Prepared for:
City of Racine
730 Washington Avenue
Racine, WI 53403

Prepared by:
AECOM
1555 N RiverCenter Dr. Suite 214
Milwaukee, WI 53212
60263726
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# Root River Streambank Erosion and Outfall Assessment

## Final Report

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# 1.0 Summary

This study was conducted to evaluate the condition of the streambanks and storm sewer outfalls along the Root River within the limits of the City of Racine (the City) and the associated erosion and erosion potential. This report represents a compilation of this study. It includes a discussion on the field methods and activities and presents Geographic Information Systems (GIS) maps of the streambank and outfall assessment results. Potential mitigation measures for critical areas in addition to associated permitting requirements, and potential grant funding sources have also been included.

The project goal was to develop an update to the prior assessment completed in 2004 and documented in the "Root River Outfall and Streambank Erosion Assessment Report" (AECOM, formerly Earth Tech, January 2005). The assessment was accomplished by identifying, characterizing, and mapping current erosion problems associated with the 50-plus stormwater outfalls and hydromodifications such as riprap, concrete, and retaining walls, and associated erosion problems along the streambanks of the Root River. This is the second full assessment of the Root River streambank and is critical for monitoring changes in erosion and streambank conditions throughout time. The baseline data collected in 2004 and this assessment are useful to assessing erosion areas over time, in addition to measuring the effectiveness of past best management practices and streambank stabilization projects. The prior report has also been helpful as a planning tool to guide expenditure of City funds to stabilize streambank reaches and outfalls in the most cost effective manner and in obtaining grant funding to cost share in those improvements.

## 1.1 Background

The Root River Watershed covers approximately 200 square miles of Southeastern Wisconsin. The study area includes approximately 14 miles of streambank within the municipal boundary of the City of Racine, which equates to roughly seven miles of evaluation along the left and right banks. "Right" and "left" bank always assumes an orientation of looking downstream. The project limits include the right bank of the river at the dog park and the portion of the river that flows through Johnson Park. The River then leaves the City limits and re-enters the City upstream of the Horlick Dam. The river leaves the City again, downstream of Horlick Dam and re-enters the City in Colonial Park. It then flows through the City to Racine Harbor and its confluence with Lake Michigan. The study area, along with the storm sewer outfalls, is presented on Figures 1-1 and 1-2.

## 1.2 Data Collection

Field data collection and assessments were completed on July 11-12, August 22 in 2012, May 8-9, May 13, May15, June 4, September 17, and September 27 in 2013. AECOM visually inspected the streambanks within the study area to document their condition. The location of the vast majority of assessment points, both streambank and outfall, were recorded with a handheld Global Positioning System (GPS) unit.

## 1.3 Data Analysis Methodology and Findings

For this project, four methods and factors of evaluating erosion and erosion potential were utilized. These methods and factors included the Bank Erodibility Hazard Index (BEHI) and Pfankuch Channel Stability Analysis, visual observations, and adjacent land use. These methods are consistent with the methods used in the 2004-2005 assessment. Data necessary to complete these assessment methods were collected at each of the same assessment points used in the 2004-2005 assessment. The results of the four rating methods were combined to develop an overall erosion rating for each stream assessment point. Each criterion was given a different weighting based upon how critical each rating is on determining the erosion potential of each location.

Once these assessments were completed, the resultant rating for each point was compared to its representative site location. Then, reviewing the ratings that were generated from these sites, and the experience developed in the 2004-2005 assessment, the assessment team's vision could be calibrated to do complete visual assessments for the remaining portions of the river.

The areas with the highest erosion/erosion potential include:

- Small section of failing bulkhead wall along right bank on private property adjacent to Spring Street, across from Lincoln Park,
- Areas south of Lincoln Park along right bank and immediately upstream of the Wisconsin Department of Natural Resources (WDNR) Steelhead Facility, (Note – the City currently has a project in design to address this area)
- Four small isolated areas, ranging in length from 25 to 100 feet, along both banks within Colonial Park,
- Areas within Johnson Park:
    - within the golf course, both banks adjacent to the western cart path bridge at hole #11, and areas immediately upstream of the western cart path bridge,

      (Note - a stabilization project for this area was completed in the summer/fall of 2013, immediately after the assessment),
    - within the golf course, right bank adjacent hole #10,
    - approximately 400 feet downstream of the eastern cart bridge (outside of golf course limits), mainly right bank with small portion of left bank,
    - approximately 2,500 feet downstream of the eastern cart bridge, along right bank (outside of golf course limits),

There are other areas that received medium to high erosion/erosion potential ratings. Some of these have other factors that should be considered when identifying critical areas. These other areas, and their respective factors, include:

- Portion of the bulk headed section along right bank within private property (Azarian Marina, north of the intersection of Villa and Water Streets. This area is a high use (boat docks) and high profile area which could be incorporated in future riverwalk improvements.

- Portion of the non-bulk headed section along the left bank within private property (Case Corporation) southeast of the intersection of Liberty and Superior Streets. This area is a high use and high profile area as it is adjacent to the City's bike/pedestrian path.

  Portion of the non-bulk headed section along the left bank adjacent to Mound Avenue between Marquette and 6th Streets. Also known as the West Bluff Lookout, this area has also been identified as an area to connect/expand the City's bike/pedestrian path and add public/park space. (Note – the City/County are already in the process of planning improvements within the parcels that comprise this area),

- River bend within Washington Park, northwest of Park High School, along both banks. This area has moderate to high erosion, along with erosion on ravine bluffs, and erosion/damage to major storm sewer outfalls. This area is a high use and high profile area that is within a public park and golf course, and is adjacent to one of the City's high schools. (Note – the City currently has a project in design to address this area.)

- There are several small isolated areas within Island and Lincoln Parks that have moderate to high erosion. Many of these are the result of foot traffic (e.g. anglers) accessing the river which have damaged the banks. There are also specific areas where trees are at risk of toppling resulting in ripped banks and flow blockage.

The outfall condition data were evaluated to determine the overall condition of the outfall and surrounding streambank. The assessment of each outfall included the condition of the outfall and the amount of sediment buildup within the outfall. Several outfalls had corrosion (metal), cracked (concrete), or had significant sediment accumulation. Outfalls exhibiting one of these conditions could still be classified with a fair condition rating. However, there were seven outfalls that resulted in a poor condition rating.

## 1.4 Recommendations

Based upon the analysis completed for this project, there are a total of six high erosion areas located along the Root River within the City. These areas do not take into account costs or public property ownership.

Five additional areas, which have moderate to moderate-high erosion were also identified as potential project sites because they have other important criteria such as key public access points, high visibility, or provide connectivity to the overall river corridor.

Recommendations presented in this report were designed to address short-term and long-term needs. The recommendations include combinations of techniques to satisfy unique site-specific requirements.

Installation of fiber rolls, stabilization seed mix and live cuttings would be suitable for shallow banks that are slightly eroded with more bare soil and some undercutting evident at the toe, as well as at intact retaining walls where toe scour is apparent. In areas where the banks are less than four feet in height and there are no site constraints at the top of bank, regrading the slope and installing fiber roll, stabilization seed mix and cuttings is recommended. If there is adequate lateral area to regrade banks that are five to six feet high, this treatment can also be used. Where scour at the toe is more prominent, stone or A-Jacks could be installed at the toe, along with erosion control blanket, seeding and cuttings. Installation of geogrids with stone, gabions, or A-Jacks are possible solutions for repairing these banks, where maintaining steep slopes with minimal property loss is a concern. J-

Hook vanes could be placed in the stream to reduce the stresses on the bank, along with providing fish habitat. Trees that need to be removed for bank regrading could be used as root wad structures for bank protection and fish habitat. Cross vanes can also be used to direct the flows away from the streambank and toward the center of the stream.

Seven outfalls were identified as being in poor condition. These outfalls are either rusted and crushed, or cracked and destroyed. These outfalls should be replaced and additional protection, such as riprap or wing walls, should be placed around the outfalls.

# 2.0 Introduction

## 2.1 Background

The Root River Watershed covers approximately 200 square miles of Southeastern Wisconsin. The Root River originates in New Berlin in Milwaukee County, and flows 43 miles through Milwaukee and Racine Counties to empty into Lake Michigan in the City of Racine.

Sections of the Root River are considered quality fisheries. In the spring and fall, migrating chinook salmon, coho salmon, brown trout, and rainbow trout can be observed at the Root River Steelhead facility in Lincoln Park in Racine. The watershed has suffered from sedimentation from construction sites and agricultural practices, channel alterations, nutrient enrichment, and streambank erosion. The Root River is listed as a 303(d) stream, with phosphorus sited as primary pollutant of concern causing water quality use restrictions. From below the Horlick Dam (River Mile 5.82) to Lake Michigan, PCBs are also identified as causing contaminated fish tissue.

The City was awarded an Urban Nonpoint Source and Stormwater Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a streambank assessment of the Root River. The grant funded preliminary data collection, fieldwork, collaboration among stakeholder, data analysis and map production, and the preparation of draft and final reports.

This is the second full assessment of the Root River streambank and is critical for monitoring changes in erosion and streambank conditions throughout time. The City of Racine (the City) conducted a streambank and outfall assessment that was completed in 2004, the “Root River Outfall and Streambank Erosion Assessment Report” (AECOM, formerly Earth Tech, January 2005). That report has been useful as a planning tool to prioritize needs and guide expenditure of City funds to stabilize outfalls and streambank reaches in the most cost effective manner and in obtaining grant funding to cost share in those improvements.

Since 2005, several major storm events have occurred. The City desired to reassess the river to determine changes in conditions due to overall river dynamics and the impacts of the major storm events. The reassessment subsequently allows the opportunity to re-prioritizing stream segments for future stabilization and erosion control projects.

The study area includes approximately 14 miles of streambank, which equates to roughly seven miles of evaluation along the left and right banks. This includes the right bank (looking downstream) of the river at the dog park and the portion of the river that flows through Johnson Park. The River then leaves the City limits and re-enters the City upstream of the Horlick Dam. The river leaves the City again, downstream of Horlick Dam and re-enters the City in Colonial Park. It then flows through the City to Racine Harbor and its confluence with Lake Michigan.

The riparian area along the river includes wooded, residential, commercial, and industrial areas. The commercial and industrial areas are primarily located near the mouth of the river and Racine Harbor.

Channel slopes vary throughout the project area from 0.003 to 3.0 percent. However, the average slope of the channel is approximately 0.1 to 0.2 percent (WDNR, 2003). The steeper the channel slope, the greater the stream velocities and the greater scouring capacity the stream will have.

## 2.2 Goals and Objectives

There is significant bank erosion in many reaches of the Root River project area. Subsequently, there are also locations of significant sediment deposition. This instability can be attributed to several factors, including high or "flashy" flow rates resulting from the urbanized watershed, and limited and/or encroached riparian buffers. These conditions have resulted in the degradation of the water quality and riparian health in and along the Root River. The Root River, in 1979, was one of the first watersheds in the state to be part of the Wisconsin Department of Natural Resources Priority Watershed Program and is listed on Wisconsin's Section 303(d) list of impaired waterbodies. Erosion can also threaten municipal infrastructure and reduce overall quality of life in the City as the river, with its many parks, is seen as a significant amenity to the public.

The primary goal of this project was to develop an updated assessment of the streambank and outfall conditions along the Root River in the City of Racine by identifying, characterizing, and mapping current conditions of streambank along the seven miles of river, and 50-plus stormwater outfalls. Hydromodifications, such as riprap, concrete, and retaining walls, were also noted and assessed. Comparison of current conditions to conditions observed in the 2004-2005 assessment also guided the new ratings in this report. This assessment is critical for monitoring changes in erosion and streambank conditions throughout time and prioritizing areas which should be a focus for future stabilization project. This prioritization can also be used as a tool for the City in planning future Capital Improvement Plan budgets and to aid in securing continued grant funds to cost share in future projects

Secondary goals include assessing the condition and success of previous City streambank stabilization projects and help determine ways future projects can be improved.

# 3.0 Previous and Ongoing Studies and Projects

There are several ongoing or completed studies and projects along this section of the Root River. The WDNR, Southeastern Wisconsin Regional Planning Commission (SEWRPC), City, Root-Pike Watershed Initiative Network (WIN), Root River Council (through RootWorks), and other organizations are actively working on monitoring, assessing or restoring various portions of the river within the study area.

## 3.1.1 WDNR Stream Classification

In November 2003, the WDNR completed the "Lower Root River Stream Morphology Assessment". This project assigned a Channel Type score to individual stream reaches within specific walkable portions of the Root River. The reaches surveyed were from Island Park in the City, upstream to the mouth of Hoods Creek in Johnson Park. In addition to classifying the reaches, the WDNR also recommended fish habitat structures appropriate to each channel type.

The survey information and stream reach classifications completed during this WDNR study were incorporated into the erosion assessment analysis as appropriate.

## 3.1.2 City of Racine Streambank Stabilization Projects

The City of Racine has conducted several streambank stabilization projects over the years. At the time of the writing of this report, the City was substantially complete with recent projects on the Root River and Hoods Creek, a tributary to the Root River, in Johnson Park. Two other projects were recently contracted by the City for design in Washington Park and near Lincoln Park upstream of the fish weir. Table 3-1 lists the various streambank projects completed, underway, or planned by the City of Racine since 2005.

## 3.1.3 Other Projects

At the time this assessment was being completed, SEWRPC was in the process of developing a Root River Watershed Restoration Plan. As described on the SEWRPC website, the plan "will provide specific, targeted recommendations to address a set of focus issues related to conditions in the watershed. Through the input of the Root River Restoration Planning Group—which includes representatives from county and municipal governments within the watershed, MMSD, the Racine Wastewater Utility, the Wisconsin Department of Natural Resources, Sweet Water, Root-Pike WIN, and others representing a broad range of interests within the watershed—four major focus areas emerged for this watershed restoration plan: water quality, recreational use and access, habitat conditions, and flooding."

The Root-Pike Watershed Initiative Network (WIN) continues to be involved with projects that support the improvement of the Root River. These include educational, environmental monitoring, invasive species control, and BMP (e.g. rain garden) construction projects.

Root River Council has developed an Urban River Revitalization Plan and the Rootworks plan (2012). The later focuses on improvement adjacent to the downtown portions of the river.

# 4.0 Data Collection

Field data collection and assessments were completed on July 11-12, August 22 in 2012, May 8-9, May 13, May15, June 4, September 17, and September 27 in 2013. AECOM visually inspected the streambanks within the study area to document their condition. The location of the vast majority of assessment points, both streambank and outfall, were recorded with a Trimble GeoXH handheld Global Positioning System (GPS) unit. During the course of fieldwork, photographs were taken to further document the existing site conditions. Data collected for analysis of the outfalls and the streambank condition are described below.

## 4.1 Streambank Data and Analysis Methodology

For this project, four methods and factors of evaluating erosion and erosion potential were utilized. These methods and factors included the Bank Erodibility Hazard Index (BEHI), Pfankuch Channel Stability Analysis, visual observations, and adjacent land use. These methods are consistent with the methods used in the 2004-2005 assessment. Data necessary to complete these assessment methods were collected at each of the same assessment points used in the 2004-2005 assessment.

As part of the four methods, several streambank criteria were recorded to evaluate the condition of the streambank. These criteria included:

- Average Width
- Average Depth
- Bank Height
- Bankfull Height
- Bank Angle
- Water Velocity
- Water Clarity
- Water Level
- Stream Substrate and Percentages
- Channel Sinuosity
- Pool Depth
- Riffle Pool Sequence
- Canopy Cover
- Riparian Composition and Percentages
- Bank Material
- Bank Modification Type, Height and Length
- Root Depth
- Root Density
- Bank Slope Gradient
- Mass Wasting
- Debris Jam Potential
- Vegetative Bank Protection
- Channel Capacity
- Bank Rock Content
- Obstructions to Flow
- Cutting
- Deposition
- Rock Angularity
- Brightness
- Consolidation
- Bottom Size Distribution
- Scouring and Deposition
- Aquatic Vegetation

In addition, field notes were entered and photographs were taken along the way to further document existing streambank conditions.

## 4.2 Outfall Data

AECOM visually inspected the outfalls along the Root River within the study area to document the condition of the outfall and the surrounding streambank. The location of each identified outfall was recorded with the GPS unit (Figures 1-1 and 1-2).

Several municipal outfalls, including RR41, RR42, RR44, RR55 and RR59 were not located. These outfalls are either submerged, buried, or inaccessible. A concrete plate covered outfall RR50.

Several outfalls were evaluated, but due to access problems or dense tree canopy, were not GPS located, rather inserted in the map based on previous locates or City system map data. Outfalls not included on the City's stormwater outfall map were recorded and evaluated as private outfalls, using a "P" as a prefix (e.g. P04), instead of the "RR" which is used by the City to identify municipal outfalls along the Root River.

Several outfall characteristics were recorded to evaluate the condition of the outfall. These criteria included:

- Outfall Ownership (Municipal or Private)
- Outfall Size
- Outfall Material
- Outfall Condition (Good, Pitted, Cracked, Crushed, Rusted, Corroded)
- Sediment Accumulation
- Flow
- Flow Appearance

Photos of each outfall were also collected to further document existing outfall conditions. The outfall condition and sediment accumulation data were then evaluated to determine the overall condition of the outfall and surrounding streambank.

# 5.0 Data Analysis

## 5.1 Streambank Erosion Analysis

Streambank erosion occurs as a result of numerous processes such as surface erosion, mass wasting, saturation, freeze-thaw, and dispersion. Erosion hazard rating procedures have been developed that characterize a variety of streambank conditions into numerical indices of the potential for bank erosion (Rosgen, 1994, 1996, 1998). The ability of a streambank to resist erosion is determined by several factors. These include:

- The ratio of streambank height to bankfull stage
- The ratio of riparian vegetation rooting depth to streambank height
- The degree of rooting density
- The composition of streambank materials
- Streambank angle
- Bank material stratigraphy and presence of soil lenses
- Bank surface protection provided by debris and vegetation

For this project, four methods and factors of evaluating erosion and erosion potential were utilized in rating the specific assessment points. These methods and factors included a BEHI analysis, Pfankuch rating, visual observations, and adjacent land use.

### 5.1.1 BEHI Analysis

The bank-erodibility hazard index (BEHI) rating guide, developed by Dr. Dave Rosgen, assists with the evaluation of bank erosion potential. The guide incorporates an index value for the ratio of bank height to bankfull height, ratio of root depth to bank height, root density, bank angle, surface protection, bank materials, and stratification. After index values are assessed, an erosion potential rating is determined. A sample BEHI worksheet and rating guide are included in Appendix A. The BEHI ratings for each stream assessment point are shown on Table 5-1.

### 5.1.2 Pfankuch Rating

The Pfankuch channel stability index is also used to evaluate channel stability, (Pfankuch, 1975). The method includes 15 categories evaluated for one of four levels of stability (excellent, good, fair, or poor). Each level corresponds to a numeric index value; values for the categories are summed, and the total corresponds to a Pfankuch rating of good, fair, or poor. A sample Pfankuch rating worksheet is included in Appendix B.

This rating evaluates the streambanks in three separate sections: upper bank, lower bank, and channel bottom. The upper bank is considered the portion of the channel above the normal high water line. The lower bank is from the normal high water line to the water's edge during the summer

low flow period. The channel bottom is the portion of the channel that is submerged during the majority of the year. The Pfankuch ratings for each stream assessment point are shown on Table 5-2.

### 5.1.3 Visual Observations

Visual observations of the existing streambank conditions were used to supplement the erosion and stability rating methods. Areas of existing erosion were rated high, whereas areas with shallow banks and heavy vegetation were rated low. The visual observation ratings for each stream assessment point are shown on Table 5-3.

### 5.1.4 Adjacent Land Use

Adjacent land use was also evaluated to determine the potential effect of land use on the condition of the streambank. Areas that are heavily developed and contain large amounts of impervious areas (buildings, parking lots, etc.) often cause erosion of the streambank due to large amounts of runoff that is unable to infiltrate and has no vegetation to slow the rate of flow across the land surface and over the streambank. Heavily vegetated and wooded areas slow down runoff and allow some infiltration, thus reducing the potential for erosion along the streambank. The adjacent land use ratings for each stream assessment point are shown on Table 5-4.

## 5.2 Erosion Rating

The results of the four ratings described above were combined to develop an overall erosion rating for each stream assessment point. Each criterion was given a different weighting, based upon how critical each rating is on determining the erosion potential of each location. Table 5-5 illustrates the weighting for each rating criteria.

The BEHI rating is considered the most representative of the rating systems, and is therefore given the highest weighting. Adjacent land use, although a factor in erosion and erosion potential, has the lowest weighting.

During the 2012/2013 field survey, each of the initial points from the 2004-2005 study were visited and reassessed to compare the present condition to that previously documented. Each point was then assigned a new erosion hazard potential rating. Then, reviewing the ratings that were generated from these sites, and the experience developed in the 2004-2005 assessment, the assessment team's vision could be calibrated to complete visual assessments for the remaining portions of the river.

Each visual assessment point was recorded with the GPS unit. The points were processed in a geographic information system to develop delineations of specific assessment ratings.

These stream assessment locations and ratings are shown on Figures 5-1 through 5-5. Bulkheaded areas were also assigned a rating based on visual assessment, even though the streambank assessment criteria are not applicable to bulkheaded banks. Only visual assessments were completed for the bulkheaded sections.

## 5.3 Outfall Assessment

The assessment of each outfall included the condition of the outfall, the amount of sediment buildup within the outfall, and erosion adjacent to the outfall and from the outfall's storm water flow.

For the overall outfall assessment rating, if both outfall condition columns were good and there was little or no sediment buildup, the outfall was considered in very good condition. If one outfall condition column had a poor rating (cracked, pitted, rusted), but the second condition column was good and there was little or no sediment buildup, then the outfall was rated in good condition. If both condition assessments were poor or there was one poor condition assessment, and there was moderate erosion adjacent to the outfall, the outfall was rated as fair. If both condition assessments were poor, and there was significant erosion around the outfall, then the outfall was rated poor. Also, if the outfall was crushed, the outfall rating was poor. Table 5-7 shows the outfall assessment ratings. Figures 5-1 through 5-5 illustrate the overall ratings for each outfall.

## 5.4 Photo Documentation

Photos were taken to document erosion areas along the streambank and outfalls. Photo locations and approximate orientations are shown in Figures 5-6 through 5-25. Photo logs are included in Appendix C.

## 5.5 Comparison to the 2004-2005 Assessment

Figures 5-26 through 5-30 present the 2013 condition assessment alongside the assessment from 2004-2005. In those figures, the inner rating lines are the 2013 ratings, while the outer lines are the 2004-2005 ratings. In general, most areas that received a moderately high rating in 2004-2005 but did not present a noticeable change in 2013 were downgraded to a moderate erosion rating. There were some areas that presented worse erosion since 2004-2005, but overall, there were more areas that had little to no change since 2004-2005. Other factors impacting differences in ratings include:

- Subjectivity of assessor – In the 2004-2005 assessment, three people conducted the assessment. One of those three people also worked on the 2013 assessment. As a result, for portions of the study area, the person conducting the 2013 assessment could be different than the 2004-2005 assessment.

- In the 2013 assessment, the assessor had the ability to use the experience from both the 2004-2005 assessment and current assessment in assigning ratings, whereas the 2004-2005 assessment had less to reference and compare.

- Conditions at the time of assessment – The extent of vegetative cover and river stage at the time of assessment can impact the amount of bank exposed, and the resultant perception of conditions.

# 6.0 Conclusions and Recommendations

## 6.1 High Rated Erosion Areas

Based upon the analysis completed for this project, the areas with the highest erosion/erosion potential are listed below and presented in Figures 5-1 to 5-5.

| ID | Location | Description | Total Bank Length |
|---|---|---|---|
| JP1 | Johnson Park | Area within the golf course, right bank adjacent to golf hole #10. Contains steep failing banks and exposed soil. | 125 ft |
| JP2 | Johnson Park | Approximately 400 feet downstream of the eastern cart bridge (outside of golf course limits), mainly right bank with small portion of left bank. Contains steep failing banks and exposed soil along with high bluff on right bank. | 1,100 ft |
| JP3 | Johnson Park | Approximately 2,500 feet downstream of the eastern cart bridge (outside of golf course limits), along right bank. Contains steep failing banks and exposed soil. | 80 ft |
| CP1 | Colonial Park | Four small isolated areas, ranging in length from 25 to 100 feet, along both banks within Colonial Park. Contains steep failing banks and exposed soil. | 225 ft |
| SS1 | Along Spring Street, south of Lincoln Park | Areas south of the park along right bank and immediately upstream on the Wisconsin Department of Natural Resources (WDNR) Steelhead Facility. The majority of this section is owned by the City, but portions are privately owned. Contains steep failing banks and exposed soil. (Note – the City is already in process of designing improvements in this area with construction planned in 2014.) | 625 ft |
| SS2 | Along Spring Street, south of Lincoln Park | A small section of failing bulkhead wall along right bank on private property adjacent to Spring Street, across from Lincoln Park | 40 ft |

Note that areas within the Johnson Park golf course, adjacent to the western cart path bridge at golf hole #11, contained steep failing banks and exposed soil at the time of the assessment, and had a resultant high erosion rating. It also had a high rating in the 2004-2005 assessment. A stabilization project for this area was completed in the summer/fall of 2013, immediately after the assessment, and is therefore not included as one of the high rated areas in this report.

