM as indicating severe impairment. Biological communities were similarly poor. In August 2006, the site rated a mIBI score of 1.60, the lowest of all sites assessed. In May 2007, the site rated a mIBI score of 4.20, which tied this site with Pepper Creek (site 8) for the second highest mIBI score of all sites assessed. This score fell at the low end of the range designated by IDEM as indicating slight impairment. During both sampling events, the number of individuals collected in the Salt Creek mainstem was the lowest of all sites. While only high-tolerant groups were collected during August 2006, pollution intolerant groups (such as mayflies, stoneflies, and caddisflies) comprised approximately 45% of the total in May 2007. This explained much of the change in score. While the presence of these low-tolerance groups indicates the presence of high-quality conditions within the stream, the low number of individuals suggests that this high-quality habitat is relatively scarce. Family-level HBI scores measured 5.00 in August 2006 and 4.49 in May 2007. These scores indicated "good" water quality with some organic pollution likely.

Site 15: Salt Creek Fixed Station (SR 130)

Site 15 (Figure 49) Salt Creek Mainstem (IDEM fixed station) is located on Salt Creek's mainstem on State Road 130 in the Pepper Creek subwatershed. Water quality data at this site reflects impacts from the southern section of the watershed and the majority of the Sager's Lake and Clark Ditch subwatersheds. Site 15 is upstream of the other mainstem sampling sites (14 and 16), and its subwatershed encompasses the drainage areas of sites 1 through 7, but not 8 through 13 (Figure 34). The subwatershed draining to site 15 includes the following primary land uses: agriculture, high and low density residential, forest, commercial, pasture/grassland, and water. No water chemistry data was collected at this site during the current study as IDEM maintains a fixed monitoring station at this location. Because Site 15 is located on the mainstem of Salt Creek coldwater fishery water quality standards apply (327 IAC 2-1.5-5).

Figure 49. Sampling site 15 - Salt Creek Mainstem (June, 2006)

Historic water quality in Salt Creek (site 15)

IDEM has maintained a fixed sampling station where Salt Creek crosses State Road 130 since 1973. Data used in the following discussion represent data collected from January 1990 through December 2006. During this sampling period, IDEM has measured dissolved oxygen, temperature, pH, and conductivity monthly at this site (190 measurements total, though totals for individual parameters may be less due to missing data in some months). In October 2001, IDEM began monthly sampling for general chemistry parameters (alkalinity, nitrogen, and phosphorus, among others) as part of the fixed station monitoring at this site (59 samples total, though totals for individual parameters may be less due to missing data in some months). The Lake Michigan Interagency Task Force on *E. coli* also sampled the site weekly during 1997 and 1998, measuring *E. coli* 30 times during the sampling period. Dissolved oxygen concentrations remained above Indiana state standards (6.0 mg/L for coldwater fisheries) for all sampling events but one. Dissolved oxygen saturations generally remained between 80 and 100% with some periods of supersaturation (>100% saturated) or undersaturation (<100%). Supersaturated conditions can occur when photosynthetic activity adds oxygen to the stream faster than it can escape the water. Supersaturated conditions occurred primarily during the spring and summer months, suggesting that photosynthetic activity was the primary cause for supersaturation. Undersaturation can occur when decomposition activity consumes oxygen faster than it can be replaced. Periods of undersaturation were observed during all parts of the year. Likewise, the temperature at site 15 exceeded the Indiana State standard for coldwater fisheries once with the event occurring in July of 2006.

Nutrient concentrations were generally high compared to accepted guidelines. Nitrate+nitrite concentrations exceeded the value the OEPA designates to protect aquatic biota (1.6 mg/L) during 52 of 59 sampling events. Nitrate+nitrite concentrations ranged from 1.2 mg/L to 6.9 mg/L with a geometric mean of 3.1 mg/L. Total phosphorus concentrations exceeded the level required to maintain aquatic biota (0.08 mg/L) during 48 of 59 sampling events. Total phosphorus concentrations ranged from 0.03 mg/L to 0.46 mg/L with a geometric mean of 0.14 mg/L. *E. coli* concentrations were also high, exceeding the Indiana state standard (235 CFU/100 mL) during 10 of 30 sampling events. Concentrations exceeded the standard regularly during March and April and periodically during June and July. Compared to other sites included in the current study, the geometric mean for E. *coli* (137 CFU/100 mL) at the State Road 130 fixed station ranked near the middle. Conductivity and turbidity measurements ranked near the middle of all sites, with periodic exceedances of guidelines (1000 µmhos/cm and 25 NTU, respectively) through the sampling period. Beginning in 2002, IDEM began monthly sampling for metals, organics, and pesticides as part of the fixed station monitoring at this site (47 samples total). During all sampling events, all parameters measured less than Indiana state standards.

In 1990, IDEM sampled the fish community in Salt Creek at site 15. Salt Creek rated an IBI score of 34 at this site. This score ranked as the second highest among all watershed sites assessed during the study but did not exceed the guideline (36) at which IDEM considers streams to be supporting of their aquatic life use designation. The second highest number of species (11) was collected at this site, but tolerant species dominated (79.1%) the fish community. This site was not sampled during the 2006 biotic community assessment/ intensive survey. This site was not sampled during the 2006 biotic community assessment/ intensive survey.

Water Quality in Salt Creek Mainstem (site 15)

Water quality data was collected at the IDEM fixed station at site 15 monthly in 2007. Collected data is reported from January 2007 through September 2007. At this fixed station, IDEM collected standard field parameters in 2007 including water temperature, DO, pH, conductivity, turbidity, and chloride. IDEM also sampled for several laboratory parameters including ammonia nitrogen, nitrate+nitrite nitrogen, total phosphorus, total suspended solids, arsenic (total and dissolved), cadmium (total and dissolved), calcium, chromium, copper (total and dissolved), iron (total and dissolved), lead (total and dissolved), nickel (total and dissolved), manganese (total and dissolved), zinc (total and dissolved), and several organic compounds. Organic compounds sampled for during 2007 include: benzopyrene, diethylhelyphthalate, hexachlorobenzene, hexachlorobenzene, hexachlorocyclopentadiene, trifluralin, dichloro-diphenyl-trichloroethane (DDT), acetochlor, alachlor, aldrin, atriazine, chlordane, clyopyrifos, cloamazone, cyanazine, desethylatrazine, dieldrin, endrin, heptachlor, lindane, methoxyclor, metalochlor, pendimehtalin, propachlor, and simazine.

During the January to September 2007 sampling period, DO concentrations remained above Indiana state standards (6.0 mg/L) for all sampling events and ranged from 6.9 mg/L during August to 13.5 mg/L in January. Conductivity concentrations were generally low early in the year and increased from 733 µmhos/cm in January to 1,068 µmhos/cm in June. Turbidity concentrations were elevated during much of the sampling period ranging from 9.1 NTU in March to 23.9 NTU in August. All samples except one exceeded the turbidity level recommended by the USEPA (9.9 NTU; 2000a). Ammonia nitrogen concentrations were generally low with only one sample (February; 0.201 mg/L) measuring above the laboratory detection level of 0.1 mg/L. In comparison, nitrate+nitrite nitrogen concentrations ranged from 0.9 mg/L in August to 5.3 mg/L in June and July. These concentrations mirror those observed along this reach of Salt Creek in the past. Total phosphorus concentrations exceeded the level required to maintain aquatic biota (0.08 mg/L) during eight of the nine sampling events. During the January sampling event, total phosphorus measured below the laboratory detection level, which is above the recommended threshold. Nonetheless, it is difficult to determine whether total phosphorus concentrations were in excess of the recommended concentration during this sampling event. Total phosphorus concentrations ranged from less than 0.1 mg/L to 0.23 mg/L in July. Total suspended solids concentrations were also elevated along this reach of Salt Creek ranging from 12 mg/L in August to 107 mg/L in April. All metal concentrations were within ranges that are typical for Indiana streams or measured below the detection level, while all organic compounds measured below the laboratory detection level during all sampling events.

Physical habitat in the Salt Creek Mainstem was better on average than most other sites**.** The site rated a QHEI score of 50.75, which was fourth highest of all sites. The score was just below the value at which IDEM considers stream habitat to be poor. Habitat quality was limited by instream cover and lack of riffle and pool development. However, riffles and pools will not develop in the sand bottom.
Overall, current water quality data supports findings observed along this reach of Salt Creek historically. Nitrate+nitrite nitrogen and total phosphorus concentrations are higher at this reach than ideal concentrations. In order to positively influence the stream's biota along this reach, both of these concentrations need to be reduced.

Site 16: Salt Creek Fixed Station (US 20)

Site 16 (Figure 50) Salt Creek Mainstem (IDEM fixed station) is located on Salt Creek's mainstem on U.S. Highway 20 in the Squirrel Creek subwatershed. Water quality data at this site reflects impacts from the entire watershed just before Salt Creek outlets into the Little Calumet River. The subwatershed draining to site 16 includes nearly all of the Salt Creek watershed and the following primary land uses: agriculture, forest, pasture/grassland, low and high density residential, commercial, and water. No water chemistry data was collected at this site during the current study as IDEM maintains a fixed monitoring station at this location. Because Site 16 is located on the mainstem of Salt Creek coldwater fishery water quality standards apply (327 IAC 2-1.5-5).

Figure 50. Sampling site 16 - Salt Creek Mainstem (June, 2006)

Historic water quality in Salt Creek (site 16)

IDEM has maintained a fixed sampling station where Salt Creek crosses U.S. Highway 20 since 1986; however, data discussed in the subsequent sections represents information collected from January 1990 through December 2006. During this timeframe, IDEM has measured dissolved oxygen, temperature, pH, and conductivity monthly at this site (190 total measurements, though totals for individual parameters may be less due to missing data in some months). In February 2002, IDEM also began monthly sampling for general chemistry parameters (alkalinity, nitrogen, phosphorus, among others) as part of the fixed station monitoring program at this site (59 samples total, though totals for individual parameters may be less due to missing data in some months). IDEM also sampled the site during the 2000 Salt Creek Assessment and the 2000 *E. coli* assessment. Dissolved oxygen concentrations were above the Indiana state standard (6.0 mg/L for coldwater streams) during all but three sampling events. Dissolved oxygen saturations generally remained between 80 and 100% with some periods of supersaturation (>100% saturated) or undersaturation (<100%). Supersaturated conditions can occur when photosynthetic activity adds oxygen to the stream faster than it can escape the water. Supersaturated conditions were measured primarily in the late summer, suggesting that photosynthetic activity was the primary cause for supersaturation. Undersaturated conditions can occur when decomposition consumes oxygen in the stream faster than it can be replaced. Undersaturation was measured primarily during the spring months.

Nutrient concentrations were generally high at the U.S. Highway 20 fixed station. Nitrate+nitrite concentrations exceeded the value designated by the OEPA to protect aquatic biota (1.6 mg/L) during 45 of 59 sampling events. Concentrations ranged from 1.1 mg/L to 5.0 mg/L with a geometric mean of 2.6 mg/L. Total phosphorus concentrations exceeded the level required to maintain aquatic biota (0.08 mg/L) during 43 of 59 sampling events. Total phosphorus concentrations ranged from 0.030 mg/L to 0.360 mg/L with a geometric mean of 0.120 mg/L. Total phosphorus concentrations were generally higher during the summer months than concentrations measured during the winter and fall. *E. coli* concentrations were high compared to state guidelines and other sites. Concentrations exceeded the Indiana state standard (235 CFU/100 mL) during nine of ten sampling events and the geometric mean (782 CFU/100 mL) was the second highest of the 16 sites included in the current study. Turbidity at the US 20 fixed station was high during much of the sampling period, exceeding Indiana state standards (20 NTU) during 63 of 139 sampling events. Turbidity measurements ranged from 4.1 NTU to 513 NTU with a geometric mean of 19.0 NTU. The highest single turbidity measurement was recorded at this site, which was twice as high as the highest measurement at any other site and more than 20 times as high as most other measurements. The geometric mean for conductivity (758 µmhos/cm) ranked as the fourth lowest of all sites, though measurements exceeded the Indiana state standard during six of the 189 sampling events. Indiana maintains a water quality standard of 750 mg/L for total dissolved solids, which corresponds with conductivities between 1,000 and 1,360 µmhos/cm. Beginning in 2002, IDEM began monthly sampling for metals, organics, and pesticides as part of the fixed station monitoring at this site. During all sampling events, all parameters measured less than Indiana state standards. This site was not sampled during the 2006 biotic community assessment/ intensive survey.

Water Quality in Salt Creek Mainstem (site 16)

Water quality data was collected at the IDEM fixed station at site 16 monthly in 2007. Collected data is report from January 2007 through September 2007. At this fixed station, IDEM collected standard field parameters in 2007 including water temperature, DO, pH, conductivity, turbidity, and chloride. IDEM also sampled for several laboratory parameters including ammonia nitrogen, nitrate+nitrite nitrogen, total phosphorus, total suspended solids, arsenic (total and dissolved), cadmium (total and dissolved), calcium, chromium, copper (total and dissolved), iron (total and dissolved), lead (total and dissolved), nickel (total and dissolved), manganese (total and dissolved), and zinc (total and dissolved). No organic compound sampling occurred along this reach of Salt Creek.

The temperature at site 16 exceeded the Indiana standard for coldwater fishery streams during 2 events. During the January to September 2007 sampling period, DO concentrations remained above Indiana state standards (6.0 mg/L) for all sampling events and ranged from 7.1 mg/L during August to 13.9 mg/L in January. Conductivity concentrations mirror those observed at the upstream reach and were generally low throughout the year. Concentrations were lowest early in the year and increased from 601µmhos/cm in January to 973 µmhos/cm in June. Concentrations observed at site 16 were lower than those observed at site 15, which is likely due to dilution from additional water being in the stream at this downstream location. Turbidity concentrations were elevated during much of the sampling period ranging from 10.2 NTU in March to 60.3 NTU in August. All samples exceeded the turbidity level recommended by the USEPA (9.9 NTU; 2000). Ammonia nitrogen concentrations were generally low with only one sample (February; 0.276 mg/L) measuring above the laboratory detection level of 0.1 mg/L. In comparison, nitrate+nitrite nitrogen concentrations ranged from 1.0 mg/L in August to 3.8 mg/L in July. These concentrations mirror those observed along this reach of Salt Creek in the past and follow a pattern similar to that observed at site 15 during the 2007 sampling. Total phosphorus concentrations exceeded the level required to maintain aquatic biota (0.08 mg/L) during eight of the nine sampling events. Again, during the January sampling event, total phosphorus measured below the laboratory detection level, which is above the recommended threshold. Nonetheless, it is difficult to determine whether total phosphorus concentrations were in excess of the recommended concentration during this sampling event. Total phosphorus concentrations ranged from less than 0.1 mg/L to 0.327 mg/L in March. Total suspended solids concentrations were also elevated along this reach of Salt Creek ranging from 14 mg/L in July to 48 mg/L in August. (No sample was collected at this reach during March.) All metal concentrations were within ranges that are typical for Indiana streams or measured below the detection level. Like upstream reaches, nitrate+nitrite nitrogen and total phosphorus concentrations are higher at this reach than ideal concentrations. In order to positively influence the stream's biota along this reach, both of these concentrations need to be reduced.

Physical habitat in the Salt Creek Mainstem was relatively good. The site rated a QHEI score of 61.75, which was second highest of all sites. The score was above the value at which IDEM considers stream habitat to be poor. The habitat quality was limited by poor channel development, narrow riparian zones, and lack of riffle development.

3.5 Summary of Water Quality Data at All Sampling Sites

Historical data suggests that high *E. coli* and conductivity measurements were prevalent throughout the watershed. Most sites exceeded Indiana water quality standards for *E. coli* and conductivity at least once during the period in which data was available. Several sites exhibited high decomposition rates with low dissolved oxygen and high ammonia concentrations. Habitat quality also rated poorly in many of the stream reaches. As a result of these and other factors, fish communities were impaired with low IBI scores at most sites during multiple assessments. However, some individual tributaries exhibited better water quality than most other streams assessed. *E. coli* and conductivity concentrations in Robbin's Ditch, the Butternut Springs Outlet, and Squirrel Creek ranked among the lowest of all sites on average. Likewise, fish communities in the Sager Lake Outlet and the Mallard's Landing Tributary ranked as the best of all current sites assessed. Conversely, Robbin's Ditch, the Lake Louise Outlet, and Block Ditch exhibited the lowest IBI scores of the current sites. The Lake Louise Outlet, along with Damon Run and Weblos Trail Tributary, rated the highest concentrations of *E. coli* and conductivity.

Current water quality sampling results support similar conclusions. *E. coli* concentrations exceeded the state standard during 81 of 121 recorded samples during the current assessment or nearly 67% of assessments. Concentrations in excess of the Indiana state standard ranged from 240 CFU/100 mL in Beauty and Salt creeks in June of 2007 to 19,000 CFU/100 mL in the Lake Louise Outlet during the same sampling events. *E. coli* concentrations measured at all sites exceeded the state standard during at least one sampling event. Block Ditch, Beauty Creek, and Butternut Springs Outlet contained the lowest average *E. coli* concentrations measured during the sampling period. Conductivity measurements were relatively low at most sites throughout the watershed; however, Robbin's Ditch average concentration was in excess of the state standard. Additionally, two other sites, Weblos Trail Tributary and Salt Creek mainstem both exhibited conductivity concentrations in excess of the state standard during at least one sampling event.

Contrary to historic water quality sampling results, nutrient concentrations were elevated throughout the Salt Creek watershed. Total phosphorus concentrations measured in the Salt Creek watershed ranged from below the detection level 0.016 mg/L in Block Ditch, Beauty Creek, Pepper Creek, the Butternut Springs Outlet, and the Sager's Lake Outlet to 0.970 mg/L in Weblos Trail Tributary. In total, concentrations exceeded the level at which streams are rated as eutrophic (Dodd et al., 1998) and the concentration where the OEPA indicates that negative effects to aquatic biota occur during 105 of 142 sampling events or nearly 75% of samples. Exceedances routinely occurred (more than 50% of samples) in all headwater streams except Beauty Creek with concentrations measuring nearly 30 times the USEPA recommended nutrient criteria for this ecoregion. Nitrate-nitrogen concentrations were similarly high; however, concentrations exceeded recognized standard during only 37 of 142 sampling events or 26% of samples. However, when exceedances occurred, concentrations measured as high as 6.2 mg/L, nearly 5 times the level recommended by the OEPA for the protection of aquatic biota and more than 20 times the USEPA recommended nutrient criteria for this ecoregion.

Biotic community assessments also indicate poorly rated communities are present within the Salt Creek watershed. mIBI scores ranged from 1.6 in the Salt Creek Mainstem to 5.6 in Clark Ditch during the fall 2006 assessment and from 2.7 in Mallard's Landing tributary to 4.7 in the Salt Creek Headwaters during the spring 2007 assessment. Most sites rated as moderately to severely impaired during both assessments. Overall, sites were limited by low individual and family density and diversity and lack of members of the EPT taxa. The macroinvertebrate communities reflect the elevated nutrient and *E. coli* concentrations and relatively poor habitat present throughout the Salt Creek watershed.

However, some individual tributaries exhibited better water quality than most other streams assessed. *E. coli* and conductivity concentrations in Robbin's Ditch, the Butternut Springs Outlet, and Squirrel Creek ranked among the lowest of all sites on average. Likewise, fish communities in the Sager Lake Outlet and the Mallard's Landing Tributary ranked as the best of all current sites assessed. Conversely, Robbin's Ditch, the Lake Louise Outlet, and Block Ditch exhibited the lowest IBI scores of the current sites. The Lake Louise Outlet, along with Damon Run and Weblos Trail Tributary, rated the highest concentrations of *E. coli* and conductivity.

3.6 Potential Water Quality Stressors, Sources, and Causes

A multifaceted approach was used to identify concerns within the Salt Creek watershed. Publicly open Committee Meetings enabled stakeholders and Committee Members to convey concerns and contribute to development of the plan. SDCF recorded comments and included them within the watershed plan draft. Draft plans were then posted to the SDCF website and hard copies were provided at public meetings. Public participants provided feedback on the plan's content. Windshield surveys were also conducted. SDCF provided disposable cameras to the Watershed Group and, in turn individual stakeholders and Committee Members provided photo-documentation of concerns. These photos were compiled, presented to the entire group at a Committee Meeting and used to further identify watershed concerns. Water quality data was then used to assess the validity of concerns and help prioritize the concerns. Table 4 lists the stressors, potential causes or sources, and the evidence. As water sampling continues, additional information becomes available, and problems are addressed, stressors and their causes can be further substantiated or eliminated in future iterations of the SCWMP.

Table 4. Potential water quality stressors, sources, and causes

Stressor: Excessive Sediment and Nutrient Loading	
Potential Source/Cause	Basis/Evidence
Siltation from urban runoff: Channel and streambank erosion and sedimentation. Increased volume and flow due to altered hydrology (ditches and drains, filled wetlands, and impervious surfaces).	Concern regarding erosion along Salt Creek was voiced at public meetings. High conductivity measurements suggest locations of urban runoff. Specifically, elevated conductivity measurements within Robbin's Ditch (site 12) and the Weblos Tributary (site 3) suggest that urban pollutant inputs within these subwatersheds. Hydric soil and national wetland inventory comparison indicates high wetland loss (Figure 16, Figure 17).
Siltation from construction: Siltation from highway, road, bridge, and land development. Sedimentation from existing and new residential development.	Suspected high levels of sediment directly downstream from development sites. Concern voiced at public meetings. Stakeholders indicated visual evidence and provided photo documentation that sediment is eroding from streambanks and that residential development and siltation from highways and roads is a problem throughout the watershed. TSS concentrations and loading data indicate that suspended solids (or sediment) are a concern in the following subwatersheds: Salt Creek Headwaters (site 5), Weblos Trail Subwatershed (site 3), and the Sager's Lake Outlet (site 6). Additionally, the Salt Creek Headwaters, Sager's Lake Outlet, and Damon Run (site 13) loaded more TSS to Salt Creek per acre of drainage than other subwatersheds. All of these subwatersheds contain significant portions of residential land and/or land currently undergoing development.
Erosion and sedimentation from cropland.	Increased sediment could be coming from agricultural operations. Concern for agricultural land use contributing to erosion and sedimentation voiced at public meeting. HEL and potentially HEL soils are present in high density in Damon Run and Salt Creek Headwaters, where high sediment areal loading rates were observed (Figure 10). These subwatersheds have large amounts of cultivated areas (Figure 51). Low adoption of no till/ residue till corn cultivation occur in Porter County (Figure 52).

Stressor: Excessive Sediment and Nutrient Loading (Continued)	
Potential Source/Cause	Basis/Evidence
Nutrient loading from agricultural sources: Fertilizer and contaminants from agricultural crop areas.	Increased nutrient levels could be coming from agricultural operations. Concern for agricultural land use contributing to increased nutrient level was voiced at public meeting. HEL and potentially HEL soils (Figure 10) in Lake Louise subwatershed, which is 15-50% cultivated (Figure 51) could contribute to high nutrient loading. Low adoption rates of no till/ residue till corn cultivation occur in Porter County (Figure 52). TMDL estimates 31% of cattle have stream access.
Nutrient loading from urban runoff: Residential lawn fertilization.	Increased nutrient levels could be coming from urban runoff. High conductivity measurements suggest locations of urban runoff. Specifically, elevated conductivity measurements within Robbin's Ditch (site 12) and the Weblos Tributary (site 3) suggest that these subwatersheds may be host to urban pollutant inputs. Several subwatersheds contain higher total phosphorus concentrations, which suggest particulate loading sources, while other subwatersheds contain elevated soluble phosphorus concentrations, which suggest nutrient loading from readily usable sources such as septic systems, animal waste, and fertilizers. Overall, Damon Run (site 13), Salt Creek Headwaters (site 5), Sager's Lake Outlet (site 6), and Butternut Springs Outlet (site 10) load more soluble and particulate phosphorus to Salt Creek than other tributaries. Lake Louise Outlet (site 1), Damon Run (site 13), and the Salt Creek Headwaters (site 5) also contain the highest nitrate-nitrogen loading rates per acre of drainage and overall for the watershed. These data lend further evidence to the source of soluble nutrients within these subwatersheds as areas of concern. Nutrient concentrations were among the highest measured in the watershed in the Lake Louise Outlet, which drains Shorewood Forest, a residential area.
Nutrient loading from septic systems.	Increased nutrient levels could be coming from malfunctioning septic systems. Soils throughout watershed are not suitable for septic systems (Figure 59). Several subwatersheds contain higher total phosphorus concentrations, which suggest particulate loading sources. Other subwatersheds contain elevated soluble phosphorus concentrations, which suggest nutrient loading from readily usable sources such as septic systems, animal waste, and fertilizers. Overall, Damon Run, Salt Creek Headwaters, Sager's Lake outlet and Butternut Springs Outlet load more soluble and particulate phosphorus to Salt Creek than other tributaries. Lake Louise Outlet (site 1), Damon Run (site 13), and the Salt Creek Headwaters (site 5) also contain the highest nitrate-nitrogen loading rates per acre of drainage and overall for the watershed. These data lend further evidence to the source of soluble nutrients within these subwatersheds as areas of concern.

Problem statement: Stakeholders expressed concern regarding excessive sediment and nutrient loading at public meetings. Water quality data confirms these concerns. Stakeholders indicated visual evidence of erosion along Salt Creek and erosion from construction sites and submitted photographs of these concerns (Figure 54, Figure 55). Erosion from cropland is another typical source of sediment, and 28% of Salt Creek land use is agricultural. SDCF observed excessive algae growth in certain segments of Salt Creek (Figure 57). Water quality data confirmed excessive nutrient concentrations. Fertilizer from agricultural and residential areas is a common source of nutrients, and both land uses are common in the Salt Creek watershed. Another potential source of nutrients is malfunctioning septic systems. Many areas in the watershed utilize septic systems, and most soils are unsuitable (Figure 59).

Stressor: Elevated Pathogens	
Potential Source/Cause	Basis/Evidence
Wastewater disposal: Human sewage from sources such as individual septic systems, combined sewer overflows, and effluent from wastewater treatment plants.	Suspected failing septic systems indicated by high *E. coli* levels (303d impairment) identified in TMDL. CSO (combined sewer overflow) concern confirmed by Point Source Committee data from the 1998 season. (Figure 62, Table 7). Concern voiced at public meeting. Soils throughout the watershed are not suitable for septic systems. All of the sampled streams within the Salt Creek watershed contain mean *E. coli* concentrations greater than the state standard. The Lake Louise Outlet (site 1), Salt Creek Headwaters (site 5), and Robbin's Ditch (site 12) contained the highest mean and individual *E. coli* concentrations recorded during sampling.
Agriculture: Animal waste from agricultural/livestock areas in runoff.	Suspected runoff from agricultural sites indicated by high *E. coli* levels (303d impairment) identified in TMDL. All of the sampled streams within the Salt Creek watershed contain mean concentrations greater than the state standard. The Lake Louise Outlet (site 1), Salt Creek Headwaters (site 5), and Robbin's Ditch (site 12) contained the highest mean and individual *E. coli* concentrations recorded during sampling. The Lake Louise Outlet and Salt Creek Headwaters subwatersheds have large amounts of cultivated areas (Figure 51). Salt Creek Headwaters subwatershed has large amounts of pastureland (Figure 24). TMDL estimates 31% of cattle have stream access.
Natural sources: Wild animal waste in runoff.	Suspected runoff of wild animal waste indicated by high *E. coli* levels (303d impairment) identified in TMDL.
Urban runoff: Domestic pet waste in runoff.	Suspected runoff of pet animal waste indicated by high *E. coli* levels (303d impairment). Pet waste clean-up/education recommended in TMDL. All of the sampled streams within the Salt Creek watershed contain mean concentrations greater than the state standard. The Lake Louise Outlet (site 1), Salt Creek Headwaters (site 5), and Robbin's Ditch (site 12) contained the highest mean *E. coli* concentration and the highest individual *E. coli* concentrations recorded during sampling.
Urban point source: Illicit connections/illegal hook-ups/dry weather flows. Straight pipe sewage discharges and municipal sewage treatment facility discharge.	Identified in TMDL.

Problem statement: Elevated pathogens are a problem within the Salt Creek watershed. All of the sampled streams within the Salt Creek watershed contain mean concentrations greater than the state standard for full-body contact recreation. This has been confirmed by the TMDL. Water quality data collected during the development of the SCWMP also confirms the problem. Suspected sources are failing septic systems, combined sewer overflows (CSOs), effluent from wastewater treatment facilities, illicit straight pipe discharges of sewage, and runoff from agricultural areas, pets, and wildlife.

Concern: Lack of Public Awareness	
Potential Source/Cause	Basis/Evidence
Runoff from residential areas: Use of fertilizers and pesticides on residential lawns, pet waste, oil disposal.	Concern voiced at public meetings. Identified in TMDL.
Lawn/roadside management: Exotics and invasives.	Concern voiced at public meetings.

Problem statement: Lack of public awareness of these issues is a concern. The group believes that the general public needs better understand certain actions and their impact on water quality. The 2007 Regional Water Quality Survey conducted for NIRPC found that "there is a willingness by those surveyed in the NIRPC region (Lake and Porter Counties) to make some adjustments in daily habits to protect the water resources" but that "more education is needed". For example according to the survey only six percent of those surveyed understood the term "watershed" and "50% of those surveyed thought that the way they cared for their homes had little or no effect on the quality of water in the lakes and streams in their community" (ETC Institute, 2007).

Concern: Degraded Biotic Communities	
Potential Source/Cause	Basis/Evidence
Habitat modification: Removal of riparian vegetation and bank modification/ destabilization.	Riparian area management suggested in TMDL. Concern voiced at public meetings. Riparian metric scores (QHEI) were low throughout the watershed suggesting that habitat modifications are occurring along the streambank. Canopy removal was noted at eight of the sixteen sites, while bank shaping or channel modifications were noted at five of 16 sites.
Channelization: Ditches and drains.	Suspected increase in pollutant loads related to drainage area and ditch management.
Hydrologic modification: Filled or drained wetlands.	Suspected increase in pollutant loads related to wetland loss throughout the watershed. Concern voiced at public meetings. Evidence of historic wetland loss (Section 2.6). Hydric soil and national wetland inventory comparison indicates high wetland loss (Figure 16, Figure 17).
Low dissolved oxygen concentrations.	Low dissolved oxygen concentrations were present in Robbin's Ditch (site 12), the Weblos Trail Tributary (site 3), and the Lake Louise Outlet (site 1). These low concentrations are likely due to a combination of the presence of a large volume of materials that require oxygen for decomposition and due to slow flow and/or shallow stream slopes.

Problem statement: Concern for degraded biotic communities has been substantiated by the TMDL, the IDEM intensive survey, and watershed sampling conducted during the development of the SCWMP. Sources could include pollutant loads, removal of riparian areas along Salt Creek, ditching, and filling wetlands. Water quality data collected for the SCWMP indicates low dissolved oxygen, sedimentation, and poor habitat.

Concern: Impact of Increased Development	
Potential Source/Cause	Basis/Evidence
Increases in impervious surface cover.	Concern voiced at public meetings. Increases in development county wide documented by 13.9% population increase between 1990 and 2006, increasing population density (centered around and between incorporated areas (Figure 27)), and increasing total number of housing units.
Inability of infrastructure (sewer system, etc.) to keep up with residential development rates.	Concern voiced at public meetings. Occurrence of CSOs
Lack of resources for ordinances and planned growth.	Concern voiced at public meetings.

Problem statement: Visual evidence of increased development has been documented throughout the Salt Creek watershed.

3.6.1 Sediment

By volume, sediment is the number one pollutant in surface waters of the United States (Davenport, 2003). Sediment from channels, agricultural operations, and urbanized areas that enters Salt Creek is considered a nonpoint source pollutant, and is addressed by this plan. Sediment is a significant pollutant because of its physical properties, potential chemical interactions, and total loads. When suspended, sediment reduces the amount of sunlight available to aquatic plants and can impair fish breathing by clogging gills. Sediment also covers fish spawning areas and food supplies, ultimately reducing the overall fish population. High concentrations of metals, phosphorus, and nitrogen can be transported to surface waters with sediment. Generally, bare, disturbed soils are particularly susceptible to erosion, and sediment can be detached and transported to streams and lakes by stormwater or enter surface waters from scouring when high energy flows erode stream banks.

3.6.1.a Agriculture

Erosion from agricultural land is a potential source of sediment to Salt Creek. Much of the land use in the Salt Creek watershed is agricultural with cultivated crops on 20% of the land and pasture/hay covering 8% of the land (Figure 26). Figure 51 show cultivated areas within the Salt Creek watershed. Cropland is often tilled in preparation for planting, leaving the soil bare. The exposed soil can be easily detached and transported into Salt Creek by stormwater runoff. In Porter County 67% of corn cropland and 6% of soybean cropland is in conventional tillage (Figure 52) (Indiana State Department of Agriculture (ISDA), 2007). Highly erodible and potentially highly erodible soils are of particular concern (Figure 10). Cropland may also be farmed to the edge of the Creek or its tributaries, exacerbating erosion and limiting filtration. Reduced tillage systems can be effective at reducing erosion from cropland by covering soils rather than leaving them bare. Agricultural runoff can also be passed through practices that remove sediment, such as filter strips, and retention ponds. Allowing livestock direct access to Salt Creek can contribute to erosion by damaging banks and removing riparian vegetation. Overgrazing by livestock can expose soils by removing vegetation and can compact soils, decreasing infiltration. No known Confined Feeding Operations (CFOs) are present in the watershed (Appendix R, IDEM, 2007a).

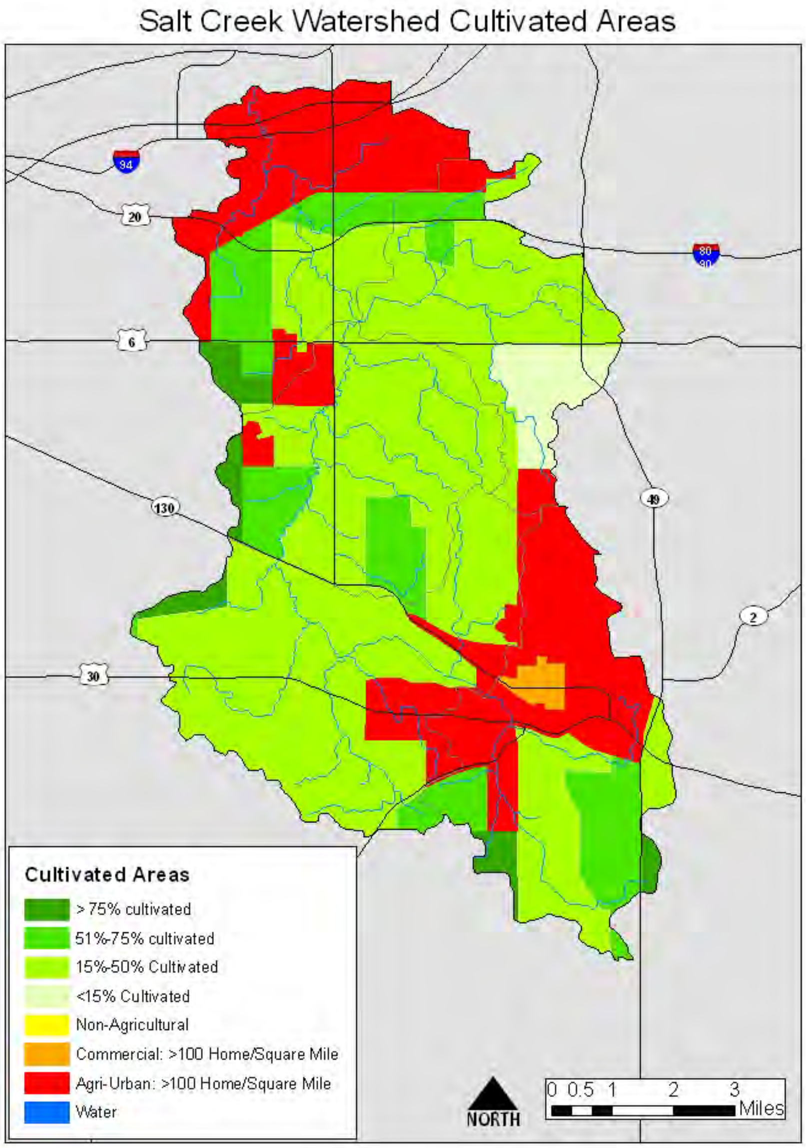

Figure 51. Salt Creek watershed cultivated areas (Source: See Appendix R)

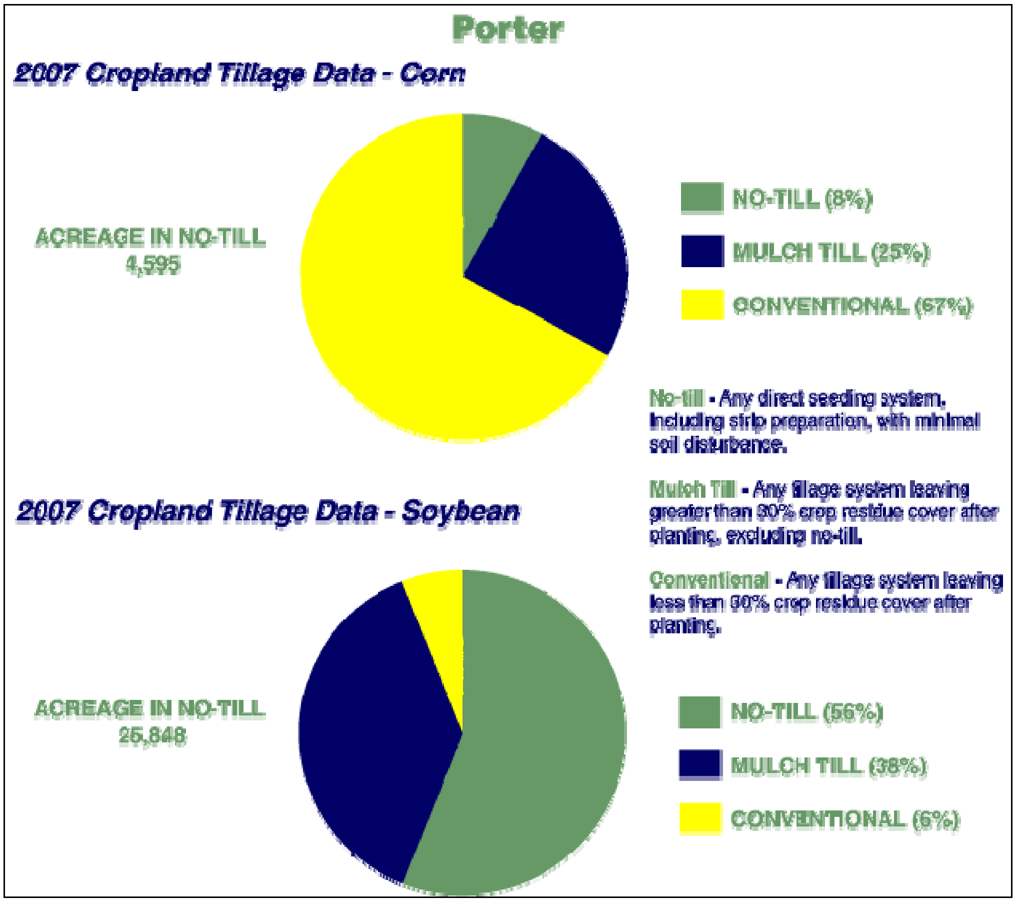

Figure 52. 2007 tillage data for corn and soybean in Porter County (ISDA, 2007)

3.6.1.b Urban

Runoff from construction sites is one potential source of sediment to Salt Creek. Construction activities involve the disturbance of land and removal of vegetation. Stakeholders reported visual observation and provided photo documentation of erosion and runoff from multiple construction sites throughout the watershed. Figure 54 and Figure 55 show representative locations of erosion from construction sites. Sites contributing sediment to Salt Creek were also covered in the press on multiple occasions during the development of this plan. This plan acknowledges runoff from construction sites as a major contributor of sediment to Salt Creek. After completion of construction, increased runoff from developed areas and impervious surfaces can continue to carry sediment to streams. Hydrology changes significantly when impervious surfaces replace the natural landscape. Increases in impervious surface typically result in an increase in runoff volume and pollutant loading. Estimated percentages of impervious surfaces in the Salt Creek watershed are shown in Figure 53. Pre and post construction best management practices (BMPs) can reduce the amount of sediment entering Salt Creek from urban areas. Low impact development (LID) practices can also lessen the impact of development and impervious surfaces on Salt Creek. The greatest development pressure in the watershed is focused in and around the City of Valparaiso (Beauty Creek, Sager's Lake, Salt Creek Headwaters), particularly along the State Road 49 corridor between Valparaiso and Chesterton (Damon Run subwatershed) and between the cities of Portage and Chesterton (Robbin's Ditch, Beauty Creek, Pepper Creek, Butternut Springs). See 2.10.1 Current Land Use and Development Trends for more information on development.

