3.14 Watershed Drainage System

3.14.1 Tributary Streams and Ravines to Lake Michigan

Waterways such as streams and ravines are a barometer of the health of their watersheds. The story of waterways, as with so many natural resources, has been one of exploitation and lack of understanding. Few waterways throughout the world have escaped pollution, channel modifications, and increased flooding as a result of mismanagement of development in the watershed (Apfelbaum & Haney 2010). Fortunately, many waterways can be restored if stressors in the watershed can be mitigated.

Tributary Streams

Humans have drastically changed the geometry and location of most streams in Wind Point watershed since European settlement in the mid 1800s. Some of these changes can be observed by looking at the pre-settlement stream mapping depicted on Figure 6 in Section 3.1. Today, twelve (12) primary streams totaling 96,911 linear feet or 18.4 miles are located within Wind Point watershed; all are tributary to Lake Michigan (Table 15; Figure 36). It is important to note that there are numerous smaller secondary tributaries branching off many of the primary tributaries but that mapping and describing all secondary tributaries is beyond the scope of this project. The swale that extends south from Tributary J, across 4 Mile Road, through ponds on SC Johnson property and finally along Shoop Park Golf Course is defined as a wetland swale by SEWRPC and is not a stream. Therefore, a summary of this area is included in Section 3.14.3.

For this watershed plan, the 12 tributary streams are labeled Tributary A through Tributary L for purposes of maintaining and reporting data although it is understood that many local names may apply to these streams. Of the 12 streams, Tributary G which is located in the central portion of the watershed, is the longest at approximately 34,679 linear feet or about 6.6 miles. Tributaries E and F, the second and third longest streams in the watershed, are 14,550 linear feet (2.8 miles) and 11,631 linear feet (2.2 miles) respectively. The remaining 9 streams account for 36,051 linear feet or 6.8 miles. Stream conditions vary greatly depending on their location, past and currently surrounding land uses, ownership, etc.

One important observation was made in fall of 2012 that all streams in the watershed are intermittent. In other words, all streams may dry up during dry periods that usually occur in summer and early fall. Aside from channelization, one of the most significant problems with streams in the watershed is the existence of headcuts adjacent to ravines on several tributaries. These headcuts likely began to form following initial changes in land use to more impervious surfaces in the early 1900s. Headcuts are described in more detail below.

Ravines

Many of the primary tributary streams in Wind Point watershed become natural ravines adjacent to Lake Michigan. Generally, ravines are defined as steep-sided or V-shaped valleys that are larger than gullies but smaller than canyons. They may contain perennial or intermittent streams, but are typically formed when moving water incises and erodes a channel into the underlying material (ICMP 2011). The shape and depth of ravines offer protection from temperature extremes as well as a more moist environment, creating a unique ecosystem within and often harboring critical species habitat. While erosion is a natural component within ravines, most of the ravines in Wind Point watershed are threatened by excessive erosion as a result of urbanization and surrounding land use changes. Significantly higher volumes of runoff are being diverted into the streams surrounding these ravines, exacerbating the erosion process and threatening ravine habitat. In 2006, Hey and Associates, Inc. was contracted by the Village of Caledonia to conduct a study of several ravines within Caledonia including Rifle Range, Cliffside Park, Breaker's, Dominican Creek, and Birch Creek Ravines. The study, entitled Ravine Erosion and Natural Resources Assessment Study, looked at erosion and ecological and bank stability in respect to these ravines and made management recommendations accordingly.

Additional recommended ravine related resources can be found at:

Ravine Restoration Toolkit, alliance for the Great Lakes: http://www.greatlakes.org/ravinerestoration/toolkit

Resident Guide for Protecting Ravines and Bluffs, City of Lake forest, IL: http://www.cityoflakeforest.com/assets/1/7/Ravine_brochure_pdf.pdf

Wisconsin coastal Management: Wisconsin Shoreline Inventory & Oblique Viewer: http://floodatlas.org/wcmp/obliqueviewer/

Tributary Streams/Ravines Inventory
In fall 2012, Applied Ecological Services, Inc. (AES) completed a field inventory of each primary tributary stream in the watershed including ravines formed near Lake Michigan. There are also numerous smaller secondary tributaries branching off many of the primary tributaries. However, mapping and describing all secondary tributaries and small ravines is beyond the scope of this project. All primary tributary streams were assessed based on divisions into "Stream Reaches" (Table 15; Figure 36). Reaches are defined as stream segments having similar hydraulic, geomorphic, riparian condition, and adjacent land use characteristics. Methodology included walking portions of each stream reach, collecting measurements, taking photos, and noting channel, streambank, and riparian corridor

conditions on Stream Inventory/ BMP Data Forms. Ravines were also documented where they were found along these stream channels. Detailed notes were also recorded related to potential Management Measure recommendations and their corresponding priority for eventual inclusion into the Action Plan section of this report. Results of the inventory including data sheets, photos, and maps of each stream reach can be found in Appendix C.

Table 15. Summary of stream and tributary reaches and lengths.

Primary Tributary Name	Map Code	Number of Reaches	Stream Length Assessed (ft)	Stream Length Assessed (mi)
Tributary A	TRA	1	3,468	0.7
Tributary B	TRB	2	3,788	0.7
Tributary C	TRC	1	2,693	0.5
Tributary D	TRD	2	2,684	0.5
Tributary E	TRE	6	14,550	2.8
Tributary F	TRF	4	11,631	2.2
Tributary G	TRG	7	34,679	6.6
Tributary H	TRH	1	4,501	0.9
Tributary I	TRI	1	5,880	1.1
Tributary J	TRJ	1	7,468	1.4
Tributary K	TRK	1	2,428	0.5
Tributary L	TRL	1	3,141	0.6
Totals		**24**	**96,911**	**18.4**

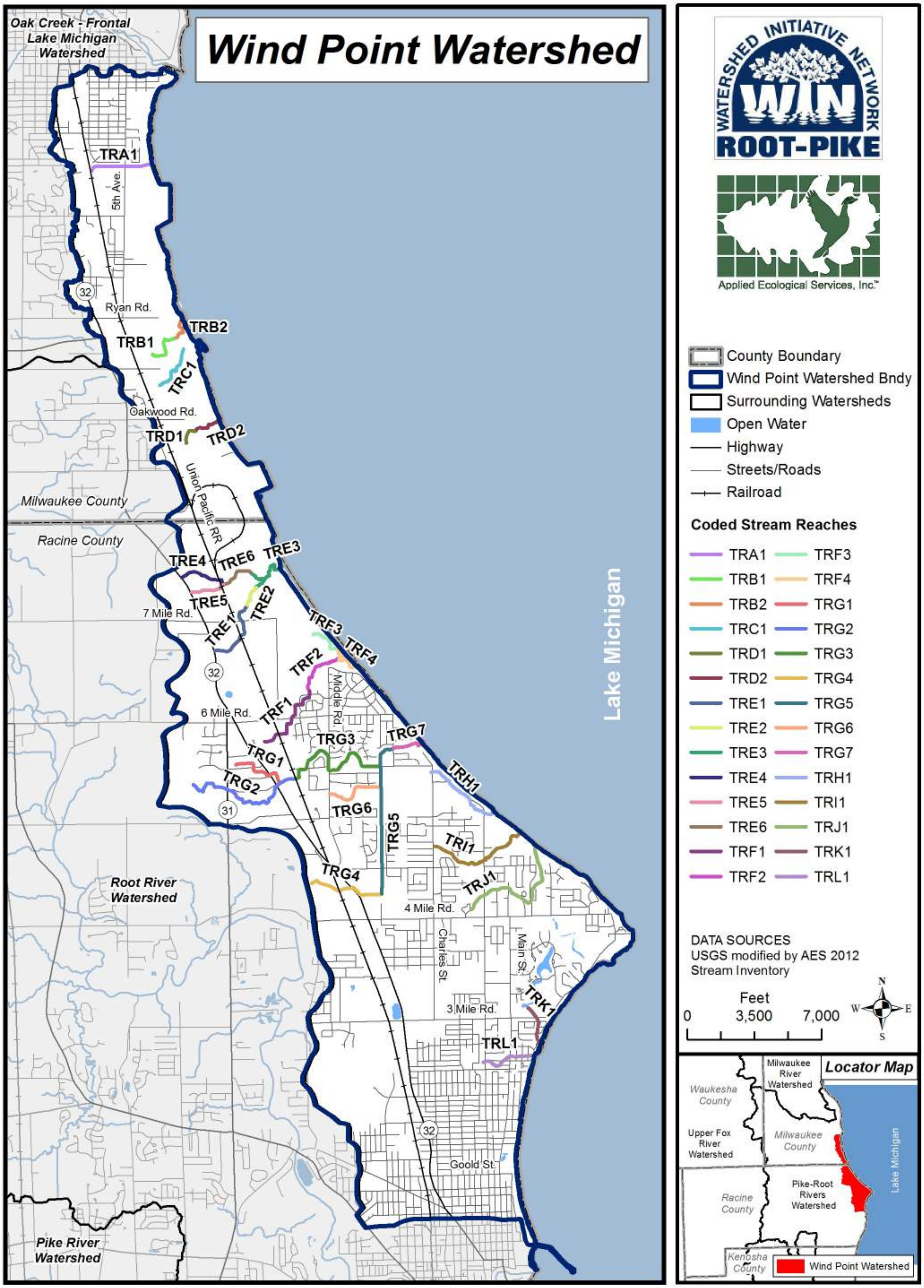


Fig. 36: Coded Stream Reaches

Tributary A

Tributary A (Reach Code: TRA) is located in the northern tip of the watershed and drains approximately 279 acres of land in South Milwaukee. Tributary A is comprised of only one reach (TRA1) beginning near the Union Pacific Railroad and continuing east for 3,468 linear feet before reaching Lake Michigan. This stream is more or less a channelized swale dominated by wetland vegetation with a riparian area consisting mostly of old field and residential lots. Despite the somewhat degraded conditions, streambank erosion is low.

Tributaries B & C

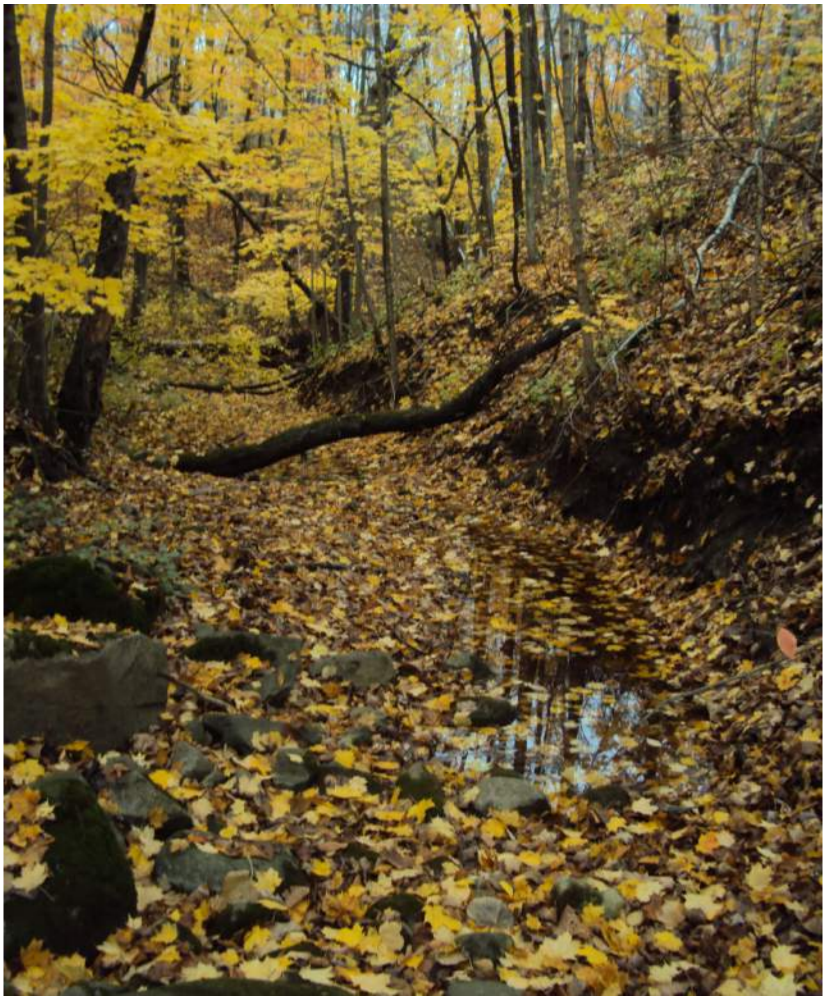
Tributaries B and C are located entirely within Milwaukee County's Bender Park and together drain 285 acres. Tributary B (Reach Code: TRB) consists of two reaches totaling 3,788 linear feet. The headwaters of Tributary B Reach 1 (TRB1) begin in a wetland complex just east of the Union Pacific Railroad. Reach 1 flows primarily through shrubland before entering a mesic woodland along Reach 2 (TRB2). Reach 1 is generally in good condition. Reach 2 becomes higher gradient as it nears Lake Michigan. As a result, streambank erosion is moderate. And a headcut was observed within Reach 2 that contributes significantly to streambank erosion and channel downcutting.

