



LA 883 ENVIRONMENTAL DESIGN SEMINAR Spring 2026 (3 Credits)

M 9:10AM–12:00PM
DSL Classroom, 2nd floor of the Main Library

Instructor

Dr. Haoyue Yang
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Human Ecology Building
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Course Description

Landscape performance is a crucial component of contemporary landscape architecture research, education, and professional practice, offering an evidence-based approach to evaluating how built landscapes achieve their environmental, social, and economic objectives. This course introduces students to landscape performance concepts, evaluation frameworks, and applied assessment methods used to quantify the outcomes of sustainable landscape projects.

Through a combination of lectures, precedent studies, guest speakers, and hands-on workshops, students will examine landscape performance in conjunction with design rating systems and explore ecosystem service modeling and human-centered evaluation methods. Students will gain practical experience applying performance assessment tools and simulation models to assess environmental, social, and economic outcomes. The course emphasizes learning from built projects through LAF Case Study Investigation (CSI) precedents and culminates in a real-world case study.

Students are expected to engage regularly with course materials, participate actively in class discussions and activities, and provide thoughtful responses that demonstrate a meaningful understanding of the course content.

Course Objectives

The primary goal of this course is to introduce students to landscape performance as a critical framework for evaluating the outcomes of design interventions. The course emphasizes applied performance evaluation methods and tools to assess environmental, social, and economic benefits. Upon successful completion of this course, students will be able to:



- Explain the role of landscape performance evaluation in demonstrating the environmental, social, and economic outcomes of sustainable landscape projects
- Critically assess design rating systems and performance approaches in relation to evidence-based landscape evaluation.
- Apply landscape performance assessment tools and simulation models to quantify performance outcomes.
- Analyze and synthesize findings from precedent landscape performance studies
- Design appropriate evaluation methods by translating existing project goals into performance questions, selecting defensible metrics, and identifying suitable tools, data sources, and assumptions.
- Communicate defensible landscape performance assessments through clear visual and written representations.
- Develop individual expertise in landscape performance that supports professional effectiveness and advocacy for sustainable planning and design strategies.

Topics

Environmental design
Landscape performance
Sensitivity analysis
SITES rating system
LEED rating system
Ecosystem service modeling
Flood mitigation
Urban cooling
Carbon storage and sequestration
Tourism and recreation
Human subject research

Books and References

- Landscape Architecture Foundation. Landscape Performance Series.
<https://www.landscapperformance.org/case-study-briefs>
- Landscape Architecture Foundation. Recorded Webinars.
<https://www.lafoundation.org/resources/category/recorded-webinars?page=0>
- Landscape Architecture Foundation. Evaluating Landscape Performance: A Guidebook for Metrics and Methods Selection. 2018.
<https://www.landscapperformance.org/sites/default/files/LAF-Evaluating-Performance-Guidebook.pdf>
- ASLA. Landscape Performance & Metrics Primer. 2018.
<https://www.scribd.com/document/813490517/Landscape-Performance-Metrics-Primer-ASLA-2018>



- Newman, G., Zhu, R., Li, D., & Barnes, M. (Eds.). (2024). Contemporary Landscape Performance Methods and Techniques: Lessons from the Houston Arboretum and Nature Center (1st ed.). Routledge.
<https://doi-org.proxy2.cl.msu.edu/10.4324/9781003495482>
- Landscape Architecture Foundation. Landscape Performance Series Reading & Resource List.
<https://www.landscapeperformance.org/sites/default/files/Resources-for-Educators-Combined-Readings.pdf>

Note:

Weekly readings will be posted on D2L.

Course Evaluation

Assignments – 20%

Precedent Study -10%

Toolkit Review Presentation – 25%

Final Project – 35%

Class attendance and discussion – 10%

Grading

90+	4.0
86-89.9	3.5
80-85.9	3.0
75-79.9	2.5
70-74.9	2.0
65-69.9	1.5
60-64.9	1.0
Below 60	0.0

Course Requirement

The format for the course will be reading and assignment intensive and discussion based. Reading will be assigned in class and regularly uploaded on the University's Desire2Learn (D2L) learning management system: <https://D2L.msu.edu>.

1. **Assignments:** A1 will require students to finish the CITI training for Human Subject Study required by IRB. A2 will require students to select individual topics within their area of interest and quantify the impacts of design scenarios using selected LAF toolkits. A3 focuses on the prediction of local ecosystem services using GIS and InVEST models.
2. **Precedent Study:** Each student will complete a precedent study based on existing Landscape Architecture Foundation (LAF) Case Study Investigations (CSI) or comparable landscape performance projects. Students will select one topic from the scheduled precedent study themes. For the selected topic, each student shall give a 15-minute presentation in class that identifies and analyzes three relevant case studies. For each case study, students are expected to document:



- The project name and context
- The performance goal(s) addressed
- The performance metric(s) used
- The method(s) or tool(s) applied
- Key limitation or consideration related to the performance evaluation

3. **Toolkit Review Presentation:** Each student will be asked to present a PowerPoint tutorial that demonstrates a detailed, step-by-step process for conducting analytic simulations or calculations of landscape benefits using a chosen Landscape Architecture Foundation (LAF) toolkit.
4. **Final Project:** The Final Project is a group-based landscape performance assessment of Glass City Metropark, Toledo, OH. Students will be assigned to one of three focus areas:
 - Social Performance
 - Environmental Performance
 - Economic PerformanceGroups will interpret existing project goals, identify appropriate performance questions, select/develop metrics and methods, analyze secondary data, and produce a final report and presentation consistent with LAF CSI-style reporting.
5. **Class Attendance and Discussion:** Students will be expected to attend class regularly and contribute to class discussions. Students will be expected to bring to discussions knowledge and expertise gained throughout their graduate program or work experience.

Software Utilized:

- ArcGIS Pro:
https://techstore.msu.edu/shop_product_detail.asp?catalog_group_id=Nw&catalog_group_name=U29mdHdhcmU&catalog_id=45&catalog_name=U3R1ZGVudCBTb2Z0d2FyZQ&pf_id=980&product_name=QXJjR0lTIDewLjYsIDegWWVhciBTdHVkZW50IEpY2Vuc2U&type=1&target=shop_product_list.asp
 - Instructions for installation:
<https://libguides.lib.msu.edu/c.php?g=1233490&p=9027010>
 - GIS Librarian: Amanda Tickner, atickner@msu.edu
- InVEST: <https://naturalcapitalproject.stanford.edu/software/invest>



Class Schedule (subject to change)

Date	Part 1 – Lecture	Precedent Studies (3 CSI Methods)	Part 2 – Workshop / In-Class Activity	Assignments Issued	Assignments Due
Jan. 12	Course Introduction Landscape Performance Assessment		CSI Report Deconstruction	Presentation 1: LAF Toolkit Review Presentation	
Jan. 19	MLK Day – No Class				
Jan. 26	SITES and LEED Rating Systems, Sensitivity Analysis		Workshop: Mapping SITES / LEED Credits to CSI Metrics		
Feb. 2	Human Subject Research I		Student LAF Toolkit Presentations	A1 Issued: IRB Training	P1 Due Before Class
Feb. 9	Human Subject Research II	Public Life, Engagement, Social Value	Workshop: Survey and Interview Design	A2 Issued: Sensitivity Analysis	
Feb. 16	Guest Lecture (Mr. Mel Vargas): Ecosystem Restoration Programs	Habitat and Biodiversity	InVEST Demo 1	A3 Issued: InVEST Project	A1 Due
Feb. 23	Guest Lecture (Mr. Scott Whitcomb): Carbon Storage, Michigan Healthy Climate Plan	Carbon Sequestration, Waste Reduction, Cost Saving	InVEST Demo 2		
Mar. 2	Spring Break				
Mar. 9	Guest Lecture (Dr. Dingding Ren): Urban Heat Island	Heat Mitigation, Urban Cooling, Thermal Comfort	InVEST Demo 3		A2 Due
Mar. 16	Special Topic: Sustainable Stormwater Management Assessment	Stormwater Performance, Flood Protection	Toledo Park Kickoff with SmithGroup: Project Goals and Available Data (Start at 9:10, switch time with lecture)	Presentation 2: Final Project	
Mar. 23	Guest Lecture (Dr. Zhihan Tao): Economic Performance	Economic Development, Property Value, Tax Revenue	Work Session: Metrics and Methods Development		A3 Due
Mar. 30	Special Topic: Health and Well-Being	Health and Well- Being Outcomes, Safety	Peer Review: Metrics and Methods Development		
Apr. 6	Special Topic: Waste Reduction and Cost Savings		Work Session: Tool Selection and Data Collection	Site Visit Apr 10	
Apr. 13	Project Review and Work Session				
Apr. 20	Project Review and Work Session				
Apr. 27	Final Presentations				P2 Due Before Class



Policy and Statements

Make-Up or Extension Policy

Under extenuating circumstances and with proper written documentation, faculty reserves the right to approve a make-up or extension. Please make every effort to notify the faculty prior to the due date. Only with approval by faculty may a student submit late work with no penalty. The following are considered extenuating circumstances:

- Illness of student (appropriate documentation = physicians report)
- Death in the family (appropriate documentation = obituary notice)
- Class field trip or MSU sponsored event (appropriate documentation = memo from instructing faculty or administrator)

Technical Assistance

Faculty will be available during office hours and via email. Faculty will make every effort to respond to emails Monday-Friday within 24 hours.

MSU Distance Learning Services Resources

If you need technical assistance at any time during the course or to report a problem, you can:

- Visit the Distance Learning Services Support Site <https://www.lib.msu.edu/dls>
 - Visit the Desire2Learn Help Site <http://help.d2l.msu.edu>
- Or call Distance Learning Services: (800) 500-1554 or (517) 355-2345

Disruptive Behavior

Article 2.III.B.4 of the [Academic Freedom Report \(AFR\)](#) for students at Michigan State University states: "The student's behavior in the classroom shall be conducive to the teaching and learning process for all concerned." Article 2.III.B.10 of the [AFR](#) states that "The student has a right to scholarly relationships with faculty based on mutual trust and civility." [General Student Regulation 5.02](#) states: "No student shall . . . interfere with the functions and services of the University (for example, but not limited to, classes . . .) such that the function or service is obstructed or disrupted. Students whose conduct adversely affects the learning environment in this classroom may be subject to disciplinary action through the Student Judicial Affairs office.

Understand When You May Drop This Course

It is the student's responsibility to understand when they need to consider un-enrolling from a course. Refer to the Michigan State University Office of the Registrar for important dates and deadlines.

Diversity Equity and Inclusiveness

Diversity, Equity and Inclusion are important, interdependent components of everyday life in the College of Agriculture and Natural Resources (CANR) and are critical to our pursuit of academic excellence. Our aim is to foster a culture where every member of CANR feels valued, supported and inspired to achieve individual and common goals with an uncommon will. This includes providing opportunity and access for all people across differences of race, age, color, ethnicity, gender, sexual orientation, gender identity, gender expression, religion,



national origin, migratory status, disability / abilities, political affiliation, veteran status and socioeconomic background. (See the full CANR statement: <https://www.canr.msu.edu/news/canr-statement-on-diversity-equity-and-inclusion>)

Inform Your Instructor of Any Accommodations Needed

From the Resource Center for Persons with Disabilities (RCPD): Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued a Verified Individual Services Accommodation ("VISA") form. Please present this form to the instructor at the start of the term and/or two weeks prior to the accommodation date (test, project, etc.). Requests received after this date may not be honored.

Commit to Integrity - Academic Honesty

As Spartans, we remain committed to honesty and integrity in our work – inside, and outside of the classroom, and permit no tolerance for academic dishonesty. The Associated Students of Michigan State University (ASMSU), launched the [Spartan Code of Honor academic pledge](#), focused on valuing academic integrity and honest work ethics at MSU. The pledge reads as follows:

*"As a Spartan, I will strive to uphold values of the **highest ethical standard**. I will practice honesty in my work, foster honesty in my peers, and take pride in knowing that **honor is worth more than grades**. I will carry these values beyond my time as a student at Michigan State University, continuing the endeavor to build personal integrity in all that I do."*

Article 2.3.3 of the [Academic Freedom Report](#) states that "The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards." In addition, the School of Planning, Design and Construction adheres to the policies on academic honesty as specified in General Student Regulations 1.0, Protection of Scholarship and Grades; the all-University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations. (See [Spartan Life: Student Handbook and Resource Guide](#) and/or the MSU Web site: www.msu.edu.)

Therefore, unless authorized by your instructor, you are expected to complete all course assignments, including homework, studio work, quizzes, tests and exams, without assistance from any source. You are expected to develop original work for this course; therefore, you may not submit any content that is not your original work or any course work you completed for another course to satisfy the requirements for this course. Also, you are not authorized to use the www.allmsu.com website to complete any course work in this course. Students who violate MSU academic integrity rules may receive a penalty grade, including a failing grade on the assignment or in the course. Contact your instructor if you are unsure about the appropriateness of your course work. (See also the [Academic Integrity](#) webpage.)

Religious Holidays, Academic Events & Athletics

If observing a religious holiday or representing MSU in a university sponsored academic or athletic event will affect a student's performance in this course, he/she should make



arrangements to submit assignments in advance as much as possible and contact faculty with any concerns.

REFLECTION

Haoyue Yang
Assistant Professor
School of Planning, Design and Construction
University of Nevada, Las Vegas
Spring 2026 Semester

Overview

Environmental Design Seminar was developed to introduce graduate landscape architecture students to the principles and practice of landscape performance. While students are often trained to design landscapes, they receive relatively little exposure to evaluating whether built projects actually achieve their intended environmental, social, and economic outcomes. This course was designed to address that gap by introducing evidence-based methods for assessing landscape performance and demonstrating the value of landscape architecture through measurable outcomes.

The course was offered as a graduate seminar that combined lectures, discussions, guest speakers, software workshops, and a semester-long case study. The course exposed students to multiple evaluation frameworks, including ecosystem service modeling, social performance assessment, economic evaluation, and Landscape Architecture Foundation (LAF) methodologies. Students ultimately applied these concepts through a comprehensive assessment of Glass City Metropark in Toledo, Ohio.

Workflow Process

The course was intentionally organized into two complementary phases that moved students from conceptual understanding to applied practice.

During the first half of the semester, students developed a foundation in landscape performance by examining individual performance topics such as ecosystem services, stormwater management, urban heat mitigation, carbon sequestration, public life, health and wellbeing and economic performance. Each week focused on a specific performance category, allowing students to explore appropriate metrics, evaluation methods, and available analytical tools. Guest lectures from researchers and practitioners enriched these discussions by illustrating how these methods are applied in professional practice. Laboratory sessions introduced GIS and InVEST modeling to familiarize students with commonly used analytical tools.

The second half of the semester shifted from learning individual methods to integrating them within a real project. Glass City Metropark served as the semester-long case study, providing students with an opportunity to synthesize knowledge acquired earlier in the course. Working in teams, students interpreted project goals, selected appropriate performance metrics, collected and analyzed available data, and developed evidence-based conclusions similar to Landscape Architecture Foundation Case Study Investigations.

This progression from theory to application reflects my teaching philosophy. Landscape performance encompasses a wide range of environmental, social, and economic topics, making it unrealistic to teach every possible method in depth within a single semester. Instead, the course emphasized fundamental concepts while encouraging students to develop independent problem-solving skills. The seminar format, rotating topical themes, guest lectures, and collaborative discussions were intended to expose students to diverse perspectives while helping them build confidence in selecting appropriate metrics and evaluation methods for unique projects.

Student Outcomes and Feedback

Overall, student feedback suggests that the course successfully introduced an emerging area of landscape architecture that students found valuable and professionally relevant. Students consistently highlighted the guest lectures, Landscape Architecture Foundation resources, and the final case study as meaningful learning experiences. Many commented that the course broadened their understanding of post-occupancy evaluation and provided practical tools that would benefit their future professional careers.

The most consistent area for improvement concerned assignment expectations. Several students indicated that assignment instructions and grading rubrics were sometimes difficult to interpret, making it challenging to understand the level of detail expected. Additional feedback focused on software instruction. Students recommended slower demonstrations, additional guided tutorials for InVEST and GIS workflows, and more time for technical support during class.

Challenges

- **Building and maintaining industry partnerships.** The collaboration with SmithGroup and Toledo Metroparks was essential to the success of the course. Their willingness to share project goals, design documents, and operations and maintenance information enabled students to conduct an authentic landscape performance assessment. Coordinating external partners and project schedules, however, required significant planning.
- **Teaching advanced analytical methods.** Many students had limited prior experience with research methods, ArcGIS Pro, and InVEST modeling. These tools have a learning curve, making slow, step-by-step demonstrations and repeated practice essential for student success.
- **Developing creative evaluation strategies.** Landscape performance does not have a uniform solution. Students needed to translate project goals into measurable performance questions, identify appropriate metrics, and justify their evaluation methods. Encouraging students to think creatively while maintaining methodological rigor was one of the most challenging aspects of the course. Reviews of Landscape Architecture Foundation (LAF) case studies, peer discussions, desk critiques, and workshops were valuable in supporting this process.
- **Coordinating guest speakers.** Inviting practitioners and researchers greatly enriched the seminar but introduced scheduling challenges. Reaching out to speakers well in advance, incorporating Zoom presentations, and inviting Ph.D. students to share their research helped.

- **Designing appropriate assessment criteria.** Because landscape performance is an emerging and interdisciplinary topic, students entered the course with varying backgrounds and limited prior knowledge. Developing grading rubrics that rewarded critical thinking, methodological reasoning, and creativity—rather than simply obtaining answers—proved challenging.

Future Improvements

- **Clarify assignment expectations.** Revise assignment descriptions and grading rubrics to provide clearer expectations, examples of successful submissions, and more transparent evaluation criteria. This addresses the most consistent theme identified in student feedback.
- **Scaffold the semester-long project.** Restructure assignments so that each contributes directly to the final landscape performance assessment. This will provide multiple opportunities for formative feedback while reducing the workload concentrated at the end of the semester.
- **Strengthen technical instruction.** Expand GIS and InVEST training by incorporating slower demonstrations, step-by-step tutorials, recorded instructional videos, and optional workshop or office-hour sessions to better support students with limited technical backgrounds.
- **Continue expanding professional partnerships.** Build additional collaborations with landscape architecture firms, public agencies, and park organizations to provide students with access to diverse real-world case studies and project documentation.
- **Refine assessment methods.** Continue improving rubrics to place greater emphasis on the evaluation process, methodological justification, and critical thinking, recognizing that landscape performance assessments often involve multiple valid approaches.
- **Increase opportunities for peer review and iterative feedback.** Incorporate additional milestone presentations and in-class work sessions so students can receive feedback throughout the semester rather than primarily at the final presentation.

Acknowledgement

This course would not have been possible without the generous support of our professional collaborators and guest speakers. I would like to express my sincere appreciation to SmithGroup for partnering with the class through the Glass City Metropark case study and to Toledo Metroparks for providing project documentation, operations and maintenance information, and access to the site. Their willingness to share real project data allowed students to experience the complexities of conducting a landscape performance assessment beyond what can be learned from published case studies.

I am also grateful to the guest lecturers, Mr. Mel Vargas, Mr. Scott Whitcomb, Dr. Dingding Ren, and Dr. Zhihan Tao, who contributed their expertise in ecosystem restoration, carbon storage, urban heat mitigation, and economic performance. Their presentations exposed students to current research and professional practice.

Finally, this course builds upon teaching materials previously developed by Dr. Wonmin Sohn, whose contributions provided an important foundation for developing this seminar.

Recognition

The success of this seminar reflects not only the support of our professional partners but also the dedication, curiosity, and hard work of the students. Their thoughtful discussions, collaborative teamwork, and commitment to applying landscape performance concepts were instrumental in shaping the course and informing future improvements.

Students (Spring 2026)

- Ava Yon
- Samia Faiza
- Adam Hershner
- Jess Le
- Christopher Nosek
- Isaiah Ramsey
- Sydney Zachos

Review of LAF Toolkit

In this assignment, you are tasked with creating a PowerPoint tutorial that demonstrates a detailed, step-by-step process for conducting analytic simulations or calculations of landscape benefits using a chosen Landscape Architecture Foundation (LAF) toolkit. Follow these guidelines:

1. Choose one tool from the LAF's Benefits Toolkit page: [Landscape Performance Benefits Toolkit](#). Alternatively, you may select a tool not listed on the LAF website.
2. Log your chosen tool in the shared Google Drive spreadsheet to avoid duplicates. Selections are on a first-come, first-served basis. There are some listed toolkits in the spreadsheet to choose.
3. Select a site that interests you and create a hypothetical development and design scenario. Use your chosen tool to input relevant values for this scenario.
4. Take screenshots at each stage of your process. Clearly highlight the input and output variables, along with their respective values, in these screenshots.

Final deliverables:

- **PDF Compilation:** Convert your PPT into a single PDF file and submit it through D2L.
- **Class Presentation:** Prepare for a 15-minute simulation presentation of your model during class, demonstrating its application and results.

Sensitivity Analysis

In this exercise, you are required to perform a **sensitivity analysis** using an application tool of your choice to identify which inputs have the greatest impact on the output and to comprehend the relationship between inputs and outputs. The requirements are as follows:

1. Select one benefit measurement tool of your interest. It can be one of LAF toolkits or not.
2. Identify the variables that are inputs to the model, and the variables that are output/results.
3. Select at least two numerical inputs to be tested (choose the inputs that would be most important or uncertain, or that likely have the greatest impact on the output).
4. Set the existing site condition as a baseline.
5. Specify the range of values for each input (e.g., $\pm 5\%$, $\pm 10\%$, and $\pm 15\%$ of the total area, for changes in impervious surfaces to compensate for the loss of forests).
6. Run the model multiple times, using different values of the selected inputs each time, while holding all other variables constant.
7. Analyze the results to see how the outputs (Y) change as inputs (X) change.
8. Visualize the relationship between X and Y using a bar or line graph.
9. Interpret the results to understand the relationships between inputs and outputs, and to identify which input has the greater impact on the outputs.

Final deliverables:

- A PDF report in letter size should be submitted via D2L

Evaluation rubrics:

	excellent	good	fair	poor	points
Completeness and depth of information on: Input and output variables/values for the selected toolkits under both baseline and alternative design scenarios					2
Interpretation of comparative results by scenario					2
Visualization and interpretation of the sensitivity analysis results					2
Limitations of the selected toolkits					2
Hierarchy of information presented (both visual and written information)					1
Completeness and clarity of information presented					1
Subtotal					/10

Precedent Study

In this assignment, each student will complete a precedent study based on existing Landscape Architecture Foundation (LAF) Case Study Investigations (CSI) or comparable landscape performance projects.

Students will select one topic from the scheduled precedent study themes. For the selected topic, each student shall give a 15-minute presentation in class that identifies and analyzes three relevant case studies. Please log your chosen tool in the shared Google Drive spreadsheet to avoid duplicates. Selections are on a first-come, first-served basis.

For each case study, students are expected to document:

- The project name and context
- The performance goal(s) addressed
- The performance metric(s) used
- The method(s) or tool(s) applied
- Key limitation or consideration related to the performance evaluation

Ecosystem Service Prediction using InVest

In this exercise, you will perform a comprehensive ecosystem service prediction using the InVEST model and evaluate the benefits of both the baseline and future land use scenarios in your area of interest. The spatial scale can be a community, city, region, or another relevant level. Overall, this exercise is designed to develop your skills in ecosystem service prediction and evaluation, as well as enhance your proficiency in using GIS tools and interpreting spatial data.

1. Find two LULC datasets from different years. Use the earlier-year data as the baseline land use scenario and the later-year data as the future land use scenario.

2. Employ at least two InVEST models to simulate the varying ecosystem services of your baseline and future land use scenarios.
3. Compile a summary table that outlines each model's input variables, data sources, and units.
4. Generate a summary table that displays each model's result statistics (units should be indicated).
5. Visualize and interpret the spatial results. Show the resultant GIS maps complete with a legend, unit, north arrow, and graphic scale.
6. Interpret each model's results

Final deliverables:

- A PDF report submitted to D2L.

Evaluation rubrics:

	excellent	good	fair	poor	points
Completeness and depth of information on:					2
• Overview of the study area selected					
• Description and map of baseline and future land use scenarios, looking at the changes of different land use type					2
• A summary table of models' input data					1
• A summary table of models' output data					1
• Visualization of the results					2
• Interpretation of the results					2
Subtotal					____/10

Final Project: Landscape Performance Assessment

Site: Glass City Metropark, Toledo, Ohio

Project Overview

The final project is a landscape performance assessment of Glass City Metropark. Students will evaluate how the park contributes to environmental sustainability, community well-being, and economic value. The project will follow the structure and methods used in the Landscape Architecture Foundation Case Study Investigation (CSI) program, which evaluates built landscape projects using measurable performance metrics.

Students will work collaboratively in small teams to analyze one category of landscape performance and produce a case study report and presentation. Students are supposed to work as a team to develop research questions. Each student must develop one landscape performance metric related to their group's focus area. Each metric must include either:

Option A – Measured Performance Result

Students calculate a performance outcome using available data sources such as GIS data, park documentation, public datasets, or LAF toolkit methods.

Examples:

- stormwater captured by green infrastructure
- carbon sequestration from planting information
- nearby property value change

Option B – Detailed Research Plan and Instrument

If full data collection is not feasible, students must develop a complete research design, including a data collection instrument.

Examples:

- visitor survey instrument
- behavioral observation protocol
- biodiversity survey method
- economic impact survey

The plan should be detailed enough that another researcher could implement the study directly.

Group Structure

Students will be assigned to three groups based on landscape performance categories.

Performance Category	Students
Environmental Performance	3 students
Social Performance	2 students
Economic Performance	2 students

Field Visit and Data Collection

The class will conduct a field visit to Glass City Metropark to gather initial observations and test data-collection methods. The purpose of the field visit is to help students refine their metrics and research instruments. During the visit, students may, but are not limited to:

- document park features
- conduct pilot observations of park users
- test survey questions
- record site photographs
- map environmental features

Final Deliverables

Each group will produce a CSI-style landscape performance case study report and deliver a 20-30-minute presentation, depending on the team size. Students should refer to past studies from the Landscape Architecture Foundation Case Study Investigation (CSI) program as examples for structure and formatting.

The written report should be formatted in letter size and clearly organized. The presentation should communicate the key findings and methods from the report.

Both the report and presentation should include the following sections related to your team's assigned performance category (Environmental, Social, or Economic):

- Project Goals and Design Intent – Key design goals and intended outcomes relevant to your performance category.
- Performance Questions – The research questions guiding your analysis.
- Methods and Metrics – The metrics selected and the methods used to calculate or evaluate them.
- Performance Findings – Results from calculations, analysis, or initial data collection. If results are not available, present a detailed research plan and instrument (e.g., survey or observation protocol).
- Limitations – Data limitations, methodological constraints, or uncertainties.
- Discussion and Implications – Interpretation of findings and implications for landscape design practice.
- References – Sources of data, literature, and tools used in the analysis.

Each student's assigned metric or research instrument could appear as a separate performance section in the report and presentation (as in the CSI report).

The final presentation should summarize the group's analysis, highlighting the performance questions, methods, results, or proposed research plans, and the broader implications for landscape architecture and landscape performance evaluation.