There are other areas that received medium to high erosion/erosion potential ratings. Some of these have other factors that should be considered when identifying important areas. These other areas, and their respective additional factors, include:

| ID | Location | Description | Total Bank Length |
|---|---|---|---|
| AM1 | Azarian Marina | Portion of the bulk headed section along right bank within private property (Azarian Marina, north of the intersection of Villa and Water Streets. This area is a high use (boat docks) and high profile area which could be incorporated in future riverwalk improvements. | 550 ft |
| CC1 | Case Corporation | Portion of the non-bulk headed section along the left bank within private property (Case Corporation) southeast of the intersection of Liberty and Superior Streets. This area is a high use and high profile area as it is adjacent to the City's bike/pedestrian path. | 500 ft |
| MA1 | Mound Avenue | Portion of the non-bulk headed section along the left bank adjacent to Mound Avenue between Marquette and 6th Streets. Also known as the West Bluff Overlook, this area has also been identified as an area to connect/expand the City's bike/pedestrian path and add public/park space. (Note – the City/County are already in process of planning improvements in the parcels that comprise this area), | 1,500 ft |
| WP1 | Washington Park | River bend within Washington Park, northwest of Park High School, along both banks. This area has moderate to high erosion, along with erosion on ravine bluffs, and erosion/damage to major storm sewer outfalls. This area is a high use and high profile area that is within a public park and golf course, and is adjacent to one of the City's high schools. (Note – the City is already in process of designing improvements in this area with construction planned in 2014.) | 1,200 ft |
| IL1 | Island and Lincoln Parks | There are several small isolated areas within Island and Lincoln Parks that have moderate to high erosion. Many of these are the result of foot traffic (e.g. anglers) accessing the river which have damaged the banks. There are also specific areas where trees are at risk of toppling resulting in ripped banks and flow blockage. | 250 ft +/- |

River systems are dynamic, and therefore conditions can change in the future where a lower rated area may become a priority.

In prioritizing these areas for future streambank stabilization work, several factors should be taken into account. These include total overall rating, property ownership, protection of infrastructure or parks, potential stream improvement, and cost. At this time, there are no obvious threats to safety of the public, or damage to dwellings or infrastructure in the high-rated sections. Stabilizing these sections of stream will improve the aesthetics, riparian habitat, and water quality of the river.

When considering a stabilization construction project, reference to this report should be made in conjunction with a field verification of current conditions, along with consideration of project specific goals, and criteria of any grant program being pursued.

## 6.2 Stabilization Methods

The 2-year discharge event occurs with sufficient frequency and with sufficient energy to have a dominant impact on the channel forming process. Attempts to reconfigure the channel itself should focus on designs around the 2-year discharge. This will require corrective strategies to incorporate one or all three of the following: armoring of the channel with stone and/or vegetation, creating a floodplain bench at the 1.5 to 2-year discharge level, deflecting the erosive forces away from the eroding banks. Stabilization will have to withstand the forces of the extreme flood flows (e.g. the 100-year discharge).

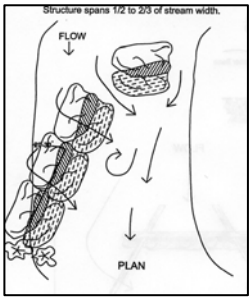
The methods applied to stabilize streambanks should be based on site-specific criteria such as nature and extent of erosion, stream dynamics, adjacent land use, soils, topography, and proximity to private property, structures, trees, and infrastructure. The general strategy in designing a streambank stabilization solution is to stabilize the toe of the slope and then slope and vegetate the bank. Alternative streambank stabilization practices are listed in Table 6-1.

Bioengineering solutions utilize living plant and/or organic materials or a combination of these materials and engineered products. The plant material portion establishes a root system that binds to the surrounding soil matrix and/or the engineered elements. While these methods are often labor-intensive to install, they often provide immediate bank protection and with time, long-term protection as the installation strengthens from further root growth. In addition, bioengineering solutions can be cost-effective, ecologically sensitive, improve water quality and wildlife habitat, and return the stream to a more natural appearance without adversely affecting the neighboring property.

Life expectancy for bioengineering techniques is dependent on the quality of the initial installation, the maintenance provided over the years, and the type of technique used. In general, these techniques grow stronger with each growing season, as the deep roots of the stabilizing vegetation become intertwined. If the vegetation becomes established and remains vigorous, these solutions can be effective for decades.

The following discussion highlights selected alternatives that appear to be most applicable to this project.

### 6.2.1 Instream Practices

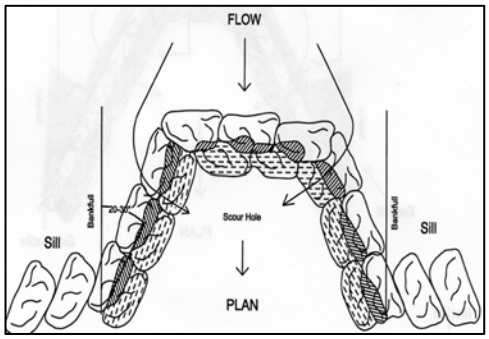



**Vanes or J-Hook Vanes –** Vanes protect the streambank by redirecting the thalweg (deepest point of flow in the channel) away from the streambank and towards the center of the channel. They also improve in-stream habitat through scour reduction, oxygenation and cover.

Vanes are bars typically constructed of rock that are oriented upstream with angles off the bank from 20 to 30 degrees. Vanes are located just down-stream of the point where the stream flow encounters the streambank at acute angles. The structure is highest next to the bank, generally starting at bankfull. The structures slope down, pointing upstream. The size of rock will depend on the size of the stream. Flat rocks are preferred because they are easier to place and stack additional rocks on top. The length of a single vane structure can span one-half to two-thirds of the base flow channel width. The slopes of the structure can range widely from 2 to 20 percent; however,

longer, flatter structures are preferred for maximum length of streambank protection and maximum habitat creation.
(NCSRI, 2003)

**Cross Vanes –** Cross vanes are used to provide grade control, to keep the thalweg in the center of the channel, and to protect the bank. These structures decrease near-bank shear stress, velocity and stream energy, but increase the energy in the center of the channel. The structure will establish grade control, reduce bank erosion, create a stable width/depth ratio, and maintain channel capacity, while maintaining sediment transport capacity, and sediment competence. A cross vane consists of two rock vanes and one center structure perpendicular to the flow. The center structure sets the invert grade of the streambed. Therefore, this structure can be used to raise the bed and is often used at the head of a riffle to set the elevation of the upstream pool.




## 6.2.2 Streambank Treatment

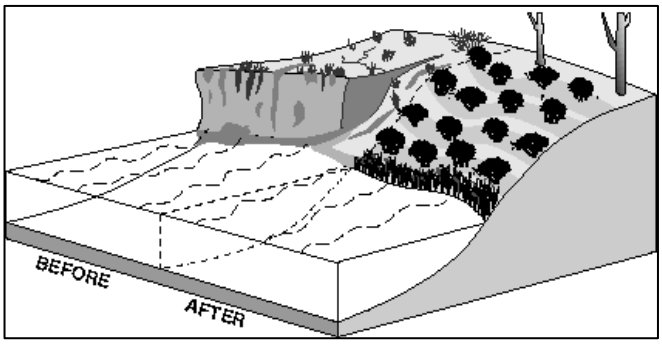
**Vegetative Pruning and Removal -** Prior to installation of bioengineered improvements, selective vegetative pruning, and removals can be performed within the project reach. The thinning of non-native and undesirable trees and shrub species increases sunlight allowing newly planted seeds and plugs to thrive in once shade suppressed areas. This is especially important for the north-facing slopes. Trees within the riparian zone can hinder stabilization by preventing sunlight from reaching ground vegetation. Trees can also add stress to the bank by their own weight, especially when leaning or overhanging. When trees within the riparian zone are removed, stabilization and habitat functions are mitigated by plantings of deep-rooted native species that strengthen soil matrices and thrive under conditions of occasional inundation.

Trees along a stream act as visual screens and noise barriers, and enhance or create new wildlife and aquatic habitat. However, dead and damaged trees should occasionally be removed to prevent debris jams within the stream channel and further erosion from subsequent movement into the channel. This includes trees that have fallen, are split, beaver girdled, or undercut by streambank erosion. Removal of roots is not generally recommended because they often hold the streambank together and their removal would likely provide an area where further erosion can occur. Trees that are partially undercut may be toppled by high winds, where the entire root wad is torn from the bank, creating a large, unprotected cavity in the bank. In some cases, the tree is flush cut, leaving the root wad in place to maintain reinforcement of the soil, and then covered with topsoil fill, erosion control fabrics, and vegetation for additional protection and stability.

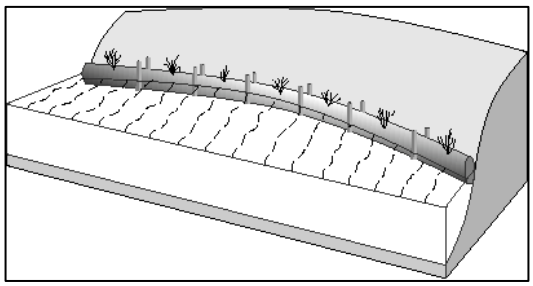
**Vegetation Selection –** A combination of stabilization seed mix and shrub cuttings are commonly utilized to mitigate for the loss of existing vegetation (as mentioned above). The stabilization seed mix is combined with a permanent or temporary erosion control blanket and is comprised of the following components: 1) a mix of deep-rooted riparian and native species that tolerate and thrive under occasional inundation and wet conditions while also tolerant to both sun and shade, 2) a blend of annual and perennial native wildflowers and forbs to add visual interest to the mix upon establishment, 3) a temporary cover crop of Canada wild rye to provide immediate erosion protection until the permanent seed matrix is established. Table 6-2 provides a typical seed mix and application rates that have been used successfully on other streambank stabilization projects in the Midwest.

Shrub cuttings are an integral component of bioengineering techniques. Combinations of sandbar willow (Salix exigua) and red-osier dogwood (Cornus stolonifera) can be used successfully. Willows are typically installed in sunny locations while dogwoods are installed in shaded areas. Both species are tolerant of periodic inundation and have aggressive rooting capabilities in most locations that can stabilize soils quickly.

**Slope Regrading** - One common method of stabilization involves slope regrading of steep eroded slopes to a stable angle of repose. Following regrading of the slope, a stabilization seed mix is applied and then covered with either permanent or temporary erosion control blanket. This type of installation can be used in combination with other stabilization techniques.

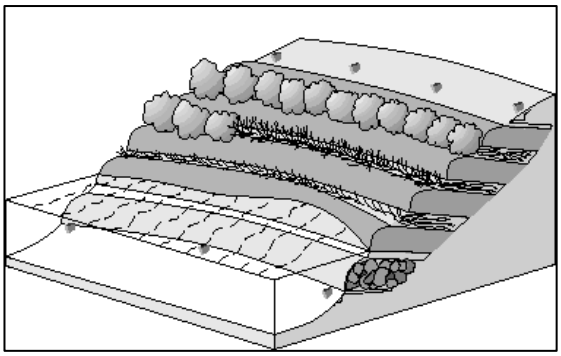



**Coir Fiber Roll -** Coir fiber roll is often utilized in areas experiencing stable/slight to moderate bank erosion. It is fabricated from coir, a coconut fiber with high tensile strength, moisture and nutrient retention properties, and a slow decomposition rate. As this natural fiber biodegrades plantings mature and spread, reinforcing the area around the fiber roll installation. This installation becomes stronger and improves with age. The fiber roll units typically specified are constructed of high-density, flexible rolls of coir fiber that are tightly bound with a braided synthetic mesh, are 12-inches in diameter and 20-feet long.

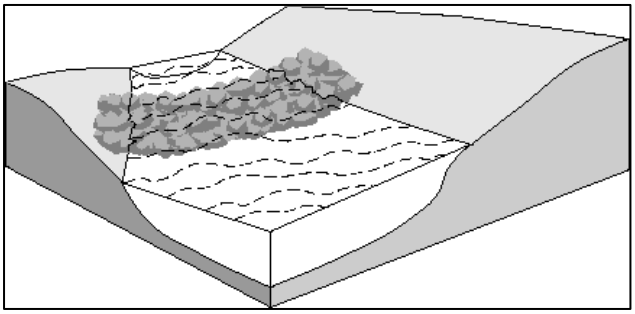


Fiber roll is generally installed either by itself at the toe of bank or in combination with erosion control blanket on a regraded slope. The former may apply to areas of stable/slight bank erosion at the toe where fiber roll is staked directly into an eroded void without trenching or excavation, other than to assure a tight fit against the bank. This application creates a naturally contoured edge that follows the existing streambank. No upslope treatment other than installation of shrub cuttings is provided.

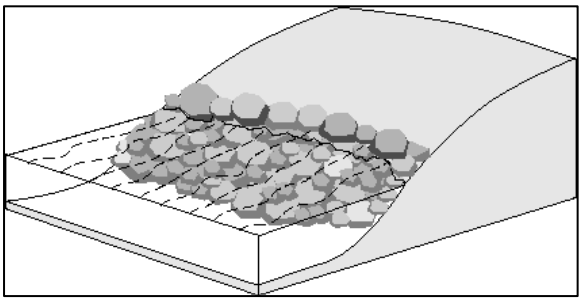
An installation of fiber roll at the toe with erosion control blanket over a regraded slope can be applied to areas of moderate bank erosion. Fiber roll is trenched into the streambed, staked, and wired down to temporarily protect the material until the plantings become established. Permanent erosion control blanket constructed of coir fiber between polypropelene mesh fabric is then installed immediately above the fiber roll on the regraded upslope area. The bottom edge of the blanket is buried under and fastened to the fiber roll, the regraded area just upslope of the fiber then receives a stabilization seed mix, and then the blanket is rolled upslope over the seeded area and staked. Upslope and upstream blanket edges are also be buried beneath soil in a shallow trench for protection against high water flows. Shrub cuttings are then inserted into the compacted backfill material between the fiber roll and the bottom edge of the upslope area and covered in permanent erosion blanket.



**Vegetated Geogrids -** Vegetated Geogrids are used to restore failed or severely scoured streambanks in areas of high erosive impact. Vegetated Geogrids are used primarily in areas of very steep slopes where regrading is not possible due to structural or other obstructions. For this project, there are several locations where existing trees of value could be preserved using this technique. Vegetated Geogrids are constructed of 12-inch to 15-inch thick lifts of compacted topsoil with a seed mix of deep-rooted native grasses, wrapped in permanent erosion control fabric with live plant material cuttings inserted between the lifts. Either A-Jacks or lunkers with riprap and compacted fill can form the base of the structure. The top of the structure blends into the existing grade at the top of bank and is constructed of temporary erosion control blanket over graded topsoil and stabilization seed mix. This method, while highly effective and often the most appropriate option, is labor and material intensive, and subsequently, are the most costly of the treatments.



**Grade Control Measures** – Grade controls are very similar to cross vanes, and are very effective in slowing velocities with a stream. They are often designed as drop structures (step-pool configuration) or as a series of riffles-pools. Typically constructed of rock, wood, or other material, these structures are placed across the channel and anchored in the streambanks. This provides a "hard point" in the streambed that resists the erosive forces of the degradation zone, and/or reduces the upstream energy slope to prevent bed scour. Some designs are simple notched logs across a stream or rock. Other designs strategically placed boulders, which are more difficult to handle but capable of withstanding much higher flows.



**Rock Toe Protection –** Rocks installed for toe protection are commonly used in moderate to severely eroded areas found typically along the outside bank of a stream bend, and along banks comprised of highly erodible soils (sand and silt). The rock is used only on the toe of the bank, keyed into the streambed and streambank, with grading and vegetation of the upper portion of the bank.

**Retaining Wall Structures –** Retaining walls are usually only applied when site limitations (e.g. structures and/or utilities) don't allow for other treatments. Modular block walls with mechanically stabilized earth (MSE) retaining walls with modular blocks can be a cost effective, long-term approach to repairing a severely eroded bank or replacing a failing bank structure. It has been utilized extensively under similar bank stabilization conditions, can withstand tremendous forces, and requires minimal excavation and no mortar or steel reinforcement. Other techniques include steel sheeting, or

reinforced concrete. Site specific conditions, including channel characteristics and soil conditions, should be considered when ultimately selecting a retaining wall system.

The images used in this section are from the document Stream Corridor Restoration: Principles, Processes, and Practices (NEH-653), by the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN3/PT.653. ISBN-0-934213-59-3. Additional information on streambank stabilization techniques can also be found in this document.

## 6.3 Recommended Treatments

Based on experience from the previous assessment and stabilization projects, and as previously stated, implementation of actual stabilization measures are site specific, taking into account the nature and extent of erosion, stream dynamics, adjacent land use, soils, topography, and proximity to private property, structures, trees, and infrastructure. Also as stated, river systems are dynamic, and therefore conditions change. What may be a feasible stabilization technique today may not be years after this document was completed. Therefore, site specific solutions are not included. The techniques discussed in the previous section are likely techniques in stabilizing the banks of the river in most of the eroded sections.

## 6.4 Special Features

Trees have grown in along portions of the bank to the point where they completely shade the banks and suppress the growth of ground vegetation. The lack of ground vegetation is a significant cause of erosion on portions of this stream. A strong population of native vegetation with long root systems capable of holding soil in place is essential to maintaining a stable channel. Selective tree removal along some reaches could provide additional sunlight to help establish vegetation necessary for a successful stabilization project. The removal of some existing trees could prevent further erosion and create the conditions required to stabilize the banks.

In some cases where trees are immediately at the bank, the soil around the roots has eroded during high flows in the channel. This exposure causes the tree to lose its anchor to the ground, and the tree can easily be toppled. Trees can also add stress to the bank by their own weight, especially when leaning or overhanging. The failure causes severe damage to the bank by loosening the soil and leading to further erosion. Select removal of the trees with the worse exposed roots and/or highest risk of toppling will reduce the risk of bank instability. The roots should be left intact to help stabilize the bank.

## 6.5 Outfall Replacements

Seven outfalls were listed on Table 5-7 as being in poor condition. These outfalls are either cracked, crushed, have pipe section sliding off, or have significant sediment accumulation. These outfalls should be considered to be cleaned, replaced, repaired, and/or augmented with additional protection, such as riprap or wing walls. Some of these activities could be incorporated into another capital improvement plan (e.g. road reconstruction, utility replacements).

## 6.6 Maintenance

Maintenance of installed streambank stabilization methods is essential to ensure initial and continued erosion protection. Bioengineering solutions provide increased protection over time, as the deep roots of the stabilizing vegetation become established.

The City and property owners adjacent to stabilization projects should periodically inspect the area and provide routine maintenance. Immediately following installation, the following maintenance procedures are recommended:

- Avoid trampling soil before vegetation is established.
- Maintain adequate moisture level for plants until vegetation is established.
- Protect vegetation; particularly live stakes, with fencing or other means, if damage from animals eating stakes is apparent.
- Pound any loose construction stakes holding coir fiber rolls into soil until secure.
- Replace damaged or dead live stakes and vegetation.

Routine maintenance procedures to sustain the stabilization application include the following:

- Monitor condition of application for defects.
- Monitor encroachment of exotic and invasive vegetation and remove undesirable species.
- Remove dead or damaged trees (flush cut within treatment areas) and limbs.
- Remove fallen woody material and debris from the stream.
- Repair or replace damaged stabilization material as needed.
- Do not fertilize plantings on or near the streambank.
- Do not mow within 20 feet of the top of treatment to provide buffer between the stabilization area and adjacent uses.
- Prune and selectively cut live brush to reduce shade canopy and maintain healthy plants.
- Allow stabilizing vegetation to grow unmowed throughout growing season. Mowing of temporary cover crops may be desirable to encourage growth of the native plantings and to reduce thatch buildup.
- Treat plants if infested by insects or disease.
- Remove cuttings and yard waste along or in channel.

Maintenance costs vary relative to the form of stabilization treatment applied. Maintenance costs are difficult to estimate, as they may be combined or shared with other maintenance and may also vary based on differing cycles of maintenance. For example, a 2-year to 3-year maintenance cycle would be more cost-effective than a 5-year cycle by minimizing cumulative problems.

## 6.7 Permitting

State, Federal, and Municipal permits may be required prior to completing construction activities. Any work related to navigable waterways, wetlands, or floodplains requires permits from one or more regulatory authorities. Applicable permits will require the project proponent to justify the project purpose and need, and evaluate practicable alternatives to avoid and minimize impacts to the environment. Depending on the nature and extent of the project, permits may require three to 12 months for approval. During the preliminary design phase, a pre-application meeting is recommended to introduce the regulatory agencies to the project. Agency review during this meeting will identify the applicable permits and expedite approval schedules.

Additional site-specific information may be required as part of the permitting process. This information includes: wetland delineation, navigability determination, ordinary high watermark (OHWM) determination, and aquatic and vegetation habitats.

Each alternative will require a similar level of permitting and agency involvement. The following is a list of applicable permits that may be required for a stabilization project:

1. Federal – Section 404 Wetland Permits.
2. State – Chapter 30 Waterway Permits; NR 103 Practicable Alternatives Analysis (wetland); NR 216 Erosion Control Permit.
3. City – NR 117 Shoreland Zoning Ordinance, Special Exemption Permit.
4. Construction easement for private properties.

# 7.0 Project Implementation

## 7.1 Cost Estimating Methods

The estimated implementation costs are approximate and are to be used only for long-term budgetary planning. Additional site-specific and materials data would be necessary to develop a detailed estimate. During preliminary design, the appropriate surveys and geotechnical investigations must be conducted to verify and adjust initial recommendations and projected cost of construction to reflect any changes in stream morphology since the streambank erosion assessment date.

The planning level cost estimates for various stabilization treatments are based on unit costs obtained from several sources including recent bid tabulations for similar projects and similar construction experience. The individual unit costs include materials, equipment, labor, and contractor overhead and profit where applicable, and range from $100/ft to $300/ft.

Table 7-1 presents estimated unit costs (material and installation only) for each stream stabilization practice considered feasible for this project. Actual costs depend on amount of excavation and grading associated with the project and the number and type of vegetation specified.

## 7.2 Priority Stream Segment Costs

The estimated conceptual construction costs for the priority sites are presented in Tables 7-2 through 7-12. Included in the estimates were mobilization, construction, engineering, permitting, program administration (inspection), and contingency. The cost of engineering is assumed to be 15 percent of the construction cost, and construction inspection an additional 10 percent. Permitting was estimated at five percent of construction and a contingency of 15 percent of the construction cost was included to cover unknown costs, difficult subsurface conditions, or increases in material and labor rates.

Because many of the site specific conditions are not know, it was assumed for the cost estimates that the stabilization projects would include typical bank grading, re-vegetation, and rock toe, with the exception of those projects anticipated to have retaining wall.

## 7.3 Outfall Replacement Costs

The estimated planning level replacement costs for the seven priority sites are presented in Table 7-13. Included in the estimates were mobilization, construction, engineering, permitting, program administration (inspection), and contingency.

## 7.4 Funding Opportunities

Securing funding opportunities to undertake stream stabilization projects is critical to future planning and implementation of recommendations for the Root River. Many funds are in the form of grants which are part of broad-based cooperative initiatives offered by a variety of local, state, federal, and private funding sources. Identifying funding sources is a crucial step toward effective restoration goals/objectives. Table 7-14 provides a list of funding sources that might be used to assist in funding the Root River projects.