Tributary C (Reach Code: TRC) consists of only one Reach (TRC1) that is 2,693 linear feet in length. This reach flows northeast through primarily open fields and shrubland until it reaches a culvert perched above the Lake Michigan bluff. From here it is presumed that water flows through a pipe to a created wetland detention facility along the bluff. Although channelization is moderate in Tributary C, streambank erosion is low and the riparian condition is in average ecological condition.

Tributary D & Clay Ravine

Tributary D (Reach Code: TRD) flows for 2,685 linear feet and drains 243 acres on property owned by We Energies. Two reaches make up the tributary. Reach 1 (TRD1) flows primarily through a wetland complex but is disturbed. It is channelized, moderately eroded, and the riparian corridor is in poor ecological condition. Reach 2 (TRD2) is naturally meandering through high quality woodland prior to entering Lake Michigan but because the gradient is high, moderate streambank erosion is occurring and erosion is severe along a ravine formation near the lake known as Clay Ravine.

Images, clockwise from left: Tributary A Reach 1 at 5th Avenue; Tributary D Reach 2 & Clay Ravine; Aerial view of Clay Ravine at Trib D Reach 2 (Source: Google Maps, 2013); Tributary B Reach 2 near Lake Michigan.





Images, counter-clockwise from top left: Aerial view of Rifle Range Ravine (Source: Google Maps, 2013); Tributary E Reach 2; Tributary E Reach 3 – Rifle Range Ravine; Tributary E Reach 5; Tributary F Reach 1; Trib F Reach 2 upstream of headcut; Trib F Reach 3 downstream of headcut

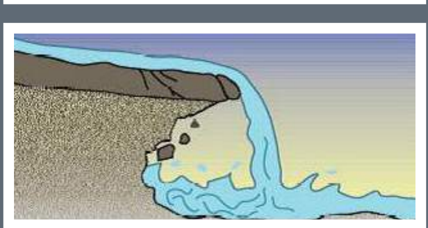
Tributary E & Rifle Range Ravine

Tributary E (Reach Code: TRE) is known locally as Rifle Range Tributary. The six stream reaches making up Tributary E span 14,550 linear feet draining 947 acres of land. Reach 1 (TRE1) begins in a wetland complex just west of State Highway 32 and flows northeast to just north of 7 Mile Road on We Energies property. Most of this reach suffers from past agricultural disturbance such as channelization and a narrow/degraded riparian corridor. Reach 2 (TRE2) is located entirely on We Energies property. This reach is naturally meandering with a riparian corridor in good ecological condition. The most concerning issue is the presence of a severe headcut at the end of Reach 2 that is migrating upstream causing significant erosion and sediment transport to Lake Michigan. Reach 3 (TRE3) begins at the headcut and continues downstream to Lake Michigan. This reach is a deep ravine (Rifle Range Ravine) exhibiting severe erosion through a high quality oak woodland. Reaches 4 and 5 (TRE4&5) are essentially wetland swales located between State Highway 32 and the C&NW Railroad. These two reaches come together to form the beginning of Reach 6 (TRE6) which meanders naturally through a high quality oak woodland before joining Reach 3. Similar to Reach 2, there is a headcut that is migrating upstream within Reach 6 and is causing erosion and

Stream Headcuts

A headcut is an erosional feature of both intermittent and perennial streams where an abrupt vertical drop, also known as a knickpoint in the stream bed occurs following hydrologic disturbances in the contributing watershed. As erosion of the knickpoint and the streambed continues, the headcut migrates upstream. This can cause significant streambank erosion and often results in a disconnected floodplain that then increased channel incision.

Controlling a headcut is one of the most difficult challenges in stream restoration. Common headcut treatments include installing check dams, or sloping the bank face and laying in fabric and rock to control continued upstream migration of the knick point. Other methods for headcut control are to elevate the incised channel by filling to original grade.



sedimentation downstream.

Tributary F & Cliffside Park Ravine

Four reaches totaling 11,631 linear feet combine to make up Tributary F (Reach Code: TRF). This tributary drains 789 acres. Reach 1 (TRF1) begins between State Highway 32 and the Union Pacific Railroad and flows northeast through mostly shrubland and agricultural fields then through a residential subdivision south of Cliffside Park. This reach is degraded by past channelization practices used by farmers and the adjacent riparian areas are in poor ecological condition. This reach is also highly channelized through the residential area via a human constructed concrete channel. Reach 2 (TRF2) begins on the south side of Cliffside Park and meanders northeast through a floodplain forest until it reaches a headcut that is actively migrating upstream. A similar condition was observed along Reach 3 (TRF3). This reach is stable and meandering through a wooded riparian area up to a second headcut. Reach 4 (TRF4) is located between the headcuts along Reaches 2 and 3 and Lake Michigan. Reach 4 forms a ravine known as Cliffside Park Ravine and is incised with highly eroded banks as a result of headcutting. The ravine study conducted by Hey and Associates identifies the following as erosion and stabilization problems within Cliffside Ravine: down-cutting of the streambed and erosion at the toe of the banks, slumping of the ravine banks at the toe of slope, and loss of vegetation on the side slopes. The study also denotes deteriorating culverts and headwall structures, undermining of culverts, and erosion downstream of culvert outfalls as structural issues within Cliffside Park Ravine.

Tributary G

Tributary G (Reach Code: TRG) is known locally as Turtle Creek. The seven stream reaches that combine to form Tributary G result in the longest tributary in the watershed at 34,679 linear feet or 6.6 miles. It drains about 2,138 acres or 3.3 square miles within the central portion of Caledonia. Tributary G has likely been altered the most by human activities. Many of these alterations including channelization and channel relocation can be observe by looking at the pre-settlement stream mapping depicted on Figure 6 in Section 3.1 and comparing it to existing mapping on Figure 36. Reaches 1 and 6 are the small tributaries that join two larger tributaries. Reach 1 begins just east of State Highway 31 and runs through turf grass lined channels within a residential subdivision prior to joining Reach 2 just east of State Highway 32. Reach 6 is mostly channelized within an agricultural parcel between Catherine Drive to the north and Rebecca Drive to the south. Reaches 2 and 3 are somewhat similar. Reach 2 begins west of State Highway 31 and flows east to the Union Pacific Railroad through a moderately channelized system. Reach 3 begins at the railroad and joins Reach 5 near 5 ½ Mile Road. Both reaches are buffered by relatively narrow/low quality floodplain woodlands.

Reach 4 begins as a swale at Holy Cross Cemetery and flows east through ditches between commercial areas prior to joining Reach 5 at Caledonia Park. Reach 5 flows north through a large human created drainage channel bordered primarily by residential development. Reach 7 becomes a ravine between Novak Road and Lake Michigan. There, slope erosion is severe and hard armoring has been installed to control erosion just east of Novak Road.

Tributaries H (Breaker's Ravine), I (Dominican Creek Ravine), & J (Birch Creek Ravine)

The characteristics of Tributaries H, I, and J are somewhat similar. One 4,500 linear foot reach (TRH1) beginning near Charles Street and entering Lake Michigan near Erie Street make up Tributary H (Reach Code: TRH). This tributary drains 332 acres in Caledonia and flows southeast through large lot residential areas near the Lake Michigan coast. There are no significant problems with Tributary H; streambank erosion is low and the adjacent riparian area is mostly natural. This reach is also identified as Breaker's Ravine. Natural debris log jams, erosion and sedimentation due to a lack of erosion control measures in new development were identified as erosion and stabilization issues for this ravine, according to the Hey and Associates study, and generally the surveyed structures within the ravine were found to be in good condition.

Tributary I (Reach Code: TRI), also known as Dominican Creek Ravine, flows for 5,880 linear feet and drains 443 acres of land between Charles Street and Lake Michigan in Caledonia. The one reach (Reach TRI1) comprising the tributary flows through a wide floodplain forest that is in good ecological condition. Overall, the stream channel is also in good condition. Streambank erosion is low and the channel is naturally meandering. The Hey and Associates ravine study identified down-cutting of the streambed and the toe of the banks as well as slumping of the ravine banks at the toe of slope as general erosion and stabilization problems for this ravine and also noted that only minor structural issues were found at one road crossing.

Tributary J (Reach Code: TRJ), also known as Birch Creek Ravine, is 7,468 linear feet in length and drains 1,040 acres of mostly residential land in the Villages of Caledonia and Wind Point. The tributary begins near the intersection of Erie Street and 4 Mile Road. From there, Tributary J flows east to near Ravenswood Lane before turning sharply to the north and to Lake Michigan. Tributary J is generally in good condition. It is naturally meandering along its length with no significant streambank erosion problems. And, the riparian corridor consists of floodplain forest in average ecological condition. The Hey and Associates ravine study concurred that generally the area was stable as were structures within this ravine, but noted excessive sediment loading in one section of the stream.

Tributaries K & L & North Bay Ravine

Tributary K (Reach Code: TRK) is the smallest stream in the watershed at 2,428 linear feet. One reach (TRK1) comprises Tributary K and drains 574 acres. The headwaters of this tributary begin just north of 3 Mile Road in a small lake west of the Prairie School. From there, the tributary flows through a channelized ditch among residential development then enters Lake Michigan near Lighthouse Drive. Tributary L (Reach Code: TRL) is 3,141 linear feet and flows east from Erie Street to Lake Michigan through residential development within the Village of North Bay. It is also referred to as the North Bay Ravine and functions as North Bay's storm water infrastructure.

Images, top to bottom, left to right: Tributary G Reach 3; Tributary G Reach 5; Tributary G Reach 7; Tributary I Reach 1; Tributary J Reach 1; Tributary L Reach 1.






Stream Channelization
Naturally meandering streams generally provide riffles and pools that benefit the system by creating habitats while oxygenating the water during low flow or summer heat. Channelized or ditched streams often lack or have poorly developed riffles and pools. Berms along channelized streams are often common where landowners spoiled soils excavated from the channel. These spoil piles often inhibit or alter natural flooding into adjacent floodplains.

Each stream reach in Wind Point watershed was characterized as either having none or low channelization (highly sinuous, no human disturbance), moderate channelization (some sinuosity but altered), or highly channelized (straightened by humans) (Table 16; Figure 37). According to the stream inventory, 34% (34,321 lf) of stream and tributary length is naturally meandering; approximately 31% (29,639 lf) is moderately channelized; 35% (34,950 lf) is highly channelized. The most severe channelization is found along Tributary A, Tributary K, Tributary G, and the upper reaches of Tributaries E, F, and D.

Channelized areas present opportunities for Management Measure projects such as artificial riffle and pool restoration and regrading or breaking of adjacent spoil piles for reconnection of the stream to adjacent floodplains. The Action Plan section of this report addresses opportunities for improving many of the channelized reaches.

Table 16. Summary of tributary channelization.