Rubric:

	excellent	good	fair	poor	points
Project Goals & Performance Questions					5
Methods and Metrics					5
Performance Findings or Research Plan					5
Limitations and Critical Reflection					5
Discussion and Implications for Practice					5
Communication Quality (Report)					5
Oral Presentation					5

Total Points: 35 points

(1) LAF Benefit Toolkit: National Stormwater Calculator

Location: IM West Parking Lot, MSU Campus, East Lansing, MI, 48823



(2) Variables in the model

Variable Inputs:

- Location
- Soil Type
- Soil Drainage
- Topography
- Precipitation/Temperature
- Land Cover
- LID Controls
- Project Cost

Variable Outputs: Summary Information

- Average annual rainfall (inches)
- Average annual runoff (inches)
- Days per year with rainfall
- Days per year with runoff
- Percent of wet days retained

- Smallest rainfall w/ runoff (inches)
- Largest rainfall w/o runoff (inches)
- Max rainfall retained (inches)

(3) Numerical inputs to test:

LID Controls

- Rain gardens
- Permeable pavement

(4) Existing Site Conditions as Baseline Scenario

- Sand: low runoff
- Soil drainage: 0.336 inches/hour
- Topography: moderately flat 5% slope
- Precipitation/Temperature taken from Capital City Airport statistics
- Land Cover: 5% lawn
- LID Controls
 - Rain gardens (0%)
 - Street planters (0%)
 - Permeable pavement (0%)
- Project Cost
 - Re-development
 - Site suitability: moderate
- 20 years to analyze
- 0.1 event threshold

(5) Range of values for input (X)

- Rain gardens (20%)
- Permeable pavement (20%)

(6) Run model, different values of selected inputs each time

See excel spreadsheet titled “LA883_SensitivityAnalysis_Zachos”

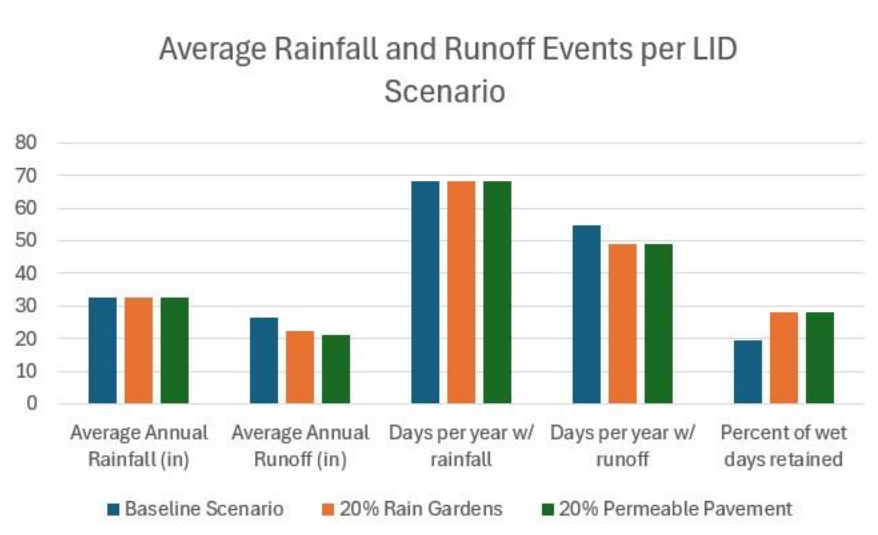
	Average Annual Rainfall (in)	Average Annual Runoff (in)	Days per year w/ rainfall	Days per year w/ runoff	Percent of wet days retained
Baseline Scenario	32.71	26.28	68.16	54.82	19.57
20% Rain Gardens	32.71	22.39	68.16	49.17	27.86
20% Permeable Pavement	32.71	21.04	68.16	49.12	27.93

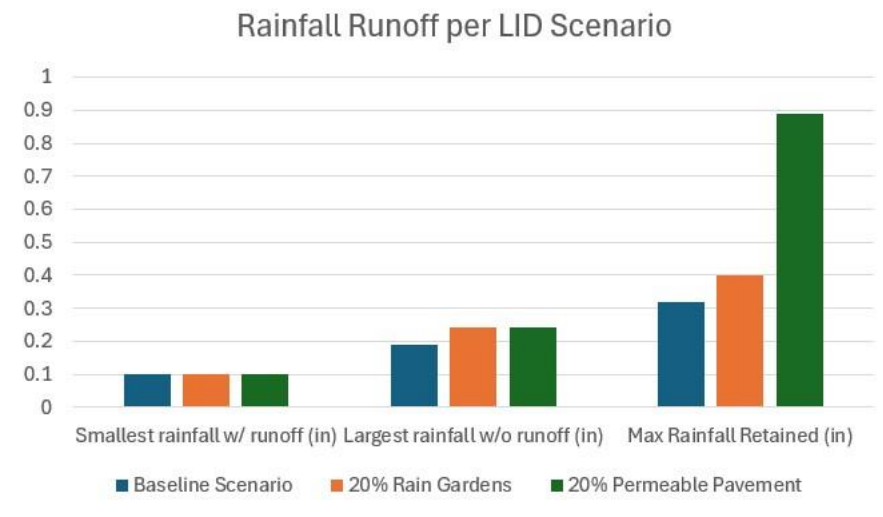
	Smallest rainfall w/ runoff (in)	Largest rainfall w/o runoff (in)	Max Rainfall Retained (in)
Baseline Scenario	0.1	0.19	0.32
20% Rain Gardens	0.1	0.24	0.4
20% Permeable Pavement	0.1	0.24	0.89

(7) Results Analysis

- Average annual runoff decreases with both LID controls. The biggest decrease occurs with permeable pavement.
- The days per year with runoff decrease with both LID Controls. The biggest decrease occurs with permeable pavement, but not by a large amount.
- The maximum rainfall retained is largest in permeable pavement.

(8) Visual relationship between percent of LID (X) and stormwater results (Y)





(9) Results Interpretation

- Permeable pavement has a generally bigger impact on stormwater calculations in the given site conditions.
- Permeable pavement decreases average runoff greater than rain gardens in the given site conditions.
- More rainfall is retained with permeable pavement than rain garden installation in the given site conditions.
- A limitation of the toolkit is the ability to compare multiple scenarios at one time. Current capability only allows results to be shown for one current scenario and one baseline scenario for side-by-side comparison.

National Stormwater Calculator

Ava Yon

EPA's National Stormwater Calculator (SWC) is a web-based application tool that estimates the annual amount of rainwater and frequency of runoff from a specific site using green infrastructure as low impact development controls.



When to Use SWC

1. When you want to measure the impact on stormwater runoff **when replacing impervious surface with pervious surface.**
2. **Comparing “existing” and “redevelopment”** scenarios to justify proposals.
3. Exploring future **climate scenarios** for a project.

Presentation Example

Location:

Meridian Mall

1982 W Grand River Ave, Okemos,
MI 48864

County:

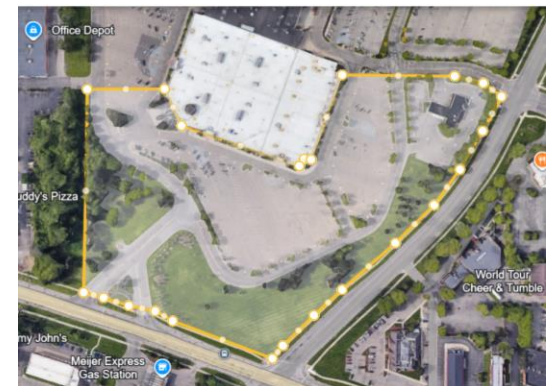
Ingham County

Area:

12 Acres

Proposal:

1. Replace 10% of parking lot with pervious paving.
2. Add rain garden to 20% of lawn area.



Find the National Stormwater Calculator



AI Mode All Shopping Images Videos Short videos News More ▾ Tools ▾



U.S. Environmental Protection Agency (.gov)

<https://www.epa.gov> › water-research › national-storm... ⋮

National Stormwater Calculator | US EPA

EPA's **National Stormwater Calculator (SWC)** is a web-based application tool that estimates the annual amount of rainwater and frequency of runoff from a ... [Read more](#)

<https://www.epa.gov/water-research/national-stormwater-calculator>

Water Research

[Watersheds Research](#) ▾

[Nutrients and Harmful Algal
Blooms Research](#) ▾

[Water Treatment and
Infrastructure Research](#) ▾

[Water Research Grants](#)

[Research Outputs](#)

[Training, Outreach, and Technical
Support](#) ▾

[Contact Us about Water Research](#)

National Stormwater Calculator

*Help control runoff and promote the
natural movement of water*

EPA's National Stormwater Calculator (SWC) is a web-based application tool that estimates the annual amount of rainwater and frequency of runoff from a specific site using green infrastructure as low impact development controls. The SWC is designed for use by anyone interested in reducing runoff from a property, including site developers, landscape architects, urban planners, and homeowners.

Software, Compatibility, and Manuals

The SWC is available as a mobile web-based application or as a desktop program (no longer supported)—both versions require an internet connection. The mobile web-based app can be used on desktop devices and mobile devices, such as smartphones and tablets, and is compatible with all operating systems. The Windows-based desktop program runs on any version of Microsoft Windows with Version 4 or higher of the .Net Framework installed.

On this Page

- [Software, Compatibility, and Manuals](#)
- [Capabilities](#)
- [Applications](#)
- [Resources and Technical Support](#)

**Access the National
Stormwater
Calculator**

Highlight Video

Get Started

Help prevent pollution by
controlling stormwater runoff.

It's one of the greatest threats to clean
water in America today.

Whether you're an urban planner, developer, landscape architect, or homeowner, this tool
can help you balance land developments and landscaping with the right amount of green
infrastructure.

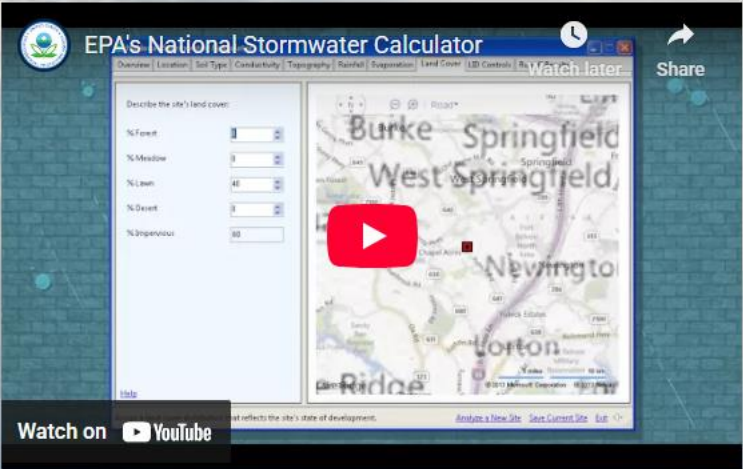
Name Your Site (Optional)

Get Started >

The SWC web app works best with the following browsers: Microsoft Edge, Google
Chrome, Mozilla Firefox, and Apple Safari.

Please contact SWC@epa.gov with any questions, suggestions, or problems with this
application.

Last updated on: April 12, 2025



Find Your Site Location





Location

Directions

Bring your site into view on the map and then mark its exact location by clicking the mouse pointer over it or entering your address or zip code below.

Use this polygon drawing tool to draw your project area on the map.

Search by address or zip code:

Enter an address or zip code

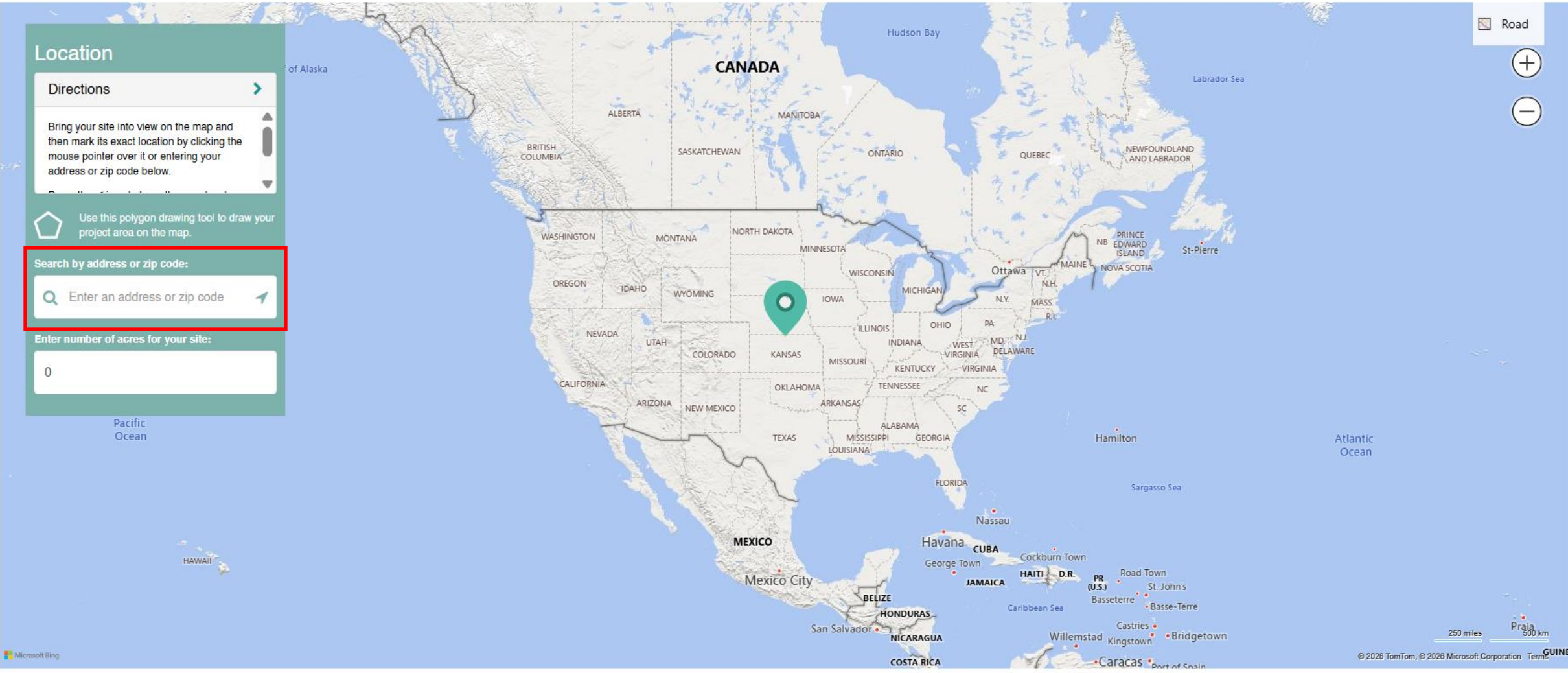
Enter number of acres for your site:

0

Road

+

-



250 miles 800 km

© 2028 TomTom, © 2028 Microsoft Corporation Terms

Find Your Site Location





Location

Directions

Bring your site into view on the map and then mark its exact location by clicking the mouse pointer over it or entering your address or zip code below.

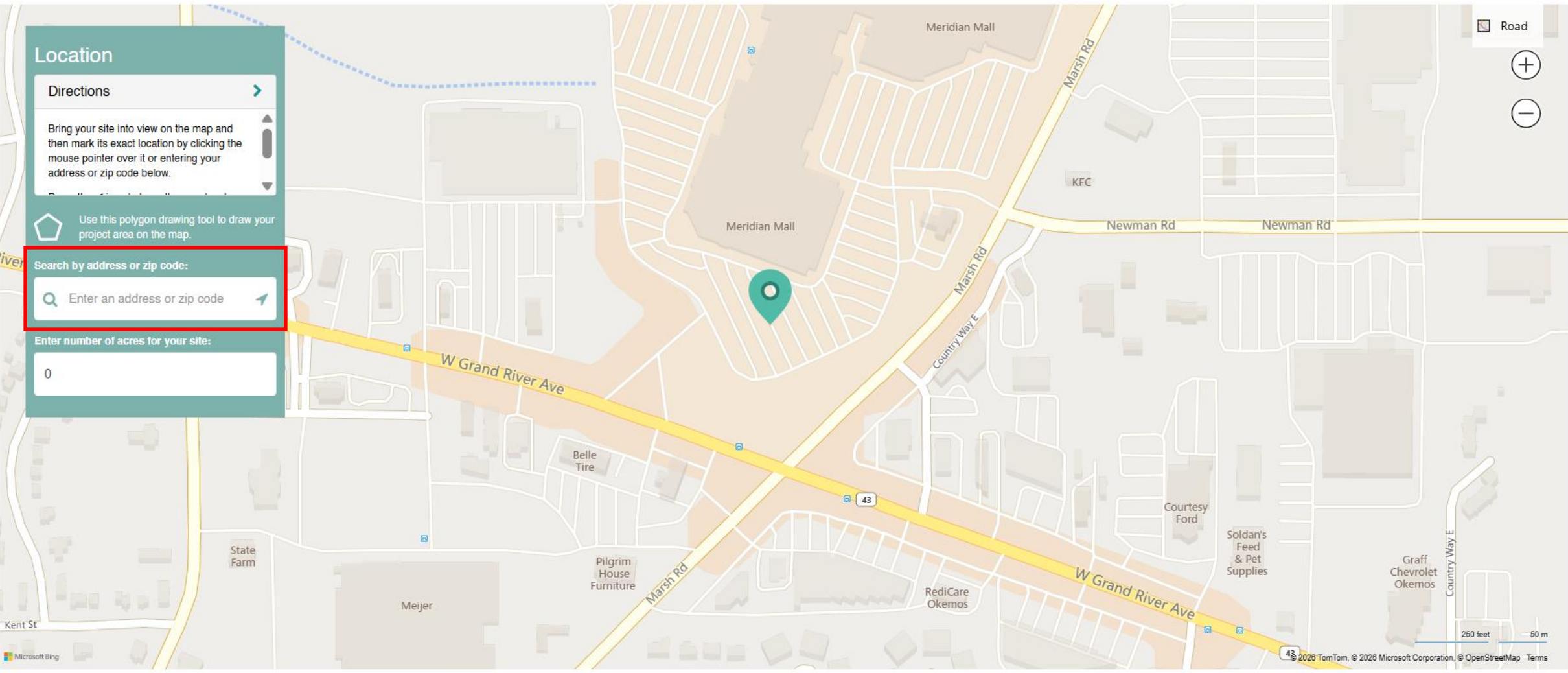
Use this polygon drawing tool to draw your project area on the map.

Search by address or zip code:

 Enter an address or zip code 

Enter number of acres for your site:

0



Road

+

-

250 feet 50 m

© 2026 TomTom, © 2026 Microsoft Corporation, © OpenStreetMap, Terms

Add Site Acreage



Location

Directions

Bring your site into view on the map and then mark its exact location by clicking the mouse pointer over it or entering your address or zip code below.



Use this polygon drawing tool to draw your project area on the map.

Search by address or zip code:



Enter an address or zip code

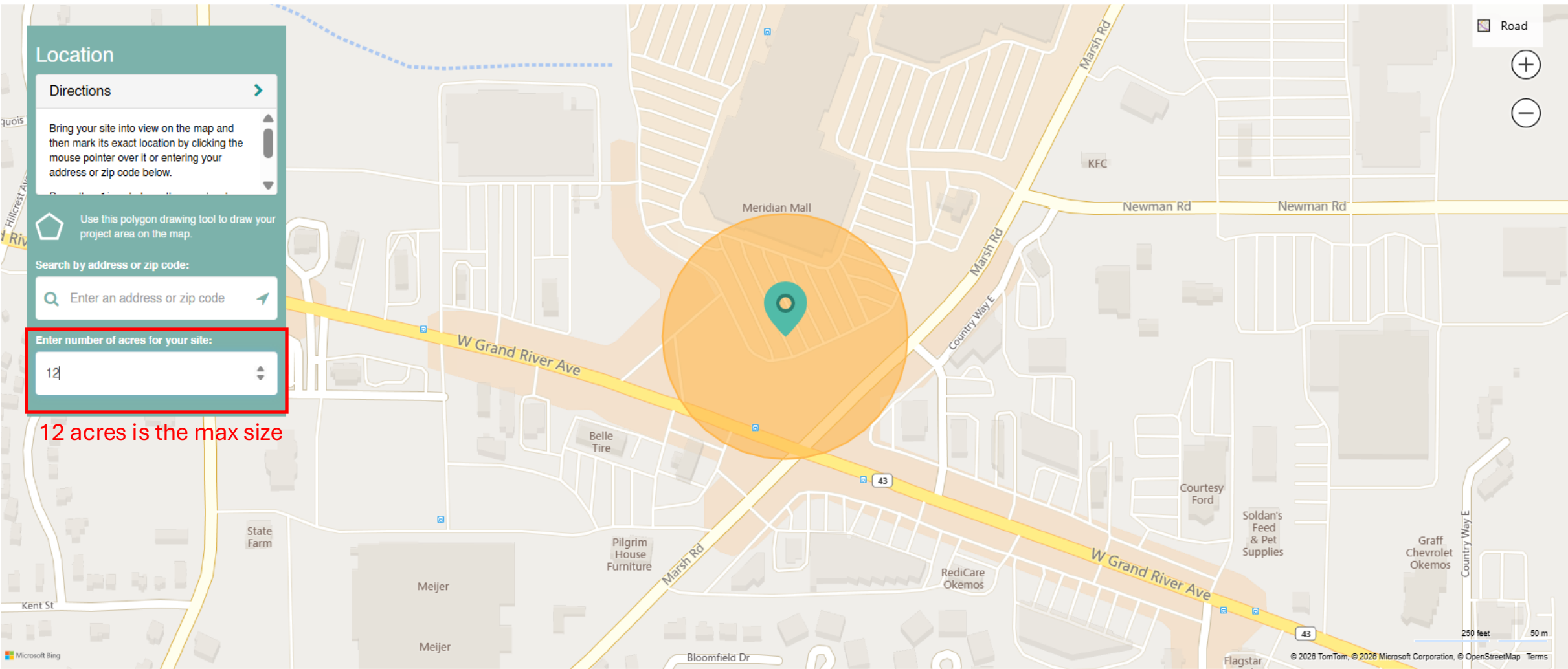


Enter number of acres for your site:

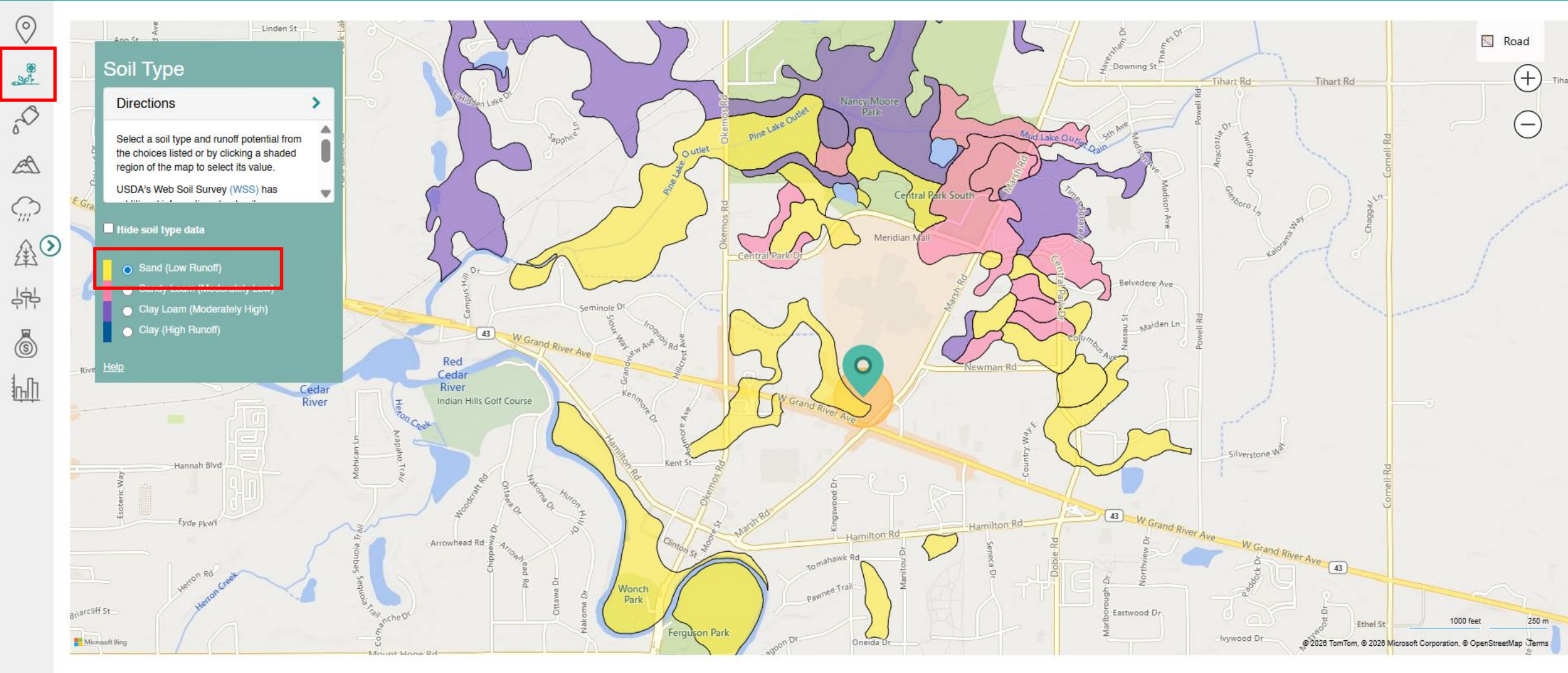
12



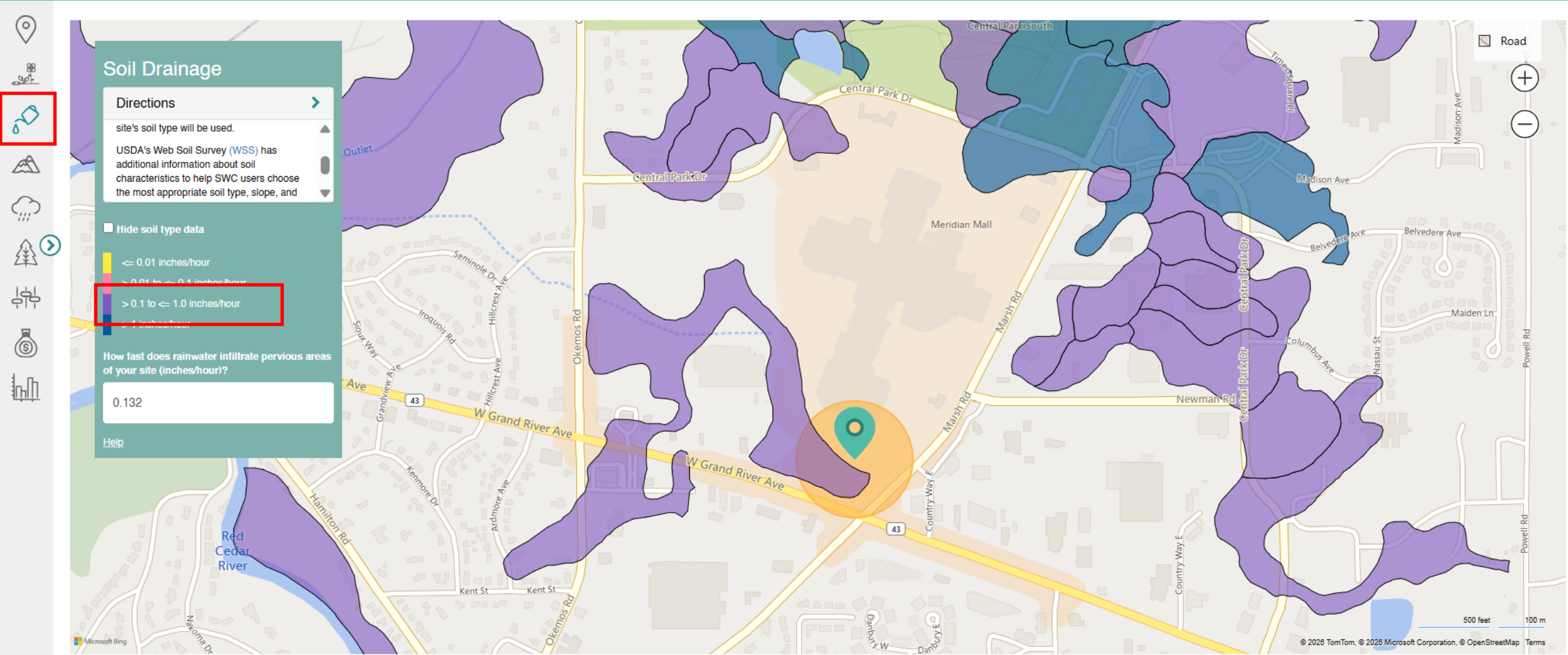
12 acres is the max size



Select Soil Type



Select Soil Drainage



Topography

Directions

Select a slope from the choices listed below or click a shaded region on the map to select its value.

USDA's Web Soil Survey (WSS) has

Hide soil type data

- Flat (2% Slope)
- Moderately Flat (2-10% Slope)
- Moderately Steep (10% Slope)
- Steep (Above 15% Slope)

Help

Microsoft Bing

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Select Rain Gage Location



Precipitation/Temperature

Directions

Select a rain gage location to use as a source of hourly precipitation data and a weather station to use as a source for daily minimum and maximum temperature (used to calculate evaporation).