# 8.0 References

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# Tables

**TABLE 3-1**

**HISTORICAL DESIGN / CONSTRUCTION PROJECTS**

| Where | Project Details | Funding |
|---|---|---|
| Island Park (2004) | This project is located on the left bank of the right (west) channel in Island Park immediately downstream on the bike path bridge on the north west side of Island Park. The project consisted of stabilizing 100 linear feet of the south side (left bank) of the Root River. The project consisted of regarding the bank and replacing turf grass and bare areas with native vegetation. At the toe, concrete A-Jacks were installed. A lesson learned from this project was that A-Jacks, while potentially a valid stabilization measure in some instance, have been damaged and have failed to .some degree, partly due to fishermen who have accessed the water. Traditional rip rap may be a more reliable toe measure. | This project was partially funded through a grant in the amount of $30,000 from the Great Lakes Basin Program for Soil Erosion and Sediment Control. The balance of the project (36,500) was paid out of the City Storm Water Utility.<br><br>Total project cost (design and construction) was $66,500. |
| Island Park (2006) | This project is located on the left bank of the right (west) channel in Island Park immediately downstream on the foot bridge adjacent to Racine Lutheran High School. The project included grading banks and stabilizing with native plantings, along with installation of J-hook vanes. The project stabilized approximately 200 feet of bank. | |

| Where | Project Details | Funding |
|---|---|---|
| Colonial Park 2009 | This project consisted of the final design and construction of a total of approximately 300 linear feet of streambank stabilization in Colonial Park, along with select cutting of several trees that were at risk of toppling (trunk/root left in place). Stabilization methods included grading a more stable side-slope and planting with seed and plugs in addition to a rock toe to protect the bank from erosion. | This project was partially funded through a Urban Nonpoint Source Grant from the WDNR.<br><br>Total project cost (design and construction) was approximately $100,000. |
| Johnson Park 2013 | This project consisted of the final design and construction of a total of approximately 600 linear feet of streambank stabilization in Colonial Park, along with select cutting of several trees that were at risk of toppling (trunk/root left in place). Stabilization methods included grading a more stable side-slope and planting with seed and plugs in addition to a rock toe to protect the bank from erosion. | This project was partially funded through a Urban Nonpoint Source Grant from the WDNR.<br><br>Total project cost (design and construction) was approximately $100,000. |
| Hoods Creek 2013 | Hoods Creek runs along the northeastern portion of the park. The creek, over time, has caused significant bank erosion along a portion of the golf course that is approximately 150 feet. The bank erosion threatened damage to a golf green and tee box. Because of the significant need to protect property. the bank was armored with rock. | The total project cost (design and construction) was approximately $55,000. |
| Spring/Washington 2014 | Anticipated work.<br>Includes two locations: (1) approximately 500 feet on bank on the right bank immediately upstream of the Steelhead Facility, and (2)in Washington Park directly north of 12$^{th}$ Street and west of Linden Avenue. Total work will likely consist of grading and stabilizing of approximately 1,000 feet of banks with native vegetation, repairing existing storm sewer outfalls, and stabilizing bluffs in Washington Park. | This project is partially funded through a Urban Nonpoint Source Grant from the WDNR and a grant from the Fund for Lake Michigan.<br><br>Total project cost (design and construction) is estimated at approximately $700,000. |

## TABLE 5-1

## BANK ERODIBILITY HAZARD INDEX

| | | | | | | | | | | | | Hazard Rating [2] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Bank Material [1] | Bank Height (ft) [1] | Bankfull Height (ft) [1] | Bank Height/ Bankfull Height | Root Depth (ft) [1] | Root Depth/ Bank Height | Root Density [1] | Weighted Root Density | Bank Angle (%) | Height of Surface Protection [1] | Weighted Surface Protection | Bank Height/ Bankfull Height | Root Depth/ Bank Height | Weighted Root Density | Bank Angle (%) | Weighted Surface Protection | Bank Material Adjustment | BEHI Rating | Ranking |
| colonial | Clay | 4 | 3 | 1.33 | 1 | 0.25 | 80 | 20 | 75 | 0 | 0 | 4.8 | 6.5 | 7.2 | 5.4 | 10.0 | 0 | 34.0 | 20 |
| dogpark1 | Clay | 3 | 2 | 1.50 | 1 | 0.33 | 60 | 20 | 90 | 0 | 0 | 5.9 | 5.6 | 7.2 | 7.9 | 10.0 | 0 | 36.6 | 20 |
| dogpark2 | Clay | 4 | 3 | 1.33 | 1 | 0.25 | 50 | 13 | 90 | 0 | 0 | 4.8 | 6.5 | 8.2 | 7.9 | 10.0 | 0 | 37.5 | 20 |
| island park 1 | Manmade Modification | 25 | 4 | 6.25 | 1 | 0.04 | 70 | 3 | 75 | 20 | 80 | 10.0 | 10.0 | 10.0 | 5.4 | 1.9 | 0 | 37.3 | 20 |
| island park 2 | Manmade Modification | 15 | 5 | 3.00 | 1 | 0.07 | 60 | 4 | 75 | 5 | 33 | 10.0 | 8.8 | 10.0 | 5.4 | 5.6 | 0 | 39.8 | 20 |
| island park 3 | Manmade Modification | 5 | 4 | 1.25 | 1 | 0.20 | 30 | 6 | 60 | 4 | 80 | 4.3 | 7.2 | 8.9 | 3.9 | 1.9 | 0 | 26.2 | 10 |
| island park 4 | Manmade Modification | 15 | 5 | 3.00 | 2 | 0.13 | 50 | 7 | 70 | 3 | 20 | 10.0 | 8.1 | 8.8 | 4.9 | 7.2 | 0 | 39.0 | 20 |
| r10sa1 | Clay | 5 | 4 | 1.25 | 2 | 0.40 | 50 | 20 | 30 | 0 | 0 | 4.3 | 4.9 | 7.2 | 2.4 | 10.0 | 0 | 28.9 | 10 |
| r11sa1 | Clay | 8 | 5 | 1.60 | 2 | 0.25 | 30 | 8 | 60 | 2 | 25 | 6.0 | 6.5 | 8.7 | 3.9 | 6.5 | 0 | 31.7 | 20 |
| r11sa2 | Manmade Modification | 6 | 6 | 1.00 | 1 | 0.17 | 40 | 7 | 70 | 3 | 50 | 1.0 | 7.7 | 8.8 | 4.9 | 4.3 | 0 | 26.7 | 10 |
| r12sa1 | Clay | 6 | 4 | 1.50 | 2 | 0.33 | 70 | 23 | 30 | 0 | 0 | 5.9 | 5.6 | 6.8 | 2.4 | 10.0 | 0 | 30.7 | 20 |
| r12sa2 | Manmade Modification | 7 | 6 | 1.17 | 2 | 0.29 | 50 | 14 | 80 | 4 | 57 | 3.3 | 6.1 | 8.0 | 5.9 | 3.7 | 0 | 27.0 | 10 |
| r12sa3 | Clay | 6 | 4 | 1.50 | 1 | 0.17 | 90 | 15 | 30 | 0 | 0 | 5.9 | 7.7 | 7.9 | 2.4 | 10.0 | 0 | 33.9 | 20 |
| r12sa4 | Manmade Modification | 10 | 5 | 2.00 | 2 | 0.20 | 70 | 14 | 70 | 5 | 50 | 7.9 | 7.2 | 8.0 | 4.9 | 4.3 | 0 | 32.3 | 20 |
| r13sa1 | Manmade Modification | 5 | 4 | 1.25 | 1 | 0.20 | 70 | 14 | 80 | 4 | 80 | 4.3 | 7.2 | 8.0 | 5.9 | 1.9 | 0 | 27.3 | 10 |
| r13sa2 | Manmade Modification | 5 | 3 | 1.67 | 2 | 0.40 | 70 | 28 | 80 | 4 | 80 | 6.3 | 4.9 | 6.1 | 5.9 | 1.9 | 0 | 25.2 | 10 |
| r13sa3a | Clay | 5 | 5 | 1.00 | 1 | 0.20 | 40 | 8 | 45 | 0 | 0 | 1.0 | 7.2 | 8.7 | 3.2 | 10.0 | 0 | 30.1 | 20 |
| r14sa1 | Clay | 5 | 3 | 1.67 | 2 | 0.40 | 80 | 32 | 45 | 3 | 50 | 6.3 | 4.9 | 5.7 | 3.2 | 4.3 | 0 | 24.4 | 10 |
| r14sa1a | Manmade Modification | 6 | 5 | 1.20 | 1 | 0.17 | 70 | 12 | 80 | 5 | 83 | 4.0 | 7.7 | 8.3 | 5.9 | 1.8 | 0 | 27.6 | 10 |
| r14sa1b | Manmade Modification | 15 | 5 | 3.00 | 3 | 0.20 | 30 | 6 | 70 | 5 | 33 | 10.0 | 7.2 | 8.9 | 4.9 | 5.6 | 0 | 36.6 | 20 |
| r14sa2 | Manmade Modification | 20 | 4 | 5.00 | 2 | 0.10 | 50 | 5 | 60 | 6 | 30 | 10.0 | 8.4 | 9.0 | 3.9 | 5.9 | 0 | 37.2 | 20 |
| r14sa3 | Manmade Modification | 10 | 4 | 2.50 | 2 | 0.20 | 60 | 12 | 60 | 4 | 40 | 8.6 | 7.2 | 8.2 | 3.9 | 5.1 | 0 | 33.0 | 20 |
| r15sa1 | Clay | 6 | 2 | 3.00 | 1 | 0.17 | 70 | 12 | 60 | 0 | 0 | 10.0 | 7.7 | 8.3 | 3.9 | 10.0 | 0 | 39.8 | 20 |
| r15sa2 | Manmade Modification | 6 | 3 | 2.00 | 1 | 0.17 | 70 | 12 | 45 | 3 | 50 | 7.9 | 7.7 | 8.3 | 3.2 | 4.3 | 0 | 31.3 | 20 |
| r15sa3 | Manmade Modification | 4 | 2 | 2.00 | 2 | 0.50 | 90 | 45 | 30 | 2 | 50 | 7.9 | 3.9 | 4.7 | 2.4 | 4.3 | 0 | 23.3 | 10 |
| r15sa4 | Clay | 6 | 2 | 3.00 | 3 | 0.50 | 80 | 40 | 45 | 0 | 0 | 10.0 | 3.9 | 5.1 | 3.2 | 10.0 | 0 | 32.2 | 20 |

## TABLE 5-1

## BANK ERODIBILITY HAZARD INDEX

| | | | | | | | | | | | | Hazard Rating [2] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Bank Material [1] | Bank Height (ft) [1] | Bankfull Height (ft) [1] | Bank Height/ Bankfull Height | Root Depth (ft) [1] | Root Depth/ Bank Height | Root Density [1] | Weighted Root Density | Bank Angle (%) | Height of Surface Protection [1] | Weighted Surface Protection | Bank Height/ Bankfull Height | Root Depth/ Bank Height | Weighted Root Density | Bank Angle (%) | Weighted Surface Protection | Bank Material Adjustment | BEHI Rating | Ranking |
| r16sa1 | Clay | 8 | 5 | 1.60 | 1 | 0.13 | 30 | 4 | 80 | 0 | 0 | 6.0 | 8.2 | 10.0 | 5.9 | 10.0 | 0 | 40.1 | 30 |
| r17sa1 | Manmade Modification | 6 | 3 | 2.00 | 1 | 0.17 | 60 | 10 | 45 | 3 | 50 | 7.9 | 7.7 | 8.4 | 3.2 | 4.3 | 0 | 31.5 | 20 |
| r18sa1 | Manmade Modification | 6 | 3 | 2.00 | 3 | 0.50 | 80 | 40 | 90 | 6 | 100 | 7.9 | 3.9 | 5.1 | 7.9 | 1.0 | 0 | 25.8 | 10 |
| r19sa1 | Manmade Modification | 10 | 2 | 5.00 | 2 | 0.20 | 60 | 12 | 45 | 6 | 60 | 10.0 | 7.2 | 8.2 | 3.2 | 3.5 | 0 | 32.1 | 20 |
| r19sa2 | Clay | 50 | 2 | 25.00 | 2 | 0.04 | 40 | 2 | 70 | 0 | 0 | 10.0 | 10.0 | 10.0 | 4.9 | 10.0 | 0 | 44.9 | 30 |
| r20sa1 | Clay | 20 | 6 | 3.33 | 2 | 0.10 | 50 | 5 | 75 | 0 | 0 | 10.0 | 8.4 | 9.0 | 5.4 | 10.0 | 0 | 42.8 | 30 |
| r21sa1 | Bedrock | 15 | 6 | 2.50 | 2 | 0.13 | 50 | 7 | 90 | 8 | 53 | 8.6 | 8.1 | 8.8 | 7.9 | 4.1 | -15 | 22.4 | 10 |
| r22sa1 | Clay | 6 | 5 | 1.20 | 2 | 0.33 | 80 | 27 | 60 | 0 | 0 | 4.0 | 5.6 | 6.3 | 3.9 | 10.0 | 0 | 29.8 | 10 |
| r22sa2 | Clay | 4 | 2 | 2.00 | 1 | 0.25 | 80 | 20 | 75 | 0 | 0 | 7.9 | 6.5 | 7.2 | 5.4 | 10.0 | 0 | 37.1 | 20 |
| r23sa1 | Clay | 12 | 5 | 2.40 | 1 | 0.08 | 30 | 3 | 80 | 0 | 0 | 8.4 | 8.6 | 10.0 | 5.9 | 10.0 | 0 | 43.0 | 30 |
| r23sa2 | Clay | 4 | 3 | 1.33 | 2 | 0.50 | 60 | 30 | 60 | 0 | 0 | 4.8 | 3.9 | 5.9 | 3.9 | 10.0 | 0 | 28.5 | 10 |
| r23sa3 | Clay | 3 | 3 | 1.00 | 1 | 0.33 | 75 | 25 | 80 | 0 | 0 | 1.0 | 5.6 | 6.5 | 5.9 | 10.0 | 0 | 29.0 | 10 |
| r23sa4 | Clay | 6 | 6 | 1.00 | 1 | 0.17 | 50 | 8 | 80 | 1 | 17 | 1.0 | 7.7 | 8.6 | 5.9 | 7.7 | 0 | 30.9 | 20 |
| r23sa5 | Clay | 5 | 4 | 1.25 | 2 | 0.40 | 75 | 30 | 90 | 0 | 0 | 4.3 | 4.9 | 5.9 | 7.9 | 10.0 | 0 | 33.0 | 20 |
| r23sa6 | Clay | 4 | 3 | 1.33 | 1 | 0.25 | 60 | 15 | 80 | 0 | 0 | 4.8 | 6.5 | 7.9 | 5.9 | 10.0 | 0 | 35.2 | 20 |
| r3sa1 | Clay | 3 | 3 | 1.00 | 2 | 0.67 | 60 | 40 | 45 | 0 | 0 | 1.0 | 3.1 | 5.1 | 3.2 | 10.0 | 0 | 22.4 | 10 |
| r4sa1 | Clay | 4 | 4 | 1.00 | 1 | 0.25 | 70 | 18 | 75 | 0 | 0 | 1.0 | 6.5 | 7.6 | 5.4 | 10.0 | 0 | 30.5 | 20 |
| r4sa2 | Clay | 3 | 2 | 1.50 | 1 | 0.33 | 70 | 23 | 60 | 0 | 0 | 5.9 | 5.6 | 6.8 | 3.9 | 10.0 | 0 | 32.1 | 20 |
| r5sa1 | Clay | 6 | 3 | 2.00 | 2 | 0.25 | 90 | 23 | 33 | 0 | 0 | 7.9 | 6.5 | 6.9 | 2.6 | 10.0 | 0 | 33.9 | 20 |
| r5sa2 | Clay | 5 | 3 | 1.67 | 1 | 0.20 | 50 | 10 | 75 | 0 | 0 | 6.3 | 7.2 | 8.4 | 5.4 | 10.0 | 0 | 37.4 | 20 |
| r6sa1 | Clay | 6 | 4 | 1.50 | 1 | 0.17 | 50 | 8 | 75 | 0 | 0 | 5.9 | 7.7 | 8.6 | 5.4 | 10.0 | 0 | 37.6 | 20 |
| r7sa1 | Clay | 4 | 2 | 2.00 | 1 | 0.25 | 75 | 19 | 60 | 0 | 0 | 7.9 | 6.5 | 7.4 | 3.9 | 10.0 | 0 | 35.7 | 20 |
| r8sa1 | Manmade Modification | 8 | 7 | 1.14 | 1 | 0.13 | 70 | 9 | 45 | 7 | 88 | 2.8 | 8.2 | 8.6 | 3.2 | 1.6 | 0 | 24.3 | 10 |
| r8sa3 | Clay | 5 | 4 | 1.25 | 2 | 0.40 | 60 | 24 | 45 | 0 | 0 | 4.3 | 4.9 | 6.7 | 3.2 | 10.0 | 0 | 29.1 | 10 |
| r8sa2 | Clay | 3 | 3 | 1.00 | 2 | 0.67 | 80 | 53 | 80 | 0 | 0 | 1.0 | 3.1 | 4.1 | 5.9 | 10.0 | 0 | 24.0 | 10 |
| r8sa4 | Manmade Modification | 5 | 4 | 1.25 | 1 | 0.20 | 60 | 12 | 45 | 5 | 100 | 4.3 | 7.2 | 8.2 | 3.2 | 1.0 | 0 | 23.9 | 10 |
| r9sa1 | Clay | 4 | 3 | 1.33 | 1 | 0.25 | 75 | 19 | 30 | 0 | 0 | 4.8 | 6.5 | 7.4 | 2.4 | 10.0 | 0 | 31.2 | 20 |
| r9sa2 | Clay | 5 | 4 | 1.25 | 2 | 0.40 | 70 | 28 | 30 | 0 | 0 | 4.3 | 4.9 | 6.1 | 2.4 | 10.0 | 0 | 27.8 | 10 |

Notes:

[1] Field Data

[2] From BEHI Worksheet

Red = Very High BEHI Rating
Orange = High BEHI Rating
Yellow = Moderate BEHI Rating
Green = Low BEHI Rating

## TABLE 5-2

## PFANKUCH CHANNEL STABILITY RATING

| Location | Bank Angle (%) | | Mass Wasting | | Debris Jam Potential | | Veg_ Bank Protection | | Channel Capacity | | Bank Rock Content | | Obstructions to Flow | | Cutting | | Deposition | | Rock Angularity | | Brightness | | Consolidation | | Bottom Size Distrib_ | | Scouring/ Deposition | | Aquatic Vegetation | | Pfankuch Rating | Stream Type | Reach Condition | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| colonial | <30% | 2 | Infrequent | 6 | Moderate to heavy | 6 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Frequent | 6 | Some intermittent | 6 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Mod. change is size | 12 | 5-30% | 12 | Scarce or absent | 4 | 85 | B5 | FAIR | 10 |
| dogpark1 | <30% | 2 | No Evidence | 3 | Moderate to heavy | 6 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | Slight dist. shift | 8 | 5-30% | 12 | Present, but spotty | 3 | 69 | F5 | GOOD | 5 |
| dogpark2 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Some intermittent | 6 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Present, but spotty | 3 | 75 | F4 | GOOD | 5 |
| island park 1 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 60 | G5 | GOOD | 5 |
| island park 2 | <30% | 2 | No Evidence | 3 | Absent | 2 | <50% density | 12 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 60 | C5 | GOOD | 5 |
| island park 3 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 61 | B5 | GOOD | 5 |
| island park 4 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 63 | G5 | GOOD | 5 |
| r10sa1 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 61 | F5 | GOOD | 5 |
| r11sa1 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 72 | B5 | FAIR | 10 |
| r11sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 69 | G5 | GOOD | 5 |
| r12sa1 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 60 | B5 | GOOD | 5 |
| r12sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 61 | G5 | GOOD | 5 |
| r12sa3 | <30% | 2 | Infrequent | 6 | Absent | 2 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 65 | B6 | FAIR | 10 |
| r12sa4 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Barely contains peak | 3 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 61 | B6 | GOOD | 5 |
| r13sa1 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 56 | B4 | GOOD | 5 |
| r13sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 56 | B6 | GOOD | 5 |
| r13sa3a | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 63 | B6 | FAIR | 10 |

## TABLE 5-2

## PFANKUCH CHANNEL STABILITY RATING

| Location | Bank Angle (%) | | Mass Wasting | | Debris Jam Potential | | Veg_ Bank Protection | | Channel Capacity | | Bank Rock Content | | Obstructions to Flow | | Cutting | | Deposition | | Rock Angularity | | Brightness | | Consolidation | | Bottom Size Distrib_ | | Scouring/ Deposition | | Aquatic Vegetation | | Pfankuch Rating | Stream Type | Reach Condition | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r14sa1 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 58 | B5 | GOOD | 5 |
| r14sa1a | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 60 | B5 | GOOD | 5 |
| r14sa1b | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 59 | B5 | GOOD | 5 |
| r14sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 73 | F5 | GOOD | 5 |
| r14sa3 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Ample (+ increase) | 1 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 70 | F6 | GOOD | 5 |
| r15sa1 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Some intermittent | 6 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 77 | F6 | GOOD | 5 |
| r15sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Ample (+ increase) | 1 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Some intermittent | 6 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 69 | F5 | GOOD | 5 |
| r15sa3 | <30% | 2 | No Evidence | 3 | Absent | 2 | 90%+ density | 3 | Ample (+ increase) | 1 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 58 | F5 | GOOD | 5 |
| r15sa4 | #### | FALSE | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Ample (+ increase) | 1 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 59 | F4 | GOOD | 5 |
| r15sa5 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | <50% density | 12 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 66 | F6 | GOOD | 5 |
| r15sa6 | <30% | 2 | No Evidence | 3 | Absent | 2 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 54 | F5 | GOOD | 5 |
| r16sa1 | <30% | 2 | Infrequent | 6 | Moderate to heavy | 6 | <50% density | 12 | Barely contains peak | 3 | 40-60% small cobbles | 4 | Some Present | 4 | Significant | 12 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 84 | E4 | FAIR | 10 |
| r17sa1 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 60 | F6 | GOOD | 5 |
| r18sa1 | <30% | 2 | No Evidence | 3 | Absent | 2 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 52 | F5 | GOOD | 5 |
| r19sa1 | <30% | 2 | No Evidence | 3 | Absent | 2 | 50-70% density | 9 | Ample (+ increase) | 1 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 58 | F6 | GOOD | 5 |
| r19sa2 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Ample (+ increase) | 1 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Some intermittent | 6 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | Mod. change is size | 12 | <5% | 6 | Scarce or absent | 4 | 72 | F6 | GOOD | 5 |

## TABLE 5-2

## PFANKUCH CHANNEL STABILITY RATING

| Location | Bank Angle (%) | | Mass Wasting | | Debris Jam Potential | | Veg_ Bank Protection | | Channel Capacity | | Bank Rock Content | | Obstructions to Flow | | Cutting | | Deposition | | Rock Angularity | | Brightness | | Consolidation | | Bottom Size Distrib_ | | Scouring/ Deposition | | Aquatic Vegetation | | Pfankuch Rating | Stream Type | Reach Condition | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| r20sa1 | 30-40% | 4 | No Evidence | 3 | Absent | 2 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Moderate | 12 | Rounded Corners | 2 | Dull, <35% bright | 2 | Moderately packed | 4 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 68 | F6 | GOOD | 5 |
| r21sa1 | 30-40% | 4 | No Evidence | 3 | Absent | 2 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Little or none | 4 | Moderate | 12 | Rounded Corners | 2 | Dull, <35% bright | 2 | Moderately packed | 4 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 68 | F6 | GOOD | 5 |
| r22sa1 | 30-40% | 4 | No Evidence | 3 | Absent | 2 | 70-90%+ density | 6 | Adequate | 2 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Moderate | 12 | Well Rounded 2D | 3 | Dull, <35% bright | 2 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Present, but spotty | 3 | 67 | F6 | GOOD | 5 |
| r22sa2 | 30-40% | 4 | No Evidence | 3 | Absent | 2 | 70-90%+ density | 6 | Ample (+ increase) | 1 | 20-40% 3-6" class | 6 | Rocks/Logs (embed) | 2 | Little or none | 4 | Moderate | 12 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Present, but spotty | 3 | 70 | F6 | GOOD | 5 |
| r23sa1 | 30-40% | 4 | Infrequent | 6 | Moderate to heavy | 6 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Frequent | 6 | Significant | 12 | Little or none | 4 | Rounded Corners | 2 | 35-65% bright | 3 | Loose assortment | 6 | Slight dist. shift | 8 | 30-50% | 18 | Scarce or absent | 4 | 98 | B4 | POOR | 15 |
| r23sa2 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Ample (+ increase) | 1 | 20-40% 3-6" class | 6 | Some Present | 4 | Some intermittent | 6 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 66 | B3 | FAIR | 10 |
| r23sa3 | <30% | 2 | No Evidence | 3 | Absent | 2 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull, <35% bright | 2 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Present, but spotty | 3 | 70 | B6 | FAIR | 10 |
| r23sa4 | <30% | 2 | Frequent(large) | 9 | Present but Small | 4 | 50-70% density | 9 | Barely contains peak | 3 | <20% 1-3" or less | 8 | Some Present | 4 | Some intermittent | 6 | Moderate | 12 | Rounded Corners | 2 | Dull, <35% bright | 2 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 89 | B6 | POOR | 15 |
| r23sa5 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Ample (+ increase) | 1 | 40-60% small cobbles | 4 | Rocks/Logs (embed) | 2 | Significant | 12 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | <5% | 6 | Scarce or absent | 4 | 66 | B6 | FAIR | 10 |
| r23sa6 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Significant | 12 | Moderate | 12 | Well Rounded 2D | 3 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Present, but spotty | 3 | 88 | B6 | POOR | 15 |
| r3sa1 | <30% | 2 | Infrequent | 6 | Moderate to heavy | 6 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Some intermittent | 6 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 79 | F4 | GOOD | 5 |
| r4sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 40-60% small cobbles | 4 | Some Present | 4 | Some intermittent | 6 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 70 | B4 | FAIR | 10 |
| r5sa1 | <30% | 2 | No Evidence | 3 | Absent | 2 | 90%+ density | 3 | Adequate | 2 | 40-60% small cobbles | 4 | Rocks/Logs (embed) | 2 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull, <35% bright | 2 | Assorted, tight pack | 2 | Mod. change is size | 12 | <5% | 6 | Scarce or absent | 4 | 58 | C5 | GOOD | 5 |
| r5sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Some intermittent | 6 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 75 | C6 | GOOD | 5 |
| r6sa1 | <30% | 2 | Infrequent | 6 | Present but Small | 4 | 50-70% density | 9 | Adequate | 2 | 20-40% 3-6" class | 6 | Some Present | 4 | Significant | 12 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 78 | B6 | FAIR | 10 |
| r7sa1 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 40-60% small cobbles | 4 | Some Present | 4 | Little or none | 4 | Some New Bars | 8 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 62 | E4 | GOOD | 5 |
| r8sa1 | 30-40% | 4 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | 65%+ w/ Lg/ Boulders | 2 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 62 | B4 | GOOD | 5 |
| r8sa2 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | <5% | 6 | Scarce or absent | 4 | 60 | B4 | GOOD | 5 |
| r8sa3 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | 70-90%+ density | 6 | Adequate | 2 | <20% 1-3" or less | 8 | Some Present | 4 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Moderately packed | 4 | Slight dist. shift | 8 | 5-30% | 12 | Scarce or absent | 4 | 68 | B4 | FAIR | 10 |
| r8sa4 | <30% | 2 | No Evidence | 3 | Present but Small | 4 | <50% density | 12 | Barely contains peak | 3 | 65%+ w/ Lg/ Boulders | 2 | Rocks/Logs (embed) | 2 | Little or none | 4 | Little or none | 4 | Rounded Corners | 2 | Dull/dark/stained | 1 | Loose assortment | 6 | No size change | 4 | 5-30% | 12 | Scarce or absent | 4 | 65 | B5 | GOOD | 5 |

Notes:
First column under each heading is from field assessment. Second column is from Pfankuch Stability Worksheet.