Primary Tributary Name	Map Code	Stream Length Assessed	None or Low Channelization		Moderate Channelization		High Channelization	
		(feet)	(feet)	(%)	(feet)	(%)	(feet)	(%)
Tributary A	TRA	3,468	0	0	0	0	3,468	100
Tributary B	TRB	3,788	1,497	40	2,291	60	0	0
Tributary C	TRC	2,693	0	0	2,693	100	0	0
Tributary D	TRD	2,684	1,537	57	0	0	1,147	43
Tributary E	TRE	14,550	6,359	44	0	0	8,191	56
Tributary F	TRF	11,631	5,264	45	1,977	17	4,390	38
Tributary G	TRG	34,679	1,815	5	17,537	51	15,326	44
Tributary H	TRH	4,501	4,501	100	0	0	0	0
Tributary I	TRI	5,880	5,880	100	0	0	0	0
Tributary J	TRJ	7,468	7,468	100	0	0	0	0
Tributary K	TRK	2,428	0	0	0	0	2,428	100
Tributary L	TRL	3,141	0	0	3,141	100	0	0
Totals		**96,911**	**34,321**	**34**	**29,639**	**31**	**34,950**	**35**


Channelization along Tributary G

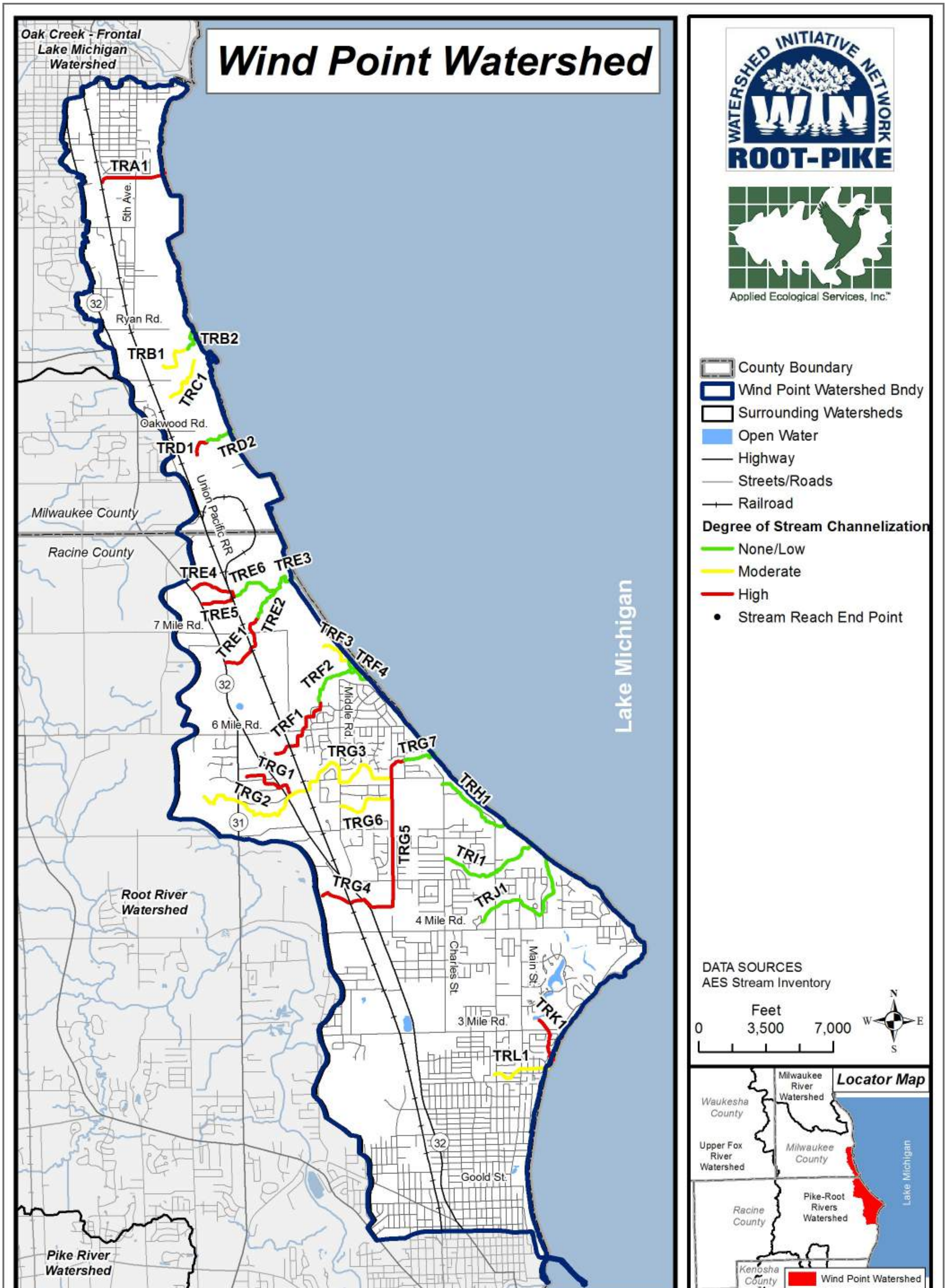


Fig. 37: Degree of Stream Channelization

Streambank Erosion

Unnatural streambank erosion generally results following an instability in flow rate or volume in the stream channel, human alteration such as channelization, or change in streambank vegetation. Resulting sediment transportation downstream can cause significant water quality problems. Streambank erosion is low on average throughout the watershed but becomes severe along Tributaries D, E, F, and G as they flow through ravines near the Lake Michigan coast. In several cases it is evident that these ravines are experiencing unnatural erosion as a result of headcut formations that are actively migrating upstream. The headcuts likely formed following increased impervious cover and stormwater runoff in the contributing watershed beginning in the early 1900s.

The location and severity of streambank erosion in the watershed is summarized in Table 17 and depicted on Figure 38. Approximately 86% (83,274 lf) of the total tributary length exhibits no or low bank erosion while moderate erosion is occurring along 7% (6,448 lf) of streambanks. Highly eroded streambanks are all associated with ravine systems near Lake Michigan and accounting for 7% (7,188 lf) of the total stream length. Many of these eroded ravines are considered "Critical Areas" because they are actively contributing significant sediment loads to Lake Michigan.

All highly eroded and some moderately eroded streambanks provide excellent opportunities for streambank or ravine stabilization projects. The Action Plan section of this report addresses and prioritizes opportunities for reducing streambank and ravine erosion.

Table 17. Summary of tributary bank erosion.

Primary Tributary Name	Map Code	Stream Length Assessed	None or Low Erosion		Moderate Erosion		High Erosion	
		(feet)	(feet)	(%)	(feet)	(%)	(feet)	(%)
Tributary A	TRA	3,468	3,468	100	0	0	0	0
Tributary B	TRB	3,788	2,291	60	1,497	40	0	0
Tributary C	TRC	2,693	2,693	100	0	0	0	0
Tributary D	TRD	2,684	0	0	1,147	43	1,537	57
Tributary E	TRE	14,550	9,360	64	1,989	14	3,201	22
Tributary F	TRF	11,631	9,181	79	0	0	2,450	21
Tributary G	TRG	34,679	32,863	95	1,815	5	0	0
Tributary H	TRH	4,501	4,501	100	0	0	0	0
Tributary I	TRI	5,880	5,880	100	0	0	0	0
Tributary J	TRJ	7,468	7,468	100	0	0	0	0
Tributary K	TRK	2,428	2,428	100	0	0	0	0
Tributary L	TRL	3,141	3,141	100	0	0	0	0
Totals		**96,911**	**83,274**	**86%**	**6,448**	**7%**	**7,188**	**7%**


Severely eroded ravine along Tributary E

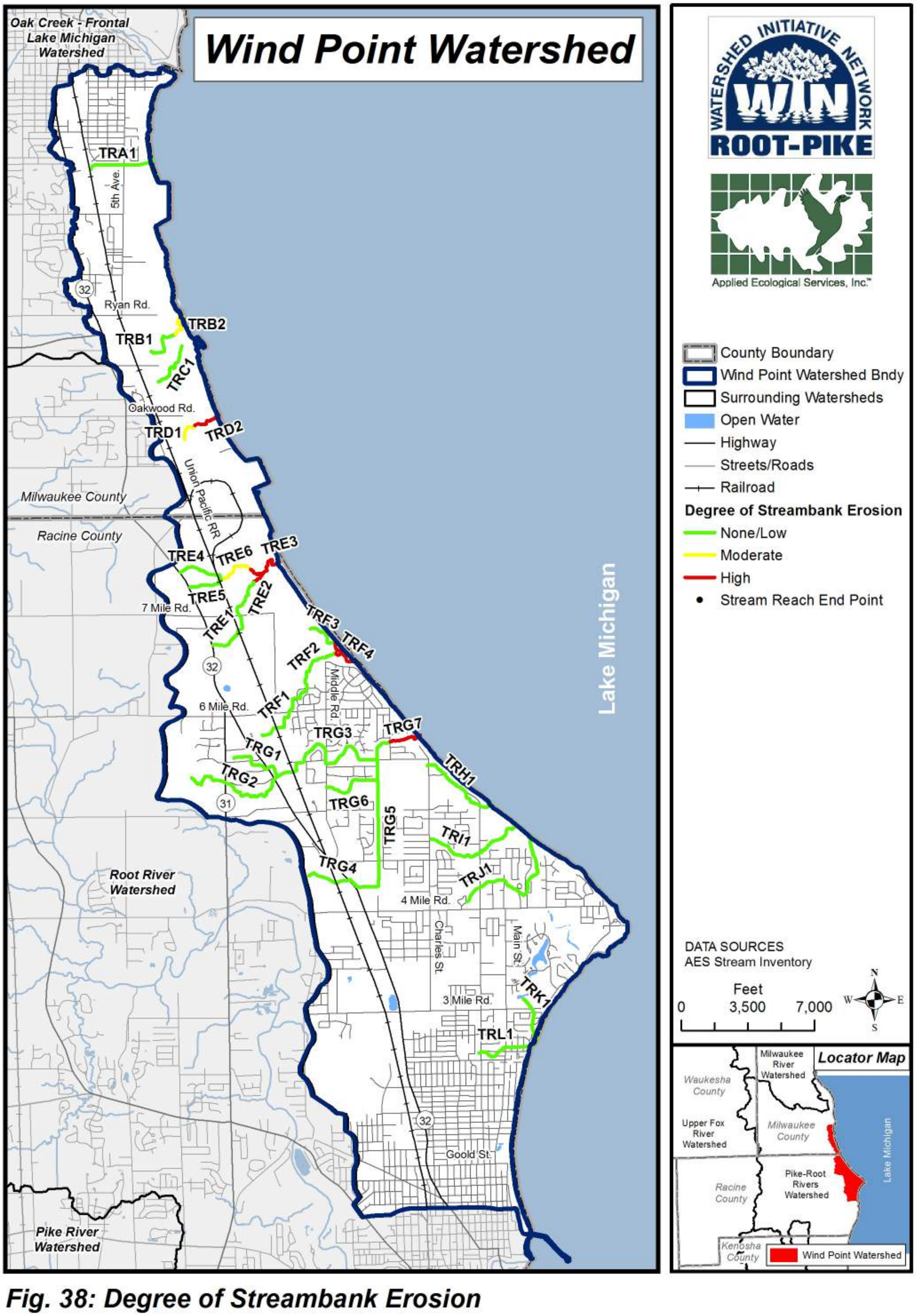


Fig. 38: Degree of Streambank Erosion

Riparian Area Condition

Riparian areas that are in good ecological condition buffer streams by filtering pollutants, providing beneficial wildlife habitat, and connecting green infrastructure. Riparian areas along tributaries was assessed during the stream inventory by noting the "Condition" as it relates to function and quality of plant communities present and hydrologic connection with the stream. Areas in "Good" condition connect hydrologically with streams during flood events and have remnant plant communities. "Average" condition riparian areas retain some hydrological connection to the adjacent stream with somewhat degraded plant communities. Areas in "Poor" condition are usually found along channelized streams that have been heavily farmed in the past causing degraded plant communities to establish.

The location and condition of riparian areas in the watershed is summarized in Table 18 and Figure 39. Approximately 22% of the riparian areas are in "Good" ecological condition, 33% are in "Average" ecological condition, and 45% are in "Poor" condition. The best riparian areas are found along Tributaries B, D, E, and I near the coast of Lake Michigan where remnant mesic and dry-mesic woodlands persist. There are several common attributes of riparian areas in poor condition. All are associated with past or present farming and development. Most are also narrow and degraded by invasive species including reed canary grass (*Phalaris arundinacea*), buckthorn (*Rhamnus sp.*), honeysuckle (*Lonicera sp.*), and box elder (*Acer negundo*). Others degraded riparian areas are comprised of turf grass within residential and commercial areas. Fortunately, ecological restoration helps eradicate these species and encourages native plant establishment. The Action Plan lists and prioritizes opportunities for improving riparian areas.

Degraded riparian area along Tributary A

Table 18. Summary of tributary area riparian condition.