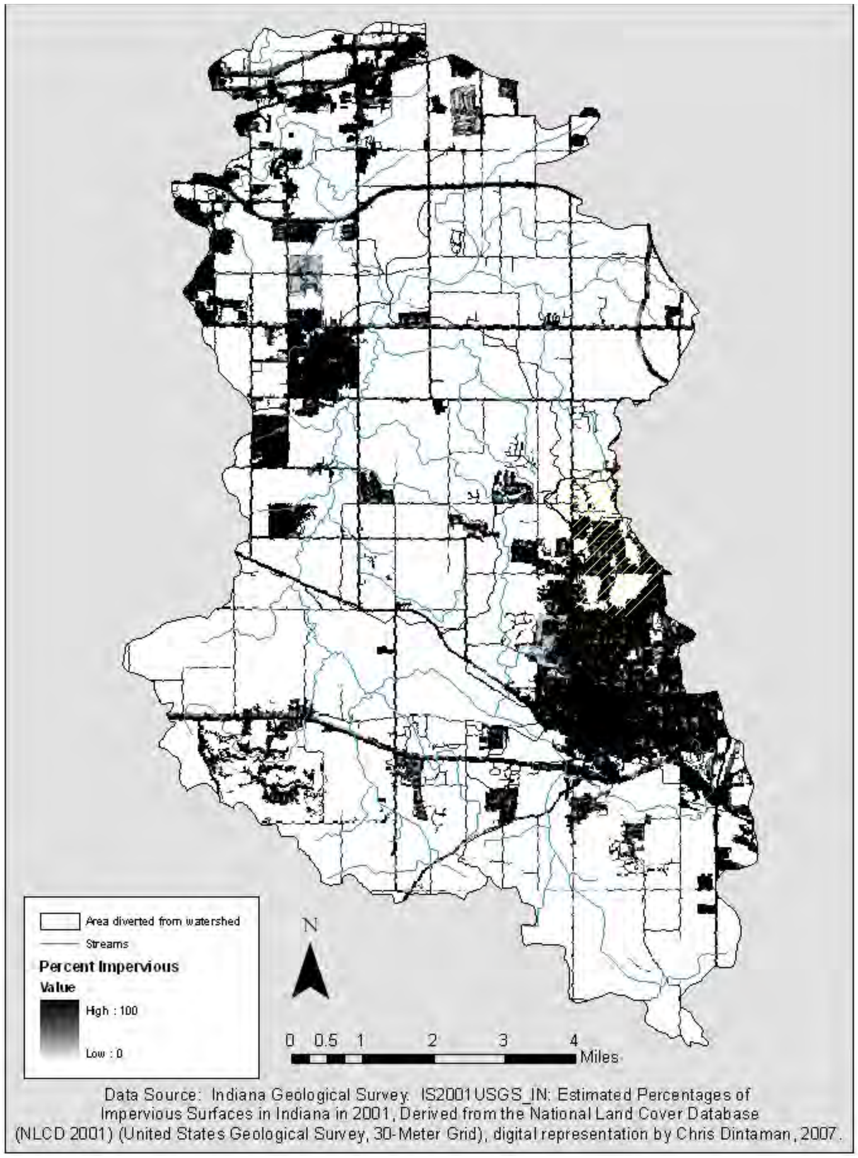

Figure 53. Salt Creek watershed estimated percent impervious surfaces (Source: See Appendix R)

Figure 54. Representative erosion and runoff from construction sites in Salt Creek watershed (2006)

Figure 55. Representative erosion and runoff from construction sites in Salt Creek watershed (2006)

3.6.1.c Channel Sources

Channel sources of sediment are bed scouring and stream bank erosion. Sediment can enter streams when unstable banks collapse into the stream. Steep slopes (shown in Figure 58) are particularly vulnerable. Additional sources are drainage ditch maintenance and concentrated flow from construction sites and cropland. Large quantities and high velocities of water can erode streambanks and streambeds, suspending sediment in the stream. The adverse consequence of streambank erosion is not only accelerated sediment loads, but also changes in stream channel stability and associated stream type. Stream channel instabilities and consequential shifts in stream type not only produce higher sediment loads, but also degrade the physical and biological function of the streams. Increases in impervious surfaces can result in increased peak flow volumes. LID and other BMPs can reduce the impacts of development and increases in impervious surfaces on flow volumes and lesson streambank erosion and scouring. Photographic documentation of representative locations of channel sources of sediment in the Salt Creek watershed is shown in Figure 56.

Figure 56. Steep slope and channel source of sediment in priority subwatershed Beauty Creek (2006)

3.6.2 Nutrients

Under natural conditions nitrogen and phosphorus limit the rate of plant and algae growth in surface waters. When nutrients, such as nitrogen and phosphorus, are introduced to a stream at higher than natural rates, aquatic plant productivity can increase dramatically. This process, known as eutrophication, may adversely affect the suitability of water for recreation and may impair biotic communities. Growth of aquatic vegetation can reach nuisance levels, impeding fishing, swimming, and boating. When excessive amounts of algae die, large amounts of oxygen are removed during the decomposition process. This removal of dissolved oxygen can be detrimental to fish populations. High concentrations of nutrients can also be toxic to fish. Nutrient loading within Salt Creek has been identified as a water quality problem and is addressed in this plan. In addition to high nutrient concentrations being detected during water quality monitoring, photographic documentation of algal growth in Salt Creek is shown in Figure 57. Sources of nutrients can include erosion and runoff from agricultural and urban areas that contain fertilizer and human and animal wastes.

Figure 57. Increase in aquatic plant productivity within Salt Creek (June, 2006)

3.6.2.a Agriculture

Commercial fertilizers and manure are commonly applied to cropland to supply nutrients to increase crop yields. Nitrogen and phosphorus are the most common nutrients applied to crops. Improperly applied or excessive nutrients can wash off of cropland or be adsorbed to sediments transported by stormwater runoff. Highly erodible soils are present in the watershed (Figure 10). Livestock manure can also contribute nutrients to streams when it is washed from pastures by runoff or directly deposited when livestock have access to streams. Livestock can suffer health impacts from drinking water high in nitrate. WHPA estimated in the Salt Creek TMDL that 31% of the cattle throughout the watershed have direct access to Salt Creek or its tributaries and spend 10% of their grazing time in the stream (2004).

3.6.2.b Urban

Excessive applications of fertilizers to yards, public lands, and golf courses can result in nutrients being washed by stormwater into nearby streams and ditches. Nutrient concentrations were among the highest measured in the watershed in the Lake Louise Outlet, which drains Shorewood Forest, a residential development. Effluent from malfunctioning septic systems and from point sources such as combined sewer overflows (CSOs) can also contribute to elevated levels of nutrients. There are several waste water treatment facilities located throughout the watershed. A map showing the locations of these and other National Pollution Discharge Elimination System (NPDES) facilities can be found in Figure 63. Additional detail on CSOs can be found in Section 3.6.3.e Point Sources.

3.6.3 E. coli

As noted earlier and in the Salt Creek TMDL there are multiple potential sources of pathogen loading in the Salt Creek watershed that are contributing to high *E. coli* levels. Some pathogens, or disease-causing organisms, can be found in water, typically as a result of fecal matter contamination (USEPA, 2006). *E. coli*, which can come from the feces of any warm-blooded animal, is used as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. The presence of *E. coli*, a normally non-pathogenic intestinal organism of warm-blooded animals, is easy to test for and indicates fecal contamination. The SCWMP addresses *E. coli* as an indicator of fecal contamination and the potential presence of pathogens. Despite the complexity of the relationship between sources and in-stream concentrations of *E. coli,* the following are considered major source categories: agricultural, septic systems, wildlife, and wastewater treatment plants.

3.6.3.a Agricultural/Livestock Runoff

Manure from livestock is a potential source of *E. coli* to Salt Creek. Figure 24 shows the location of pastureland in the watershed. Manure contributes to the degradation of Salt Creek water quality under three circumstances: direct deposition, flow changes carrying deposited manure to streams, and through land application of manure and subsequent surface water runoff. The following details these three pathways. While grazing, livestock deposit fecal matter directly onto pastureland and frequently directly into streams. SDCF documented visual evidence of livestock in Salt Creek (Figure 58). Additionally, under low flow conditions, livestock in the stream can be a dominant source of *E. coli*. Secondarily manure deposited onto pastureland is exposed to the environment for a period of time and can run off during storm events. Finally, land application of manure helps reduce or eliminate the need for commercial fertilizers. However, manure runoff from pasture and inappropriate land application can be a prominent source of *E. co*li during high flows.

Figure 58. Representative photograph of a cow in Salt Creek (June, 2006)

The number and location of livestock was estimated by a windshield survey of the watershed conducted during the development of the Salt Creek TMDL. During the windshield survey, observations were recorded as every road in the watershed was driven and the livestock were counted. Survey observations indicated an estimated 305 beef cattle, 56 dairy cattle, 29 goats, 78 horses, and 16 sheep in the watershed (WHPA, 2004). The total estimated production from livestock was calculated by multiplying the number of animals by the estimated amount of *E. coli* produced from each animal. This calculation indicated that 2.3×10^{15} CFU/year originate from beef cattle, 1.1×10^{15} CFU/year originate from dairy cattle, 8.2×10^{12} CFU/year from goats, 6.5×10^{14} CFU/year originate from horses, and 6.4×10^{12}CFU/year originate from sheep. See Appendix K for more information on the Salt Creek *E. coli* TMDL source characterization.

In the Salt Creek watershed most cattle and horse owners graze their livestock year round, but ’bed’ their animals at night in a barn (Ames, 2003). While grazing, livestock deposit fecal matter directly onto pastureland and often times directly into streams. Manure deposited onto pastureland is exposed to the environment for a period of time and is available for runoff during storm events. Alternatively, the manure from the barn is collected and applied to croplands. Land application of manure helps reduce or eliminate the need for commercial fertilizers. It can be applied in four different ways 1) surface broadcast followed by disking, 2) broadcast without incorporation 3) injection under the surface, or 4) irrigation. In Porter County, Indiana, animal manure is generally applied with incorporation in the spring (April - May) and fall (October - November) (Ames, 2003; Sutton, 2003). It is estimated that livestock farmers only collect and store manure from cattle and horse deposits in their barns where the animals bed at night (Ames, 2003). It is assumed that livestock usually spend 1/3 of a typical day indoors. Therefore, the amount of total manure from cattle and horses applied to land was estimated to be 1/3 of the amount produced by each animal. This fraction of the total for horse and cattle manure is distributed over the four months manure is applied to fields. The TMDL assumes that cattle manure is applied to cropland, horse manure is applied to pastureland, and no manure is applied to forest or built-up areas. The manure that is not applied by the livestock owners is assumed to all be added directly to the pasture by the animals. The manure deposited directly by the animals onto pastureland (2/3 of total) is not incorporated, but remains a source for runoff events. This fraction of the total for horse and cattle manure is distributed over twelve months because the animals are allowed to graze throughout the year.

Access to streams allows livestock to input manure directly into the streams. During a meeting on February 6, 2003, the county agents indicated where livestock have stream access (Ames et al., 2003). Based on these discussions, 31% of the total cattle in the watershed have access to a stream. It was estimated that these cattle would only spend 10% of grazing time in the stream. It was assumed that most horse owners do not allow their horses access for fear of disease, so no access was input for horses (Ames et al., 2003).

3.6.3.b Septic Systems

Onsite sewage disposal (septic) systems are designed for the purpose of wastewater treatment. For optimal functionality, the systems must be properly engineered and installed, located in suitable soils, and receive routine maintenance. Systems that are not regularly maintained, have outdated or inefficient designs, or are installed in inappropriate soils often result in septic failure. Most of the soils in the Salt Creek watershed are severely limited for septic system suitability, and many are moderately or slightly impaired (Figure 59). Discharge of effluent associated with failing septic systems can introduce pathogens, parasites, bacteria, and viruses, which can cause disease through body contact or ingestion of contaminated water. *E. coli* and other pathogens pose a particular threat when sewage pools on soil or migrates to recreational waters.

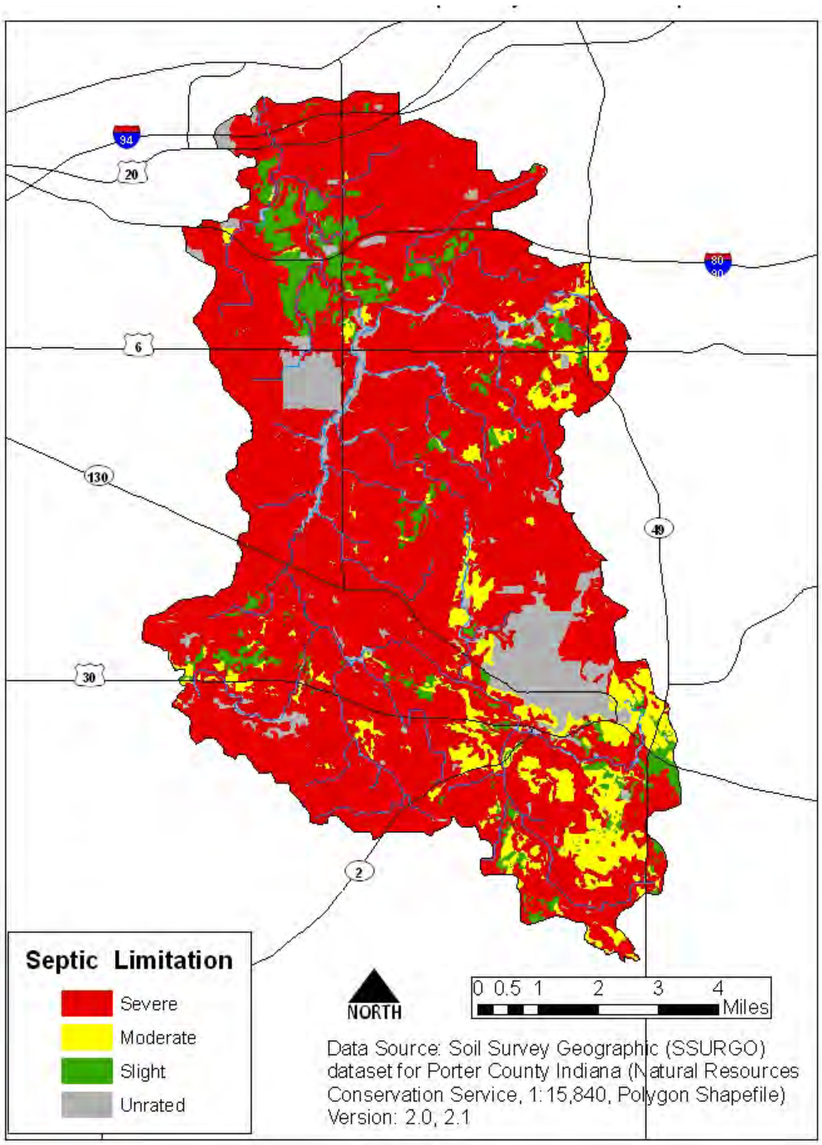

Figure 59. Salt Creek watershed soil limitation for septic systems (Source: See Appendix R)

The highest numbers of houses on septic systems in the Salt Creek watershed are in the Damon Run subwatershed and in portions of the Clark Ditch and Sager's Lake subwatersheds (Figure 60). In 2005 the constructionof a lift station connecting some of the residential development in the Damon Run subwatershed to the Portage Waste Water Treatment Facility enabled households in that area previously on septic or connected to small package plants to connect to the municipal treatment facility. This is an ongoing process. As residents currently using septic systems convert to the municipal service, a decrease in the loading of *E. coli* and other pathogens and pollutants in this subwatershed is expected.

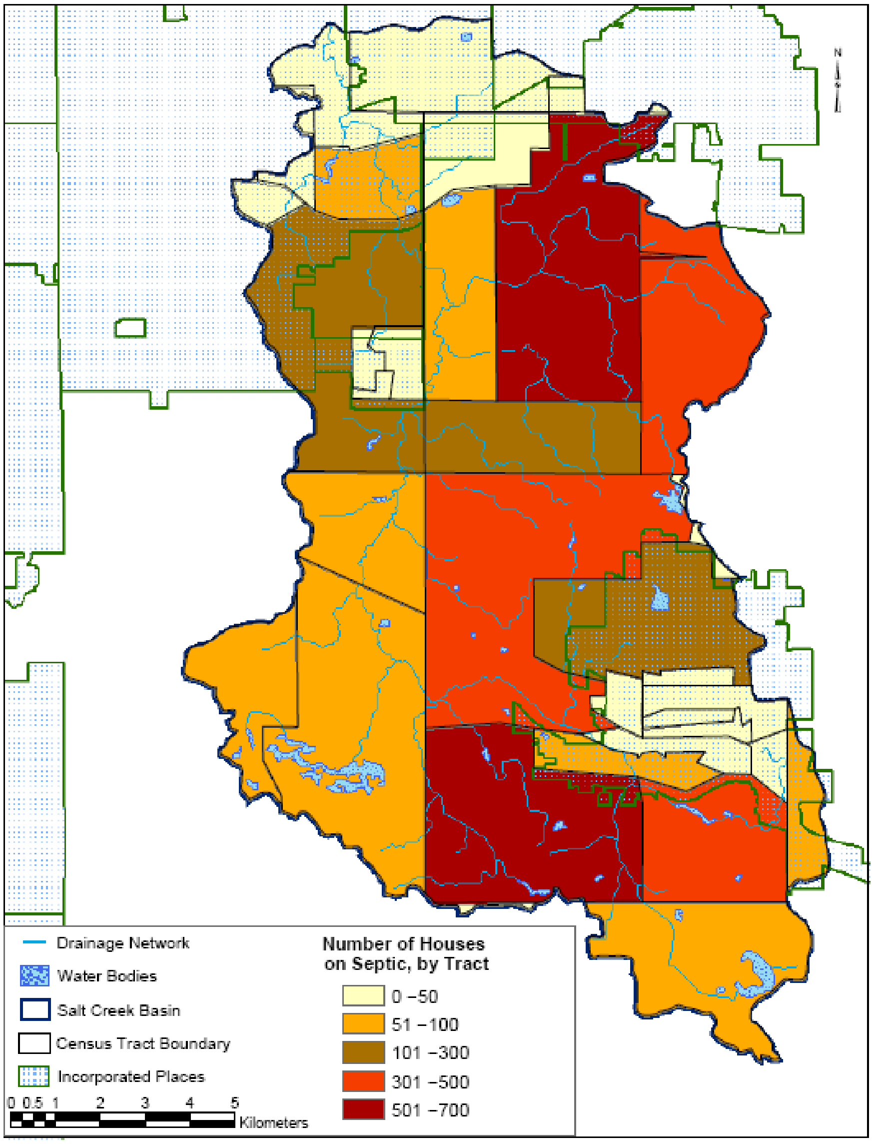

Figure 60. Number of houses on septic systems in the Salt Creek watershed (WHPA, 2004)

Another septic-related issue within the watershed is the presence of septage waste sites. Septage waste sites are permitted septage (septic tank waste) sites where the waste is land applied, as defined by 327 IAC 7, 327 IAC 7-6, and 327 IAC 7-7 of the IAC. Locations of access points to managed sites, provided by personnel of IDEM, Office of Land Quality (IDEM, OLQ) within the Salt Creek watershed are shown Figure 61. The data is current as of January 24, 2007.

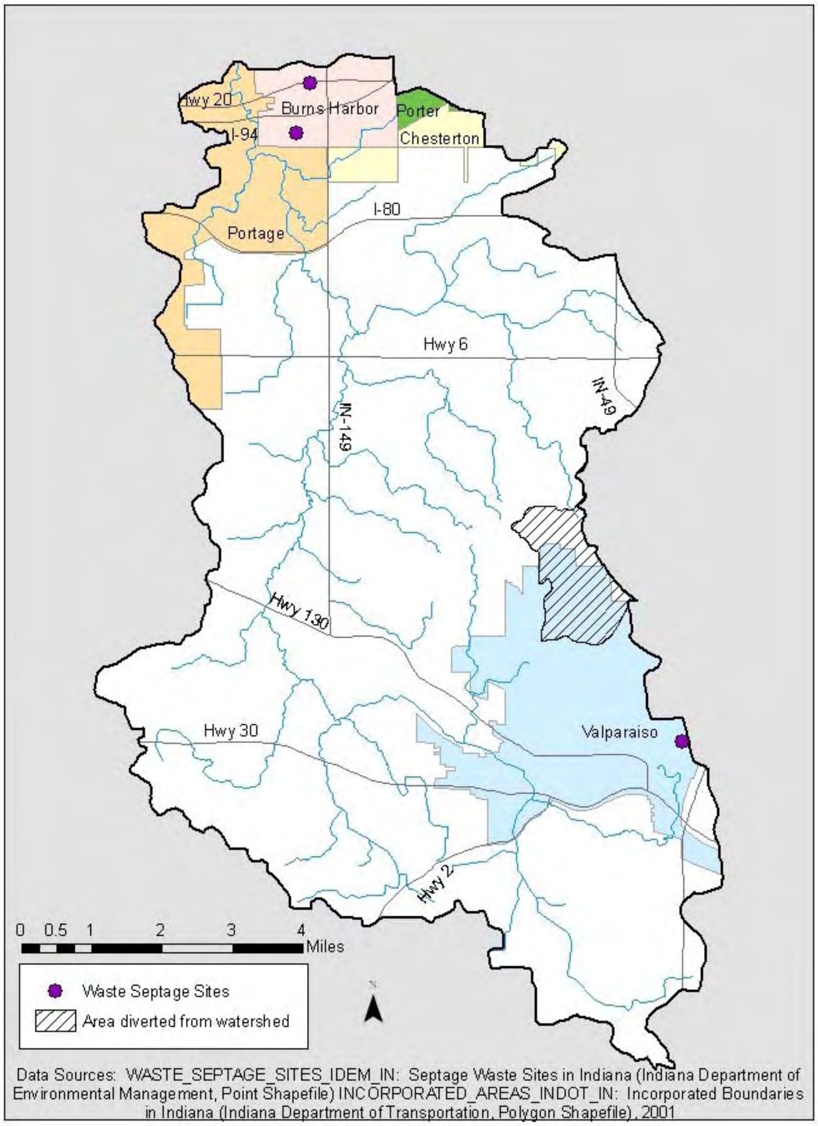

Figure 61. Septage waste sites within the Salt Creek watershed (IDEM, 2007)

3.6.3.c Wildlife

Wildlife also contributes to *E. coli* in streams through runoff of fecal matter. The wildlife assumed to be major contributors in the watershed are coyote, deer, duck, geese, opossum, raccoon, turkey, squirrel, rabbit, and mice. IDNR surveys wildlife to establish population trends for specific species but does not survey to determine population numbers (Byer, 2003). The Salt Creek *E. coli* TMDL lists estimates of animal density, amount of fecal matter, and *E. coli* content in fecal matter for wildlife in the watershed (See Appendix K for more information.). The numbers of each type of animal in the land uses were calculated by multiplying their assumed densities with the area of each land use type (Table 5). The estimated amount of *E. coli* from wildlife each year was then calculated by multiplying the number of each animal by the amount of manure produced by each. As Table 6 shows, waste from raccoon, rabbit, and deer produce an estimated 86% of the total *E. coli* from wildlife in the watershed. This plan recognizes wildlife as an uncontrollable source of *E. coli*, which will be addressed through public education related to feeding wildlife.

Table 5. Estimated number of wildlife in various land uses in the Salt Creek watershed (WHPA, 2004)

Animals	Cropland (number)	Forest (number)	Pastureland (number)	Total (number)
Coyote	23	31	22	76
Deer	364	482	343	1,189
Duck	94	124	89	307
Geese	129	171	122	422
Opossum	82	109	77	268
Raccoon	587	1,088	553	2,228
Turkey	24	31	22	77
Squirrel	469	994	708	2,171
Rabbit	1,760	2,331	1,659	5,750
Mice	5,867	5,530	7,769	19,166

Table 6. The estimated *E. coli* load from wildlife in the Salt Creek watershed (WHPA, 2004)

Animals	Cropland (CFU/year)	Forest (CFU/year)	Pastureland (CFU/year)	Total (CFU/year)	% of Total
Coyote	3.78×10^{12}	5.09×10^{12}	3.61×10^{12}	1.25×10^{13}	1
Deer	1.03×10^{14}	1.36×10^{14}	9.67×10^{13}	3.35×10^{14}	30
Duck	5.15×10^{12}	6.79×10^{12}	4.87×10^{12}	1.68×10^{13}	2
Geese	1.06×10^{13}	1.40×10^{13}	1.00×10^{13}	3.47×10^{13}	3
Opossum	6.79×10^{12}	9.03×10^{12}	6.38×10^{12}	2.22×10^{13}	2
Raccoon	9.64×10^{13}	1.79×10^{14}	9.08×10^{13}	3.66×10^{14}	33
Turkey	1.32×10^{12}	1.71×10^{12}	1.21×10^{12}	4.24×10^{12}	0
Squirrel	8.56×10^{12}	1.81×10^{13}	1.29×10^{13}	3.96×10^{13}	4
Rabbit	7.71×10^{13}	1.02×10^{14}	7.27×10^{13}	2.52×10^{14}	23
Mice	6.42×10^{12}	6.06×10^{12}	8.51×10^{12}	2.10×10^{13}	2
Total				1.10×10^{15}	

CFU = colony forming units

<u>3.6.3.d Urban Stormwater Runoff</u>

Runoff from urban and industrial areas can potentially contribute bacteria to streams and rivers. The bacteria can come from such sources as pet feces, urban wildlife, sanitary sewer cross-connections, and deficient solid waste collection. The accumulation rates for fecal coliform range from 1.8×10^8 to 2.1×10^{10} count/acre/day (USEPA, 2000b). More information on these estimations from the Salt Creek *E. coli* TMDL can be found in Appendix J

<u>3.6.3.e Point Sources</u>

Although the focus of the SCWMP is on addressing nonpoint sources of pollution, the Watershed Group acknowledges that point sources are also contributing pollution throughout the watershed. Several NPDES permitted facilities contribute to elevated *E. coli* levels in Salt Creek (Figure 63). Load estimates associated with those facilities are shown in Table 7. The Watershed Group continues to work toward reducing nonpoint sources of *E. coli*; however, it must be noted that this activity alone will not resolve elevated *E. coli* levels. As is the case with the City of Valparaiso, some wastewater treatment facilities and package plants within the watershed have improved their efficiency in recent years (
Figure 62); nonetheless, regular CSO events still occur. These events contribute significantly to *E. coli* loading throughout the watershed.

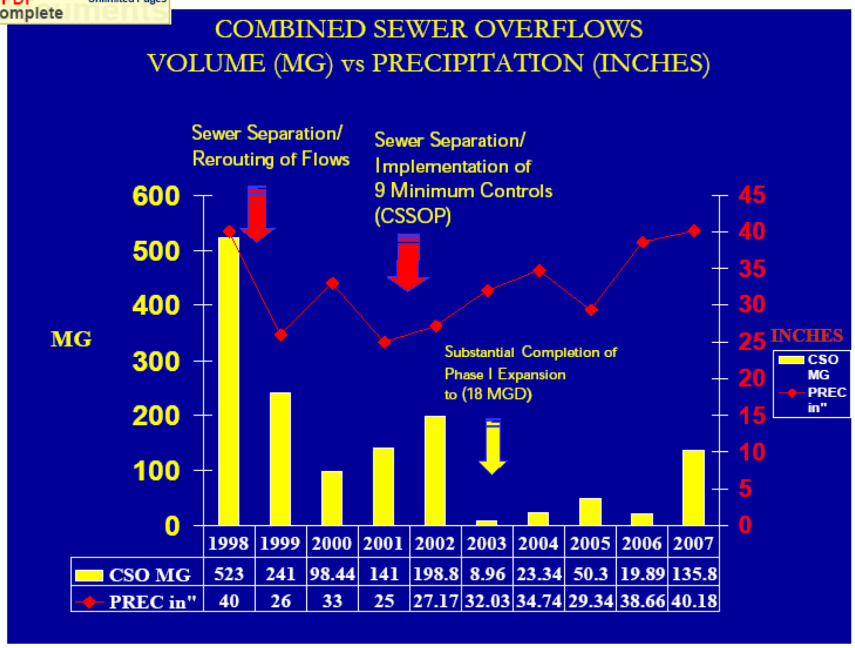

Figure 62. Combined sewer overflow activity (Valparaiso Water Reclamation Department, 2007)

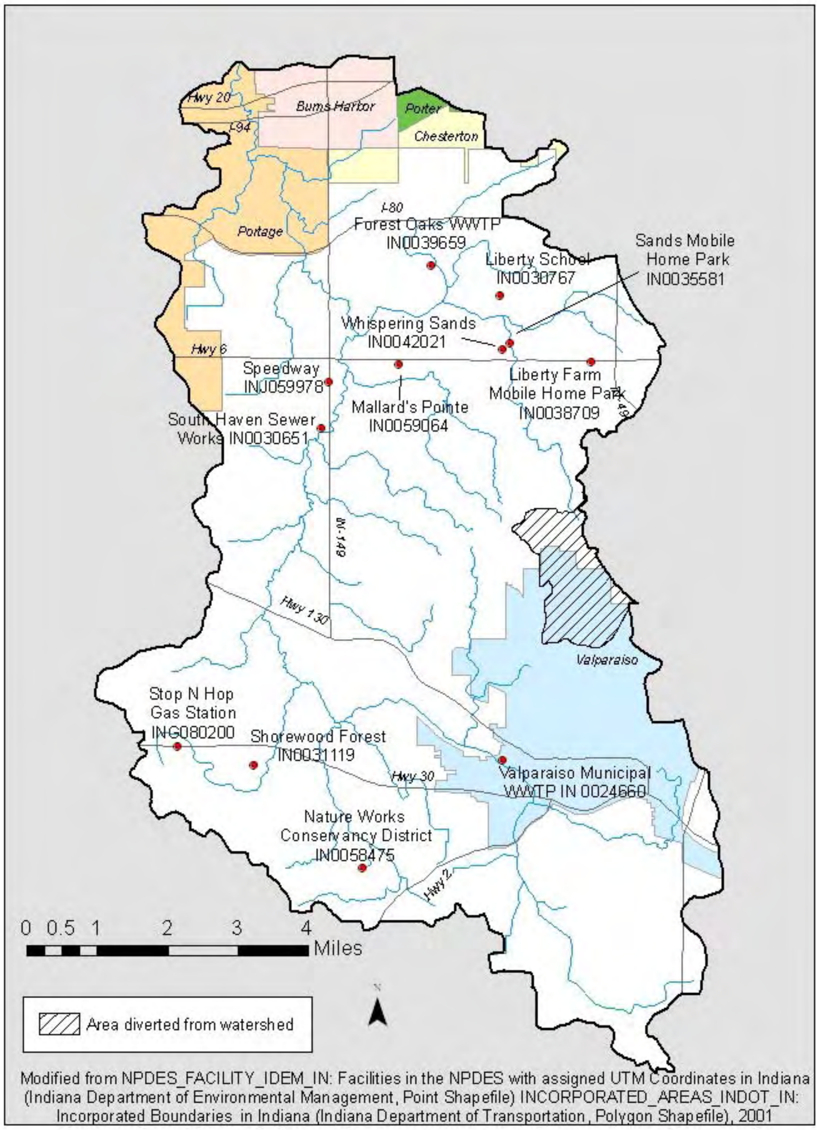

Figure 63. NPDES facilities in the Salt Creek watershed (Source: See Appendix R)

Table 7. Average flow and estimated annual *E. coli* loads from NPDES facilities (WHPA, 2004)

Permit Number	Data Period	Ave. Flow (MG/yr)	Ave. E. coli (CFU /100 mL)	Load from Effluent (CFU/yr)	Ave. Bypass 1994-2001 (no/yr)	Ave. Bypass Flow (MG/yr)	Load from Bypass* (CFU/yr)	Total Load (CFU/yr)
IN0024660	6/01-4/02	1,803	8	3.63×10^{11}	12	126	4.78×10^{15}	4.78×10^{15}
IN0030651	1/89-4/02	429	17	2.63×10^{11}	4	1.13	4.28×10^{13}	4.31×10^{13}
IN0030767	6/01-4/02	7	58	3.29×10^{10}	0.25	0.04	1.52×10^{12}	1.55×10^{12}
IN0031119	10/91-4/02	75	14	5.40×10^{10}	–	–	–	5.40×10^{10}
IN0035581	4/89-4/02	5	235±	4.45×10^{10}	0.13	0.003	1.14×10^{11}	1.59×10^{11}
IN0038709	4/90-4/02	10	235±	8.91×10^{10}	–	–	–	8.91×10^{10}
IN0039659	4/89-4/02	18	122**	4.21×10^{10}	–	–	–	4.21×10^{10}
IN0042021	5/92-10/00	16	390**	2.73×10^{11}	0.13	188	7.13×10^{15}	7.13×10^{15}
IN0058475	9/96-6/01	15	19	9.45×10^{9}	–	–	–	9.45×10^{9}
IN0059064	6/99-4/02	4	235±	3.56×10^{10}	–	–	–	3.56×10^{10}
TOTAL				**1.21×10^{12}**			**1.20×10^{16}**	**1.20×10^{16}**

*[*Assumes concentration in sewage of 1 x 10^6 CFU/100mL [Turner et al., 1997]; **, E.coli data not available because facility measures fecal coliform only. Therefore, it was assumed that 40% of the fecal coliform counts consists of E. coli [Turner et al., 1997]; ±, E. coli and/or fecal data not available because facility measures chlorine only so the single sample limit was used to estimate load (235 CFU/100mL); –, no bypasses reported; ave, average; yr, year; max., maximum; MG, million gallons; no., number; CFU, colony forming units.]*

Illicit Discharges (from TMDL)

Illicit discharges usually involve an illegal or improper connection to a storm drain or a “straight pipe” to receiving waters. Illicit discharge of sewage can derive from domestic and industrial sources. Such sources are difficult to identify. Often owners are not even aware of the problem. Programs to identify illicit connections can be resource intensive. However, illicit discharges may be a major source of fecal loading in a watershed. Information about existing or potential illicit discharges in the Salt Creek watershed is not available. Keith Letta of the Porter County Health Department believes that illicit discharges are not a significant problem in the watershed (Letta, 2003).

<u>3.6.3.f Estimated Source Proportions of *E. coli* Loadings</u>

Current load proportions estimated by combining the delivery potential by the availability of *E. coli* from a particular source category are presented in Table 8. NPDES wastewater treatment plant effluent loadings are identified through effluent monitoring. Dry weather loads are dominated by septic systems, illicit connections and livestock in the streams. Wet weather loads are more varied, in part due to a greater number of sources, including CSOs, urban runoff, and surface applied manure.

Table 8. Assumed *E. coli* delivery dotential by source, season, and landscape condition

Source/estimated delivery potential	Spring (wet)	Spring (dry)	Summer (wet)	Summer (dry)	Fall (wet)	Fall (dry)	Winter
Overgrazed pasture	High	Low	High	Low	High	Low	High
Failing septic	Very high	Very high	Very high	Very high	Very high	Very high	Very high
Illicit connections	Very high	Very high	Very high	Very high	Very high	Very high	Very high
CSO (includes bypasses)	High	Low	High	Low	High	Low	high
Surface applied manure	High	NA	Low	NA	High	NA	
Manure incorporation	Low	NA	Low	NA	low	NA	NA
waterfowl	Very high	Very high	Very high	Very high	Very high	Very high	Very high
Urban runoff	High	NA	High	NA	High	NA	NA
Cattle in the stream	NA	High	NA	High	NA	High	NA

3.6.4 Impaired Biotic Communities

Impaired biotic communities in Salt Creek and its tributaries likely result from a combination of chemical and physical factors. The impact of excessive sediment and nutrient concentrations is addressed above in Section 3.6.1- Sediment and Section 3.6.2- Nutrients. Low dissolved oxygen concentrations, high chloride concentrations, and other chemical factors may also contribute to impairment of several tributaries. In addition to these water quality stressors, hydromodification, siltation and embeddedness are major contributors to impaired biotic communities in Salt Creek.

3.6.4.a Hydromodification

Hydromodification activities adversely affect stream and groundwater flow, stream gradient, sediment load, and channel width and depth. Hydromodification activities that can contribute to these issues and were noted within the Salt Creek Watershed Management Plan include channelization, ditching (Figure 64, Figure 65) wetland loss, flow restriction through dams (Figure 66), straightening, and urbanization. Salt Creek water quality data documents flashy flows, particularly in Beauty Creek (the Sager's Lake subwatershed).

Figure 64. Altered hydrology in Salt Creek (partial concrete channel) (2006)

Figure 65. Altered hydrology in Salt Creek (partial concrete channel) (2006)

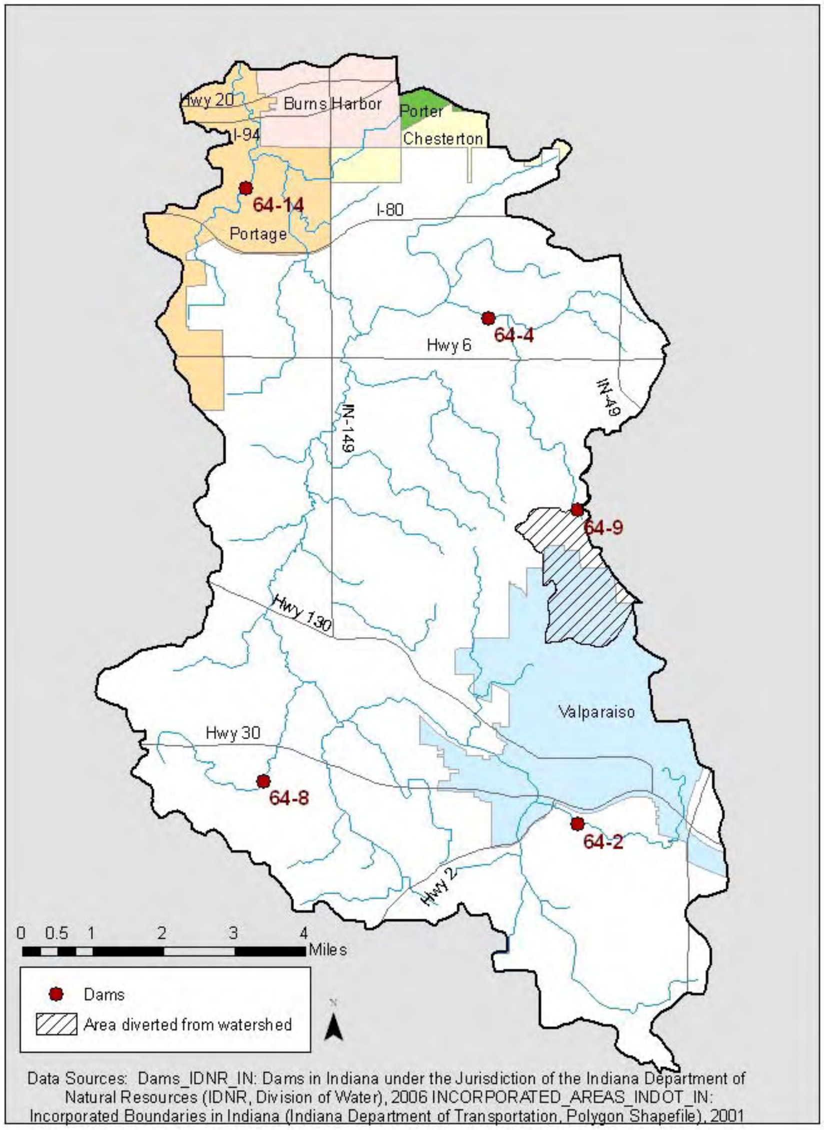

Figure 66. Dams in the Salt Creek watershed (Source: See Appendix R)

Figure 66 shows dams in the Salt Creek watershed that are under the jurisdiction of IDNR (IDNR, 2006). Inspections are required for dams under DNR jurisdiction, but ownership and maintenance responsibilities vary. Table 9 provides names and identification numbers of dams and information regarding height above the natural stream bed, drainage area, reservoir capacity, relative hazard potential, and status of structures. Hazard potential refers to the relative hazard associated with a catastrophic failure of the dam. Low hazard potential indicates no loss of human life, but possible damage to crops. Significant hazard potential indicates no loss of human life, but possible damage to county roads and farm crops and flooding downstream. High hazard potential indicates possible loss of human life, major infrastructure damage, and homes destroyed. Structure refers to the permit status of the dam. Approved indicates that a permit was obtained to construct the dam prior to construction. Not approved indicates that the dam is not permitted, but is within IDNR jurisdiction. Before '45 indicates that the dam was grandfathered in. NA before 45 indicates that the dam is not approved, within IDNR jurisdiction, and was built prior to 1945.

Table 9. Characteristics of dams in the Salt Creek watershed (IDNR, 2006)

State ID	Name	Drainage Area (mi^2)	Maximum Storage (acre-ft)	Hazard Potential	Structure	Height (ft)
64-14	Robbin's Pond Dam	2.73	120	Significant	Not Approved	18
64-2	Lake of the Woods Dam	6.3	237	High	NA before 45	22
64-4	Roy Nicholson Dam (In-channel)	3	0	Low	Not Approved	10
64-8	Lake Louise Dam	2.56	723	High	Approved	45
64-9	Loomis Lake Dam	0.6	485	High	NA before 45	17

3.6.4.b Siltation and Embeddedness

Siltation, or sedimentation, is the settling and accumulation of sediment on the stream bottom. Embeddedness is the degree to which sediment covers or mixes with spawning gravel or substrate. As detailed in Section 3.6.1- Sediment, sediment can impair fish breathing by clogging gills and can cover fish spawning areas and food supplies, ultimately reducing the overall fish population. SDCF documented visual evidence of sedimentation in Salt Creek (Figure 67). During QHEI evaluation extensive embeddedness was noted at sampling sites 2, 4, 5, 6, 8, 9, 10, 12, and 13. Moderate embeddedness was noted at sites 3 and 11. Low embeddedness was noted at sites 1, 7, 14, and 16. Only site 15 exhibited no embeddedness. See Section 3.6.1- Sediment for more information on the sources of sediment that contribute to siltation and embeddedness. Stakeholders also provided photographic documentation of siltation and embeddedness in tributaries throughout the watershed. Figure 67 shows a representative photograph of siltation and embeddedness observed watershed wide.

Figure 67. Representative photograph of siltation and embeddedness in Salt Creek (2006)

3.6.4.c Low Dissolved Oxygen and Elevated Temperatures

Dissolved oxygen, or DO, is essential for respiration of aquatic organisms. Fish need at least three to five mg/L of DO. Salt Creek is recognized as a coldwater fishery stream; therefore, DO should not fall below four mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. As detailed in Section 3.6.2- Nutrients, eutrophication from excessive nutrient concentrations can result in decomposition of organic material reducing DO concentrations. Lack of turbulence can limit the diffusuion of oxygen into Salt Creek, while high temperatures limit the amount of oxygen which can be dissolved in Salt Creek. Water temperature affects the amount of oxygen dissolved in the water column as colder water holds more dissolved oxygen. Water temperature also regulates the metabolism, activity, and reproduction of aquatic organisms. Water temperatures can become elevated due to lack of instream cover and from elevated temperatures associated with surface runoff. Low DO concentrations in Block Ditch and Robbin's Ditch were identified by water quality monitoring and are acknowledged as a water quality concern in this plan. Addressing other water quality concerns, such as high nutrient concentrations, is expected to improve DO concentrations.