Red = Poor Pfankuch Rating
Yellow = Fair Pfankuch Rating
Green = Good Pfankuch Rating

**TABLE 5-3**

**VISUAL RATING**

| Location | Ranking |
|---|---|
| colonial | 4 |
| dogpark1 | 4 |
| dogpark2 | 8 |
| island park 1 | 4 |
| island park 2 | 4 |
| island park 3 | 4 |
| island park 4 | 4 |
| r10sa1 | 4 |
| r11sa1 | 4 |
| r11sa2 | 8 |
| r12sa1 | 0 |
| r12sa2 | 4 |
| r12sa3 | 4 |
| r12sa4 | 4 |
| r13sa1 | 4 |
| r13sa2 | 4 |
| r13sa3a | 4 |
| r14sa1 | 4 |
| r14sa1a | 0 |
| r14sa1b | 4 |
| r14sa2 | 0 |
| r14sa3 | 4 |
| r15sa1 | 4 |
| r15sa2 | 4 |
| r15sa3 | 4 |
| r15sa4 | 0 |
| r15sa5 | 8 |
| r15sa6 | 4 |

| Location | Ranking |
|---|---|
| r16sa1 | 12 |
| r17sa1 | 4 |
| r18sa1 | 0 |
| r19sa1 | 4 |
| r19sa2 | 8 |
| r20sa1 | 8 |
| r21sa1 | 8 |
| r22sa1 | 0 |
| r22sa2 | 0 |
| r23sa1 | 12 |
| r23sa2 | 8 |
| r23sa3 | 4 |
| r23sa4 | 12 |
| r23sa5 | 12 |
| r23sa6 | 12 |
| r3sa1 | 4 |
| r4sa1 | 4 |
| r4sa2 | 4 |
| r5sa1 | 0 |
| r5sa2 | 4 |
| r6sa1 | 4 |
| r7sa1 | 4 |
| r8sa1 | 4 |
| r8sa2 | 4 |
| r8sa3 | 4 |
| r8sa4 | 8 |
| r9sa1 | 8 |
| r9sa2 | 8 |

| | | |
|---|---|---|
| Red | = | High Erosion |
| Orange | = | Moderate to High Erosion |
| Yellow = | = | Moderate Erosion |
| Green | = | Low Erosion |

**TABLE 5-4**

**ADJACENT LAND USE**

| Location | Land Use | Rating |
|---|---|---|
| colonial | Wooded | 0 |
| dogpark1 | Wooded | 0 |
| dogpark2 | Wooded | 0 |
| island park 1 | Wooded | 0 |
| island park 2 | Residential | 4 |
| island park 3 | Wooded | 0 |
| island park 4 | Residential | 4 |
| r10sa1 | Residential | 4 |
| r11sa1 | Commercial/Industrial | 6 |
| r11sa2 | Commercial/Industrial | 6 |
| r12sa1 | Park/open | 2 |
| r12sa2 | Park/open | 2 |
| r12sa3 | Wooded | 0 |
| r12sa4 | Residential | 4 |
| r13sa1 | Wooded | 0 |
| r13sa2 | Wooded | 0 |
| r13sa3a | Park/open | 2 |
| r14sa1 | Park/open | 2 |
| r14sa1a | Wooded | 0 |
| r14sa1b | Residential | 4 |
| r14sa2 | Park/open | 2 |
| r14sa3 | Residential | 4 |
| r15sa1 | Park/open | 2 |
| r15sa2 | Park/open | 2 |
| r15sa3 | Park/open | 2 |
| r15sa4 | Residential | 4 |
| r15sa5 | Residential | 4 |
| r15sa6 | Park/open | 2 |

| Location | Land Use | Rating |
|---|---|---|
| r16sa1 | Residential | 4 |
| r17sa1 | Commercial/Industrial | 6 |
| r18sa1 | Commercial/Industrial | 6 |
| r19sa1 | Commercial/Industrial | 6 |
| r19sa2 | Commercial/Industrial | 6 |
| r20sa1 | Commercial/Industrial | 6 |
| r21sa1 | Commercial/Industrial | 6 |
| r22sa1 | Commercial/Industrial | 6 |
| r22sa2 | Wooded | 0 |
| r23sa1 | Wooded | 0 |
| r23sa2 | Wooded | 0 |
| r23sa3 | Park/open | 2 |
| r23sa4 | Park/open | 2 |
| r23sa5 | Park/open | 2 |
| r23sa6 | Park/open | 2 |
| r3sa1 | Wooded | 0 |
| r4sa1 | Wooded | 0 |
| r4sa2 | Wooded | 0 |
| r5sa1 | Wooded | 0 |
| r5sa2 | Wooded | 0 |
| r6sa1 | Park/open | 2 |
| r7sa1 | Park/open | 2 |
| r8sa1 | Park/open | 2 |
| r8sa2 | Park/open | 2 |
| r8sa3 | Wooded | 0 |
| r8sa4 | Park/open | 2 |
| r9sa1 | Park/open | 2 |
| r9sa2 | Park/open | 2 |

| | | |
|---|---|---|
| Red | = | High Erosion |
| Orange | = | Moderate to High Erosion |
| Yellow = | = | Moderate Erosion |
| Green | = | Low Erosion |

**TABLE 5-5**

**WEIGHTING OF RATINGS**

| Rating System | Erosion Condition | | | |
|---|---|---|---|---|
| | Low | Moderate | Moderate-High | High |
| BEHI | 0 | 10 | 20 | 30 |
| Pfankuch | 5 (Good) | 10 (Fair) | 15 (Poor) | |
| Visual | 0 | 4 | 8 | 12 |
| Adjacent Land Use | 0 | 2 | 4 | 6 |

**TABLE 5-6**

**OVERALL EROSION RATINGS**

| Location | Overall Ranking |
|---|---|
| colonial | 34 |
| dogpark1 | 29 |
| dogpark2 | 33 |
| island park 1 | 29 |
| island park 2 | 33 |
| island park 3 | 19 |
| island park 4 | 33 |
| r10sa1 | 23 |
| r11sa1 | 40 |
| r11sa2 | 29 |
| r12sa1 | 27 |
| r12sa2 | 21 |
| r12sa3 | 34 |
| r12sa4 | 33 |
| r13sa1 | 19 |
| r13sa2 | 19 |
| r13sa3a | 36 |
| r14sa1 | 21 |
| r14sa1a | 15 |
| r14sa1b | 33 |
| r14sa2 | 27 |
| r14sa3 | 33 |
| r15sa1 | 31 |
| r15sa2 | 31 |
| r15sa3 | 21 |
| r15sa4 | 29 |
| r15sa5 | 47 |
| r15sa6 | 31 |

| Location | Overall Ranking |
|---|---|
| r16sa1 | 56 |
| r17sa1 | 35 |
| r18sa1 | 21 |
| r19sa1 | 35 |
| r19sa2 | 49 |
| r20sa1 | 49 |
| r21sa1 | 29 |
| r22sa1 | 21 |
| r22sa2 | 25 |
| r23sa1 | 57 |
| r23sa2 | 28 |
| r23sa3 | 26 |
| r23sa4 | 49 |
| r23sa5 | 44 |
| r23sa6 | 49 |
| r3sa1 | 19 |
| r4sa1 | 29 |
| r4sa2 | 34 |
| r5sa1 | 25 |
| r5sa2 | 29 |
| r6sa1 | 36 |
| r7sa1 | 31 |
| r8sa1 | 21 |
| r8sa2 | 21 |
| r8sa3 | 24 |
| r8sa4 | 25 |
| r9sa1 | 35 |
| r9sa2 | 25 |

| | | |
|---|---|---|
| Red | = | High Erosion |
| Orange | = | Moderate to High Erosion |
| Yellow = | = | Moderate Erosion |
| Green | = | Low Erosion |

## TABLE 5-7
## OUTFALL ASSESSMENTS

| Outfall Ownership | Outfall ID | Outfall Size (in) | Outfall Material | Outfall Condition | Outfall Condition 2 | Erosion Rating | Sediment | Flow | Flow Appearance | 2013 Outfall Rating | 2005 Outfall Rating | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRIVATE | P01 | 18 | Concrete | Good | Good | Moderate | None | No | NA | Excellent | Excellent | |
| PRIVATE | P02 | 30 | Concrete | Good | Good | Moderate | None | No | NA | Excellent | Excellent | |
| PRIVATE | P03 | 48 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| PRIVATE | P04 | 30 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| PRIVATE | P05 | 54 | Concrete | Good | Good | Moderate | Little | Yes | Clear | Excellent | Good | |
| PRIVATE | P06 | 60 | Concrete | Good | Good | Moderate | Little | Yes | Clear | Excellent | Excellent | |
| PRIVATE | P08 | 12 | Smooth Metal | Good | Good | Moderate | Little | No | NA | Excellent | Excellent | |
| PRIVATE | P09 | 12 | Smooth Metal | Good | Good | Moderate | >1/4 full | No | NA | Fair | Fair | |
| PRIVATE | P11 | 12 | Concrete | Corroded | Good | Moderate | None | No | NA | Fair | Fair | |
| PRIVATE | P11A | 12 | Concrete | Good | Good | Moderate | None | No | NA | Excellent | NA | |
| PRIVATE | P12 | 10 | Corrugated Metal | Good | Corroded | Moderate | None | No | NA | Good | Excellent | |
| PRIVATE | P12A | 24 | Corrugated Metal | Good | Good | Moderate | None | No | NA | Excellent | NA | |
| PRIVATE | P12B | 24 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | NA | |
| PRIVATE | P12C | 24 | Concrete | Good | Good | Low (Bulkheaded) | None | No | NA | Excellent | NA | |
| PRIVATE | P13 | 48 | Concrete | Good | Good | Low (Bulkheaded) | Little | No | NA | Excellent | Excellent | |
| PRIVATE | P15 | 24 | Smooth Metal | Cracked | Good | Moderately High | >1/4 full | No | NA | Poor | Poor | |
| PRIVATE | P16 | 24 | Concrete | Good | Good | Low (Bulkheaded) | None | No | Clear | Excellent | NA | |
| MUNICIPAL | RR01 | 40 x 64 | Corrugated Metal | Good | Good | Moderate | None | No | NA | Excellent | Excellent | |
| MUNICIPAL | RR02 | 18 | Concrete | Good | Good | Moderate | >1/4 full | No | NA | Fair | Excellent | |
| MUNICIPAL | RR06 | 27 (Failed Section) | Concrete | Cracked | Cracked | Moderate | None | No | NA | Poor | Excellent | |
| MUNICIPAL | RR12B | 24 | Concrete | Good | Good | Low (Bulkheaded) | None | Yes | Clear | Excellent | NA | |
| MUNICIPAL | RR14 | 18 | Corrugated Metal | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR15 | 84 | Corrugated Metal | Good | Corroded | High | None | Yes | Clear | Fair | Good | |
| MUNICIPAL | RR16 | 48 | Concrete | Good | Good | Moderate | 1/4 full | Yes | Cloudy | Good | Good | |
| MUNICIPAL | RR17 | 30 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR18 | 48 | Concrete | Good | Good | Moderate | Little | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR19 | 12 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Poor | Replaced since last assessment |
| MUNICIPAL | RR20 | 48 | Concrete | Good | Pitted | Moderate | None | Yes | Clear | Good | Good | |
| MUNICIPAL | RR20A | 24 | Smooth Metal | Good | Good | Moderate | >1/4 full | No | NA | Fair | Fair | |
| MUNICIPAL | RR20B | 15 | Smooth Metal | Good | Good | Moderate | >1/4 full | Yes | Clear | Fair | NA | |
| MUNICIPAL | RR22 | 48 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Good | |
| MUNICIPAL | RR23 | 12 | Concrete | Good | Good | Moderate | 1/4 full | Yes | Clear | Good | Good | |
| MUNICIPAL | RR24 | 8 | Concrete | Good | Good | Moderate | >1/4 full | Yes | Clear | Fair | Poor | Replaced since last assessment |
| MUNICIPAL | RR25 | 36 | Concrete | Good | Corroded | Moderate | None | Yes | Clear | Fair | Good | |
| MUNICIPAL | RR26 | 12 | Smooth Metal | Cracked | Crushed | Moderate | >1/4 full | No | NA | Poor | Poor | |
| MUNICIPAL | RR27 | 21 | Concrete | Good | Corroded | Moderate | None | No | NA | Fair | Excellent | |
| MUNICIPAL | RR28 | 15 | Corrugated Metal | Good | Good | Low | None | No | NA | Excellent | Excellent | |

# TABLE 5-7
# OUTFALL ASSESSMENTS

| Outfall Ownership | Outfall ID | Outfall Size (in) | Outfall Material | Outfall Condition | Outfall Condition 2 | Erosion Rating | Sediment | Flow | Flow Appearance | 2013 Outfall Rating | 2005 Outfall Rating | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MUNICIPAL | RR29 | 12 | Corrugated Metal | Pitted | Rusted | Low | None | No | NA | Fair | Fair | |
| MUNICIPAL | RR30 | BULKHEADED | NA | NA | NA | NA | NA | NA | NA | N/A | Poor | |
| MUNICIPAL | RR30B | 12 | Corrugated Metal | Good | Good | Moderate | None | No | NA | Excellent | NA | |
| MUNICIPAL | RR31 | 24 | Concrete | Good | Good | Low | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR31A | 18 | Smooth Metal | Good | Corroded | Moderately High | None | No | NA | Good | N/A | |
| MUNICIPAL | RR31B | 15 | Corrugated Metal | Good | Good | Moderately High | None | No | NA | Excellent | NA | |
| MUNICIPAL | RR32 | 15 | Corrugated Metal | Good | Good | Moderately High | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR33 | 24 | Concrete | Good | Corroded | Moderately High | None | Yes | Clear | Fair | Good | |
| MUNICIPAL | RR34 | 24 | Concrete | Good | Good | Moderately High | None | No | NA | Excellent | Excellent | |
| MUNICIPAL | RR35 | 34 x 52 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR36 | 40 x 40 | Concrete | Good | Pitted | Moderate (Bulkheaded) | Little | Yes | Clear | Fair | Good | |
| MUNICIPAL | RR37E-1 | 60 | Corrugated Metal | Cracked | Corroded | Moderate | None | Yes | Clear | Poor | NA | |
| MUNICIPAL | RR37E-2 | 108 | Concrete | Cracked | Corroded | Moderate | None | Yes | Clear | Poor | NA | |
| MUNICIPAL | RR37w | 84 | Corrugated Metal | Good | Corroded | Moderate | None | Yes | Clear | Good | Good | |
| MUNICIPAL | RR38 | 30 | Concrete | Good | Good | Moderate | >1/4 full | No | NA | Fair | Fair | |
| MUNICIPAL | RR39 | 27 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR40 | 60 | Concrete | Good | Pitted | Moderate | None | Yes | Clear | Good | NA | |
| MUNICIPAL | RR41 | NOT LOCATED | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| MUNICIPAL | RR42 | NOT LOCATED | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| MUNICIPAL | RR43 | 27 | Smooth Metal | Pitted | Rusted | Low (Bulkheaded) | None | No | NA | Fair | Fair | |
| MUNICIPAL | RR44 | NOT LOCATED | NA | NA | NA | NA | NA | NA | NA | N/A | Excellent | |
| MUNICIPAL | RR45 | 30 | Concrete | Pitted | Good | Low (Bulkheaded) | None | Yes | Clear | Good | Excellent | |
| MUNICIPAL | RR46 | 48 | Concrete | Good | Pitted | Low (Bulkheaded) | None | Yes | Clear | Good | Good | |
| MUNICIPAL | RR47 | 60 | Concrete | Good | Pitted | Low (Bulkheaded) | None | Yes | Clear | Good | Good | |
| MUNICIPAL | RR49 | 30 | Concrete | Cracked | Crushed | Low (Bulkheaded) | None | No | NA | Poor | Poor | |
| MUNICIPAL | RR50 | BULKHEADED | NA | NA | NA | NA | NA | NA | NA | N/A | | |
| MUNICIPAL | RR51 | 18 | Corrugated Metal | Rusted | Corroded | Moderate | None | Yes | Clear | Poor | Poor | |
| MUNICIPAL | RR53 | 54 | Concrete | Good | Good | Moderate | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR55 | NOT LOCATED | NA | NA | NA | NA | NA | NA | NA | NA | Excellent | |
| MUNICIPAL | RR56 | 10 | Plastic | Good | Good | NA | None | Yes | Clear | Excellent | NA | |
| MUNICIPAL | RR57 | 12 | Concrete | Good | Good | Low (Bulkheaded) | None | No | NA | Excellent | Excellent | |
| MUNICIPAL | RR58 | 18 | Plastic | Good | Good | Low (Bulkheaded) | None | Yes | Clear | Excellent | Excellent | |
| MUNICIPAL | RR59 | NOT LOCATED | NA | NA | NA | NA | NA | NA | NA | NA | Excellent | |
| MUNICIPAL | RR60 | 20 | Concrete | Good | Good | Moderate | None | No | NA | Excellent | Excellent | |
| MUNICIPAL | RR60A | 15 | Concrete | Good | Good | Moderate | None | No | NA | Excellent | NA | |
| MUNICIPAL | RR61 | 60 | Concrete | Good | Good | Low | None | Yes | Clear | Excellent | Excellent | |

**TABLE 6-1**
**ALTERNATIVE STABILIZATION PRACTICES**

| INSTREAM PRACTICES |
|---|
| Vanes or J-Hook Vanes |
| Cross Vanes |
| **STREAMBANK TREATMENT** |
| Bank Shaping and Planting |
| Branch Packing |
| Brush Mattresses |
| Coconut Fiber Roll |
| Dormant Post Plantings |
| Vegetated Gabions |
| Joint Plantings |
| Live Cribwalls |
| Live Stakes |
| Live Fascines |
| Log, Rootwad, and Boulder Revetments |
| Riprap |
| Stone Toe Protection |
| Tree Revetments |
| Vegetated Geogrids |

**TABLE 6-2**
**STREAMBANK BUFFER SEED MIXTURE**

| Seed Mix | Pounds/ Acre |
|---|---|
| Andropogon scoparius | 4 |
| Anemone Canadensis | 0.07 |
| Aster lateriflorus | 0.13 |
| Bouteloua curtipendula | 4.3 |
| Calamagrostis Canadensis | 0.13 |
| Carex cristatella | 1.33 |
| Carex tribuloides | 0.16 |
| Echinacea pupurea | 1.0 |
| Eleocharis erythropoda | 0.06 |
| Elymus Canadensis | 3.33 |
| Elymus virginicus | 1.5 |
| Epilobium Coloratum | 0.06 |
| Eupatorium perfoliatum | 0.07 |
| Juncus dudleyi | 0.01 |
| Juncus torreyi | 0.06 |
| Leersia oryzoides | 0.75 |
| Liatris pycnostachya | 0.18 |
| Lobelia cardinalis | 0.01 |
| Leebelia silphitica | 0.01 |
| Physostegia virginiana | 0.06 |
| Poa palustris | 1.67 |
| Rudbeckia subtomentosa | 0.06 |
| Scirpus atrovirens | 0.77 |
| Scutellaria epilobifolia | 0.13 |
| Spartina pectinata | 0.55 |
| Sporobolus heterolepis | 0.3 |
| Sorghastrum nutans | 3.67 |

**TABLE 7-1**
**COST FOR STREAM STABILIZATION PRACTICES**

| BMP | Unit | Unit Cost |
|---|---|---|
| Vanes and J-Hook Vanes | each | $1,000 - $2,000 |
| Cross Vanes | each | $2,000 - $6,000 |
| Bank Shaping and Planting | square yard | $40 - $50 |
| Brush Mattress | square yard | $200 - $500 |
| Coconut Fiber Roll | square yard | $10 - $20 |
| Coir Fabric | square yard | $3 - $7 |
| Live Stakes | square yard | $20 - $60 |
| Gabion (2 high) | foot | $150 - $200 |
| Green Gabion (2 high) | foot | $150 - $250 |
| Riprap | square foot | $10 - $15 |
| Toe Protection | foot | $25 - $50 |
| Joint Plantings | square foot | $20 - $30 |
| Live Cribwall | foot | $100 - $150 |
| Live Fascines | foot | $20 - $60 |
| Rootwad | each | $35 - $50 |
| Tree Revetment | foot | $15 - $30 |
| Vegetated Geogrid | foot | $50 - $100 |

**TABLE 7-2**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE JP1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 300 | $50 | $15,000 |
| Rock Toe Stabilization | Linear Feet | 125 | $50 | $6,250 |
| | | Subtotal | | $26,000 |
| | | Engineering (15%) | | $4,000 |
| | | Permitting (5%) | | $1,000 |
| | | Inspection (10%) | | $3,000 |
| | | Contingency (15%) | | $4,000 |
| | | **Estimated Total Cost** | | $38,000 |

**TABLE 7-3**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE JP2**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 4000 | $50 | $200,000 |
| Rock Toe Stabilization | Linear Feet | 1100 | $50 | $55,000 |
| | | Subtotal | | $260,000 |
| | | Engineering (15%) | | $39,000 |
| | | Permitting (5%) | | $13,000 |
| | | Inspection (10%) | | $26,000 |
| | | Contingency (15%) | | $39,000 |
| | | **Estimated Total Cost** | | $377,000 |

**TABLE 7-4**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE JP3**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 200 | $50 | $10,000 |
| Rock Toe Stabilization | Linear Feet | 80 | $50 | $4,000 |
| | | Subtotal | | $19,000 |
| | | Engineering (15%) | | $3,000 |
| | | Permitting (5%) | | $1,000 |
| | | Inspection (10%) | | $2,000 |
| | | Contingency (15%) | | $3,000 |
| | | **Estimated Total Cost** | | $28,000 |

**TABLE 7-5**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE CP1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 600 | $50 | $30,000 |
| Rock Toe Stabilization | Linear Feet | 225 | $50 | $11,250 |
| | | Subtotal | | $46,000 |
| | | Engineering (15%) | | $7,000 |
| | | Permitting (5%) | | $2,000 |
| | | Inspection (10%) | | $5,000 |
| | | Contingency (15%) | | $7,000 |
| | | **Estimated Total Cost** | | $67,000 |

**TABLE 7-6**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE SS1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 1700 | $50 | $85,000 |
| Rock Toe Stabilization | Linear Feet | 625 | $50 | $31,250 |
| | | Subtotal | | $121,000 |
| | | Engineering (15%) | | $18,000 |
| | | Permitting (5%) | | $6,000 |
| | | Inspection (10%) | | $12,000 |
| | | Contingency (15%) | | $18,000 |
| | | **Estimated Total Cost** | | $175,000 |

**TABLE 7-7**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE SS2**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Rebuilding Retaining Wall | SF | 600 | $50 | $30,000 |
| | | Subtotal | | $35,000 |
| | | Engineering (15%) | | $5,000 |
| | | Permitting (5%) | | $2,000 |
| | | Inspection (10%) | | $4,000 |
| | | Contingency (15%) | | $5,000 |
| | | **Estimated Total Cost** | | $51,000 |

**TABLE 7-8**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE AM1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Rebuilding Retaining Wall | SF | 5500 | $50 | $275,000 |
| | | Subtotal | | $280,000 |
| | | Engineering (15%) | | $42,000 |
| | | Permitting (5%) | | $14,000 |
| | | Inspection (10%) | | $28,000 |
| | | Contingency (15%) | | $42,000 |
| | | **Estimated Total Cost** | | $406,000 |

**TABLE 7-9**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE CC1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 1900 | $50 | $95,000 |
| Rock Toe Stabilization | Linear Feet | 500 | $50 | $25,000 |
| | | Subtotal | | $125,000 |
| | | Engineering (15%) | | $19,000 |
| | | Permitting (5%) | | $6,000 |
| | | Inspection (10%) | | $13,000 |
| | | Contingency (15%) | | $19,000 |
| | | **Estimated Total Cost** | | $182,000 |