Primary Tributary Name	Map Code	Stream Length Assessed	Good Condition		Average Condition		Poor Condition	
		(feet)	(feet)	(%)	(feet)	(%)	(feet)	(%)
Tributary A	TRA	3,468	0	0	0	0	3,468	100
Tributary B	TRB	3,788	1,497	40	2,291	60	0	0
Tributary C	TRC	2,693	0	0	2,693	100	0	0
Tributary D	TRD	2,684	1,537	57	0	0	1,147	43
Tributary E	TRE	14,550	6,359	44	4,410	30	3,781	26
Tributary F	TRF	11,631	5,264	45	1,977	17	4,390	38
Tributary G	TRG	34,679	0	0	9,046	26	25,632	74
Tributary H	TRH	4,501	0	0	4,501	100	0	0
Tributary I	TRI	5,880	5,880	100	0	0	0	0
Tributary J	TRJ	7,468	0	0	7,468	100	0	0
Tributary K	TRK	2,428	0	0	0	0	2,428	100
Tributary L	TRL	3,141	0	0	0	0	3,141	100
Totals		**96,911**	**20,537**	**22%**	**32,386**	**33%**	**43,987**	**45%**

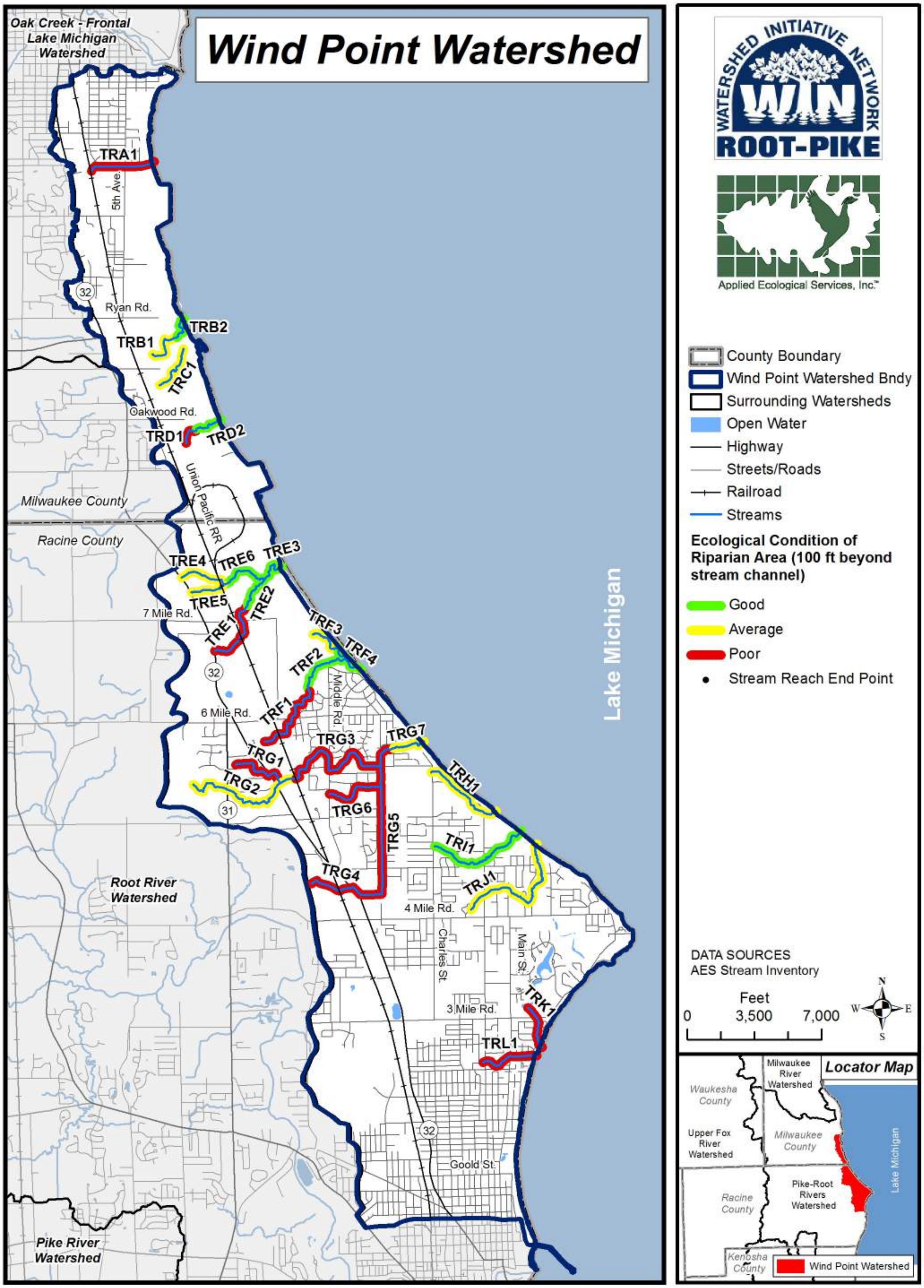


Fig. 39: Ecological Condition of Riparian Areas

3.14.2 Detention Basins

Over the past half century, the drainage system in Wind Point watershed has changed from farmland driven drain tiles, channels, and ditches to one that is driven by runoff from developed areas. Most developed areas are drained by swales and stormsewers to the tributaries of the watershed or directly to Lake Michigan. More recently, detention basins are part of a development site. A detention basin is a human-made structure that is designed by engineers for the temporary storage of stormwater runoff with a controlled release rate that is usually designed to hold and release water based on predevelopment rates. Detention basins can also provide excellent wildlife habitat and improve water quality if designed with the proper configuration, slopes, and water depths then planted with native prairie and wetland vegetation. Detention basins capture runoff from several developed areas of the watershed making the quality and quantity of water leaving these basins critically important to the health of the watershed.

Detention basins can be designed and constructed as wet bottom, wetland bottom, or dry bottom and planted with various types of natural or manicured vegetation. Wet and wetland bottom basins typically hold water that is controlled by the elevation of the outlet structure. Wet bottom basins are usually greater than 3 feet deep and do not have emergent vegetation throughout whereas wetland bottom detention basins are shallow enough to be dominated by emergent wetland plants. These designs promote water quality treatment via settling and plant uptake and also support wildlife. Dry bottom basins are designed to drain completely after temporarily storing and infiltrating stormwater following rain events. They can be planted to either turf grasses or naturalized with native vegetation.

Thirty nine (39) detention basins were located and inventoried within Wind Point watershed (Figure 40). Applied Ecological Services, Inc. (AES) completed a basic assessment of each detention basin in fall 2012. Assessment methodology included a visit to each basin and collection of data relevant to existing conditions. Detailed notes were recorded related to existing ecological/ water quality benefit condition and potential retrofit Management Measures for eventual inclusion into the Action Plan section of this report. Results of the inventory and detailed summaries of each detention basin can be found in Appendix C. Ten (10) dry bottom turf grass, 13 naturalized wet or wetland bottom, and 16 wet or wetland bottom with turf slopes detention basins were inventoried (Figure 40).

Of the 39 basins, 10 (26%) provide "Good" ecological and water quality benefits while 18 (46%) basins provide "Average" benefits. The remaining 11 (28%) basins provide "Poor" ecological and water quality benefits because most were designed simply to meet stormwater storage volume requirements. Designs that also improve water quality and wildlife habitat were not necessarily considered because they are not required under local regulations. Often, regulations require that Best Management Practices (BMPs) be part of permitted developments to provide healthy aquatic ecology, sustainability, minimize human intervention, and to treat stormwater as a multiple use resource. However, detailed examples and standardized specifications are not always provided leaving a great deal of ambiguity regarding what is actually required.

Naturalized detention basin at Audubon Arboretum Subdivision

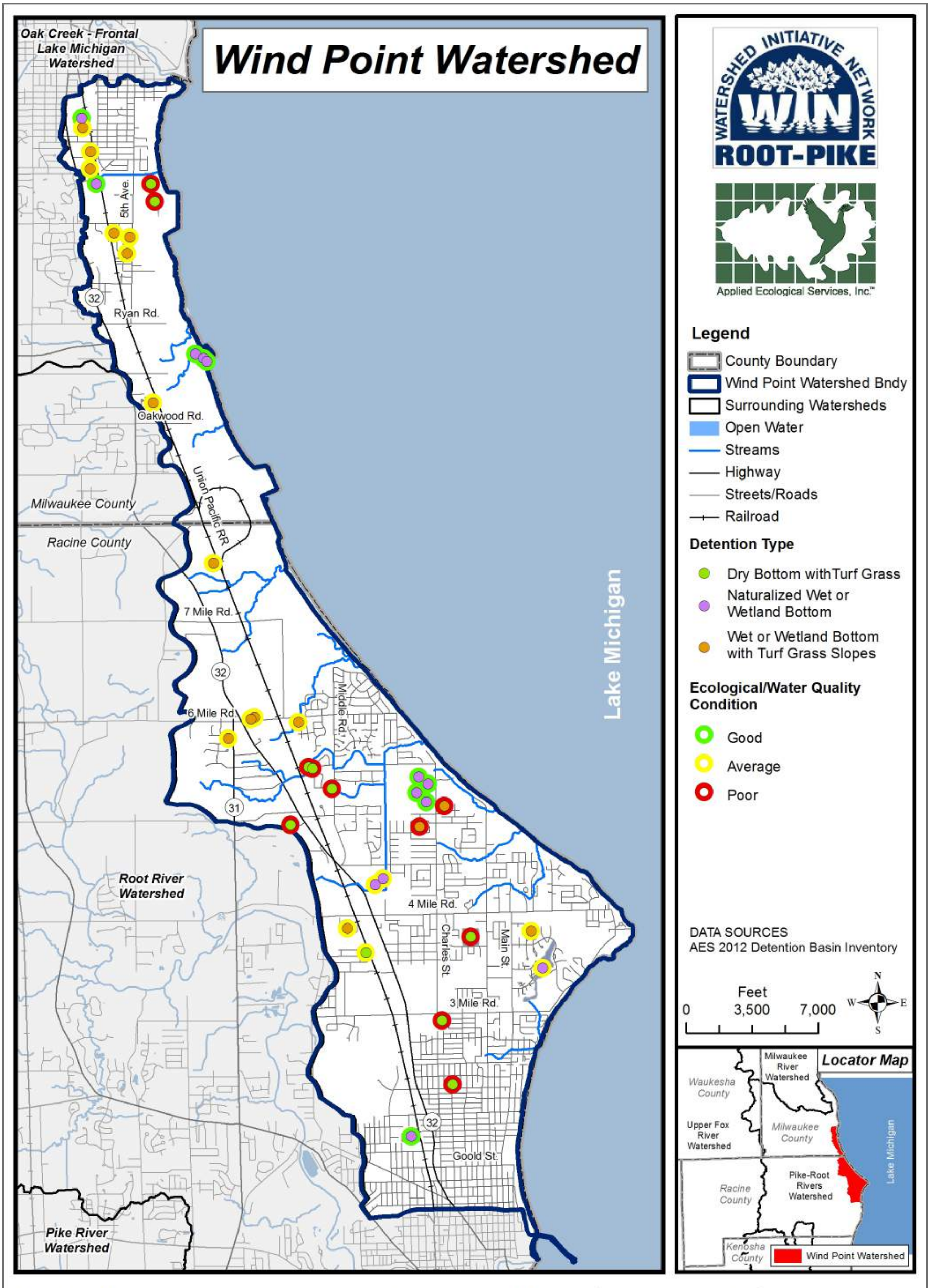


Fig. 40: Detention Basin Locations & Ecological/Water Quality Benefit Condition

The majority of dry bottom detention basins are located in the southern half of the watershed within the municipalities of Caledonia and Racine. Of the 10 dry bottom basins in the watershed all are planted with turf grass. Unfortunately, turf grass basins provide limited water quality benefits and wildlife habitat. Dry bottom basins planted with turf grass hold water for shorter periods following rain events and infiltrate less water compared to dry bottom basins naturalized with deep rooted native vegetation. Many of the dry bottom basins in the watershed present excellent retrofit opportunities and most would be relatively easy to naturalize with native plantings.

Wet and wetland bottom detention basins are found scattered throughout the watershed. Individual development sites tend to have basins that are all similarly planted. For example, most wet and wetland bottom basins in a development are planted with either turf grass along the basin slopes or are naturalized with native vegetation along the slopes and emergent edge. Basins planted with turf grass are designed with aesthetics in mind and not necessarily the potential water quality and wildlife habitat benefits. Because of this, most homeowner and business associations will likely disapprove of installing water quality retrofits such as native plant buffers unless they can be designed to look formal and require minimal maintenance. Thirteen (13) of the 29 wet and wetland bottom detention basins in the watershed are naturalized with native vegetation. Perhaps the best example of naturalized basins can be found at Audubon Arboretum Subdivision in Caledonia. The remaining 16 wet and wetland bottom basins have turf grass slopes. Like most dry bottom basins, the side slopes and emergent areas of wet and wetland bottom basins can be retrofitted with native vegetation relatively easily.

Images, top to bottom: Typical dry bottom turf grass detention at Stephan Rd.; naturalized section of pond at Prairie School; wet bottom basin with turf slopes in development off Shore Dr.