3.6.4.d Road Salt

Road salt is a common constituent of stormwater runoff during the winter throughout the Midwest. . Higher concentrations result in areas where various forms of salt are applied to roads for controlling icy, slippery road conditions. Elevated chloride concentrations were found in Robbin's Ditch during IDEM's 2006 biotic community assessment/intensive survey. Additionally, chloride contributes to conductivity measurements and high conductivity measurements occurred in the Robbin's Ditch and Weblos Tributary subwatersheds.

3.6.5 Potential Unverified and Other Sources.

3.6.5.a Indiana Salmonid Stocking Program

Several sections of Salt Creek are designated as salmonid streams (Figure 68). During the development of the SCWMP the question was raised, "What are the impacts of non-native salmonid stockings in Indiana streams on native fish stocks and improving biotic communities?" In short, very little research on this matter has been conducted or documented in peer reviewed scientific literature for northwestern Indiana. The only study that could be readily found was conducted by Thomas Simon and Paul Stewart entitled "Structure and Function of Fish Communities in the Southern Lake Michigan Basin with Emphasis on Restoration of Native Fish Communities" (Simon and Stewart, 1999).

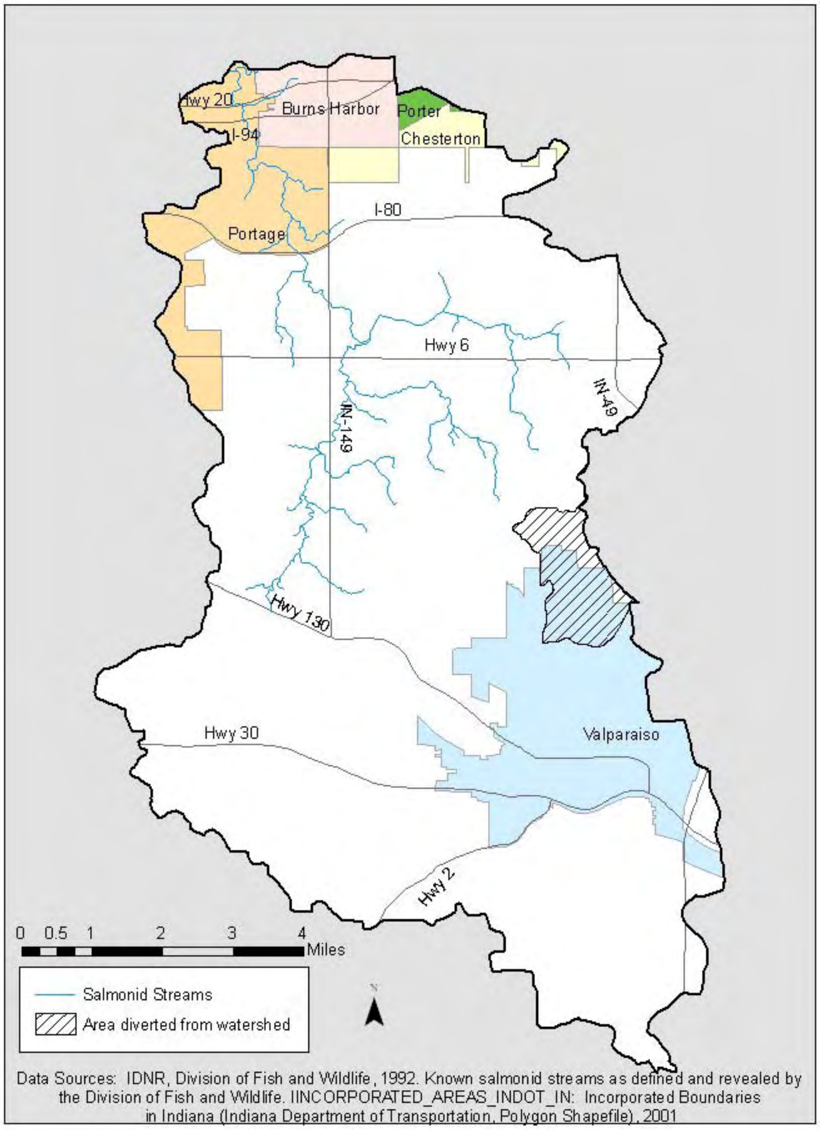

Figure 68. Salmonid streams in the Salt Creek watershed (Source: See Appendix R)

Simon and Stewart state that stocking programs contribute to the impairment of native fish communities and that non-indigenous (non-native) species have restructured the function of Lake Michigan tributaries, causing disruptions in trophic dynamics, guild structure, and species diversity. In the same study they also state that the effects of fish stocking on native fish communities in northwestern Indiana and on public lands have not been examined. Perhaps more importantly, they indicate that habitat degradation and land use practices in the watershed have negatively impacted waterbodies and resident fish populations.

Following is a brief summary and history of Indiana's salmonid stocking program. The intent is to provide the Salt Creek watershed stakeholders with information on why the DNR stocks salmonids, how salmonids may impact native fish communities during different phases of their life cycle, and where informational gaps may occur.

Indiana's trout and salmon (salmonid) stocking program is part of a Great Lakes wide effort to restore fish stocks within the Great Lakes. During the 1940s and 1950s intense commercial harvesting and predation by parasitic sea lamprey nearly decimated native lake trout stocks. Alewives, which were unintentionally introduced into Lake Michigan in 1949 from the Atlantic Ocean, depleted food sources for themselves and other native fishes. Their high numbers and ability to out-compete fish with similar diets led to depletions and local extinctions of native species. These disruptions in the native fish community and food web, coupled with habitat alterations and degradation, contributed to the decline of important commercial and sport fisheries.

Rehabilitation of the Lake Michigan fish community began in 1960 with the extension of the sea lamprey control program to Lake Michigan, plantings of lake trout and the introduction of coho salmon, chinook salmon, brown trout and steelhead trout. Lake trout planting began in 1965 and coho salmon and chinook salmon were introduced from the Pacific Northwest in 1966 and 1967. Rainbow trout, or steelhead, and brown trout were also extensively planted. Of the five major salmonids stocked, only lake trout was released with the main objective being rehabilitation (i.e. to re-establish reproducing populations). The others were stocked to provide angling opportunities and to utilize the overabundance of nonnative alewives, which became a nuisance when vast numbers died and washed up on local beaches.

The Indiana Department of Natural Resources (IDNR), Division of Fish & Wildlife has been stocking trout and salmon (salmonids) along Indiana's Lake Michigan shoreline and tributaries since the late 1960s. The area stocked extends from Michigan City to Whiting, Indiana and includes sites along the St. Joseph River, Trail Creek, and the East Branch of the Little Calumet River. Although trout and salmon are not directly stocked in the Salt Creek watershed, they are able to migrate into Salt Creek via its confluence with the East Branch of the Little Calumet River near Burns Harbor.

The DNR currently stocks four species of salmonid: chinook salmon, coho salmon, winter-run (Manistee) and summer-run (Skamania) steelhead, and brown trout. Chinook salmon are stocked in early May as six-month old fingerlings. Coho salmon are stocked in early November as 12-month old yearlings. Winter-run steelhead are stocked in December as eight-month old fingerlings. Summer-run steelhead are stocked in early April as 14-month old yearlings and also in October as eight-month old fingerlings. Brown trout are stocked in early July as eight-month old fingerlings. Most of these fingerlings only reside in the streams for approximately three weeks before migrating out to Lake Michigan. Some steelhead may remain in the streams for several months before migrating to the lake. During this short time period, it is believed that steelhead primarily rely on aquatic or terrestrial insects for food. Once they migrate into Lake Michigan, they soon switch to a predominately fish-based diet.

After spending anywhere from two to five years in Lake Michigan dependent on species, mature trout and salmon return to the streams to spawn during the Fall. Typically, they return to the streams in which they were stocked. Once they enter the streams, they go through major physiological changes. This is especially true of coho and chinook salmon. Part of the physiological change that occurs in salmon is the degeneration of their digestive tracts. As a result of this degeneration, salmon stop feeding and rely on fat stores which were built up while out in the lake. This means that salmon do not likely prey upon native fish stocks soon after entering the tributaries to spawn. Soon after spawning, coho and chinook salmon die. The nutrients from salmon carcasses likely influence primary and secondary productivity in the streams and therefore likely play a role in supporting aquatic food webs.

Conversely, steelhead and brown trout on the other hand may survive their time in Lake Michigan's inlet streams and return to spawn again in coming years. Adult steelhead and brown trout may also continue to feed while they are in the streams since their digestive tracts do not degenerate. No known scientific studies have been conducted in Indiana tributaries which document forage habits of spawning run steelhead or brown trout. However, salmon eggs are a likely a primary component based on knowledge of Pacific Northwest steelhead populations.

Very few progeny actually result from trout and salmon spawning activity in Indiana waters. High quality spawning and rearing habitat and good water quality are necessary for the eggs to develop and hatch. The major limiting factors in Indiana are water temperature, sedimentation, and habitat alteration/destruction. There are limited locations in which the IDNR has been able to identify spawning success. However, without the stocking program, Indiana would not have a viable salmonid sport fishery.

It has been established that Indiana's stocking program is an integral part of lake wide fisheries management program as stated above. However, Salt Creek's designation in part as salmonid stream by the state also results in more rigorous water quality standards (Great Lakes Water Quality Standards) when compared to standards for warm water streams. This makes meeting and maintaining those standards more challenging. More research needs to be done to determine the impacts of salmonid stockings on native fish communities and improving biotic communities in local Lake Michigan tributaries. Informational gaps still exist on foraging habits and nutrient cycling to name just a few. It has been established that habitat alterations and land use changes impact water quality and aquatic communities locally. The challenge is to meet multiple goals established by different agencies and other stakeholders.

3.6.5.b Other Possible Sources

This plan acknowledges, but does not investigate the possibility of contamination to Salt Creek from contaminated sites such as open dumps, leaking underground storage tanks, industrial waste sites, gasoline stations, and dry cleaning facilities. This plan acknowledges the possibility of pollution to Salt Creek from unidentified sources.

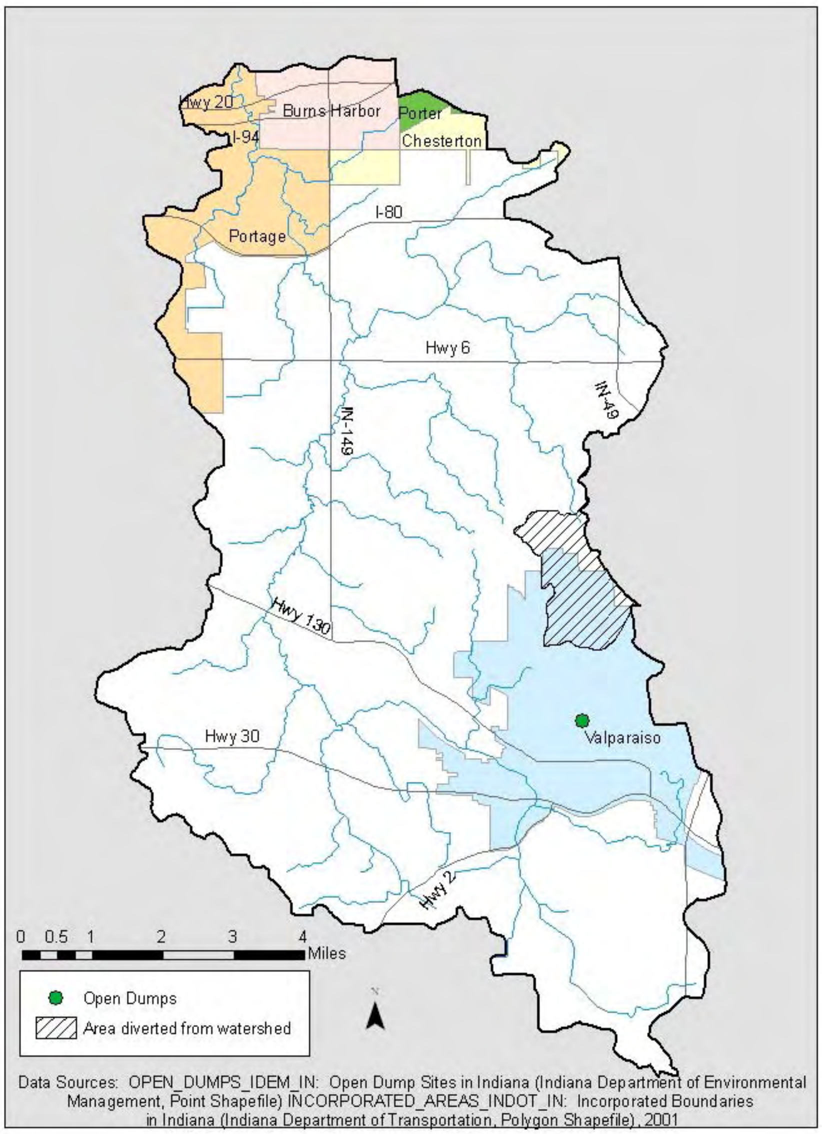

Figure 69. Open dump sites in the Salt Creek watershed (Source: See Appendix R)

Figure 69 shows open dump sites, provided by personnel of IDEM-OLQ. Open Dumps are sites that are not regulated and are illegal dump sites of solid waste, as defined by IAC 10-2-28 329 and IAC 10-2-128 of the IAC. The data are current as of January 24, 2007.

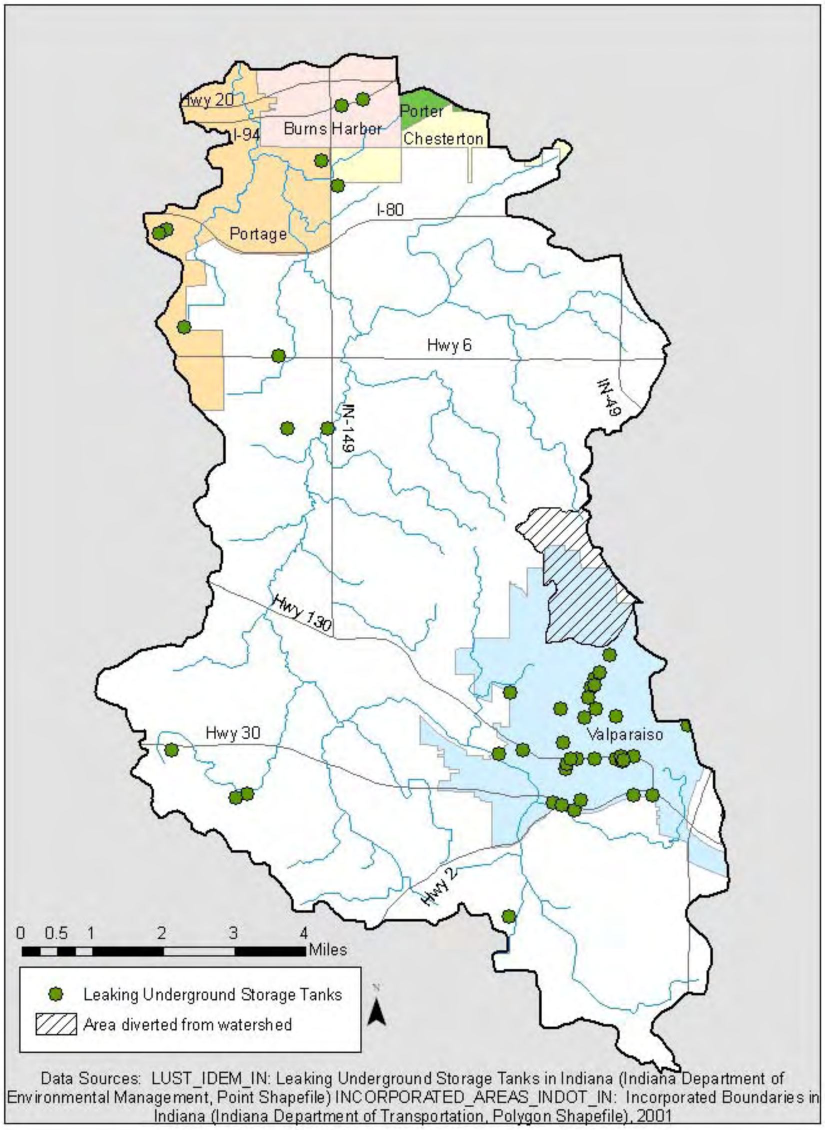

Figure 70. Leaking underground storage tanks in the Salt Creek watershed (Source: See Appendix R)

Figure 70 shows known sites with leaking underground storage tanks, provided by personnel of IDEM-OLQ. Regulated underground storage tanks (USTs) contain regulated substances including petroleum and hazardous substances such as those typically found at gasoline stations, fleet fueling facilities, and industrial sites. If a release from a UST system is suspected or confirmed, the owner and operator must report it to IDEM. These sites are called Leaking USTs. Actions must be taken as described in the UST rules - 329 IAC 9-4 and 5 (IAC, 2008b). Data are current as of January 24, 2007.

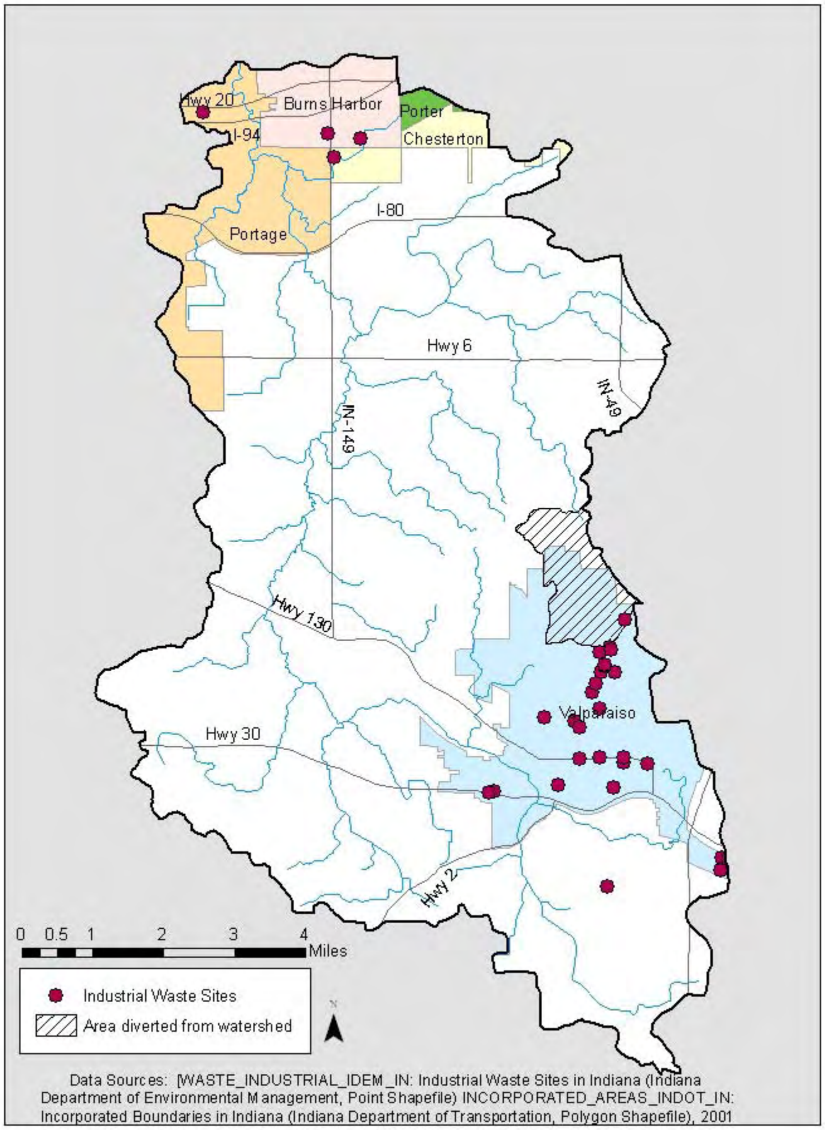

Figure 71. Industrial waste sites in the Salt Creek watershed (Source: See Appendix R)

Figure 71 shows the locations of access points to industrial waste site locations, provided by personnel of IDEM-OLQ. Global positioning system (GPS) points locate the entrance to facilities that generate and/or manage hazardous waste, non-hazardous industrial waste, and solid waste. GPS points may be collected if the location has significant environmental issues. Data are current as of January 24, 2007.

3.7 Critical, Priority, and Intermediate Areas

The Salt Creek Watershed Group established three management areas based upon historic and current water quality data, confirmed sources, projected future development, and causes of impairment. Two management areas need treatment for either restoration (to improve existing poor water quality) or protection (to protect relatively good water quality). These are the "Critical" and "Priority" areas of the watershed and are further described below. The third management area will be addressed by on-going efforts under the Lake Michigan Coastal Nonpoint Source Management Program.

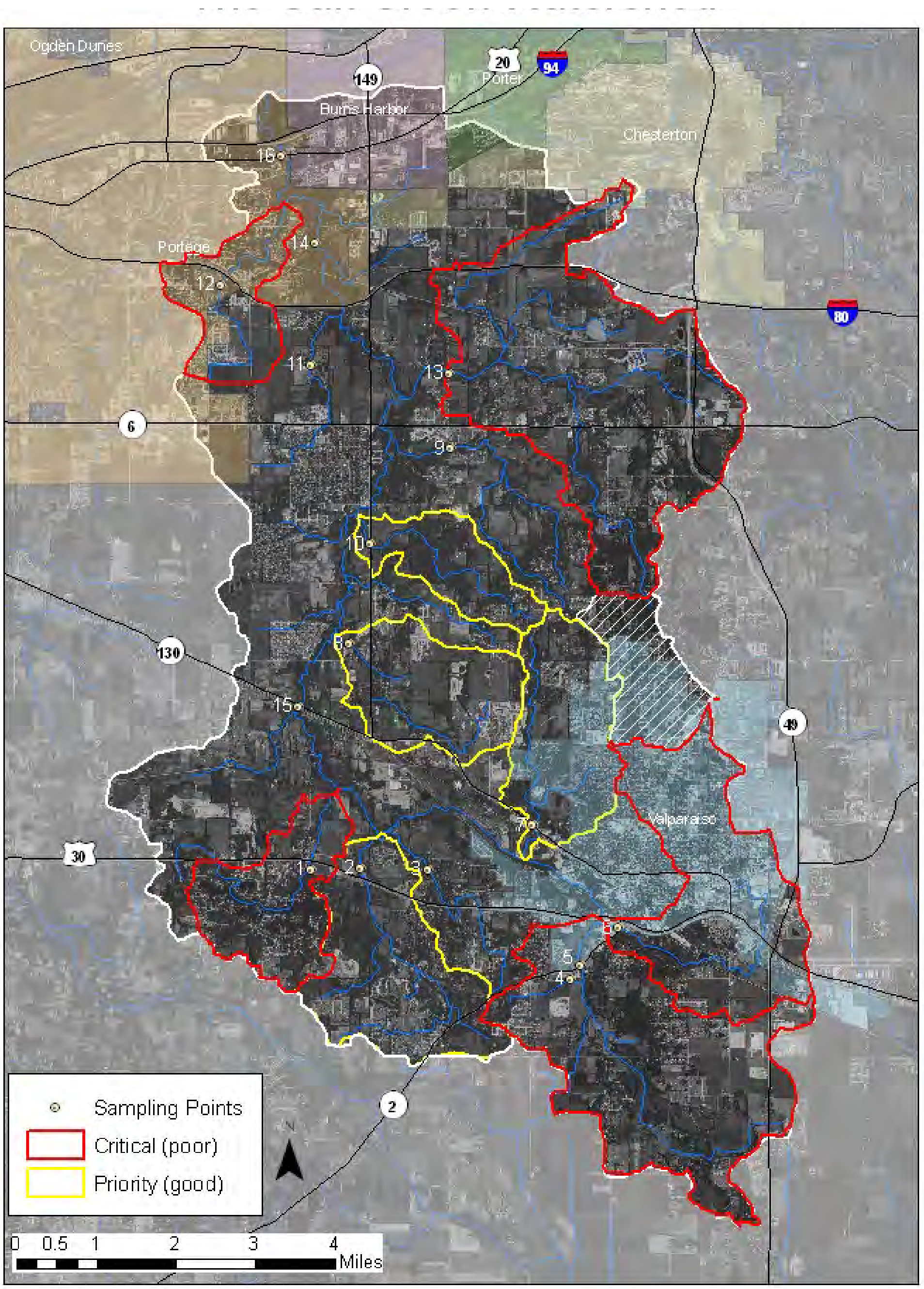

Figure 72. Salt Creek watershed critical and priority areas (Source: See Appendix R)

Critical Management Areas are considered critical for implementation of practices to improve water quality. The Salt Creek watershed critical management areas are based on poor water quality and consist of the following five subwatersheds: Lake Louise Outlet, Salt Creek Headwaters (including Block Ditch), Sager's Lake Outlet, Damon Run, and Robbin's Ditch.

Priority Management Areas are crucial for the long-term environmental health of Salt Creek and require protective measures to maintain and/or enhance existing, relatively good water quality. Four subwatersheds are designated as priority areas in need of protection due to accelerated development pressures and existing threats to water quality. The four subwatersheds are Clark Ditch, Pepper Creek, Butternut Springs Outlet, and Beauty Creek. Subwatersheds designated as priority management areas for preservation generally need a limited number of practices to prevent pollution increases due to changes in land use or intensity. Protecting these subwatersheds now prevents future short term degradation of Salt Creek and ensures the benefits of addressing sources in the critical management areas.

Intermediate Management Areas are the areas not included as priority or critical areas of the watershed. As part of the Indiana Lake Michigan Coastal Program, approved in August 2002, IDNR is required to development a coastal nonpoint source management program The Coastal Nonpoint Pollution Control Program, which falls under Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA), is jointly administered by NOAA and the USEPA The program consists of a set of management measures that Indiana must use in controlling polluted runoff. The measures included in the Indiana program are designed to control runoff from five main sources: agriculture, urban areas, marinas, hydromodification (shoreline and stream channel modification), and wetlands and vegetated shorelines or riparian areas. These measures are backed by enforceable state policies and actions that will ensure implementation of the program. The conditionally-approved Indiana Coastal Nonpoint Source Management Program focuses on pollution prevention, minimizing the creation of polluted runoff rather than cleaning up already contaminated water. The program encourages pollution prevention efforts at a local level, particularly improvements to land use planning and zoning practices to protect coastal water quality.

4.0 GOALS, OBJECTIVES, AND RESOURCES

Goal 1: Reduce nitrate loading by 65%, phosphorus loading by 66% and sediment loading by 33% by 2028.

Table 10. Goal 1 objective and action register

Timeline (years):	1 to 10	1 to 20	10 to 20

Goal 1: Reduce nitrate by 65%, phosphorus by 66%, and sediment loading 33% by 2028								
Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Reduce stormwater related impact associated with nutrient and sediment.	1. Implement LID and other BMPs to address stormwater runoff from development.	Identify BMP sites/project partners. Implement LID and other BMPs including but not limited to vegetated swales, pervious paving/building materials, rain gardens, rain barrels, planter boxes, bioretention islands, created wetlands (listed in Appendix P).	SDCF, property owners, municipalities, parks departments	Identify five partners by 2028. Install 10 BMPs by 2028.	Greater than $100,000	NIRPC, PCCRVC. IDNR, IDEM, municipalities, property owners	IDEM 319, municipal MS4 fees, IDNR 6217, LARE, EPA	USFWS, IDEM, IDNR, NRCS, SWCD, EPA
	2. Demonstrate and promote priority LID BMPs that address stormwater runoff from development.	Identify BMP sites/project partners. Demonstrate priority LID BMPs including but not limited to pervious paving/building materials, planter boxes, bioretention islands, green roofs (listed in Appendix P).	SDCF, property owners, municipalities, parks departments, developers	Identify five partners by 2028. Install 10 BMPs by 2028.	Greater than $100,000	NIRPC, PCCRVC. IDNR, IDEM, municipalities, property owners, developers	IDEM 319, municipal MS4 fees, IDNR 6217, LARE, EPA	USFWS, IDEM, IDNR, NRCS, SWCD, EPA
	3. Reduce agricultural sources of nutrient and sediment.	Work with the agricultural community to promote educational incentive programs for BMPs including but not limited to conservation tillage, no-till, contour row crops, stream bank stabilization, stream in a ditch, nutrient management, manure collection, storage, and management, filter strips, and livestock exclusion (listed in Appendix P). Promote CORE 4 approach on cultivated and cropland.	NRCS, SDCF, ISDA, SWCD, IDNR, IDEM, CTIC	Identify eight partners/farms by 2028. Implement reduced tillage on 80 acres, filter/stream restoration on 100 liner feet, and have CORE4 approach adopted by eight farmers by 2028.	Greater than $70,000	NIRPC, SWCD, NRCS, IDNR, CTIC, property owners, ISDA	NRCS, SWCD, IDEM 319, IDNR, ISDA	NRCS, SWCD, Indiana Conservation Tillage Initiative, ISDA, CTIC, Purdue, IDEM, EPA, RC&D

Timeline (years):	1 to 10	1 to 20	10 to 20

Goal 1: Reduce nitrate by 65%, phosphorus by 66%, and sediment loading 33% by 2028 (continued)

Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Restore/ maintain natural hydrology to reduce nutrient and sediment.	4. Implement restoration projects that reduce nutrient and sediment pollution.	Restore wetlands, stream in a ditch, streambank stabilization, daylighting.	IDNR, property owners, drainage board, SDCF, Portage, INDU	Identification of three restoration sites by 2028. 100 linear ft. restored/ stabilized by 2028.	Greater than $100,000	IDNR, IDEM, CTIC, municipalities, property owners	NOAA, LARE, IDEM 319, USFWS, GLWR	IDNR, IDEM, drainage boards, EPA, RC&D
Foster interest in and educate the public on nonpoint sources of nutrient and sediment in the Salt Creek watershed.	5. Educate the public and encourage proper lawn chemical management.	Release PSAs, Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, Purdue, SWCD, Master Gardeners/ Naturalists, property owners/lakes associations	Two PSAs distributed by 2028. Two outreach events held by 2028.	Less than $25,000	IDEM, property owners	LMCP, EPA, GLAHNF, IDEM 319	EPA, Purdue
	6. Educate the public on and encourage native landscaping, rain gardens, & rain barrels. Promote management practices to control exotics.	Foster interest by demonstrating BMPs. Build contacts. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, USEPA, Purdue, Master Gardeners, NIRPC, nurseries, land trusts, SWCD, property owners, landscape architects, Taltree, IDNR, the Nature Conservancy (TNC), INDOT, Utility Co. FRIENDS, INDU	Demonstrate two BMPs by 2010. Five outreach events held by 2018.	Greater than $50,000	IDEM, NIRPC, IDNR, parks departments, ICRAT	LMCP, EPA, GLAHNF, IDEM 319, foundations	EPA, Purdue, residents, nurseries, garden centers

Timeline (years):	1 to 10	1 to 20	10 to 20

Goal 1: Reduce nitrate by 65%, phosphorus by 66%, and sediment loading 33% by 2028 (continued)								
Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Foster interest in and educate the public on nonpoint sources of nutrient and sediment in the Salt Creek watershed.	7. Educate and work with residents to prevent septic system problems.	Further identify priority areas. Collaborate with property owners. Isolate and address violations. Improve operation and maintenance (O&M)of non-failing systems. Pursue alternatives to onsite sewage disposal systems (OSDSs). Generate media coverage. Host public meetings. Increase awareness. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, health departments, property owners	Identify septic priority areas by 2028. Host a minimum of one outreach event by 2013. Distribute 200 outreach pieces by 2028. Distribute two press releases by 2028.	$25,000-$100,000	Health departments, IDEM, property owners	State Revolving Fund (SRF), IDEM 319, USDA Rural Housing Service	Local/ state health departments, IOWPA, Purdue, ICCMODs

Nitrate-Nitrogen Goal: The final indicator of success for this section of the goal will be the six selected target stream sites obtaining nitrate-nitrogen concentrations of 1.2 mg/L within 20 years. This target concentration is based upon OEPA's recommended concentration for headwater streams. Three subwatersheds serve as the primary target for nitrate-nitrogen loading reductions; therefore, if these streams meet their target and the other streams continue to maintain low nitrate-nitrogen concentrations, then the streams will meet their goal. Overall, if all of the streams meet their target, then the resulting loads will result in 478 pounds (217 kg) less nitrate-nitrogen loading from Salt Creek to the Little Calumet River per year. Additional indicators of progress toward Goal 4 Objectives 1 through 4 include reduced visual evidence of excessive aquatic plant/algae production, improved mIBI scores, the number of BMPs implemented and demonstrated, the number of developers who utilize LID practices, and acres of wetlands restored. Indicators of progress toward achieving Goal 1 Objectives 5 through 7 include the number of participants at meetings and outreach events, the number of outreach events held, the number of participants adopting best practices and installing rain gardens/barrels, the number of nurseries/landscapers offering native landscaping services, and the number of press releases, public sevice announcements (PSAs), and outreach brochures distributed.

Interim Goal: In the next 10 years, watershed stakeholders would like the six target streams sites to reduce nitrate-nitrogen loads to Salt Creek by 418 pounds (190 kg) per year. The interim indicator of success will be a 56% reduction in nitrate-nitrogen loading when the six target stream sites will meet the OEPA's target concentration for wadeable streams (1.5 mg/L).

As stated above, the State of Indiana maintains water quality standards for many pollutants. However, the state does not currently have a water quality standard for nitrate-nitrogen. (IDEM maintains a drinking water standard for nitrate-nitrogen of 10 mg/L.) The 2008 impaired waterbodies listing methodology details the proposed methods for determining the impairment of Indiana streams based on total phosphorus concentration (IDEM, 2007). As described, the nitrate-nitrogen concentration cannot exceed 10 mg/L in concert with other nutrient or physical exceedances (total phosphorus, dissolved oxygen, pH, or algal condition). As the Salt Creek watershed streams already possess nitrate-nitrogen concentrations below this level (10 mg/L), it was determined that the target would be the levels recommended by the OEPA for modified warmwater habitat headwater (1.5 mg/L) and wadeable (1.2 mg/L) streams. Required load reductions were calculated based on median stream flows and targeted concentrations. The targeted reductions are listed in Table 11.

Table 11. Comparison of nitrate-nitrogen concentrations to target values for selected streams

Sampling Station	Watershed Size in Acres (Hectares)	Average Concentration (mg/L)	Current Average Load (kg/yr (lbs/yr))	% Reduction to Meet Interim Goal (1.5 mg/L)	% Reduction to Meet Long-term Goal (1.2 mg/L)
1. Lake Louise Outlet	1,828 (739.8)	2.33	11.69 (25.77)	35.4	48.3
5. Salt Creek Headwaters	4,916 (1,989)	0.28	3.52 (7.76)	0	0
6. Sager's Lake Outlet	3,556 (1,439)	0.11	1.32 (2.91)	0	0
12. Robbin's Ditch	1,404 (567.8)	1.07	3.59 (7.92)	5.7	24.5
13. Damon Run	7,014 (2,838)	0.52	7.29 (16.1)	0	0
14. Salt Creek Mainstem	44,335 (17,942)	3.18	332.06 (732.07)	56.6	65.2

Total Phosphorus Goal: The final indicator of success for this section of the goal will be the six selected target sites obtaining total phosphorus concentrations of 0.08 mg/L within 20 years. This target concentration is based upon OEPA's recommended concentration for headwater streams. Based on data listed below, most implementation projects targeting a reduction in total phosphorus loading should occur within the headwaters portion of each of the subwatersheds. If all of the streams meet their target, then the resulting loads will result in 32 pounds (14.5 kg) less phosphorus loading from Salt Creek to the Little Calumet River per year. Additional indicators of progress toward of Goal 1 Objectives 1 through 4 include reduced visual evidence of excessive aquatic plant/algae production, improved mIBI scores, the number of BMPs implemented and demonstrated, the number of developers who utilize LID practices, and acres of wetlands restored.
Indicators of progress toward Goal 1 Objectives 5 through 7 include the number of participants at meetings and outreach events, the number of outreach events held, the number of participants adopting best practices and installing rain gardens/barrels and participating in septic program, the number of nurseries/landscapers offering native landscaping services, and the number of press releases, PSA, and outreach brochures distributed.

Interim Goal: In the next 10 years, watershed stakeholders would like the six target stream sites to load 27 pounds (12.3 kg) less phosphorus to the Little Calumet River per year. The interim indicator of success will be a 57% reduction in total phosphorus loading at which point the six target stream sites will meet the OEPA's target concentration for wadeable streams (0.10 mg/L).

As stated above, the State of Indiana maintains water quality standards for many pollutants. However, the state does not currently have a water quality standard for total phosphorus. The 2008 impaired waterbodies listing methodology details methods for determining the impairment of Indiana streams based on total phosphorus concentration (IDEM, 2007). As described, the total phosphorus concentration cannot exceed 0.3 mg/L in concert with other nutrient or physical exceedances (nitrate-nitrogen, dissolved oxygen, pH, or algal condition). As the Salt Creek watershed streams already possess total phosphorus concentrations below this level (0.3 mg/L), it was determined that the target would be the levels recommended by the OEPA for modified warmwater habitat headwater (0.10 mg/L) and wadeable (0.08 mg/L) streams. Required load reductions were calculated based on median stream flows and targeted concentrations. The targeted reductions are listed in Table 12.

Table 12. Comparison of total phosphorus (TP) concentrations to target values for selected streams

Sampling Station	Watershed Size in Acres (Hectares)	Current Average Concentration (mg/L)	Current Average Load (kg/yr (lbs/yr))	% Reduction to Meet Interim Goal (0.1 mg/L)	% Reduction to Meet Long-term Goal (0.8 mg/L)
1. Lake Louise Outlet	1,828 (739.8)	0.170	0.85 (1.87)	40.6	52.5
5. Salt Creek Headwaters	4,916 (1,989)	0.140	1.98 (4.37)	38.2	50.6
6. Sager's Lake Outlet	3,556 (1,439)	0.094	0.88 (1.94)	5.7	24.6
12. Robbin's Ditch	1,404 (567.8)	0.167	0.45 (0.99)	49.5	59.6
13. Damon Run	7,014 (2,838)	0.119	2.08 (4.59)	30.7	44.5
14. Salt Creek Mainstem	44,335 (17,942)	0.216	22.34 (49.25)	57	65.6

Total Suspended Solids Goal: The final indicator of success for this section of the goal will be the six selected target sites obtaining TSS concentrations of 25 mg/L within 20 years. This target concentration is based upon the level at which deleterious effects begin to occur within the fish community (Waters, 1998). As four of the target subwatersheds already meet this goal, a 33% reduction is necessary within the two other target sites. If TSS loading rates do not increase within the four streams that already meet the goal and the two remaining streams meet their target, then the resulting loads will result in 2,620 pounds (1188 kg) less TSS loading from Salt Creek to the Little Calumet River per year. Meeting the 25 mg/L goal may require up to 20 years in order for the stream to stabilize and the channel bed to flush existing deposited sediment. Additional indicators of progress toward of Goal 1 Objectives 1 through 4 include reduced visual evidence of sedimentation/embeddedness, improved mIBI scores, the number of BMPs implemented and demonstrated, the number of developers who utilize LID practices, and acres of wetlands restored. Indicators of progress toward of Goal 1 Objectives 5 through 7 include the number of participants at meetings and outreach events, the number of outreach events held, the number of participants adopting best practices and installing rain gardens/barrels, the number of nurseries/landscapers offering native landscaping services, and the number of press releases, PSAs, and outreach brochures distributed.

Interim Goal: TSS loading within Salt Creek is relatively low compared with other streams throughout the region. Nonetheless, the Steering Committee chose to set an interim goal that targets keeping TSS concentrations below the upper concentration at which negative effects within the fish community are observed (80 mg/L; Waters, 1998). All stream sites are currently below this concentration on average; however, during prolonged storm events some sites exhibited elevated TSS concentrations that exceed this target concentration. This interim goal is specifically targeted at these events, and the interim indicator of success will be none of the selected streams exceeding the target concentration.

Like total phosphorus, the state does not currently have a water quality standard for TSS. Furthermore, the draft 2008 list of impaired waterbodies (303(d) list) does not detail methodology for determining the impairment of Indiana streams based on TSS concentration (IDEM, 2007). However, information listed on the IDEM TMDL website indicates that streams may be listed for sediment impairment if the TSS concentration exceeds 30 mg/L. As only two of the sample sites within the Salt Creek watershed possess average concentrations in excess of this level and only 12 exceedances of this level occurred in the 112 samples collected, a decision was made to target the excessive concentrations which result during prolonged storm events. Therefore, a higher concentration (80 mg/L) was utilized as the interim goal. The overall goal will ultimately result in in-stream TSS concentrations that are lower than IDEM's target concentration (25 mg/L compared to the 30 mg/L target). Required reductions are listed in Table 13.