**TABLE 7-10**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE MA1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 5800 | $50 | $290,000 |
| Rock Toe Stabilization | Linear Feet | 1500 | $50 | $75,000 |
| | | Subtotal | | $370,000 |
| | | Engineering (15%) | | $56,000 |
| | | Permitting (5%) | | $19,000 |
| | | Inspection (10%) | | $37,000 |
| | | Contingency (15%) | | $56,000 |
| | | **Estimated Total Cost** | | $538,000 |

**TABLE 7-11**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE WP1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 4700 | $50 | $235,000 |
| Rock Toe Stabilization | Linear Feet | 1200 | $50 | $60,000 |
| | | Subtotal | | $300,000 |
| | | Engineering (15%) | | $45,000 |
| | | Permitting (5%) | | $15,000 |
| | | Inspection (10%) | | $30,000 |
| | | Contingency (15%) | | $45,000 |
| | | **Estimated Total Cost** | | $435,000 |

**TABLE 7-12**
**ESTIMATED STREAMBANK STABILIZATION COSTS**
**SITE IL1**

| Activity / Treatment | Units | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|
| Mobilization | LS | 1 | $5,000 | $5,000 |
| Regrading and Revegetating Banks | SY | 700 | $50 | $35,000 |
| Rock Toe Stabilization | Linear Feet | 250 | $50 | $12,500 |
| | | Subtotal | | $53,000 |
| | | Engineering (15%) | | $8,000 |
| | | Permitting (5%) | | $3,000 |
| | | Inspection (10%) | | $5,000 |
| | | Contingency (15%) | | $8,000 |
| | | **Estimated Total Cost** | | $77,000 |

**TABLE 7-13**
**OUTFALL REPLACEMENT COST ESTIMATES**

| Cost Item | Outfall | | | | | | |
|---|---|---|---|---|---|---|---|
| | P15 | RR06 | RR26 | RR37E-1 | RR37E-2 | RR49 | RR51 |
| Pipe | $1,000 | $2,000 | $500 | $3,000 | $10,000 | $1,000 | $500 |
| Rip Rap | $500 | $500 | $500 | $2,000 | $2,000 | $500 | $500 |
| End Section | $1,000 | $1,000 | $1,000 | $10,000 | $10,000 | $1,000 | $1,000 |
| Subtotal | $2,500 | $3,500 | $2,000 | $15,000 | $22,000 | $2,500 | $2,000 |
| Mobilization, Inspection, Contingency | $1,000 | $1,000 | $1,000 | $5,000 | $8,000 | $1,000 | $1,000 |
| **Total** | **$3,500** | **$4,500** | **$3,000** | **$20,000** | **$30,000** | **$3,500** | **$3,000** |

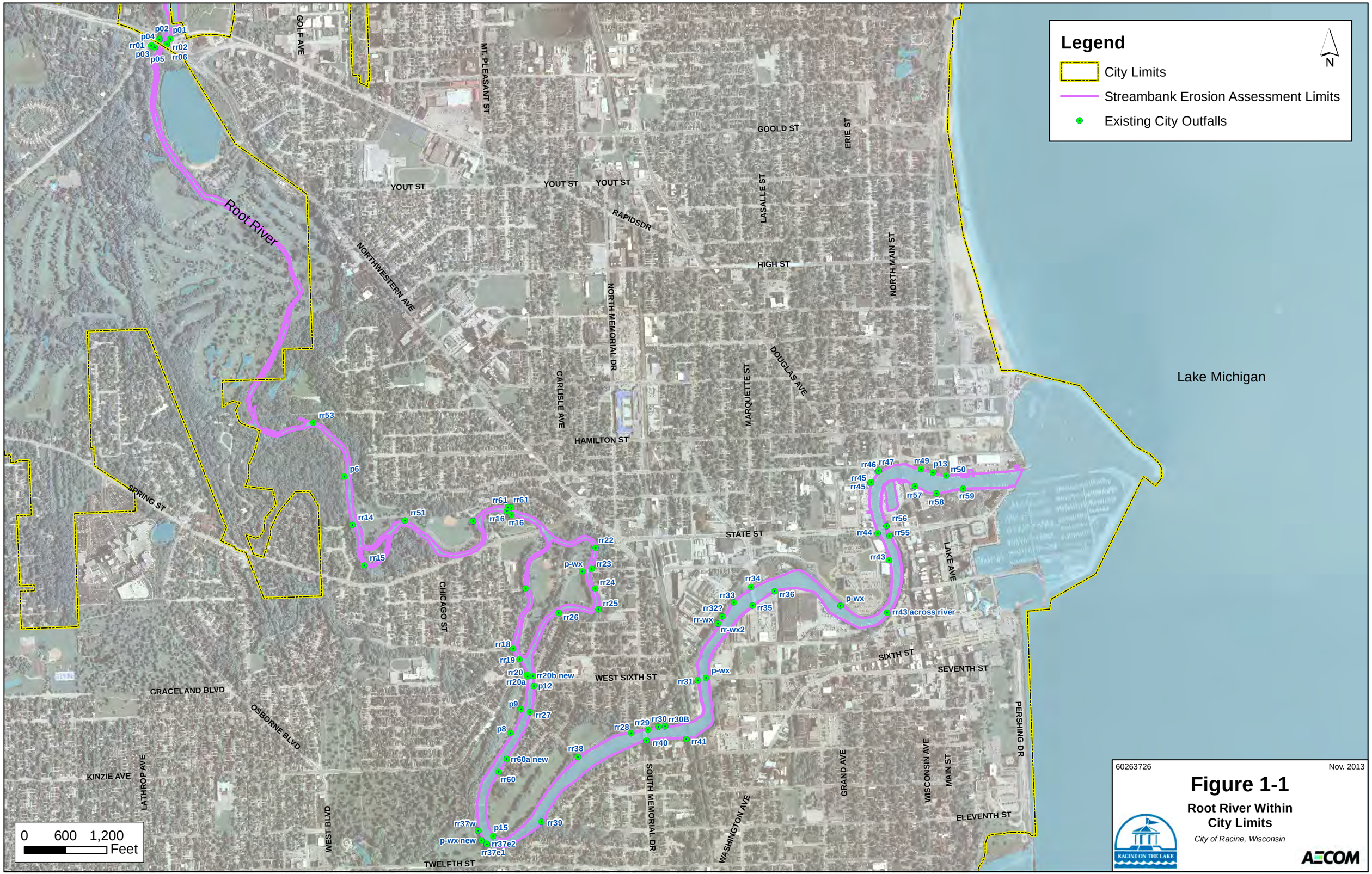
**TABLE 7-14**
**STREAMBANK FUNDING OPPORTUNITIES**

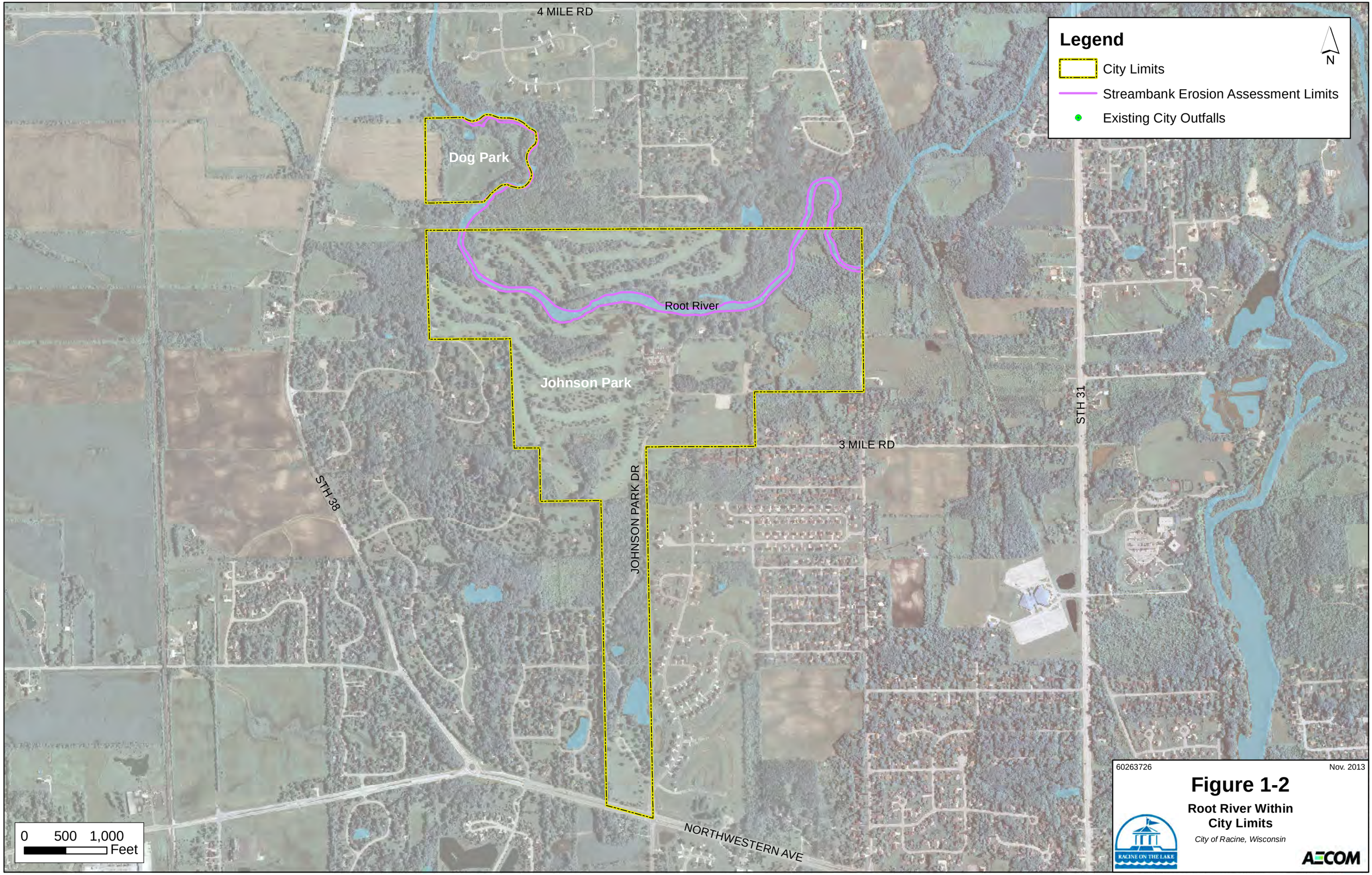
| Funding Source * | Grant Description | Eligible Applicants | Eligible Projects | Eligibility Criteria | Funding Award | Grant Cycle | Funding Term | Application Deadline | Contact |
|---|---|---|---|---|---|---|---|---|---|
| DNR | "River Protection Grant Program"<br><br>Protect rivers through water quality, fisheries habitat and natural beauty enhancements. | Units of local government Nonprofit conservation organizations Qualified river management organizations. | 1. River organization development<br>2. Information and education<br>3. Assessments of water quality, fish aquatic life and nonpoint source evaluation.<br>4. Purchase of land or easements<br>5. Development of local ordinances<br>6. Restoration of in stream or shoreland habitat | Contact WDNR Regional Office Environmental Grant Specialist | River Planning<br><br>Grants: $10,000<br><br>max per grant and<br><br>75% State share mix<br><br>River Management<br><br>Grants: $50,000 max<br><br>per grant and 75%<br><br>State Share max | | | Contact WDNR Regional Office Environmental Grant Specialist. | www.dnr.wi.gov/aid/rivers.html |
| DNR | "Urban Nonpoint Source and Targeted Runoff Management Grants"<br><br>Promote urban runoff management for existing, developing and redevelopment of urban areas | Local governmental units | 1. Stormwater detention pond<br>2. Urban streambank stabilization<br>Land acquisition to increase permeable areas for infiltration. | Implement urban runoff performance standards (Wis. Admin Code NR151) achieving water quality standards protecting groundwater. | • Funding Amount depends on the biennial budget<br>• 70% technical assistance<br>standard cost-share<br><br>funds for 50% of the<br><br>project cost | Every Second Year<br>Note: Depends on funding and number of projects | Two years with a possible one year extension | April 15, 2003 | www.dnr.wi.gov/aid/urbannonpoint.html |

**TABLE 7-14**
**STREAMBANK FUNDING OPPORTUNITIES**

| Funding Source * | Grant Description | Eligible Applicants | Eligible Projects | Eligibility Criteria | Funding Award | Grant Cycle | Funding Term | Application Deadline | Contact |
|---|---|---|---|---|---|---|---|---|---|
| DNR | "Stewardship Program"<br><br>To provide outdoor recreation, protect lands, sensitive to environmental degradation, conserve and restore wildlife habitat and protect water quality | Local units of government<br>Nonprofit conservation | 1. Acquire property<br>2. Urban Rivers: to restore an protect river corridors and river fronts in urban areas<br>3. State Trails:<br>4. Urban Green Space | Depends if 501 © (3) status or a local government:<br><br>Please see information on website listed under Contact information. | Funding varies by programs: | Contact local Community Service Specialist WDNR | Contact local Community Service Specialist WDNR | Contact local Community Service Specialist WDNR | www.dnr.wi.gov/topic/stewardship/grants/ |
| Fund for Lake Michigan (WE Energies) | Enhance the health of Lake Michigan and its shoreline and tributary river systems for the benefit of the people, plants and animals that depend upon the system for water, recreation and commerce. | Local units of government<br>Nonprofit groups | Design and construction of projects the fulfill grant mission. | See information on website, listed under Contact information. | Varies | Varies | Varies | Varies | www.fundforlakemichigan.org |
| EPA | Great Lakes Restoration Initiative (GLRI) | Local units of government<br>Nonprofit groups | Multi-program initiative offering various grant programs over time. Visit website for latest grant program information. | See information on website, listed under Contact information. | Varies | Varies | Varies | Varies | www.epa.gov/glnpo/glri/ |

# Figures


Legend
City Limits
Streambank Erosion Assessment Limits
Existing City Outfalls
N
Root River
Lake Michigan
GOLF AVE
MT. PLEASANT ST
YOUT ST
YOUT ST
YOUT ST
GOOLD ST
ERIE ST
LASALLE ST
RAPIDSDR
NORTHWESTERN AVE
HIGH ST
NORTH MAIN ST
NORTH MEMORIAL DR
CARLISLE AVE
MARQUETTE ST
DOUGLAS AVE
HAMILTON ST
SPRING ST
CHICAGO ST
STATE ST
LAKE AVE
GRACELAND BLVD
OSBORNE BLVD
KINZIE AVE
LATHROP AVE
WEST BLVD
WEST SIXTH ST
SIXTH ST
SEVENTH ST
ELEVENTH ST
TWELFTH ST
SOUTH MEMORIAL DR
WASHINGTON AVE
GRAND AVE
WISCONSIN AVE
MAIN ST
PERSHING DR
p01
p02
p03
p04
p05
rr01
rr02
rr06
rr53
p6
rr14
rr15
rr51
rr61
rr61
rr16
rr16
rr22
p-wx
rr23
rr24
rr25
rr26
rr18
rr19
rr20
rr20b new
rr20a
p12
p9
rr27
p8
rr60a new
rr60
rr37w
p15
p-wx new
rr37e2
rr37e1
rr39
rr38
rr28
rr29
rr30
rr30B
rr40
rr41
rr31
p-wx
rr34
rr33
rr32?
rr-wx
rr-wx2
rr36
rr35
p-wx
rr43 across river
rr43
rr44
rr45
rr45
rr46
rr47
rr49
p13
rr50
rr57
rr58
rr59
rr56
rr55
0 600 1,200 Feet
60263726
Nov. 2013
Figure 1-1
Root River Within City Limits
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM




60263726 Nov. 2013

# Figure 1-2

**Root River Within City Limits**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

## Legend

City Limits

**Stream Assessment**
- Low
- Medium
- Medium to High
- High

**2013 Outfall Rating**
- Excellent
- Good
- Fair
- Poor
- Not Rated

**Streambank Erosion Assessment Rating**
- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

N

0 200 400 Feet

Erosion Site CC1

Erosion Site MA1

Erosion Site AM1

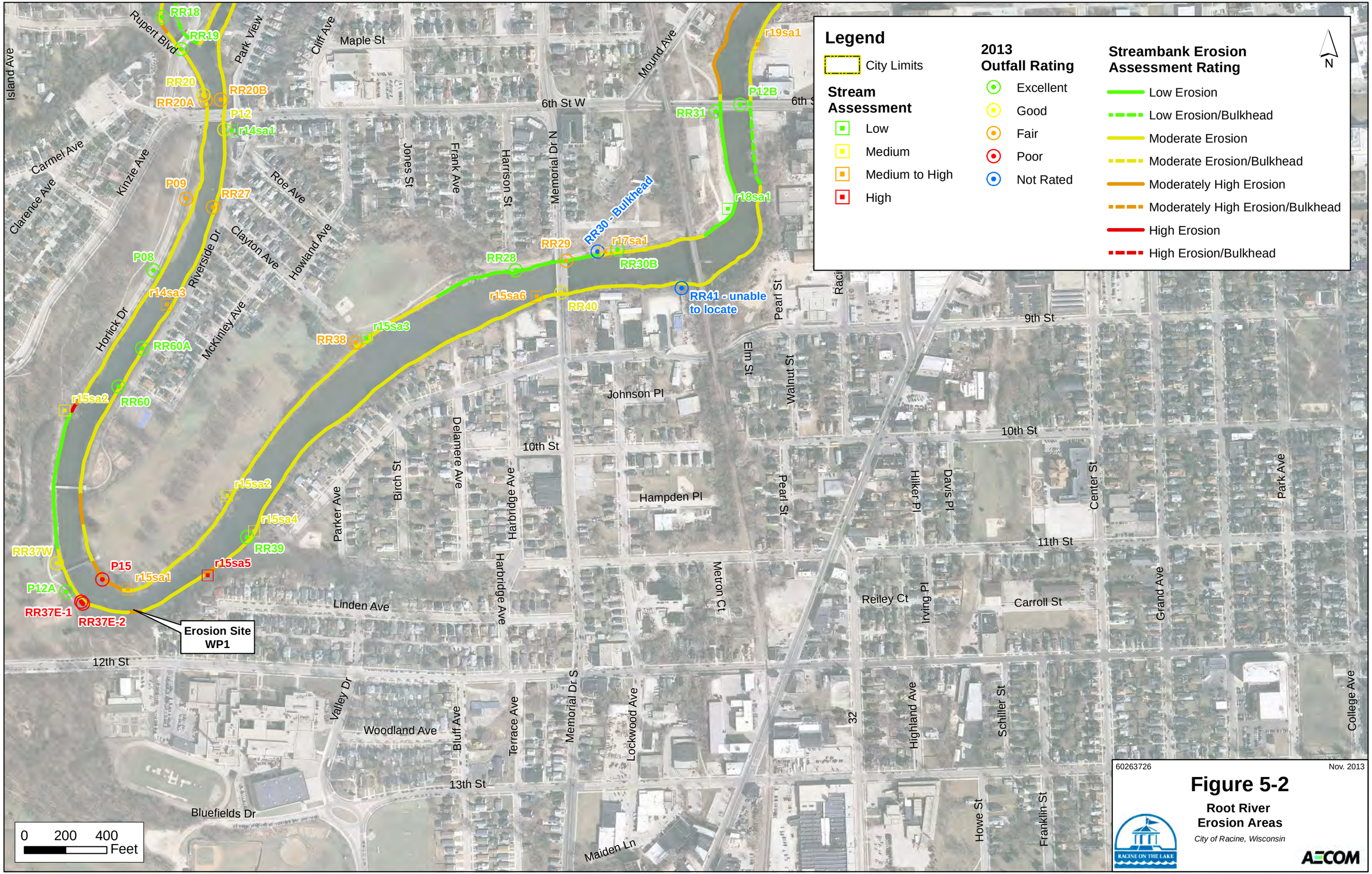
60263726 Nov. 2013

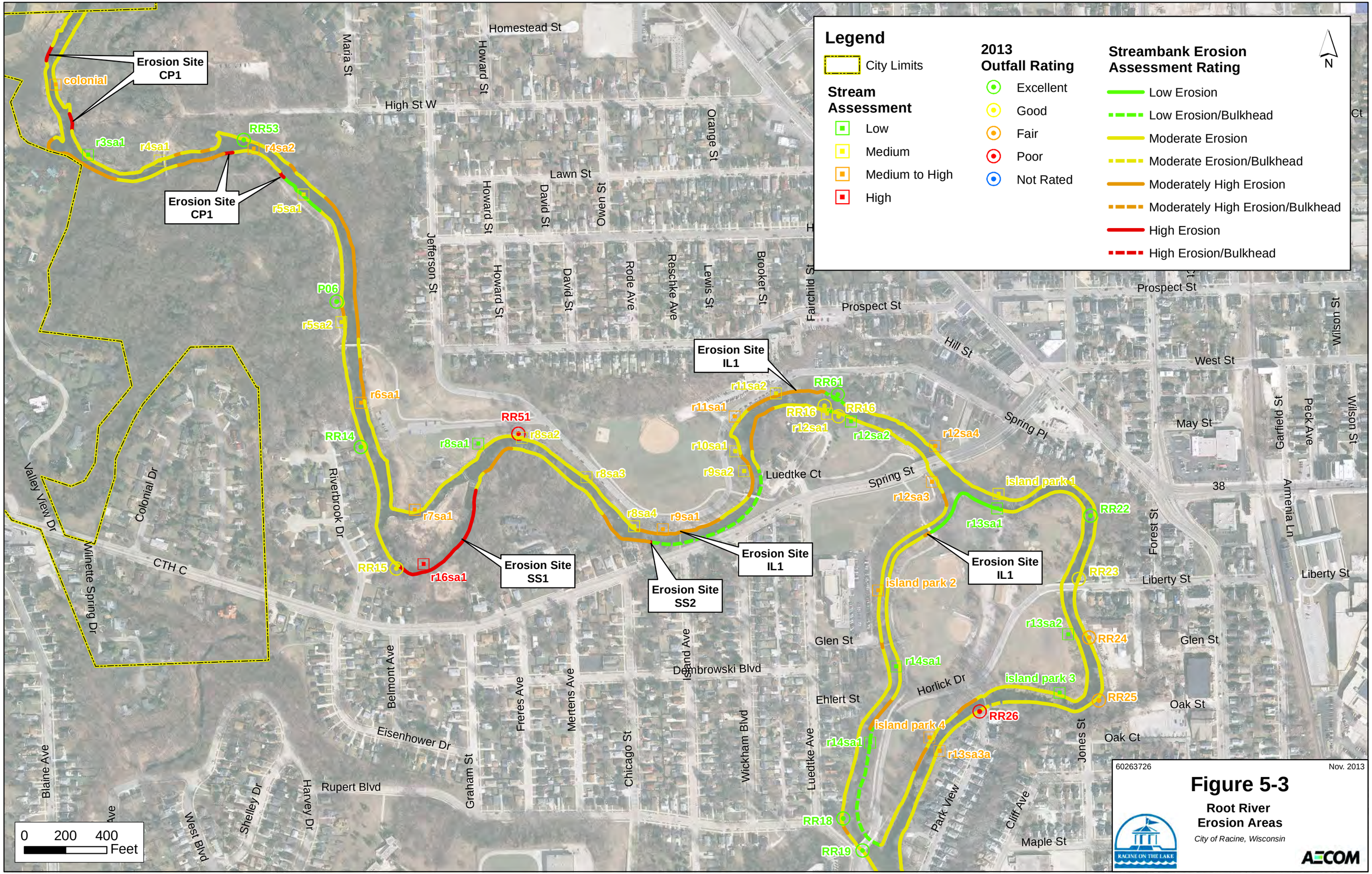
# Figure 5-1

**Root River Erosion Areas**

*City of Racine, Wisconsin*

AECOM


Legend
City Limits
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
N
RR18
RR19
RR20
RR20A
RR20B
P12
r14sa1
P09
RR27
P08
r14sa3
RR60A
RR60
r15sa2
RR38
r15sa3
RR28
r15sa6
RR29
RR30 - Bulkhead
r17sa1
RR30B
RR40
RR41 - unable to locate
r18sa1
RR31
P12B
r19sa1
r15sa2
r15sa4
RR39
r15sa5
RR37W
P15
r15sa1
P12A
RR37E-1
RR37E-2
Erosion Site WP1
Rupert Blvd
Park View
Cliff Ave
Maple St
Island Ave
Carmel Ave
Clarence Ave
Kinzie Ave
Roe Ave
Jones St
Frank Ave
Harrison St
Memorial Dr N
Mound Ave
6th St W
Riverside Dr
Clayton Ave
Howland Ave
Horlick Dr
McKinley Ave
Johnson Pl
Pearl St
Elm St
Walnut St
9th St
10th St
Delamere Ave
Parker Ave
Birch St
Harbridge Ave
Hampden Pl
Hilker Pl
Davis Pl
Center St
Park Ave
11th St
Metron Ct
Reiley Ct
Irving Pl
Carroll St
Grand Ave
Linden Ave
12th St
Valley Dr
Woodland Ave
Bluff Ave
Terrace Ave
Memorial Dr S
Lockwood Ave
Highland Ave
Schiller St
College Ave
13th St
Bluefields Dr
Maiden Ln
Howe St
Franklin St
0 200 400 Feet
60263726
Nov. 2013
Figure 5-2
Root River
Erosion Areas
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