Rain Gage:

CAPITAL CITY AIRPORT

Weather Station:

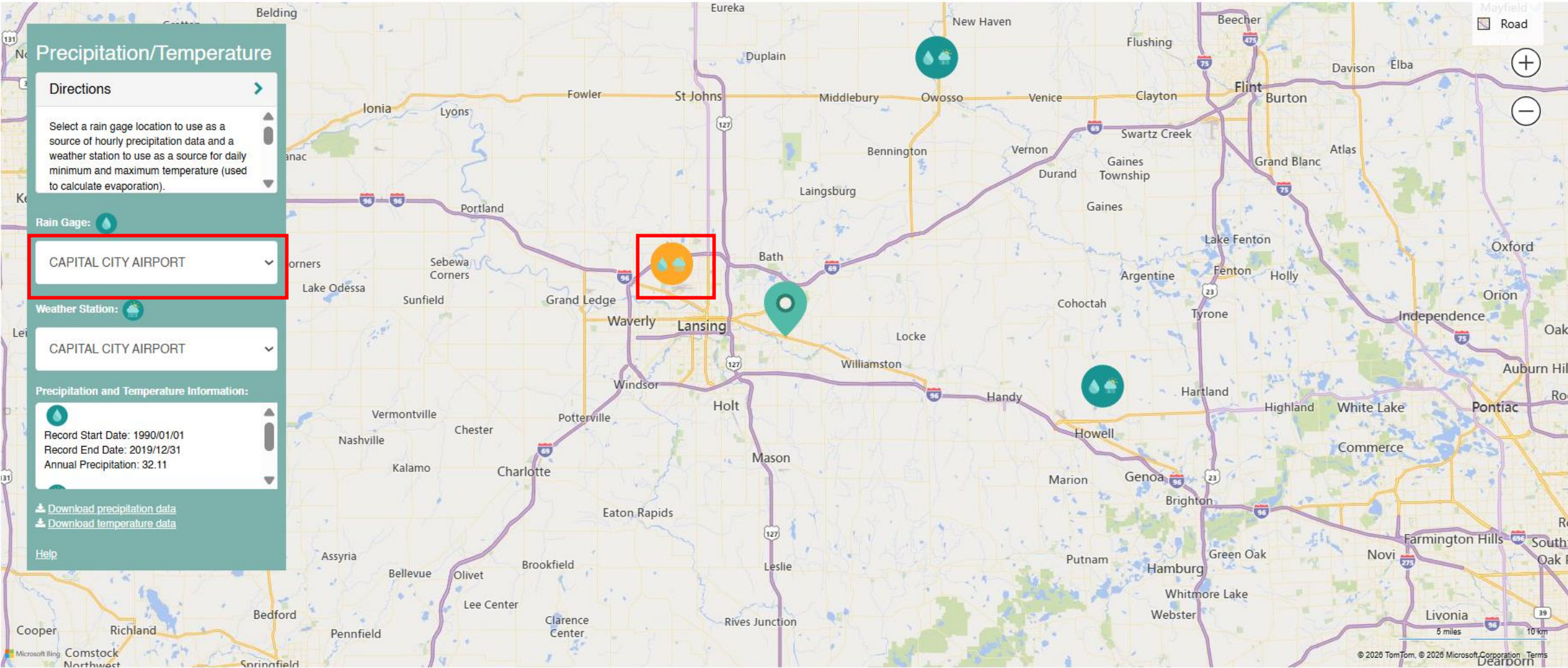
CAPITAL CITY AIRPORT

Precipitation and Temperature Information:

Record Start Date: 1990/01/01
Record End Date: 2019/12/31
Annual Precipitation: 32.11

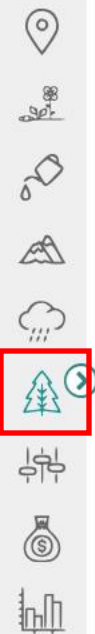
[Download precipitation data](#)
[Download temperature data](#)

[Help](#)



Map showing the Lansing, Michigan area. A red box highlights the Capital City Airport location. The map includes major roads, cities, and weather icons. A sidebar on the left contains navigation and data options.

Select Land Cover

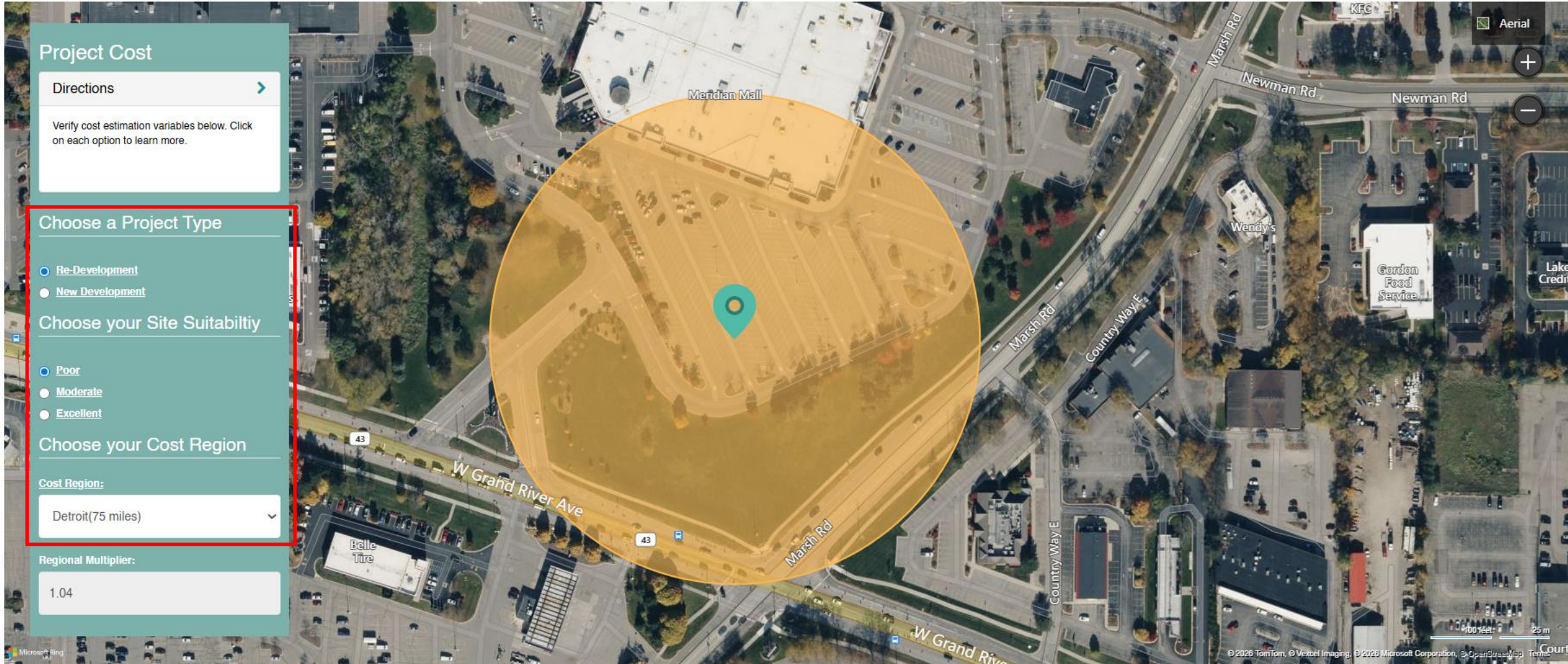


The screenshot displays a web application interface for land cover analysis. On the left, a teal sidebar contains a 'Land Cover' section with five sliders: Forest (0%), Meadow (0%), Lawn (40%), Desert (0%), and Impervious (60%). Above these sliders is a 'Directions' section with a description and a link. The main map area shows an aerial view of a commercial district. A large orange polygon highlights a specific site, and a teal pin marks a location within it. The map includes labels for streets such as W Grand River Ave, Marsh Rd, and Country Way E, and buildings like Meridian Mall, Wendy's, and Gordon Food Service. A scale bar and copyright information are visible at the bottom right.




Directions

1.04



Generate Results for BASELINE SCENARIO

Results

Directions

The Results page is where the site's hydrologic response to a long term period of historical hourly rainfall is computed and reported on. Statistics for both annual and daily rainfall/runoff are presented.

The user controls on this page are grouped together in three sections:

1. Options

The Options section allows you to specify how the rainfall record should be analyzed with respect to:

- The number of most recent years of rainfall record to use (Years to Analyze)
- The minimum amount of daily rainfall or runoff that will constitute a measurable event (Event Threshold)
- Whether subsequent days of back to back daily events should be counted or not (Ignore Consecutive Days)

2. Actions

The Actions section contains commands that allow you to:

- Refresh results after site data have changed
- Use the most current results as a baseline scenario that can be compared with results from subsequent runs

3. Reports

The Reports section allows you to select how the rainfall/runoff results generated for the site should be displayed.

Options:

Years to Analyze:

20

Event Threshold:

0.1

☐ Ignore Consecutive Days

Actions:

Refresh Results

Use as Baseline Scenario

Remove Baseline Scenario

Print Results to PDF File

Generating Results

Processing of results may take some time



Generate Results for BASELINE SCENARIO



Directions

The Results page is where the site's hydrologic response to a long term period of historical hourly rainfall is computed and reported on. Statistics for both annual and daily rainfall/runoff are presented.

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3. Reports

The Reports section allows you to select how the rainfall/runoff results generated for the site should be displayed.

Options:

Years to Analyze:

20

Event Threshold:

0.1

☐ Ignore Consecutive Days

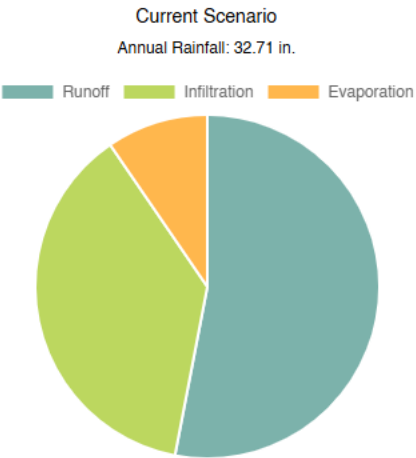
Actions:

Refresh Results

Use as Baseline Scenario

Remove Baseline Scenario

Print Results to PDF File



Statistic	Current Scenario
Average Annual Rainfall (inches)	32.71
Average Annual Runoff (inches)	17.38
Days per Year with Rainfall	68.16
Days per Year with Runoff	43.98
Percent of Wet Days Retained	35.48
Smallest Rainfall w/ Runoff (inches)	0.10
Largest Rainfall w/o Runoff (inches)	0.27
Max Rainfall Retained (inches)	0.92

Edit the LID Variables for SIMULATED SCENARIO

LID Controls

Directions

Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.

Click a practice to learn more about it or to

Disconnection:

0

%

Rain Harvesting:

0

%

Rain Gardens:

20

%

Green Roofs:

0

%

Street Planters:

0

%

Infiltration Basins:

0

%

Permeable Pavement:

10

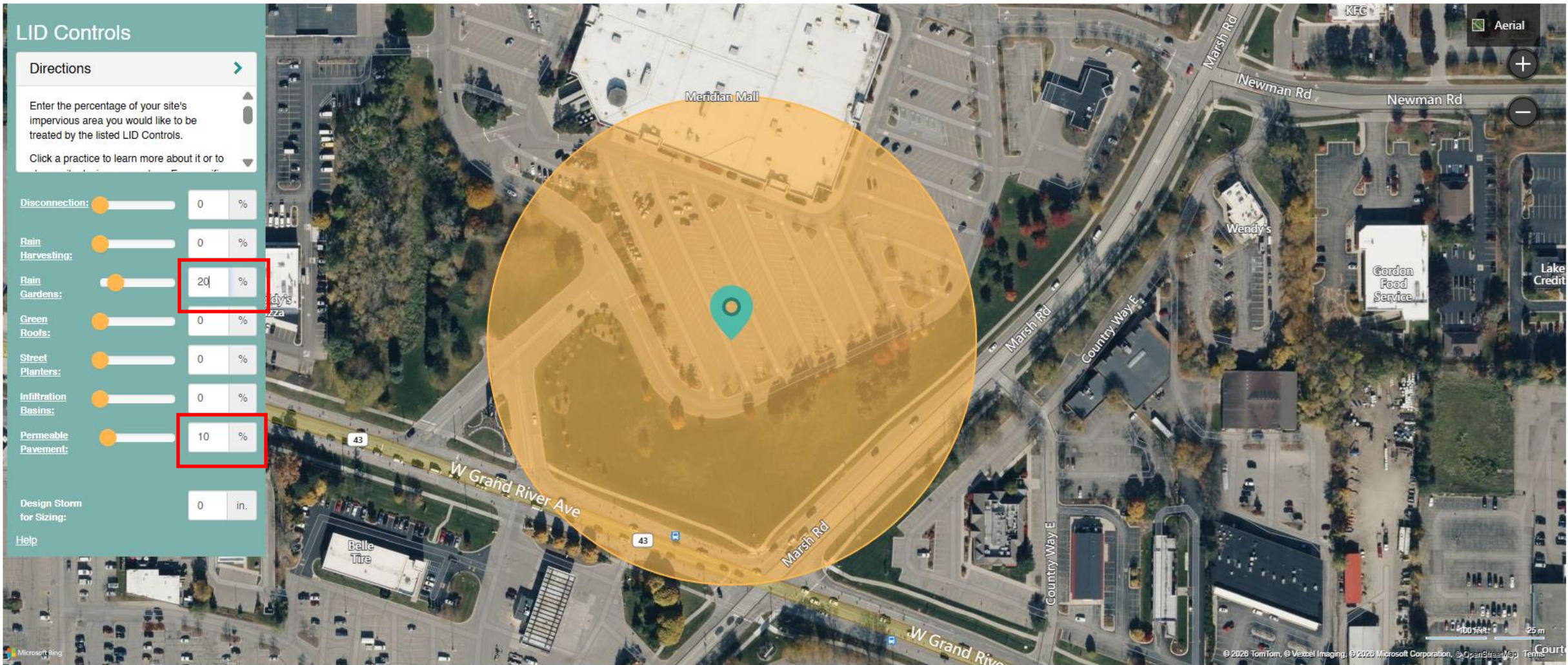
%

Design Storm for Sizing:

0

in.

[Help](#)



Results

Directions

The Results page is where the site's hydrologic response to a long term period of historical hourly rainfall is computed and reported on. Statistics for both annual and daily rainfall/runoff are presented.

The user controls on this page are grouped together in three sections:

- Options**

The Options section allows you to specify how the rainfall record should be analyzed with respect to:

- The number of most recent years of rainfall record to use (Years to Analyze)
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- Whether subsequent days of back to back daily events should be counted or not (Ignore Consecutive Days)

- Actions**

The Actions section contains commands that allow you to:

- Refresh results after site data have changed
- Use the most current results as a baseline scenario that can be compared with results from previous scenarios

- Reports**

The Reports section allows you to select how the rainfall/runoff results generated for the site should be displayed.

Options:

Years to Analyze:

Event Threshold:

☐ Ignore Consecutive Days

Actions:

Refresh Results
Remove Baseline
Print Results to PDF

Summary Results

Current Scenario
Annual Rainfall: 32.71 in.

Baseline Scenario
Annual Rainfall: 32.71 in.

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	32.71	32.71
Average Daily Rainfall (inches)	17.38	17.38
Average Hourly Rainfall (inches)	68.16	68.16
Days per Year with Runoff	43.98	43.98
Percent of Wet Days Retained	35.48	35.48
Smallest Rainfall w/ Runoff (inches)	0.10	0.10
Largest Rainfall w/o Runoff (inches)	0.27	0.27
Max Rainfall Retained (inches)	0.92	0.92

Refresh Results

Remove Baseline Scenario

Print Results to PDF
File

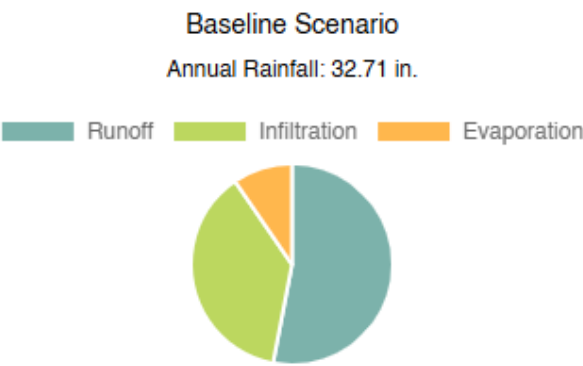
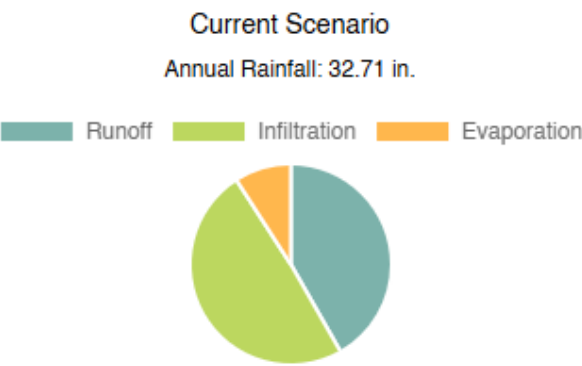
Generating Results

Processing of results may take some time



Results

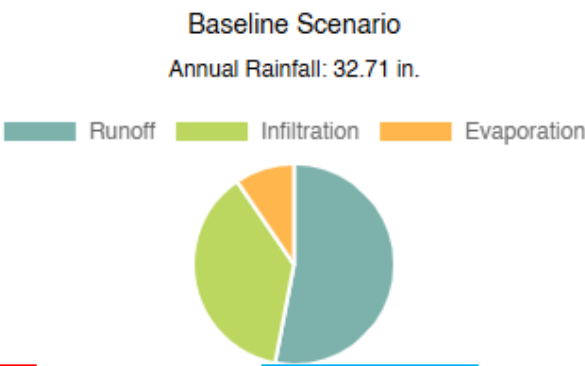
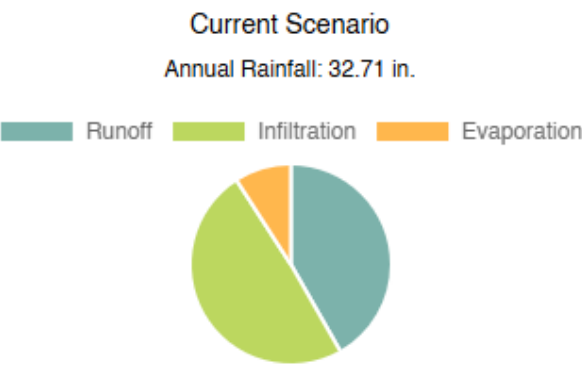
Summary Results



Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	32.71	32.71
Average Annual Runoff (inches)	13.69	17.38
Days per Year with Rainfall	68.16	68.16
Days per Year with Runoff	37.33	43.98
Percent of Wet Days Retained	45.23	35.48
Smallest Rainfall w/ Runoff (inches)	0.15	0.10
Largest Rainfall w/o Runoff (inches)	0.36	0.27
Max Rainfall Retained (inches)	1.17	0.92

Results

Summary Results



Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	32.71	32.71
Average Annual Runoff (inches)	13.69	17.38
Days per Year with Rainfall	68.16	68.16
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Largest Rainfall w/o Runoff (inches)	0.36	0.27
Max Rainfall Retained (inches)	1.17	0.92

Other Results

Actions:

Refresh Results

Use as Baseline
Scenario

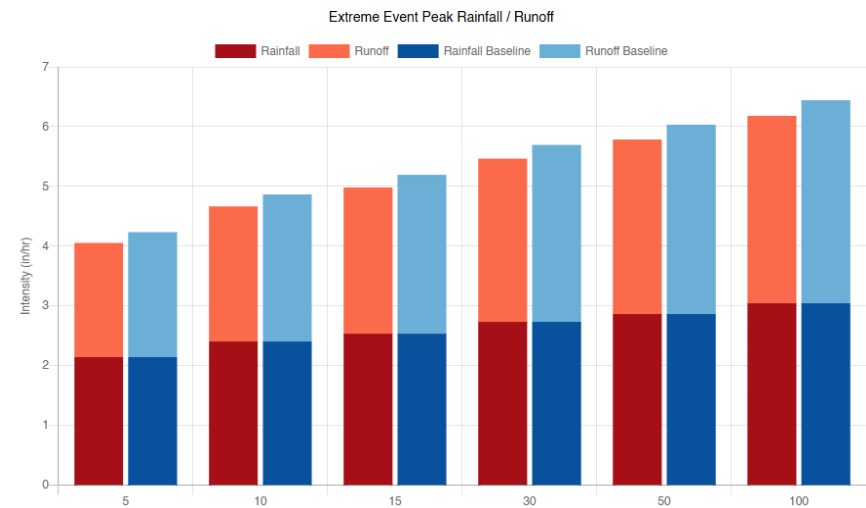
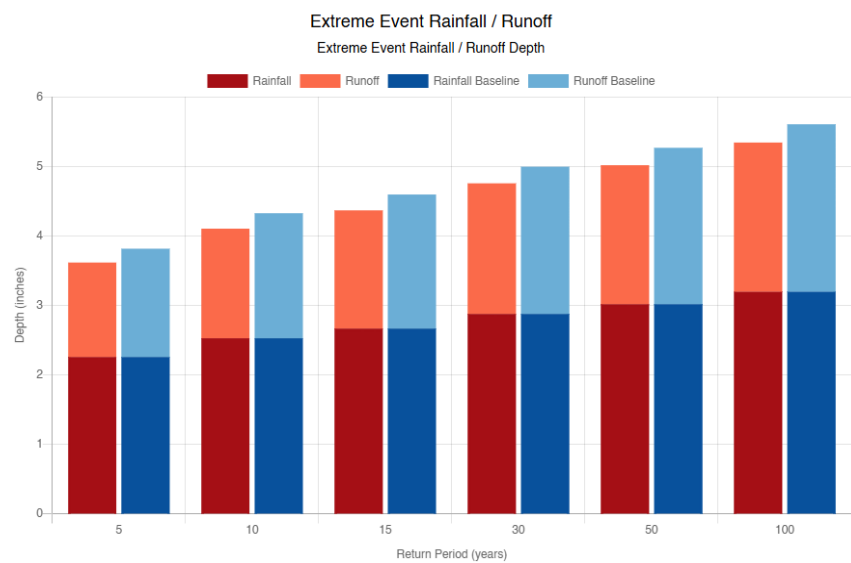
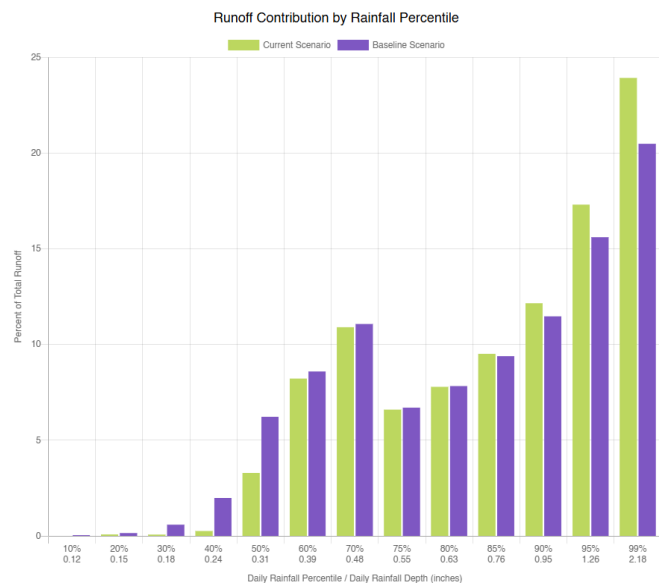
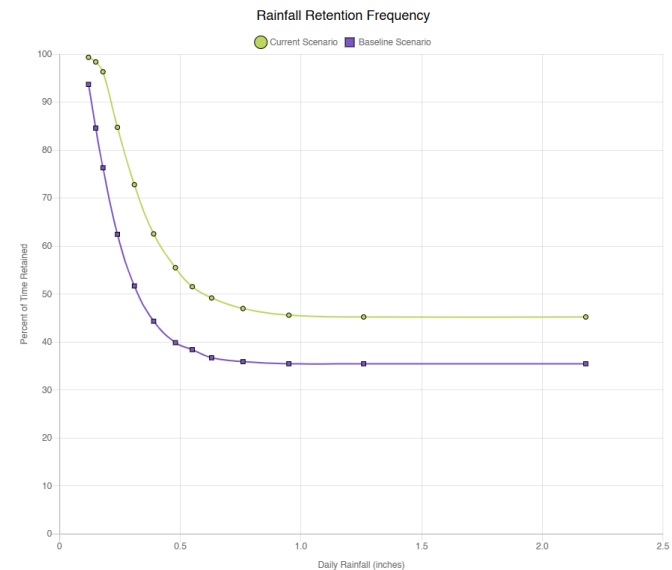
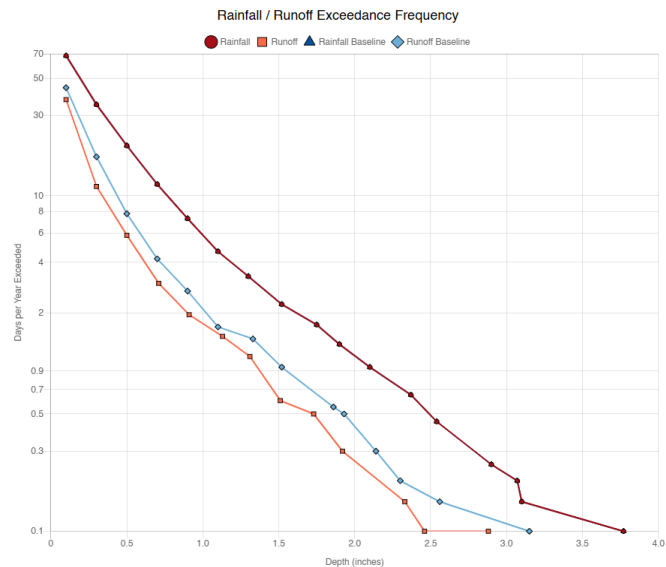
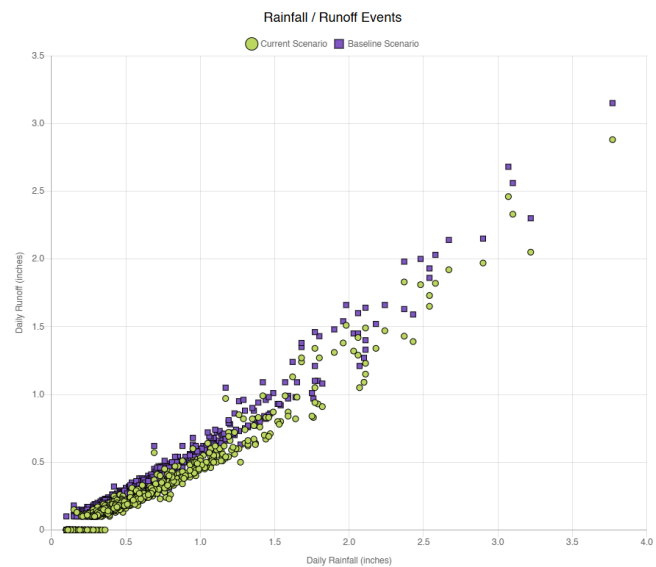
Remove Baseline
Scenario

Print Results to PDF
File

Reports:

- ☐ Site Description ⓘ
- ☒ Summary Results ⓘ
- ☐ Rainfall / Runoff Events ⓘ
- ☐ Rainfall / Runoff Exceedance Frequency ⓘ
- ☐ Rainfall Retention Frequency ⓘ
- ☐ Runoff Contribution by Rainfall Percentile ⓘ
- ☐ Extreme Event Rainfall / Runoff ⓘ
- ☐ Cost Summary ⓘ

Other Results



Other Results

Cost Summary								
Estimate of Probable Capital Costs (estimates in 2020 US.\$)								
Maintenance Costs Graphical View								
Cost By LID Control Type	Drainage Area %	Has Pre-Treatment?	Current Scenario (C)		Baseline Scenario (B)		Difference (C - B)	
			Low	High	Low	High	Low	High
Disconnection	0 / 0	No / No	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Rainwater Harvesting	0 / 0	No / No	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Rain Gardens	20 / 0	No / No	\$41,087.31	\$54,886.63	\$0.00	\$0.00	\$41,087.31	\$54,886.63
Green Roofs	0 / 0	No / No	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Street Planters	0 / 0	No / No	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Infiltration Basins	0 / 0	No / No	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Permeable Pavement	10 / 0	No / No	\$470,556.54	\$564,437.68	\$0.00	\$0.00	\$470,556.54	\$564,437.68
Total	30 / 0	Varies	\$511,643.85	\$619,324.31	\$0.00	\$0.00	\$511,643.85	\$619,324.31