Table 13. Comparison of total suspended solids concentrations to target values for selected streams

Sampling Station	Watershed Size in Acres (Hectares)	Average Concentration (mg/L)	Current Average Load (kg/yr (lbs/yr))	% Reduction to Meet Interim Goal (80 mg/L)	% Reduction to Meet Long-term Goal (25 mg/L)
1. Lake Louise Outlet	1,828 (739.8)	8.70	43.41 (95.70)	0	0
5. Salt Creek Headwaters	4,916 (1,989)	30.63	392.36 (865.01)	0	22.2
6. Sager's Lake Outlet	3,556 (1,439)	17.10	147.97 (326.22)	0	0
12. Robbin's Ditch	1,404 (567.8)	8.94	27.06 (59.66)	0	0
13. Damon Run	7,014 (2,838)	11.36	160.74 (354.37)	0	0
14. Salt Creek Mainstem	44,335 (17,942)	29.13	3,593.25 (7,921.60)	0	33.1

Goal 2: Reduce pathogen concentrations (*E. coli*) 86% 2028

Table 14. Goal 2 objective and action register

Timeline (years):	1 to 10	1 to 20	10 to 20

Goal 2: Reduce pathogen (*E. coli*) concentrations by 86% by 2028								
Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Reduce *E. coli* levels.	1. Reduce agricultural sources of *E. coli*.	Work with agricultural community to promote appropriate technologies for watering, manure management alternatives, and livestock exclusion (listed in Appendix P).	SDCF, NRCS, IDEM, SWCD, property owners	Identify two agricultural partners by 2018, Implement four BMPs for *E. coli* reduction by 2018.	Greater than $50,000	NRCS, property owners	NRCS, SWCD, Purdue	NRCS, SWCD, Indiana Conservation Tillage Initiative, ISDA, CTIC, Purdue
	2. Reduce the occurrence of CSOs.	Work with municipalities and residents to increase capacity, disconnect combined sewers, and conserve household water.	Municipalities, property owners, IDEM, NIRPC	Reduced CSO occurrence by 50 % by 2018.	Greater than $100,000	Municipalities	SRF (Not eligible for IDEM 319)	IDEM, EPA
Foster interest in and educate the public on nonpoint sources of *E. coli* in the Salt Creek watershed.	3. Educate and work with residents to prevent septic system problems.	Further identify priority areas. Collaborate with property owners. Isolate and address violations. Improve O&M of non-failing systems. Pursue alternatives to OSDSs. Generate media coverage, Host public meetings. Increase awareness. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, health departments, property owners	Identify septic priority areas by 2018. Host one outreach event by 2013. Distribute two press releases by 2018.	$25,000-$100,000	Health departments, IDEM, property owners	SRF, IDEM 319, USDA Rural Housing Service	Local/ state health departments, IOWPA, Purdue, ICCMODs
	4. Encourage and educate the public to properly manage pet waste.	Conduct media campaign. Increase awareness. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, SHLT, dog parks, veterinarians, groomers	Host one outreach event by 2028. Distribute two press releases by 2028.	Less than $25,000	IDEM	IDEM	EPA (nonpoint source) NPS Toolkit

E. coli Goal: The final indicator of success for this goal will be the six selected targeted stream sites obtaining *E. coli* concentrations which meet the state standard (235 colonies/100 mL) within 20 years.

> Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of designated uses and corresponding numeric criteria. Designated uses reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and recreation. Criteria express the condition of the water that is necessary to support the designated uses. Numeric criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody.

All water bodies in Indiana are designated for recreational use. The numeric criteria associated with protecting the recreational use are described below:

> "This subsection establishes bacteriological quality for recreational uses. In addition to subsection (a), the criteria in this subsection are to be used to evaluate waters for full body contact recreational uses, to establish wastewater treatment requirements, and to establish effluent limits during the recreational season, which is defined as the months of April through October, inclusive. *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period." (IAC, 2008a)

The part of the standard that states that no samples shall not exceed 235 counts/100 mL is typically referred to as the "not-to-exceed" standard whereas 125 counts/ 100 mL is referred to as the geometric mean standard.

Indiana's water quality assessment and 303(d) listing methodology for waterbody impairments and TMDL load development for the 2008 cycle includes two different criteria for Human Health Recreational Use Support assessments depending on the type of data set being used in making the assessment (IDEM, 2007). For data sets consisting of five equally spaced samples over a 30-day period, the geometric mean must not exceed 125 CFU/ 100mL and not more than one sample shall exceed 576 CFU/ 100 mL. For data sets consisting of 10 or more grab samples where no five of which are equally spaced over a 30-day period not more than 10% of measurements shall exceed 576 CFU/ 100mL and not more than one sample shall exceed 2,400 CFU/mL.

The SCWMP's *E. coli* long term goal is reflective of what is expected to be accomplished by fully implementing the measures outlined in this plan and the watershed's septic system issue being resolved through a combination of incentives, demonstrations, education, enforcement, and increased reliance on Publicly Owned Treatment Works hookups. It does not account for the point source reductions that were identified as being required in the TMDL. In 2018 the plan will be updated and revised as appropriate, based upon accomplishments associated with this plan and required through the Salt Creek TMDL, new monitoring data, new program opportunities, and land use changes. While stakeholders expect to meet the 125 CFU/ 100 mL standard once the point sources reductions are achieved and plan measures have been fully implemented, the Steering Committee will determine what, if any, additional controls/measures are needed at that time. Additional indicators of progress toward achievement of Goal 2 include the number of BMPs implemented and demonstrated, the number of developers who utilize LID practices, reduced occurrence of CSOs, acres of wetlands restored, the number of participants at meetings and outreach events, the number of outreach events held, the number of property owners who remediate failing septic systems, improve operation and maintenance of non-failing systems, or pursue alternative systems, and the number of press releases, PSAs, and outreach brochures distributed.

Interim Goal: The interim indicator of success for this goal will be the six selected targeted stream sites obtaining *E. coli* concentrations which meet the state not to exceed standard (576 colonies/100 mL) within 10 years.

Table 15. Comparison of *E. coli* values to target values in selected streams

Sampling Station	Watershed Size in Acres (Hectares)	Average Concentration (CFU/100 mL)	Current Average Load (CFU/ yr)	% Reduction to Meet Interim Goal (576 CFU/ 100 mL)	% Reduction to Meet Long-term Goal (235 CFU/ 100 mL)
1. Lake Louise Outlet	1,828 (739.8)	2,670.00	12,313.87	76.5	90.4
5. Salt Creek Headwaters	4,916 (1,989)	1,466.25	18,909.34	62.8	84.8
6. Sager's Lake Outlet	3,556 (1,439)	813.75	8,311.39	42.8	76.7
12. Robbin's Ditch	1,404 (567.8)	1,400.00	1,177.65	47.1	78.4
13. Damon Run	7,014 (2,838)	1,372.50	15,781.47	47.3	78.5
14. Salt Creek Mainstem	44,335 (17,942)	1,112.50	155,425	64.4	85.5

Goal 3: Improve stakeholder and public involvement

Table 16. Goal 3 objective and action register

Timeline (years):	1 to 10	1 to 20	10 to 20

Goal 3: Improve stakeholder and public involvement								
Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Encourage volunteer participation in Salt Creek watershed management.	1. Promote and coordinate volunteer involvement.	Coordinate ongoing volunteer water quality monitoring program. Identify volunteer opportunities and coordinate volunteer events and activities, including but not limited to installation, planting, and maintenance of rain gardens, data entry, and storm drain stenciling.	SDCF, Valparaiso university (VU), Purdue, Hoosier Riverwatch, Master Gardeners/ Naturalists	Begin volunteer water quality monitoring by 2013, engage five volunteers annually by 2013.	$25,000-$100,000	IDEM, EPA	IDEM, EPA	IDNR, EPA, IDEM, universities
Foster interest in and educate the public on Salt Creek water quality concerns and ongoing watershed activities.	2. Promote alternatives to impervious surfaces.	Pursue demonstration projects. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, planning departments, drainage commissions, stormwater boards, EPA, NIRPC, IDEM, municipalities	Demonstrate alternatives at one site by 2018. Host one outreach event by 2018.	Greater than $100,000	IDEM 319, EPA, IDNR	IDNR, IDEM, EPA	EPA
	3. Encourage planning/zoning measures that protect water quality, such as buffers, headwaters protection, and green space requirements.	Participate in planning processes with public officials. Develop, post, and distribute outreach materials. Sponsor events/ workshops.	SDCF, EPA, Planning with Power, IDNR	Identify relevant planning processes and partners by 2018. Host a minimum of two outreach event by 2028.	$25,000-$100,000	EPA	IDEM 319, EPA	Local planning departments/ commissions, EPA, Planning with Power

Timeline (years): 1 to 10 | 1 to 20 | 10 to 20

Objective	Activity	Action Steps	Responsibility/ Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Goal 3: Improve stakeholder and public involvement (Continued)								
Foster interest & educate the public on Salt Creek water quality concerns and ongoing watershed activities.	4. Promote LID principles and practices, increase awareness.	Build contacts. Develop, post, and distribute outreach materials. Sponsor events and workshops.	SDCF, IDEM, EPA, IDNR, NIRPC, municipalities, VU	A minimum of three outreach event by 2028.	$25,000-$100,000	EPA, IDNR, IDEM, NIRPC, QLC	EPA, IDNR, IDEM	EPA
	5. Promote proper household water conservation and management.	Release PSAs. Develop, post, and distribute outreach materials. Sponsor events and workshops.	NIRPC	Distribute a minimum of three PSAs and one outreach brochure and host a minimum of three outreach events by 2028.	Less than $25,000	IDEM, NIRPC	LMCP, EPA, GLAHNF (Not 319 eligible)	EPA, IDEM

The Salt Creek Watershed Group will improve stakeholder and public involvement by developing partnerships and conducting public education and outreach. The Group will encourage volunteer participation in Salt Creek watershed management activities. The Group will demonstrate low impact development (LID) and other BMPs throughout the watershed to encourage the use of such practices. Outreach materials will be developed and distributed to educate the public on water quality issues. Indicators of progress toward Goal 3 include the number of outreach and volunteer events held, the number of participants and volunteers trained and involved, the number of PSAs, press releases, and outreach brochures developed and distributed, ordinance code changes, the number of demonstration practices installed, the number of people who adopt best practices, and the number of sites incorporating LID and other BMPs into their design. The continued efforts of Committee Members and stakeholders are needed to implement this plan and ensure its success in achieving their vision for the watershed.

Goal 4: Reduce pollutants and improve habitat so as to support a biotic community to meet aquatic life support criteria.

Table 17. Goal 4 objective and action register

Timeline (years): 1 to 10 | 1 to 20 | 10 to 20

Goal 4: Improve biotic communities								
Objective	Activity	Action Steps	Responsibility / Partners	Milestones	Cost Estimate	Potential Financial Partners	Potential Funding Sources	Technical Resources
Improve instream, streambank, and riparian habitat (particularly headwater streams).	1. Restore and manage stream bank and riparian habitat to reduce erosion.	Identify project partners and potential projects. Promote and install practices that prevent erosion from streambank and riparian areas, including, but not limited to streambank restoration/ stabilization, riparian corridor protection/restoration, and stream in a ditch.	Property owners, drainage board, SDCF, USACE, IDNR, parks departments, INDU	Identify five restoration sites and potential partners by 2028. 100 linear feet restored/stabilized by 2028.	Greater than $100,000	Property owners	IDEM 319, IDNR 6217, LARE, USFWS	USFWS, INDU, OEPA
	2. Restore natural hydrology and improve flow dynamics and hydrologic function.	Identify project partners and potential projects. Promote and install practices that restore natural hydrology, including but not limited to stream in a ditch and wetland restoration.	EPA, SWCD, CTIC, SDCF, INDU	Identify five restoration sites and potential partners by 2028.	Greater than $100,000	IDEM, IDNR	IDEM 319, IDNR 6217, LARE, USFWS	USEPA, CTIC, OEPA
	3. Increase turbulence and reduce water temperatures within streams to increase dissolved oxygen.	Identify project partners and potential projects. Promote and install practices that increase DO, including but not limited to riparian corridor protection/restoration, instream habitat improvement.	Property owners, drainage board, SDCF, USACE, IDNR, parks departments, INDU	Identify five restoration sites and potential partners by 2028.	Greater than $100,000	Property owners	IDEM 319, IDNR 6217, LARE, USFWS	USFWS, INDU, OEPA
Reduce chloride concentrations.	4. Work with departments of transportation to reduce road salt related impacts.	Encourage and promote efficient use of road salt and alternatives. Build and educate contacts and increase awareness of road salt alternatives, develop, post, and distribute outreach materials, sponsor events/ workshops. Further investigate sources of chlorides.	INDOT, IDNR, municipalities	Conduct one outreach event and produce one outreach brochure by 2028. Further identify chloride sources by 2028.	Greater than $100,000	Municipalities, INDOT, USDOT-FHA, CZM	IDEM 319, EPA, INDOT, USDOT-FHA, CZM	EPA, NOAA

Macroinvertebrate Goal:
The final indicator of success for this goal will be the density and diversity of EPT taxa improving by one scoring metric level. Because of the poor quality associated with the fish and macroinvertebrate communities in Salt Creek, it is likely that these communities could be rated as fully supporting with the Watershed Group pursuing Goals 1 through 3. With this in mind, watershed stakeholders wish to set an interim goal that is attainable within the foreseeable future. This goal will focus on both water quality and habitat improvements and will be measured via water chemistry, habitat, and macroinvertebrate assessments conducted in the future. Activities toward achieving this goal should focus on addressing issues in headwater areas before implementation begins downstream. The chemical, physical, and biological health of headwater streams has a great impact on the larger downstream sections. The headwaters are the source of larger downstream waterbodies, and poor water quality in these areas can degrade water quality downstream. Water quantity issues in headwater streams further exacerbate flashy flows and streambank erosion downsteam.

Additional indicators of progress toward Goal 4 include improved mIBI and QHEI scores, reduced nutrient, sediment, and chloride concentrations, reduced temperature and increased DO, acres of wetlands restored, linear feet of riparian buffers installed, linear feet of stream restored, photographic monitoring results, reduced peak flows, number of outreach events held and number of participants, number of press releases and outreach brochures produced and distributed, reduced use of road salt and increased use of road salt alternatives.

5.0 RECENTLY COMPLETED AND ON-GOING WATERSHED ACTIVITIES

City of Portage

Portage Outdoor Science Education Program (2008-2009)
The Portage Parks and Recreation Department will partner with the Portage Township Schools to develop a K-12 outdoor science education curriculum. The IDNR-LMCP funded project will be to develop a series of field trip-based lesson plans specifically developed for each of the thirteen different grade levels. The educational sessions will focus on five separate and diverse natural areas within Portage including a fen, a natural dune area on the Lake Michigan shoreline, an upland wooded 16-acre (6.5 hectare) parcel, a black oak savanna, and over three miles (five kilometers) of Salt Creek. Each series of lesson plans will include classroom-based pre-field trip instruction on a particular subject. Subject matter for the outdoor science curriculum will include environmental and conservation issues, preservation practices, habitat identification, wildlife biology, geology, botany, meteorology/water cycle, and ecosystems. All materials will meet the Indiana Academic Standards as established by the Indiana Department of Education.

Salt Creek Habitat Restoration Project (2008-2009)
This IDNR-LMCP funded project will concentrate on stream and habitat restoration along a 1.5 mile (2.4 kilometer) portion of Salt Creek, from the southern boundry of Imagination Glen Park to the intersection of the Indiana Toll Road. The Portage Parks and Recreation Department will work with River Tenders and Northwest Indiana Steelheaders to implement this project. Both organizations have an extensive experience with projects that have addressed eliminating stream bank erosion, increasing creek flow, creating and improving fish habitat, and providing appropriate access to streams and creeks. The project will concentrate on log jam removal, bank improvement strategies, habitat improvement structure (LUNKERS) introduction, and proper and accessible access point establishment at several locations.

Salt Creek Habitat Restoration (2007-2009)
The proposed Salt Creek Habitat Restoration Project will concentrate on stream and habitat restoration along a 1.78 mile (2.86 kilometer) portion of Salt Creek, from the southern boundry of Imagination Glen Park to the intersection of US 20. Portage Parks and Recreation Department will work with River Tenders and Northwest Indiana Steelheaders to implement this project. Both organizations have an extensive experience with projects that have addressed eliminating stream bank erosion, increasing creek flow, creating and improving fish habitat and providing appropriate access to streams and creeks. The project will concentrate on log jam removal, bank improvement strategies, habitat improvement structure (LUNKERS) introduction, and proper and accessible access poin establishment at several locations.

Imagination Glen Green Roof (2007-2008)
The Portage Parks Department partnered with SDCF to install a green roof on a concession stand at Imagination Glen in 2007 with funding from IDEM. A workshop on green roofs will be held and interpretive signage will be installed in 2008 to showcase the site.

Salt Creek Corridor Preservation (ongoing)
Portage Parks and the Portage Parks Foundation are working to keep the Salt Creek corridor intact for the benefit of water quality and recreational opportunities. As of December 19, 2007, three parcels (Ameriplex Woods, Imagination Glen, and Brennan Woods) along the corridor have been preserved and three additional parcels are in the process of being acquired.

Ameriplex Woods (2007-ongoing)
This property, located near the Ameriplex development, encompasses the confluence of Salt Creek and the Little Calumet River. When developed, the park will provide many recreational activities including hiking, cross-country skiing, and fishing access on the Little Calumet River. The property is still under development. Portage Parks is currently undergoing an environmental restoration of the property by removing invasive plants and other non-native species.

Brennan Woods (2007-ongoing)

The Portage Parks Foundation acquired 130 acres (53 hectares) just south of Imagination Glen Park through a partnership involving local, state, and federal entities. Each agency worked together to save this magnificent property along Salt Creek, and it will soon provide additional hiking, fishing, and nature study opportunities when developed.

Restore and Enhance Samuelson's Fen and Salt Creek Corridor at Imagination Glen Park (2003-2005)
This IDNR- LMCP-funded project restored and enhanced the natural communities associated with a 33 acre (13 hectare) wetland on the east side of Portage which bisects the 250 acre (101 hectare) Imagination Glen Park between Salt Creek and residential developments. Restoration activities included removal of non-native species using controlled burns and development of a management plan for future burns. Selective plantings were completed to enhance existing flora. Plugging and removal of drain tiles was conducted within the fen to allow it to return to its natural state. The long term management plan includes construction of a nature trail around the fen and along the banks of Salt Creek and installation of interpretive signs to educate the public about the unique natural resource.

City of Valparaiso

Forest Park Golf Course Rain Gardens (2007-2008)
The City of Valparaiso partnered with SDCF to design and install two rain gardens at Forest Park Golf Course with IDEM-funding. The rain gardens were planted in the spring of 2008.

Stimson Drain Stormwater Best Management Practices Design Project (1999-2002)
The City of Valparaiso conducted a preliminary Stimson Drain Stormwater Management Study. The study, completed in 2002, identified significant development pressure in the Stimson Drain watershed as an issue and recommended further investigation to identify applicable BMPs. In late 2002 the City received IDNR-LMCP funding to identify and analyze suitable BMPs for the watershed.

Stimson Drain Stormwater Management Study- Phase II Report (2004)
The City of Valparaiso prepared a report that provided an analysis of the Stimson Drain Watershed and proposed various BMPs for use in the subwatersheds. The recommendations were proposed to be implemented as development occurs. Because the watershed is located outside the corporate boundaries of the City, the report was provided to the Porter County Planning Commission and to the Porter County Drainage Board for implementation.

Porter County Jail Alternative Stormwater Management Demonstration Project (2002-2005)
The City of Valparaiso was funded by IDNR- LMCP for a Porter County Jail Alternative Stormwater Management Demonstration Project within the Stimson Drain subwatershed. The project aimed to demonstrate several low impact development (LID) BMPs at the Porter County Jail to manage stormwater runoff. LID BMPs included curb cuts to by-pass inlets, an extended detention basin, vegetated swales, rain gardens, modular pavement, underground storage, and native vegetation. Monitoring is underway to assess the impacts of the LID approach and the efficacy of the BMPs.

Tree and Landscaping Ordinance
The City of Valparaiso has enacted a tree and landscaping ordinance, which emphasizes preservation of existing vegetation and minimizing land disturbance. Developers must present landscape plans, which show intent to work with the site's natural features and existing vegetation to the Park Department horticulturalist and a site review committee. Tree replacement is required based on the below ratio for every non-exempt tree of 10" Diameter Breast Height (DBH) or greater that is removed.

- 1:1 tree replacement to removal for trees between 10" DBH and less than 16" DBH
- 2:1 tree replacement to removal for trees between 16" DBH and less than 24" DBH
- 3:1 tree replacement to removal for trees between 24" DBH and less than 30" DBH
- 4:1 tree replacement to removal for trees 30" DBH and over

Valparaiso Department of Water Works Rain Garden
The Valparaiso Department of Water Works developed a rain garden at the north end of the main parking

lot located at 205 Billings Street. The department constructed the rain garden on its property to control and treat stormwater runoff. Since the department has a wellhead protection program in place, the rain garden is also a great way to protect groundwater.

Water Conservation Plan (2007-2008)
The Valparaiso Utilities Board hired a consultant to help develop a water conservation plan and another to conduct a customer survey. The actions follow recommendations a 2006 study of the City's water capacity and mineral hardness. The consultant will work with a task force appointed by the board to look for ways of reducing water use, which could postpone the need for additional wells.

The City is also developing a unified development ordinance.

Valparaiso University

BMP Demonstration (2007-2008)
Valparaiso University professors and administrators began meeting with SDCF in 2007 to discuss the possibility of demonstrating appropriate BMPs on campus. A vegetated swale was planted on campus 2008.

Volunteer Monitoring with SDCF (2007-ongoing)
Several students in Dr. John Schoer's courses at Valparaiso University attended a Riverwatch Basic Training Workshop in 2007 to participate in volunteer monitoring in the Dunes Creek watershed. If funding is obtained for a Salt Creek volunteer monitoring program, the students will participate, and additional students will be trained to monitor Salt Creek water quality.

Valparaiso University Macroinvertebrate Monitoring (ongoing)
Valparaiso University students monitor benthic macroinvertebrates at five sampling sites in the Salt Creek watershed as part of an upper level ecology class. The sampling helps the students understand stream ecology in addition to assessing Salt Creek water quality.

Unincorporated Porter County

Unified Development Ordinance (effective June 2007)
A Unified Development Ordinance for unincorporated Porter County was adopted by the Porter County Commissioners in 2007. The ordinance establishes conservation and design standards for developers with mandatory green space requirements. It also includes a watershed overlay district, which is intended (in part) to reduce nutrient loss, erosion, and siltation, moderate floods, protect wetlands, and provide wildlife habitat. The overlay creates a buffer around priority waterbodies in which certain land uses are excluded. Salt Creek's mainstem is a priority one waterbody (500 foot buffer) and many tributaries are priority two (300 foot buffer) or priority three (100 foot buffer) waterbodies. Uses within the district that are not allowed include construction-material landfills, gas stations, and junk yards.

Porter County Comprehensive Land Use Plan
Porter County recently adopted a Comprehensive Land Use Plan, which is intended to help the county preserve and maintain its natural features. The plan includes measures to limit development around environmentally sensitive areas, protect prime farmland, preserve scenic road and stream corridors, support sound conservation practices, and reduce pollution. The plan also encourages conservation development in which developers cluster homes, preserve open space, and protect environmental features.

Acquisition of Meridian Property in Porter County
The County will purchase 0.9 acres (0.4 hectate) with a house and 17 acres (6.9 hectares) with a pond for preservation and future passive park use. The site is part of a 71 acre (29 hectare) site, to be purchased in its entirety by the Park Department for a future county park. The site is currently agricultural and wooded, and Swanson-Lamporte Ditch flows through the property (headwater tributary to Salt Creek). The future uses at this site include walking trails, fishing, and outdoor classroom projects. The site will include Americans wih Disabilities Act (ADA) accessible parking in the future. The Park Department will grant the

landowners a three year life estate; after three years the house will be used as a Porter County Park Department Property Manager residence.

Shorewood Forest Property Owner's Association (SFPOA)

Lake Louise Watershed Assessments
The Shorewood Forest Property Owner's Association completed several assessments of Lake Louise and its watershed. The Lake Louise Water Quality Assessment was completed in 2003, and the Lake Louise Watershed Assessment was completed in 2004.

Bans
The SFPOA has banned phosphate fertilizers and putting grass or leaves in the street where they can contribute nutrients to stormwater entering storm drains.

Newsletters
The SFPOA issues a monthly newsletter. Articles in 2007 newsletters have included articles on proper pet waste disposal, proper use of fertilizers and disposal of yard waste, the Lake Louise Watershed Management Plan, the phosphate ban, aquatic invasive plants, and natural landscaping.

Erosion Control Projects
The SFPOA completed several improvements to tributaries/ditches in the Lake Louise watershed to control the sedimentation and possible pollution of Lake Louise. Improvements completed on the Roxbury Ravine include grade control structures and bed and bank stabilization. Work has begun on the Atassi Drain, including replacing a culvert. Several improvements are being considered for the Atassi and Devon Ditches, including wetland restoration, ravine stabilization, grassed waterways, check dams, and channel widening.

Point Source Actions (from TMDL)

NPDES permits Only five out of the ten NPDES facilities within the watershed that discharge *E. coli* are required to monitor *E. coli* levels in their effluent. The five that do not monitor *E. coli* monitor either chlorine and/or fecal coliform. *E. coli* measurements from all facilities would be helpful in the development of the SCWMP. During the next permit renewal, *E. coli* limits and *E. coli* monitoring will be added to the permit requirements for all facilities.

CSO Long Term Control Plan In 1994, the USEPA published the National Combined Sewer Overflow (CSO) Control Policy. In accordance with that policy, IDEM amended Indiana's CSO Strategy to bring Indiana into compliance with the requirements of the Clean Water Act. Phase I of the National CSO Policy requires that "nine minimum controls" be implemented. These controls are designed to assist local communities in meeting water quality standards, including *E. coli*. The nine minimum controls are 1) proper operational and regular maintenance 2) maximum use of the collection system for storage 3) review and modification of pretreatment programs 4) maximization of flow to the treatment plant 5) prohibition of CSO discharges during dry weather 6) control of solid and floatable materials in CSO discharges 7) pollution prevention programs 8) public notification of CSO occurrences and impacts, and 9) monitoring to effectively characterize CSO impacts.

Bypasses Bypasses are defined as "the intentional diversion of waste streams from any portion of an Industrial User's treatment facility (40 Code of Federal Regulations (CFR) 122.41(m) (l))." Section 402 of the Clean Water Act prohibits "bypasses" from wastewater treatment facilities unless: (a) It was unavoidable to prevent loss of life, personal injury, or severe property damage. (b) There was no feasible alternative to bypass. (c) The industrial user submitted notices as required under Federal, State, or local regulations. (d) It does not result in any condition which violates the users permit. Of the bypass exceptions, (b) requiring "no feasible alternative" has been challenged most often. However, in a recent federal case, *United States v. City of Toledo, Ohio,* the Federal Court ruled that "any bypass which occurs because of inadequate plant capacity is unauthorized...to the extent that there are 'feasible alternatives,' including construction or installation of additional treatment capacity (USEPA, 2000c)." The ruling emphasizes the importance of communities assessing whether each treatment facility has adequate storage and/or treatment capacity. Ensuring sufficient facility capacity will reduce the occurrence of bypasses in Salt Creek.

Stormwater Program The EPA Phase II stormwater rule, effective October 29, 1999, requires communities with populations under 100,000 to meet permit program conditions aimed at controlling water pollution caused by stormwater runoff. The rule requires communities to implement a municipal stormwater management program that includes a list of six minimum stormwater control measures:

1. Public education and outreach on stormwater impacts: develop and implement a program to educate the public on stormwater discharge impacts to water bodies and the steps necessary to reduce stormwater pollution.

2. Public involvement: develop and implement a public participation program to assist in the implementation of the stormwater management program.

3. Illicit discharge detection and elimination: develop and implement a program that includes ordinances prohibiting illicit connections or discharges (including dumping), create storm sewer maps, and offer public education on the hazards of illicit discharges.

4. Construction site stormwater runoff control: develop, implement, and enforce a program to control stormwater runoff from construction activities on land disturbances of one or more acres.

5. Post-construction site stormwater management in new developments and redevelopment: develop, implement, and enforce a program that addresses stormwater runoff from new development and redevelopment, generally using structural and non-structural best management practices (BMPs).

6. Pollution prevention/good housekeeping for municipal operations: develop and implement a program that considers pollution prevention and good housekeeping measures for maintenance activities, street runoff controls, storm sewer waste disposal, and flood control management projects as they relate to municipal operations.

Table 18. Entities required to implement EPA Phase II Stormwater Regulations (WHPA, 2004)

Permit ID	Designated Entity	Type of Designation	Operator's Name
INR040149	Nature Works Conservancy District	Residential Population and Location in UA	Nathan Howell
INR040036	Town of Chesterton	Urbanized Area	Jennifer Gadzala
INR040090	City of Portage	Urbanized Area	Craig Hendrix
INR040140	Porter County	Urbanized Area	Kevin Breitzke
INR040115	Town of Porter	Urbanized Area	Brenda Bruckheimer
Unknown	Twin Creeks Conservancy District	Urbanized Area	Richard Motsinger
INR040073	City of Valparaiso	Urbanized Area	Matthew J. Kras
INR040073	Valparaiso University	University Enrollment and Location in UA	Matthew J. Kras
INR040103	Valparaiso Lakes Area Conservancy District	Residential Population and Location in UA	Bob Minarich

Indiana's Rule 13 meets the guidelines set by the EPA's Phase II stormwater regulations. In August 2003, IDEM sent a letter of notification to the entities which are required to obtain a permit and implement Phase II regulations. The permit applications were due November 4, 2003. In the Salt Creek watershed there are nine entities which are required to implement Phase II stormwater regulations (Table 18).

The City of Valparaiso has already begun implementing some of the six minimum control measures (MCMs) required by Rule 13:

1. Public Education and Outreach - the information regarding Phase II is on the City website and will be updated regularly.

2. Illicit Discharge Detection and Elimination - the City is currently working on photographing and mapping all outfalls from conveyance systems with a pipe diameter of twelve-inches or larger and open ditches with a two-foot or larger bottom width.

3. Construction Site Stormwater Runoff Control - the City currently requires erosion control measures, usually silt fencing, at construction sites for the stormwater runoff.

Valparaiso City Utilities Water Reclamation Department
The Valparaiso City Utilities Water Reclamation Department is responsible for the operation and maintenance of their wastewater collection system and wastewater treatment plant. The collection system consists of separate and combined systems, including approximately 200 miles (322 kilometers) of sewer and 28 pump stations within the 7,000 acre (2,833 hectare) service area. The City of Valparaiso has taken strides to maximize flow at the plant and reduce CSOs as highlighted below:

- Constructed three CSO storage tanks in 1987 located at the plant to retain 4.5 million gallons (17,034 kiloliters) of combined sewage during a wet weather event's first flush.
- Upgraded and expanded the plant in early 2001 to increase its average design flow (from six to eight million gallons per day (mgd)) and its peak flow (from 13.5 to 18 mgd) capacity, thereby increasing its wet weather capacity. A portion of this project included modifying the CSO storage tanks to provide a flowthrough treatment facility equivalent to primary clarification and control of settleable and floatable material up to 100 mgd utilizing Romag fine screens. This CSO flow-through treatment facility was one of the first of its kind in Indiana.
- Eliminated Farrell Street CSO in 2002, resulting in only one CSO outfall remaining at the plant.
- Undergone several sewer interceptor and separation projects resulting in less stormwater conveyed to the plant. Two examples include (1) diverted stormwater from a 66-inch combined sewer as part of Phase I of the Union Street sewer separation project, and (2) replaced a main storm sewer in the southwest portion of the City resulting in a large stormwater detention basin being disconnected from the combined sewer.
- Installed an additional flow meter at the plant prior to the CSO storage tanks to monitor the wet weather flow conveyed to the plant and the CSO tanks. The data collected from this meter will allow the City to track the effect of sewer separation improvements by comparing historical rainfall data and will allow for the proper sizing of a CSO disinfection system, which is scheduled to be constructed in 2011.
- Submitted their revised CSO long term control plan (LTCP) in November 2006 and received approval from IDEM. Valparaiso's LTCP was the 30th plan approved in the State.
- Strive to operate the wastewater plant to fully maximize its capacity, especially during wet weather. For example, the operations staff reduces the plant recycle streams to the maximum extent practical to meet the plant's effluent limits yet push as much wet weather flow through the plant and the CSO tanks as possible to prevent a CSO or reduce its discharge volume. The City also continuously works to improve their sewer maintenance program as highlighted below:
- Upgraded the City's pump stations to include monitoring via radio frequency telemetry and alarms that are communicated to the supervisory control and data acquisition (SCADA) system. This telemetry communication allows for instant response time by the staff thereby greatly reducing the risk of basement backups and overflows within the community.
- Included purchase of three natural gas generators for the City's high flow pump stations in the Utility's 2007 capital improvement plan (CIP). Additionally, the City now requires developers to provide natural gas generators on all future accepted pump stations within the service jurisdiction.
- Utilizing GPS to provide an accurate inventory and location of the City's sewer infrastructure as part of a City-wide geographic information system (GIS) and included in the Utility's CIP.
- Strives to provide regular cleaning and televising of sewer mains and catch basins, especially within the combined sewer system. The maintenance program documents on a daily basis the amount of lineal feet of sewer cleaned and televised. This aggressive style of maintenance and televising has allowed the City

to discover problem areas with respect to inflow, infiltration, and damaged pipe. Recently, the City performed sewer lining in various areas to eliminate collapses and reduce infiltration.

6.0 MEASURING PROGRESS AND PLAN EVALUATION

Save the Dunes Conservation Fund (SDCF) embraces a watershed-wide approach to achieving its water quality goals within 20 years. The first measure of success will be the completion of the SCWMP in compliance with IDEM's checklist guidelines. This is considered an insitutional goal. Going forward, SDCF's role changes from overseeing plan development to facilitating the action steps necessary for achieving the identified environmental goals. The overall success of the plan is dependent upon the partners' implementation of action items for improving water quality to attain *E. coli*, nutrient, sediment, and biotic water quality standards. The watershed management plan identifies general timeframes and implementation activities. Specific implementation plans will be developed as opportunities and implementation funding becomes avaiable. The implementation of the SCWMP will be tracked through a system of adminsitrative, social, and environmental indicators. For example, environmental indicators will include the number of wetland acres restored, buffers installed and linear feet of stream restoration projects completed. Administrative indicators include the number and type of BMPs implemented once the implementation phase is underway. Water quality monitoring results will be used to refine the neccessary loading results needed and help document the impact of implementation projects. Social or behavioral indicators will focus on documenting involvement, such as the number of property owner responses, the number of volunteer hours logged, the number of stakeholders recruited and involved in committee and public meetings, the number of partners providing project support, and the amount of match received. Community indicators of social change such as ordinance changes will also be used.

As new information about the watershed becomes available, it will be incorporated into the watershed management plan by using an adaptive management process. Adaptive management is a blend of implementation, monitoring, and evaluating practical management that allows for experimentation and provides the opportunity to "learn by doing". It is a necessary and useful process because of the uncertainty about landowner participation, funding opportunities, how ecosystems function, and how management affects ecosystems. Because several of the watershed goals are long-term goals (i.e. it will take more than ten years to attain), adaptive management is essential to ensure the actions stakeholders take are helping achieve those goals. Adaptive management provides stakeholders a framework to make timely adjustments to their implementation efforts if the monitoring results indicate such adjustments are needed.

7.0 IMPLEMENTATION

SDCF will be the lead entity promoting the implementation of the SCWMP. Expanding upon the partnerships developed during the plan development phase, SDCF will solicit additional partners to support the implementation of the plan. Once the SCWMP is approved, SDCF will coordinate the funding, implementation, and evaluation of the plan. Annual updates and upcoming events will be posted online at www.savedunes.org. As of the writing of this plan (June 17th , 2008), SDCF has applied for several grants to begin implementing the SCWMP. SDCF has been awarded IDEM Section 319 funds to demonstrate conservation/low impact development (LID) and to develop and implement a cost-share and education program in the Salt Creek watershed. SDCF has applied for Lake and River Enhancement (LARE) funds to conduct an engineering feasibility study on four potential projects in the watershed.

Salt Creek Implementation Demonstration (IDEM-319)
(March 13, 2008-March 12, 2011)
SDCF will develop partnerships with local stakeholders in the Salt Creek watershed and identify, promote, and monitor projects that demonstrate conservation design/low impact development (CD/LID) and reduce the impacts of nonpoint source pollution. SDCF will identify and develop partnerships and projects in part through an education and outreach program that promotes CD/LID and will consist of at least a measurement of associated cost/benefits savings of appropriate projects, press releases, and at least one outreach event for each CD/LID project. Prospective projects will be prioritized based upon demonstration value, project size, public access/visibility, suitability to address an existing nonpoint source problem, and proximity to Salt Creek and its tributaries or location in critical areas as defined by the SCWMP. SDCF will monitor, as appropriate, the CD/LID projects with a ground-based photographic monitoring method developed by the USDA and promoted by the USEPA (Hall, 2001). The method involves precisely repeating photographs of the same tract of ground over time to document change. Sediment and nutrient load reductions will be estimated when appropriate using the Spreadsheet Tool for Estimation of Pollutant Load (STEPL), the US EPA Region 5 Load Estimation Model, or other evaluation tool.

Salt Creek Watershed Cost-share and Education (IDEM-319)
SDCF will continue to identify partners and projects in critical areas identified in the SCWMP that address the goals of the Plan. A 319 cost-share program will be developed in accordance with IDEM Cost-share Program Guidance and will be submitted to IDEM for approval prior to implementation. SDCF will publicize the cost-share program through the SDCF web page and newsletter, and partner organizations, such as the NRCS, Porter County SWCD, and local universities. SDCF will continue to facilitate meetings of the Salt Creek Watershed group biannually. SDCF will conduct targeted outreach toward relevant groups, such as farmers, builders, and developers. For example, SDCF will coordinate with the partners (e.g., Porter County SWCD, and NRCS) to conduct no less than three field day events (e.g., agricultural pasture walks). Interpretive signage may be installed if a practice is new and the project has public visibility. SDCF will continue to develop partnerships with and conduct outreach to local governments and planners, such as municipal and county employees, elected officials, City and Town Councils, and parks departments. SDCF will investigate potential future funding sources to continue implementation of the SCWMP.

SDCF will continue a chemical and biological water quality monitoring program in the Salt Creek watershed to track the impact of the installed practices/systems. SDCF will revise the existing Quality Assurance Project Plan (QAPP) or develop a new QAPP and submit it to IDEM for approval prior to initiating monitoring activities. SDCF will continue coordinating volunteer sampling. Cost-shared practices/systems will also be documented as appropriate utilizing ground-based photographic monitoring method developed by the USDA and promoted by USEPA (Hall, 2001). Sediment and nutrient load reductions will be estimated when appropriate using STEPL, the US EPA Region 5 Load Estimation Model, or other evaluation tool.

Salt Creek Engineering Feasibility Study (LARE)
In order to maximize the resources available to implement the plan and ensure the success of implementation activities, SDCF proposes to conduct a preliminary engineering feasibility study to assess and prepare preliminary designs for four projects in the watershed. This project will determine the feasibility of daylighting the headwaters of Robbin's Ditch, enhancing the Thorgren Basin, stabilizing the Zurbo Ravine, and restoring hydrology in the Lake Louise subwatershed. Each of the proposed projects is expected to improve Salt Creek water quality, enhance fish and wildlife habitat, and educate the public on protecting the Salt Creek watershed. Evaluating the projects will enable SDCF to prioritize the projects, evaluate costs and benefits, prepare for physical design, and ensure successful implementation of feasible projects.

Other Nonpoint Source Actions

Exotic Species Control: Future management of the Salt Creek watershed should include not only direct efforts to limit the expansion of exotic species, but also funding and support for research into biological control, and restoration of natural processes such as fire. See Section 2.9- Exotic and Invasive Species for more information.

Monitoring: Monitoring is an important component of this watershed management plan. Without monitoring, stakeholders will not know when or whether they have achieved their goals; or worse, they will not make timely refinements to their actions to ensure the actions they are taking will achieve their goals. The previous section details how stakeholders will monitor their progress toward achieving the goals set in this watershed management plan.

Nonpoint Source Actions Suggested in TMDL
Nonpoint source pollution can be reduced by the implementation of BMPs. BMPs are structural and management practices which are used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities (IDEM, 2002). A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs can be implemented by livestock owners, farmers, and urban planners. From the TMDL for reduction of *E. coli* runoff, the following are recommended:

Buffer and Riparian Area Management Management of riparian areas protects streambanks and river banks with a buffer zone of vegetation, either grasses, legumes, or trees. Riparian areas are along the sides of streams. Management of this area is beneficial for streams near urban areas, cropland, and pastureland. Riparian area buffer zones can trap coliform bacteria, soluble nutrients, and soluble pesticides in runoff water if the runoff moves over the buffer area in a shallow, even flow. The area prevents sediment and other pollutants from reaching those bodies of water as well as provides shade to the water body. They reduce water erosion, slow runoff, trap soil particles, and provide food and nesting cover for wildlife. Additionally, riparian buffers can provide necessary shade to streams, thereby reducing water temperatures and increasing the amount of dissolved oxygen that is possible within the stream. The effectiveness of riparian buffer zones is increased as the width of the zone is increased.

Manure Collection, Storage, and Utilization Collecting, storing, and handling manure in such a way that nutrients or bacteria do not run off into surface waters or leach down into ground water. Manure is collected each day and stored. Manure is then applied to cropland in an environmentally safe manner.

Contour Row Crops Farming with row patterns and field operations aligned at or nearly perpendicular to the slope of the land. Row patterns follow established grades or terraces or diversions, if present. This practice reduces erosion, controls water runoff, and improves water quality. Contours are established at a nearly perpendicular direction to the slope of the land. Contours may be designed with a slight slope on soils which are slowly or very slowly drained to allow for surface drainage. Excess runoff from contours is often directed to field borders, vegetative filter strips, or grassed waterways. Contour farming decreases sheet and rill erosion by creating furrows or small dams, reducing transport and providing opportunities for deposition. Contour farming reduces surface runoff of dissolved nutrients and pesticides by reducing runoff. Contour farming also increases the time between onset of rainfall and initiation of runoff, which helps move some dissolved chemicals below the soil surface and reduces runoff losses. Contour farming is most effective on fields relatively free of gullies and depressions, and where slopes are uniform. Contour farming is often used in combination with other practices, such as terraces or grassed waterways, especially for control of excess runoff.