Legend
City Limits
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
N
Erosion Site CP1
Erosion Site CP1
Erosion Site IL1
Erosion Site SS1
Erosion Site SS2
Erosion Site IL1
Erosion Site IL1
colonial
r3sa1
r4sa1
RR53
r4sa2
r5sa1
P06
r5sa2
r6sa1
RR14
RR51
r8sa1
r8sa2
r8sa3
r8sa4
r9sa1
r9sa2
r7sa1
RR15
r16sa1
r11sa2
r11sa1
RR61
RR16
RR16
r12sa1
r12sa2
r12sa4
r10sa1
r12sa3
island park 1
RR22
r13sa1
island park 2
RR23
r13sa2
RR24
r14sa1
island park 3
RR25
RR26
island park 4
r14sa1
r13sa3a
RR18
RR19
Homestead St
Maria St
High St W
Howard St
Orange St
Lawn St
Howard St
David St
Owen St
Jefferson St
Howard St
David St
Rode Ave
Reschke Ave
Lewis St
Brooker St
Fairchild St
Prospect St
Prospect St
Hill St
West St
Wilson St
Spring Pl
May St
Garfield St
Peck Ave
Wilson St
Luedtke Ct
Spring St
Forest St
38
Armenia Ln
Liberty St
Liberty St
Glen St
Glen St
Oak St
Oak Ct
Jones St
Ct
Valley View Dr
Colonial Dr
Riverbrook Dr
Wilnette Spring Dr
CTH C
Belmont Ave
Eisenhower Dr
Freres Ave
Mertens Ave
Graham St
Chicago St
Island Ave
Wickham Blvd
Luedtke Ave
Denbrowski Blvd
Ehlert St
Horlick Dr
Park View
Cliff Ave
Maple St
Blaine Ave
West Blvd
Shelley Dr
Harvey Dr
Rupert Blvd
0 200 400 Feet
60263726
Nov. 2013
Figure 5-3
Root River
Erosion Areas
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM

## Legend

City Limits

**Stream Assessment**
- Low
- Medium
- Medium to High
- High

**2013 Outfall Rating**
- Excellent
- Good
- Fair
- Poor
- Not Rated

**Streambank Erosion Assessment Rating**
- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

N

r22sa2
r22sa1
P01
P02
P03
RR01
RR02
RR06
P04
P05

Cranberry Ln
Henry Cir
Shorewood Dr
Partridge Ter
Dan-Mor Ln
Riverbend Dr
Buckley Rd
Riverwalk Ct
Riverpark Ln
Patzke Ln
Mona Park Rd
31
Miller Ln
38
Markridge Dr
Markridge Cir
Hanlon Dr
Old Mill Dr
Rapids Ct
Green Bay Rd
Galway Rd
Limerick Ln
Wexford Rd
Donegal Rd
Kerry Rd
MM
K
Wolff St
Romayne Ave
Golf Ave
Fergus Ave
Eaton Ln
Fox Dr
Floyd Dr

0 200 400 Feet

60263726 Nov. 2013

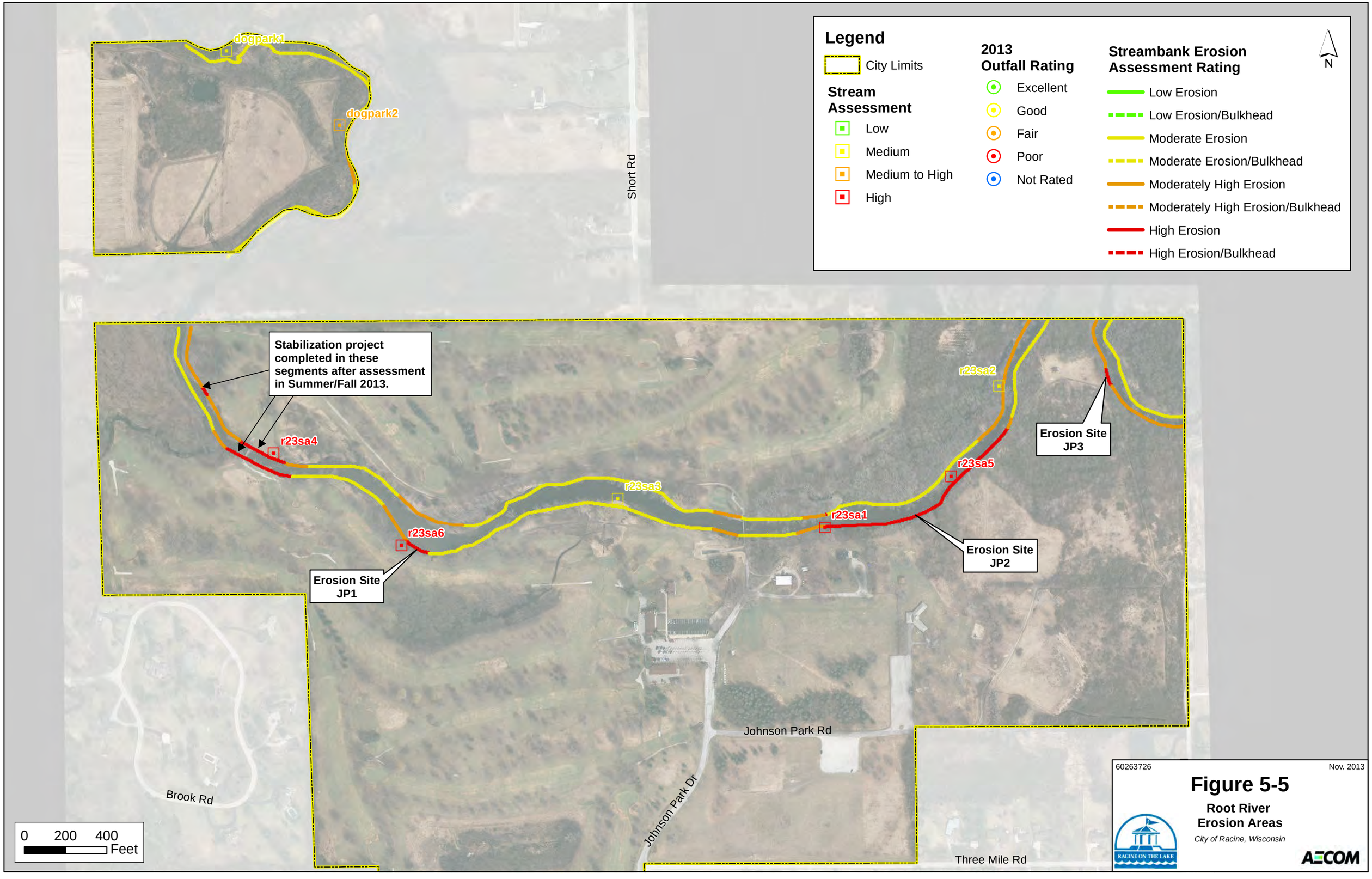
# Figure 5-4

**Root River Erosion Areas**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM




60263726 Nov. 2013

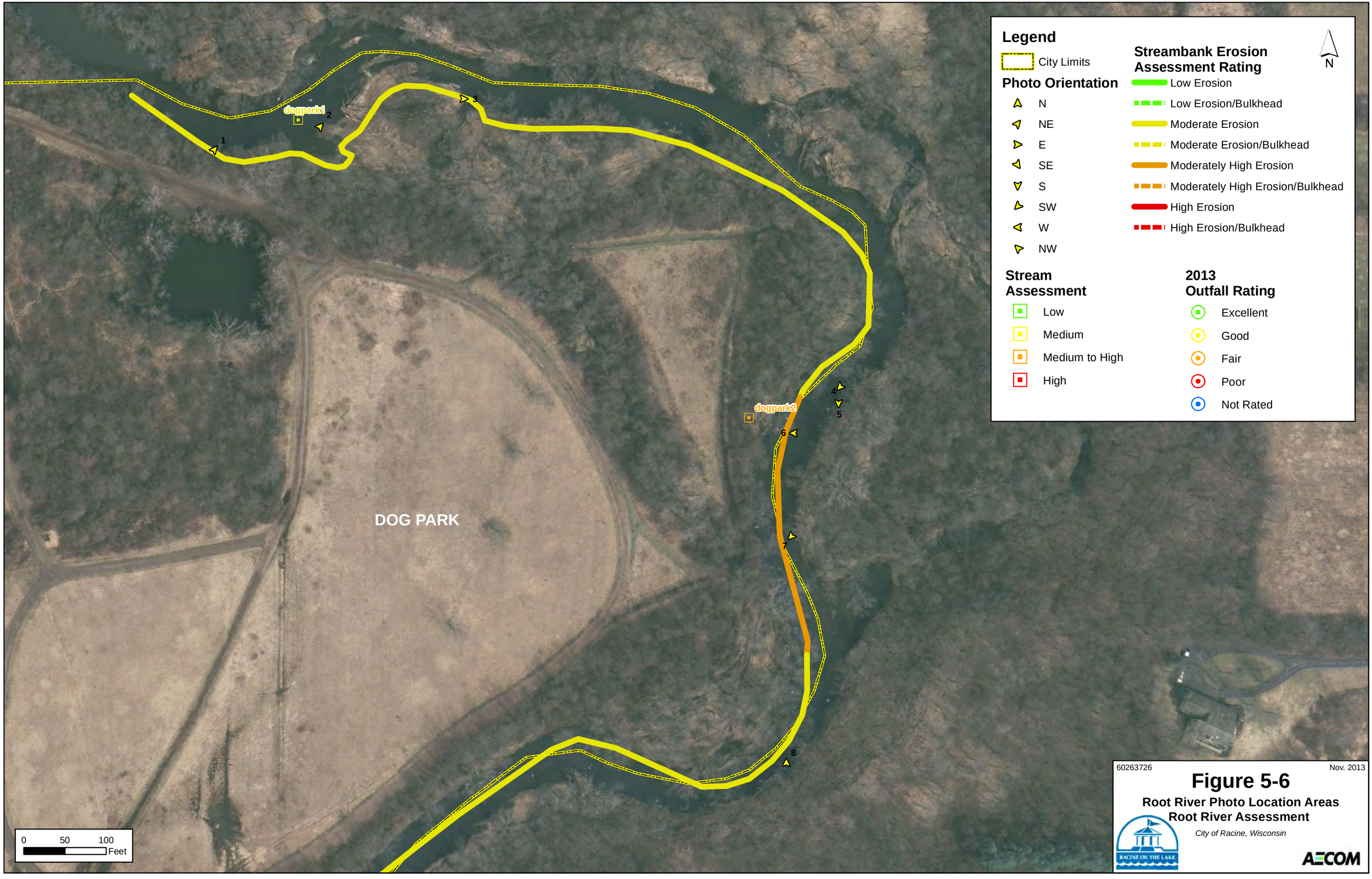
# Figure 5-5

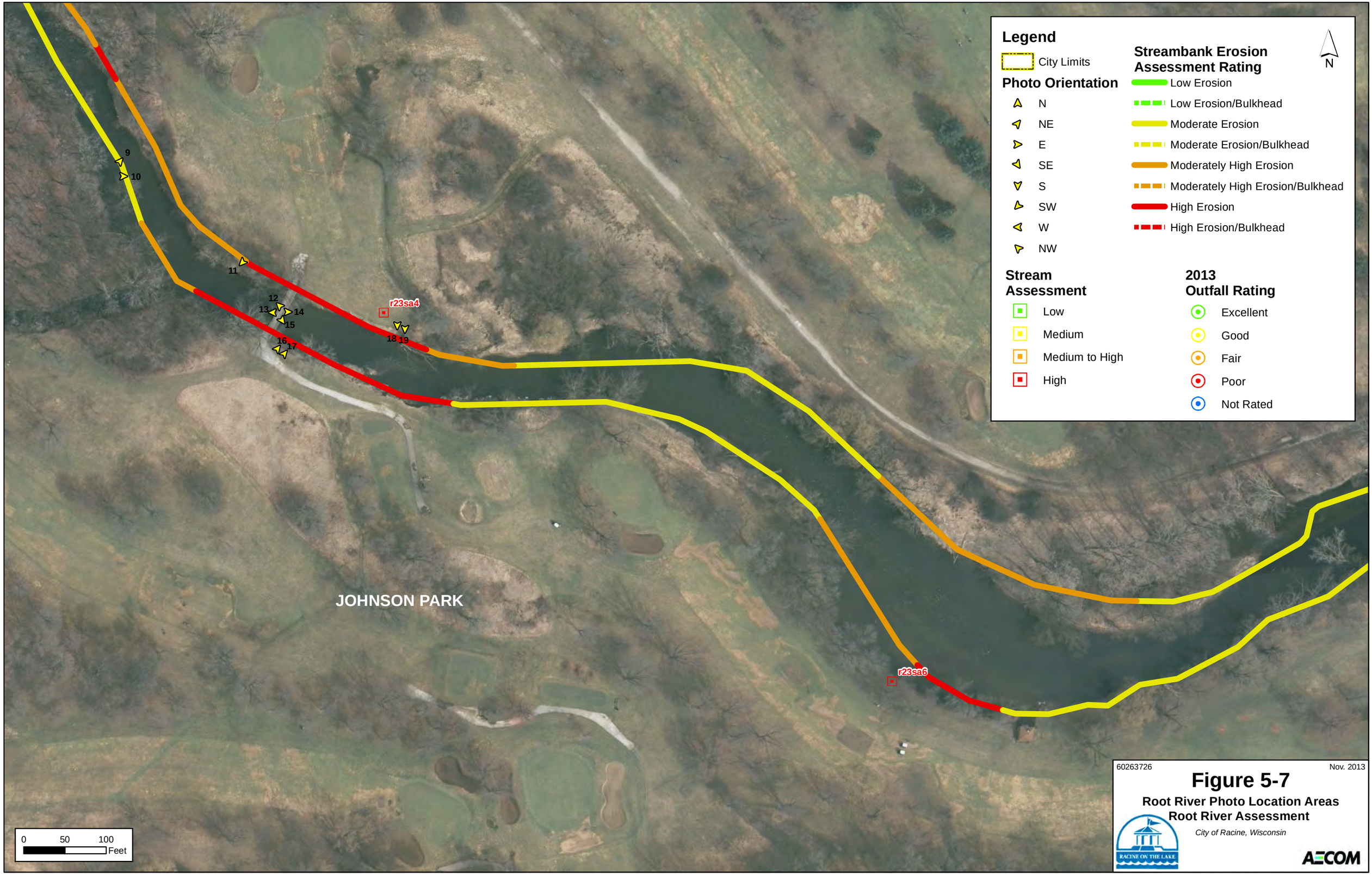
**Root River Erosion Areas**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


dogpark1
dogpark2
1
2
3
4
5
6
7
8
DOG PARK
0
50
100
Feet
N
Legend
City Limits
Photo Orientation
N
NE
E
SE
S
SW
W
NW
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
60263726
Nov. 2013
Figure 5-6
Root River Photo Location Areas
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


9
10
11
12
13
14
15
16
17
18
19
r23sa4
r23sa6
JOHNSON PARK
0
50
100
Feet
Legend
City Limits
Photo Orientation
N
NE
E
SE
S
SW
W
NW
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
N
60263726
Nov. 2013
Figure 5-7
Root River Photo Location Areas
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

N

JOHNSON PARK

r23sa2
r23sa5
r23sa1
20
21
22
23
24
25
26
27

0 50 100 Feet

60263726 Nov. 2013

# Figure 5-8

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

N

r23sa2

r23sa5

25

26

27

28

29

30

JOHNSON PARK

0 50 100 Feet

60263726 Nov. 2013

# Figure 5-9

**Root River Photo Location Areas**
**Root River Assessment**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


60263726 Nov. 2013

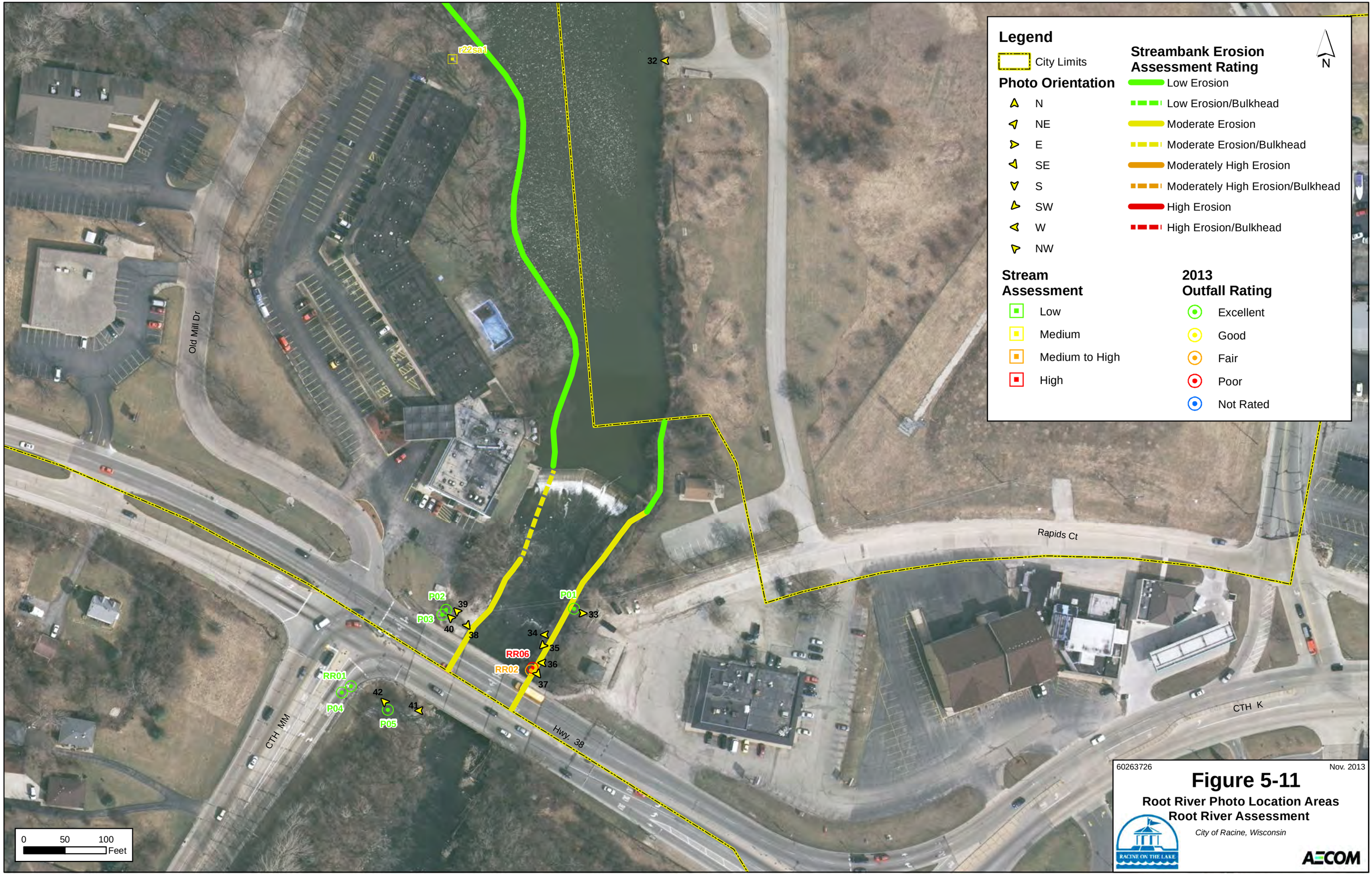
# Figure 5-10

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM




60263726 Nov. 2013

# Figure 5-11

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

Westwood Cir

High St W

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

N

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

colonial

r3sa1

r4sa1

r4sa2

r5sa1

RR53

43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65

0 50 100 Feet

60263726 Nov. 2013

# Figure 5-12

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

60263726 Nov. 2013

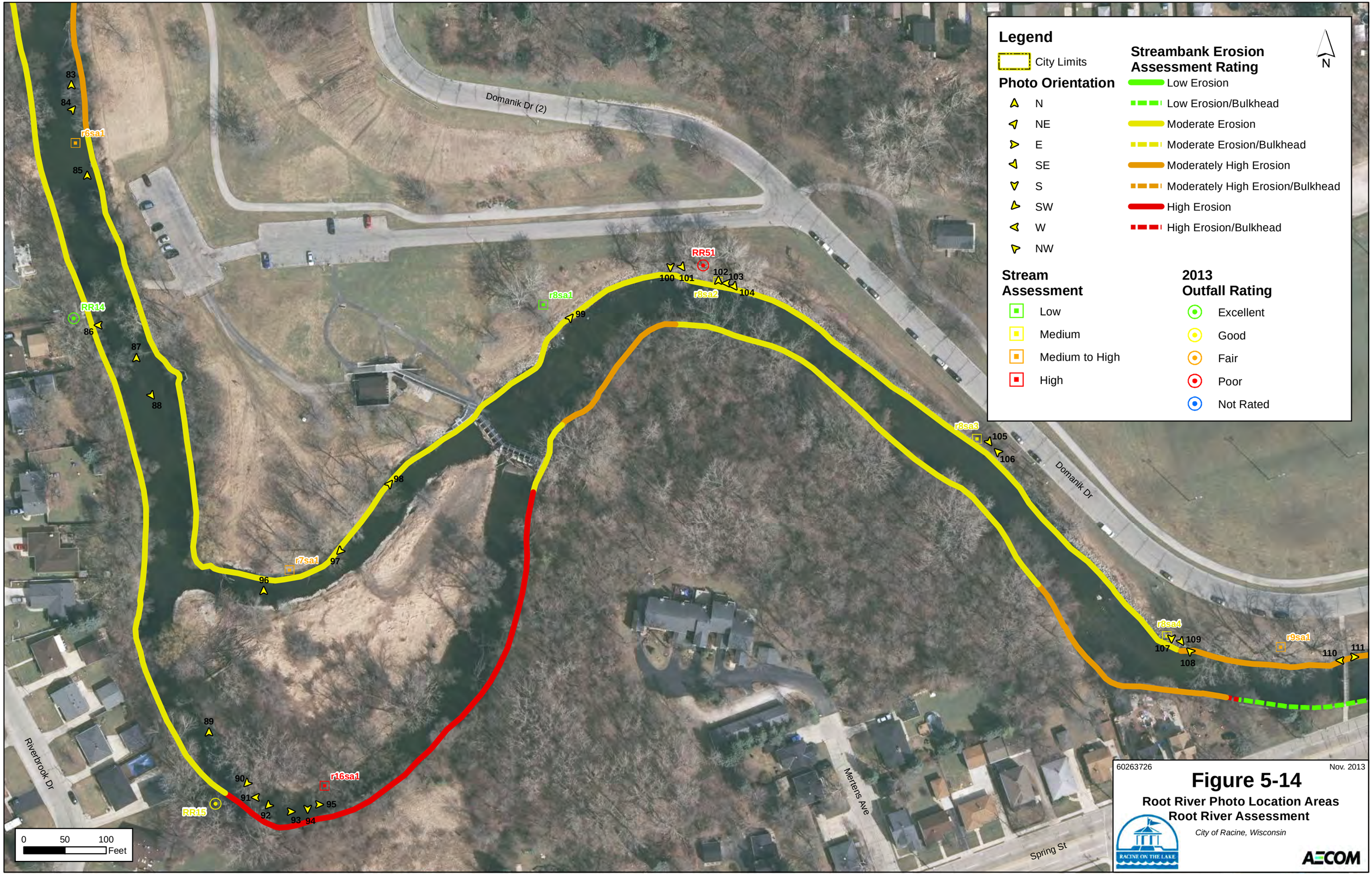
# Figure 5-13

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM




60263726 Nov. 2013

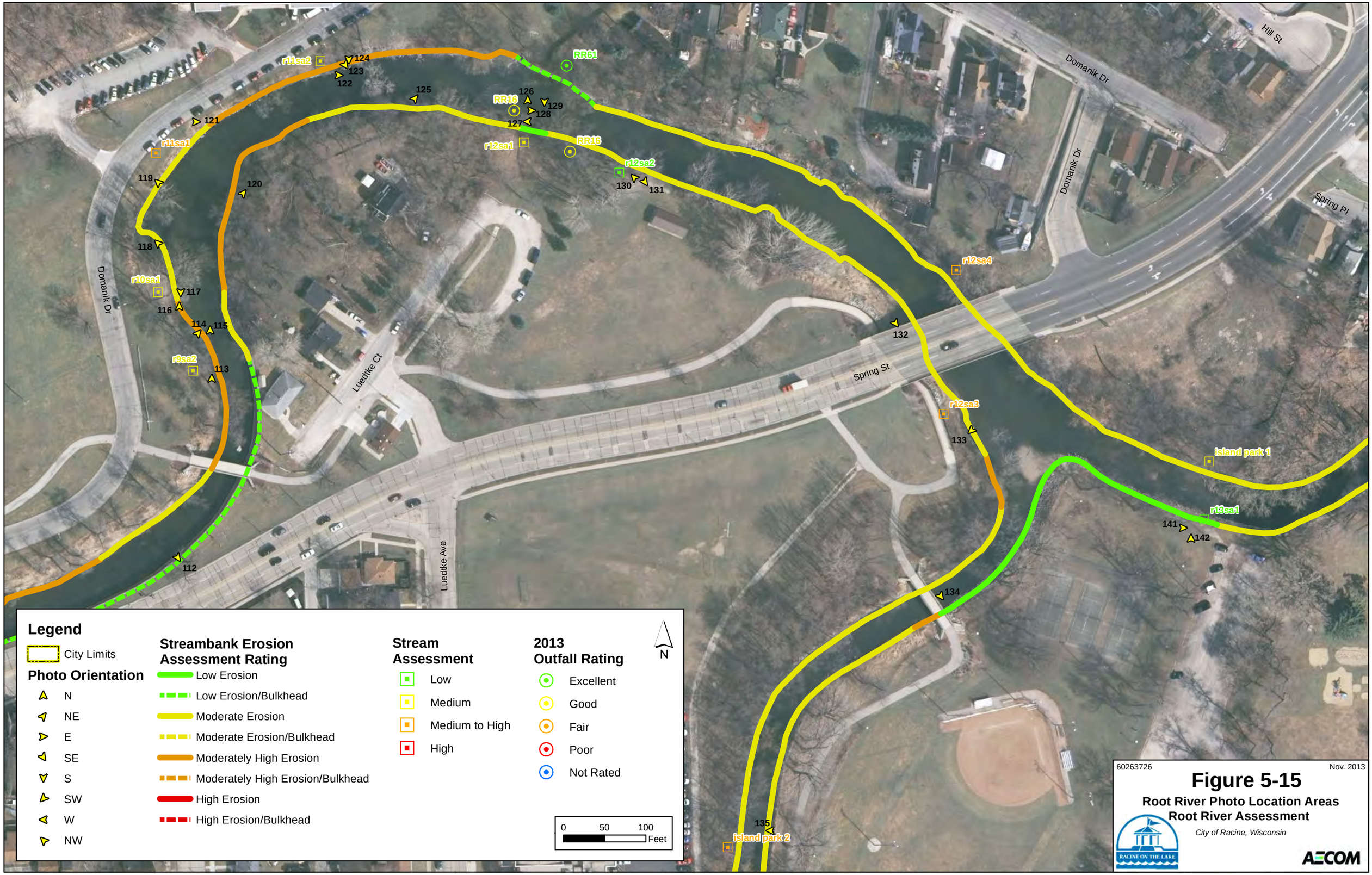
# Figure 5-14

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


r11sa2
124
123
122
125
RR61
RR16
126
129
128
127
121
r11sa1
RR16
r12sa1
r12sa2
130
131
119
120
118
r10sa1
117
116
114
115
r9sa2
113
Domanik Dr
Luedtke Ct
Spring St
r12sa4
132
r12sa3
133
Hill St
Domanik Dr
Domanik Dr
Spring Pl
island park 1
r13sa1
141
142
112
Luedtke Ave
134
135
island park 2
Legend
City Limits
Photo Orientation
N
NE
E
SE
S
SW
W
NW
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
N
0
50
100
Feet
60263726
Nov. 2013
Figure 5-15
Root River Photo Location Areas
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