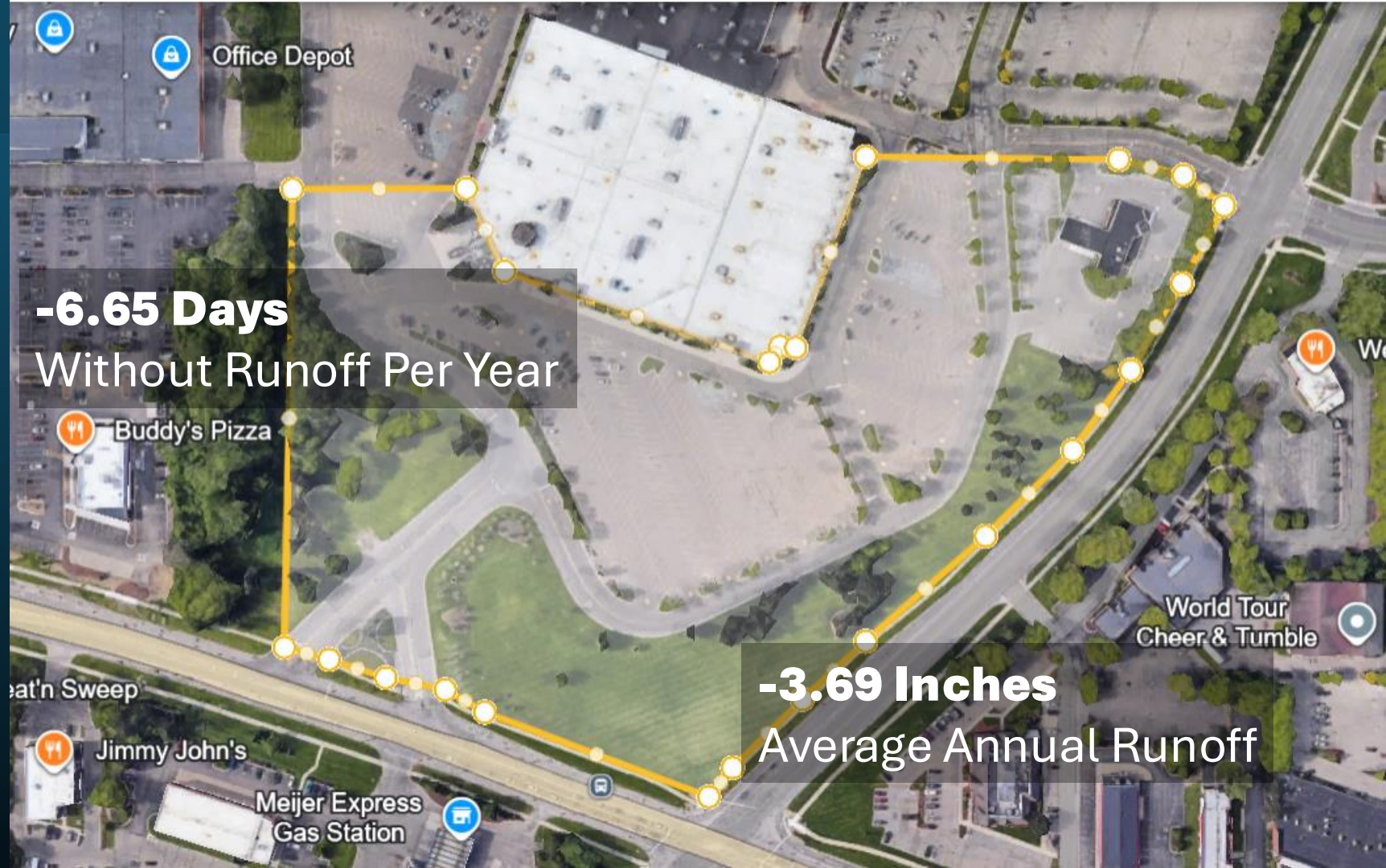
Note: site complexity variables that affect cost shown below:

Current Scenario		Baseline Scenario	Chart Key	
Dev. Type	Re-Development	Re-Development	D - Disconnection	IB - Infiltration Basins
Site Suitability	Poor	Poor	RH - Rain Harvesting	PP - Permeable Pavement
Topography	Flat (2% Slope)	Flat (2% Slope)	RG - Rain Gardens	
Soil Type	A	A	GR - Green Roofs	
Cost Region	Detroit(75 miles) 1.04	Detroit(75 miles) 1.04	SP - Street Planters	

Using the Results

Proposal:

1. Replace 10% of parking lot with pervious paving.
2. Add rain garden to 20% of lawn area.



Resources

EPA's SWC Site

<https://www.epa.gov/water-research/national-stormwater-calculator>

Web User Guide

<https://www.epa.gov/system/files/documents/2022-08/National%20Stormwater%20Calculator%20Web%20App%20User%20Guide-Version%203.4.0.pdf>

Desktop User Guide

<https://www.epa.gov/system/files/documents/2022-08/National%20Stormwater%20Calculator%20Web%20App%20User%20Guide-Version%203.4.0.pdf>

Adam Hershner

Habitat and Biodiversity

Three Areas of Focus



Habitat creation, preservation,
and restoration



Habitat quality



Population and species
richness

Habitat Creation, Preservation, and Recreation

This relates to the presence of ecosystems on the site, either existing, historical, or new. Any site that changes the existing conditions into something green or ecological relates to this goal.

Common tools used for data collection:

- [NRCS Web Soil Survey](#)
- [Integrated Valuation of Ecosystem Services and Tradeoffs \(InVEST\) v 3.3.3](#)
- [ArcGIS](#)

Habitat Quality

This relates to the health, density, and standing of all habitats on the site and their continued survivability. Any impact on ecosystems fits within this category, notably more fragile systems such as wetlands or savannahs.

Common tools used for data collection:

- [Integrated Valuation of Ecosystem Services and Tradeoffs \(InVEST\) v 3.3.3](#)
- [iNaturalist](#)
- [Universal Floristic Quality Assessment Calculator](#)

Population and Species Richness

This relates to the diversity of biomass present on the site, notably flora and fauna. These are often categorizing through a three metric system, using a Species Richness Index, the Shannon Index, and the Simpson Index.

Common tools used for data collection:

- [Global, Americas, and European Biodiversity Metrics](#)
- [Naturalist](#)
- [Universal Floristic Quality Assessment Calculator](#)
- [eBird](#) (and [Merlin Bird ID](#))
- Active species surveys

Overall Goal Limitations



Many species are difficult to spot or confirm presences of, making biodiversity numbers impossible to prove beyond a reasonable doubt



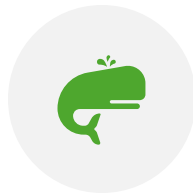
Some biodiversity indexes skew for native species, others do not



Certain indexes (Shannon) take into account both species richness and species abundance, which calculates future uncertainty or stability



Habitats are difficult to modulate and recreate, with some requiring many years before reaching their "proper" habitat form; often post-construction site surveying doesn't extend to the full length of required time



Any pre-design metrics can only be predicted for potential increased species unless actively introduced



Crosswinds Marsh Wetland Interpretive Preserve



- 
- Designed by SmithGroup
 - 27600 Haggerty Road
New Boston, Michigan 48164
 - 1,050 acres
 - \$18.5 million
 - Completion date in 1995



Fast Facts

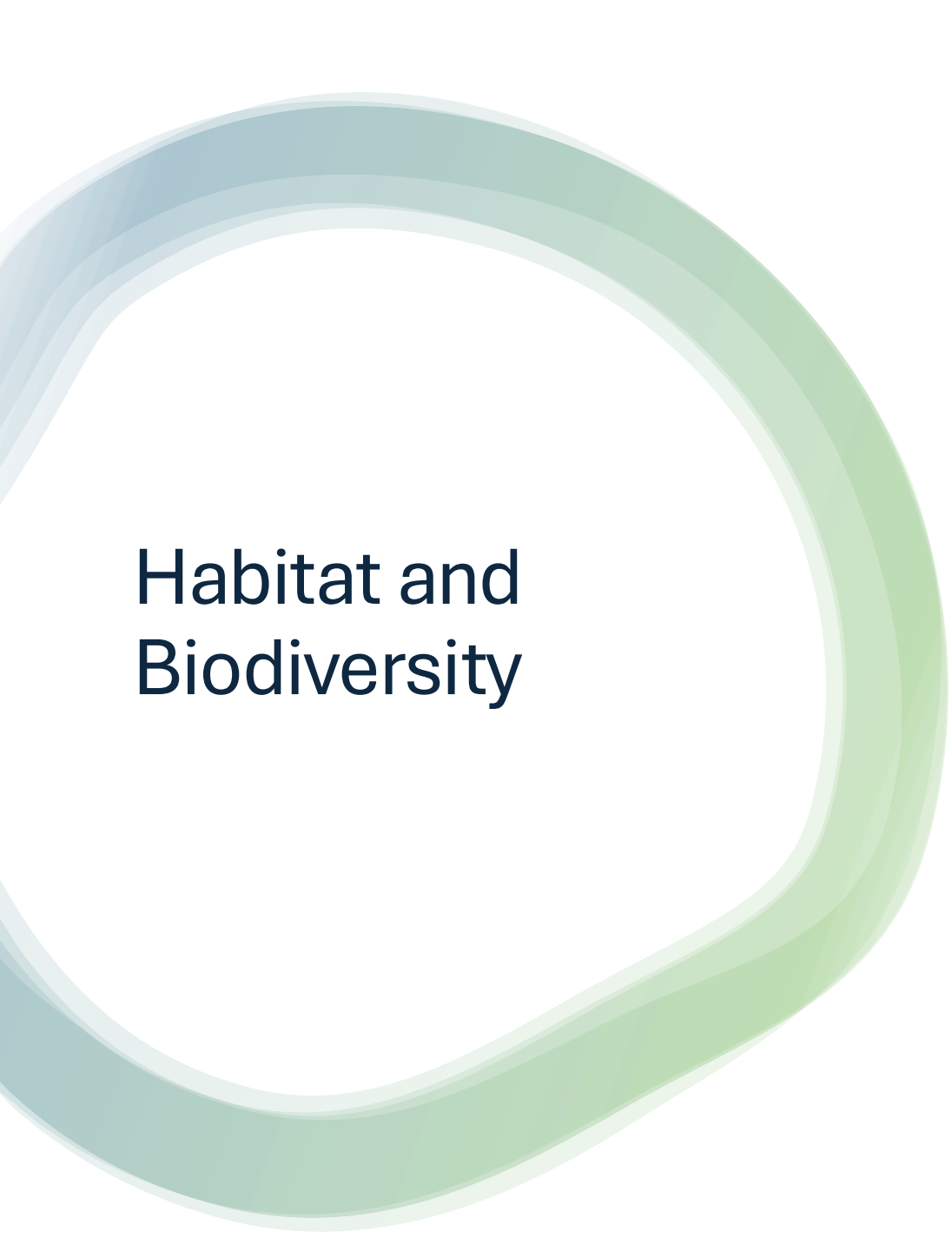
This project was designed to counteract the construction required for the DTW airport, who had an expansion on top of existing wetlands. This was designed to vastly overcompensate for the construction and restore historical wetlands from its agricultural present.

Goals:

- Recreate existing wetlands to a greater amount than the new airport runway
- Counteract the historical agricultural damage to site
- Recreate habitats for previous species and endangered animals, particularly the Bald Eagle







Habitat and Biodiversity

Habitat creation, preservation, and restoration

- Restored over 100 acres of historical wetland habitat that had been drained for agriculture and residential use.
- A diversity of wetland habitat types including forested, wet meadow, emergent, submergent, and deep water areas were created on the site.

Habitat quality

- By carefully grading and sculpting the land to follow site hydrology, no pumps, dykes, or artificial methods are required to maintain the natural systems.

Population and species richness

- Over 300,000 native aquatic plants, 10,000 seedlings, and 300 acres of wetland seed were added to the site to create self-sustaining wetland communities.
- Sensitive planning created and limited human access to habitat for several threatened species. These include bald eagle nesting sites and 20 acres set aside for the propagation and reestablishment of three rare plant species relocated from the airport.
- Created a variety of habitat types for over 200 species of birds, 170 species of plants, 20 fish, 30 mammals, 21 reptiles and amphibians, and 70 species of butterflies and dragonflies.

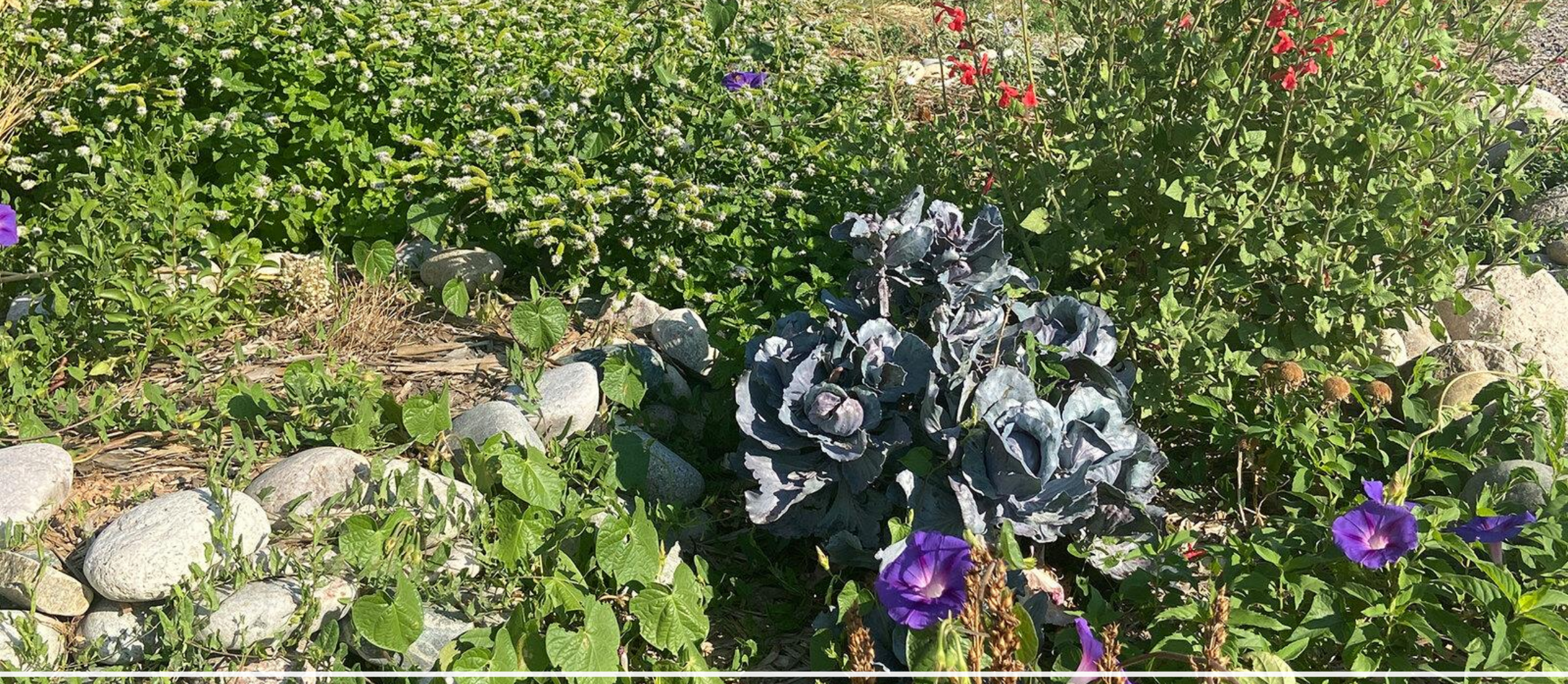
Key Methods of Testing



Five years of post-construction monitoring and evaluation in partnership with Wayne County,



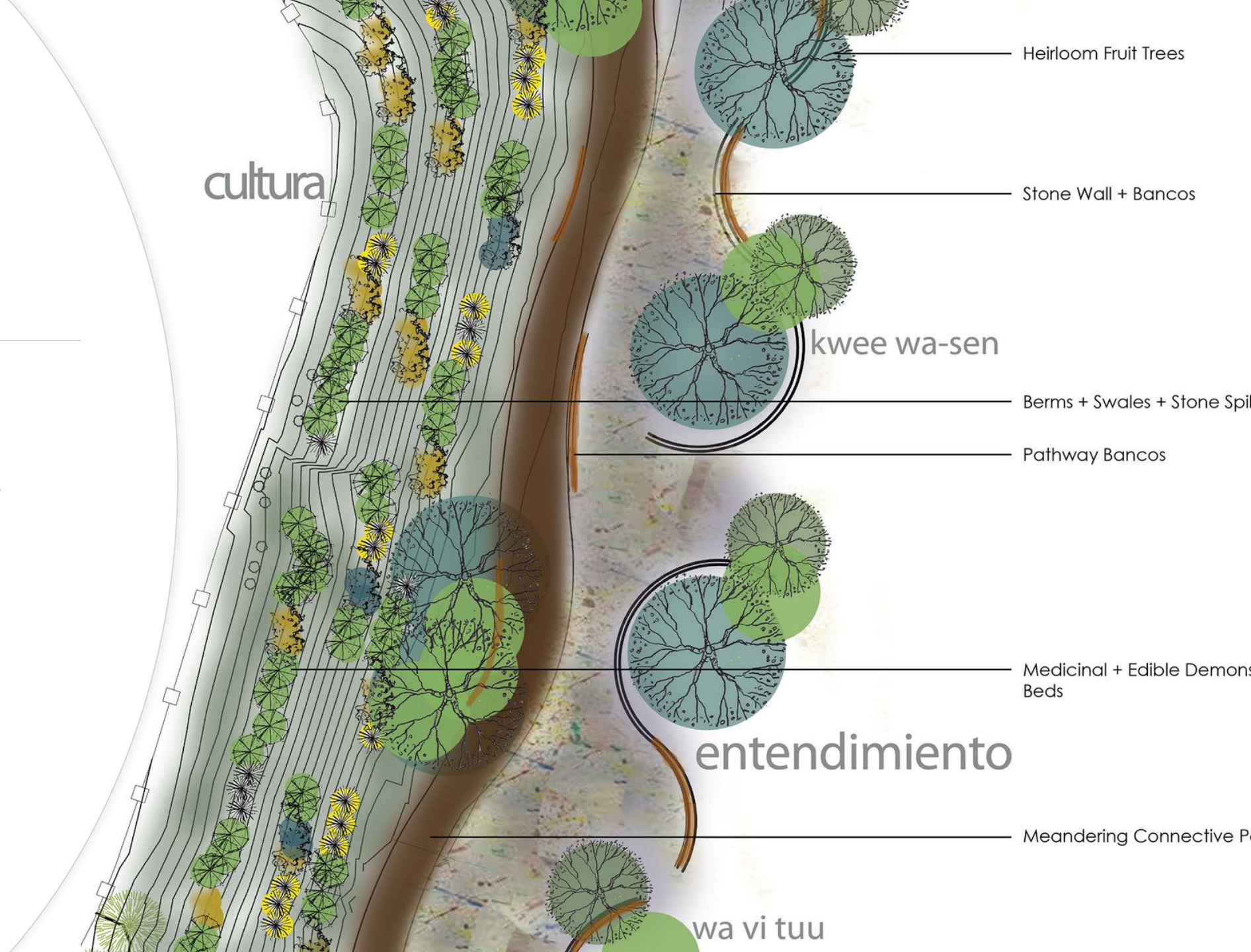
Hydrologic analysis to assess water changes, using standard USDA and U.S. Army Corps of Engineers modeling software.



Española Healing Foods Oasis



- Designed by Radicle
- 313 N Paseo De Oñate Española, New Mexico 87532
- 1 acre
- \$500,000
- Completion date in 2018



Fast Facts

An ethno-botanic public demonstration garden, restoring the city's only public park. Due to its difficult position on a sheer slope with high pollution levels, this site showcases how small sites can be used for great effect, as well as community enrichment alongside ecological.

Goals:

- Regenerate the heavily-degraded slope
- Test out mycoremediation
- Cultivate a biodiverse ecosystem, with a focus on culturally significant plants, pollinators, historical dye plants, and edible plants
- Manage stormwater flow and high-drought predictions for the area that led to its previous decay



Reference Site

City Hall

Española Healing Foods Oasis

Española Library
+ Lucero Recreation Center

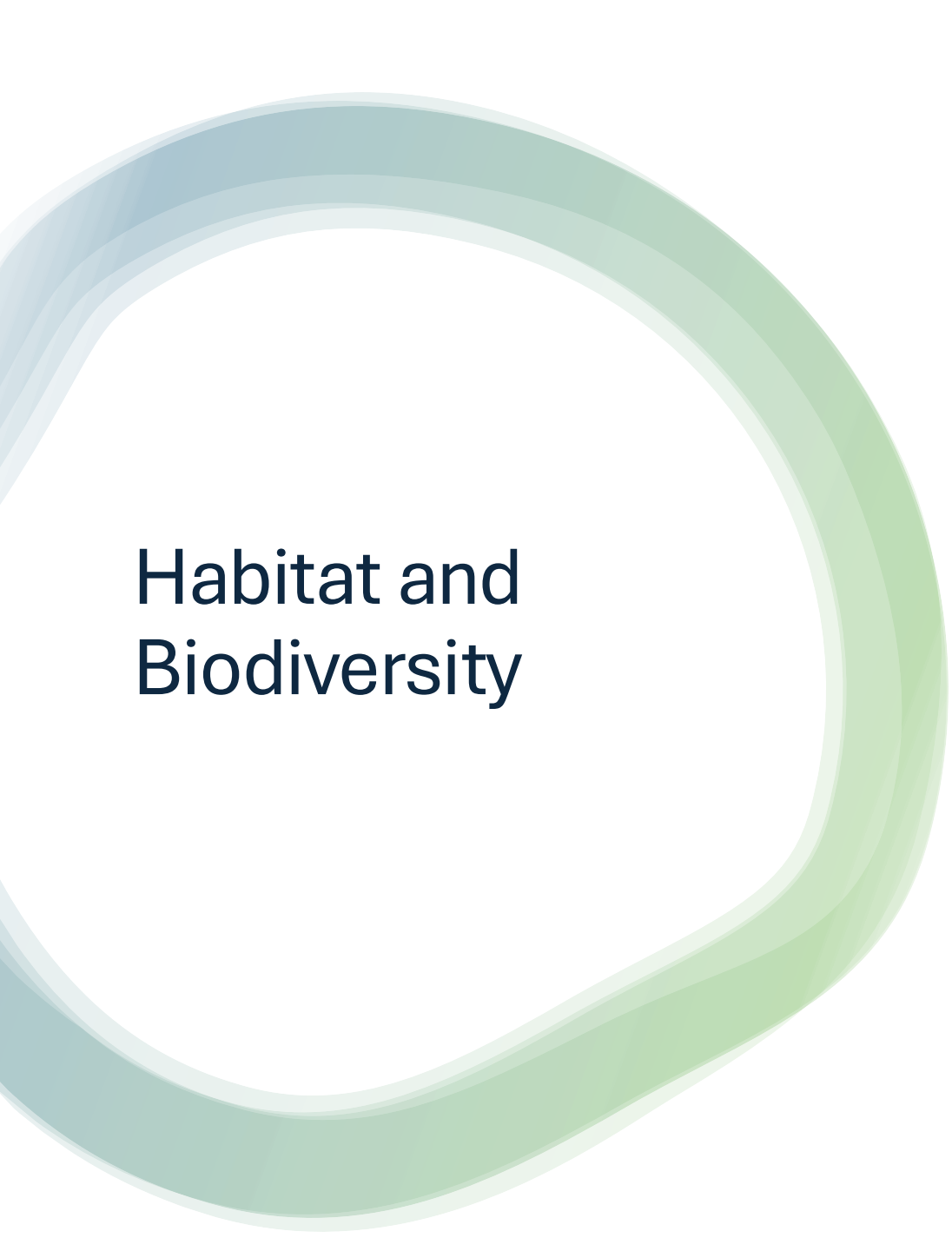
Valdez Park

N Paseo De Oñate

Vietnam Veterans Memorial Park Road







Habitat and Biodiversity

Habitat creation, preservation, and restoration

- More than doubles soil microbial biomass carbon and supports a more fungaldominated microbial community in intensively cultivated garden zones, compared to adjacent degraded soils.

Habitat quality

- Planting techniques demonstrate traditional, regenerative Indigenous practices designed to maximize water efficiency and soil health in arid environments. Dryland farming methods, which conserve soil moisture and maximize limited rainfall, include terrace farming, rock mulching, and ollas. Terrace farming slows runoff and reduces erosion, rock mulching retains moisture and regulates soil temperature, and ollas—sub-surface clay vessels—gradually release water at the root zone.
- As a mycoremediation pilot project, the uppermost swale which receives the first flush of runoff from the parking lot was inoculated with nearly 40 mycelium bricks/ceremonial mushroom pillows.

Population and species richness

- The garden incorporates over 200 plant species featuring edible, ceremonial/medicinal, fiber, and dye plants that are native or regionally adapted and significant to local Indigenous, Hispanic, and Anglo cultures.
- Increases plant species diversity nearly 4 times compared to the adjacent reference site, as measured by the Simpson's Diversity Index (0.919 vs. 0.237).
- Increases total plant species richness over 17 times compared to the adjacent reference site, from 4 identified species to 71 species in the garden.
- Improves habitat quality for native pollinators by introducing 55 native plant species to the site that provide nectar, pollen, and larval host resources.

Key Methods of Testing



Soil test built from and confirming
NRCS Web Soil Survey



Xerces Society's Streamlined Bee
Monitoring Protocol



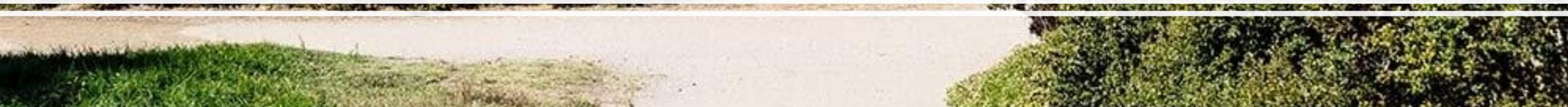
Complete florist diversity study,
utilizing Species Richness
Biodiversity Metric and Simpson's
Diversity Index (1-D)



Continued project maintenance
and development



Crissy Field



- Designed by Hargreaves Associates
- 1199 East Beach
San Francisco, California 94129
- 100 acres
- \$25 million
- Completion date in 2001



Fast Facts

This site was previously used as a military base point, excavating the existing dune network. In 1994, the base was decommissioned and given back to the National Park System, with this plan making it into the largest public park of San Francisco, notably focusing on both restoration and public use.

Goals:

- Remove existing rubble and military base
- Recreate historical dunes and sand ecology
- Reintroduce pedestrian water access, including sailboarding and kayaking
- Create habitats for endangered or threatened species





WILDLIFE PROTECTION AREA

This area is subject to the National
Antiquities Act.

Restrictions: No hunting and traps
or traps along shore waters.

All visitors must stay on the
trail to avoid any damage.

FOLLOW PARK REGULATIONS

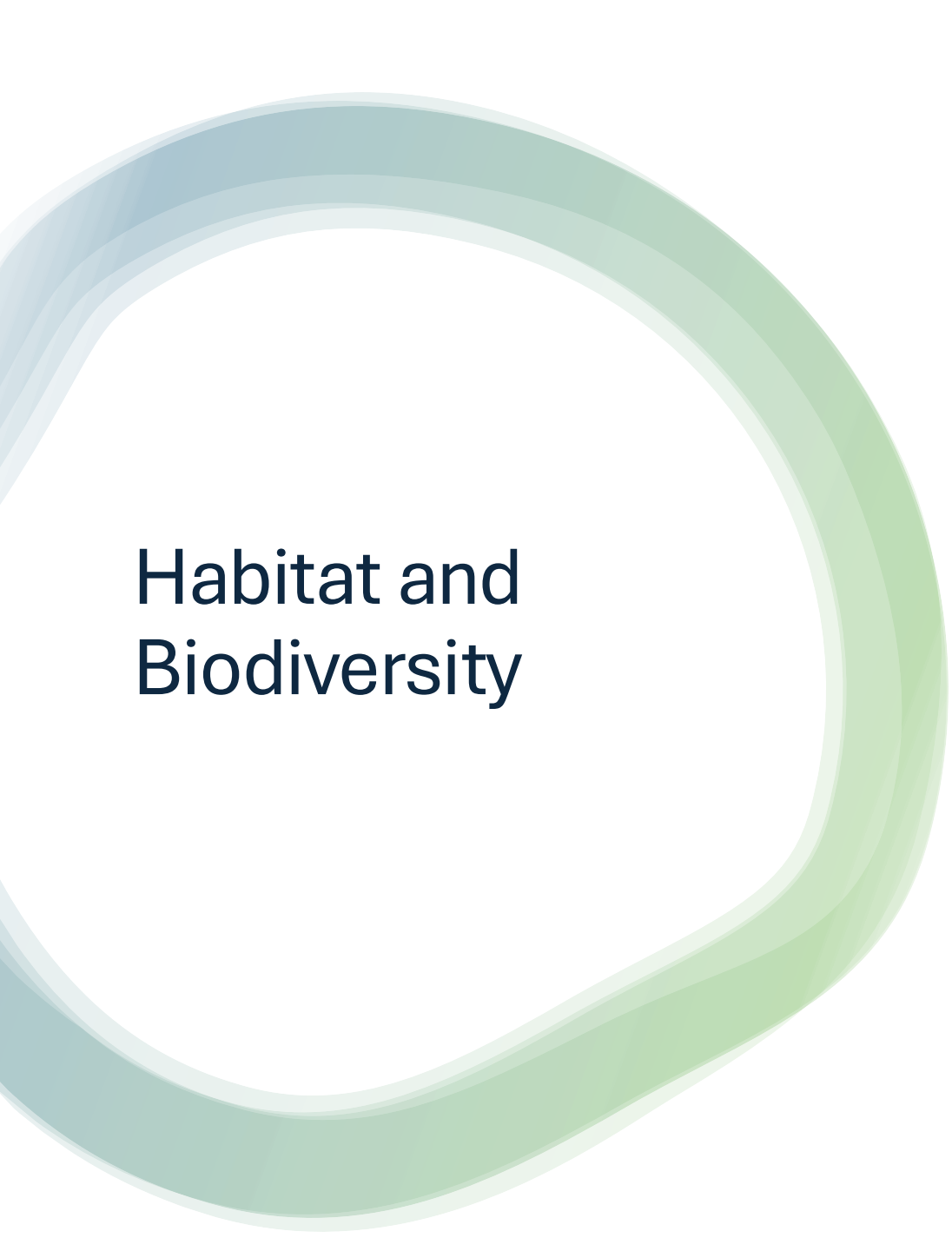
Help protect the National
Antiquities Act.