Crop Residue Management No-till farming is a year-round conservation farming system. In its pure form, no-till does not include any tillage operations either before or after planting. The practice reduces wind and water erosion, catches snow, conserves soil water, protects water quality, and provides wildlife habitat. No-till helps control soil erosion and improve water quality by maintaining maximum residue levels on the soil surface. These plant residues: 1) protect soil particles and applied nutrients and pesticides from detachment by wind and water; 2) increase infiltration; and 3) reduce the speed at which wind and water move over the soil surface. While no-till is one preferred method other till reduction systems will be promoted as appropriate.

Drift Fences Drift fences (short fences or barriers) can be installed to direct livestock movement. The fences manipulate livestock patterns in a way that reduces soil erosion problems and keeps livestock away from surface waters. A drift fence can be used to block a gentle slope where continual trailing of animals is causing gullies. This will force the animals to utilize different areas. A drift fence parallel to a stream keeps animals out and prevents direct input of *E. coli* to the stream.

Pet Clean-up / Education Education programs for pet owners can improve water quality of runoff from urban areas. Teaching citizens to pick up and dispose of their pet's feces can reduce the amount of *E. coli* entering the streams through stormwater.

Septic Management Programs for management of septic systems can provide a systematic approach to reducing septic system pollution. One example of such a program is the Community Septic Management Program adopted by Massachusetts. The program is implemented at the local level where each community can decide between two options 1) development of a plan which requires regular inspection of all septic systems at least every 7 years or 2) creation of a local plan to monitor proper maintenance of systems. Both approaches provide some form of funding to homeowners for septic repair and upgrade. Other communities have passed septic management ordinances that require pumping of septic tanks at regular intervals. Although difficult to enforce, requiring proper maintenance of septic systems can help alleviate pollution. Public education about septic system maintenance is a good first step to decreasing septic system pollution. Most septic system owners want to maintain their system to help extend the life and effectiveness of their systems as well as benefit the environment.

7.1 Future Considerations

There are several considerations stakeholders should keep in mind as they implement the SCWMP. Many of these considerations are noted in the proceeding sections of this text, but due to their importance, they warrant reiteration.

Permits, Easements, and Agreements
As the activities recommended in the SCWMP are implemented, consideration must be given to necessary permits and agreements. All necessary permits must be obtained prior to implementing practices. Permission from property owners must be obtained in writing prior to commencement of work.

Operation and Maintenance
All structural BMPs have to be operated and maintained in accordance with their design objective. For example detention BMPs must have the settable solids removed from their forebays and sediment deposition zones in order to function properly.

Plan Revisions
This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as other stakeholders become more active in implementing the plan. SDCF will coordinate the funding, implementation, and evaluation of the SCWMP. Annual updates will be posted on www.savedunes.org.

Unaddressed and Unfunded Actions
Certain actions necessary toward achieving watershed goals will not be carried out or coordinated directly by SDCF. For example, activities such as septic system maintenance are difficult to fund using public funding sources. Such activities must be funded by property owners or private institutions, and will likely be addressed through education and outreach only. This plan acknowledges point sources of pollution, but implementation of the plan does not include point sources actions. The goals of the SCWMP will be pursued through nonpoint source actions. Point source actions recommended in the TMDL are listed in Section 5.0- Recently Completed and Ongoing Activities. Point source pollution issues must be addressed and controlled in order to achieve watershed goals.

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ACRONYMS

ADA	Americans with Disabilities Act
APHA	American Public Health Association
ASAE	American Society of Agricultural Engineers
BMP	Best Management Practice
CD	Conservation Design
CFO	Combined Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
CIP	Capital Improvement Plan
CSO	Combined Sewer Overflow
CTIC	Conservation Technology Information Center
CZARA	Coastal Zone Act Reauthorization Amendments
CZM	Coastal Zone Management
DBH	Diameter Breast Height
DDT	Dichloro-diphenyl-trichloroethane
DO	Dissolved Oxygen
EPT	*Ephemeroptera, Plecoptera, Trichoptera*
FRIENDS	Friends of the Indiana Dunes
GIS	Geographic Information System
GLAHNF	Great Lakes Aquatic Habitat Network and Fund
GLWR	Great lakes Watershed Restoration
GPS	Global Positioning System
HBI	Hilsenhoff Biotic Index
HEL	Highly Erodible Land
HSPF	Hydrologic Simulation Program-Fortran
HUC	Hydrologic Unit Code
IAC	Indiana Administrative Code
IBI	Index of Biotic Integrity
IBRC	Indiana Business Research Center
ICCMODS	Indiana Capacity Center for Management of Onsite/Decentralized Systems
ICRAT	Indiana Coastal Restoration Action Team
IDEM	Indiana Department of Environmental Management
IDEM-OLQ	Indiana Department of Environmental Management- Office of Land Quality
IDNP	Indiana Division of Nature Preserves
IDNR	Indiana Department of Natural Resources

INDOT	Indiana Department of Transportation
INDU	Indiana Dunes National Lakeshore
INHDC	Indiana Natural Heritage Data Center
IOWPA	Indiana Onsite Wastewater Professional Association
ISDA	Indiana State Department of Agriculture
LAs	Load Allocations
LARE	Lake and River Enhancement
LID	Low Impact Development
LMCP	Lake Michigan Coastal Program
LTCP	Long Term Control Plan
LUST	Leaking Underground Storage Tank
MCM	Minimum Control Measure
MGD	Million gallons per day
mIBI	Macroinvertebrate Index of Biotic Integrity
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer
MWH	Modified Warmwater Habitat
NESC	National Environmental Services Center
NH4	Ammonium-Nitrogen
NIRPC	Northwestern Indiana Regional Planning Commission
NO3	Nitrate-Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
NSFC	National Small Flows Clearinghouse
NTU	Nephelometric Turbidity Units
NWI	National Wetlands inventory
O&M	Operation and Maintenance
OEPA	Ohio Environmental Protection Agency
OSDS	Onsite Sewage Disposal Systems
PCCRVC	Porter County Community, Recreation, and Visitor Commission
PFA	Public Fishing Area
POTW	Publicly Owned treatment Works
PSA	Public Service Announcement
QAPP	Quality Assurance Project Plan
QDMA	Quality Deer Management Association

QHEI	Qualitative Habitat Evaluation Index
QLC	Quality of Life Council
RC&D	Resource Conservation and Development Council
SCADA	Supervisory Control and Data Acquisition
SCWMP	Salt Creek Watershed Management Plan
SDCF	Save the Dunes Conservation Fund
SFPOA	Shorewood Forest Property Owner's Association
SR	State Road
SRF	State Revolving Fund
SRP	Soluble Reactive Phosphorus
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	Soil and Water Conservation District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VADEQ	Virginia Department of Environmental Quality
VU	Valparaiso University
WLAs	Wasteload Allocations
WHPA	Wittman Hydro Planning Associates, Inc.
WWH	Warmwater Habitat
WWTP	Wastewater Treatment Plant

GLOSSARY OF TERMS

303(d) List – a list identifying waterbodies that are impaired by one or more water quality elements thereby limiting the performance of designated beneficial uses.

Allelopathic- an effect whereby a plant species chemically antagonizes others in its environment, in order to gain competitive advantage.

Aquifer – any geologic formation containing water, especially one that supplies water for wells, springs, etc.

Baseline- initial or existing conditions of flux before management intervention or impact.

Basin- the largest single watershed management unit for water planning that combines the drainage of a series of subbasins; often have a total area of more than a thousand square miles (640,000 acres).

Best management practices (BMPs) – practices implemented to control or reduce nonpoint source pollution.

Channelization – straightening of a stream; often the result of human activity.

Coliform – intestinal waterborne bacteria that indicate fecal contamination. Exposure may lead to human health risks.

Combined sewer- a sewer receiving both intercepted surface runoff and municipal sewage.

Designated Uses – state-established uses that waters should support (e.g. fishing, swimming, aquatic life).

Ecoregion – a geographic area characterized by climate, soils, geology, and vegetation.

Ecosystem – a community of living organisms and their interrelated physical and chemical environment.

Effluent- the treated or untreated liquids that flow out or are discharged from a water treatment plant, sewer or industrial outfall.

Erosion – the removal of soil particles by the action of water, wind, ice, or other agent.

Evapotranspiration - the combined processes of evaporation and transpiration. It can be defined as the sum of water used by vegetation and water lost by evaporation.

Exotic species – an introduced species not native or endemic to the area in question.

Geometric mean- based on no less than five (5) samples equally spaced over a thirty (30) day period

Flood plain- a nearly flat area of land along the course of a stream that is naturally subject to flooding.

Gradient – measure of a degree of incline; the steepness of a slope.

Groundwater – water that flows or seeps downward and saturates soil or rock.

Headwater – the origins of a stream.

Hydrologic Unit Code (HUC) – unique numerical code created by the U.S. Geological Survey to indicate the size and location of a watershed within the United States.

Impervious Surface – any material covering the ground that does not allow water to pass through or infiltrate (e.g. roads, driveways, roofs).

Infiltration – downward movement of water through layers of soil.

(Benthic) Macroinvertebrates – animals lacking a backbone that are large enough to see without a microscope.

Mainstem- the main channel of a river or stream.

Mesic- neither wet (hydric) nor dry (xeric); intermediate in moisture.

National Pollutant Discharge Elimination System (NPDES) – national program in which pollutant dischargers such as factories and treatment plants are given permits with set limits of discharge allowable.

Nonpoint Source Pollution (NPS) – pollution generated from large areas with no identifiable source (e.g., stormwater run-off from streets, development, commercial and residential areas).

Old field – an area arising from any disturbance that causes bare ground and a reset of succession, typically refers to abandoned or unused farmland

Organic Pollution- any oxygen demanding particulates which include anything that requires oxygen to be broken down-nutrients, fertilizer, sewage, leaf or woody material, etc.

Pathogens- disease-causing organisms, especially viruses, bacteria, or fungi.

Pioneer species- (fish) species that dominate unstable environments affected by anthropogenic stresses and are the first to re-colonize sections of headwater streams after desiccation

Permeable – capable of conveying water (e.g., soil, porous materials).

Point Source Pollution – pollution originating from a "point," such as a pipe, vent, or culvert.

Pollutant – as defined by the Clean Water Act (Section 502(6)): "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

Pool – an area of relatively deep, slow-moving water in a stream.

Riffle – an area of shallow, swift moving water in a stream.

Riparian Zone – an area, adjacent to a waterbody, which is often vegetated and constitutes a buffer zone between the nearby land and water.

Sediment – soil, sand, and minerals washed from the land into a waterbody.

Sedimentation – the process by which soil particles (sediment) enter, accumulate, and settle to the bottom of a waterbody.

Septic system- an on-site system designed to treat and dispose of domestic sewage; a typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent that remains after decomposition of solids by bacteria in the tank; must be pumped out periodically.

Siltation- particles carried in water that are deposited on the bottom of a waterbody

Storm drain – constructed opening in a road system through which run-off from the road surface flows on its way to a waterbody.

Stormwater – the surface water run-off resulting from precipitation falling within a watershed.

Substrate – the material that makes up the bottom layer of a stream.

Total Maximum Daily Load (TMDL) – calculation of the maximum amount of a pollutant that a waterbody can receive before becoming unsafe and a plan to lower pollution to that identified safe level.

Tributary – a stream that contributes its water to another stream or waterbody.

Turbidity – presence of sediment or other particles in water, making it unclear, murky, or opaque.

Upland- Dry land located at an elevation above wetlands or waterways.

Upstream waters- rivers, creeks, and tributaries that empty to another; also, any water located in the opposite direction of the current of a river, creek, or other tributary.

Water Quality – the condition of water with regard to the presence or absence of pollution.

Water Quality Standard – recommended or enforceable maximum contaminant levels of chemicals or materials in water.

Watershed (Basin) – the area of land that water flows over or under on its way to a common waterbody.

Wetlands – lands where water saturation is the dominant factor in determining the nature of soil development and the types of plant and animal communities.

APPENDICES

Appendix A. Salt Creek watershed management plan distribution list

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Porter County Library
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Porter County Library
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Appendix B. Salt Creek Watershed Committee Members

Save the Dunes Conservation Fund

Salt Creek Watershed Steering Committee

October, 2006

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Save the Dunes Conservation Fund

Salt Creek Watershed Technical Advisory Committee

October, 2006

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Save the Dunes Conservation Fund

Salt Creek Watershed
Volunteer and Outreach Committee

October, 2006

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Appendix C. Salt Creek watershed workshop binder coverpage

May 16, 2006

WATERSHED BASED PLANNING

Developing a Framework for Managing the Salt Creek Watershed

Sponsored by:

Save the Dunes Conservation Fund
Porter County Plan Commission
Red Fish Development LLC
Porter County Surveyor
Conservation Technology Information Center
Indiana Department of Environmental Management
US Environmental Protection Agency
Tetra Tech, Inc.

Porter County Administration Center ▪ 155 Indiana Avenue ▪ Valparaiso, Indiana

Appendix D. Salt Creek watershed workshop agenda

Watershed Based Planning

Save the Dunes Conservation Fund

Developing a Framework for Managing the Salt Creek Watershed

This workshop seeks to build on efforts to protect and restore Salt Creek in Porter County, Indiana, through a locally lead, collaborative process to identify problems and develop and implement achievable solutions.

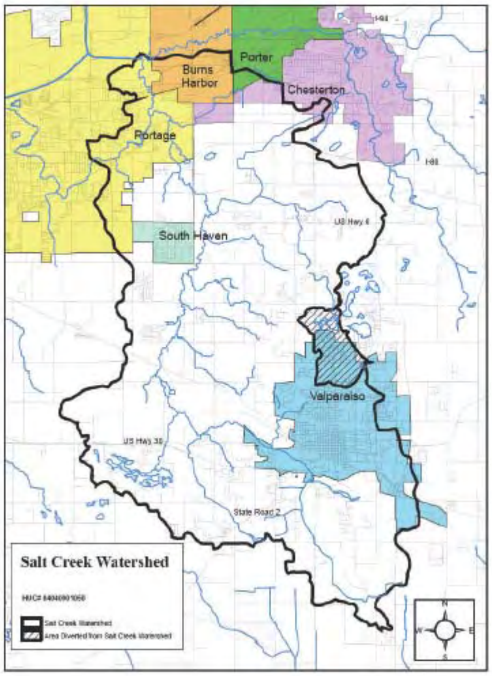
May 16, 2006 Porter County Administration Center 155 Indiana Avenue, Valparaiso, Indiana

8:30 – 9:00	**Registration**	*Save the Dunes Staff*
9:00 – 9:15	**Welcome and Introductions**	*Thomas Anderson* *SDCF Executive Director*
9:15 – 9:30	**Opening Remarks**	*Karen Tallian* *Indiana State Senator*
9:30 – 9:45	**Workshop Objectives and the Benefits of a Watershed Approach**	*Christine Livingston* *SDCF Watershed Coordinator*
9:45 – 10:45	**Watersheds: How They Work (Or Not)** • Watershed structure and function • Impacts of land use and land management on water quality	*Barry Tonning, Tetra Tech*
10:45 – 11:00	**Break**	
11:00 – 12:00	**Assessing Problems and Developing Solutions** • Measuring water quality and stream health • Management practices to address problems	*Barry Tonning, Tetra Tech*
12:00 – 1:00	**Lunch and Presentation** • Development and trends in Porter County • Potential impacts on water quality	*Robert Thompson* *Porter Co. Plan Commission*
1:00 – 1:30	**Agricultural Practices and Ongoing Efforts** • Ag management practices to protect water quality	*Bill Moran, NRCS*
1:30 – 2:30	**Salt Creek Watershed Assessment** • Review of assessment data and Salt Creek TMDL • Identification of key problems and likely source area	*Barry Tonning, Tetra Tech*
2:30 – 2:45	**Break**	
2:45 – 3:30	**Management Practices for the Salt Creek Watershed** • Linking problems, threats, and source areas • Possible solutions for particular areas • Organizing for success: public outreach, involvement, and planning	*Facilitated Discussion*
3:40 – 4:00	**Integrating and Coordinating Activities** • Summary of today's discussions • How do we integrate our efforts? • What's next – forging a cooperative planning approach	*Christine Livingston* *SDCF Watershed Coordinator*
4:00	**Workshop Adjourns**	

Final Agenda May 16, 2006

TETRA TECH

Appendix E. Salt Creek brochure



WATERSHED BASED PLANNING

Developing a Framework for Managing the *Salt Creek Watershed*

Mission Statement

The Salt Creek watershed group will foster improved communication, collaboration, education, and ecological understanding, and develop strategies to conserve, protect, and enhance the resources of the watershed.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
www.savedunes.org
(219)879-3564

WHY DEVELOP A WATERSHED MANAGEMENT PLAN?

Watershed management is an effective way to cross traditional boundaries and bring people in a region together to make responsible land use choices. Almost every activity on the land has the potential to affect the quality of water in our communities. Effects from increases in human population and industrial, commercial, and residential development include; degraded water quality, decreased recreational and aesthetic value and loss of habitat for fish and wildlife. There is a critical need for us to improve the quality of our water and protect it from these impacts. A well developed watershed management plan is an important step in this process.

Salt Creek at Butternut Springs Outlet

THE SALT CREEK WATERSHED PROJECT

Save the Dunes Conservation Fund (SDCF) is currently funded by the Indiana Department of Environmental Management (IDEM) to coordinate the development and implementation of a watershed management plan in the Salt Creek watershed. The 49,573 acre watershed includes sections of Valparaiso, Chesterton, Portage, Burns Harbor, Porter, and South Haven (see map on reverse). The Salt Creek Watershed Management Plan will assess current water quality and identify pollutant sources. The final plan will guide the process of improving water quality in the Salt Creek watershed while accommodating important economic, social, and recreational uses.

Guest speaker Bill Moran describes agricultural practices at the Salt Creek watershed workshop.

Save the Dunes Conservation Fund

YOU CAN MAKE A DIFFERENCE!

If you drink water from Lake Michigan, enjoy the beach, own property within the Salt Creek watershed, or have concern for protection of our natural resources, you have a vested interest in improving Salt Creek water quality. Broad-based participation in the development of the Salt Creek Watershed Management Plan ensures that everyone's interests are represented. **All meetings are open to the public (see schedule below).** Listed below are simple things you can do to help.

- Get involved in the Salt Creek watershed planning process!
- Volunteer for programs, such as stream monitoring and storm drain marking.
- Minimize use of lawn fertilizers and pesticides or use low phosphorus fertilizer.
- Make sure your septic system functions properly.
- Dispose of waste properly, rather than dumping waste down storm drains.
- Keep yard waste and trash out of the streets and gutters.
- Wash your car at a carwash or on your lawn to keep runoff out of storm drains.
- Pick up after your pets.
- For more information visit www.savedunes.org/water_program/salt_creek/.

Volunteers monitor water quality to identify critical areas in the watershed.

Portage students mark storm drains to educate residents on the negative impact of stormwater runoff on Salt Creek.

Meeting Schedule

Porter County Administration Center
155 Indiana Avenue, Suite 309, Valparaiso, Indiana
The following Tuesdays:

Technical & Outreach Committees at 9am	All Committees at 3pm
August 29, 2006	November 14, 2006
February 6, 2007	May 1, 2007
August 7, 2007	November 6, 2007

Note: Meeting dates and locations are subject to change. For additional information please contact Christine Livingston at (219) 879-3564 or cll@savedunes.org.

This project has been funded in part by the United States Environmental Protection Agency under assistance agreement [illegible] to the Indiana Department of Environmental Management. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation.

Appendix F. Press releases

For Immediate Release
Tuesday, June 13, 2006

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3564 Email: cll@savedunes.org

Watershed Management to Protect Water Quality!

Salt Creek Watershed Management Planning Underway.

Tuesday, June 20, 2006, 9:00 am.
Porter County Administration Center, Suite 309

Save the Dunes Conservation Fund (SDCF) is leading an effort to develop and implement a plan for the management of the Salt Creek watershed, which occupies much of Porter County, including sections of Valparaiso, Portage, Chesterton, Porter, Burns Harbor, and South Haven. Many issues and concerns were identified by participants at the kick off meeting, which was held May 16, 2006. Involved citizens want the Salt Creek Watershed Management Plan to promote better stewardship of private and public land, identify and implement ways to improve land use management, and increase public understanding and awareness about water quality issues.

Development of the Salt Creek Watershed Management Plan is underway and will provide a framework for achieving a healthy Salt Creek watershed. Public input during this process is critical to ensure everyone's interests are represented. The public is encouraged to attend the Salt Creek Committee Meetings. Save the Dunes Conservation Fund will hold its first Planning and Technical Advisory and Volunteer/Outreach Committee Meetings on Tuesday, June 20, 2006 at 9:00 am at the Porter County Administration Center, Suite 309. Jenny Orsburn, of the Department of Natural Resources will present information on the Lake Michigan Coastal Program's watershed management efforts. The group will then develop a list of the most pressing water quality concerns for Salt Creek and will draft its vision and mission statements. Plans for this summer's water quality monitoring program will also be discussed.

Save the Dunes Conservation Fund has been funded in part by IDEM's 319 Grant Program to develop the Salt Creek Watershed Management Plan.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3564 / Fx. 219-872-4875

For Immediate Release
Thursday, August 24, 2006

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3564 Email: cll@savedunes.org

Salt Creek Watershed Meeting August 29th

The public is invited to attend the upcoming Salt Creek Committee Meeting on Tuesday, August 29, 2006 at 9:00 am at the Porter County Administration Center, Suite 309. Public participation is essential to ensure that broad interests are represented. The upcoming meeting will include a presentation by Shorewood Forest Community Manager, Christian Anderson on management efforts for Lake Louise. Mary Beth Wiseman of the Northwestern Indiana Regional Plan Commission (NIRPC) will present on the *Watershed Management Plan for Lake, Porter, and LaPorte Counties* and how Salt Creek efforts fit into this regional plan. Updates on completed sections of the plan and water quality sampling location changes will follow these presentations. SDCF will welcome responses from attendees on personal observations of water quality concerns within the watershed.

Save the Dunes Conservation Fund (SDCF) is funded in part by IDEM's 319 Grant Program to develop the Salt Creek Watershed Management Plan. The Salt Creek watershed occupies much of Porter County, including sections of Valparaiso, Portage, Chesterton, Porter, Burns Harbor, and South Haven. If you live within the Salt Creek watershed, you have a vested interest in the improvement of Salt Creek water quality! The mission of the Salt Creek Watershed Group is to foster improved communication, collaboration, education, and ecological understanding and develop strategies that conserve, protect, and enhance the resources of the watershed.

A current draft of the Salt Creek Watershed Management Plan may be downloaded from Save the Dunes Conservation Fund's web page located on the Save the Dunes website at www.savedunes.net/water_program/salt_creek/.

For more information please contact Christine Livingston at cll@savedunes.org.

Save the Dunes Conservation Fund
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For Immediate Release
Tuesday November 14, 2006

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3564 Email: cll@savedunes.org

Watershed Management to Protect Water Quality!

Salt Creek Watershed Management Planning Underway.

Tuesday, November 14, 2006, 3:00 pm.
Porter County Administration Center, Suite 309

Save the Dunes Conservation Fund (SDCF) funded by IDEM's 319 Grant Program to develop and implement a plan for the management of the Salt Creek watershed. The watershed occupies nearly 20% Porter County, including parts of Valparaiso, Portage, Chesterton, Porter, Burns Harbor, and South Haven. The Salt Creek Watershed Group continues to pursue their mission statement: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance*

Development of the Salt Creek Watershed Management Plan is underway. The public is encouraged to attend the Salt Creek Committee Meetings. Save the Dunes Conservation Fund will hold its first Salt Creek Steering Committee Meeting jointly with the working group meeting on Tuesday, November 14, 2006 at 3:00 pm at the Porter County Administration Center, Suite 309. SDCF Water Program Director Christine Livingston will show pictures of good and bad practices throughout the watershed and discuss the current status of the draft Salt Creek Watershed Plan. Jeff Jones and Colin Highlands will discuss the Portage Parks Department's efforts to acquire and protect the Salt Creek corridor in Portage. The group will then decide on action items for the next quarter.

Save the Dunes Conservation Fund
444 Barker Road
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For Immediate Release
Wednesday January 31, 2007

Contact: Christine Livingston, Water Program Director
Office: 219-879-3564 Email: cll@savedunes.org

Protecting Salt Creek Water Quality through Watershed Management!

Tuesday, February 6th 9:00 am
Porter County Administration Center, Suite 309

Save the Dunes Conservation Fund (SDCF) is coordinating the development and implementation of a watershed management plan for the Salt Creek watershed. Salt Creek watershed planning and management is a community driven process, and partners include representatives from Porter County, Valparaiso, Portage, Chesterton, Porter, Burns Harbor, South Haven, government agencies, Valparaiso University, local developers, concerned citizens, and many others.

The Salt Creek Watershed Group continues to pursue their mission statement: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

The public is encouraged to attend the Salt Creek Committee Meetings. The next Salt Creek Technical Advisory and Outreach Committee Meeting will be held Tuesday February 6, 2007 from 9:00 to 10:30 am at the Porter County Administration Center, Suite 309. The meeting will focus on Salt Creek water quality data and will include a presentation by Charles Morris, Environmental Manager from IDEM's Biological Studies Section on Salt Creek water quality and biological data from the summer of 2006 study. Residents of the Salt Creek watershed are encouraged to share their knowledge of the Salt Creek watershed to help interpret this data. Development and implementation of the Salt Creek Watershed Management Plan is funded by IDEM's 319 Grant Program. For more information on this project or to download a current draft of the Salt Creek Watershed Management Plan, please visit www.savedunes.org/water_program/salt_creek/.

Save the Dunes Conservation Fund
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For Immediate Release
Wednesday April 25, 2007

Contact: Christine Livingston, Water Program Director
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Salt Creek Watershed Committee works to protect water quality

Tuesday May 1st, 3:00 pm
Porter County Administration Center, Suite 309

Save the Dunes Conservation Fund (SDCF) is coordinating the development and implementation of a watershed management plan for the Salt Creek watershed. Watershed management is a community driven process, and partners include representatives from Porter County, Valparaiso, Portage, Chesterton, Porter, Burns Harbor, South Haven, government agencies, Valparaiso University, local developers, concerned citizens, and many others.

The Salt Creek Watershed Group continues to pursue their mission statement: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

The next Salt Creek Committee Meeting will be held Tuesday May 1st, 2007 from 3:00 to 4:30 am at the Porter County Administration Center, Suite 309. The public is encouraged to attend the Salt Creek Committee Meetings. The meeting will include a presentation by Robert Thompson, Executive Director of the Porter County Plan Commission on the proposed Porter County Unified Development Ordinance and how the watershed overlay will help protect the Salt Creek watershed. The group will also discuss potential implementation projects and potential pollutant sources throughout the watershed. Development and implementation of the Salt Creek Watershed Management Plan is funded by IDEM's 319 Grant Program. For more information on this project or to download a current draft of the Salt Creek Watershed Management Plan, please visit www.savedunes.org/water_program/salt_creek/.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3564 / Fx. 219-872-4875

For Immediate Release

Thursday August 2nd, 2007

Contact: Christine Livingston, Water Program Director
Office: 219-879-3564 Email: cll@savedunes.org

How Can We Improve Salt Creek Water Quality?
Help Decide at the Salt Creek Watershed Committee Meeting

Tuesday August 7th, 9:00 am
Porter County Administration Center, Suite 309

Results from Save the Dunes Conservation Fund (SDCF)'s Salt Creek water quality monitoring program are in, and the Salt Creek Watershed Committee is ready to interpret the data to guide the watershed management process. Water quality monitoring began in 2006 to investigate the sources of nonpoint source pollution that lead to impaired water quality in Salt Creek. With the 2007 monitoring program complete, the Committee will now incorporate the results into the Salt Creek Watershed Management Plan. The final plan will facilitate the process of improving Salt Creek water quality.

The public is encouraged to attend the Salt Creek Committee Meeting on Tuesday August 7th, 2007 from 9:00 to 10:30 am at the Porter County Administration Center, Suite 309 in Valparaiso. Watershed management is a community driven process, and broad-based participation in the development of the plan will ensure that everyone's interests are represented. The August 7th meeting will include a presentation on the Salt Creek water quality monitoring program and results. The group will discuss the data to identify potential pollutant sources and determine critical areas throughout the watershed.

The 49,573 acre Salt Creek watershed includes sections of Valparaiso, Chesterton, Portage, Burns Harbor, Porter, and South Haven. The Indiana Department of Environmental Management (IDEM) has identified sections of Salt Creek on the 303(d) list of impaired waters as impaired for excessive *Escherichia coli (E. coli)* concentrations and impaired biotic communities. SDCF is funded by IDEM's 319 Grant Program to coordinate the development and implementation of the Salt Creek Watershed Management Plan to address these water quality concerns.

The Salt Creek Watershed Committee was formed in 2006 to oversee the development of the Plan. The Committee includes representatives from Porter County, all municipalities within the watershed, government agencies, Valparaiso University, local developers, concerned citizens, and many others. The group continues to pursue their mission: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

Save the Dunes Conservation Fund
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For Immediate Release

Tuesday, November 6th, 2007 .

Contact: Christine Livingston, Water Program Director
Office: 219-879-3564 Email: cll@savedunes.org

Salt Creek Watershed Plan in the Home Stretch

Tuesday November 13th, 3:00 pm
Porter County Administration Center, Suite 309

With development of the Salt Creek Watershed Management Plan (SCWMP) nearly complete, the Salt Creek Watershed Group is eager to put the plan into action to protect and improve Salt Creek water quality. The Group will hold its final meeting to wrap up the two-year process of developing the SCWMP on November 13th, 2007. The final plan will include goals for improving Salt Creek water quality and activities that will aid in achieving those goals. "Completing the SCWMP is not the end of the Group's work to improve Salt Creek, it's just the beginning!" explains Save the Dunes Water Program Director, Christine Livingston. "There is a lot to be done, but with the commitment from communities throughout the watershed we are already on our way to protecting water quality." Livingston further claims.

Many exciting projects and partnerships are already underway to jump start the implementation of the SCWMP. For example, Save the Dunes Conservation Fund (SDCF) is partnering with the Portage Parks Department to install a green (vegetated) roof on a concession stand at the new Imagination Glen Park soccer complex. A green roof consists of a vegetated green space on top of a human-made, impervious structure. Soil and plants in green roof systems act like a sponge and absorb excess stormwater that would normally run off the roof and into a stormdrain or nearby Salt Creek. Park Assistant Superintendent, Jeff Jones will provide the Watershed Group with an overview and update of the project at Tuesday's meeting.

SDCF is also working with the City of Valparaiso to install rain gardens at Forest Park Golf Course. A rain garden is a shallow, vegetated depression that helps clean and manage stormwater runoff on site. The bowl-shaped gardens collect run-off from impervious surfaces and allow it to infiltrate into the ground. Aesthetically-pleasing native plants help the garden absorb stormwater, while providing additional benefits such as wildlife habitat. Two rain gardens will collect stormwater from the golf course and help to store, infiltrate, and clean the water before it enters Salt Creek. City of Valparaiso Engineer, David Pilz will provide the Watershed Group with an update on the project at Tuesday's meeting and discuss future features that might be incorporated into the Golf Course.

Watershed management is a community driven process, and broad-based participation in the development of the plan will ensure that everyone's interests are represented. SDCF is funded by IDEM's 319 Grant Program to coordinate the development and implementation of the Salt Creek Watershed Management Plan to address water quality concerns. The Salt Creek Watershed Committee was formed in 2006 to oversee the development of the Plan. The Committee includes representatives from Porter County, Valparaiso, Portage, Chesterton, Porter, Burns Harbor, government agencies, Valparaiso University, local developers, concerned citizens, and many others.

The public is encouraged to attend the Salt Creek Committee Meeting on Tuesday November 13th, 2007 from 3:00 to 4:30 pm at the Porter County Administration Center, Suite 309 in Valparaiso as the group continues to pursue their mission: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

Save the Dunes Conservation Fund

444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3564 / Fx. 219-872-4875

For Immediate Release: Wednesday, March 12, 2008
Contact: Christine Livingston, Water Program Director
Office: 219-879-3564 Email: cll@savedunes.org

Public Welcome at Salt Creek Committee Meeting to Finalize Plan

Wednesday, March 19th, 2008, 9:00 am
The Barker Center
444 Barker Road, Michigan City, IN 46360

The State of Indiana has reviewed the draft Salt Creek Watershed Management Plan (SCWMP) and provided feedback to Save the Dunes Conservation Fund (SDCF). The Salt Creek Watershed Committee will hold a final meeting to wrap up the two-year process of developing the SCWMP before finalizing the plan and focusing on implementation. The plan includes goals for improving Salt Creek water quality and activities toward achieving those goals.

"This meeting is the last chance for the public to provide input on the watershed plan," says SDCF Water Program Director, Christine Livingston. She continues, "We've developed many partnerships with stakeholders throughout the watershed. With all the momentum generated while developing the Plan, we're in a great position to move right into getting projects in the ground."

Demonstration projects were installed while developing the plan to get the ball rolling. For example, SDCF partnered with the Portage Parks Department to install a green (vegetated) roof on a concession stand at the new Imagination Glen Park soccer complex. A green roof consists of a vegetated green space on top of a human-made, impervious structure. Soil and plants in green roof systems act like a sponge and absorb excess stormwater that would normally run off the roof and into a stormdrain or nearby Salt Creek. SDCF is also working with the City of Valparaiso to install rain gardens at Forest Park Golf Course. A rain garden is a shallow, vegetated depression that helps clean and manage stormwater runoff on site. The bowl-shaped gardens collect runoff from impervious surfaces and allow it to infiltrate into the ground. Aesthetically-pleasing native plants help the garden absorb stormwater, while providing additional benefits such as wildlife habitat. Two rain gardens will collect stormwater from the golf course and help to store, infiltrate, and clean the water before it enters Salt Creek.

Watershed management is a community driven process, and broad-based participation in the development of the plan will ensure that everyone's interests are represented. SDCF is funded by the Indiana Department of Environmental Management (IDEM)'s 319 Grant Program to coordinate the development and implementation of the Salt Creek Watershed Management Plan to address water quality concerns. Visit http://www.savedunes.org/water_program/water_program/ to download the draft plan. The Salt Creek Watershed Committee was formed in 2006 to oversee the development of the Plan. The Committee includes representatives from Porter County, Valparaiso, Portage, Chesterton, Porter, Burns Harbor, government agencies, Valparaiso University, local developers, concerned citizens, and many others.

The public is encouraged to attend the Salt Creek Committee meeting on Wednesday March 19th from 9:00 to 10:30 am at the Barker Center in Michigan City as the Salt Creek Watershed Group continues to pursue their mission: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
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For Immediate Release: Tuesday, June 17th, 2008
Contact: Christine Livingston, Water Program Director
Office: 219-879-3564 Email: cll@savedunes.org

Salt Creek Watershed Plan Complete!
Tour the Exciting Projects Already Underway

Thursday, June 26th, 2008, 9:30 am
Forest Park Golf Course - 1155 Sheffield Dr, Valparaiso, IN 46385

The Salt Creek Watershed Committee will meet on June 26th to celebrate the completion of the recently approved Salt Creek Watershed Management Plan (SCWMP) and tour implementation projects. Save the Dunes Conservation Fund (SDCF) coordinated the two-year process of developing the SCWMP with funding from the Indiana Department of Environmental Management (IDEM). The 49,573 acre Salt Creek watershed includes sections of Valparaiso, Portage, Chesterton, Porter, Burns Harbor, South Haven, Shorewood Forest, and unincorporated Porter County. Salt Creek is currently impaired for high *E. coli* concentrations and impaired biotic communities. The IDEM-approved SCWMP includes goals for improving Salt Creek water quality and activities toward achieving those goals. SDCF will hold the final committee meeting under the current grant cycle on Thursday June 26th before transitioning into a newly acquired implementation grant entitled *Salt Creek Implementation Demonstration*.

Demonstration projects were installed while developing the plan to improve water quality and build momentum toward implementing the plan. SDCF has partnered with the Portage Parks Department to install a green (vegetated) roof at Imagination Glen Park and with Valparaiso University to install a vegetated swale on campus. The upcoming Salt Creek meeting will be held at Forest Park Golf Course where SDCF partnered with the Valparaiso Department of Parks and Recreation to install two rain gardens. A rain garden is a shallow, vegetated depression that helps clean and manage stormwater runoff on site. The bowl-shaped gardens collect runoff from impervious surfaces and allow it to infiltrate into the ground. Aesthetically-pleasing native plants help the garden absorb stormwater, while providing additional benefits such as wildlife habitat. The partners also planted riparian buffers to filter stormwater before it enters Salt Creek.

SDCF Water Program Director, Christine Livingston explains “it seems fitting to hold the meeting at the site of one of projects to show stakeholders the fruits of their labor. The Forest Park projects are just the beginning of the watershed group’s efforts to protect and improve Salt Creek”. Although the SCWMP is complete, it is never too late for the public to get involved in Salt Creek watershed management. All Salt Creek committee meetings are open to the public. The SCWMP is available for download at http://www.savedunes.org/water_program/water_program/. SDCF will continue working with watershed group to develop partnerships and identify, promote, and monitor projects that demonstrate conservation design/ low impact development (CD/LID) and reduce the impacts of nonpoint source pollution through the IDEM Section 319-funded *Salt Creek Implementation Demonstration* Project. There are many opportunities for volunteers to get involved in on the ground projects, such as planting rain gardens, monitoring water quality, and installing best management practices, such as rain barrels, on their own properties.

The public is encouraged to attend the Salt Creek Committee Meeting on Thursday June 26th, from 9:30 to 10:30 am at the Forest Park Golf Course in Valparaiso as the Salt Creek Watershed Group continues to pursue their mission: *The Salt Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed and will develop strategies that conserve, protect, and enhance the resources of the watershed.*

Save the Dunes Conservation Fund

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Appendix G. Endangered threatened and rare species

Species Name	Common Name	State Status	Fed Status
	PLANTS		
Lathyrus venosus	Smooth Veiny Pea	ST	"
Vaccinium oxycoccos	Small Cranberry	ST	"
Hypericum pyramicatum	Great St. John's-wort	ST	"
Panicum leibergii	Leiberg's Witchgrass	ST	"
Drosera intermedia	Spoon-leaved Sundew	SR	"
Plantago cordata	Heart-leaved Plantain	SE	"
Myosotis laxa	Smaller Forget-me-not	ST	"
Carex leptonervia	Finely-nerved Sedge	SE	"
Carex atherodes	Awned Sedge	SE	"
Zannichellia palustris	Horned Pondweed	SR	"
Potamogeton richardsonii	Redheadgrass	SR	"
Potamogeton pusillus	Slender Pondweed	WL	"
Myriophyllum pinnatum	Cutleaf Water-milfoil	SE	"
Lemna minima	Least Duckweed	SE	"
Sorbus decora	Northern Mountain-ash	SX	"
	REPTILES		
Thamnophis butleri	Butler's Garter Snake	SE	"
Emydoidea blandingii	Blanding's Turtle	SE	"
Clemmys guttata	Spottted Turtle	SE	"
	BIRDS AND MAMMALS		
Bartramia longicauda	Upland Sandpiper	SE	"
Cistothorus platensis	Sedge Wren	SE	"
Taxidea tuxus	American Badger	"	"
Lynx rufus	Bobcat	"	"
	INSECTS		
Hadena ectypa	The Starry Campion Moth	ST	"
Euphydryas phaeton	Baltimore Checkerspot Butterfly	SR	"
Euphyes dion	Sedge Skipper Butterfly	SR	"
Poanes viator viator	Big Broad-winged Skipper Butterfly	ST	"
	HIGH QUALITY NATURAL COMMUNITY		
	Mesic Prairie	SG	"
	Fen	SG	"

Fed: LE = listed federal endangered; LT = listed federal threatened; C = federal candidate species

State: SE = stated endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SG = state significant; WL = watch list; no rank = not ranked but tracked to monitor status

Appendix H. Historic places within the Salt Creek watershed (National Register of Historic Places)

Heritage Hall, 1875.
Valparaiso
Education

Immanuel Lutheran Church, 1891.
Valparaiso
Architecture

Dr. David J. Loring Residence and Clinic, 1906.
Valparaiso
Health/Medicine, Social History

Porter County Jail (1871) and Sheriff's House (1860).
Valparaiso
Architecture, Politics/Government, Social History

Porter County Memorial Hall, 1893.
Valparaiso
Architecture, Performing Arts

Davis Garland Rose House, 1860.
Valparaiso
Architecture

Valparaiso Downtown Commercial District, 1870-1930
Valparaiso
Architecture, Commerce, Politics/Government

Appendix I. Prior studies conducted in the Salt Creek watershed.

Year	**Organization**	**Topic**	**Study/Report**
1990-2000	IDEM	Fisheries	Fish Survey Results
1990-2000	IDEM	Macroinvertebrates	Macroinvertebrate Index of Biotic Integrity
1990-2006	IDEM	Metals	Salt Creek Metal Survey
1990-2006	IDEM	Organics	Salt Creek Organics Survey
1990-2006	IDEM	Stream Chemistry	General Chemistry
1999-2006	City of Valparaiso Utilities	Stream Chemistry	Stream Sampling
2000	IDEM	Fisheries	Fish Survey Results
2000-2006	IDEM	Stream Chemistry	General Chemistry
2001	Applied Ecological Services, Inc.	Watershed Management	Watershed Diagnostic Study of the Little Calumet-Galien River Watershed
2002-2006	IDEM	Pesticides	Pesticides present in stream
2003	JFNew	Stream Chemistry	Lake Louise Water Quality Assessment
2003	Lake Michigan Interagency Task Force on *E. coli*	Pathogens	*E. coli* Sampling
2004	Wittman Hydro Planning Associates, Inc.	Pathogens	Salt Creek *E. coli* Total Maximum Daily Load
2005-2006	Valparaiso University	Stream Chemistry	General Chemistry
2005	Northwestern Indiana Regional Planning Commission	Watershed Management	Watershed Management Plan for Lake, Porter, and LaPorte Counties
2006	IDEM	Fisheries	Biotic Community Assessment/Intensive Survey

Appendix J. Hydrologic calibration and verification (from TMDL)

Calibration of the hydrologic component of the Salt Creek HSPF (Hydrologic Simulation Program-Fortran) watershed model was a stepwise process as described in the TMDL document (Approach). The four watershed characteristics were addressed sequentially. Each step involved an iterative process of executing the model, interpreting the results as described in the Approach, and adjusting input parameters accordingly. All final, calibrated input parameters were within the published, possible ranges (USEPA, 2000d). Table A 1 presents a comparison of the annual flows observed at the McCool gage with the corresponding annual flows predicted by the calibrated model. The mean annual discharge at the gage from 1947 to 1990 was 14.0 inches (35.6 centimeters). The average annual flow for the calibration period was 15 inches (38 centimeters). Flow data from 1991 was ideal for the verification period because 1991 was a wetter than average year. The average annual flow for 1991 was 19.3 inches (49 centimeters). Calibration with data from a wet year provided the opportunity to evaluate the model under conditions different than the calibration period.