60263726 Nov. 2013

# Figure 5-16

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

N

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

60263726 Nov. 2013

# Figure 5-17

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


Rupert Blvd
Park View
6th St W
Carmel Ave
Kinzie Ave
Columbia St
Horlick Dr
Riverside Dr
Roe Ave
Howland Ave
Jones St
Clayton Ave
RR18
140
166
RR19
167
RR20
168
RR20A
RR20B
169
170
171
172
P12
r14sa1
173
P09
174
175
RR27
0 50 100 Feet
Legend
City Limits
Photo Orientation
N
NE
E
SE
S
SW
W
NW
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
N
60263726
Nov. 2013
Figure 5-18
Root River Photo Location Areas
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


60263726 Nov. 2013

# Figure 5-19

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM


60263726 Nov. 2013

# Figure 5-20

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

N

Harrison St
Memorial Dr N
Riverview Ter
Memorial Dr S
Harbridge Ave
Delamere Ave
9th St

RR30
r17sa1
RR30B
231
230
RR29
RR28
224
228
229
227
RR40
r15sa6
225
226
RR41

0 50 100 Feet

60263726 Nov. 2013

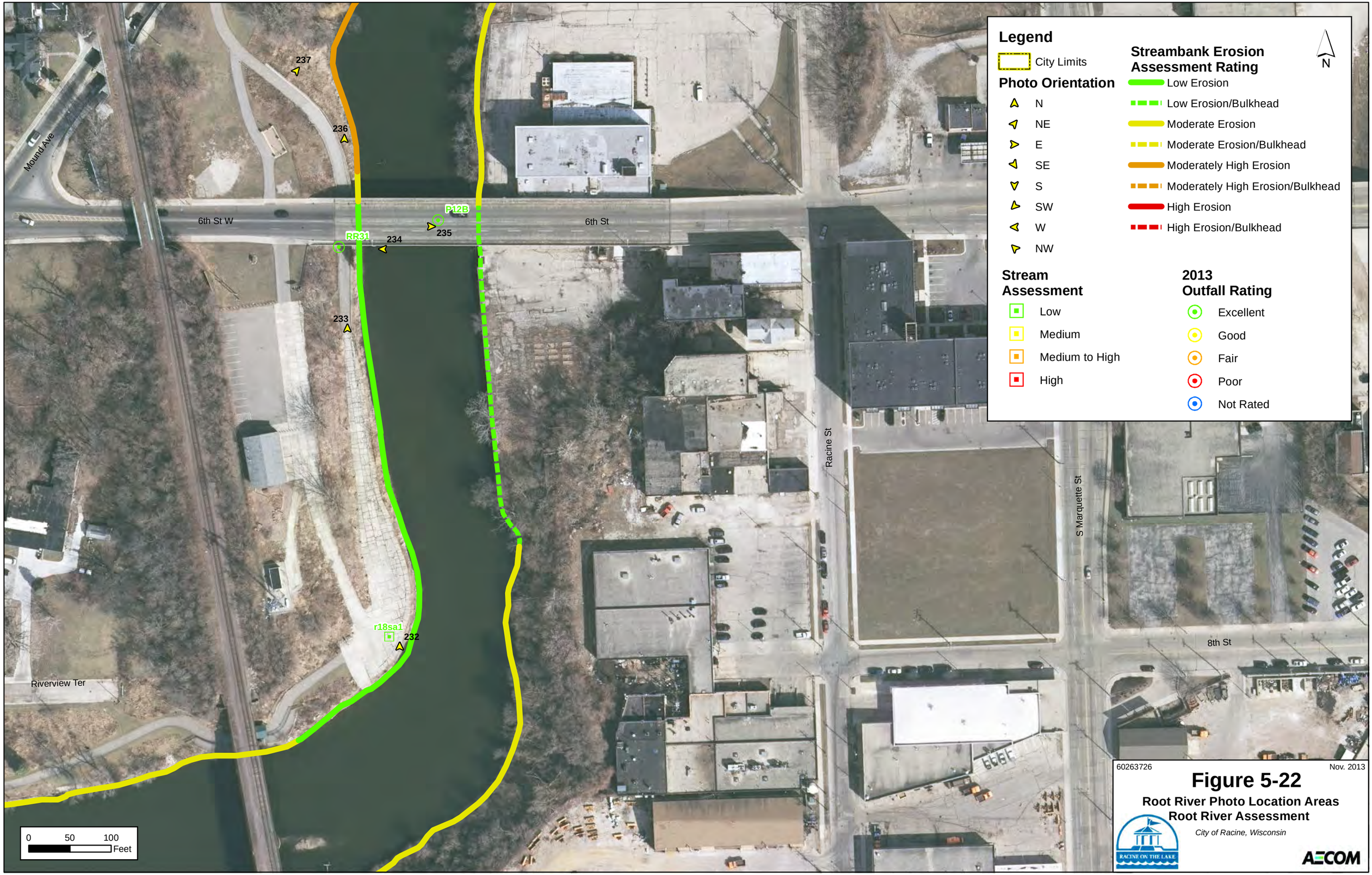
# Figure 5-21

**Root River Photo Location Areas**
**Root River Assessment**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM




60263726 Nov. 2013

# Figure 5-22

**Root River Photo Location Areas**
**Root River Assessment**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

N

0 50 100 Feet

Marquette St

S Marquette St

Mound Ave

RR31B RR31A RR32 RR33 RR34 RR35 RR36

238 239 240 241 242 243 244 245 246 247

r19sa2 r20sa1

60263726 Nov. 2013

# Figure 5-23

## Root River Photo Location Areas
## Root River Assessment

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

## Legend

City Limits

### Photo Orientation

- N
- NE
- E
- SE
- S
- SW
- W
- NW

### Streambank Erosion Assessment Rating

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

### Stream Assessment

- Low
- Medium
- Medium to High
- High

### 2013 Outfall Rating

- Excellent
- Good
- Fair
- Poor
- Not Rated

N

RR43

258

r21sa1

248

249

250

P12C

252

251

253

254

255

256

P16

257

0 50 100 Feet

60263726 Nov. 2013

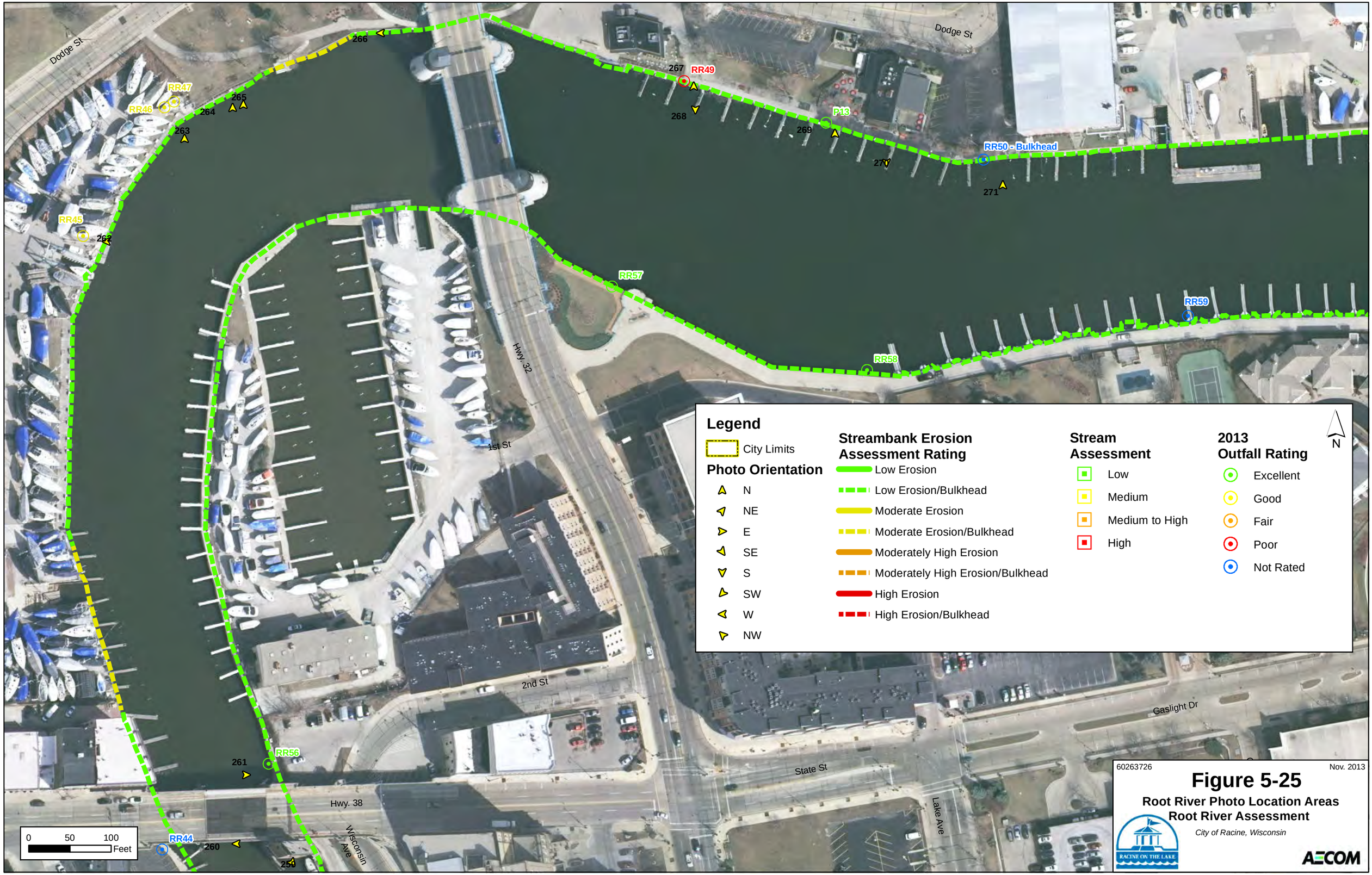
# Figure 5-24

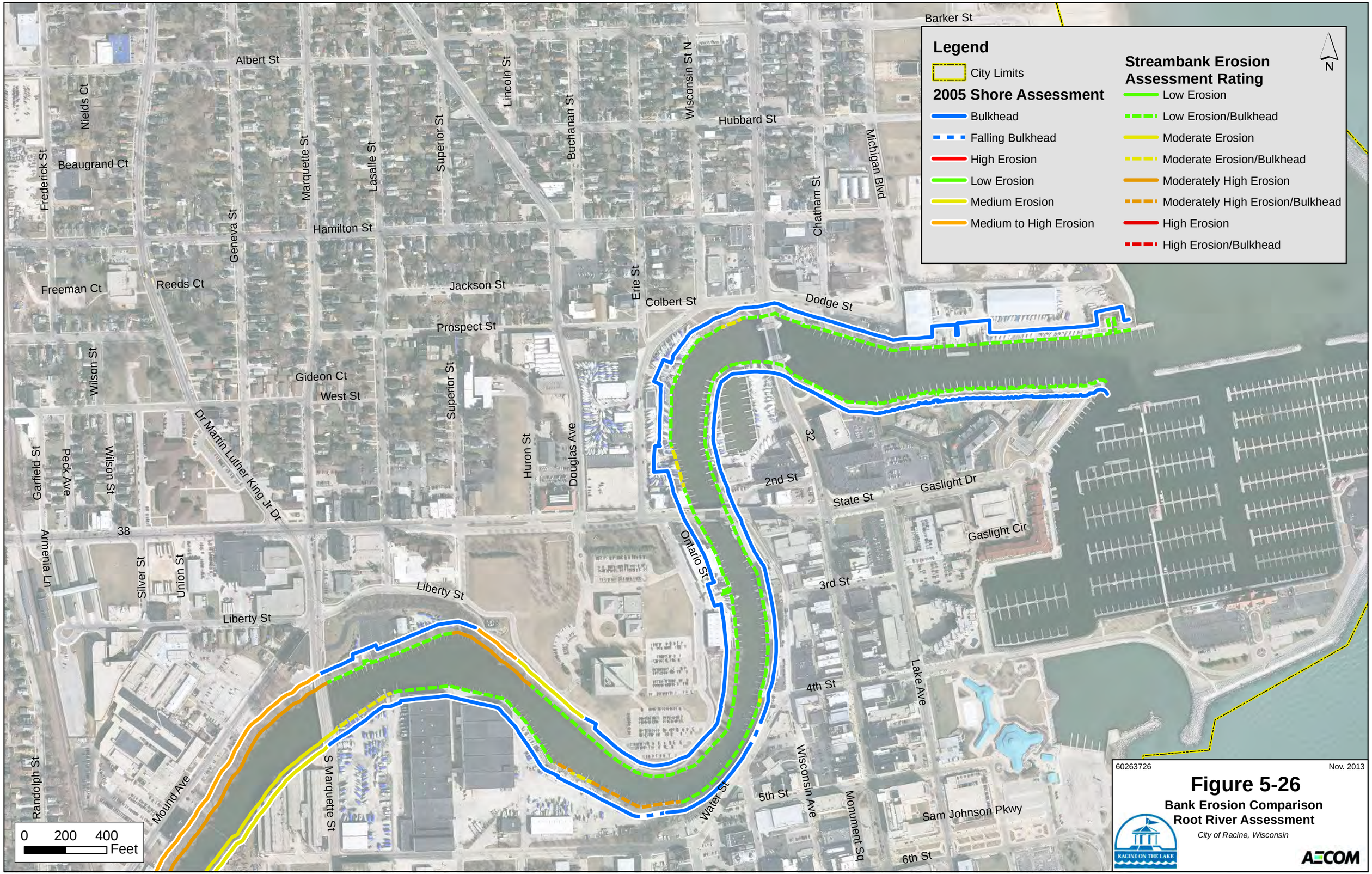
**Root River Photo Location Areas**
**Root River Assessment**

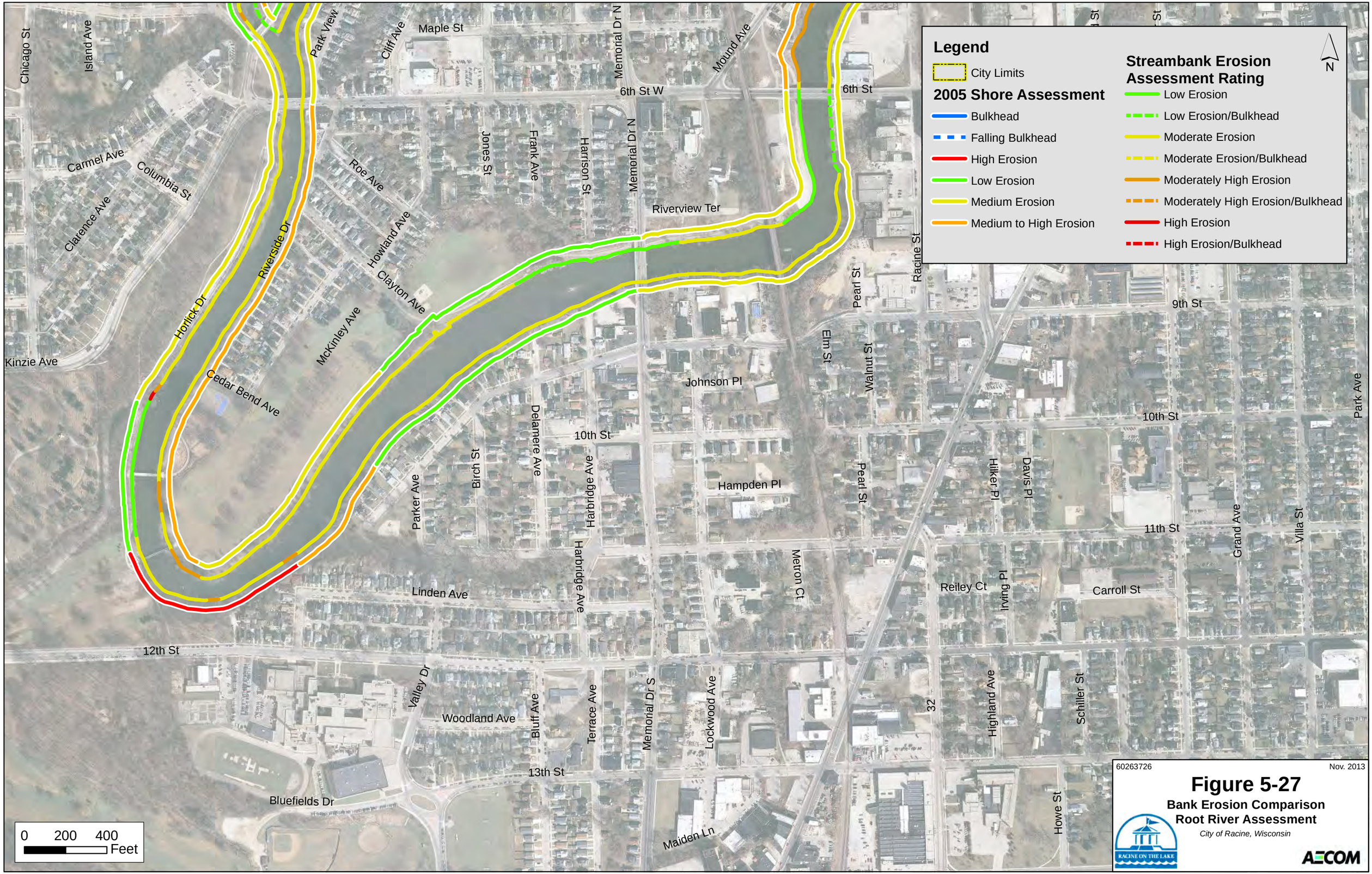
*City of Racine, Wisconsin*

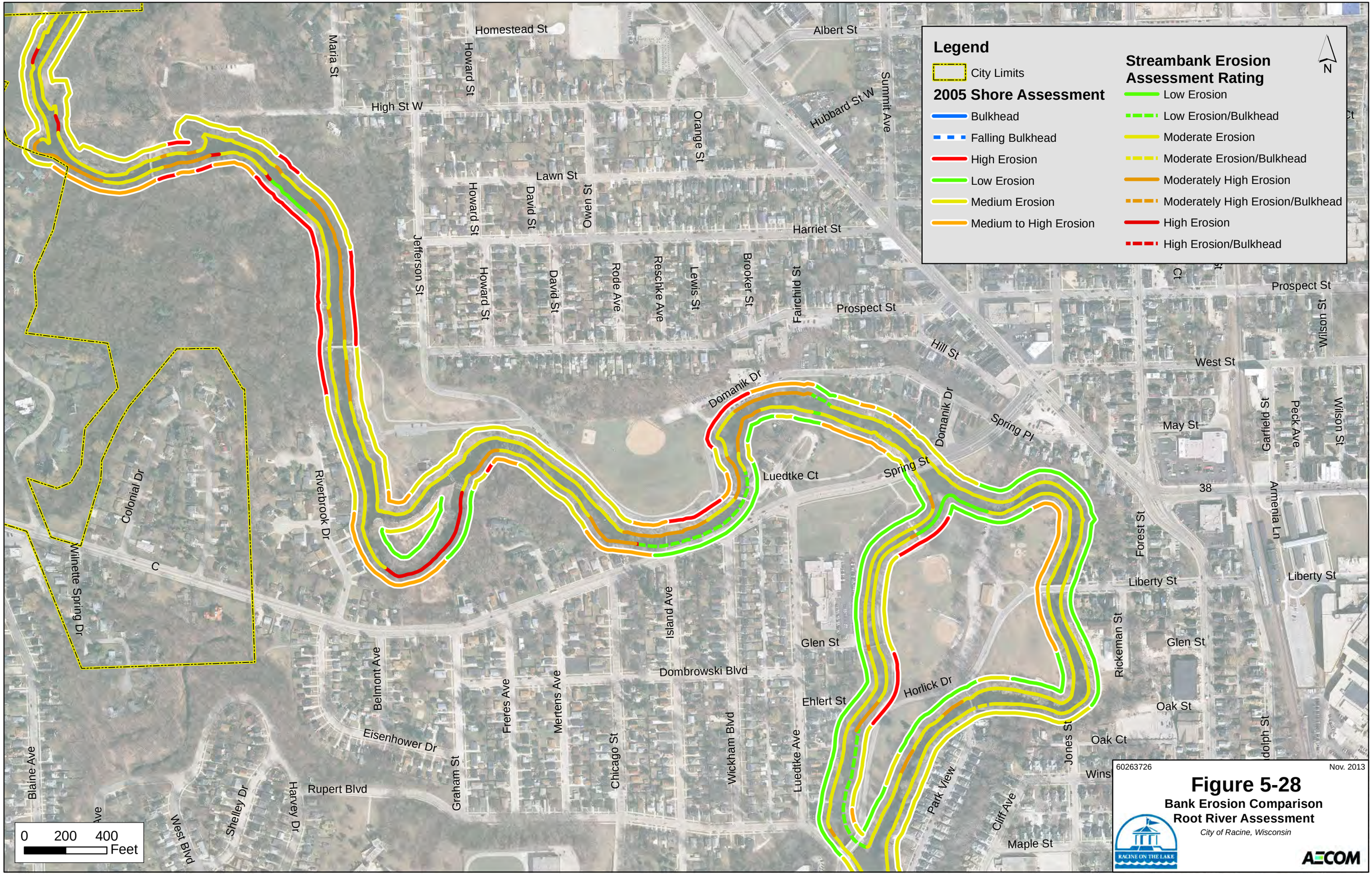
RACINE ON THE LAKE

AECOM


Dodge St
Dodge St
266
267
RR49
268
269
270
271
RR47
RR46
265
264
263
RR45
262
P13
RR50 - Bulkhead
RR57
RR59
RR58
Hwy. 32
1st St
2nd St
Gaslight Dr
State St
Lake Ave
Hwy. 38
Wisconsin Ave
RR56
261
RR44
260
259
0 50 100 Feet
Legend
City Limits
Photo Orientation
N
NE
E
SE
S
SW
W
NW
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
Stream Assessment
Low
Medium
Medium to High
High
2013 Outfall Rating
Excellent
Good
Fair
Poor
Not Rated
N
60263726
Nov. 2013
Figure 5-25
Root River Photo Location Areas
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