3.14.3 Wetlands & Potential Wetland Restoration Sites

Wetlands are a critical part of the earth's hydrologic system, receiving water from snowmelt and rain, slowly releasing it from the land to recharge streams and lakes (Apfelbaum & Haney 2010). Functional wetlands do more for water quality improvement and flood reduction than any other natural resource. In addition, wetlands typically provide habitat for a wide variety of plant and animal species. They also provide some groundwater recharge capabilities and filter sediments and nutrients. A diverse network of wetlands remained intact in Wind Point watershed until the 1830s when European settlers began to alter significant portions of the watershed's natural hydrology and wetland processes. Where it was feasible, wetlands were drained, streams channelized, and existing vegetation cleared to farm the rich soils.

There were approximately 2,945 acres of wetlands in the watershed prior to European settlement based on the most up to date hydric soils mapping provided by the USDA Natural Resources Conservation Service (NRCS). According to existing wetland inventories, about 577 acres or 20% of the pre-European settlement wetlands remain (Table 19; Figure 41). The largest loss of wetlands occurred in the southern portion of the watershed on a large flat plateau between Six Mile Road and the southern end of the watershed. Early vegetation mapping suggests this area was southern lowland forest and marsh. The vast majority of this historic wetland has since been drained and developed primarily to residential development.

Existing wetland information and mapping is available for the entire Wind Point watershed via the 2005 Regional Wetland Inventory and 2005 Advanced Disposal Identification of Disposal Areas (ADID) Wetland Inventory conducted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) in conjunction with the Wisconsin Department of Natural Resources (WDNR). The wetland features were delineated according to the definitions of the Wisconsin Wetland Inventory Classification Guide, with the addition of special features such as drained wetlands and drainage ditches. ADID wetlands and waters include all aquatic resources located within Primary Environmental Corridors and natural areas as identified by SEWRPC and categorized as either "Wetlands", "Lakes/Ponds", or "Natural Area Wetlands". "Other Wetlands" are located outside Primary Environmental Corridors. Of the 577 total acres of wetlands in Wind Point watershed, 395 acres have been identified as ADID wetlands by SEWRPC (Table 19; Figure 41). These include 127.3 acres of ADID Wetlands and 0.33 acres of ADID Lakes/Ponds. The remaining 449.3 acres is "Other Wetlands".

Most existing wetlands in Wind Point watershed are concentrated around stream reaches and are relatively small and fragmented. Many of the existing wetlands were inspected by Applied Ecological Services, Inc. in fall of 2012 during reconnaissance of the watershed (Appendix C). Most have been negatively impacted by farming and other human practices at some point in the last 150 years to the extent that hydrology has changed and invasive species such as narrow leaved cattail (*Typha angustifolia*), common and glossy buckthorn (*Rhamnus sp.*), reed canary grass (*Phalaris arundinacea*), and common reed (*Phragmites australis*) now dominate.

Some of the largest existing wetland complexes can be found near the headwaters of Tributary A between the Union Pacific Railroad and 5th Avenue, along Tributaries B & C in Bender Park, Cliffside Park, at the headwaters of Tributary D on WE Energies property, and a wetland swale extending from Lake Michigan and north of Four Mile Road and through The Johnson Foundation at Wingspread.

Table 19. Milwaukee and Racine County wetlands and attributes.

Wetland Category	Acres	Wetland Attributes
ADID Wetlands	127.3	The intersection of 2005 wetlands and primary environmental corridors as defined by SEWRPC
ADID Lakes/Ponds	0.33	Generally all deep water features within primary corridors and natural areas that are to be protected
Other Wetlands	449.3	Additional wetlands outside of the SEWRPC primary corridors that are to be protected

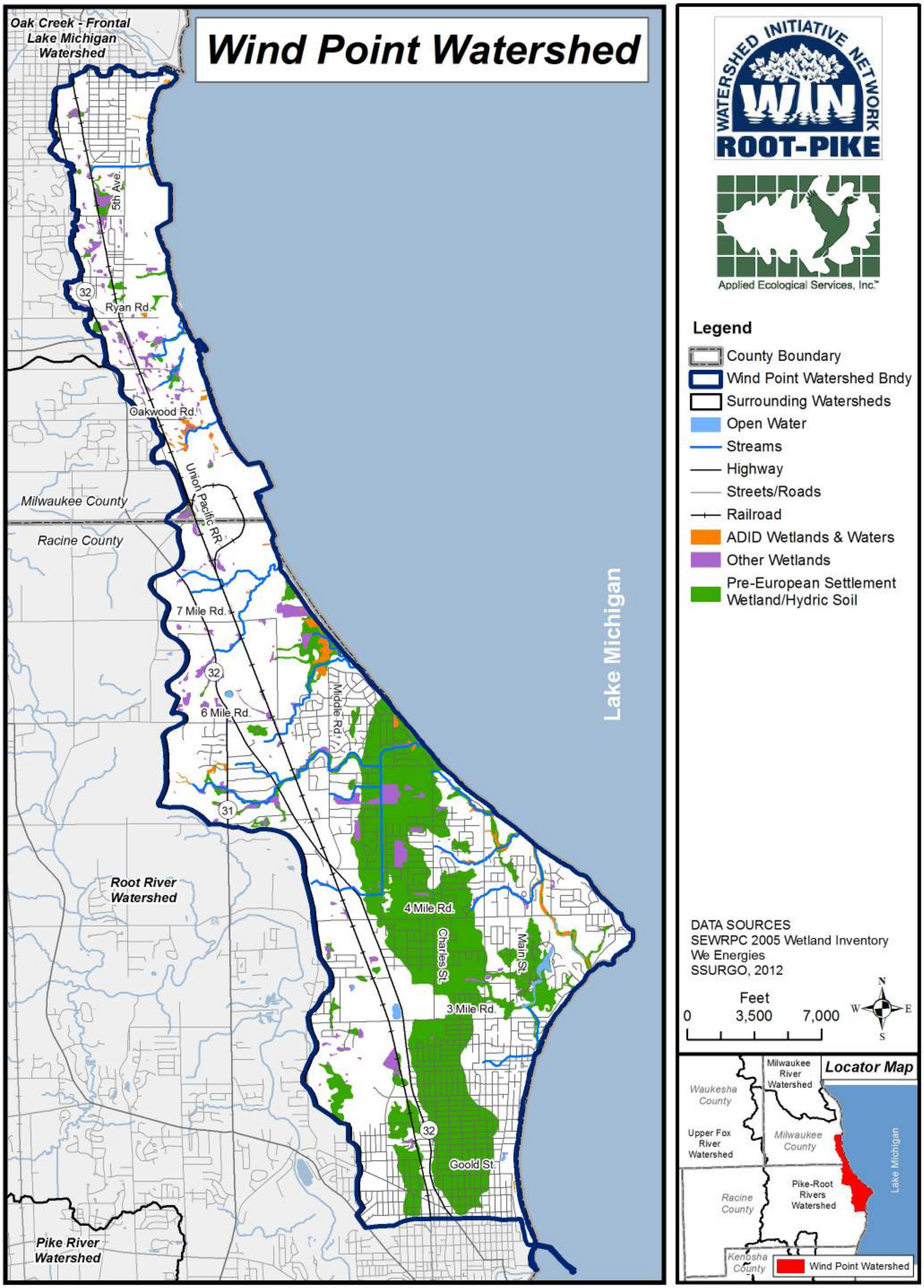


Fig. 41: Pre-European Settlement Wetlands & Existing Wetlands (2013)

Potential Wetland Restoration Sites

Wetland restoration projects are among the most beneficial in the context of improving watershed health. Wetlands are vitally important because they improve basic environmental functions such as storing floodwaters, increasing biodiversity, creating green infrastructure, and improving water quality. The wetland restoration process involves returning hydrology (water) and vegetation to soils that once supported wetlands but no longer do because of human impacts such as tile and ditch draining and/or filling. Potential wetland restoration sites were identified using a Geographic Information Systems (GIS) exercise whereby sites were selected that include at least 5 acres of drained hydric soils located on an open or partially open parcel where no wetlands currently exist.

The GIS exercise resulted in 28 sites meeting the above criteria. However, the extent of development in Wind Point watershed limits the number and size of potential wetland restoration sites. Of the original 28 sites, 25 sites accounting for 516 acres were determined to be potentially feasible or have at least limited feasibility after careful review of each site using 2012 aerial photography, open space inventory results, existing (2012) land use, and field visits where appropriate (Table 20; Figure 42). Of the 25 sites, 14 are “Potentially Feasible”, and 11 have “Limited Feasibility”. Most of the wetland restoration sites are located in the southern half of the watershed on remaining agricultural fields or vacant parcels that overlap a large swath of drained hydric soils. The three sites that were eliminated were found in areas where the proximity of existing development simply would not allow for wetland restoration. It is important to note that a feasibility study beyond the scope of this project will need to be completed prior to the planning and implementation of any potential wetland restoration.

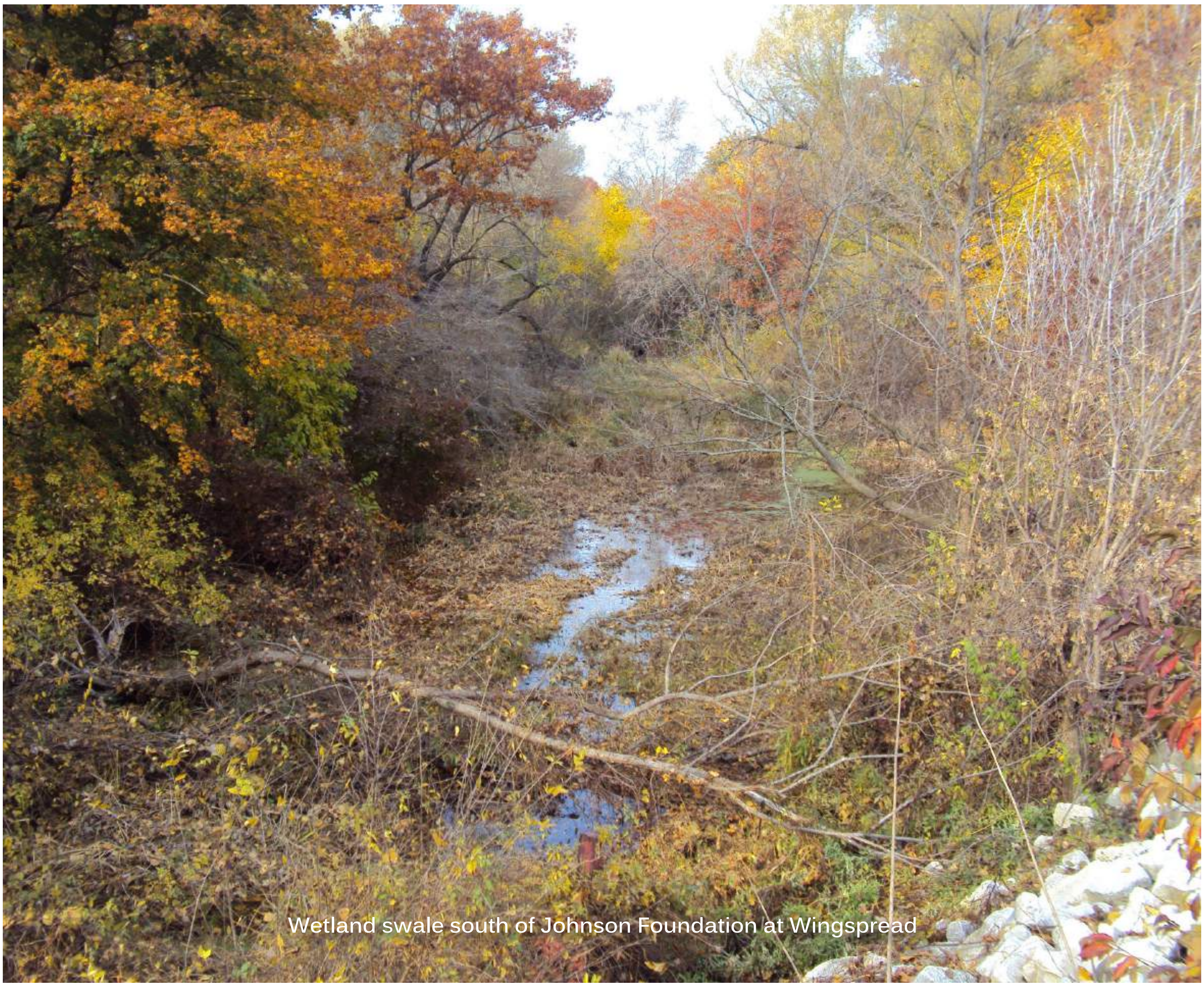

Wetland swale south of Johnson Foundation at Wingspread

Table 20. Size, feasibility, and existing condition of potential wetland restoration sites.