Comparison of observed and simulated values for annual flow and baseflow contribution from the calibrated model were flows were less than ten percent which is considered "very good" (Figure A 1). The annual baseflow component at the McCool gage was estimated to be about 50%, based on 45 complete years of record. The simulated baseflow contribution for the calibration years averaged 52% (Table A 1). The simulated baseflow contribution for the verification period was 54%, somewhat lower than the average for the period of record. A lower portion of baseflow contribution is expected in a wetter year.

Table A 1. Comparison of simulated and observed conditions for 1988-90

Water Year	Simulated Baseflow (%)	Simulated Flow (inches)	Observed Flow (inches)	Residual (Sim-Obs)	Error (%)
Calibration Period					
1988	59	11.5	12.1	-0.6	-5.2
1989	50	16.3	15.2	1.1	6.7
1990	46	17.0	17	0	0
Average	52	15.0	14.8	0.2	1.3
Validation Period					
1991	54	21.6	19.3	1.3	6.0

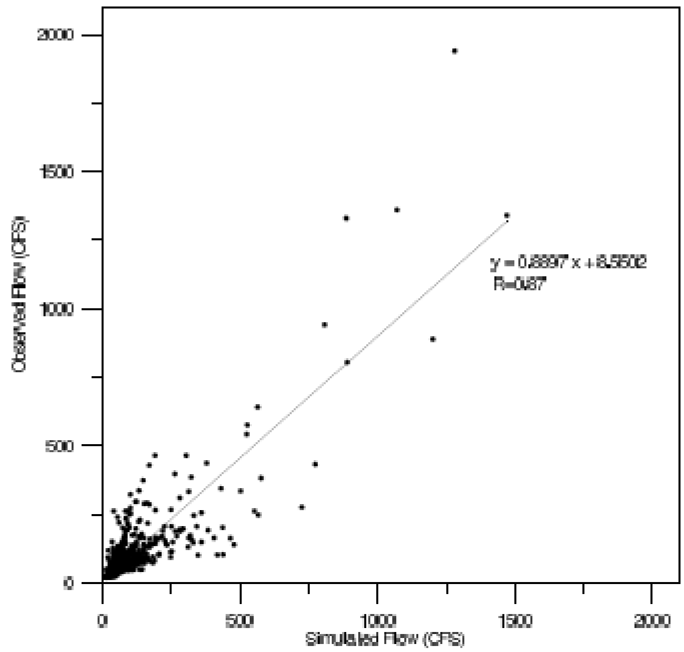
Table A 2 presents statistical results for monthly and daily flows predicted by the calibrated model. The results for the calibration and verification periods show good agreement based on monthly and daily comparisons. The correlation coefficients for the monthly and daily values for the calibration period indicate that the results are "good" as described by Donigian (2002). By the same standards, results from the verification period indicate that the predictive capacity of the model is "good" for daily flows and categorized as "very good" for monthly flows.

Table A 2. Summary statistics from flow calibration and verification

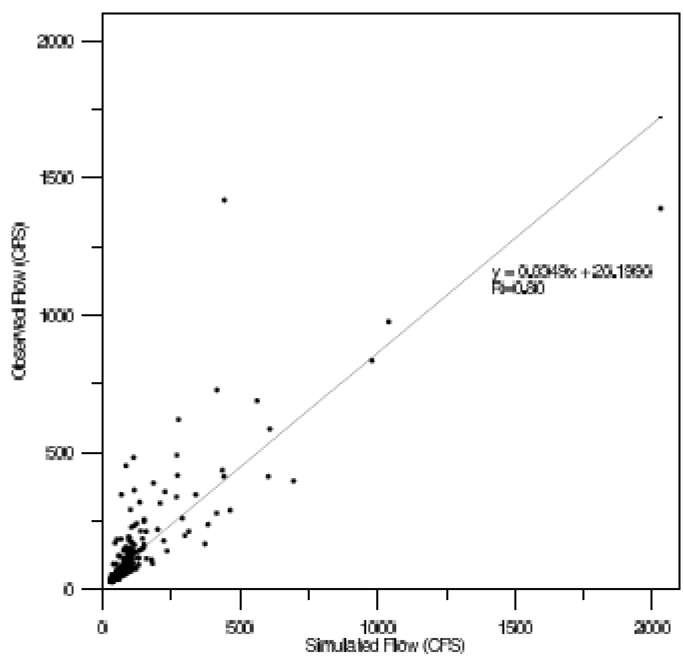
		Correlation Coefficient, R	Coefficient of Determination, R^2	NS Model Fit Efficiency
Calibration: Water Years 1988-1990	Average Monthly	0.91	0.83	0.83
	Average Daily	0.87	0.76	0.76
Verification: Water Year 1991	Average Monthly	0.93	0.86	0.80
	Average Daily	0.80	0.63	0.63

NS= Nash-Suttcliffe

Graphical comparisons of output were also employed to add weight to the evaluation of model performance. Figure A 1 shows the scatter plots of observed and predicted daily flows at McCool. The scatter plots for the daily calibration and verification results both show graphically the correlation features of the results. Figure A 2 shows observed and predicted flow-duration curves at the same site. The flow-duration curves for both calibration and verification show reasonable representation of the flow distribution. Figure A 3 shows a time series plot of simulated and observed flows at McCool. Simulated daily flows matched well with observed flows. Some difficulties were encountered in matching exactly the magnitude or timing of storm events. In many cases, the model simulates small storm events that are not reflected in the observed data. Difficulties in matching exactly the timing or magnitude of storm flows can largely be attributed to spatial and temporal uncertainties in the input climate data. Inherent approximations are introduced by using data from only one climate site to represent the entire watershed. There are numerous additional uncertainties in the measured input data and data used for calibration, including: 1) spatial variability errors in soils and land use data, 2) errors in flow measurements, and 3) errors caused by sampling strategies.

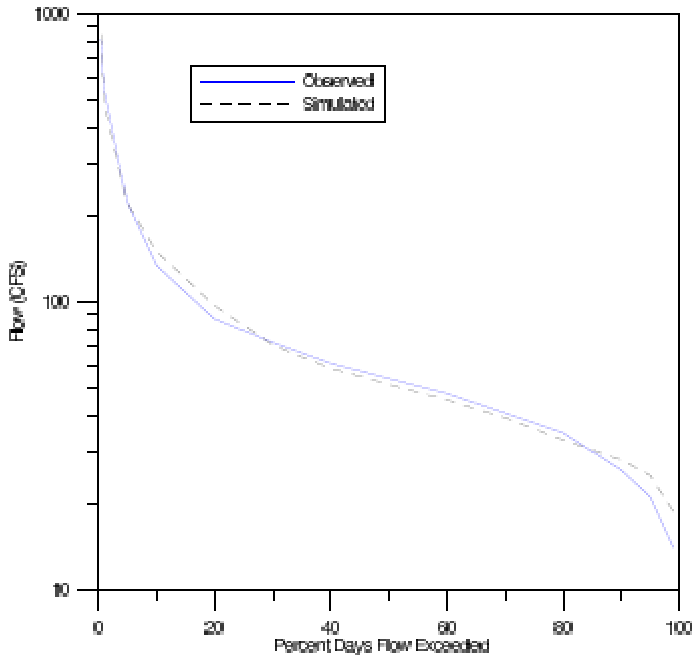


(a) Daily flow for the calibration period at McCool.

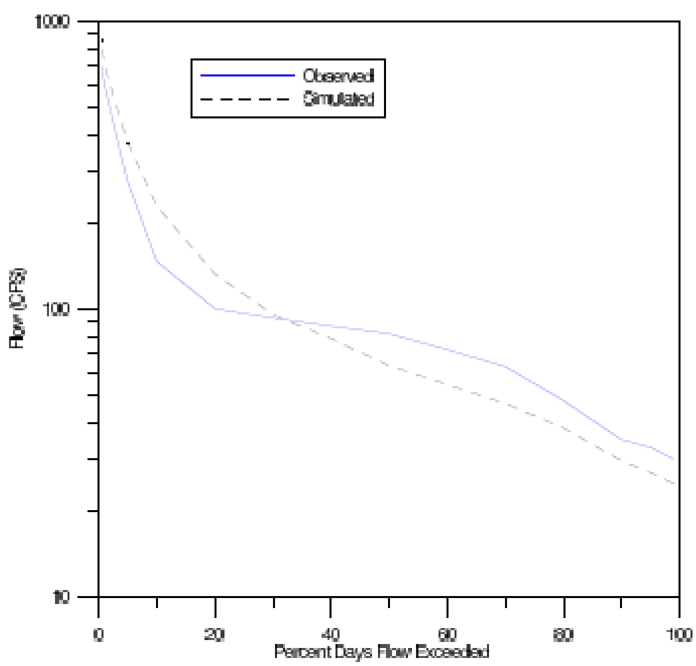


(b) Daily flow for the verification period at McCool.

Figure A 1. Relationship between daily flow values at USGS McCool gage on Salt Creek and nearby Porter gage on the Little Calumet River, 1970–1991



(a) Flow-duration curve for calibration period at McCool.



(b) Flow-duration curve for the validation period at McCool.

Figure A 2. Observed and predicted daily flows at McCool

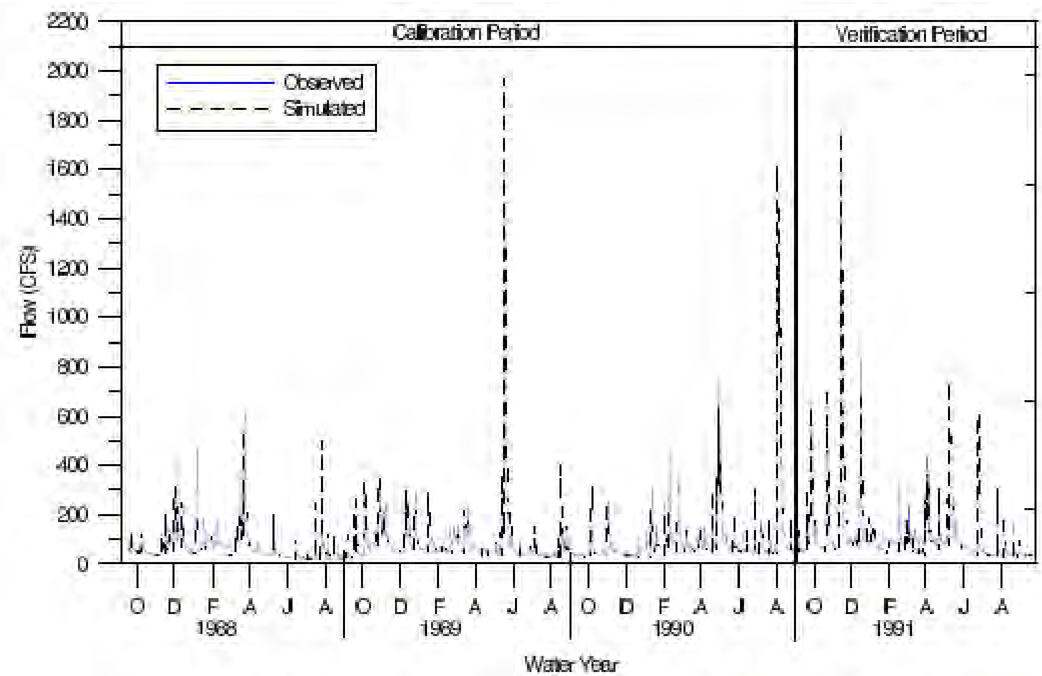


Figure A 3. Observed and simulated daily flows in Salt Creek at McCool for the calibration and verification periods

Appendix K. Salt Creek *E. coli* TMDL nonpoint source characterization (from TMDL)

The source inventory characterizes the type, magnitude, and location of potential sources of contaminant loading to a waterbody. The assessment characterizes the known and suspected sources of *E. coli* loading to Salt Creek and presents estimates that will be used as a starting point for subsequent modeling activities. The assessment of contributions from nonpoint sources was aided by use of the Bacterial Indicator Tool (herein referred to as "the Spreadsheet"). The Spreadsheet, distributed with BASINS 3.0, is a spreadsheet that estimates the bacteria contribution from multiple nonpoint sources (USEPA, 2000b). The Spreadsheet was developed to provide a scientific basis for assigning values to source-loading parameters and has been used successfully for development of TMDLs across the country. The Spreadsheet was written specifically for TMDL development for fecal coliform, but was designed for adaptation for use with nutrients and other fecal indicators. The Spreadsheet was adapted for use with *E. coli* by modifying the amount of bacteria in animal fecal matter from fecal coliform to *E. coli*. For example, the amount of fecal coliform in one gram of cow manure was changed to reflect the amount of the *E. coli* in one gram of cow manure. The Spreadsheet estimates loading rates from livestock, wildlife, and failing septics. In addition, the Spreadsheet estimates the accumulation rate and storage limits of waste buildup on four different land uses (cropland, forest, built-up, and pastureland). Output from the Spreadsheet was designed for use as input to dynamic water quality models such as the Hydrologic Simulation Program-Fortran (HSPF).

Nonpoint Sources

Nonpoint source (NPS) pollution comes from diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land activities that contribute pollution to streams during wet weather events. Rain or snow-melt moves over and through the ground where pollutants have accumulated, transports the contaminants, and deposits them into nearby waterbodies. Bacterial NPS pollution is generated by both human and non-human (animal) sources via land use activities. Typical nonpoint sources of *E. coli* include, but are not limited to:

- Manure application to cropland
- Livestock grazing on pastureland
- Livestock with direct access to streams
- Wildlife
- Urban land activities
- Leaking / failed septic systems

Parameters for each source described above were input into the Spreadsheet. The Spreadsheet allows the watershed to be divided into a maximum of ten subwatersheds. The watershed was divided Salt Creek into five subwatersheds (Figure A 4). The subwatersheds were chosen based on the natural topographic divisions within the watershed. Typically the divisions were made at the confluence of major tributaries to Salt Creek. The subwatersheds were delineated with a Geographic Information System (GIS) that allowed for use of best professional judgment. The subwatershed data was then input into the Spreadsheet. The Spreadsheet estimates the monthly accumulation rate and storage limit of bacteria for four land use categories: built-up, cropland, forest, and pastureland (Figure A 5). The accumulation rates and storage values are determined for each subwatershed / land use combination. The accumulation rate (ACQOP) and storage limit (SQOLIM) can be used as input for the dynamic water quality model HSPF as MON-ACCUM (accumulation rate) and MON-SQOLIM (storage limit). The effects of failed septics and cattle with direct access to streams are calculated as a constant monthly load for each subwatershed (Figure A 5). The estimated loads can be used as input for modeling. Table A 3 summarizes the output sheets in the Spreadsheet.

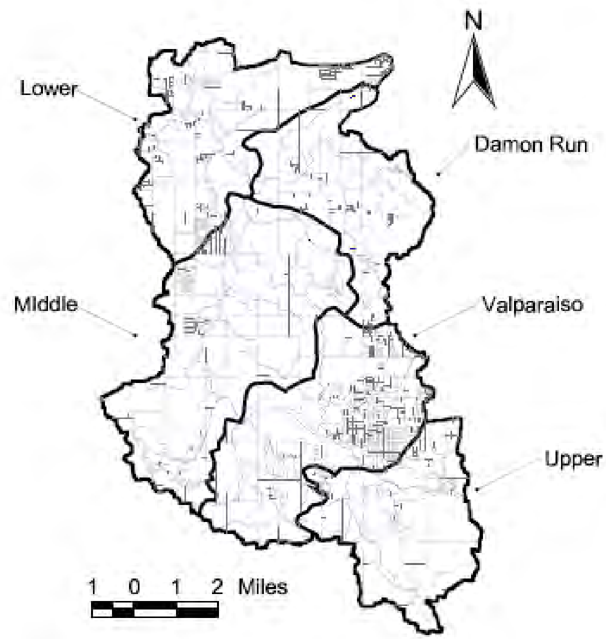


Figure A 4. The five Salt Creek subwatersheds; Upper, Valparaiso, Middle, Damon, and Lower

Subwatershed Land use

The Salt Creek watershed was divided into five subwatersheds and four land use types (Figure A 4 & Figure A 5). The geographic distribution of land use was modified from the Indiana Land Cover Dataset (USGS, 1999) presented in the Basin Characterization. The 15 land use types delineated by the Dataset were appropriately grouped according to the four general land use types recognized by the Bacterial Indicator Tool (cropland, forest, built-up, pasture). The loading for each land use is modeled to reflect the practices that occur in that area. The Spreadsheet allows for build-up and wash-off of *E. coli* in conjunction with rain events for each land use type.

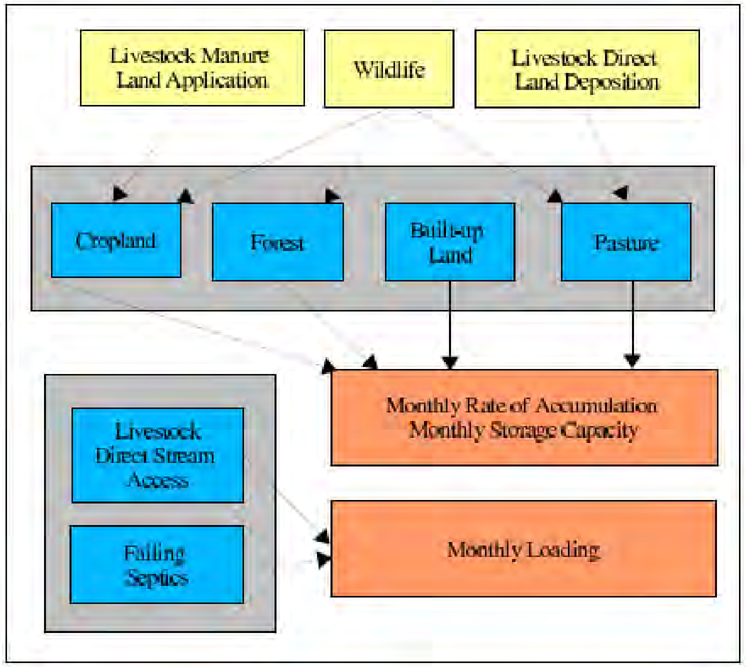


Figure A 5. Schematic of the Bacterial Indicator Tool

used to calculate *E. coli* nonpoint source accumulation rates and storage limits

Livestock

Manure from livestock is a potential source of *E. coli* to Salt Creek. The number of animals, the amount of manure produced by each animal, and the concentration of *E. coli* in the manure are used to calculate the impact of livestock on Salt Creek (Table A 5 & Table A 6). The *E. coli* concentrations in livestock feces are estimates by researchers who study *E. coli* extensively and have experience with the relevant species. The *E. coli* estimate for chickens was provided by Dr. Mike Jenkins of the Agricultural Research Service (Jenkins, 2003). The *E. coli* concentration for horse manure was provided by Dr. Robert Atwill of the University of California-Davis (Atwill, 2003). The *E. coli* concentration for cow manure was provided by a study performed by Jordan and McEwen (Jordan and McEwen, 1997).

Table A 3. Description of the output worksheets provided in the Bacterial Indicator Tool Modified from USEPA, 2000b

Worksheet Name	Purpose
Cropland	Calculates monthly rate of accumulation and storage limit of *E. coli* on cropland from wildlife, and application of hog, cattle, and poultry manure.
Forest	Calculates monthly rate of accumulation and storage limit of *E. coli* on forestland from wildlife.
Built-up	Calculates monthly rate of accumulation and storage limit of *E. coli* on built-up land from literature values.
Pasture	Calculates monthly rate of accumulation and storage limit of *E. coli* on pastureland from wildlife, cattle, horse, sheep, and other grazing.
Cattle in Streams	Calculates the monthly loading and flow rate of *E. coli* contributed directly to the stream by beef cattle.
Septics	Calculates the monthly loading and flow rate of *E. coli* contributed by failing septics.
ACQOP & SQOLIM	Summarizes the monthly rate of accumulation and storage capacity for *E. coli* for the four land uses. Provides input parameters for HSPF (ACQOP/MON-ACCUM and SQOLIM/MON-SQOLIM)

The *E. coli* concentration number for cow was also verified by Dr. Atwill and Dr. Jeffery Karns (Atwill, 2003, Karns, 2003). Dr. John Patterson verified that all the livestock estimates for *E. coli* concentrations in fecal matter were reasonable (Patterson, 2003). The quantity of manure produced from chickens, cows, horses, pigs, and sheep are values provided by the American Society of Agricultural Engineers (ASAE) in the Spreadsheet references (USEPA, 2000b). The quantity for goats was estimated to be similar to the value provided for white-tailed deer (Virginia Department of Environmental Quality (VADEQ), 2001).

The number and location of livestock was determined by a windshield survey of the watershed. During the windshield survey observations were recorded as every road in the watershed was driven and the livestock were counted. The locations were marked with a Global Position System (GPS). The data were then overlayed on a watershed map and clipped to the watershed so as to not include observations outside of the watershed boundaries. Additional information about livestock and verification of the windshield survey data was provided from a meeting on February 6, 2003 with members of the Porter County Natural Resource Conservation Service (NRCS), the Porter County Farm Service Agency, and the Porter County Cooperative Extension Service (Table A 6) (Ames et al., 2003). Based on the survey and the subsequent meeting with local agricultural professionals, no chickens or swine were located within the watershed.

The total estimated production from livestock was calculated by multiplying the number of animals times the estimated amount of *E. coli* produced from each animal (Table A 7).

Table A 4. Land use information for the five subwatersheds in the Salt Creek watershed

Subwatersheds	Built-up (%)	Cropland (%)	Forest (%)	Pasture (%)	Total Area (% of total)
Upper Salt Creek	15	29	27	29	16
Valparaiso	44	11	28	17	22
Middle Salt Creek	13	28	33	26	28
Damon Run	12	21	41	26	15
Lower Salt Creek	25	31	29	15	19
Entire Watershed	22	24	32	22	100

Pastureland / Cropland

In the Salt Creek watershed most cattle and horse owners graze their livestock year round, but 'bed' their animals at night in a barn (Ames, 2003). While grazing, livestock deposit fecal matter directly onto pastureland and often times directly into streams. Manure deposited onto pastureland is exposed to the environment for a period of time and is available for runoff during storm events. The manure from the barn is collected and applied to croplands. Because of this variation in source type, manure from livestock is treated as three separate sources in the Spreadsheet; originating from pasture grazing, direct input into streams, and manure applied to cropland.

Table A 5. Livestock sources of *E. coli* in Salt Creek watershed

Animals	Estimated *E. coli* in fecal matter (CFU / gram feces)	Estimated amount of fecal matter (grams / day / animal)	Estimated Loading Rate of *E. coli* (CFU / day / animal)
Cattle, Beef[1,2,4,5]	10^6	2.1×10^4	2.1×10^{10}
Cattle, Dairy[1,2,4,5]	10^6	5.5×10^4	5.5×10^{10}
Chicken[1,3]	10^6	1.2×10^2	1.2×10^8
Goats[1]	10^6	7.7×10^2	7.7×10^8
Hogs[1]	10^6	5.0×10^3	5.0×10^9
Horses[1,2]	10^6	2.3×10^4	2.3×10^{10}
Sheep[1]	10^6	9.1×10^2	9.1×10^8

CFU = colony forming units; [1], E. coli concentration provided by [Patterson, 2003];[2], E. coli concentration provided by [Atwill, 2003];[3], E. coli concentration provided by [Jenkins, 2003]; [4], E. coli concentration provided by [Karns, 2003];[5], E. coli concentration provided by [Jordan and McEwen, 1997].

Table A 6. Estimated number of livestock in the Salt Creek subwatersheds

Subwatersheds	Cattle, Beef (number)	Cattle, Dairy (number)	Goats (number)	Horses (number)	Sheep (number)
Upper Salt Creek	65	0	3	4	0
Valparaiso	0	0	0	16	0
Middle Salt Creek	144	0	3	26	11
Damon Run	81	56	23	30	5
Lower Salt Creek	15	0	0	2	0
Total in Watershed	305	56	29	78	16

Table A 7. The estimated *E. coli* production from livestock in the Salt Creek subwatersheds

Subwatersheds	Cattle, Beef (CFU/year)	Cattle, Dairy (CFU/year)	Goats (CFU/year)	Horses (CFU/year)	Sheep (CFU/year)
Upper Salt Creek	5.0×10^{14}	0	8.5×10^{11}	3.3×10^{13}	0
Valparaiso	0	0	0	1.3×10^{14}	0
Middle Salt Creek	1.1×10^{15}	0	8.5×10^{11}	2.2×10^{14}	4.4×10^{12}
Damon Run	6.2×10^{14}	1.1×10^{15}	6.5×10^{12}	2.5×10^{14}	2.0×10^{12}
Lower Salt Creek	1.1×10^{14}	0	0	1.7×10^{13}	0
Total in Watershed	2.3×10^{15}	1.1×10^{15}	8.2×10^{12}	6.5×10^{14}	6.4×10^{12}

CFU = colony forming units

Land application of manure helps reduce or eliminate the need for commercial fertilizers. It can be applied in four different ways 1) surface broadcast followed by disking 2) broadcast without incorporation 3) injection under the surface, or 4) irrigation. In Porter County, Indiana animal manure is generally applied with incorporation in the spring (April - May) and fall (October - November) (Ames, 2003, Sutton, 2003). It is estimated that livestock farmers only collect and store manure from cattle and horse deposits in their barns where the animals bed at night (Ames, 2003). It is assumed that livestock usually spend 1/3 of a typical day indoors. Therefore, the amount of total manure from cattle and horses applied to land was estimated to be 1/3 of the amount produced by each animal. This fraction of the total for horse and cattle manure is distributed over the four months manure is applied to fields. The Spreadsheet assumes that cattle manure is applied to cropland, horse manure is applied to pastureland, and no manure is applied to forest or built-up areas.

The manure that is not applied by the livestock owners is assumed to all be added directly to the pasture by the animals. The manure deposited directly by the animals onto pastureland (2/3 of total) is not incorporated, but remains a source for runoff events. This fraction of the total for horse and cattle manure is distributed over twelve months because the animals are allowed to graze throughout the year. Access to streams allows livestock to input manure directly into the streams. During the meeting on February 6, 2003, the county agents indicated where livestock have stream access (Ames et al., 2003). Based on these discussions, 31% of the total cattle in the watershed have access to a stream. It was estimated that these cattle would only spend 10% of grazing time in the stream. It was assumed that most horse owners do not allow their horses access for fear of disease, so no access was input for horses (Ames et al., 2003).

Wildlife

Wildlife also contributes to *E. coli* in streams through runoff of fecal matter. The wildlife assumed to be major contributors in the watershed are coyote, deer, duck, geese, opossum, raccoon, turkey, squirrel, rabbit, and mice. IDNR surveys wildlife to establish population trends for specific species but does not survey to determine population numbers (Byer, 2003). Therefore, other resources determined the densities of the wildlife. The deer density was estimated by the Quality Deer Management Association (Table 5) ((Quality Deer management Association (QDMA, 2002). The wildlife densities for coyote were estimated by officials at the NRCS (Table 5) (Ames et al., 2003). The estimates for turkey, opossum, and squirrel were estimated from IDNR harvest numbers (IDNR, 2002b). The raccoon were estimated from a density range given on the IDNR website (IDNR, 2002b). The density of geese was estimated using Indiana state population numbers for geese, historic population data, and the windshield survey (USGS, 1999, IDNR, 2002a). The density of ducks was estimated from the U.S. Fish and Wildlife Service Adaptive Harvest Management (USFWS, 2002). The wildlife densities were assumed to be similar in all land uses, except built-up. The Spreadsheet assumes no wildlife in the built-up areas of the watershed.

The *E. coli* load in fecal matter for wildlife was based on the work of Dr. Rob Atwill, researcher of *E. coli* and wildlife studies at the University of California - Davis (Atwill, 2003). The estimated amount of fecal matter produced per animal for deer, geese, and raccoon were provided from an EPA approved TMDL for fecal coliform in Virginia (VADEQ, 2001). The amount of fecal matter produced by turkey and duck was provided by the ASAE in the Spreadsheet references (USEPA, 2000b). Opossum values are assumed to be similar to that of a small dog. This value was provided by ASAE (USEPA, 2000b). The amount of fecal matter from coyote is assumed to be similar to a large dog (VADEQ, 2001; WOW, 2003).

The numbers of each type of animal in the land uses were calculated by multiplying their assumed densities with the area of each land use type (Table A 4 &Table 5). The estimated amount of *E. coli* from wildlife each year was then calculated by multiplying the number of each animal times the amount of manure produced by each (Table 5 & Table 6). As Table 6 shows, waste from raccoon, rabbit, and deer produce 86% of the total *E. coli* from wildlife in the watershed.

Urban / Industrial Lands

Runoff from urban and industrial areas can potentially contribute bacteria to streams and rivers. The bacteria can come from such sources as pet feces, urban wildlife, sanitary sewer cross-connections, and deficient solid waste collection. To assess the impact of the urban runoff, the Spreadsheet divides the built-up areas into four sub-categories and calculates the loading rates for each of these divisions based on published accumulation rates (USEPA, 2000b). Unfortunately, similar accumulation rates are not available for *E. coli*, so WHPA estimated loading rates for *E. coli* based on the published values for fecal coliform. This estimation assigns the entire built-up area one accumulation rate instead of different rates for each sub-category.

E. coli is a subset of fecal coliform, meaning measurement of fecal coliform includes all measurement of *E. coli*, along with other pathogens. The amount of *E. coli* will be lower than the amount of fecal coliform in manure. Therefore, the low-end of the range for the fecal coliform accumulation rates was used as an estimation for *E. coli*. The accumulation rates for fecal coliform range from $1.8x10^{8}$– $2.1x10^{10}$ count/acre/day (USEPA, 2000b). The accumulation rate for *E. coli* in urban areas was designated as $1.8x10^{8}$ count/acre/day.

Septic Systems

Failing septic systems contribute pathogen loads to receiving waters. However, specific information regarding the location and nature of failed systems in the watershed is unknown. The distribution of failed septics in the watershed was estimated using available information (U.S. Census Bureau, 1999, NESC, 2001). The technique used is described briefly in EPA's Protocol for Developing Pathogen TMDLs (USEPA, 2001) and in more detail in results describing a similar application to nutrient loads (Nizeyimana et al., 1996). The method uses information from the 1990 census and county level failure rates published by the National Small Flows Clearinghouse (NSFC). Porter County population and housing information was retrieved from the U.S. Census Bureau (U.S. Census Bureau, 1999). Septic tank use is included in the housing information from the 1990 census. Unfortunately, the same information was not included in the 2000 census. Using data from 1990 may result in underestimating the impact from failing septics. The population of the county increased by about 20,000 people from 1990 to 2000. However, problems with failed or leaky septics are generally attributed to older homes. The underestimation may derive from the likelihood that some older septics failed in the 10 years that have passed since the NSFC survey.

Table A 8. Number of people on septic systems and number of failed septic systems

Subwatersheds	Estimated People with Septics (number)	Estimated People with Failed Septics (number)
Upper Salt Creek	237	3.1
Valparaiso	246	3.2
Middle Salt Creek	252	3.3
Damon Run	84	1.1
Lower Salt Creek	203	2.6

Figure 60 shows the block group distribution of houses on septic in the watershed. The number of persons per household in each tract was estimated by dividing the number of persons in the tract by the number of houses in the tract. The number of persons on septic in each tract was then estimated by multiplying the estimated number of persons per household by the number of houses on septic in the tract (Figure A 7). The population density on septic was then estimated by dividing the number of persons on septic in the tract by the tract area (Figure A 7). The population density on septic was then used with GIS software to calculate the number of persons on septic in each of the five subwatersheds (Table A 8).

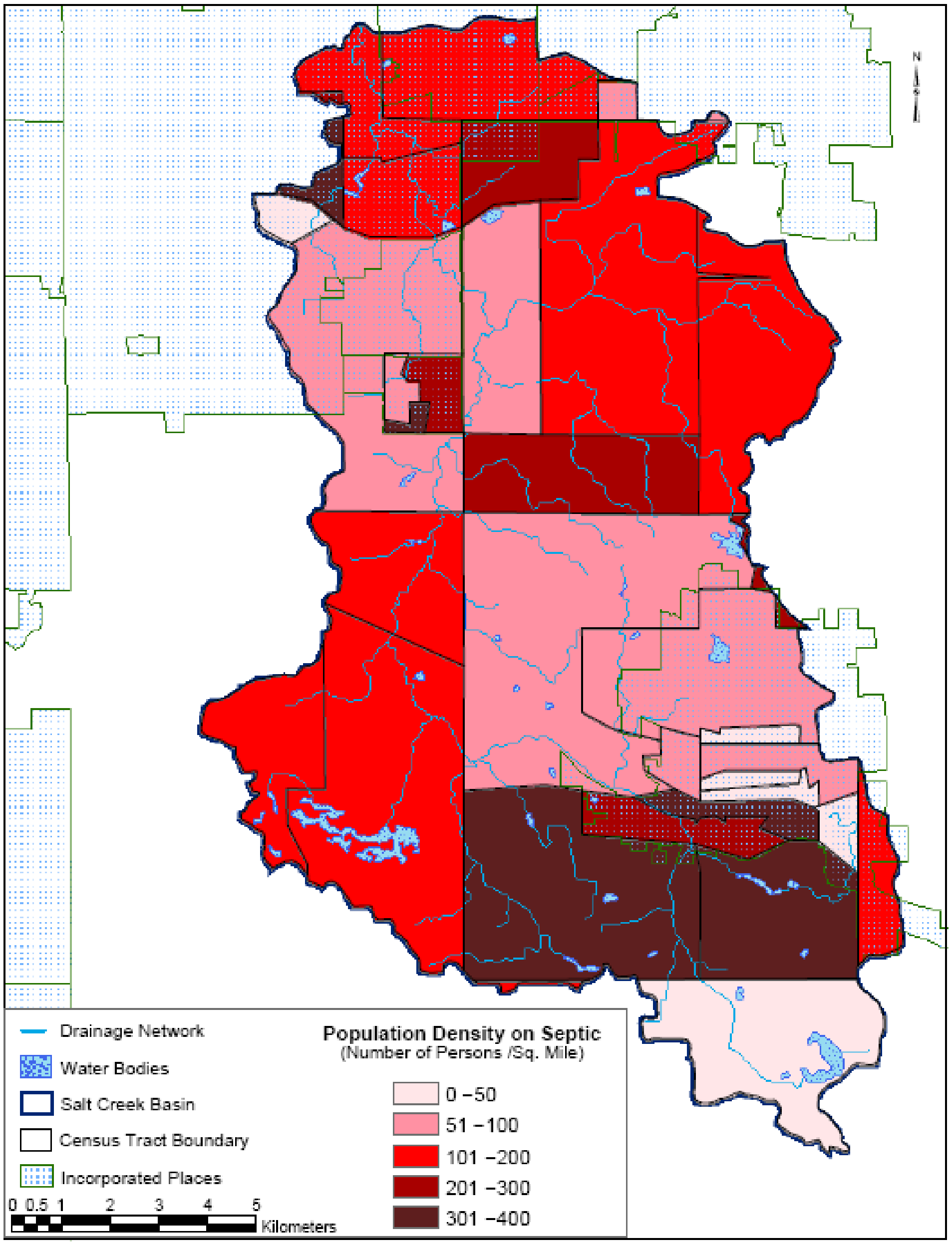


Figure A 6. Population density of septic systems in the Salt Creek watershed.

According to census data, the population of Porter County increased by approximately 20,000 people from 1990 to 2000. The highest population densities on septic system are located in the southern portion of the watershed in portions of the Clark Ditch and Sager's Lake subwatersheds (Figure A 6). Figure 60 shows the block group distribution of houses on septic in the watershed based upon the 1990 census. The number of persons per household in each tract was estimated by dividing the number of persons in the tract by the number of houses in the tract. The population density on septic was then estimated by dividing the number of persons on septic in the tract by the tract area (Figure A 6, Figure A 7).

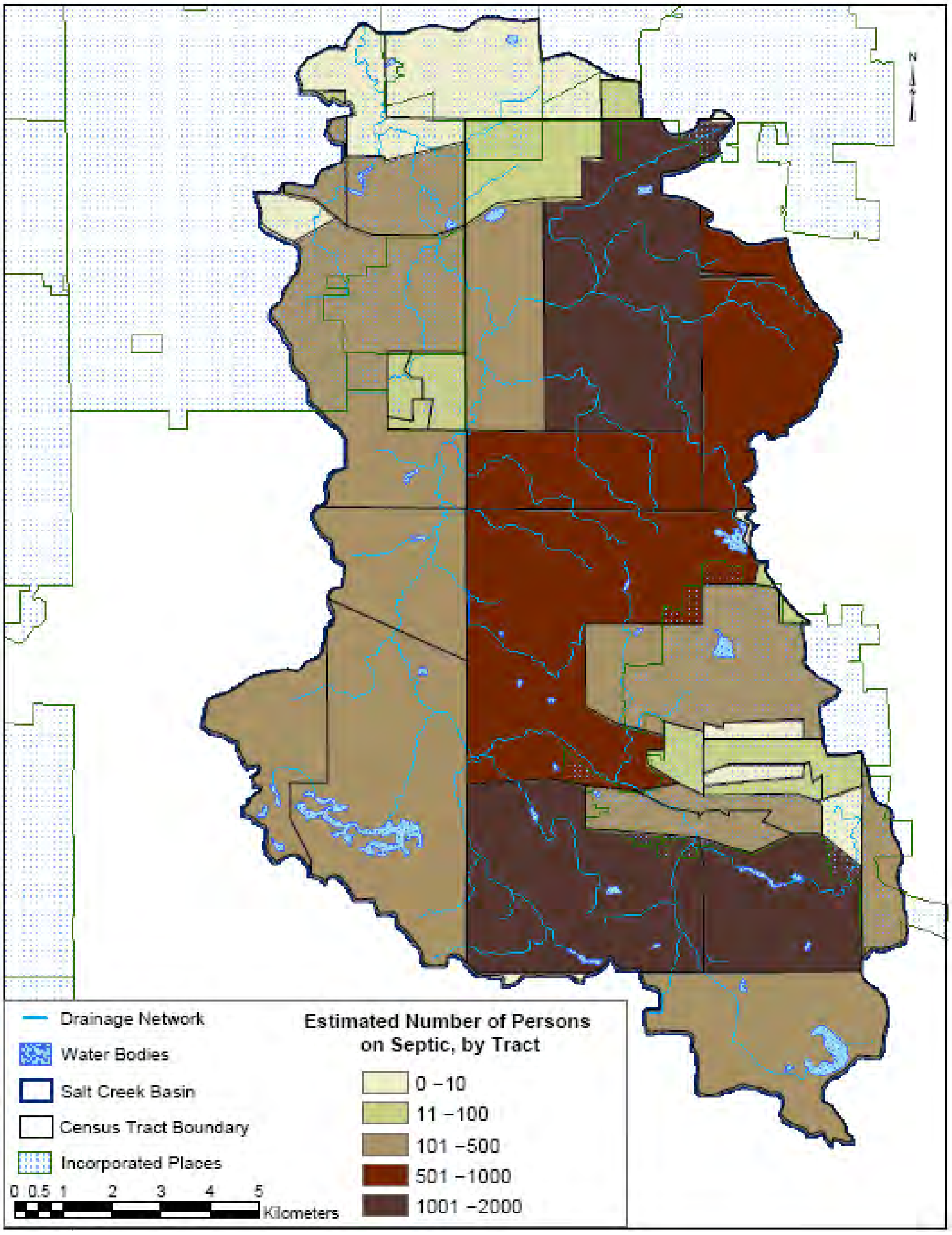


Figure A 7. Number of people with septic systems in the Salt Creek watershed

Loads from failing septics in each subwatershed were calculated with the Spreadsheet. The number of persons on septic for each subwatershed was multiplied by the septic failure rate for the area. The septic failure rate was estimated from data collected by the NSFC. The NSFC surveyed local and state public health agencies across the country in the early 1990s regarding the status of on-site systems (NESC, 2001). Unfortunately, a failure rate for Porter County was not available. We used instead the failure rate published for LaPorte County (1.3 %). The LaPorte County rate is indicative of failure rates for the counties in the region that responded to the survey. This septic failure rate was also confirmed by the Porter County Health Department's numbers of repair permits issued in Porter County in 2002 and an estimation of septic failure (Letta, 2003). The failure rate was used in conjunction with the number of people on septic systems to calculate the number of failed septics in each subwatershed (Table A 8). The subwatershed loading rates were calculated with a typical effluent discharge rate of 70 gallons/person/day (265 liters/person/day) and the average *E. coli* concentration of sewage when it reaches the stream (Horsley and Whitten, 1996). The

E. coli concentration of septic sewage at the point when it reaches the stream was not available, so the *E. coli* concentration in raw sewage was used (8.8 x 10^6 CFU/100mL) (Turner et al., 1997). This value is most likely an overestimation because the *E. coli* population would probably be reduced from detrimental environmental conditions as it moved from the septic tank to the stream. However, there is evidence that *E. coli* can survive and even reproduce in the natural environment given the right environmental conditions (Turco, 2002). In addition, the probable underestimation of the septic failure rate may be balanced from this overestimation in *E. coli* concentration.