May 15 - July 1

The trail is closed, except for
emergency or authorized
personnel.

For more information
call 415-774-1000





Habitat and Biodiversity

Habitat creation, preservation, and restoration

- Remediated approximately 38,000 cu yds of contaminated soil on-site through low temperature thermal desorption
- Restored 40 acres of habitat consisting of 22 acres of vegetated dune and dune swale habitat and 18 acres of tidal marsh, allowing fresh and salt water to merge at Crissy Field for the first time in 100 years.

Habitat quality

- Interaction points without interference, such as boardwalks and grass separators.

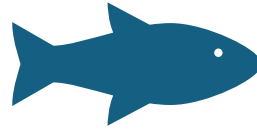
Population and species richness

- Supports ongoing native species establishment, as evidenced by an increase in Native Species Richness from 4.2 to 5.2 in the high elevation marsh habitat between 2002 and 2004.
- Provides habitat for 145 observed bird species representing 36 families, including 9 listed as endangered species or species of concern at a federal and/or state level, as observed from 2000 to 2004.
- Provides habitat for at least 19 species of fish representing 12 families and at least 13 macrocrustacean species as observed in Crissy Marsh from 2000 to 2004.
- The restoration of dune and marsh habitats reintroduced nearly 100,000 plants to the site, including 110 native species,

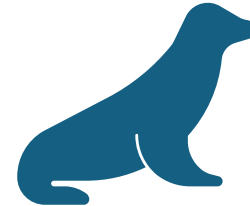
Key Methods of Testing



LTDD soil kilning and historical
NRCS Web Soil Survey



On-site species identification
surveys



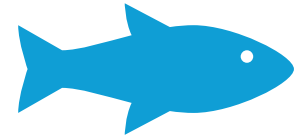
Catch-and-release aquatic
species surveys



Habitat creation,
preservation, and restoration



Habitat quality



Population and species
richness

GLASS CITY METROPARK

Environmental Landscape Performance Assessment

CONTENTS

- Introduction and Project Overview
- Project Goals and Design Intent
- Performance Focus and Questions
 - Methods and Metrics
 - Performance Findings
 - Limitations
- Conclusion
- References



Photo Source: Metroparks Toledo

INTRODUCTION



PROJECT GOALS

This research evaluated Glass City Metropark 6 years after its initial Phase 1 construction, and 3 years after Phase 2 construction. It is intended to **assess the environmental benefits of the park** and **investigate if the design meets the primary objectives** set before construction and completion. This investigation was conducted in collaboration with the design firm SmithGroup. SmithGroup's environmental design goals for this site design included **prioritizing reforestation, improving water quality, and adhering to the 80/20 rule of park development.**

The research involved collecting and reviewing both primary and secondary source data. This data consisted of **collecting citizen science records** on species biodiversity, **calculating total runoff** and comparing current site conditions with former, and **calculating carbon sequestration of trees** planted on site.

1. Quantify the park's ecological impacts.
2. Evaluate effectiveness of ecological design elements.
3. Identify key ecological benefits and limitations.
4. Establish basis for future ecological managements.
5. Contribute to broader landscape performance assessment studies.

CARBON STORAGE AND SEQUESTRATION



How does planting new tree species influence carbon sequestration in the area?
How could carbon sequestration be predicted for 20 years from now?

Methods and Metrics

METHODOLOGY OVERVIEW

- Data Source: iTree Eco v6.1.57
 - Collects data from complete tree inventories to quantify environmental effects, structure, and value to communities.
- Personal Site Observations
 - Collected from trees installed during Phase 1 and Phase 2 of construction



Figure 1.1. Different tree species measured on site. Source: 1-6 taken during site visit on April 10, 2026.

Methods and Metrics

TRACKED METRICS

- Tree Observations On-site
 - Measure diameter breast height (DBH)
 - Convert on-site DBH values into DBH weighted average
 - Apply DBH weight to complete planting inventory

DBH Weight = (Average DBH – DBH at planting) / DBH at planting

Table 1.1. Site Measurements taken on April 10, 2026.

Design Phase	Species Name	DBH (in)
1	Crabapple	6
1	Red Sunset Maple	7.5
1	London Planetree	12
1	Bald Cypress	7.25
1	Elm	7.5
2	Red Maple	6.25
2	Kentucky Coffee tree	8
2	Redbud	7
2	Hawthorn	6

Table 1.2. Calculations for DBH Weighted Average

Design Phase	Average DBH (in)	DBH at planting (in)	DBH Weight (in)
1	7.06	1.5	3.71
2	6.81	1.5	3.54
London Planetree*	12	1.5	7

*London Planetree excluded from average DBH weight calculations for faster than average growth rate

Methods and Metrics

TRACKED METRICS

- iTree Eco Process

Figure 1.2. DBH Categories in iTree Eco

Project Configuration > Define Data Fields > DBH

ID	Description	DBH (in)
1	0 - 3 in	1.5
2	3 - 6 in	4.5
3	6 - 12 in	9
4	12 - 18 in	15
5	18 - 24 in	21
6	24 - 30 in	27
7	30 - 36 in	33
8	36 - 42 in	39
9	42 - 48 in	45
10	> 48 in	52.8

Figure 1.3. % Dieback Categories in iTree Eco

Project Configuration > Define Data Fields > Crown Health

ID	Description	% Dieback
1	0%	0
2	1% - 5%	3
3	5% - 10%	8
4	10% - 15%	13
5	15% - 20%	18
6	20% - 25%	23
7	25% - 30%	28
8	30% - 35%	33
9	35% - 40%	38
10	40% - 45%	43
11	45% - 50%	48
12	50% - 55%	53
13	55% - 60%	58
14	60% - 65%	63
15	65% - 70%	68
16	70% - 75%	73
17	75% - 80%	78
18	80% - 85%	83
19	85% - 90%	88
20	90% - 95%	93
21	95% - 99%	98
22	100%	100

Methods and Metrics

TRACKED METRICS

- iTree Eco Analysis – Phase 1
- Inputs
 - Species Name
 - DBH
 - % Crown Dieback (10)
 - Land Use (Park)

Table 1.3. Annual Carbon Sequestration for Phase 1

Species	Gross Carbon Sequestration (ton/yr)	CO ₂ Equivalent (ton/yr)
Ironwood	0.01	0.05
Amur Maple	0.06	0.23
Red Maple	0.12	0.43
Serviceberry spp	0.12	0.45
Downy Hawthorn	0.03	0.11
Black Gum	0.04	0.13
Honeylocust	0.05	0.19
Kentucky Coffee tree	0.03	0.12
Witchhazel spp	0.01	0.02
Japanese Flowering Crabapple	0.07	0.24
American Sycamore	0.03	0.10
Swamp White Oak	0.08	0.29
Bur Oak	0.03	0.11
Redbud	0.03	0.12
Common Linden	0.03	0.11
Elm spp	0.05	0.19
TOTAL	0.79	2.90

Methods and Metrics

TRACKED METRICS

- iTree Eco Analysis – Phase 2
- Inputs
 - Species Name
 - DBH
 - % Crown Dieback (10)
 - Land Use (Park)

Table 1.4. Annual Carbon Sequestration for Phase 2

Species	Gross Carbon Sequestration (ton/yr)	CO ₂ Equivalent (ton/yr)
Ironwood	0.04	0.13
Red Maple	0.45	1.67
Sugar Maple	0.15	0.55
Serviceberry spp	0.46	1.68
American Hornbeam	0.09	0.31
Downy Hawthorn	0.24	0.89
Honeylocust	0.16	0.59
Kentucky Coffee tree	0.04	0.14
Witchhazel spp	0.09	0.32
Tuliptree spp	0.20	0.73
Japanese Flowering Crabapple	0.13	0.47
Norway Spruce	0.12	0.43
Serbian Spruce	0.07	0.24
London Planetree	0.44	1.63
Redbud	0.05	0.19
Common Linden	0.24	0.89
Elm spp	0.08	0.31
TOTAL	3.73	13.69

Methods and Metrics

TRACKED METRICS

- Convert Gross Carbon Sequestration
 - Convert into pounds per year
 - Estimate 20-year forecast

Phase 1: $2.90 \text{ tons/yr} \times 2000 \text{ lbs} =$
5,800 lbs CO₂/year

Phase 2: $13.69 \text{ tons/yr} \times 2000 \text{ lbs}$
= 27,380 lbs CO₂/year

20-year forecast: (Phase 1 + Phase 2) x 20 years

Performance Findings

The 1,149 newly planted trees have sequestered roughly **33,180 lbs of CO₂ this year.**

When compared with the former industrial site barren of trees.

These trees are projected to sequester over **663,600 lbs of CO₂ over the next 20 years.**

Table 1.5. Summary Table of Performance Findings

Design Phase	CO ₂ Sequestered in lbs (1 year)	CO ₂ Sequestered in lbs (20 years)
Phase 1	5,800	116,000
Phase 2	27,380	547,600
TOTAL	33,180	663,600

Limitations

- **Not every tree included in the planting plan was measured** on-site individually. Real DBH measurements and estimated DBH measurements used in iTree Eco could vary.
- Some **specific tree varieties were not listed** under iTree Eco's tree inventory database and were **substituted for similar** varieties for calculations. This could have shifted the carbon sequestration results slightly.
- DBH at planting values were **determined from standard and average values** taken from other sources. Actual DBH at planting values could be different resulting in a slightly different calculation.
- The 20-year projection of carbon sequestration is based on a **constant sequestration value**. Trees grow and sequester more carbon over time, making the projection a rough estimate and not biologically grounded.

Discussion

- This study highlights the importance of designing for **long term ecological performance**.
- Understanding how **canopy growth changes site performance over time** leads to lasting impacts in carbon storage and sequestration.
- **Transforming degraded land into multifunctional landscapes** has many environmental benefits.



Figure 1.4. The Glass City Event Lawn. Source: Metroparks Toledo

HABITAT QUALITY

How much has bird species richness increased after habitat improvements, compared to pre-design conditions in Glass City Metropark?



Red Winged Black Bird



Red-breasted Nuthatch



Blue Grosbeak



Lark Sparrow

- Nature-based play area inspired by Blue Grosbeak, a **native migratory bird**
- Reinforces park's identity as **habitat stopover**

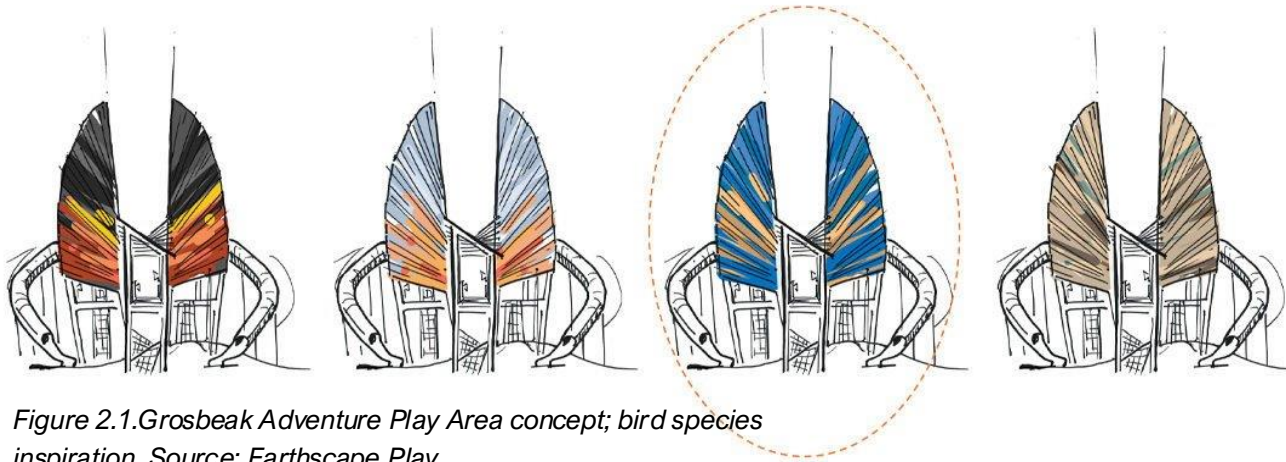


Figure 2.1. Grosbeak Adventure Play Area concept; bird species inspiration. Source: Earthscape Play

- Designed to connect users with **bird habitat and ecology**
- Functions as both a **recreational space and ecological education feature**

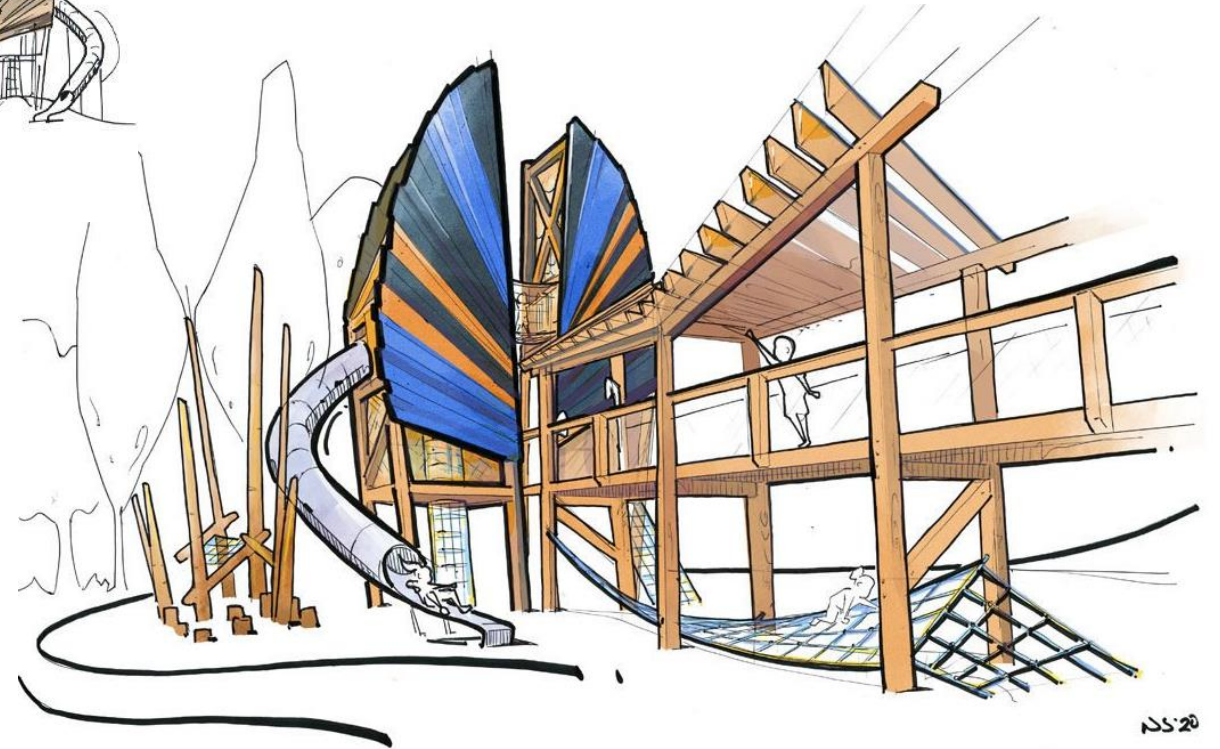


Figure 2.2. Grosbeak Adventure Play Area conceptual render. Source: Earthscape Play

Methods and Metrics

METHODOLOGY OVERVIEW

- Data Source: eBird
 - Global biodiversity platform by Cornell Lab of Ornithology
 - Provides bird sighting data compiled by birdwatchers, experts, and organizations
 - Supports large-scale species tracking
- Personal site visit observations
- Time Periods: eBird data collected from pre-implementation, Phase 1, and Phase 2

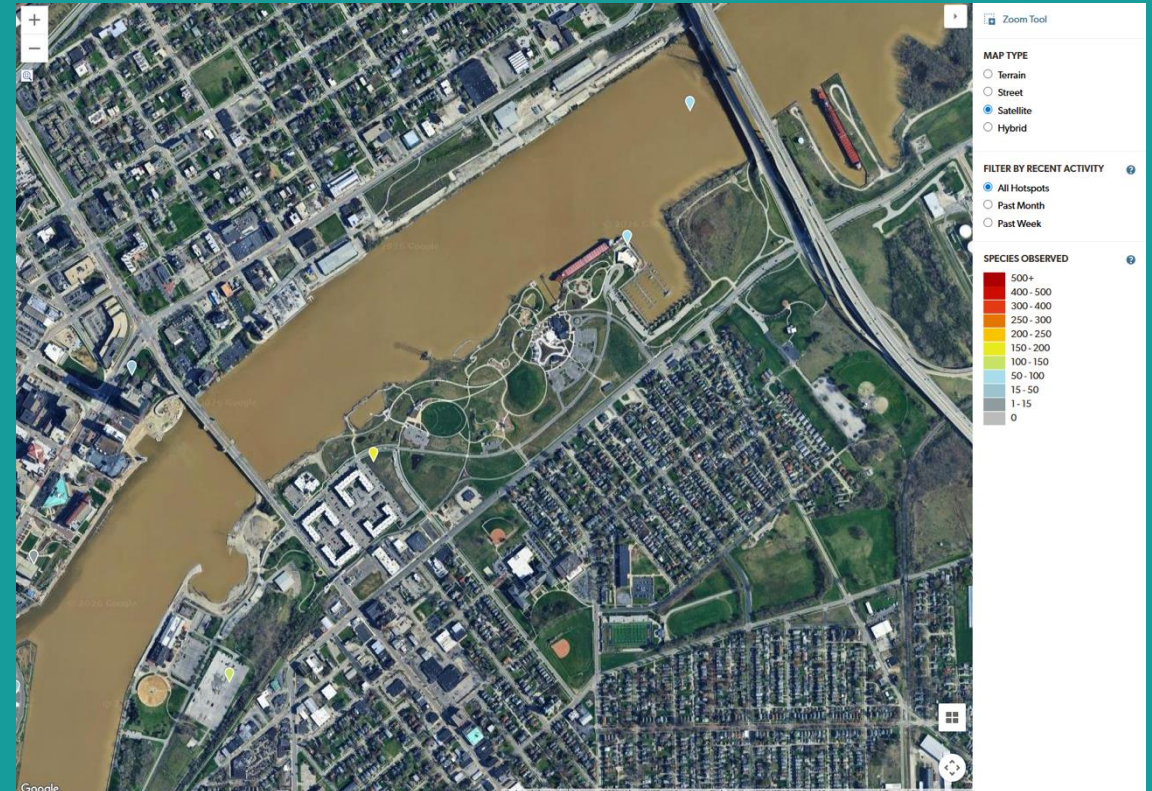


Figure 2.3. eBird Hotspot Map including Glass City Metropark. Source: eBird Hotspot

Methods and Metrics

TRACKED METRICS

- Total Species Observed Annually
 - Richness of bird species observed each year (2020-2025)
- Conservation Species Classifications
- Annual Counts of Selected Indicator Species
 - Track key species across each design phase to last full year (2020, 2023, 2025)
- Percent Change in Species Richness



Figure 2.4. Images of bird species found at Glass City Metropark (in order: left to right, up to down): 1. Barn Swallow, 2. Bald Eagle, 3. Cooper's Hawk, 4. Great Blue Heron, 5. Grayling Goose, and 6. Killdeer. Source: eBird website reference

Performance Findings

- **Fastest growth** occurred between **2022–2024** (**76 → 125 species**)
- Slight decline in **2025**, but still above earlier years
- Overall trend shows **increasing species richness over time**, peaking in recent years

*Phase 1 open in December 2020
**Phase 2 open in June 2023

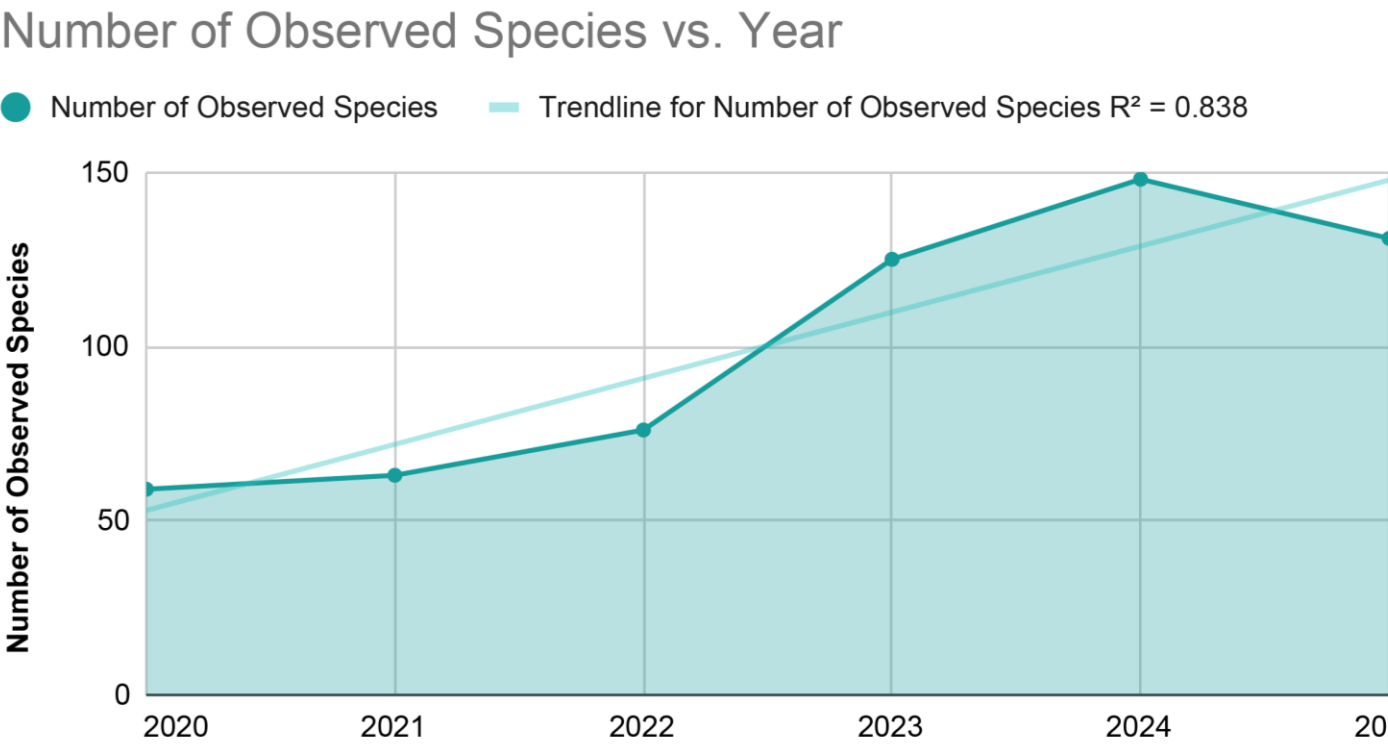


Figure 2.5. Total species observed annually within Glass City Metropark (2020–2025). Source: eBird Bar chart with adaptations

Hotspot Observed Data	2020*	2021	2022	2023**	2024	2025
Bird Observations: Total avian species observed within each year						
Glass City Metropark	59	63	76	125	148	131

Table 2.1. Total species observed annually within Glass City Metropark (2020–2025). Source: eBird Bar chart with adaptations

Performance Findings

- Percents calculated from **159 total observed species (2013–2026)**
- Includes species across **multiple conservation categories**
- Indicates presence of **higher-priority conservation species** alongside common birds

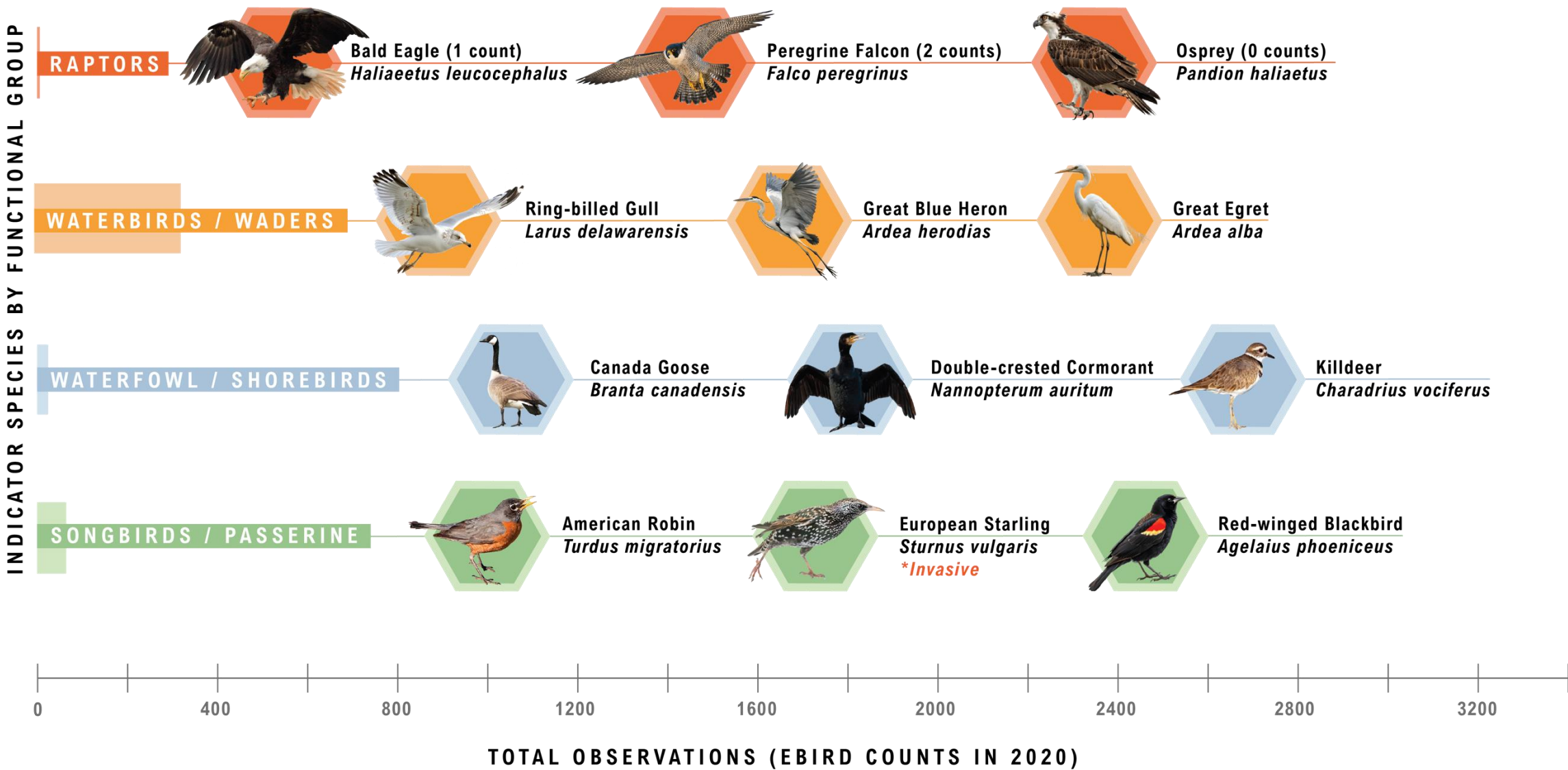
Table 2.2. Distribution of bird species by conservation status within Glass City Metropark. Source: IUCN Red List