Map ID #	Area (ac)	Feasibility	Existing Condition
1	≈ 44	Limited Feasibility	Located at John H. Batton Airport (Batten International Airport)
2	≈ 25	Potentially Feasible	Located on vacant land owned by Vulcan Materials Company south of 3 mile road
3	≈ 76	Potentially Feasible	Located on vacant land owned by Vulcan Materials Company east of Charles Street
4	≈ 14	Potentially Feasible	Located on vacant land owned by Vulcan Materials Company west of Charles Street
5	≈ 8	Limited Feasibility	Located on private residential lot west of Erie Street
6	≈ 2	Limited Feasibility	Located in undeveloped residential area off Ruby Avenue
7	≈ 4	Potentially Feasible	Located on private agricultural land south of the Prairie School
8	≈ 8	Limited Feasibility	Located on private residential Lot east of N. Main Street
9	≈ 3	Potentially Feasible	Located on Shoop Park Golf Course
10	≈ 4	Potentially Feasible	Located in area that is currently a created pond at Johnson Foundation's Wingspread
11	≈ 14	Limited Feasibility	Located across several private residential lots south of 4 Mile Road
12	≈ 5.5	Limited Feasibility	Located on private residential/agricultural lots
13	≈ 7	Limited Feasibility	Located on private residential/agricultural lots
14	≈ 9	Potentially Feasible	Located on private agricultural land west of Erie Street
15	≈ 30	Potentially Feasible	Located on private agricultural land north of 4 Mile Road and adjacent to Crawford Park
16	≈ 12	Potentially Feasible	Located on private agricultural land south 4 ½ Mile Road
17	≈ 11	Limited Feasibility	Located across multiple private residential and agricultural lots east of Middle Road
18	≈ 7.5	Limited Feasibility	Located across multiple private residential and agricultural lots east of Charles Street
19	≈ 130	Limited Feasibility	Large drained wetland complex on land that is currently a defunct development surrounded by agricultural land between 5 Mile and 5 ½ Mile Roads
20	≈ 16.5	Potentially Feasible	Located on private agricultural land along Tributary G and east of Middle Road
21	≈ 15	Potentially Feasible	Located on private agricultural land along Tributary G and east of Middle Road
22	≈ 46.5	Potentially Feasible	Located at headwaters of Tributary F within Cliffside Park
23	≈ 9	Limited Feasibility	Located on partially developed land owned by WE Energies
24	≈ 5	Potentially Feasible	Located on vacant private land owned by DuPont
25	≈ 5	Potentially Feasible	Located near the headwaters of Tributary A
26	≈ 5	Potentially Feasible	Located on private agricultural land along Tributary G Reach 2

Note: A feasibility study will need to be completed prior to the planning and restoration of any potential wetland restoration.

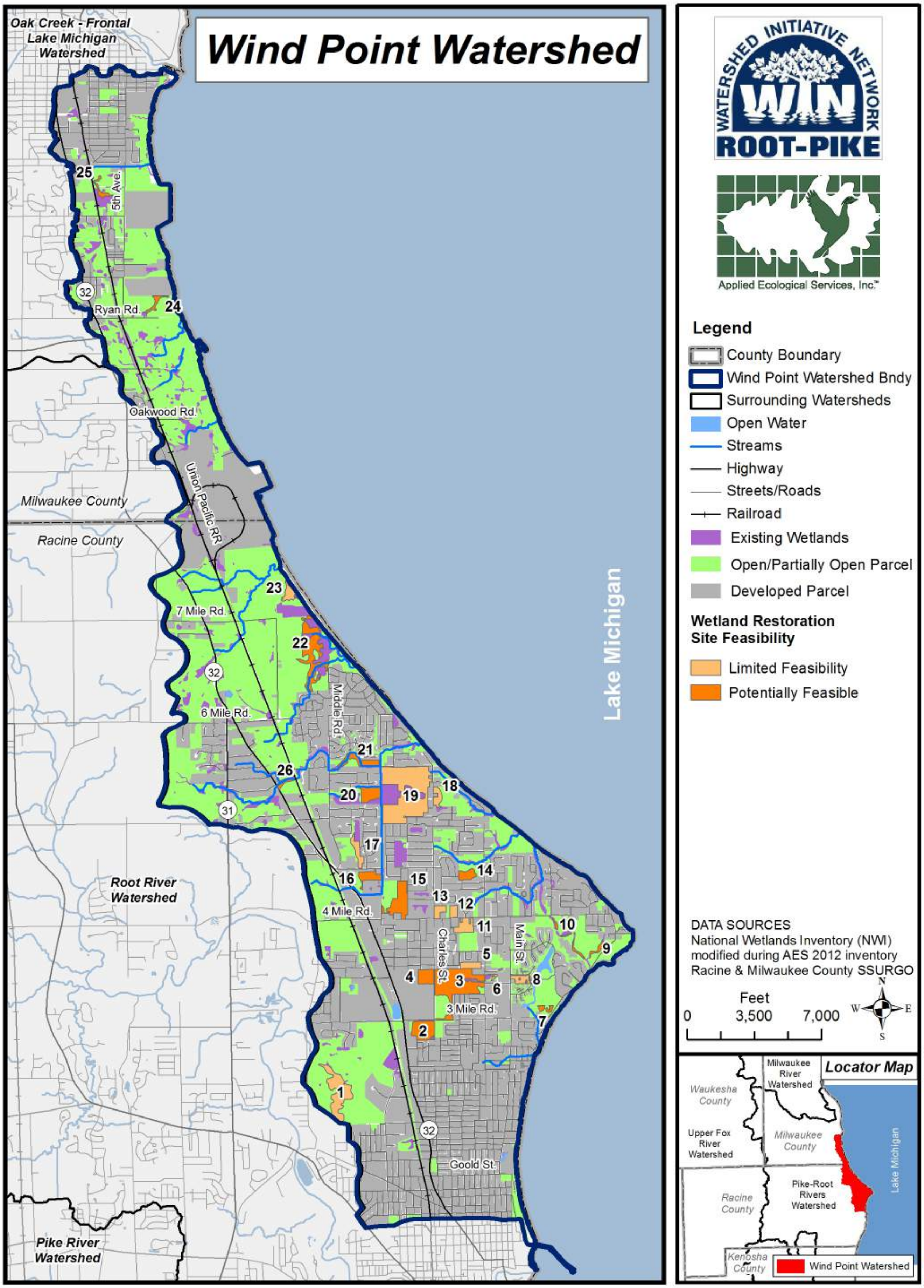


Fig. 42: Potential Wetland Restoration Sites

Wetland restoration recommendations are included and prioritized in the Action Plan section of this report. Site #s 9, 10, 11, 14, 15, 16, 19, 20, 21, and 22 are among the highest priority because of their location, size, or potential to remediate watershed problems. Municipalities should strongly consider requiring “Conservation or Low Impact Design” development that incorporates wetland restoration on parcels slated for future development.

Another potential option is to restore large wetland complexes as part of a wetland mitigation bank. In this case, wetlands are restored on private or public land and must meet certain performance criteria before they become “fully certified.” Following certification, developers are able to buy wetland mitigation credits from the wetland bank for wetland impacts occurring elsewhere in the watershed. A fully certified acre of restored wetland can sell between $40 and $100 thousand dollars. Although this may seem like an enormous expense to a developer, it is often cheaper than going through a long permitting process to impact wetlands and provide mitigation on the development site. It is also possible that entities such as wastewater treatment plants could purchase “water quality trading credits” from wetland mitigation banks as a way to offset phosphorus in plant effluent.

Potential wetland restoration Site #21 along Trib G Reach 3

3.14.4 Floodplain

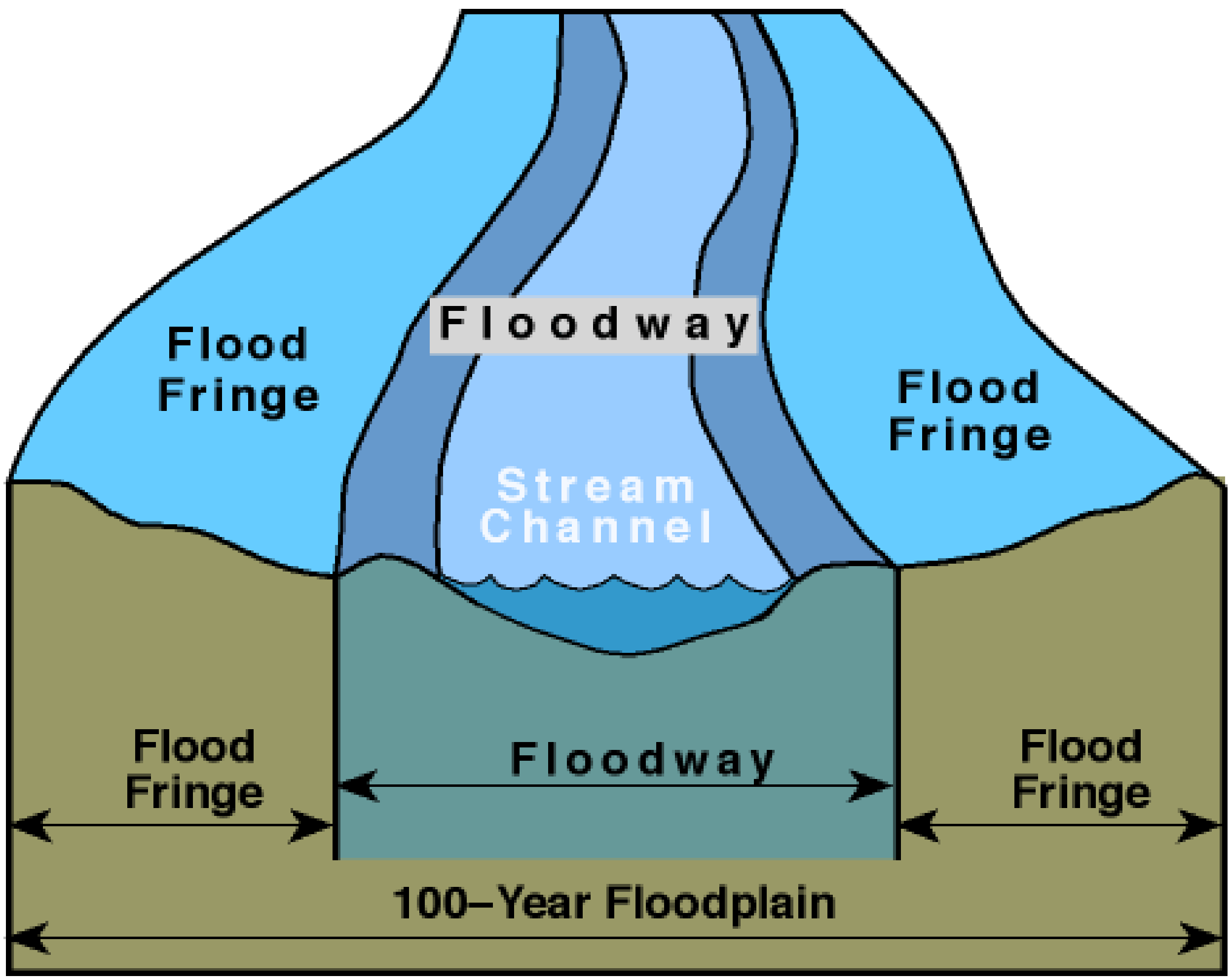
FEMA 100-Year Floodplain

Functional floodplains along stream, river, and lake corridors perform a variety of green infrastructure benefits such as flood storage, water quality improvement, passive recreation, and wildlife habitat. The most important function however is the capacity of the floodplain to hold water following significant rain events to minimize flooding downstream. The 100-year floodplain is defined by the Federal Emergency Management Agency (FEMA) as the area that would be inundated during a flood event that has a one percent chance of occurring in any given year (100-year flood). 100-year floods can and do occur more frequently, however the 100-year flood has become the accepted national standard for floodplain regulatory and flood insurance purposes and was developed in part to guide floodplain development to lessen the damaging effects of floods.

The 100-year floodplain along streams also includes the floodway. The floodway is the portion of the stream or river channel that comprises the adjacent land areas that must be reserved to discharge the 100-year flood without increasing the water surface. Figure 43 depicts the 100-year floodplain and floodway in relation to a hypothetical stream channel.

Figure 44 depicts the 100-year floodplain which occupies 235 acres or about 2% of the watershed. The most extensive floodplain areas are associated with Lake Michigan coastal areas. Other floodplain areas have been delineated along the lower reaches of Tributaries A, D, G, and J. A large wetland swale near Wind Point and the pond adjacent to the Prairie School are also within the floodplain.

Figure 43. 100-year floodplain and floodway depiction along streams.