Illicit Discharges

Illicit discharges usually involve an illegal or improper connection to a storm drains or a “straight pipe” to receiving waters. Illicit discharge of sewage can derive from domestic and industrial sources. Such sources are difficult to identify; often owners are not even aware of the problem. Programs to identify illicit connections can be resource intensive. However, illicit discharges can be a major source of fecal loading in a watershed. Information about existing or potential illicit discharges in the Salt Creek watershed is not available. Keith Letta of the Porter County Health Department believes that illicit discharges are not a significant problem in the watershed (Letta, 2003). Due to lack of information, potential loading rates from this source category were not estimated.

Uncertainty in Loading Estimates

The objective of the source assessment is to estimate the type, magnitude, and location of *E. coli* loading to Salt Creek. These estimates were required in order to begin modeling the effects of the combined loading on water quality in the stream. It is clear that uncertainty exists with respect to some of the loading from the identified potential sources. For instance, illicit discharges of residential sewage to streams or ditches were not identified. It is unlikely that none exist in the watershed. Similarly, there is uncertainty in the density of wildlife and urban loading rates. The estimates presented here are merely a starting point for the modeling process.

Appendix L. Total Maximum Daily Load analysis (from TMDL Chapter 6)

A TMDL represents the maximum capacity of a waterbody to assimilate a pollutant while safely meeting the respective water quality standard. The TMDL for a given waterbody and pollutant is the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels (USEPA, 2001). The sum of the allocations must not result in the exceedance of the water quality standard. In addition, a margin of safety (MOS) must be included in the analysis, either implicitly or explicitly. The MOS accounts for any uncertainty in the relationship between loads and conditions in the receiving water and helps to ensure that the water quality standard is met. These concepts can be expressed conceptually by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

Developing allocations for point and nonpoint sources presents a challenge for bacteria TMDLs. TMDLs are traditionally expressed in terms of loads (mass per unit time). However, mass is not an appropriate unit for pathogens. Concentrations of indicators such as *E. coli* are usually reported in units of "colony forming units per unit volume" or "counts per unit volume." In addition, the dynamic nature of bacteria loading and the range of critical conditions presented by such diffuse sources makes assignment of fixed loads insufficient for the quantification required by a TMDL. Federal regulations allow TMDLs to be expressed in "other appropriate measures" (40 CFR 130.2 (i)). It is common for bacteria TMDLs to be expressed as a concentration or as a percent reduction required for attainment of the standard. This TMDL is expressed as a total percent reduction based on a statistical measure of the existing and target conditions. The WLA and LA are expressed as portions of the total reduction, the sum of which equals the reduction necessary to achieve the loading capacity of Salt Creek. An explicit MOS is included in the TMDL.

L.1 Critical Conditions

The goal of the TMDL program is to reduce the *E. coli* concentrations in Salt Creek to a level that meets its designated-use standard for a full body contact recreational stream. Indiana's water quality standard for recreational waters is set forth in 327 I.A.C. 2-1-6 and 2-1.5-8(e)(2) (IAC, 2008a). The standard reads *"E. coli* bacteria, using membrane filter (MF) shall not exceed one hundred twenty five (125) per one hundred (100) milliliters as a geometric mean based on no less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period."

The analysis of existing water quality data presented in Section 3 demonstrated that there is no single critical condition associated with violations of the dual *E. coli* standard in Salt Creek. Load-duration curve analysis revealed that exceedances of the single-sample standard occur throughout the flow regime. A higher percentage of exceedances were observed, however, in the high-to-middle range of flows (2-60 percent flow duration), indicating that concentrations above the standard are likely associated with nonpoint sources or other event-driven inputs such as storm sewer discharges and CSOs. Additional analyses presented in the Section 3 confirmed that exceedances in the creek and its tributaries were associated with precipitation events. The modeling analysis presented in Section 5 also confirmed the importance of precipitation events in contributing to elevated concentrations in the creek. The HSPF model of the watershed employed for this analysis was calibrated over an entire recreational season. The calibration period provided a good opportunity for evaluating a range of conditions in the watershed and allowed proper consideration of the critical conditions of impairment.

L.2 Technical Approach

The TMDL and respective allocations were developed in terms of the percent reductions required for attainment. The needed reductions were calculated by a statistical method that utilizes the frequency distributions of predicted *E. coli* concentrations. The method employed is modeled after concepts presented as Statistical Rollback Theory by Ott (1995). Frequency distributions of *E. coli* concentrations predicted by the watershed model were analyzed to assess the linkage of sources with in-stream effects and set the TMDL values.

A frequency distribution is an excellent way to graphically represent hydrologic data sets. Figure 30 shows the results of the analysis. Existing conditions were defined as the distribution of concentrations predicted by the calibrated model. The distribution includes the predicted *E. coli* concentration for each day of the calibration period (the 1998 recreational season). By using the distribution of the entire recreational season, the range of conditions that represent the critical conditions is incorporated into the TMDL. The predicted distribution was approximated as lognormal. Distributions of water quality data are commonly lognormal. The lognormal regression is included on the graph with the resulting correlation coefficient.

A cumulative frequency distribution is constructed by first ranking the data from the smallest value to the largest value. The smallest value is assigned a rank of i=1 and the largest a rank of i=n, where n equals the sample size of the data set. The "plotting position" is plotted on the horizontal axis. The plotting position is a function of the rank i and the sample size n. An advantage of using frequency distributions is that all of the data are displayed and every data point has a distinct position.

Graphical analysis of *E. coli* distributions predicted by the model allows convenient comparison of scenarios with both the single-sample and geometric-mean standard. The 100th percentile of the data set represents the maximum concentration and allows direct comparison with the single-sample standard. The geometric mean of the data set is given by the 50th percentile and allows comparison with the geometric mean standard. For existing conditions, the watershed and regression models predict a 100th percentile value of 1,445 CFU/100ml (Figure 30). The WLA and LA were calculated as portions of the total reduction required to achieve the loading capacity. The loading capacity was defined as a distribution with a 100th percentile value equal to the single-sample standard of 235 CFU/100ml.

L.3 WLA

The WLA represents the portion of the TMDL assigned to point sources. A detailed description of the point sources of *E. coli* in the watershed is presented in Section 4. Ten NPDES facilities in the watershed are point sources of *E. coli*. Discharges from the ten permitted facilities include treated sanitary wastewater. All ten permittees are required to treat the waste stream and to monitor for *E. coli*, fecal coliform, or residual chlorine. Some are required to monitor for a combination of the three parameters. All of the permits are issued with the purpose of meeting the water quality standard for *E. coli* in the receiving water. It was assumed that those permittees required only to monitor for residual chlorine were meeting the single-sample standard if the permitted residual levels were met. All facilities required to monitor for only residual chlorine will be required by IDEM during the next permit cycle to monitor for *E. coli*.

In addition to treated wastewater from the permitted dischargers, point source contributions include intermittent discharges of untreated sanitary wastewater due to bypasses and CSOs. Load estimates based on 1998 data from Discharge Monitoring Reports showed that inputs due to the CSO at Valparaiso and bypasses from several of the facilities were significantly higher than the combined ambient inputs. Bypasses are defined as "the intentional diversion of waste streams from any portion of an Industrial User's treatment facility" (40 CFR122.41(m)(l)). Section 402 of the Clean Water Act prohibits bypasses from wastewater treatment facilities unless the bypass does not violate the permit or other specific extenuating circumstances are present. Indiana has in place a CSO Control Strategy to bring the State into compliance with the requirements of the Clean Water Act. The City of Valparaiso's Long Term Control Plan (LTCP) for the CSO was submitted to the State earlier in 2003 and is currently under review. The LTCP will help the City in meeting the water quality standard for *E. coli*.

The WLA was calculated as the percent reduction achievable by eliminating all bypass flows and reducing the CSO input concentrations to the geometric mean standard of 125 CFU/100ml. The geometric mean standard was used to calculate the percent reduction achievable by the point-source controls described above, the model inputs were adjusted accordingly, and the resulting distribution of predicted concentrations was fitted to a lognormal model (Figure 39) in the same way as described above for the existing conditions. The model predicts how the distribution of concentrations will change in the post-control state. The post-control distribution is lower, as expected, and tilted more toward the right. Unlike Ott's Statistical Rollback Theory, the analysis presented here does not assume geometric scaling of post-control distributions. The tilt is represented by the lognormal model as a decrease in the slope of the regression line. The tilt is due to the reduction of CSO inputs in the model. CSO inputs are sporadic, but cause very high daily concentrations. Reducing CSO inputs in the model reduces values in the upper end of the distribution, causing the regression line to decrease and tilt more toward the right. The lognormal model of the post-control scenario predicts a distribution with a 100th percentile concentration of 1,023 CFU/100ml. The resulting reduction of 29% represents the WLA of the TMDL (Table 1). The reduction is achievable by eliminating all bypass flows and reducing the CSO input loads and does not require a reduction in limits for the permitted facilities.

L.4 LA

The LA represents the portion of the TMDL assigned to nonpoint sources. Nonpoint source pollution is derived from diffuse sources that generally involve land activities. A detailed description of the nonpoint sources of *E. coli* in the watershed is presented in Section 4 of the TMDL. The LA was calculated as the percent reduction required to reduce concentrations in addition to the WLA to the loading capacity of the creek. The loading capacity was defined as conditions that yield a 100th percentile concentration equal to the single-sample standard of 235 CFU/100ml. Specifically, the LA was calculated as the reduction required to reduce the 100th percentile concentration from conditions modeling post-control of the CSO (1,023 CFU/100ml) to the loading capacity (235 CFU/100ml) (Figure 30). The required reduction for the LA is 55%.

L.5 MOS

The MOS accounts for any uncertainty in the relationship between loads and conditions in the receiving water. Uncertainties in the source assessment and the linkage analysis were identified in Sections 4.3 and 5.3, respectively. An explicit 4% MOS was incorporated into the TMDL by reserving a portion of the loading capacity. A relatively low MOS was chosen because the overall uncertainty was minimized by use of a comprehensive watershed loading model. The loading capacity was defined as a distribution with a 100th percentile value equal to the single-sample standard of 235 CFU/100ml. The TMDL must incorporate a MOS that accounts for uncertainty in the analysis linking pollutant loads and conditions in the creek. The MOS was incorporated by defining target conditions as an additional 4 % of the TMDL. The result is a distribution with a 100th percentile equal to 170 CFU/100ml. The TMDL was calculated as the percent reduction required such that the 100th percentile of the distribution representing existing conditions is equal to that representing the target conditions. The total reduction required is 88%. The MOS portion of the TMDL is relatively low compared to the LA and the WLA. However, the MOS was determined with a 100th percentile value that is 28% lower than the single-sample standard and is considered appropriate given the robust modeling analysis used for linking sources and conditions in the creek.

L.6 Summary of TMDL Components

The TMDL was calculated by determining the total percent reduction required to reduce the 100th percentile of the distribution from existing conditions to the target conditions (Figure 30). Of the total 88% reduction required to meet the target conditions, 29% is the WLA, 55%is assigned to the LA, and 4 % is the MOS. The TMDL elements are summarized in Table 1.

H.7 Post-TMDL Distribution

The predicted post-TMDL distribution of concentrations is shown in Figure 30. The 100th percentile of the distribution was defined as necessary for achievement of the TMDL (described above). The slope of the regression was estimated as having a range. The slope was bracketed between the slope of the post-control distribution (upper bound) and the slope of the modeled distributions in the middle frequencies (30%-70% cumulative frequency). Reducing nonpoint source inputs will reduce the slope of the distribution similar to the change in slope seen by reducing CSO inputs. Like the CSO, diffuse sources are episodic, but contribute high daily concentrations. It is assumed that reducing nonpoint source inputs will not decrease the slope of the distribution more than the slope represented by the middle range of concentrations since these concentrations should be unaffected by nonpoint source controls.

The geometric mean of the lognormal distribution is estimated by the 50th percentile. While this value represents the geometric mean of the distribution of concentrations over the entire recreational season and the geometric water quality standard applies only to a subset of the samples over any 30-day period, it is useful to compare the predicted geometric mean with the geometric standard. Given the assumptions to estimate the slope of the distribution, the geometric mean of the post-TMDL distribution was estimated to be between 30 and 70 CFU/100ml, values well below the geometric mean standard of 125 CFU/100ml.

Appendix M. Salt Creek water chemistry data tables from the current study

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/L)	% Dissolved P	Total P (mg/L)	TSS (mg/L)	*E. coli* (CFU/100 mL)
1. Lake Louise Outlet	5/7/07	base	2.545	12.7	6.7	64.9	7.35	0.858	3.6	1.9	0.035	0.210	6.4	1000
	5/16/07	storm	1.842	13.3	6.42	61.5	7.42	812	3	2.6	0.041	0.260	7.6	19000
	5/22/07	base	1.732	12.91	7.76	74.6	7.69	846	0.2	1.2	0.027	0.120	5.2	40
	6/5/07	base	2.152	13.26	6.81	66.7	7.63	854	0.36	2.6	0.07	0.160	9.6	220
	6/19/07	storm	1.915	15.07	7.41	75.5	7.5	845	0.17	4	0.058	0.210	8.6	480
	7/5/07	base	1.811	15.05	7.1	72.3	7.52	840	0.16	2	<0.015	0.200	15	300
	7/17/07	base	2.206	14.64	7.13	72	7.54	842	0.48	1.5	<0.015	0.088	8.8	110
	7/17/07	base	2.206	14.64	7.13	72	7.54	842	0.64	1.5	<0.015	0.096	10	170
	7/24/07	base	2.257	14.32	7.53	75.6	7.58	849	0.14	2.8	<0.015	0.110	8.4	210

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/L)	% Dissolved P	Total P (mg/L)	TSS (mg/L)	*E. coli* (CFU/100 mL)
2. Clark Ditch	5/7/07	base	2.771	12.16	8.66	82.7	7.82	0.641	0.07	0.31	0.047	0.047	13	150
	5/16/07	storm	2.969	14.4	8.78	85.9	7.82	623	0.12	0.14	0.056	0.191	12	810
	5/22/07	base	1.883	15.81	7.93	81.5	8	724	0.12	0.18	0.034	0.156	26	350
	6/5/07	base	2.62	15.83	7.13	73.8	7.99	757	0.22	0.27	0.078	0.160	32	2300
	6/19/07	storm	1.448	20.74	6.68	76.4	7.99	755	0.13	0.24	0.068	0.190	26	1100
	7/5/07	base	1.079	20.62	7.11	81.2	8.04	783	<0.042	0.44	0.054	0.082	20	1800
	7/17/07	base	0.903	19.68	7.42	83.2	8.09	830	0.12	0.43	<0.015	0.050	14	1100
	7/24/07	base	1.685	19.05	7.08	78.3	8.04	770	0.21	0.23	0.085	0.140	42	1100

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
3. Weblos Trail Tributary	5/7/07	base	0.006	12.83	6.6	64	7.38	0.768	0.03	<0.0070	0.042	0.180	5.2	100
	5/16/07	storm	0.912	13.7	6.52	62.8	7.44	789	0.067	<0.0070	0.055	0.183	10	460
	5/22/07	base	0.397	13.91	6.5	64.1	7.61	929	0.16	0	0.03	0.131	13	760
	6/5/07	base	0.508	15.19	5.07	51.9	7.58	955	0.12	0.009	0.088	0.170	12	4700
	6/19/07	storm	0.425	19.93	5.06	57.1	7.58	1042	0.14	<0.0070	0.087	0.190	9.6	350
	7/5/07	base	0.313	18.88	5.66	62.5	7.6	1067	<0.042	<0.0070	0.055	0.100	12	410
	7/17/07	base	0.162	18.09	6.53	71	7.69	1149	0.19	<0.0070	<0.015	0.057	7.2	490
	7/24/07	base	0.217	16.85	6.61	70	7.66	1061	0.1	<0.0070	0.089	0.090	6.4	370
Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 4. Block Ditch	5/7/07	base	0.4	10.73	6.75	62.5	7.49	0.934	0.18	0.22	0.023	0.120	2.6	200
	5/16/07	storm	0.595	11.3	7.06	64.4	7.41	869	0.41	0.057	0.035	0.740	120	220
	5/22/07	base	0.693	12.58	4.38	42.1	7.47	931	0.3	0.11	0.0175	0.077	6	20
	6/5/07	base	0.464	12.66	4.64	44.8	7.47	911	0.35	0.086	0.04	0.080	2.4	560
	6/19/07	storm	1.3125	16.27	4.17	43.6	7.38	899	0.27	<0.0070	<0.015	0.100	2.4	1000
	7/5/07	base	0.2712	15.99	5.27	54.8	7.38	910	<0.042	0.1	<0.015	0.034	100	170
	7/17/07	base	0.802	16	4.58	47.6	7.41	915	<0.042	<0.0070	<0.015	<0.016	1.8	90
	7/24/07	base	0.861	14.74	4.9	49.6	7.45	932	0.12	<0.0070	0.065	0.026	18	130

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 5. Salt Creek Headwaters	5/7/07	base	6.186	10.55	7.74	71.3	7.6	0.7	0.09	0.4	0.029	0.170	6	300
	5/16/07	storm	8.518	13	7.11	68	7.58	634	0.15	0.26	0.035	0.210	53	690
	5/22/07	base	4.661	14.11	6.86	67.7	7.79	699	0.12	0.32	0.023	0.129	32	260
	6/5/07	base	5.85	13.93	6.82	67.8	7.83	677	0.12	0.32	0.051	0.100	18	2800
	6/19/07	storm	5.834	20.71	5.11	58.4	7.68	645	0.22	0.26	0.053	0.320	46	4900
	7/5/07	base	3.383	19.08	5.87	64.9	7.68	652	<0.042	0.24	<0.015	0.082	43	540
	7/17/07	base	2.524	19.31	5.8	64.5	7.79	683	<0.042	0.21	0.051	0.058	31	1300
	7/24/07	base	2.991	17.07	6.35	67.5	7.8	689	<0.042	0.2	<0.015	0.050	16	940
Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 6. Sagers Lake Outlet	5/7/07	base	3.455	12.93	8.07	78.5	7.8	0.868	0.06	<0.0070	0.023	0.110	6.8	60
	5/16/07	storm	4.452	15.6	8.72	87.7	7.9	266	0.11	0.043	0.035	0.137	11	500
	5/22/07	base	2.885	15.91	8.98	89.9	7.9	913	0.098	0.046	0.0186	0.097	11	100
	6/5/07	base	4.66	17.03	7.34	77.9	7.89	896	0.11	0.11	0.04	0.080	18	890
	6/19/07	storm	5.308	22	7.19	84.3	7.81	794	0.35	0.25	<0.015	0.170	35	3100
	7/5/07	base	2.562	21.05	6.96	80.2	7.8	909	<0.042	<0.0070	0.052	0.045	12	510
	7/17/07	base	1.921	20.17	7.39	83.7	7.86	947	0.11	<0.0070	<0.015	0.046	25	1100
	7/24/07	base	1.734	19.44	7.24	80.8	7.92	894	0.1	<0.0070	<0.015	0.065	18	250

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 7. Beauty Creek	5/7/07	base	2.003	14.86	8.65	87.8	7.57	0.918	0.06	0.21	0.023	0.100	1.6	40
	5/16/07	storm	1.338	15.9	8.82	85.3	7.66	801	0.052	0.19	0.035	0.114	<1.0	100
	5/22/07	base	1.07	12.53	9.09	86.9	7.81	913	0.079	0.15	0.0175	0.070	3.2	20
	5/22/07	base	1.07	12.53	9.09	86.9	7.81	913	0.079	0.14	0.0243	0.067	3.6	10
	6/5/07	base	1.587	13.24	7.67	75.1	7.55	836	0.056	0.23	0.04	0.070	5.4	1000
	6/19/07	storm	1.203	14.41	8.49	85.2	7.67	910	0.16	0.13	<0.015	0.110	3.8	240
	7/5/07	base	1.285	14.49	8.67	87.3	7.66	913	<0.042	0.13	<0.015	<0.016	3	160
	7/17/07	base	1.219	13.94	8.59	85.3	7.68	912	<0.042	0.12	<0.015	<0.016	4	200
	7/24/07	base	1.025	13.54	8.71	85.9	7.71	915	0.31	0.12	<0.015	<0.016	3.2	140
	7/24/07	base	1.025	13.54	8.71	85.9	7.71	915	0.23	0.13	0.078	0.030	2.4	170

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 8. Pepper Creek	5/7/07	base	2.582	15.4	8.3	85.2	7.82	0.824	0.083	0.15	0.027	0.181	13	90
	5/16/07	storm	3.621	14.8	8.98	88.6	7.99	728	0.052	0.26	0.035	0.140	3	660
	5/22/07	base	2.192	14.11	8.95	89.2	8.1	823	0.14	0.081	0.0175	0.083	11	80
	6/5/07	base	2.781	14.38	8.05	80.8	8.19	821	0.21	0.13	0.04	0.083	16	630
	6/19/07	storm	2.018	16.86	8.29	87.7	8.05	785	<0.042	<0.0070	<0.015	0.120	11	800
	7/5/07	base	1.9	16.78	8.39	88.6	8.06	797	<0.042	<0.0070	<0.015	<0.016	7	410
	7/5/07	base	1.9	16.78	8.39	88.6	8.06	797	<0.042	<0.0070	<0.015	<0.016	12	260
	7/17/07	base	1.751	15.89	8.59	89	8.08	776	<0.042	<0.0070	<0.015	<0.016	15	1000
	7/24/07	base	2.027	15.45	8.53	87.6	8.09	781	0.23	<0.0070	<0.015	0.034	8.8	700

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 9. Mallard's Landing Tributary	5/7/07	base	0.979	16.79	9.23	97.6	8.03	0.734	0.089	0.076	0.033	0.116	4.6	50
	5/16/07	storm	0.585	15.2	9.15	91	8.1	664	0.094	0.14	0.062	0.181	59	780
	5/22/07	base	0.842	18.09	8.67	93.7	8.17	788	0.19	0.2	0.0487	0.120	7.2	260
	6/5/07	base	0.844	15.27	7.27	74.4	8.16	776	0.12	0.29	0.069	0.120	12	1800
	6/19/07	storm	0.57	19.82	7.12	80	8.1	764	0.1	0.35	0.066	0.150	16	3100
	7/5/07	base	0.386	20.02	7.27	82	8.14	803	<0.042	0.32	0.067	0.077	6.5	470
	7/17/07	base	0.456	18.84	7.17	79	8.14	771	0.1	0.26	0.069	0.051	4.2	0
	7/24/07	base	0.55	17.49	7.68	82.4	8.16	796	0.29	0.27	0.069	0.075	5.6	430
Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
10. Butternut Springs Outlet	5/7/07	base	1.431	16.28	8.86	92.5	8.18	0.629	<0.042	0.013	0.023	0.113	7.2	150
	5/16/07	storm	2.057	15.6	9.06	91.1	8.11	528	0.052	0.095	0.035	0.118	6	1600
	5/22/07	base	0.907	16.37	8.73	91.2	8.27	651	0.081	0.049	0.022	0.067	8	120
	6/5/07	base	10.037	16.24	7.9	82.5	8.33	640	0	0.089	0.04	0.080	13	360
	6/19/07	storm	0.823	21.66	7.67	89.3	8.26	614	<0.042	<0.0070	<0.015	0.100	13	410
	7/5/07	base	0.531	21.83	7.71	90.1	8.25	609	<0.042	0.14	<0.015	<0.016	10	280
	7/17/07	base	0.936	20.11	7.69	87	8.29	608	<0.042	<0.0070	<0.015	<0.016	7.6	430
	7/24/07	base	0.955	19.44	8	89.2	8.33	621	0.18	<0.0070	0.065	0.020	7.6	300
	8/22/06	base	0.042	16.8	5.25	60.3	7.7	642	0.13	2.3		0.081	2	

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 11. Squirrel Creek	5/7/07	base	0.573	18.84	11.91	131.3	8.33	0.813	<0.042	0.74	0.023	0.126	8.4	10
	5/16/07	storm	2.058	20	9.82	108.1	8.13	819	0.052	0.41	0.035	0.240	13	3100
	5/16/07	storm	2.058	20	9.82	108.1	8.13	819	0.14	0.42	0.038	0.240	10	4400
	5/22/07	base	0.667	23.62	8.84	102.5	8.05	858	0.11	0.7	0.0476	0.128	4	30
	6/5/07	base	1.004	22.48	9.63	114.1	8.49	894	0.057	0.17	0.039	0.210	8	120
	6/19/07	storm	2.118	26.66	9.03	115.6	8.13	905	<0.042	<0.0070	0.16	0.330	11	2300
	7/5/07	base	0.12	24.12	8.48	104.7	7.98	756	<0.042	0.77	0.11	0.160	4.5	140
	7/17/07	base	0.055	16.08	5.04	52.4	7.36	715	0.21	2.8	<0.015	0.037	10	170
	7/24/07	base	0.22	16.98	7.93	84	7.55	715	<0.042	2.5	<0.015	0.041	4	130

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 12. Robbins Ditch	5/7/07	base	0.701	15.31	8.4	86.3	7.73	1.433	0.36	1.7	0.044	0.142	3.6	890
	5/16/07	storm	1.327	16.5	7.6	77.9	7.72	1112	0.11	1.8	0.061	0.170	<1.0	1300
	5/22/07	base	0.311	16.7	8.57	81.7	7.81	1480	0.2	1	0.05	0.131	4	390
	6/5/07	base	0.445	15.69	7.67	79.3	8.19	1082	0.086	0.9	0.1	0.120	2	1300
	6/5/07	base	0.445	15.69	7.67	79.3	8.19	1082	0.1	0.92	0.095	0.150	4.8	3200
	6/19/07	storm	4.287	22.51	5.77	68.3	7.64	735	0.11	1.7	0.12	0.230	16	>12000
	6/19/07	storm	4.287	22.51	5.77	68.3	7.64	735	<0.042	1.6	0.12	0.240	18	>12000
	7/5/07	base	0.137	21.64	4.8	56.5	7.57	1103	0.11	0.4	0.15	0.200	6	430
	7/17/07	base	0.041	20.9	2.45	28.1	7.55	814	0.47	0.41	0.12	0.170	9	5100
	7/24/07	base	0.135	19.17	4.11	45.7	7.82	1487	0.27	0.66	0.16	0.170	22	390

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 13. Damon Run	5/7/07	base	8.411	17.08	11.15	118.5	7.96	0.714	0.072	0.25	0.032	0.141	4	90
	5/7/07	base	8.411	17.08	11.15	118.5	7.96	0.714	0.071	0.25	0.033	0.152	4.6	110
	5/16/07	storm	12.523	16.4	9.89	101.2	7.86	704	0.085	0.66	0.05	0.210	8	590
	5/22/07	base	5.271	18.18	10.01	109.2	8.04	799	0.17	0.39	0.031	0.120	4.8	210
	6/5/07	base	5.628	16.58	7.68	80.8	8	778	0.13	0.43	0.074	0.100	20	500
	6/19/07	storm	6.64	21.82	7.11	83.1	7.81	715	0.31	0.55	0.072	0.180	26	4100
	7/5/07	base	2.966	21.11	7.47	86.1	7.97	810	<0.042	0.54	<0.015	0.066	8.5	580
	7/17/07	base	2.013	19.01	6.51	72.1	7.85	699	0.11	0.71	<0.015	0.056	10	4500
	7/24/07	base	3.742	18.19	7.77	84.6	7.98	838	0.21	0.62	0.061	0.078	9.6	410

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 14. Mainstem at Lenburg Road	5/7/07	base		16.54	8.56	90	7.94	0.851	0.069	1.8	0.048	0.196	14	100
	5/16/07	storm		16.8	7.37	76.1	7.91	758	0.084	2.8	0.069	0.260	32	1500
	5/22/07	base		16.49	7.73	80.9	8.09	885	0.081	2.1	0.065	0.168	21	240
	6/5/07	base	56.657	17.64	7.03	75.6	8.17	864	0.097	1.9	0.15	0.260	57	1400
	6/19/07	storm	44.865	23.58	6.74	81.5	7.96	843	0.24	2.7	0.11	0.300	49	4500
	7/5/07	base	33.651	22.74	7.26	86.4	8.01	1028	0.12	6.2	0.17	0.230	22	350
	7/17/07	base	26.337	20.82	7.56	86.8	8.18	975	<0.042	4.1	0.12	0.130	18	430
	7/24/07	base	35.06	19.86	7.54	84.8	8.2	958	<0.042	3.8	0.13	0.180	20	380

Site	Date	Event	Flow (cfs)	Temp (deg C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolved P	Total P (mg/ L)	TSS (mg/L)	E. coli (CFU/ 100 mL)
Site 15. Salt Creek at SR 130	5/15/06			12.5	9.3		7.8	843	<0.1	2.8		0.200	42	
	6/26/06			19.9	8.7		8.1	1031	<0.1	5		0.360	19	
	7/25/06			24.9	7.3		8.3	947	<0.1	3.5		0.160	23	
	8/28/06			20.9	7.9		7.9	902	<0.1	4		0.220	24	
	9/14/06			18	7.3		7.7	618	<0.1	1.3		0.260	68	
	5/7/07	base	28.157	19.2	8.4		8	992	<0.1	4		0.180	14	
	5/16/07	storm	42.057											
	5/22/07	base												
	6/5/07	base	24.943	20.26	8.64		8.05	1068	<0.1	5.3		0.200	24	
	6/19/07	storm	30.698											
	7/5/07	base	20.343	19.93	9.65		8.19	1023	<0.1	5.3		0.230	14	

Site	Date	Event	Flow (cfs)	Temp (° C)	DO (mg/L)	% Sat	pH	Conductivity (mg/L)	Ammonia N (mg/L)	Nitrate + Nitrite (mg/ L)	% Dissolve d P	Total P (mg/ L)	TSS (mg/L)	*E. coli* (CFU/ 100 mL)
Site 16. Salt Creek at US 20	5/15/06			12.2	9.5		7.9	791	<0.1	1.8		0.180	49	
	6/26/06			20.4	8.5		8.1	980	<0.1	3.9		0.260	36	
	7/25/06			25.1	7.1		8.3	872	<0.1	2.4		0.170	37	
	8/28/06			21.1	7.5		7.8	851	<0.1	2.2		0.190	48	
	9/14/06			17.8	7.2		7.7	532	<0.1	1.4		0.360	121	
	5/7/07	base		21.8	7.9		8	930	<0.1	2.8		0.140	20	
	5/16/07	storm												
	5/22/07	base												
	6/5/07	base		21.85	8.18		8.04	973	<0.1	3.3		0.140	30	
	6/19/07	storm												
	7/5/07	base		20.67	9.29		8.18	965	<0.1	3.8		0.120	14	

Appendix N. Macroinvertebrate results from the current study.

Table A 9. Macroinvertebrates collected from the Salt Creek watershed streams in 2006

Taxa (Scientific Name)		Site 2	Site 5	Site 7	Site 8	Site 9	Site 10	Site 13	Site 14
Order	**Family**	**Count**	**Count**	**Count**	**Count**	**Count**	**Count**	**Count**	**Count**
Amphipoda	Gammaridae		12	91	70	13	58	63	4
Coleoptera	Elmidae	2	2				4		
Coleoptera	Gyrinidae	2							
Coleoptera	Helodidae					2			
Decopoda	Astacidae	1							
Diptera	Chironomidae	2				3	18		1
Diptera	Ephydridae			12					
Ephemeroptera	Baetidae	6						6	
Ephemeroptera	Heptageniidae	3							
Arthropoda	Ascellidae	2							
Gastropoda	Lymnaeidae							2	
Gastropoda	Physidae					2		3	
Gastropoda	Planorbidae					2			
Gastropoda	Hydrobiidae					2			
Hemiptera	Corixidae							7	
Hemiptera	Gerridae	2							
Hemiptera	Mesoveliidae		1						
Hirudinea		1							
Hirudinea	Glossiphoniidae								1
Isopoda	Asillidae	2	4		8	4		7	
Megaloptera	Sialidae							5	
Platyhelminthes	Turbellaria	4							
Odonata	Coenagrionidae	2							
Odonata	Calopterygidae		6						
Arthropoda	Ascellidae	2							
Pelecypoda	Sphaeriidae							10	
Platyhelminthes	Turbellaria	2				8			
Trichoptera	Hydropsychidae	85			2		2	8	
TOTAL		**118**	**25**	**103**	**80**	**36**	**82**	**111**	**6**

Table A 10. Salt Creek watershed streams mIBI metrics, August 22, 2006

mIBI Metric	S2	S5	S7	S8	S9	S10	S13	S14
HBI	6	4	6	6	6	6	2	4
No. Taxa (family)	6	0	0	0	2	0	2	0
Total Count (# individuals)	2	0	2	2	0	2	2	0
% Dominant Taxa	0	4	0	0	4	0	2	0
EPT Index (# families)	6	0	0	0	0	0	0	0
EPT Count (# individuals)	6	0	0	0	0	0	0	0
EPT Count/Total Count	8	0	0	0	0	0	0	0
EPT Abun./Chir. Abun.	8	3	3	2	3	3	6	3
Chironomid Count	8	8	8	8	8	8	8	8
mIBI Score	5.60	2.10	2.10	2.00	2.50	2.10	2.40	1.60
Ranking	Slight	Mod	Mod	Mod	Mod	Mod	Mod	Sev

Table A 11. Clark Ditch (site 2) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Coleoptera	Elmidae	2	2	2	4	8	1.69
Coleoptera	Gyrinidae	2	2	2	5	10	1.69
Decopoda	Astacidae	1		1	8	8	0.85
Diptera	Chironomidae	2	2	2	6	12	1.69
Ephemeroptera	Baetidae	6	6	6	4	24	5.08
Ephemeroptera	Heptageniidae	3	3	3	4	12	2.54
Arthropoda	Ascellidae	2		2	8	16	1.69
Hemiptera	Gerridae	2		2	5	10	1.69
Hirudinea		1		1	0	0	0.85
Isopoda	Asillidae	2		2	8	16	1.69
Platyhelminthes	Turbellaria	4		4	4	16	3.39
Odonata	Coenagrionidae	2		2	6.1	12.2	1.69
Arthropoda	Ascellidae	2		2	8	16	1.69
Platyhelminthes	Turbellaria	2		2	4	8	1.69
Trichoptera	Hydropsychidae	85	85	85	4	340	72.03
TOTALS		**118**	**100**	**118**		**508.2**	100.00

Table A 12. Salt Creek Headwaters (site 5) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	12		12	4	48	41.38
Coleoptera	Elmidae	5		5	4	20	17.24
Diptera	Chironomidae	1			6	6	3.45
Hemiptera	Mesoveliidae	1		1		0	3.45
Isopoda	Asillidae	4		4	8	32	13.79
Odonata	Calopterygidae	6		6	5	30	20.69
TOTALS		**29**	**0**	**28**		**136.0**	100.00

Table A 13. Beauty Creek (site 7) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	91		91	4	364	87.50
Diptera	Chironomidae	1			6	6	0.96
Diptera	Ephydridae	12		12	6	72	11.54
TOTALS		**104**	**0**	**103**		**442.0**	100.00

Table A 14. Pepper Creek (site 8) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	70		70	4	280	86.42
Diptera	Chironomidae	1			6	6	1.23
Isopoda	Asillidae	8		8	8	64	9.88
Trichoptera	Hydropsychidae	2	2	2	4	8	2.47
TOTALS		**81**	**2**	**80**		**358.0**	100.00

Table A 15. Mallard's Landing (site 9) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	13		13	4	52	36.11
Coleoptera	Helodidae	2		2		0	5.56
Diptera	Chironomidae	3		3	6	18	8.33
Gastropoda	Physidae	2		2	8	16	5.56
Gastropoda	Planorbidae	2		2		0	5.56
Gastropoda	Hydrobiidae	2		2		0	5.56
Isopoda	Asillidae	4		4	8	32	11.11
Platyhelminthes	Turbellaria	8		8	4	32	22.22
TOTALS		**36**	**0**	**36**		**150.0**	100.00

Table A 16. Butternut Springs (site 10) multi-habitat macroinvertebrate results, August 22, 2006

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	58		58	4	232	70.73
Coleoptera	Elmidae	4		4	4	16	4.88
Diptera	Chironomidae	18		18	6	108	21.95
Trichoptera	Hydropsychidae	2		2	4	8	2.44
TOTALS		**82**	**0**	**82**		**364.0**	100.00

Table A 17. Damon Run (site 13) multi-habitat macroinvertebrate results, August 22, 2006

Order	**Family**	**#**	**EPT**	**# w/t**	**Tolerance (t)**	**# x t**	**%**
Amphipoda	Gammaridae	63		63	4	252	56.25
Diptera	Chironomidae	1			6	6	0.89
Ephemeroptera	Baetidae	6	6	6	4	24	5.36
Gastropoda	Lymnaeidae	2		2	6.9	13.8	1.79
Gastropoda	Physidae	3		3	8	24	2.68
Hemiptera	Corixidae	7		7	10	70	6.25
Isopoda	Asillidae	7		7	8	56	6.25
Megaloptera	Sialidae	5		5	4	20	4.46
Pelecypoda	Sphaeriidae	10		10	8	80	8.93
Trichoptera	Hydropsychidae	8		8	4	32	7.14
TOTALS		**112**	**6**	**111**		**577.8**	100.00

Table A 18. Salt Creek (site 14) multi-habitat macroinvertebrate results, August 22, 2006

Order	**Family**	**#**	**EPT**	**# w/t**	**Tolerance (t)**	**# x t**	**%**
Amphipoda	Gammaridae	4		4	4	16	66.67
Diptera	Chironomidae	1		1	6	6	16.67
Isopoda	Asillidae	1		1	8	8	16.67
TOTALS		**6**	**0**	**6**		**30.0**	100.00

Table A 19. Macroinvertebrates collected from the Salt Creek watershed streams in 2007

Order	Family	Site 2	Site 5	Site 7	Site 8	Site 9	Site 10	Site 13	Site 14
Amphipoda	Gammaridae	11	18	53	59	95	52	42	7
Bivalvia	*Corbicula fluminea*	2				3	4	3	
Bivalvia	Sphaeriidae						1		
Coleoptera	Dytiscidae			5					
Coleoptera	Elmidae	15			1		7		
Coleoptera	Haliplidae		1						
Coleoptera	Hydrophilidae		4		9		1	1	4
Decopoda	Astacidae	3	1						
Diptera	Chironomidae	2							
Diptera	Ephydridae			1					
Diptera	Stratiomyidae		1						
Diptera	Syrphidae		2						
Diptera	Tipulidae			1			1		
Ephemeroptera	Baetidae		3	1	1	1			
Ephemeroptera	Heptageniidae		1			1			
Ephemeroptera	Siphlonuridae								11
Gastropoda	Physidae	2			4			1	
Gastropoda	Planorbidae						1		
Gastropoda	Viviparidae	2						1	
Hemiptera	Belostomatidae				1				
Hemiptera	Gerridae	3		1			4		3
Hemiptera	Notonectidae								3
Hemiptera	Pleidae	2							
Hemiptera	Veliidae	1							
Isopoda	Asillidae	19	38		10	4	1	23	
Lepidoptera	Langessa		1	2					
Megaloptera	Sialidae	4							2
Odonata	Aeshnidae	1			1		7		
Odonata	Agrionidae	12			2	1	12	12	4
Odonata	Coenagrionidae	16	4			1			4
Odonata	Libellulidae		1						
Plecoptera	Perlidae	1	14					10	10
Plecoptera	Perlodidae				2				
Trichoptera	Brachycentridae			6	1		1		
Trichoptera	Hydropsychidae	3	11		16			1	1
Trichoptera	Limnephilidae	2	1		2		4	2	
Trichoptera	Odontoceridae		1				3	1	
TOTAL		101	102	70	109	106	99	97	49

Table A 20. Clark Ditch (site 2) mIBI metrics, May 29, 2007

mIBI Metric	**S2**	**S5**	**S7**	**S8**	**S9**	**S10**	**S13**	**S14**
HBI	2	2	8	6	6	6	4	6
No. Taxa (family)	8	6	2	4	0	4	4	2
Total Count (# individuals)	2	2	0	2	2	2	2	0
% Dominant Taxa	8	4	0	2	0	2	4	6
EPT Index (# families)	2	6	0	4	0	2	4	2
EPT Count (# individuals)	0	2	0	2	0	0	0	2
EPT Count/Total Count	0	4	0	2	0	0	2	4
EPT Abun./Chir. Abun.	4	8	8	8	8	8	8	8
Chironomid Count	8	8	8	8	8	8	8	8
mIBI Score	3.80	4.70	2.90	4.20	2.70	3.60	4.00	4.20
Ranking	Mod	Slight	Mod	Slight	Mod	Mod	Slight	Slight

Table A 21. Clark Ditch (site 2) multi-habitat macroinvertebrate results, May 29, 2007

Order	**Family**	**#**	**EPT**	**# w/t**	**Tolerance (t)**	**# x t**	**%**
Amphipoda	Gammaridae	11		11	4	44	10.89
Bivalvia	*Corbicula fluminea*	2		2	3.2	6.4	1.98
Coleoptera	Elmidae	15		15	4	60	14.85
Decopoda	Astacidae	3		3	8	24	2.97
Diptera	Chironomidae	2		2	6	12	1.98
Gastropoda	Physidae	2		2	8	16	1.98
Gastropoda	Viviparidae	2		2	6	12	1.98
Hemiptera	Gerridae	3		3	5	15	2.97
Hemiptera	Pleidae	2		0		0	1.98
Hemiptera	Veliidae	1		0		0	0.99
Isopoda	Asillidae	19		19	8	152	18.81
Megaloptera	Sialidae	4		4	4	16	3.96
Odonata	Aeshnidae	1		1	3	3	0.99
Odonata	Agrionidae	12		12	5	60	11.88
Odonata	Coenagrionidae	16		16	6.1	97.6	15.84
Plecoptera	Perlidae	1	1	1	1	1	0.99
Trichoptera	Hydropsychidae	3	3	3	4	12	2.97
Trichoptera	Limnephilidae	2	2	2	4	8	1.98
TOTALS		**101**	**6**	**98**		**539.0**	100.00

Table A 22. Salt Creek Headwaters (site 5) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	18		18	4	72	17.65
Coleoptera	Haliplidae	1		1	7	7	0.98
Coleoptera	Hydrophilidae	4		4	5	20	3.92
Decopoda	Astacidae	1		1	8	8	0.98
Diptera	Stratiomyidae	1		0		0	0.98
Diptera	Syrphidae	2		2	10	20	1.96
Ephemeroptera	Baetidae	3	3	3	4	12	2.94
Ephemeroptera	Heptageniidae	1	1	1	4	4	0.98
Isopoda	Asillidae	38		38	8	304	37.25
Lepidoptera	Langessa	1		0		0	0.98
Odonata	Libellulidae	1		1	9	9	0.98
Plecoptera	Perlidae	14	14	14	1	14	13.73
Trichoptera	Hydropsychidae	11	11	11	4	44	10.78
Trichoptera	Hydroptilidae			0	4	0	0.00
Trichoptera	Limnephilidae	1	1	1	4	4	0.98
Trichoptera	Odontoceridae	1	1	0	0	0	0.98
TOTALS		**102**	**31**	**99**		**542.4**	100.00

Table A 23. Beauty Creek (site 7) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	53		53	4	212	75.71
Coleoptera	Dytiscidae	5		5	5	25	7.14
Diptera	Ephydridae	1		1	6	6	1.43
Diptera	Tipulidae	1		1	3	3	1.43
Ephemeroptera	Baetidae	1	1	1	4	4	1.43
Hemiptera	Gerridae	1		1	5	5	1.43
Lepidoptera	Langessa	2		0		0	2.86
Trichoptera	Brachycentridae	6	6	6	1	6	8.57
TOTALS		**70**	**7**	**68**		**261.0**	100.00

Table A 24. Pepper Creek (site 8) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	59		59	4	236	54.13
Coleoptera	Elmidae	1		1	4	4	0.92
Coleoptera	Hydrophilidae	9		9	5	45	8.26
Ephemeroptera	Baetidae	1	1	1	4	4	0.92
Gastropoda	Physidae	4		4	8	32	3.67
Hemiptera	Belostomatidae	1		0		0	0.92
Isopoda	Asillidae	10		10	8	80	9.17
Odonata	Aeshnidae	1		1	3	3	0.92
Odonata	Agrionidae	2		2	5	10	1.83
Plecoptera	Perlodidae	2	2	2	2	4	1.83
Trichoptera	Brachycentridae	1	1	1	1	1	0.92
Trichoptera	Hydropsychidae	16	16	16	4	64	14.68
Trichoptera	Limnephilidae	2	2	2	4	8	1.83
TOTALS		**109**	**22**	**108**		**491.0**	100.00

Table A 25. Mallard's Landing (site 9) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	95		95	4	380	89.62
Bivalvia	*Corbicula fluminea*	3		3	3.2	9.6	2.83
Ephemeroptera	Baetidae	1	1	1	4	4	0.94
Ephemeroptera	Heptageniidae	1	1	1	4	4	0.94
Isopoda	Asillidae	4		4	8	32	3.77
Odonata	Agrionidae	1		1	5	5	0.94
Odonata	Coenagrionidae	1		1	6.1	6.1	0.94
TOTALS		**106**	**2**	**106**		**440.7**	100.00

Table A 26. Butternut Springs (site 10) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	52		52	4	208	52.53
Bivalvia	*Corbicula fluminea*	4		4	3.2	12.8	4.04
Bivalvia	Sphaeriidae	1		1	8	8	1.01
Coleoptera	Elmidae	7		7	4	28	7.07
Coleoptera	Hydrophilidae	1		1	5	5	1.01
Diptera	Tipulidae	1		1	3	3	1.01
Gastropoda	Planorbidae	1		1	7	7	1.01
Hemiptera	Gerridae	4		4	5	20	4.04
Isopoda	Asillidae	1		1	8	8	1.01
Odonata	Aeshnidae	7		7	3	21	7.07
Odonata	Agrionidae	12		12	5	60	12.12
Trichoptera	Brachycentridae	1	1	1	1	1	1.01
Trichoptera	Limnephilidae	4	4	4	4	16	4.04
Trichoptera	Odontoceridae	3	3	0	0	0	3.03
TOTALS		**99**	**8**	**96**		**397.8**	100.00

Table A 27. Damon Run (site 13) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	42		42	4	168	43.30
Bivalvia	*Corbicula fluminea*	3		3	3.2	9.6	3.09
Coleoptera	Hydrophilidae	1		1	5	5	1.03
Gastropoda	Physidae	1		1	8	8	1.03
Gastropoda	Viviparidae	1		1	6	6	1.03
Isopoda	Asillidae	23		23	8	184	23.71
Odonata	Agrionidae	12		12	5	60	12.37
Plecoptera	Perlidae	10	10	10	1	10	10.31
Trichoptera	Hydropsychidae	1	1	1	4	4	1.03
Trichoptera	Limnephilidae	2	2	2	4	8	2.06
Trichoptera	Odontoceridae	1	1	0	0	0	1.03
TOTALS		**97**	**14**	**96**		**462.6**	100.00

Table A 28. Salt Creek (site 14) multi-habitat macroinvertebrate results, May 29, 2007

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Gammaridae	7		7	4	28	14.29
Coleoptera	Hydrophilidae	4		4	5	20	8.16
Ephemeroptera	Siphlonuridae	11	11	11	7	77	22.45
Hemiptera	Gerridae	3		3	5	15	6.12
Hemiptera	Notonectidae	3		0		0	6.12
Megaloptera	Sialidae	2		2	4	8	4.08
Odonata	Agrionidae	4		4	5	20	8.16
Odonata	Coenagrionidae	4		4	6.1	24.4	8.16
Plecoptera	Perlidae	10	10	10	1	10	20.41
Trichoptera	Hydropsychidae	1	1	1	4	4	2.04
TOTALS		**49**	**22**	**46**		**206.4**	100.00

Appendix O. QHEI Results from the current study

Table A 29. Salt Creek QHEI scores from August 22, 2006.