Species Classification	Count	Percent* (%)
Species of Concern	9	5.7
Threatened	2	1.3
Endangered	2	1.3

*Percentage of all observed sightings in all years

Performance Findings

Figure 2.6. Total annual sightings of selected indicator species within Glass City Metropark. Species were selected based on suitability to represent avian functional groups. Source: eBird Bar chart with adaptations



Performance Findings

Figure 2.6. Total annual sightings of selected indicator species within Glass City Metropark. Species were selected based on suitability to represent avian functional groups. Source: eBird Bar chart with adaptations

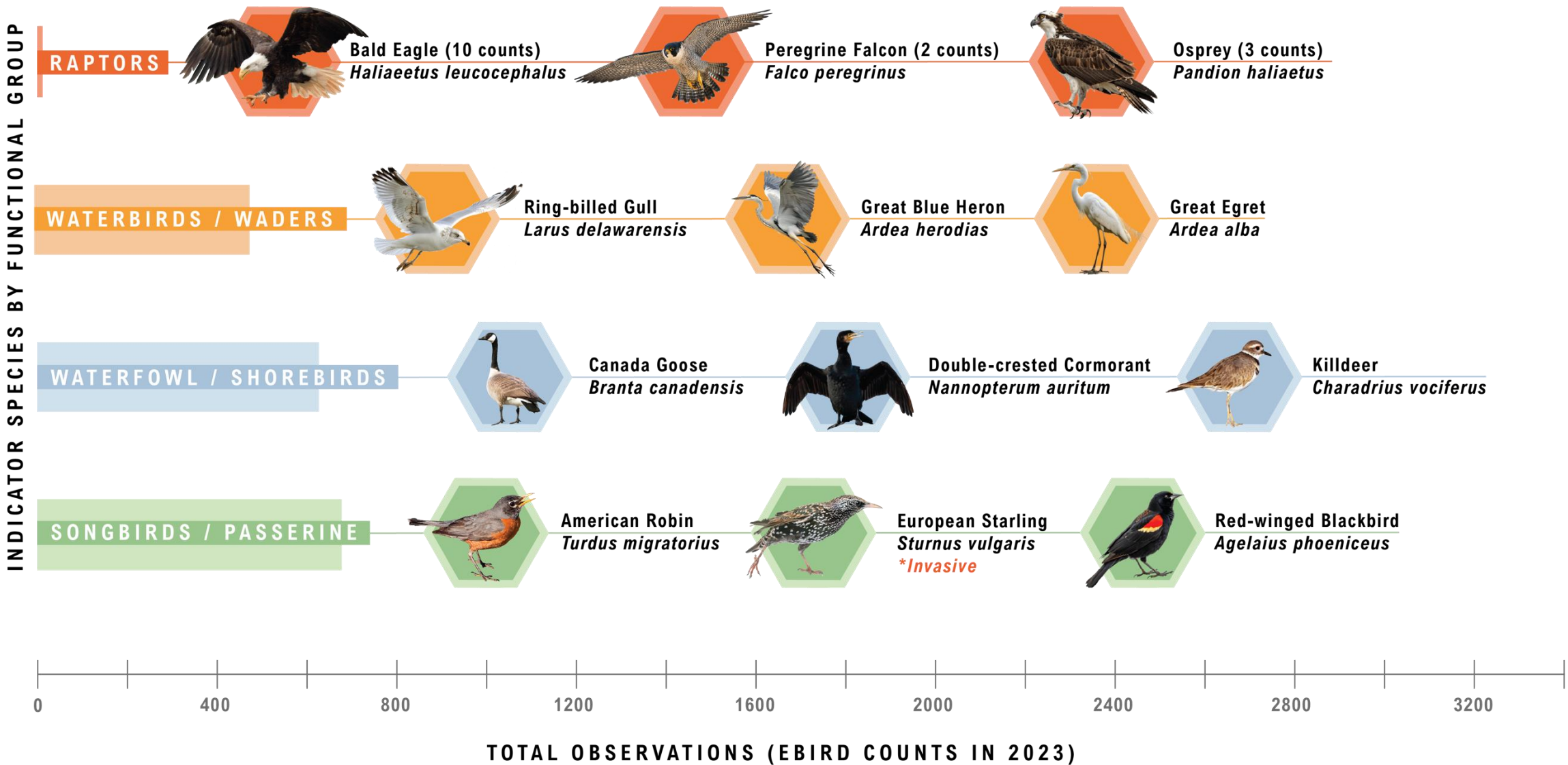
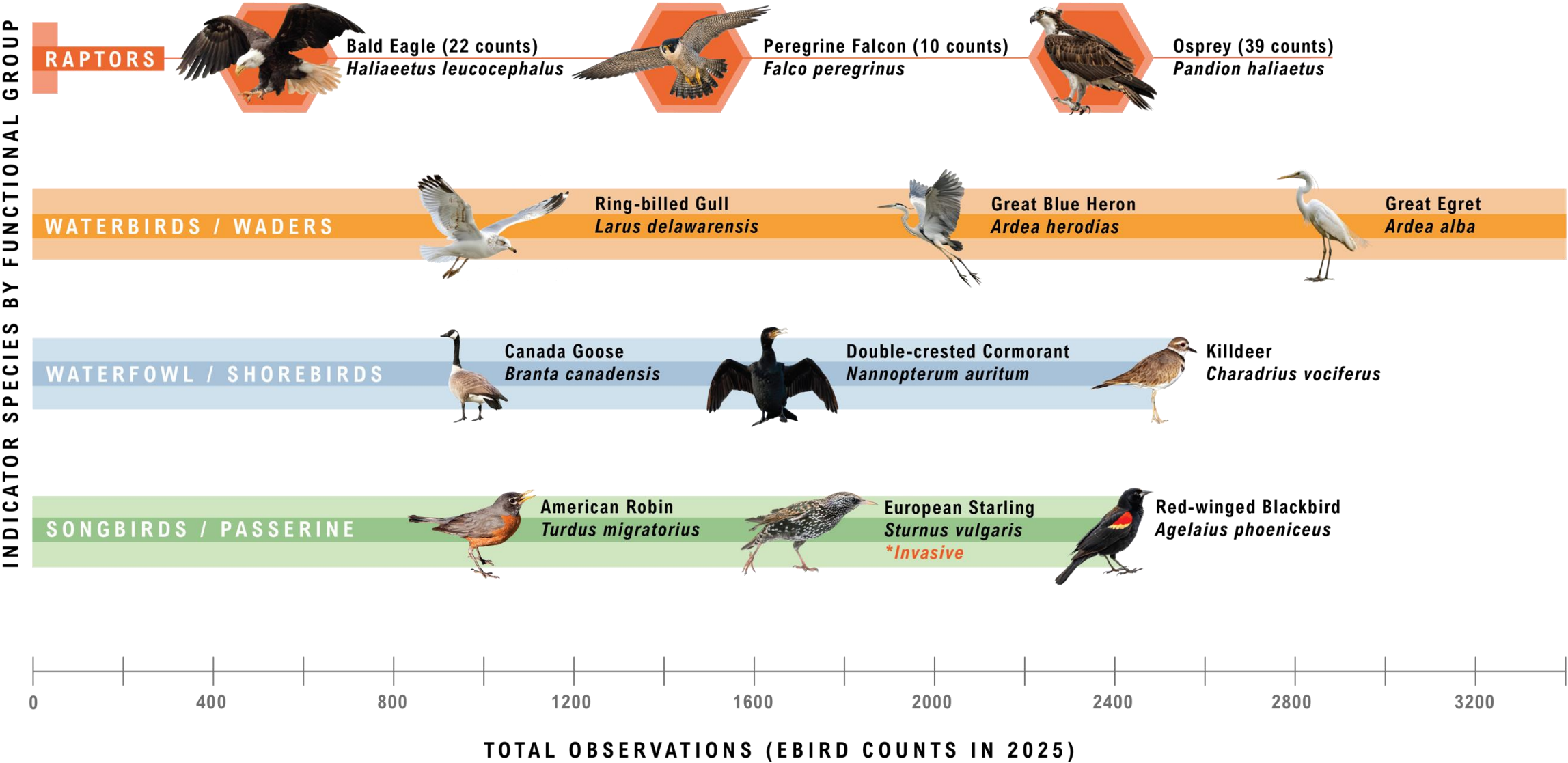


Figure 2.6. Total annual sightings of selected indicator species within Glass City Metropark. Species were selected based on suitability to represent avian functional groups. Source: eBird Bar chart with adaptations

Performance Findings



Performance Findings

- Field session collected qualitative observations to support eBird trends
 - Direct Observation
 - Merlin Bird ID (audio)
- Data recorded in 15-minute intervals across grassland/open field and riverfront edge habitats
- 15 total species observed across multiple functional groups

Time (Approx.)	Habitat Type	Observed Species	Number Observed	Observed Behavior
2:00–2:15 PM	Grassland / Open Field	Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	9	Perching, foraging
2:00–2:15 PM	Riverfront Edge	Canada Goose (<i>Branta canadensis</i>)	2	Flying, swimming, walking
2:00–2:15 PM	Riverfront Edge	Ring-billed Gull (<i>Larus delawarensis</i>)	18	Flying
2:00–2:15 PM	Grassland / Open Field	Horned Lark (<i>Eremophila alpestris</i>)	4	Flying
2:00–2:15 PM	Grassland / Open Field	American Robin (<i>Turdus migratorius</i>)	8	Flying, perching, foraging
2:15–2:30 PM	Grassland / Open Field	Killdeer (<i>Charadrius vociferus</i>)	7	Flying, nesting, resting
2:15–2:30 PM	Riverfront Edge	Double-crested Cormorant (<i>Nannopterum auritum</i>)	5	Flying, foraging
2:15–2:30 PM	Riverfront Edge	Bald Eagle (<i>Haliaeetus leucocephalus</i>)	1	Flying, perching, nesting

Figure 2.7. Field observations of avian and wildlife presence and behavior recording in 15-minute intervals during site visit to Glass City Metropark. Site Observations taken on April 10, 2026.

Performance Findings

- Raptors observed in low numbers with wide-ranging movement across habitats
- Terrestrial mammals present, indicating edge habitat supports broader ecological activity

Time (Approx.)	Habitat Type	Observed Species	Number Observed	Observed Behavior
2:15–2:30 PM	Grassland / Open Field	Peregrine Falcon (<i>Falco peregrinus</i>)	1	Flying, foraging, vocalizing
2:30–2:45 PM	Grassland / Open Field	House Sparrow (<i>Passer domesticus</i>)	6	Flying, perching, Socializing
2:30–2:45 PM	Grassland / Open Field	European Starling (<i>Sturnus vulgaris</i>)	1	Vocalizing
2:30–2:45 PM	Riverfront Edge	Great Blue Heron (<i>Ardea herodias</i>)	1	Flying, wading
2:30–2:45 PM	Grassland / Open Field	American Crow (<i>Corvus brachyrhynchos</i>)	1	Flying
2:30–2:45 PM	Grassland / Open Field	Groundhog (<i>Marmota monax</i>)	1	Foraging
2:30–2:45 PM	Grassland / Open Field	Eastern Cottontail (<i>Sylvilagus floridanus</i>)	1	Foraging
2:30–2:45 PM	Grassland / Open Field	House Sparrow (<i>Passer domesticus</i>)	6	Flying, perching, Socializing

Figure 2.8. Field observations of avian and wildlife presence and behavior recording in 15-minute intervals during site visit to Glass City Metropark. Site Observations taken on April 10, 2026.

Performance Findings

PERCENT CHANGE FORMULA

$$\text{percent change} = \frac{\text{final} - \text{initial}}{|\text{initial}|} \times 100$$

Percent change between phases:

Pre-implementation → Phase 1 = +74.4%

Phase 1 → Phase 2 = +41.3%

Bird Species Richness by Project Phase

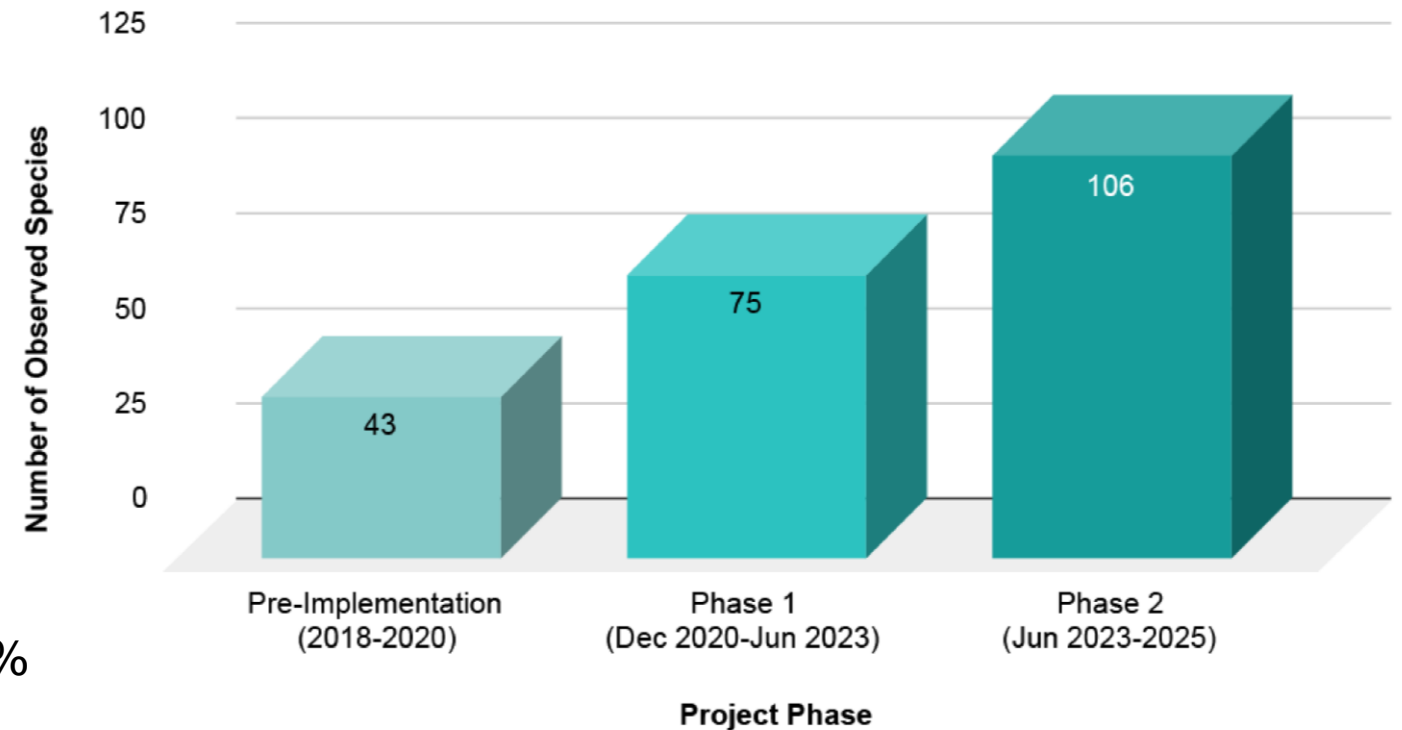


Figure 2.9. Overall growth of total observed bird species between years. Source: eBird Bar chart with adaptations

Limitations

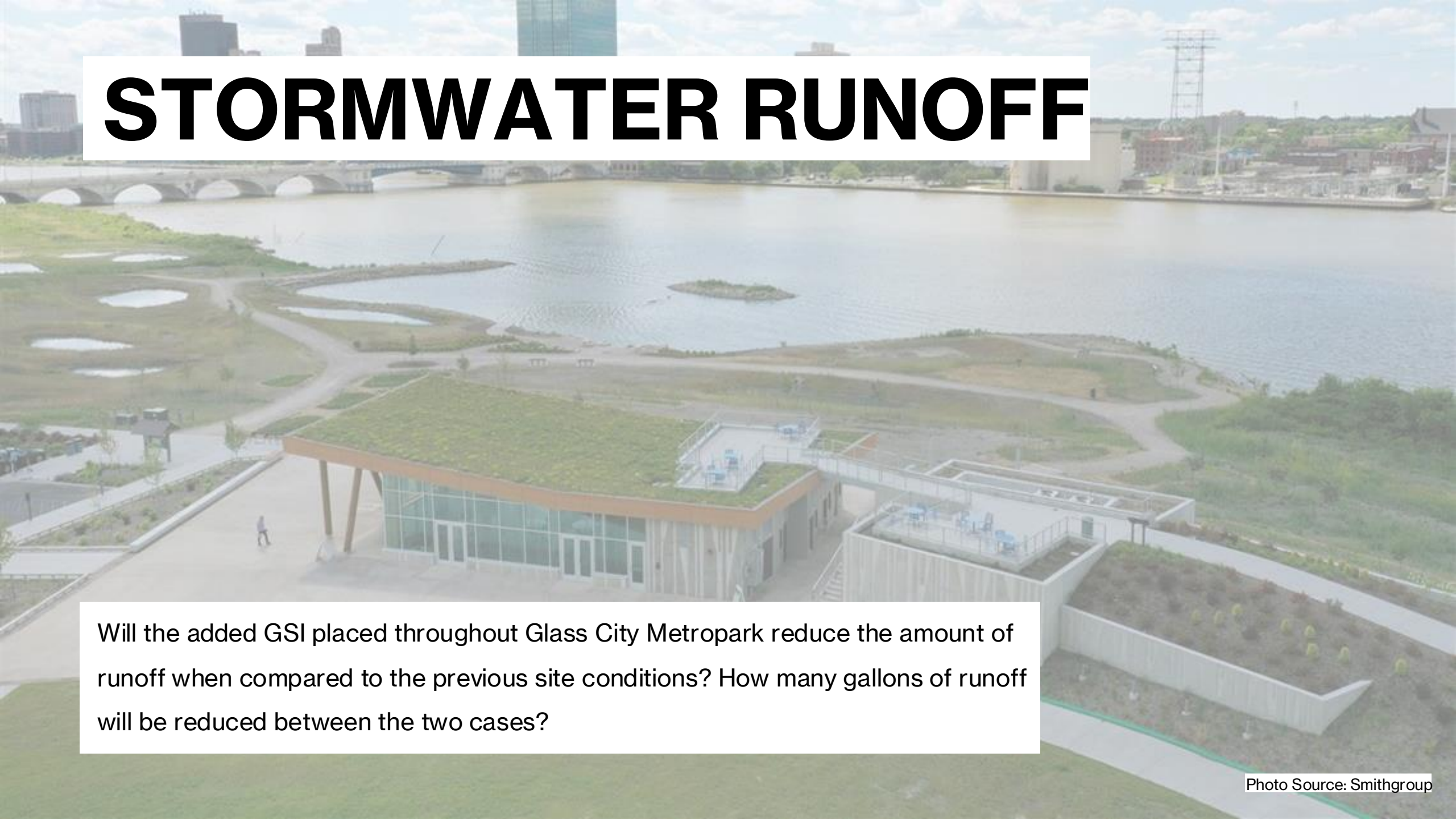
- Bird observations are **based on citizen science data**, which may introduce some **sampling bias** and affect the accuracy of species records.
- The **increasing popularity of birdwatching** may lead to more observations being reported over time on platforms like eBird, which can influence trends.
- The **COVID-19 pandemic** may have reduced outdoor activity, leading to fewer observations and lower reported species counts beginning in 2020.
- **Public access was limited during construction** of Phase 1 and Phase 2, resulting in fewer recorded observations during these periods.

Discussion

- eBird + field data show **more species and more diverse activity**
- **Mixed habitats** support broader functional bird groups
- Rise in **water-associated species** indicates effective river restoration
- Presence of **raptors** signals a stronger, more stable ecosystem
- Results highlight the value of **phased ecological design, habitat diversity, and long-term monitoring**



STORMWATER RUNOFF

An aerial photograph of Glass City Metropark. In the foreground, a modern building with a large glass facade and a green roof is visible. The roof has several rooftop gardens and a small outdoor seating area. The building is situated on a grassy area with winding paths. In the background, a large body of water, likely the Maumee River, stretches across the frame. A multi-arched bridge is visible in the distance. The city skyline is visible in the far background under a blue sky with scattered clouds.

Will the added GSI placed throughout Glass City Metropark reduce the amount of runoff when compared to the previous site conditions? How many gallons of runoff will be reduced between the two cases?

Methods and Metrics

METHODOLOGY OVERVIEW

- Source: ArcGIS Pro
 - Find different land cover types between the current park and previous industrial site
 - Traced site, separating it into 6 different categories
 1. Turf
 2. Garden beds
 3. Stormwater infrastructure (GSI)
 4. Pervious paths
 5. Impervious paths
 6. Dense tree plantings



Figure 3.1: Different land cover types (in order: left to right, up to down): 1. Turf, 2. Garden Beds, 3. Stormwater Infrastructure (GSI), 4. Pervious Gravel Paths, 5. Impervious Concrete/Asphalt Paths, and 6. Dense Tree Plantings. Source: 1-5 taken on site April 10, 2026, Photo 6 Source: Google Earth

Methods and Metrics

METHODOLOGY OVERVIEW

CURRENT METROPARK:



Figure 3.2: Digitized GIS map displaying boundary of study and the separate land cover categories of the Current Metropark. Source: ArcGIS Pro.

FORMER INDUSTRIAL:



Figure 3.3: Digitized GIS map displaying boundary of study and the separate land cover categories of the Former Industrial area. Source: ArcGIS Pro.

Methods and Metrics

METHODOLOGY OVERVIEW

- Apply the NRCS Curve Number Method
 - o This method is a widely used planning-level model that estimates the direct runoff from a rainfall
 - o Equation:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

- Separate the method into finding 3 distinct factors:
 1. **Weighted Curve Number (CN)**
 - Estimation for the **volume of direct runoff or infiltration** from rainfall a site can handle
 - Based off soil hydrologic type
 2. **Potential Maximum Retention (S)**
 - **Max amount of water the site can retain** after a rainstorm begins
 3. **Storm strength (P)**
 - **How many inches of water will fall** during the simulated test

Methods and Metrics

TRACKED METRICS

- Finding both Curve Numbers
 - Multiplied the percentage of land cover type by its respective curve number
 - Got each curve number type from the "urban hydrology for small watersheds" manual
 - Higher the curve number = higher runoff
 - The Current Metropark CN = 78
 - Former Industrial CN = 95

Table 3.1: Calculations of the current site's land cover percentage, curve number under soil type 'C', and Weighted curve number.

Calculated Curve Weight and Soil CN			
Land Cover Type	Soil Type 'C' CN	Percentage	Weighted Curve Number (% x CN)
Impervious	98	18.14%	.1814 x 98 = 17.7772
Pervious	74	2.67%	.0267 x 74 = 1.9758
Garden Bed	74	3.95%	.0395 x 74 = 2.923
Retention Basin	70	6.12%	.0612 x 70 = 4.284
Forested	70	19.28%	.1928 x 70 = 13.496
Turf	74	50.17%	.5017 x 74 = 37.1258
Current			77.5818 = 78

Table 3.2: Calculations of the former site's land cover percentage, curve number under soil type 'C', and Weighted curve number.

Former Industrial: Calculated Curve Weight and Soil CN			
Land Cover Type	Soil Type 'C' CN	Percentage	Weighted Curve Number (% x CN)
Impervious	98	49.12%	.4912 x 98 = 48.1349
Turf/open land	91	50.88%	.5088 x 91 = 46.3033
Previous			94.4382 = 95

Methods and Metrics

TRACKED METRICS

- Finding Maximum Retention (S)
 - Using the Weighted Curve Numbers, solve for 'S' with this equation:

$$S = \left(\frac{1000}{CN} \right) - 10$$

- Current Metropark = $(1000 / 78) - 10$
= **2.8205 in**
- Former Industrial = $(1000 / 95) - 10$
= **0.5263 in**

- Setting the rain fall amount for the simulation (P)
 - A 1-inch rainfall event was chosen to be calculated in
 - Ensures an even measurement between both calculations

Performance Findings

- For the current metropark, it was found that only **0.05 in of runoff** enters the Maumee River on the current metropark
 - Compared to the former industrial site which had **0.5 in of runoff**
- To better visualize, the inches of runoff was converted into gallons
 - 1-inch storm spread across 63.44 acres = 27,154 gallons
 - Current Park = $0.0538 \times 63.44 \times 27,154 = 92,679$ gallons of runoff
 - Former Industrial Site = $0.5291 \times 63.44 \times 27,154 = 911,454$ gallons of runoff

Table 3.3: Findings of the study between the current metropark and former industrial area. The graph displays each steps findings throughout the process, showing the curve numbers, amount of water retained (in), amount of runoff (in), and the amount of runoff converted to gallons.

Findings: Industrial versus Current Conditions				
	Curve Number	Water Retained	Runoff (in)	Runoff (gallons)
Current Metropark	78	2.8205	0.0538	92,679
Former Industrial	95	.5263	0.5291	911,454
Results	-17	+2.29 in	-.4753 in	-818,775 gallons

Performance Findings

In total, the redesign of Glass City Metro Park allowed for a **90% decrease** in runoff during a 1-inch rainstorm event, preventing **818,775 extra gallons of water runoff** from entering into the Maumee River, compared to the previous site's conditions.

Industrial vs. Current Conditions: Runoff Amount (gallons)

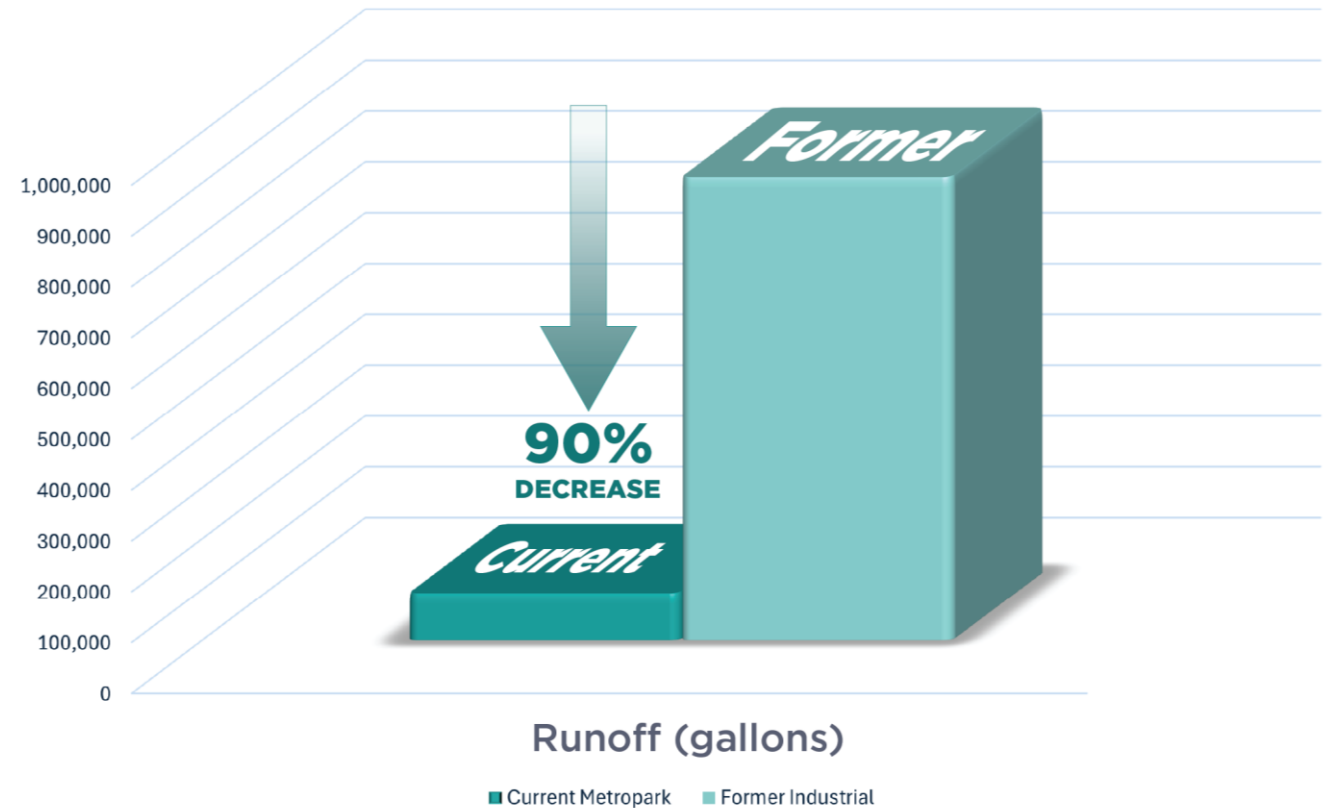


Figure 3.4: Graph displaying the variance in runoff (gallons) of the current metropark and the former industrial site.