Legend
City Limits
2005 Shore Assessment
Bulkhead
Falling Bulkhead
High Erosion
Low Erosion
Medium Erosion
Medium to High Erosion
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
N
Barker St
Albert St
Nields Ct
Frederick St
Beaugrand Ct
Marquette St
Lasalle St
Superior St
Lincoln St
Buchanan St
Wisconsin St N
Hubbard St
Michigan Blvd
Chatham St
Geneva St
Hamilton St
Freeman Ct
Reeds Ct
Jackson St
Erie St
Colbert St
Dodge St
Prospect St
Wilson St
Gideon Ct
West St
Superior St
Huron St
Douglas Ave
Dr Martin Luther King Jr Dr
Garfield St
Peck Ave
Wilson St
32
2nd St
State St
Gaslight Dr
Gaslight Cir
38
Armenia Ln
Silver St
Union St
Liberty St
Liberty St
Ontario St
3rd St
4th St
Lake Ave
Randolph St
Mound Ave
S Marquette St
Water St
5th St
Wisconsin Ave
Monument Sq
Sam Johnson Pkwy
6th St
0 200 400
Feet
60263726
Nov. 2013
Figure 5-26
Bank Erosion Comparison
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


Legend
City Limits
2005 Shore Assessment
Bulkhead
Falling Bulkhead
High Erosion
Low Erosion
Medium Erosion
Medium to High Erosion
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
N
Chicago St
Island Ave
Park View
Cliff Ave
Maple St
Memorial Dr N
Mound Ave
6th St W
6th St
Carmel Ave
Columbia St
Clarence Ave
Riverside Dr
Roe Ave
Howland Ave
Jones St
Frank Ave
Harrison St
Memorial Dr N
Riverview Ter
Racine St
Pearl St
Elm St
Walnut St
9th St
Horlick Dr
Clayton Ave
McKinley Ave
Kinzie Ave
Cedar Bend Ave
Johnson Pl
Park Ave
10th St
Delamere Ave
Birch St
Parker Ave
Harbridge Ave
Hampden Pl
Pearl St
Hilker Pl
Davis Pl
11th St
Grand Ave
Villa St
Linden Ave
Metron Ct
Reiley Ct
Irving Pl
Carroll St
12th St
Valley Dr
Woodland Ave
Bluff Ave
Terrace Ave
Memorial Dr S
Lockwood Ave
32
Highland Ave
Schiller St
13th St
Bluefields Dr
Maiden Ln
Howe St
0 200 400 Feet
60263726
Nov. 2013
Figure 5-27
Bank Erosion Comparison
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM


Legend
City Limits
2005 Shore Assessment
Bulkhead
Falling Bulkhead
High Erosion
Low Erosion
Medium Erosion
Medium to High Erosion
Streambank Erosion Assessment Rating
Low Erosion
Low Erosion/Bulkhead
Moderate Erosion
Moderate Erosion/Bulkhead
Moderately High Erosion
Moderately High Erosion/Bulkhead
High Erosion
High Erosion/Bulkhead
N
Homestead St
Albert St
Maria St
Howard St
High St W
Hubbard St W
Summit Ave
Orange St
Lawn St
Owen St
David St
Harriet St
Jefferson St
Rode Ave
Reschke Ave
Lewis St
Brooker St
Fairchild St
Prospect St
Hill St
Domanik Dr
Spring Pl
West St
May St
Wilson St
Garfield St
Peck Ave
Ct
Luedtke Ct
Spring St
38
Armenia Ln
Forest St
Liberty St
Rickeman St
Glen St
Horlick Dr
Oak St
Oak Ct
Jones St
Park View
Cliff Ave
Maple St
Colonial Dr
Milinette Spring Dr
Riverbrook Dr
Belmont Ave
Eisenhower Dr
Freres Ave
Mertens Ave
Chicago St
Island Ave
Dombrowski Blvd
Wickham Blvd
Luedtke Ave
Ehlert St
Blaine Ave
Rupert Blvd
Graham St
Shelley Dr
Harvey Dr
West Blvd
0 200 400 Feet
60263726
Nov. 2013
Figure 5-28
Bank Erosion Comparison
Root River Assessment
City of Racine, Wisconsin
RACINE ON THE LAKE
AECOM

Riverpark Ln
Patzke Ln
Dan-Mor Ln
Mona Park Rd
Riverbend Dr
Green Bay Rd
Buckley Rd
Miller Ln
38
Old Mill Dr
Markridge Dr
Hanlon Dr
Galway Rd
Limerick Ln
Wexford Rd
Donegal Rd
Markridge Cir
Kerry Rd
MM
Rivershore Dr
Rapids Ct
Wolff St
Golf Ave
Fergus Ave
Eaton Ln
Romayne Ave
Romayne Ave
Jacato Dr
K
Rapids Dr
Fox Dr
Floyd Dr
Conrad Dr
Cecelia Park Dr
Barbara Dr
Windsor Dr

## Legend

City Limits

**2005 Shore Assessment**

- Bulkhead
- Falling Bulkhead
- High Erosion
- Low Erosion
- Medium Erosion
- Medium to High Erosion

**Streambank Erosion Assessment Rating**

- Low Erosion
- Low Erosion/Bulkhead
- Moderate Erosion
- Moderate Erosion/Bulkhead
- Moderately High Erosion
- Moderately High Erosion/Bulkhead
- High Erosion
- High Erosion/Bulkhead

N

0 200 400 Feet

60263726 Nov. 2013

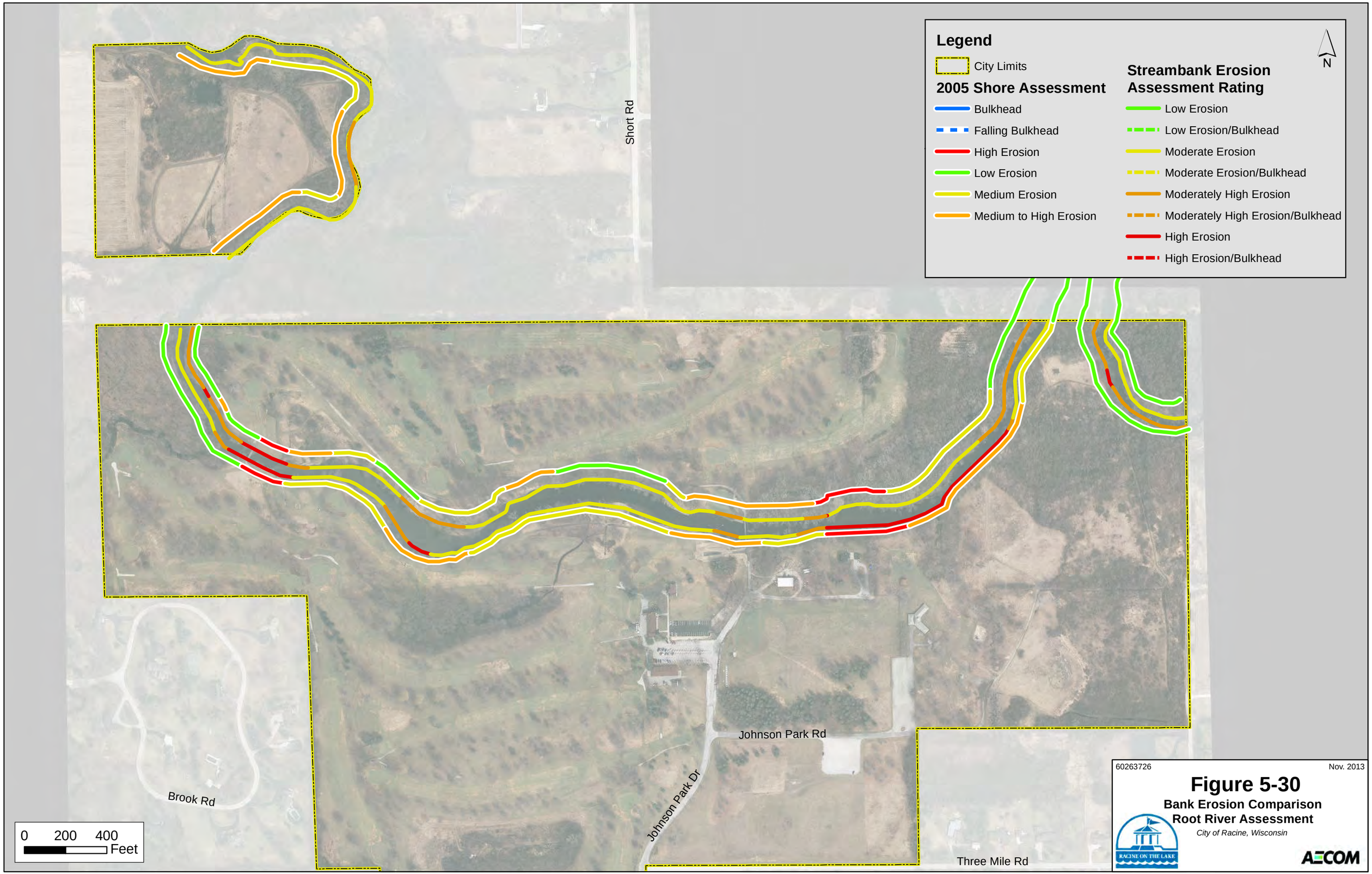
# Figure 5-29

**Bank Erosion Comparison**
**Root River Assessment**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM




60263726 Nov. 2013

# Figure 5-30

**Bank Erosion Comparison**
**Root River Assessment**

*City of Racine, Wisconsin*

RACINE ON THE LAKE

AECOM

# Appendix A

# BEHI Worksheet and Rating Guide

## Bank Erodibility Hazard Rating Guide

Stream _____ Reach _____ Date _____ Crew _____

Bank Erosion Potential

| Bank Height (ft): / Bankfull Height (ft): | | Bank Height/ Bankfull Ht | Root Depth/ Bank Height | Root Density % | Bank Angle (Degrees) | Surface Protection% |
|---|---|---|---|---|---|---|
| VERY LOW | Value | 1.0-1.1 | 1.0-0.9 | 100-80 | 0-20 | 100-80 |
| | Index | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| LOW | Value | 1.11-1.19 | 0.89-0.5 | 79-55 | 21-60 | 79-55 |
| | Index | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| MODERATE | Value | 1.2-1.5 | 0.49-0.3 | 54-30 | 61-80 | 54-30 |
| | Index | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| HIGH | Value | 1.6-2.0 | 0.29-0.15 | 29-15 | 81-90 | 29-15 |
| | Index | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| VERY HIGH | Value | 2.1-2.8 | 0.14-0.05 | 14-5.0 | 91-119 | 14-10 |
| | Index | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| EXTREME | Value | >2.8 | <0.05 | <5 | >119 | <10 |
| | Index | 10 | 10 | 10 | 10 | 10 |
| | Choice | V: I: | V: I: | V: I: | V: I: | V: I: |
| V = value, I = index | | | | **SUB-TOTAL** (Sum one index from each column) | | |

**Bank Material Description:**

**Bank Materials**

**Bedrock** (Bedrock banks have very low bank erosion potential)

**Boulders** (Banks composed of boulders have low bank erosion potential)

**Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

**Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)

**Sand** (Add 10 points)

**Silt Clay** (+ 0: no adjustment)

**BANK MATERIAL ADJUSTMENT** _____

**Stratification Comments:**

**Stratification**

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

**STRATIFICATION ADJUSTMENT** _____

| VERY LOW | LOW | MODERATE | HIGH | VERY HIGH | EXTREME |
|---|---|---|---|---|---|
| 5-9.5 | 10-19.5 | 20-29.5 | 30-39.5 | 40-45 | 46-50 |

**Bank location description (circle one)**

Straight Reach Outside of Bend

**GRAND TOTAL** _____

**BEHI RATING** _____

# Appendix B

# Pfankuch Rating Worksheet

# PFANKUCH CHANNEL STABILITY EVALUATION

Reach Location.....Date.....Observers.....STREAM TYPE.....

| | catagory | | EXCELLENT | | GOOD | | FAIR | | POOR | |
|---|---|---|---|---|---|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 | Bank slope gradient 30-40%. | 4 | Bank slope gradient 40-60%. | 6 | Bank slope gradient 60% + | 8 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting | 3 | Infrequent. Mostly healed over. Low future potential | 6 | Frequent or large, causing sediment nearly year long | 9 | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | 2 | Present, but mostly small twigs and limbs. | 4 | Moderate to heavy amounts, mostly larger sizes. | 6 | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 | <50-70% density. Lower vigor and fewer species form a shallow, discontinuous root mass. | 9 | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7 | 1 | Adequate. Bank overflows rare. W/D ratio 8-15. | 2 | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common | 2 | 40-65%. Mostly small boulders to cobbles 6-12". | 4 | 20-40% with most in the 3-6" diameter class. | 6 | <20% rock fragments of gravel sizes, 1-3" or less. | 8 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | 2 | Some present causing erosive cross currents and minor pool filling. Obstructions newer and less firm. | 4 | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 | Frequent obstructions cause erosion year-long. Sediment traps full, channel migration occurring. | 8 |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6" | 4 | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". | 6 | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident. | 12 | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars | 4 | Some new bar increase, mostly from coarse gravel. | 8 | Moder. deposition of new gravel and course sand on old and some new bars. | 12 | Extensive deposits of predominately fine particles. Accelerated bar development. | 16 |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 | Rounded corners and edges, surfaces smooth, flat. | 2 | Corners and edges well rounded in two dimensions. | 3 | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 | Mostly dull, but may have <35% bright surfaces. | 2 | Modure dull and bright. ie 35-65% mixture range. | 3 | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 | Moderately packed with some overlapping. | 4 | Mostly loose assortment with no apparent overlap. | 6 | No packing evident. Loose assortment easily moved. | 8 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100%. | 4 | Distribution shift light. Stable material 50-80%. | 8 | Moder. change in sizes. Stable materials 20-50%. | 12 | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 | More than 50% of the bottom in a state of flux or change nearly year-long. | 24 |
| | 15 | Aquatic Vegetation | Abundant. Growth moss-like, dark green, perennial. In swift water too. | 1 | Common. Algal forms in low velocity and pool areas. Moss here too. | 2 | Present but spotty, mostly in backwater. Seasonal algal growth makes rocks slick. | 3 | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | totals..... | | | | | | | | |

Stream Width.....x avg. depth.....x mean velocity.....=Q.....cfs

Gauge Ht.....Reach Gradient.....Stream Order.....Sinuosity Ratio.....

Width Bf.....Depth Bf.....W/D Ratio.....Bf Dischrge (Q Bf).....

Drainage Area.....Valley Gradient.....Stream Length.....Valley Length.....

Sinuosity.....Entrenchment Ratio.....Length Meander (Lm).....Belt Width.....

**Sediment Supply**
Extreme.....
Very High.....
High.....
Moderate.....
Low.....

**Stream Bed Stability**
Aggrading.....
Degrading.....
Stable.....

**Width/Depth Ratio Condition**
Normal.....
High.....
Very High.....

TOTAL SCORE for Reach E.....+ G.....+ F.....+ P.....=

Remarks.....

[ ] Stream Type

[ ] Pfankuch Rating

[ ] from table Reach Condition

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

# Appendix C

# Photo Logs

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11


Photo 12


Photo 13


Photo 14


Photo 15


Photo 16


Photo 17


Photo 18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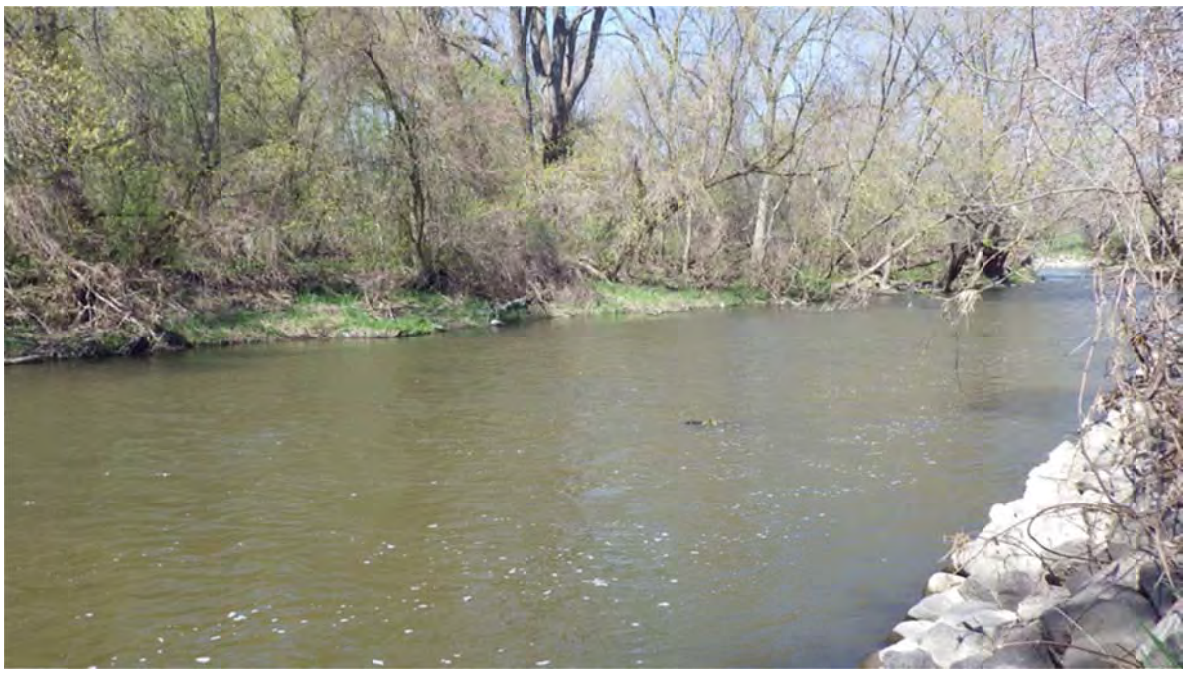

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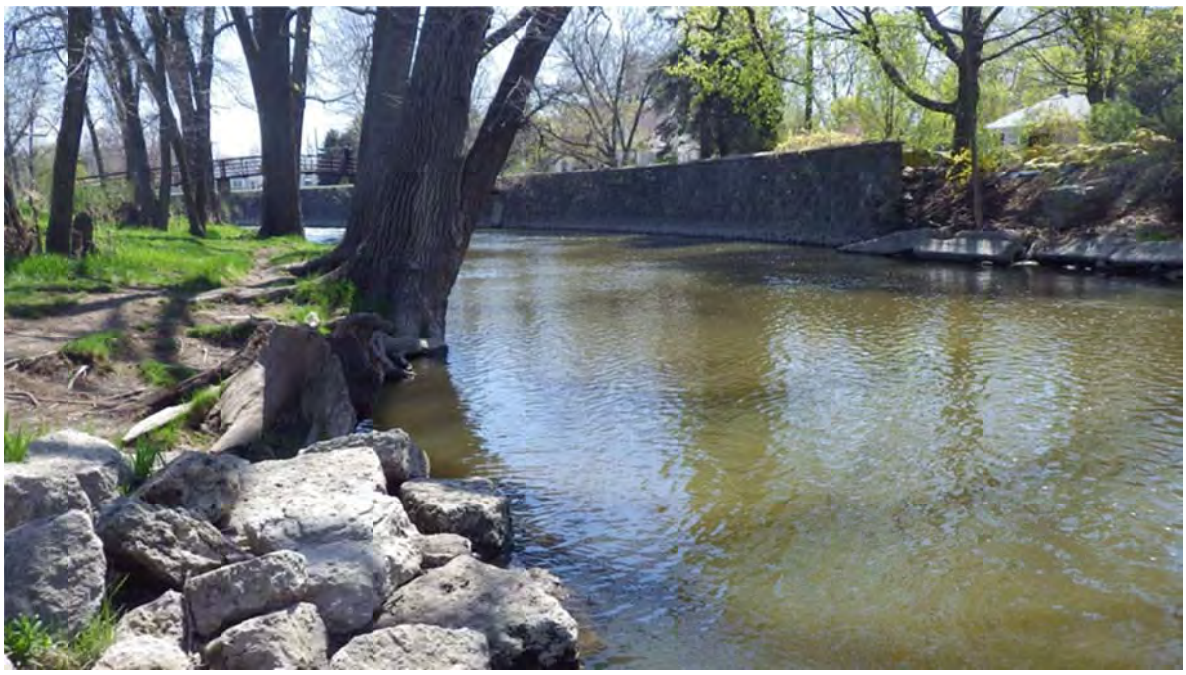

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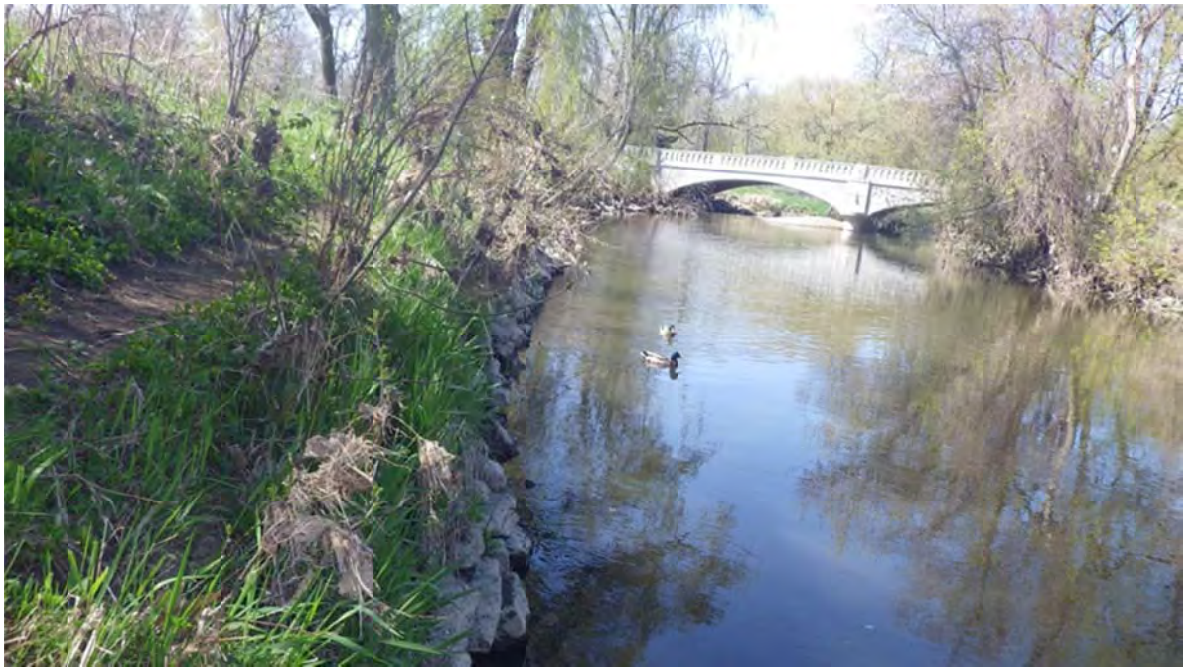

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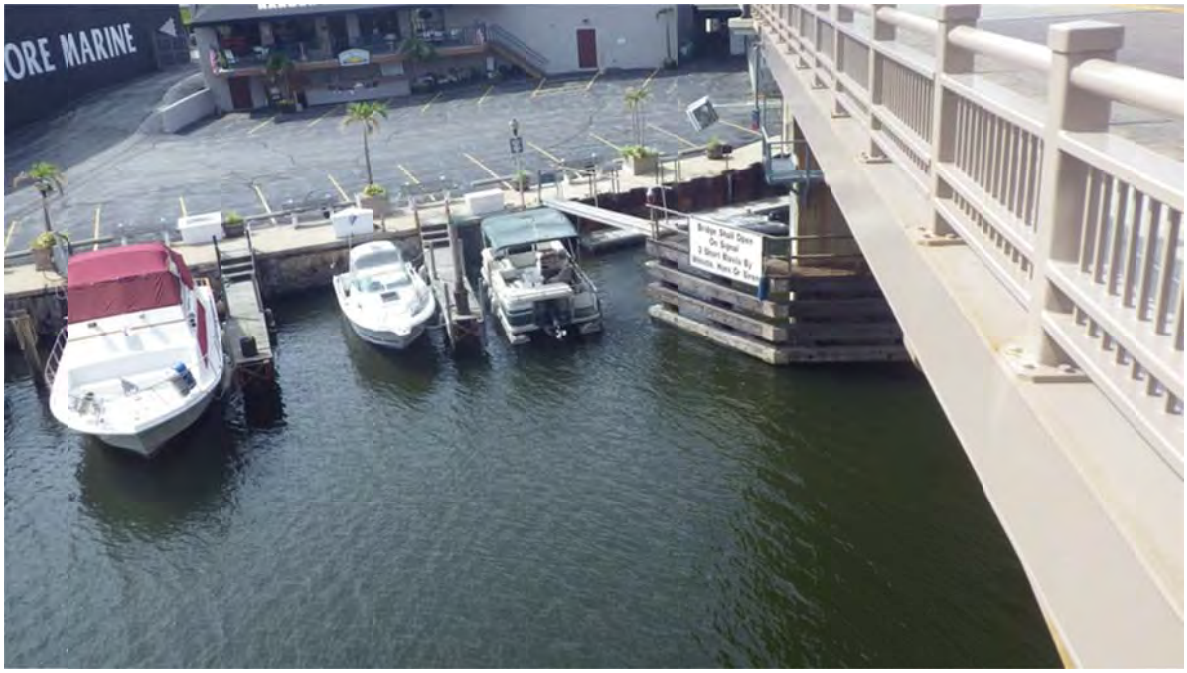


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