Stream Name	Site Number	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score	
Maximum Possible Score		**20**	**20**	**20**	**10**	**12**	**8**	**10**	**100.00**	
Lake Louise Outlet	S1	13	6	8	4.5	4	0	10	**45.50**	Non-supporting
Clark Ditch	S2	1	6	11	5.5	5	0	8	**36.50**	Non-supporting
Weblos Trail Tributary	S3	13	8	8	5	0	0	4	**38.00**	Non-supporting
Block Ditch	S4	5	6	8	7.5	0	0	4	**30.50**	Non-supporting
Headwaters	S5	7	9	11	4	3	7	4	**45.00**	Non-supporting
Sager's Lake Outlet	S6	8	11	9	6.25	6	1	8	**49.25**	Non-supporting
Beauty Creek	S7	16	14	15	5.25	10	4	10	**74.25**	Fully supporting
Pepper Creek	S8	5	9	11	7.5	4	0	10	**46.50**	Non-supporting
Mallard’s Landing Tributary	S9	3	14	12	10	9	2	8	**58.00**	Partially supporting
Butternut Springs Outlet	S10	1	6	8	7	4	0	10	**36.00**	Non-supporting
Squirrel Creek	S11	11	5	8	3	0	0	8	**35.00**	Non-supporting
Robbin’s Ditch	S12	1	3	4	5	0	0	10	**23.00**	Non-supporting
Damon Run	S13	4	8	9	10	4	0	4	**39.00**	Non-supporting
Salt Creek (Lenburg Road)	S14	3	7	9	10	5	0	10	**44.00**	Non-supporting
Salt Creek (SR 130)	S15	14	5	12	9.75	0	0	10	**50.75**	Non-supporting
Salt Creek (US 20)	S16	13	13	10	6.75	9	0	10	**61.75**	Partially supporting

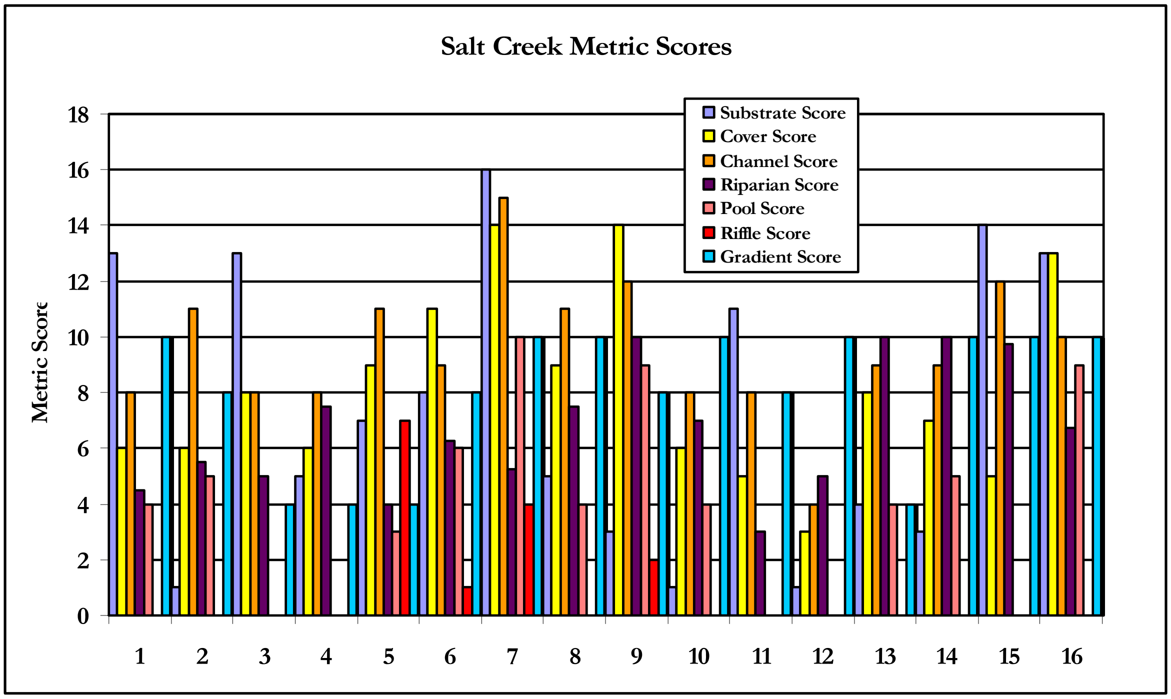


Figure A 8. Salt Creek metric scores from August 22, 2006

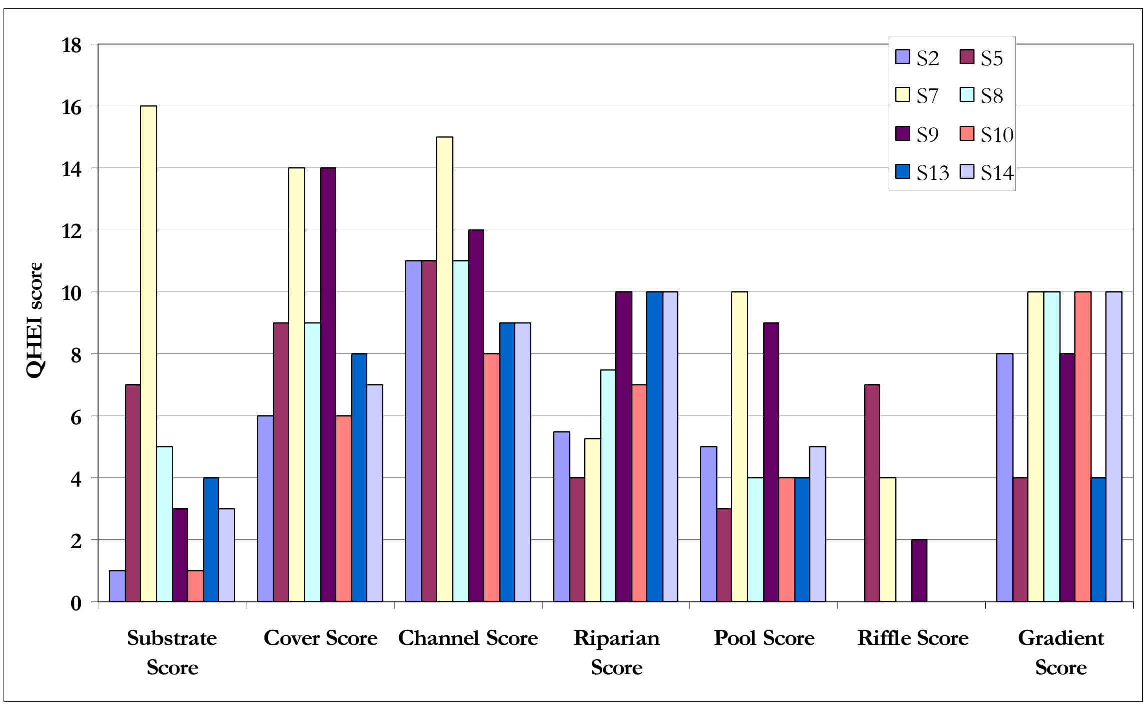


Figure A 9. QHEI metric comparison for sites where macroinvertebrate sampling occurred in 2006.

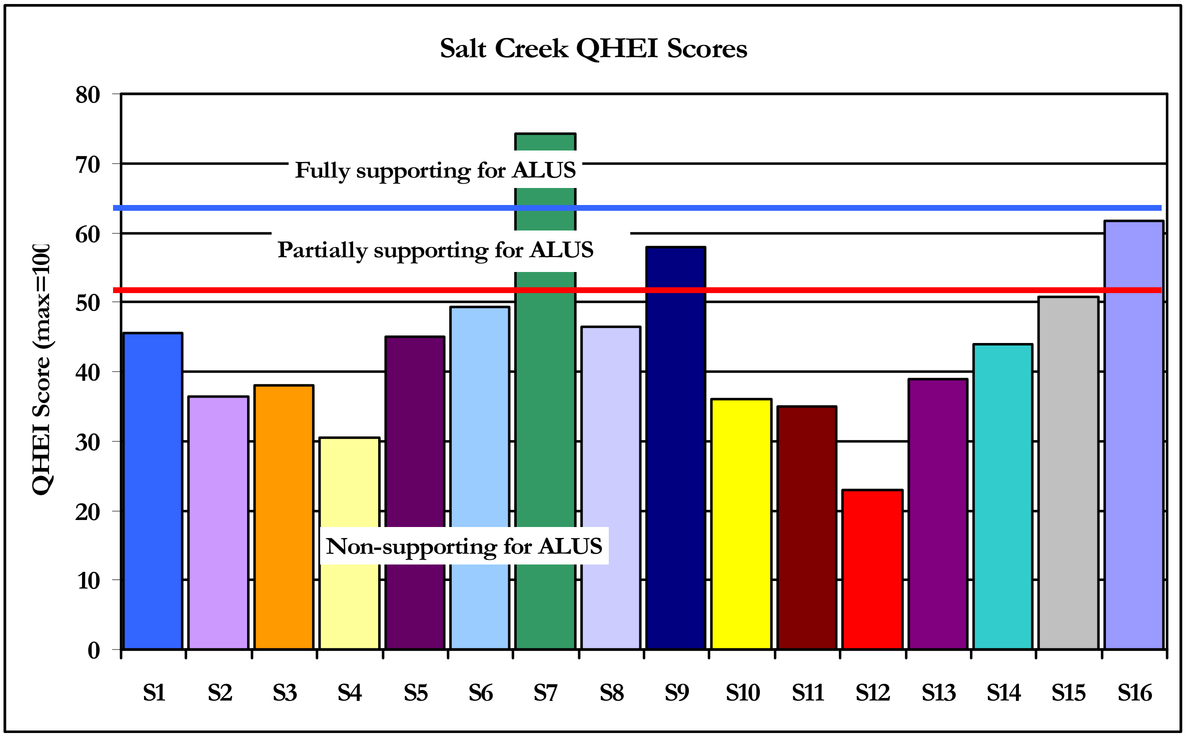


Figure A 10. Salt Creek QHEI scores from August 22, 2006

Appendix P. Salt Creek watershed BMP list

BMP removal efficiencies were taken from the “BMPList” worksheet in STEPL unless otherwise noted. The acres to meet the N, P, and TSS goals were estimated for selected practices by determining the pollutant reduction associated with implementing the BMP on one acre within the Salt Creek watershed using the USEPA Region 5 model. The total reduction necessary to meet the goal was then divided by the reduction per acre to obtain an estimate of the acres of the BMP necessary to achieve the goal. The acres of each BMP needed to meet the goal were calculated assuming the goal would be met using only that BMP. Removal efficiencies, acres necessary to meet goals, and approximate costs are estimates and are for planning purposes only. The actual number and types of BMPs implemented and associated removal efficiencies and costs will depend upon several factors including site specific conditions (soil, hydrology, etc.), identification of willing partners, and available resources.

Table A 30. Salt Creek watershed agricultural best management practices

Agricultural Best Management Practice (BMP)	Goals/Activities	N % removal efficiency	Acres to meet N goal	P % removal efficiency	Acres to meet P goal	TSS % removal efficiency	Acres to meet TSS goal	Approximate Cost	Hydro-logic benefit
Conservation Crop Rotation	1.3								No
Contour Farming	1.3, 2.1	49%	239	55%	32	41%	1.3	$12/acre	Yes
Cover (Crops) and Green Manure	1.3, 2.1							$14/acre	No
Filter Strip (Buffer Strip)	1.3, 2.1	Up to 70%	119.5	75-85%	16	Up to 65%	1.3	$190/acre	Yes
Nutrient/Pest Management Planning	1.3, 2.1							$9/acre	No
Residue Management, Reduced tillage systems	1.3	55%	119.5	45%	16	75%	0.7	$10/acre	Yes
Strip Cropping	1.3, 2.1		119.5		16		0.7	$12/acre	Yes
Terrace	1.3, 2.1	20-55%		70-85%		up to 85%			Yes
Alternative Watering System	1.3, 2.1								Yes
Animal Trails and Walkways	1.3, 2.1								No
Streambank Fencing (Livestock Exclusion)	2.1, 4.1	75%		75%		75%		$1.60/foot	Yes
Runoff Management System	1.3, 2.1	ND		83%		ND			Yes
Waste Management Systems	2.1	80%		90%		ND			No
Waste Storage Facility	2.1	65%		60%		ND			No

Table A 31. Salt Creek watershed urban best management practices

Urban Best Management Practice (BMP)	Goals/Activities	N % removal efficiency	Acres to meet N goal	P % removal efficiency	Acres to meet P goal	TSS % removal efficiency	Acres to meet TSS goal	Approximate Cost	Hydro-logic benefit
Bioretention Facility	1.1, 1.2	63%		80%		ND		$5-$40/sq ft	Yes
Concrete (Grid) Pavement	1.1, 1.2, 3.2	90%		90%		90%			Yes
Extended Wet Detention	1.1, 1.2	55%		69%		86%		$35,000 to $110,000	Yes
Filter Strip	1.1, 1.2	53%	108.6	61%	64	65%	3.9	$190/acre	Yes
Grass Swale	1.1, 1.2	10%		25%		65%		$2-$3/ ft	Yes
Green Roof	1.1, 1.2							$12-$24/ sq ft	Yes
Infiltration Basin	1.1, 1.2	60%		65%		75%			Yes
Level Spreaders	1.1, 1.2								Yes
Cistern	1.1, 1.2, 1.6	0%		0%		0%			Yes
Rain Barrel	1.1, 1.2, 1.6	0%		0%		0%		$75-$200	Yes
Delaware Sand Filter	1.1, 1.2	ND		38%		83%			No
Vegetated Infiltration Swale	1.1, 1.2, 1.6	50%		65%		90%			Yes
Wet Swale	1.1, 1.2, 1.6	40%		20%		80%			Yes
Porous Pavement	1.1, 1.2, 3.2	85%	50.3	65%	45.7	90%	3.3	$1-$5/sq ft	Yes
Rain Garden	1.1, 1.2, 1.6							$5-$40/sq foot	Yes
Seasonal (weekly) Street Sweeping	1.1	ND		6%		16%			No
Settling Basin	1.1, 1.2	ND		52%		82%			Yes
Wet Pond	1.1, 1.2	35%		45%		60%			Yes

Table A 32. Salt Creek watershed best management practices

Best Management Practice (BMP)	Goals/Activities	N % removal efficiency	Acres to meet N goal	P % removal efficiency	Acres to meet P goal	TSS % removal efficiency	Acres to meet TSS goal	Approximate Cost	Hydro-logic benefit
Wetland Detention	1.1, 1.2, 1.3, 1.4, 2.1, 4.2	20%	217.3	44%	64	78%	3.9	$1,500-$2,500/acre	Yes
Wetland Restoration	1.1, 1.2, 1.3, 1.4, 4.1, 4.2, 4.3							$1,000-$2,000/acre	Yes
Stream in a Ditch	1.1, 1.2, 1.3, 1.4, 4.1, 4.2, 4.3								Yes
Stream Channel (Bank) Stabilization	2.1, 4.1	75%		75%		75%			Yes
Critical Area Planting	1.3							$1,300/acre	Yes
Daylighting	1.1, 1.2, 1.3, 1.4, 4.1, 4.2, 4.3								Yes
Riparian Vegetion Establishment (Herbaceous)	1.1, 1.2, 1.3, 1.4, 2.1, 4.1, 4.3							$225/acre	No
Riparian Vegetion Establishment (Forested)	1.1, 1.2, 1.3, 1.4, 2.1, 4.1, 4.3							$500/acre	Yes

BMP Descriptions
BMP descriptions for the practices listed above are taken from the BMP Descriptions for STEPL and Region 5 Model (available for download at http://bering.tetratech-ffx.com/stepl/STEPLmain_files/BestManagementPracticesDefinitions.pdf). BMPs not described in the STEPL/Region 5 Model definitions are described below.

Alternative Watering System- Alternative gravity flow or pressure livestock watering system designed to reduce uncontrolled stream access.

Nutrient/Pest Management Planning- Development of nutrient and/or pest management plans according to FOTG specifications 590 and 595. According to FOTG specifications, nutrient management is managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments. Pest management is utilizing environmentally sensitive prevention, avoidance, monitoring, and suppression strategies to manage weeds, insects, diseases, animals and other organisms (including invasiveand non-invasive species), that directly or indirectly cause damage or annoyance.

Green Roof- A roof consiting of vegetation and soil or a growing medium planted over a waterproofing membrane to absorb and evapotranspire rainwater. Additional layers, such as a root barrier and drainage and irrigation systems, may also be included.

Level Spreader- A device used to disperse concentrated runoff uniformly over the ground surface as sheet flow (FOTG code 580).

Cistern- A system that collects and stores stormwater from a roof or other impervious surface for reuse that can be located either above or below ground. Distinguishable from a rain barrel by its larger size.

Rain Barrel- A small (approximately 55 gallon) barrel that collects and stores stormwater from a roof or other impervious surface for reuse.

Delaware Sand Filter- See STEPL-Sand Filter. The Delaware sand filter utilizes underground concrete vaults with a sedimentation chamber and a filtration chamber to filter stormwater.

Vegetated Infiltration Swale- A broad, shallow swale with vegetated side slopes and bottom to remove stormwater pollutants though filtration, soil absorption, and uptake by vegetation.

Wet Swale- A broad open channel used to temporarily store stormwater. It is constructed with existing soils and has no underlying filtering bed.

Rain Garden- A shallow, attractively-landscaped depression that helps to manage stormwater runoff on site. The bowl-shaped gardens create “bioretention areas” by collecting stormwater runoff from impervious surfaces and allowing it to be slowly absorbed and filtered by soil and plants.

Wetland Restoration- The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions, such as water storage and filtration, to former or degraded wetland.

Stream in a Ditch- Stream design intended to modify a traditional drainage ditch to mimic a natural stream by incorporating a primary channel to accommodate bank-full flows and a wider vegetated bench to accommodate larger flows. The primary channel meanders within the wider channel, which functions as a miniature floodplain. Stream in a ditch design slows water velocities, stabilizes banks, provides habitat, and filters pollutants.

Daylighting- Removing a stream from underground pipe or culvert to restore its natural form and function. Daylighting exposes the stream to sunlight, improving water quality and habitat.

Herbaceous Riparian Buffer Establishment/Enhancement- Establishing or enhancing a riparian herbaceous buffer according to FOTG specification 390. Riparian areas are ecosystems that occur along water courses or at the fring of water bodies. Buffers filter stormwater pollutants, reduce erosion, and provide habitat. Riparian herbaceous cover consistes of gresses, grass-like plants and forbs.

Forested Riparian Buffer Establishment/Enhancement - Establishing or enhancing a riparian forest buffer according to FOTG specification 391. A riparian forest buffer is an area of predominantly trees and/or shrubs located adjacent to and up-gradient from water courses or water bodies. Buffers filter stormwater pollutants, reduce erosion, and provide habitat.

Appendix Q. City of Valparaiso and Unincorporated Porter County zoning maps

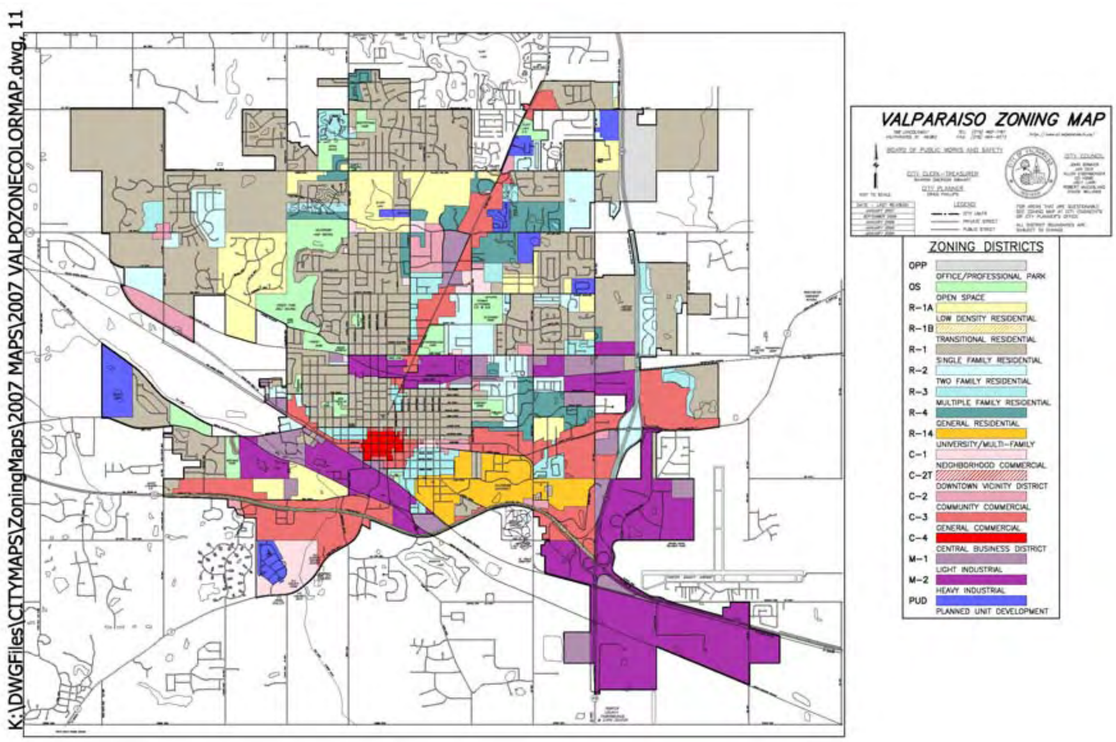


Figure A 11. City of Valparaiso Zoning Map (Valparaiso, 2004)

To view a full sized map see the Appendix CD included with this plan or visit http://www.ci.valparaiso.in.us/Government/citymaps/ZoningMap/ValpoZoningMap.pdf.

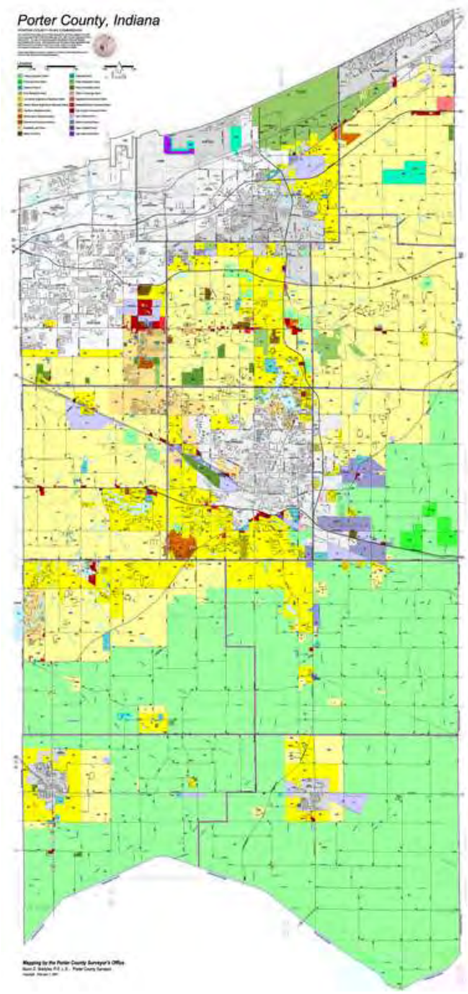


Figure A 12. Porter County Zoning Map (Porter County Surveyor's Office, 2007)

To view a full sized map see the Appendix CD included with this plan or visit http://www.porterco.org/assets/files/pdf/plcm/UDO_Zoning_Map.pdf.

Appendix R. GIS data sources

The following geographic information systems (GIS) data sources were used to create one or more of the maps in the Salt Creek Watershed Management Plan as listed below:

(VLACD, 2006). Valparaiso Lakes Area Conservancy District. The watershed boundary for the Valparaiso Chain of Lakes Watershed was provided by the Valparaiso Lakes Area Conservancy District. This layer was clipped to the Salt Creek watershed boundary to display the area diverted from the watershed.

(Choi, 2005) Choi, J.Y., B. Engel and L. Theller. 2005. Online Watershed Delineation. http://pasture.ecn.purdue.edu/~watergen/

(IDEM, 2007a) Indiana Department of Environmental Management, Office of Land Quality, Compliance and Response Branch, Solid Waste Compliance Section. 2007. CONFINED_FEEDING_OPERATIONS_IDEM_IN: Confined Feeding Operation Facilities in Indiana(Indiana Department of Environmental Management, Point Shapefile)

(IDEM, 2007b) Indiana Department of Environmental Management, Office of Land Quality, Compliance and Response Branch, Solid Waste Compliance Section. 2007. OPEN_DUMPS_IDEM_IN: Open Dump Sites in Indiana (Indiana Department of Environmental Management, Point Shapefile).

(IDEM, 2007c) Indiana Department of Environmental Management, Office of Land Quality, Compliance and Response Branch, Solid Waste Compliance Section. 2007. WASTE_SEPTAGE_SITES_IDEM_IN:Septage Waste Sites in Indiana (Indiana Department of Environmental Management, Point Shapefile).

(IDEM, 2007d) Indiana Department of Environmental Management, Office of Land Quality, Compliance and Response Branch, Industrial Waste Section. 2007. WASTE_INDUSTRIAL_IDEM_IN: Industrial Waste Sites in Indiana (Indiana Department of Environmental Management, Point Shapefile).

(IDEM, 2007e) Indiana Department of Environmental Management, Office of Land Quality, Remediation Service Branch, Leaking Underground Storage Tank Section. 2007. LUST_IDEM_IN: Leaking Underground Storage Tanks in Indiana (Indiana Department of Environmental Management, Point Shapefile).

(IDEM, 2006) Indiana Department of Environmental Management, Office of Water Quality. 2006. IMPAIRED_STREAMS_IDEM_IN: Impaired Streams in Indiana on the 303(d) List of 2006 (Indiana Department of Environmental Management, Line Shapefile).

(IDEM, 2002) Indiana Department of Environmental Management, Office of Water Quality, Data Management Section. 2002. NPDES_FACILITY_IDEM_IN: Facilities in the National Pollutant Discharge Elimination System with Assigned UTM Coordinates in Indiana (Indiana Department of Environmental Management, Point Shapefile).

(IDNR, 2006) Indiana Department of Natural Resources. 2006. Dams_IDNR_IN: Dams in Indiana under the Jurisdiction of the Indiana Department of Natural Resources (Indiana Department of Natural Resources, Point Shapefile).

(IDNR, 1992) Indiana Dept. of Natural Resources, Division of Fish and Wildlife. 1992. Known salmonid streams as defined and revealed by the Division of Fish and Wildlife. Obtained from Linda Lambert, Indiana Dept. of Natural Resources.

(INDOT, 2001) Indiana Department of Transportation, Graphics and Engineering. 2001. INCORPORATED_AREAS_INDOT_IN: Incorporated Boundaries in Indiana (Indiana Department of Transportation, Polygon Shapefile).

(INHDC, 2007) Indiana Natural Heritage Data Center. MANAGED_LANDS_IDNR_IN: Lands owned and managed by the IDNR (Indiana Department of Natural Resources, 1:24,000, Polygon Shapefile)

(INDOT, 2004) Indiana Department of Transportation. 2004. HIGHWAYS_INDOTMODEL_IN: Highways in Indiana (Indiana Department of Transportation, 1:24,000 Line Shapefile).

(IGS, 2004) Indiana Geological Survey. 2004. CENSUS_MCD_POPCHANGE_IN: Population Densities and Changes of Densities of Minor Civil Divisions in Indiana from 1890 to 2000 (United States Census Bureau, 1:500,000, Polygon Shapefile), digital representation by Denver Harper, 2004.

(IGS, 2003) Indiana Geological Survey. 2003. ECOREGIONS_USGS_IN: Ecoregions, Levels III and IV, Indiana (U.S. Geological Survey, 1:250,000, Polygon Shapefile).

(IGS, 2007a) Indiana Geological Survey. 2007. IS2001USGS_IN: Estimated Percentages of Impervious Surfaces in Indiana in 2001, Derived from the National Land Cover Database (NLCD 2001) (United States Geological Survey, 30-Meter Grid), digital representation by Chris Dintaman, 2007.

(IGS, 2007b) Indiana Geological Survey. 2007. LC2001USGS_IN: 2001 Land Cover in Indiana, Derived from the National Land Cover Database (NLCD 2001) (United States Geological Survey, 30-Meter Grid), digital representation by Chris Dintaman.

(IGS, 2007c) Indiana Geological Survey. 2007. TC2001USGS_IN: Estimated Percentage of Tree Canopy in Indiana in 2001, Derived from the National Land Cover Database (NLCD 2001) (United States Geological Survey, 30-Meter Grid), digital representation by Chris Dintaman.

(US Census Bureau, 2005) U.S. Census Bureau, Indiana Department of Transportation. 2005. ROADS_2005_INDOT_IN: Indiana Roads from INDOT and TIGER Files, 2005 (INDOT, 1:100,000, Line Shapefile).

(USDS, 2004) U. S. Department of Agriculture, National Agricultural Statistics Service

CULTIVATED_AREAS_USDA_IN: Cultivated Areas in Indiana in 2004 (United States Department of Agriculture, 1:100,000, Polygon Shapefile)

(USDA, 1994) U. S. Department of Agriculture, Natural Resources Conservation Service. 1994. SOILS_STATSGO_IN: Soil Associations in Indiana (U.S. Dept. of Agriculture, 1:250,000, Polygon Shapefile).

(USDA, 2005) U. S. Department of Agriculture, Natural Resources Conservation Service. 2005. SOILS_SSURGO_TABLES_NRCS_IN: Soil Survey Geographic (SSURGO) database for Porter County, Indiana.

(USDA, 2002a) U.S. Department of Agriculture, Natural Resources Conservation Service, Indiana Department of Environmental Management, Indiana Department of Natural Resources, Division of Water. 2002. WATERSHEDS_HUC11__USGS_IN: Watersheds, 11-digit Hydrologic Units, in Indiana, (Derived from US Geological Survey, Polygon Shapefile).

(USDA, 2002b) U.S. Department of Agriculture, Natural Resources Conservation Service, Indiana Department of Environmental Management, Indiana Department of Natural Resources, Division of Water. 2002. WATERSHEDS_HUC14_SUBWATERSHEDS_USGS_IN: Subwatersheds, 14-digit, Hydrologic Units, in Indiana, (US Geological Survey, 1:24000 Polygon Shapefile).

(USFWS, 1992) U.S. Fish and Wildlife Service, National Wetland Inventory. 1992. WETLANDS_NWI_POLY_IN: National Wetland Inventory Polygons by County in Indiana (US Fish and Wildlife Service, 1:2M, Polygon Shapefile).

(USGS, 2001) U.S. Geological Survey and U.S. Environmental Protection Agency. 2001. HYDROGRAPHY_LINE_NHD_IN: Streams, Rivers, Canals, and Ditches in Indiana (United States Geological Survey, 1:100,000, Polygon Shapefile).

Salt Creek watershed map sources by Figure:

Figure 1. Actual and official boundaries of the Salt Creek watershed- Area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); Roads (US Census Bureau, 2005)

Figures 2-6. Salt Creek subwatersheds- These maps were generously produced by Craig Shillinglaw in March and April of 2006 as a volunteer contribution for Save the Dunes.

Figures 7- 9 were taken from the Salt Creek *E. coli* TMDL (WHPA, 2003)

Figure 10-11. Salt Creek watershed highly erodible land and dominant soil hydrologic groups- SURGO (USDA, 2005); Hydrography (USGS, 2001); 14 Digit HUC Watersheds (USDA, 2002b); Highways (INDOT, 2004)

Figures 12-15 were taken from the Salt Creek *E. coli* TMDL (WHPA, 2003)

Figures 16, 18-22- National Wetland Inventory (USFWS, 1992); Area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Hydrography (USGS, 2001); 14 Digit HUC Watersheds (USDA, 2002b)

Figure 17. Salt Creek watershed soil hydric ratings- SURGO (USDA, 2005); Area diverted from watershed (City of Valparaiso); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a)

Figure 23. Salt Creek Ecoregions- Ecoregions (IGS, 2003); Area diverted from watershed (City of Valparaiso); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a)

Figures 24-25. Land cover in the Salt Creek watershed- Land Cover (IGS, 2007b); 11 Digit HUC Watersheds (USDA, 2002a)

Figure 26 was taken from the Salt Creek *E. coli* TMDL (WHPA, 2003)

Figure 27. Change in population density, 1990-2000- Census Population Change (IGS, 2004); SURGO (USDA, 2005); Hydrography (USGS, 2001); 14 Digit HUC Watersheds (USDA, 2002b); Highways (INDOT, 2004)

Figure 28. National Park Service property within the Salt Creek watershed- Managed Lands (INHDC, 2007); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); Roads (US Census Bureau, 2005); Incorporated Areas (INDOT, 2001)

Figure 29. 303(d) impaired streams in the Salt Creek watershed- Impaired streams (IDEM, 2006); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a)

Figure 30 was taken from the Salt Creek *E. coli* TMDL (WHPA, 2003)

Figure 31. IDEM 2006 biotic community assessment/intensive survey sampling was provided by IDEM in 2006.

Figure 32. Map of stream sampling sites- GPS locations of stream sampling sites were collected by JFNew. Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso);

Figure 33-34. Sampling site subwatersheds- Subwatersheds generated using Purdue's Online Watershed Delineator (OWL) (Choi, 2005); GPS locations of stream sampling sites were collected by JFNew. Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Highways (INDOT, 2004)

Figures 35-50 are photographs taken by SDCF in June 2006

Figure 51. Salt Creek watershed cultivated areas- Cultivated areas (USDA, 2004); Hydrography (USGS, 2001); 14 Digit HUC Watersheds (USDA, 2002b)

Figure 52 was taken from the Indiana State Department of Agriculture website (ISDA, 2007)

Figure 53. Salt Creek watershed estimated percent impervious surfaces- Estimated percentage impervious surfaces (IGS, 2007a) Hydrography (USGS, 2001); 14 Digit HUC Watersheds (USDA, 2002b); area diverted from watershed (City of Valparaiso);

Figures 54-58 are photographs taken by SDCF and watershed stakeholders in 2006

Figure 59. Salt Creek watershed soil suitability for septic systems- Porter County Soil Survey (USDA, 1976); 11 Digit HUC Watersheds (USDA, 2002a); SURGO (USDA, 2005)

Figure 60 was taken from the Salt Creek *E. coli* TMDL (WHPA, 2003)

Figure 61. Septage waste sites within the Salt Creek watershed- Septage waste sites (IDEM, 2007c); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 62 was provided by the Valparaiso Water Reclamation Department (2007)

Figure 63. NPDES facilities in the Salt Creek watershed- NPDES facilities (IDEM, 2002), Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figures 64, 65, and 67 are photographs taken by SDCF and watershed stakeholders in 2006

Figure 66. Dams in the Salt Creek watershed- Dams (IDNR, 2006); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 68. Salmonid streams in the Salt Creek watershed- Salmonid streams (IDNR, 1992); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 69. Open dump sites in the Salt Creek watershed- Open dump sites (IDEM, 2007b); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 70. Leaking underground storage tanks in the Salt Creek watershed- LUSTs (IDEM, 2007e); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 71. Industrial waste sites in the Salt Creek watershed- Industrial waste sites (IDEM, 2007d); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001); Highways (INDOT, 2004)

Figure 72. Salt Creek watershed critical and priority areas- GPS locations of stream sampling sites were collected by JFNew and critical and priority subwatersheds were generated by JFNew. 2005 statewide aerial photos; Highways (INDOT, 2004); Hydrography (USGS, 2001); 11 Digit HUC Watersheds (USDA, 2002a); area diverted from watershed (City of Valparaiso); Incorporated Areas (INDOT, 2001)