Limitations

- **Former industrial land-cover conditions** were modeled based on historic site use rather than detailed archival mapping.
- Though cross checked with modern imagery, **land-cover for current site was mapped off of older imagery**, meaning some areas labeled as one land cover could have changed.
- Curve numbers describe average conditions that are useful for design purposes. **If the rainfall event used is a historical storm, the modeling accuracy decreases.**
- **Soil conditions** were interpreted from publicly available mapping and **may vary locally.**
- The model estimates runoff volume only and **does not account for peak flow timing, water quality treatment, or subsurface drainage** infrastructure.
- Rainfall event chosen **does not reflect extreme or historical storm events**; the site's runoff amount varies on storm size.

Discussion

- This study demonstrates the importance of reducing runoff. **importance of green spaces and green infrastructure**
 - When GSI is implemented, and runoff is reduced, **less pollution** enters important waterways like the Maumee River.
- **Reclaiming former industrial sites** helps to reduce both pollution and runoff
 - This helps protect ecosystems and create necessary community spaces for people.



Figure 3.5: Community gathering to use Glass City Metropark Source: Metroparks Toledo

Conclusion

- **Habitat quality improved significantly**
 - 159 total bird species; **+41% increase** post-Phase 2
 - Greater diversity across **functional groups + trophic levels**
- **Stormwater management highly effective**
 - **~90% runoff reduction** during 1-inch storm
 - **~818,775 gallons prevented** from entering the Maumee River
- **Carbon sequestration provides long-term benefit**
 - **33,180 lbs CO₂/year** captured by 1,149 trees
 - **663,600+ lbs CO₂ projected** over 20 years

- **Design strategies are working**
 - Habitat diversity, GSI, and reforestation drive performance
 - Transforms former industrial site into **high-functioning ecological system**
- **Key takeaway**
 - **Phased ecological design + long-term planning = measurable environmental impact**
- **Future focus**
 - Continue **monitoring, adaptive management, and maintenance**

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Assorted Images

- Grosbeak Playground Towers at Glass City MetroPark - Earthscape Play Inc. (2026, February 4). Earthscape Play Inc. <https://www.earthscapeplay.com/projects/glass-city-metropark-bird-inspired-playground-towers-toledo/>
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THANK YOU



Glass City Metropark, Toledo, Ohio

Landscape Performance Assessment - Social Performance

Name: Samia Tasnim Faiza, Adam Hershner

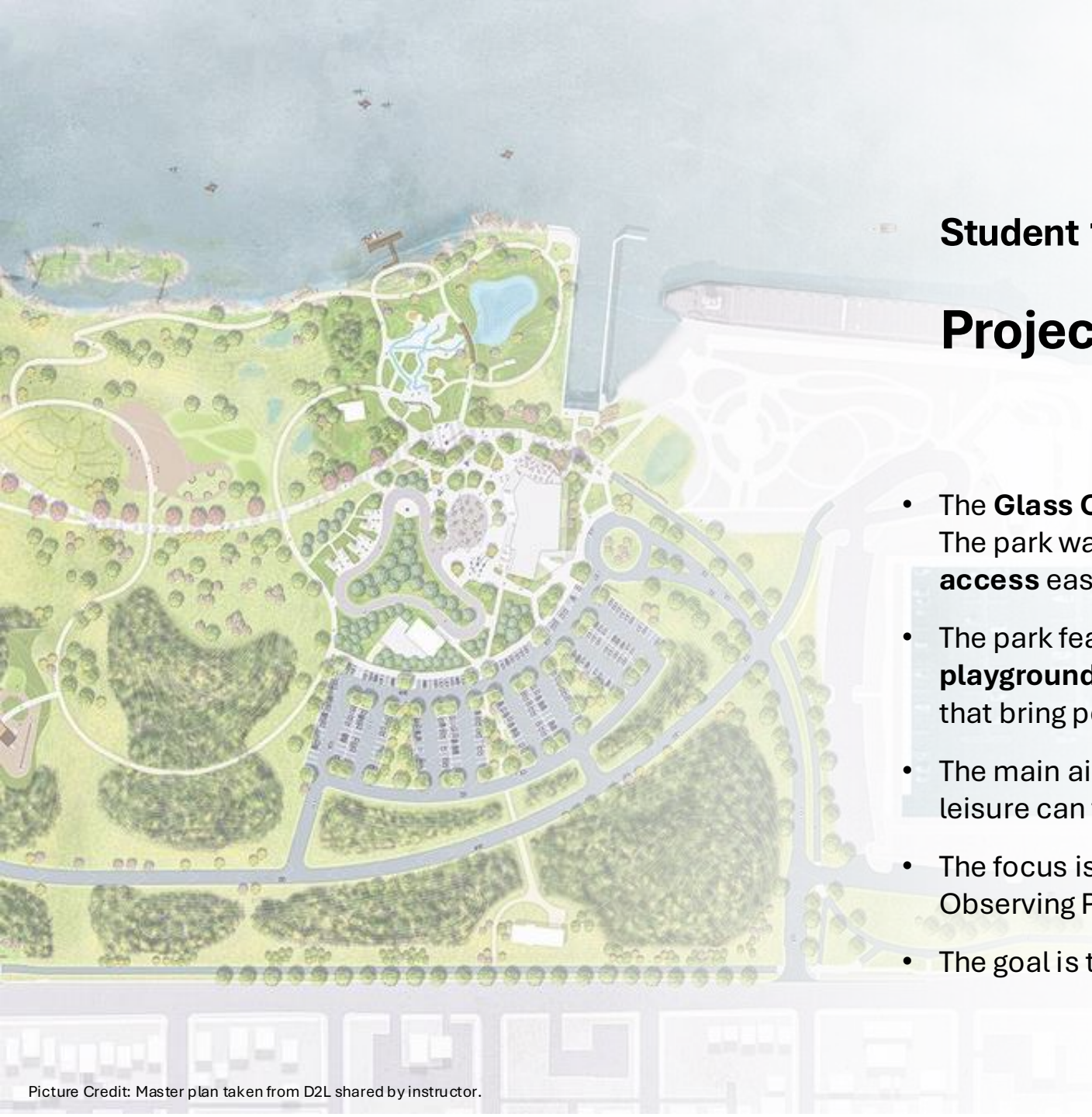
Course: LA 883, Spring 2026

Course instructor: Dr. Haoyue Yang

School: Michigan State University



Picture Credit: <https://metroparkstoledofoundation.org/projects-and-programs/gc-riverwalk/>



Student 1: Samia Tasnim Faiza

Project Overview:

- The **Glass City Metropark** is a large public park situated in Toledo, Ohio. The park was created to allow **outdoor activities** and make **waterfront access** easier for everyone.
- The park features **open lawns, walking paths, benches, and children playground**. It offers splendid views of the river and allows gatherings that bring people closer together.
- The main aim of the design is to create a place where socialization and leisure can take place safely and comfortably.
- The focus is on behavioral observation using **SOPARNA** (System for Observing Physical Activity and Recreation in Natural Areas)
- The goal is to understand how people use different park spaces.

Project **Goals** and **Objective**:

- The goal of this project is to focus on social performance analytics and evaluate how well “Glass City Metropark” supports community gathering, recreation, social interaction, and user activity through behavioral observation.
- It also focuses on how people use different spaces, what activities they do, and how they interact with each other.
- The goal is to create a welcoming space for all users.



Methods – SOPARNA Toolkit:

- **SOPARNA** was used for this behavioral observation study.
- The observation was focused on three zones (**Glass City Metropark Slides, Metropark Riverwalk, and Prairie and Pollinator Discover Play Area**).
- SOPARNA toolkit was used to systematically observe and record user behavior, activity types, and social interactions across different park zones.
- Observations were conducted at a specific time of the day, and behavior mapping was used to identify patterns of use and social engagement.



Data Collection: Behavioral Observation Data

Observation Zone	Group Size	Activity Type	Age Range Group (y/o)	Interactive Level	Duration (minutes/seconds)	Notes
Glass City Riverwalk (Boardwalk across Pavilion) - 1	2 adults	Playing, Socializing	(18 - 20)	Interaction: High, Active	Recorded time: 4:53	Two young adults were playing and running after one another on the boardwalk bridge. The interactive rope bridges are an attraction of the park which is used by all age groups of people.
Glass City Riverwalk (Boardwalk across Pavilion) - 2	2 adults	Dog strolling	(30 - 35)	Interaction: Medium, Moderately active	Recorded time: 9:11	One man and a woman were strolling a dog near the boardwalk area. They both took a break after 9 minutes 11 seconds, hence that was the amount of time I could record.
Glass City Metropark Slides	11 children	Playing, Socializing, Running	(2 - 12)	Interaction: High, Active	Recorded time: 7:53	Three groups of families were present in the area where each of the families were busy playing and interacting with their children. Family 1: 4 members, Family 2: 4 members, Family 3: 3 members
Prairie and Pollinator Discover Play Area	9 children	Playing, Socializing, Running	(2 - 10)	Interaction: High, Active	Recorded time: 5:23	A total of 9 children were playing, waiting for their turns to use the slides, eating, running , and socializing with each other.

Fig: Table shows overall data collection during the entire observation time

Data Collection: Using Bar Chart

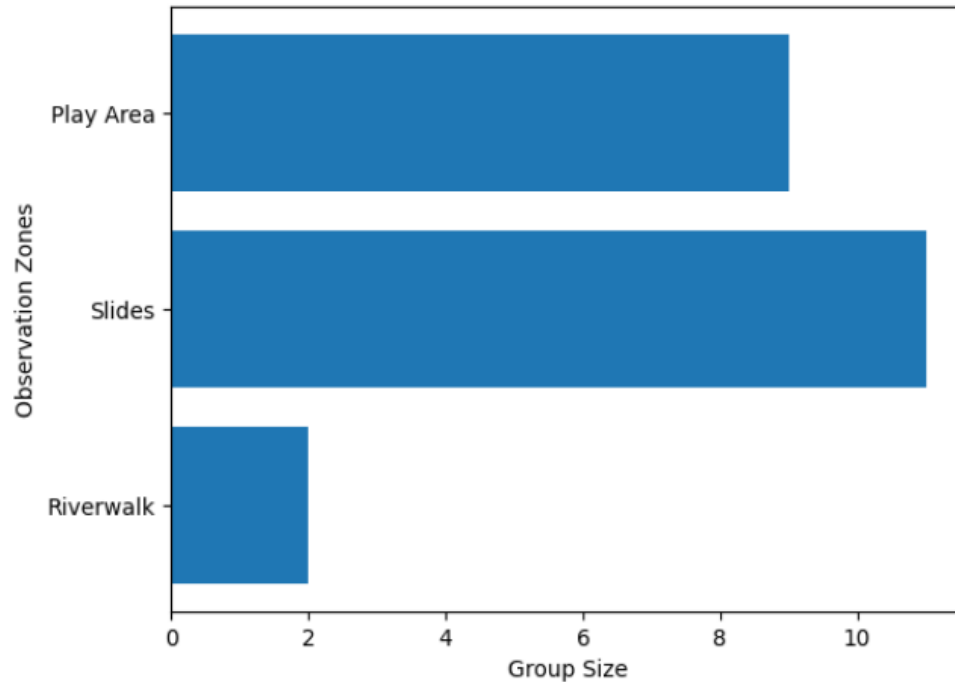


Fig: Bar graph showing Group Size vs Observation Zones

- Metropark Slides and Prairie and Pollinator Discover Play Area have larger group sizes, while Glass City Riverwalk has smaller group size.

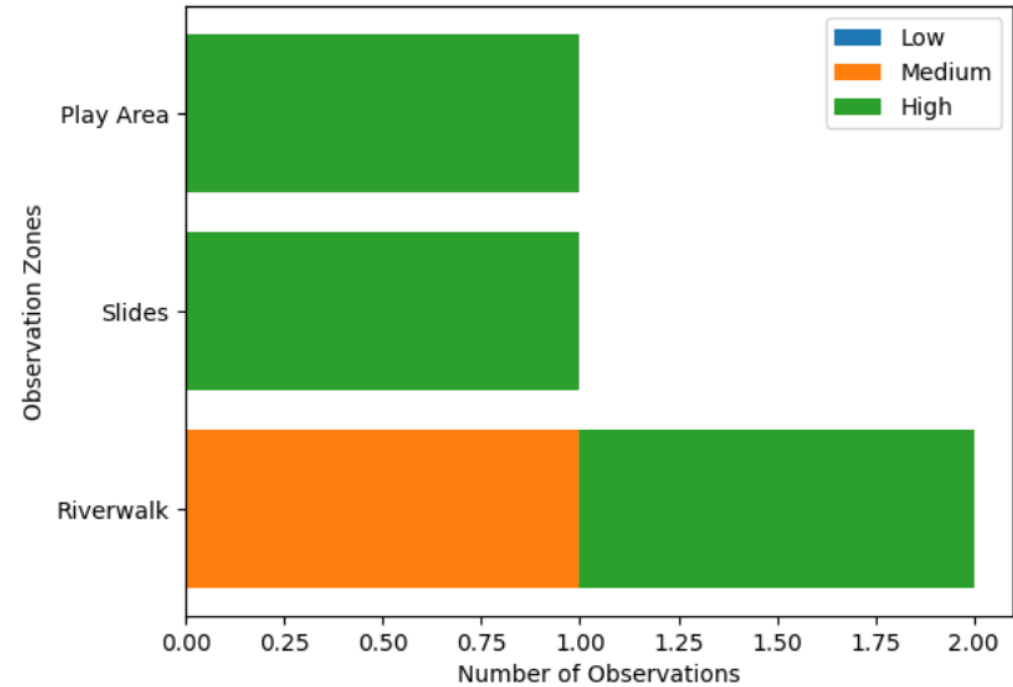


Fig: Bar graph showing Social Interaction Levels vs Observation Zones

- Prairie and Pollinator Discover Play Area and Metropark Slides show only high interaction, meaning these spaces strongly support social activity.

Performance Findings:

I have observed areas at the **Boardwalk (Across the Glass City Pavilion), Prairie and Pollinator Discover Play Area**, and **Glass City Metro Park Slides**. The observed areas were engaging and interactive. Since they were playground areas, it was mostly occupied with children and parents.

- All the observation zones shows high levels of social interaction, especially among children and families.
- Riverwalk areas show mixed interaction levels, supporting both movement and casual social use.
- Larger group sizes are concentrated in play zones, while smaller groups dominate linear spaces.



Limitations

- The observations were done for a **limited period of time** so it may not show full patterns.
- Findings show at **only one** time and day of the week which is challenging as it may not fully understand visitor reasons just by observing.
- Weather conditions such as **temperature, wind, or rain** can significantly also affect how people use the park.
- Behavioral observation did not **capture user opinions, motivations, or satisfaction**.
- Observations are **limited to only three selected zones** and did not represent the entire park equally.



Conclusion:

- The study shows that Glass City Metropark supports **strong social interaction**, especially in play areas where group activities are common.
- Spaces like the riverwalk provide more **flexible use**, allowing both **movement** and **casual interaction**.
- The findings highlight that design elements such as **play structures, seating, and spaces** influence how people gather and interact.
- Overall, the park successfully **promotes social engagement**, but further data collection would provide a more complete understanding of **user behavior**.





Student 2: Adam Hershner

Proposed Further Research

Project Objectives

- Create a variety of amenities for all seasons.
- Return waterfront access to Toledo.
- Create an extension of Toledo's existing and vibrant culture within the site.
- Create unique opportunities that are not found in other parks; the "best" riverside park.
- Focus on Discovery Play, Water Play, and Winter Play as the three most critical program elements.
- Create regional interconnectivity within both surrounding neighborhoods and all of northwest Ohio.
- Establish a strong foundation for future phases of the Riverwalk project.



Performance Questions

Has community engagement and visitor numbers increased across different phases of development?

Which amenities are being most utilized, and which are being underutilized?

Do users of Glass City Metropark have a positive opinion of the park?





Proposed Benefit: Year-Round and Diverse Programming

Offers a range of recreational activities throughout all seasons of use.

Background

Due to the project site originally being an industrial brownfield without usable amenities, there is little existing data on whether the site experienced much social recreational before construction completion. Prior visit and use numbers were not obtained.

As the metropark is a phased project, attention was paid to the divisions of times open, with Phase I being opened to the public on December 10th, 2020, and Phase II being opened to the public on June 9th, 2023.

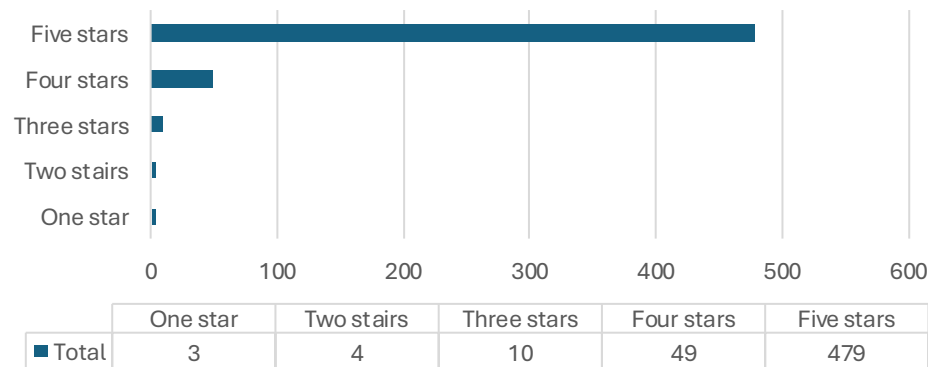


Methods

The chosen method of initial research was through the analysis of Glass City Metropark's Google Reviews.

The final collection date being April 22nd, 2026. In total, **545 reviews** were analyzed, with the earliest being from December 11th, 2020, exactly one day after the Phase I project was opened. The latest review was from April 22nd, 2026. The five-star rating average was 4.8.

Rating of Existing Reviews



Glass City Metropark

1505 Front St, Toledo, OH 43605, United States

[Write a review](#)

4.8 ★★★★★ 545 reviews ⓘ

All river views 27 splash pad 21 Glass City Riverwalk 14 ice skating 25
roller skating 12 skate rentals 8 walking trails 13 fire pits 6
picnic areas 10 playground 47

Sort by

Most relevant Newest Highest rating Lowest rating



Joe Thourot

Local Guide · 33 reviews · 2344 photos

★★★★★ a day ago

NEW

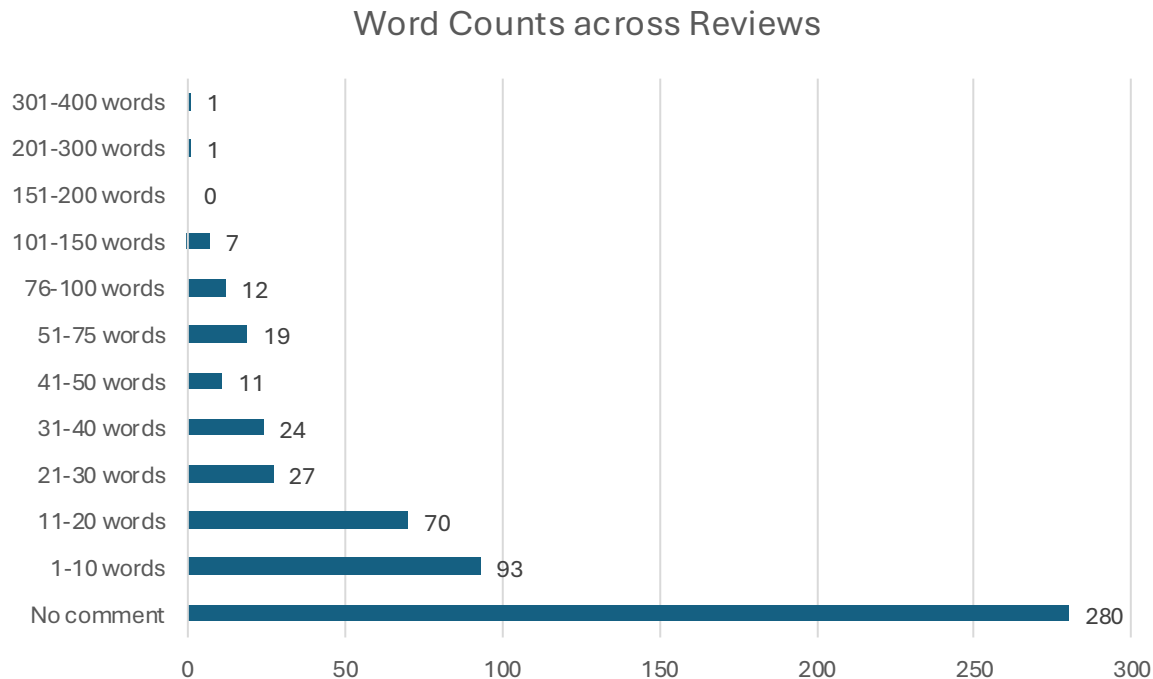
Great place for walk or a skate!!! 🏡 📸



Hover to react

Comment Analysis

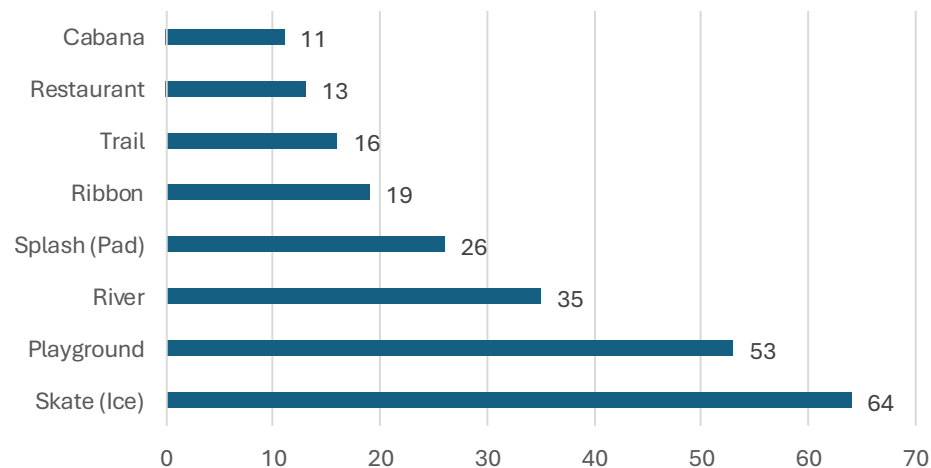
Calculations were completed in Excel, utilizing Pivot Tables and graphs to best visualize the collected data. Straight data counts were completed based on data input. Additional data was collected through comparable case studies, research papers, and information provided by SmithGroup during their project brief.



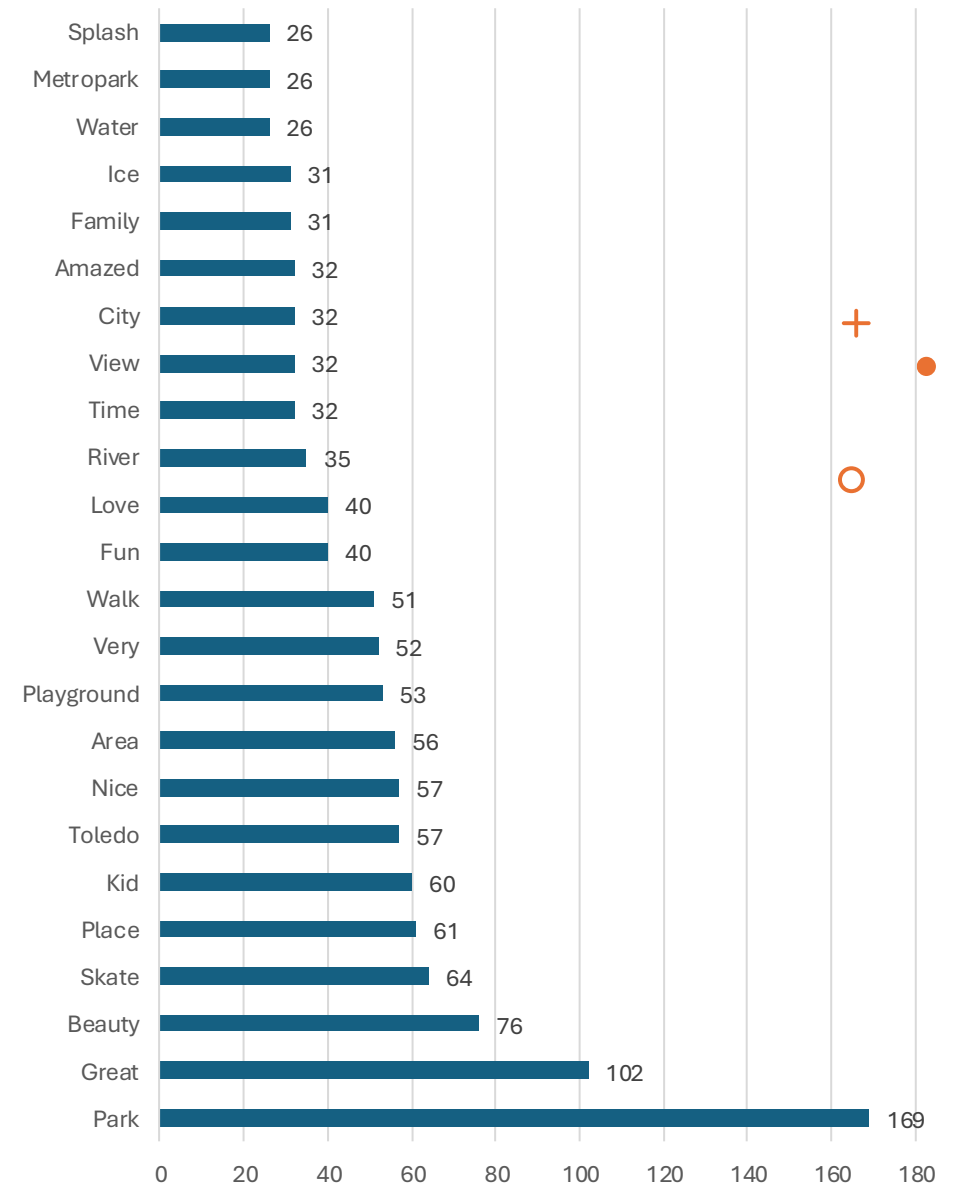
A third-party cloud program was utilized to seek out all repeating words, assembling them into a notated list per mention.

Mentions of specific amenities by name were grouped into a secondary list.

Specific Amenities Mentioned by Name



Consolidated Words from Google Reviews

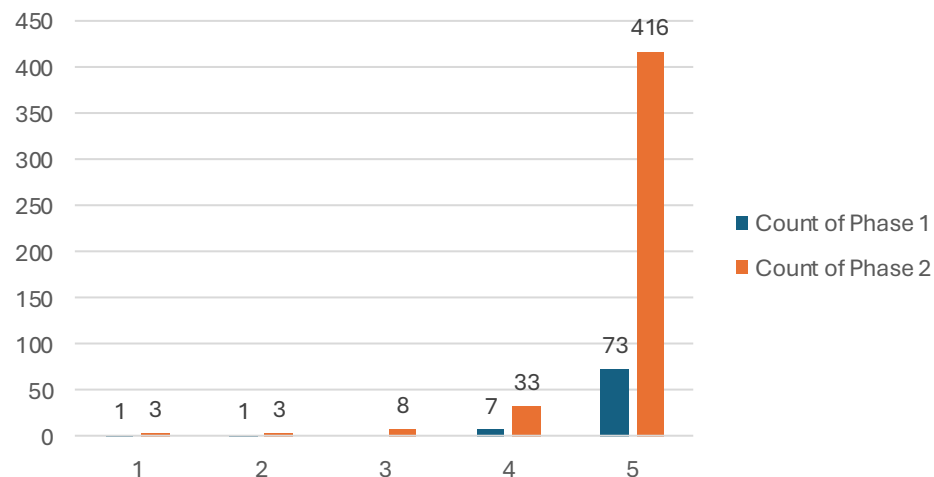


Phasing Analysis

A secondary analysis was done through dividing reviews into those published while the project had released only Phase I (being all reviews before June 9th, 2023) and those in Phase II, where multiple additional amenities were introduced. As seen, the number of reviews increases from 82 within a two and a half year period to 463 within a nearly two years period, showcasing a dramatic increase in overall users of the site through phasing changes.



Division of Ratings Across Project Phases



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“Glass City Riverwalk | Toledo OH.” *Facebook.com*, 2026, www.facebook.com/glasscityriverwalk/.