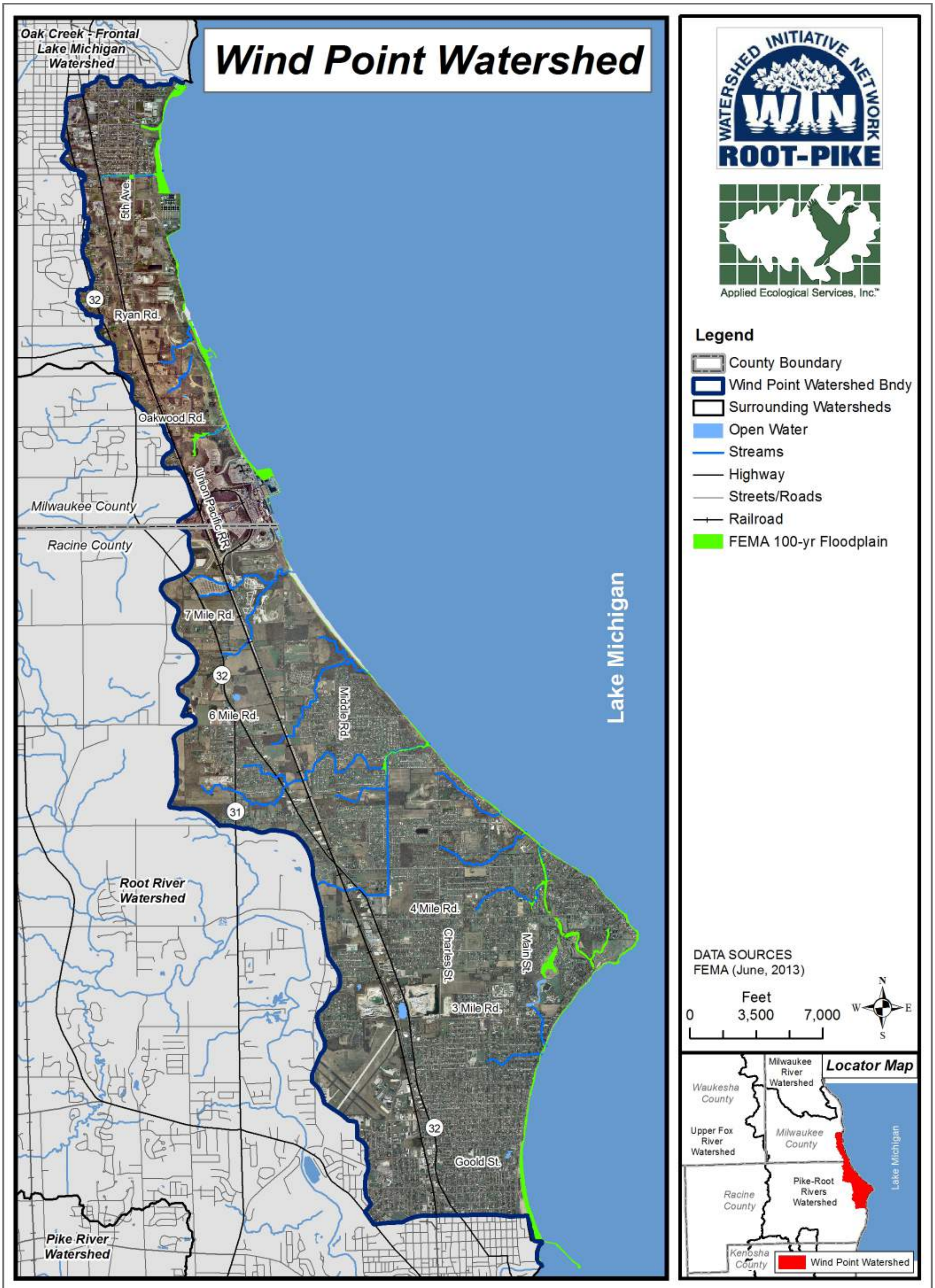


Fig. 44: FEMA 100-Year Floodplain

3.15 Groundwater Aquifers & Recharge, Contamination Potential, & Water Supply

Groundwater Aquifers and Recharge

Groundwater is water that saturates small spaces between sand, gravel, silt, clay particles, or crevices in underground rocks. Groundwater is found in aquifers or underground formations that provide readily available quantities of water to wells, springs, or streams. Groundwater sources available to southeastern Wisconsin are found in shallow, unconfined aquifer units and deep, semi-confined or confined aquifer units (Figure 45). Both shallow and deep aquifers are tapped and used by private and public users and municipalities.

The hydrogeology of Wind Point watershed falls entirely within the Silurian dolomite aquifer. This aquifer, formerly known as the Niagara dolomite aquifer, is the uppermost bedrock aquifer in the area, hydraulically connected to the adjacent sand and gravel aquifer, and generally falls under water table conditions. It is also the primary source of most public water supplies and wells within the watershed. Below the Silurian dolomite aquifer are the upper and lower sandstone aquifers. The upper sandstone aquifer includes sandstone and dolomite of the Ancell and Prairie du Chien Groups, while the lower sandstone aquifer is made up of the thick sedimentary sequences of Cambrian sandstone (SEWRPC, 2002).

Groundwater modeling studies conducted by Southeastern Wisconsin Regional Planning Commission (SEWRPC) for the southeastern Wisconsin region in 2010 suggest that deep water aquifers are experiencing excessive drawdown centered on the area of eastern Waukesha County (see Figure 46, left image). Drawdowns in this area exceed 400 feet. This is part of a larger general drawdown occurring in Milwaukee and Chicago and the area around them. Simulated drawdowns within the shallow aquifer (see Figure 46, right image), however, appear much smaller in size and extent. This is because of the unconfined nature of the aquifer and its connection to surface water bodies. “Under natural conditions, most ground water recharge to the shallow aquifer flows through the shallow aquifer and discharges to surface water bodies as baseflow. Pumping the shallow aquifer can reduce the natural ground-water discharge, intercepting it before it reaches surface water bodies and then discharging it to those few rivers that receive wastewater effluent (SEWRPC, 2010).” Rather than result in large drawdowns, groundwater deficits in the shallow aquifer effectively reduce groundwater baseflow (SEWRPC, 2010).

As the pumping of the deep aquifers and subsequent drawdowns has progressed, water from the shallow aquifer has been diverted downwards toward the deep aquifers. Groundwater recharge of the deep sandstone aquifer does not occur within Wind Point watershed due to the Maquoketa shale formation which underlies the area and serves as an aquitard.

Soil-water balance recharge occurs mostly along the northern portion of Wind Point watershed (Figure 47). The lower soil-water balance recharge values across the watershed generally relate to areas of increased urban development such as in the northern- and southern-most portions of the watershed, while higher recharge areas tend to occur where the land is more vegetated such as within parks and open space (SEWRPC, 2008).

Figure 45. Aquifer Systems in Southeastern Wisconsin. Source: SEWRPC, 2002.

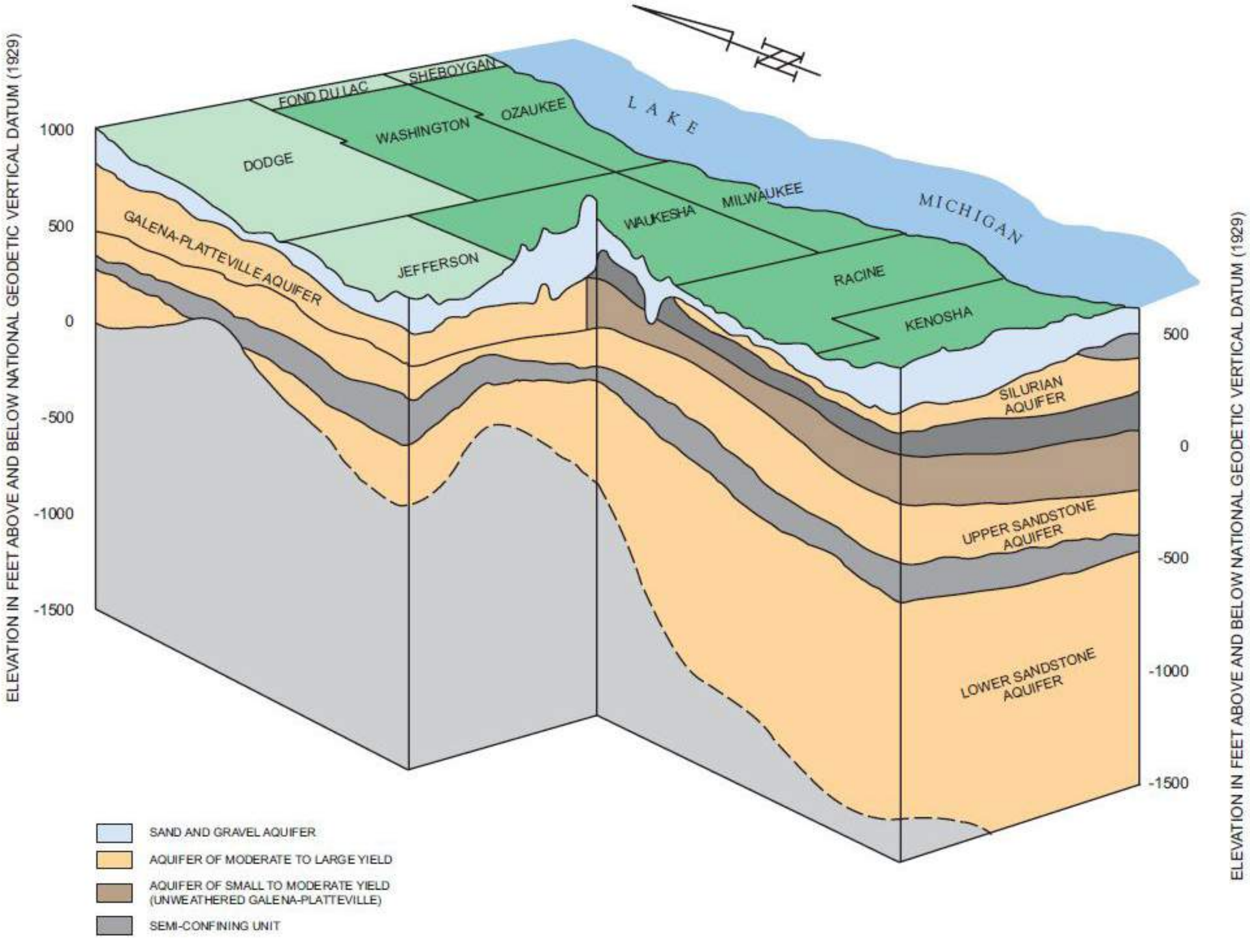
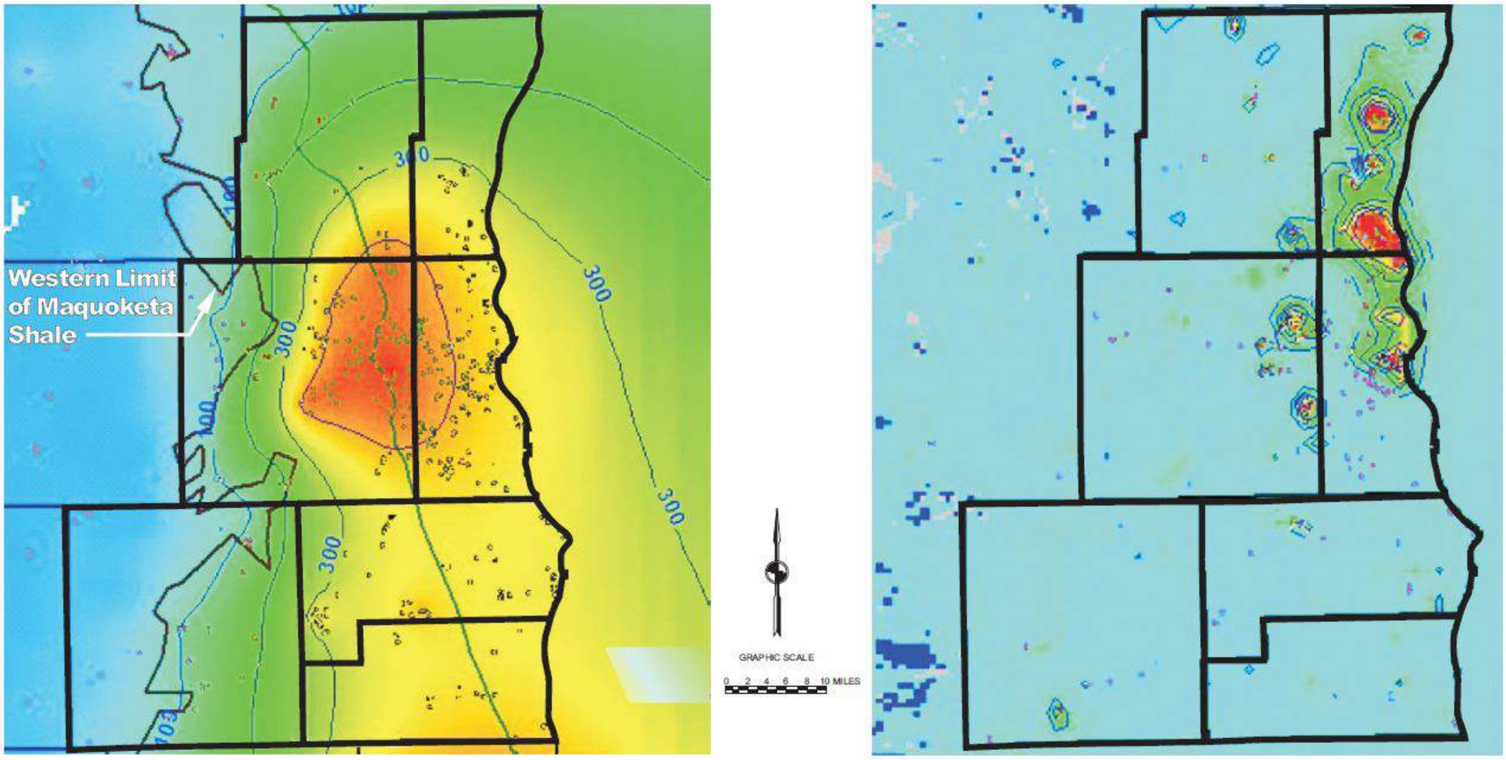


Figure 46. Simulated drawdowns for SEWRPC Region between 1860 and 2000. Left image depicts deep aquifers and right image depicts the shallow aquifer. Source: SEWRPC, 2010.



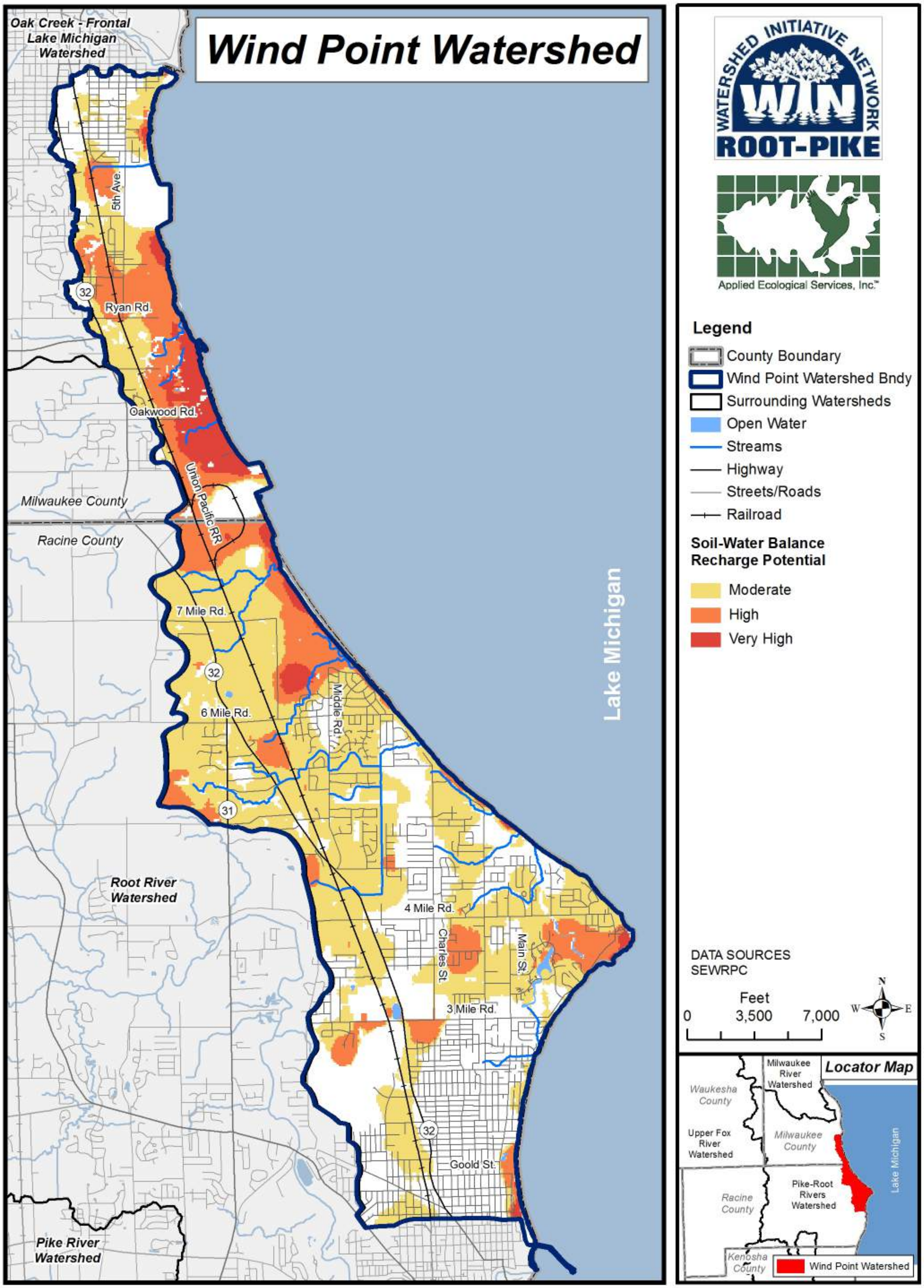


Fig. 47: Soil-Water Balance Recharge Potential

Groundwater Contamination Potential

In SEWRPC's research into groundwater resources, they determined areas in which shallow groundwater resources were potentially susceptible to contamination. They did this by measuring three parameters: 1) distance from the land surface to the aquifer, 2) properties of materials through which contaminants have to pass to reach the aquifer, and 3) rates at which such contaminants can travel (SEWRPC, 2002).

SEWRPC also identifies areas which should be targeted for groundwater protection measures. These areas are also referred to as Special Management Areas and include naturally vulnerable areas, potential problem areas, and wellhead protection areas. Naturally vulnerable areas include those identified as being vulnerable to contamination or critical groundwater recharge areas, either to deep or shallow groundwater aquifers. All of the Village of Wind Point and a portion of neighboring Caledonia were determined by the study to include areas that are highly vulnerable to potential contamination (Figure 48), due predominantly to shallow depth to aquifer. Additionally, the southern portion of the watershed that falls generally within Racine and the Village of North Bay were determined to be moderately vulnerable where low soil percolation compensates for shallow depths to aquifer.

Potential problem areas are places where naturally vulnerable areas overlap areas where potential contaminant sources are located. For the Wind Point watershed, much of the Wind Point area and area surrounding and including North Bay fall within this category.

Finally, wellhead protection areas can be determined in order to protect municipal wells within the shallow aquifer. Wisconsin Administrative Code NR 881 requires a Wellhead Protection Plan for all municipal water supply wells built since 1992, with voluntary compliance for existing wells prior to that date. These plans are meant to delineate and protect the area of land that supplies groundwater to a well, as determined by hydrogeologic analysis (SEWRPC, 2002).

Well contamination is a real concern for southeastern Wisconsin. In January of 2013, Wisconsin Department of Natural Resources (WDNR) began investigating the extent of well contamination in the region, which included parts of Caledonia within Wind Point watershed. Both public and private wells were affected by molybdenum and boron levels exceeding the state groundwater standard (Bergquist, 2013). WDNR completed an initial investigation into the sources of the contaminants and could not identify the source of the molybdenum and that the data on boron suggested that neither We Energies coal ash landfills nor the Hunts Landfill is the origin of the boron. WDNR recommends that private well owners in Caledonia have their water tested for molybdenum along with their recommended annual testing for bacteria and nitrates (WDNR, 2013).

Community Water Supply

Groundwater is an essential resource to the southeastern Wisconsin region as underlying aquifers provide the drinking water supply for many people. According to a WDNR well inventory within in Wind Point watershed, there are 87 private drinking water wells with depths ranging from 83 to 325 feet, with an average depth of 155 feet. Seven (7) public water supply wells are located within Wind Point watershed but only four are active (Table 21).

Table 21. Public water supply wells within Wind Point watershed.

Well ID	Facility	Depth (ft)	Well Status	Casing Diameter
BG740	Racine Crestview San District	1,200	Permanently Filled	12
BG741	Caledonia Water Utility – Village	1,500	Inactive	12
FG771	Northside Calvary Church	N/A	Active	6
FG798	New Hope Lutheran Church	N/A	Active	6
FG805	East Side Community Center	N/A	Active	7
FG811	Prince of Peace Lutheran Church	N/A	Permanently Filled	6
GU727	Johnsons Bar	N/A	Active	6

Source: Wisconsin Department of Natural Resources – Well Inventory

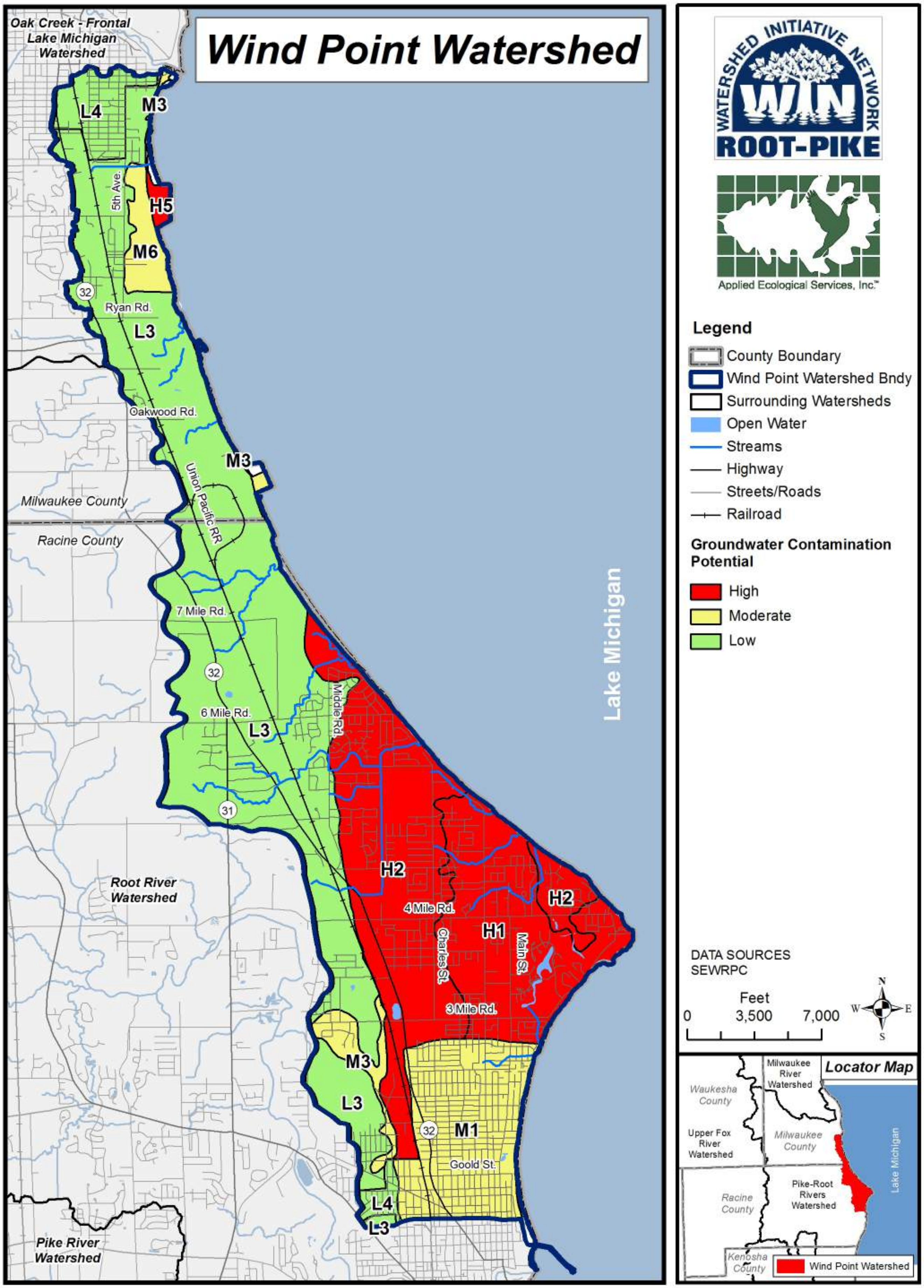


Fig. 48: Groundwater Contamination Potential