Limitations

- All Google Reviews are self-initiated, which necessitates outside factors to inspire someone to leave one; this tends towards either highly positive or highly negative responses, which is not indicative of the average experience of the site.
- Reviews can be completed at any time; as such, while it can be consolidated to roughly the correct time period for when the review was left, it is equally likely that the collected dates are inaccurate to when the user actually visited the site.
- The number of reviews (545) is incomparable to the number of estimated visitors to the site within the past two years (500,000), leading to probable differences to the average user.

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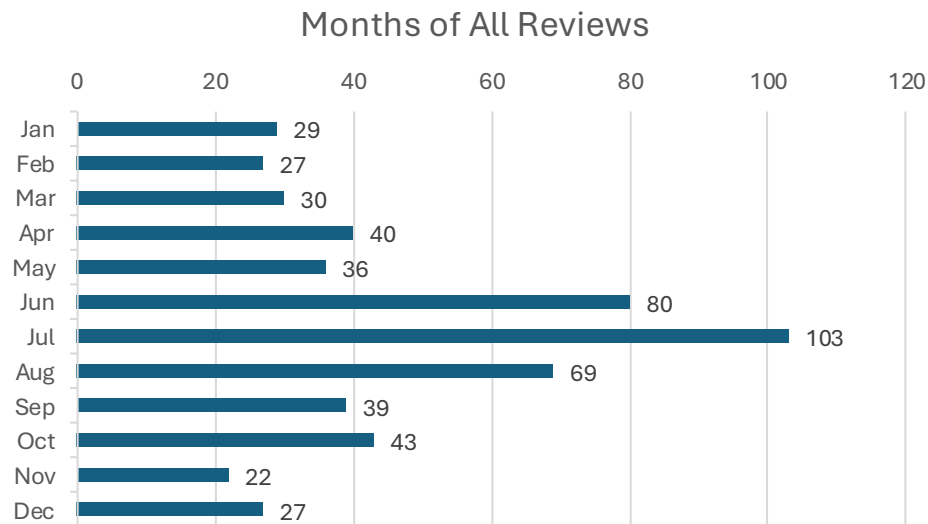
Proposed Further Research

Due to all data currently gathered being insubstantial in terms of raw numbers and accurate scaling, additional will need to be gathered. While one visit to the site was made, it was of a limited timeframe and did not involve interaction with users of the site. As such, the suggested continuation of this study would be that of an intrapersonal anonymous survey.

In taking directive from a similar CSB study done at Rainier Beach Urban Farm and Wetlands, they noted an exceptionally higher rate of completion for paper surveys over digital, with a ratio of 57 completed paper surveys and 3 digital surveys. As such, it would be advantageous to offer both options, ideally in combination with an on-site activity, such as one of their numerous festivals or volunteering events. The digital survey can be shared online, such as the existing *Glass City Riverwalk* or *Metroparks Toledo* Facebooks.

Optimal Time Analysis

To further increase potential answers, Glass City Metropark's existing Google Reviews were analyzed for periods of high activity, utilizing the days and months of posting. As shown, there is a significant spike during the months of June, July, and August, increasing potential for answers, with the next highest months being September and October.



Survey Questions

According to a research study by Brent Chudoba with additional research from PubMed Central, a public-facing survey should be under ten minutes to maximize completion and responses rate, with a potential question range of 11-25.

With that question limit in mind, the category of social benefits to focus on is the previously-analyzed, being ***Year-Round and Diverse Programming***. Notable questions to consider include:

- How often do you visit the site?
 - With answers divided into first visit, a few times per year, a few times per month, and a few times per week.
- When did you first visit the site?
 - With answers divided into first visit, since the release of Phase II, or prior to Phase II.
- What amenities do you most often use?
- What are your favourite parts of the site?
- Do you feel that the site has a good variety of amenities?
- How would you rate your overall experience at the site?



To consolidate experiences with those of the Google Reviews for attempted clarity, the most-repeated words can be assembled into a word cloud attached to the survey, with a question asking if these words are equivalent to what the survey taker feels about Glass City Metropark. This question could also be limited to the digital version to save on size and ink costs for the paper version.



Sources

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Thank you.

An aerial photograph of Glass City Metro Park at sunset. The park features a large green field with winding paths, a playground with colorful equipment, and a parking lot filled with cars. In the background, the city skyline is visible, including several tall skyscrapers, with the sun setting behind them, casting a warm orange glow over the scene.

Glass City Metro Park Economic Performance

Evaluating Revenue

Isaiah Ramsey

Glass City Metropark

Glass City Metropark, being a large-scale waterfront park that offers public recreational space, generates a lot of revenue.

- Skating rentals
- Event spaces
- Restaurants

Goals and Design Intent

Focusing on how the park generates revenue, how efficiently it operates relative to visitation, and how design strategies influence long-term financial outcomes.



Performance Question

- *What is the total annual revenue generated by the park?*
- *How much revenue is generated per visit?*

Sub Questions

- *Which revenue streams contribute the most?*
- *How much money is saved through design decision?*



Datasets

This study uses multiple data sources to evaluate the economic performance.

- Financial Documents
- Financial Quotes
- Rental Fee Brochures
- Event Pricing Guide
- PLACER Visitor Data
- Maintenance Sheet Guide

Focusing on **direct revenue** retained by Glass City and estimated **cost savings**.



PLACER Visitor Data

Daily Visits (2025)

Day	Daily Visit
Monday	66887
Tuesday	65522
Wednesday	67204
Thursday	62282
Friday	100796
Saturday	150060
Sunday	115212

[1]

- 657,963 total visits in the year
- This is strictly **visits** not unique visitors

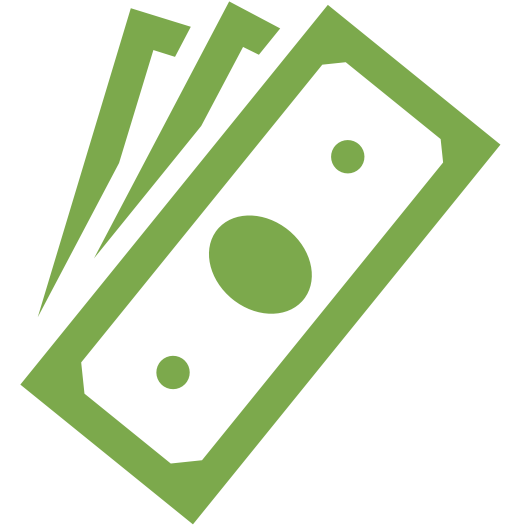


Revenue Categories

To better understand how Glass City Metropark generates income, the revenue was **divided into categories** based on how money is produced/managed.

- Facility Rentals
- Concessions and Vendors
- Programs and Recreation

This also allows for an easier breakdown and analysis of where majority of revenue is being generated.



Facility Rentals Revenue

(Direct User Fees For Space)

- Glass City Pavillion
- Grosbeak Shelter
- Pollinator Shelter
- Kayak Share Locker Rental
- Permit Fees



Rental	Apx. Generated Revenue (Yearly)
Glass City Pavillion	\$100,000
Grosbeak Shelter	\$4,000
Pollinator Shelter	\$1,000
Kayak Share Locker Rental	\$10,000
Permit Fees	\$50,000
Total	\$165,000

Concession/Vendor Revenue

(Partnership-Based Revenue Sharing)

- Restaurant and concessions
- Catering Services
- Marina Services
- Merchandise Licensing

Concession/Vendor	Apx. Revenue Generated (Yearly)
The Garden	\$100,000
Hajjar Hospitality (Catering)	\$30,000
Brenner 75 Marine	\$10,000
Jupmode	\$5,000
Total	\$145,000

(This total represents the amount the park makes through agreement)



[2]

Program and Recreation Revenue

(Activity-Based Fees)

- Ice Skating
- Roller Skating
- Tours
- Workshops

Recreation/Program Type	Apx. Revenue Generated (Yearly)
Ice Skating Rental & Admission	\$150,000
Roller Skating Rental	\$20,000
Modest Program Fees	\$2,000
Total	\$172,000

[2]

Revenue Breakdown

Program & Recreation contributes to majority of the revenue at Glass City Metropark.



Total Annual Revenue

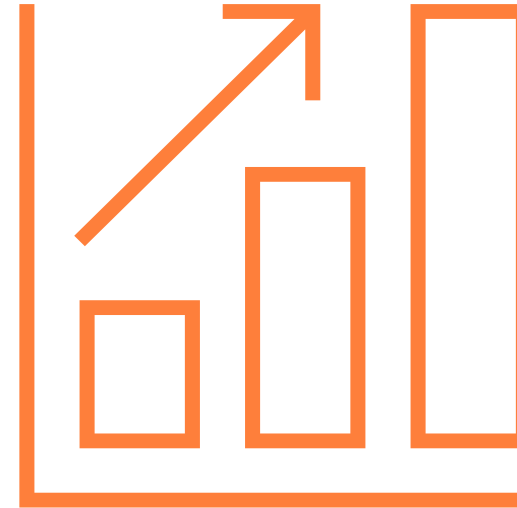
Total Revenue

$$\begin{array}{r} + 165,000 \\ + 145,000 \\ + 172,000 \\ \hline = \$482,000 \end{array}$$

The total direct revenue made by Glass City Metropark.

Revenue Per Visit

$$\frac{\$482,000}{657,963 \text{ visits}} = \$0.73 \text{ per visit}$$



Savings Through Design

Glass City Metropark uses naturalized landscapes to reduce maintenance, which allow the park to save money. Out of the 23.6 mowable acres the park is on, only 5 acres gets mowed. These few acres consists of a buffer near pathways and high-use areas.

This design **minimizes intensive maintenance** while **supporting ecological functions** like habitat creation and stormwater management

Maintenance Finance Breakdown

Total mowing cost = 35,036 (annually) ^[3]

Total mowing area = 5 acres

Cost per acre = $\$35,036 / 5 \text{ acres} = \$7,007 \text{ per acre}$



Savings Through Design

Glass City Metropark uses naturalized landscapes to reduce maintenance, which allow the park to save money. Out of the 23.6 acres the park is on, only 5 acres gets mowed. These few acres consists of a buffer near pathways and high-use areas.

This design **minimizes intensive maintenance** while **supporting ecological functions** like habitat creation and stormwater management

Full Maintenance Scenario

Expense for Full Mow = \$7,007 x 23.6 acres = **\$165,371**

Savings

\$165,371 - \$35,036 = **\$130,335** avoided



Discussion

Low Revenue per Visit Reflects Design Intent

The park generates $\approx \$0.73$, which is consistent with the park's role as a publicly accessible landscape where many amenities are free to use.

Primary Revenue Driver

Majority of direct revenue is generated through recreational experiences and programming.

- Economic activity is concentrated in specific programmed nodes
- Partnerships with private operators are essential to financial performance



Discussion

Ecological Design as Cost-Reduction Strategy

The parks use of naturalized landscape reduces maintenance costs $\approx$ \$130,000 annually.

- Design decisions can function as long-term financial strategies
- Economic performance is not only influenced by income, but also cost avoidance



Limitations

Revenue Constraints

- Revenue values are approximate, not financial records.
- Complete revenue was not attained.(Parking lot, etc.)

Visitor Data Interpretation

- This study is based on visits data not unique visitor data. This leads to lower per-visit revenue amount.

Limited Scope of Maintenance Costs

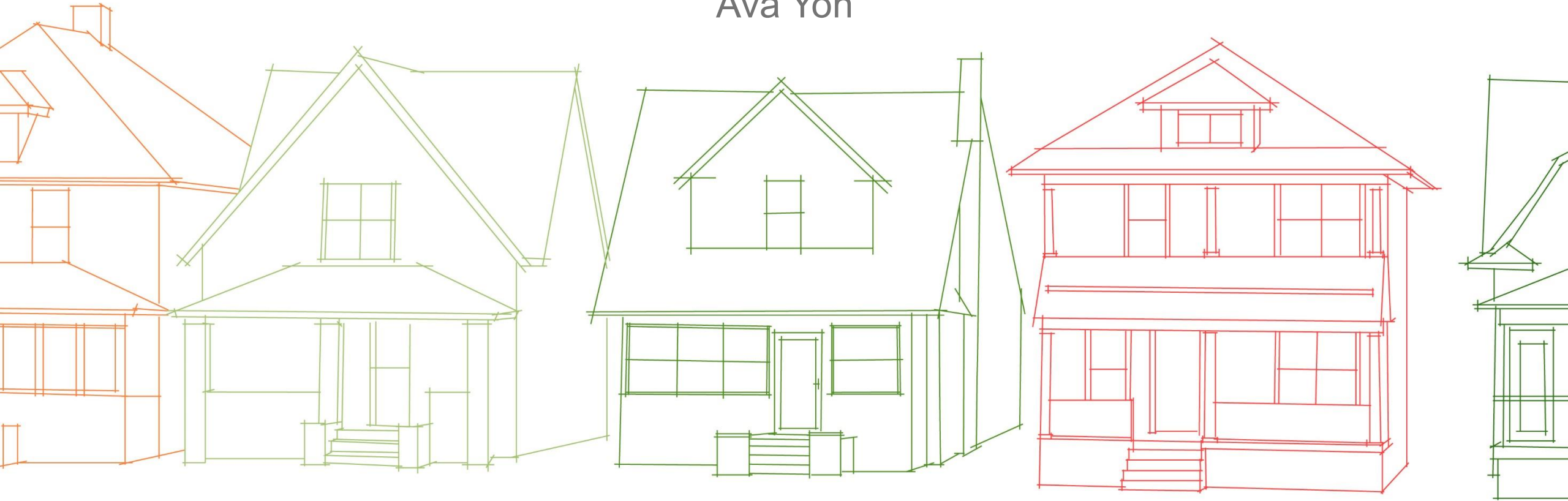
- The savings is only focused on mowing. Potentially more costs avoided through invasive species management, infrastructure upkeep (material).



Glass City Metropark Economic Impacts

Property Value Assessment

Ava Yon





Background

East Toledo used to be home to industrial employers such as railroads, oil refineries, utilities, and shipyards [6].

Many businesses were abandoned in the later half of the 20th century, leaving a long-lived impact on Toledo's neighborhoods and economy [7].

Garfield neighborhood had a consistent history of low incomes, housing burdens, and service fragmentation [8].



Toledo Shipyards, Front Street, early Postcard View. Shipbuilding was an important industry, dating back to the 1800s, with several companies operating at different times along the river on Front Street.



Maumee Rolling Mill, Front Street, 1890s. It went into business in 1884, and became one of the East Side's largest pre-1900 industries, employing as many as 500 workers. Nearby streets of Steel, Carbon, and Licking took their names from the rolling mill. It was torn down in the early 1900s to make way for the Toledo Railway & Light Company, which later became the Toledo Edison Acme Plant.



Design Intent

Glass City Metropark's role as a catalyst for new private investment and economic activity in adjacent neighborhoods.



How it can be Measured

Identifying changes in surrounding property values [4].





Performance Question

How has the development of Glass City Metropark in Toledo, Ohio, affected local economy through property values?



Datasets

- Parcel Boundaries and Numbers [1]
- Zoning Ordinances [2, 3]
- AREIS Lucas County Real Estate Property Values [5]
- Bureau of Labor Statistics Inflation Rate [9, 10]
- Zillow Housing Data [11]





Considered Timeline

- Property Values are taken from 2020 and 2026
- Glass City Metropark opened phase one in 2020



Property Value Definition

- Property values assessed in the Lucas County Real Estate Website, AREIS, are the combined value of land and building within the parcel area [5].
- Full market property values from 2020 and 2026 were used in this study.

Value Change History (100%)

Land	Building	Total	Tax Year	Reason	Change Date
17,700	41,700	59,400	2024	REVAL	09-SEP-2024
16,000	32,900	48,900	2021	TRI UPDATE	09-AUG-2021
9,500	37,000	46,500	2020	COMB	26-MAR-2020
8,400	37,000	45,400	2018	REVAL	13-DEC-2018
8,200	36,200	44,400	2015	TRIENNIAL	13-JUL-2015
8,200	36,200	44,400	2015	TRIENNIAL	13-JUL-2015
8,200	36,200	44,400	2015	TRIENNIAL	13-JUL-2015

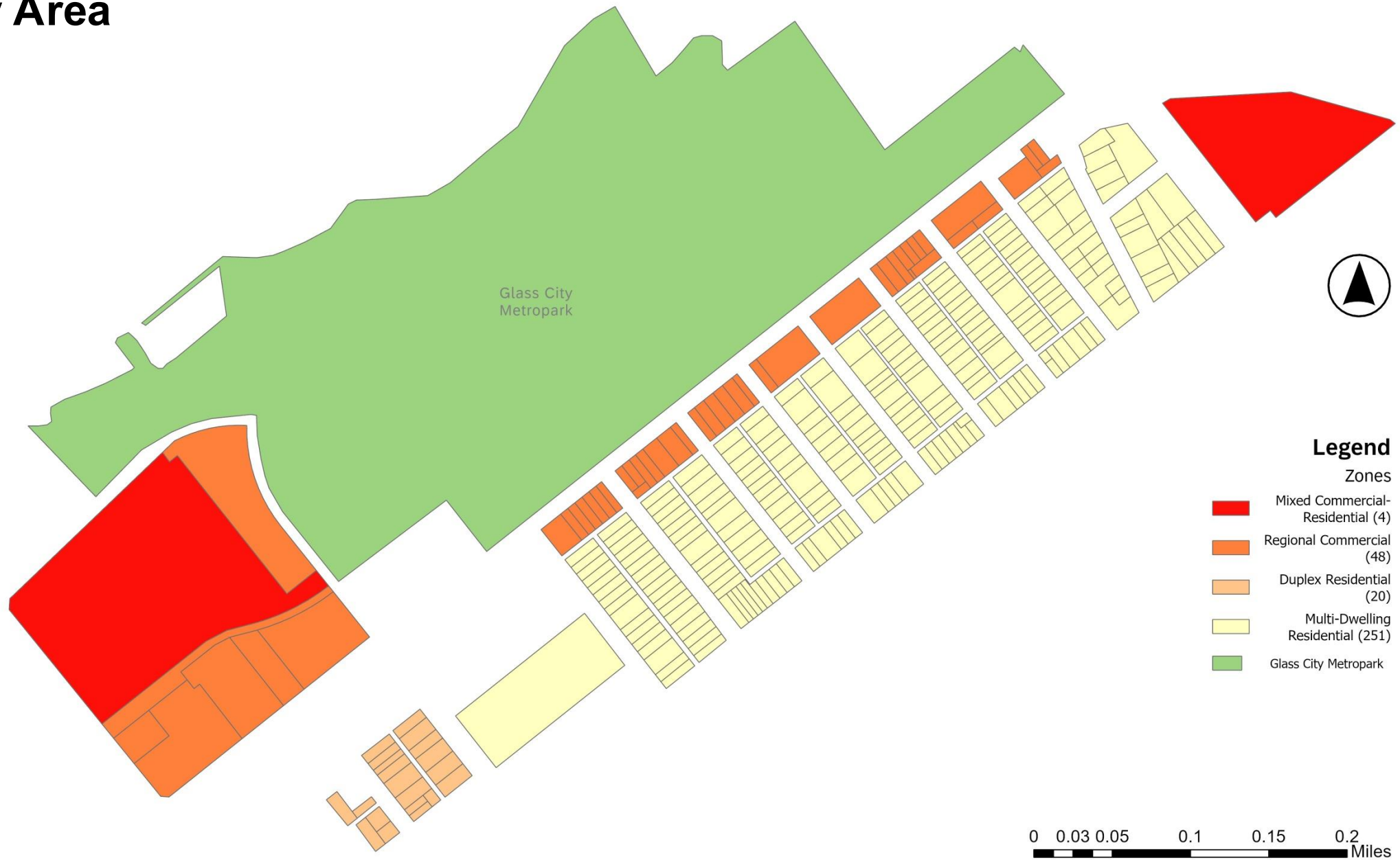


Surrounding Context

Glass City Metropark – Toledo, Ohio



Study Area



Determining Property Values

1

Using AREIS Real Estate Data Website, the property report card was downloaded for each parcel.

2

The 100% total market values from 2020 and 2026 were recorded.

Parcel ID: 17-03434		KATIE MOLINE - LUCAS COUNTY AUDITOR		RESIDENTIAL/AGRICULTURAL									
Owner: JONES CRYSTAL D ETAL (OR SURVTC) 136 OSWALD ST		Card 1 of 1 Assr #: 08292014		Market Area: 802R DTE #: 00300 - TOLEDO CITY - TOLEDO CSD Tax Year: 2026 LUC: 520 - 2FAM-PLAT									
GENERAL INFORMATION													
Topo: 1 - Paved		Spec Use: 520-2 Family-Plat											
Street: 22 - City Water / City Sewer		Traffic: 6-Resside											
Utilities: 22 - City Water / City Sewer		Corner Lot: No											
Legal: YONDOTA NEW PLAT LOT 167 NE 36 FT & 168...S													
ADMINISTRATIVE													
DATE	SOURCE	ENTRY	ADMIN	DATA ENTRY	REVIEWER								
02/29/12	7-lfr	8-Road	237-Final Value Review	9990	670								
09/09/09		0-Missing	240-Bor/Appeal Review	920	670								
 													
1703434 2/8/2024													
LAND INFORMATION													
TYPE	CODE	FRONT	DEPTH	SQFT	AC								
1	01-Residential Land	30	80	2,400	.0551								
INFL1: 1-None INFL2: 1-None													
Total SF: 2,400 Total AC: .0551													
PERMITS													
DATE	TAXYR	PERMIT #	PURPOSE	STATUS	% COMP								
SALES/TRANSFER HISTORY													
DATE	CONV #	# OF PARCELS	DEED	VALIDITY	TYPE	PRICE							
08/11/21	21204154	1	FD	X - Exempt Transfe	2 - Land & Building								
08/22/00	00203857	21	WD	8 - Unrevd	2 - Land & Building								
08/14/96	96106793	1	ST	0 - Validvac / L&B	2 - Land & Building	5,000							
CONDO COMPLEX													
COMPLEX #	COMPLEX NAME	YR DECLARED	# BLDGS	# UNITS									
VALUE HISTORY													
CLASS	2026 R	CLASS	2025 R	CLASS	2024 R	CLASS	2023 R	CLASS	2022 R	CLASS	2021 R	CLASS	2020 R
100% L	8,200	100% L	8,200	100% L	8,200	100% L	6,800	100% L	6,800	100% L	6,800	100% L	5,600
B	34,300	B	34,300	B	34,300	B	23,100	B	23,100	B	23,100	B	19,000
T	42,500	T	42,500	T	42,500	T	29,900	T	29,900	T	29,900	T	24,600
35% L	2,870	35% L	2,870	35% L	2,870	35% L	2,380	35% L	2,380	35% L	2,380	35% L	1,960
B	12,010	B	12,010	B	12,010	B	8,090	B	8,090	B	8,090	B	6,650
T	14,880	T	14,880	T	14,880	T	10,470	T	10,470	T	10,470	T	8,610

Adjusting for Inflation

3 **Determining the Infaltion Rate**
Consumer Price Index (CPI)
 $(CPI_{2026}-CPI_{2020})/CPI_{2020}$ = Inflation
rate
CPI 2020 = 258.8 [9]
CPI 2026 = 318 [10]
Inflation rate = 22.9%

4 **Apply inflation multiplier to all 2020
property values**
Multiplier = 1.229

Parcel ID	2020 Property Value	Inflation Multiplier	2020 Property Value Adjusted for Inflation
1703531	45,800	1.229	56288
1703634	800	1.229	983
1017171	39,200	1.229	48177
400397	40,600	1.229	49897
1016954	40,900	1.229	50266
1017311	30,700	1.229	37730
1016864	36,200	1.229	44490
1016781	34,300	1.229	42155
1016957	37,000	1.229	45473
1017341	26,900	1.229	33060
966821	15,300	1.229	18804
1016877	11,200	1.229	13765
1887756	346,000	1.229	425234
400337	34,700	1.229	42646

Table 1.0 Sample of inflation calculation table.

Calculating Changes

5

Percent Value Change

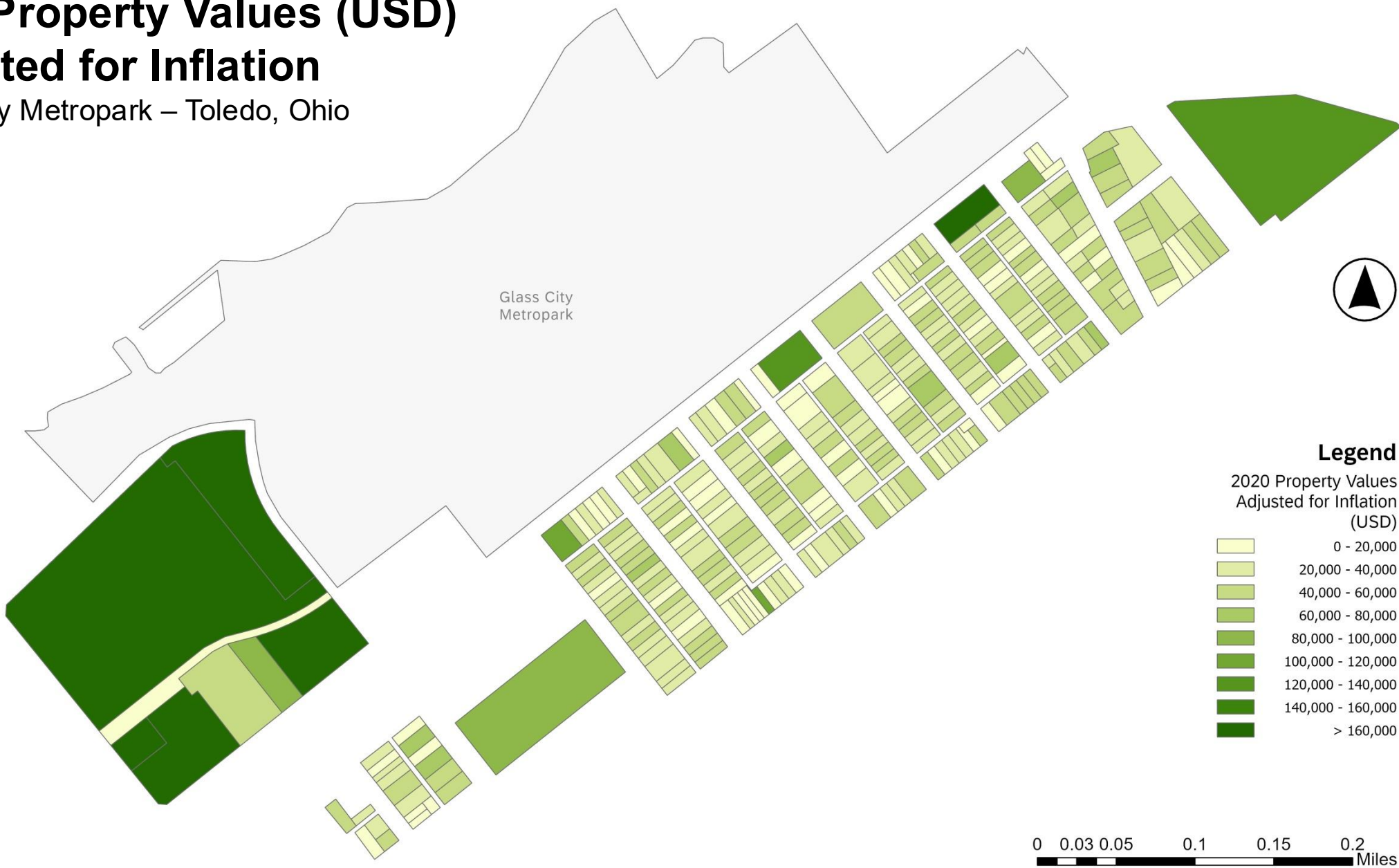
$[(2026 \# - 2020 \text{ Inflation } \#) / 2026 \#] * 100 = \text{Percent Value Change}$

Parcel ID	2020 Property Value	2020 Property Value Adjusted for Inflation	2026 Property Value	Absolute Change	Percent Value Change
1703531	45,800	56288	75,300	19,012	33.8
1703634	800	983	6,500	5,517	561.1
1017171	39,200	48177	51,300	3,123	6.5
400397	40,600	49897	44,500	-5,397	-10.8
1016954	40,900	50266	56,200	5,934	11.8
1017311	30,700	37730	54,100	16,370	43.4
1016864	36,200	44490	50,400	5,910	13.3
1016781	34,300	42155	39,000	-3,155	-7.5
1016957	37,000	45473	56,200	10,727	23.6
1017341	26,900	33060	34,800	1,740	5.3
966821	15,300	18804	37,500	18,696	99.4
1016877	11,200	13765	27,000	13,235	96.2
1887756	346,000	425234	346,000	-79,234	-18.6
400337	34,700	42646	54,300	11,654	27.3

Table 2.0 Sample of change calculation table.

2020 Property Values (USD) Adjusted for Inflation

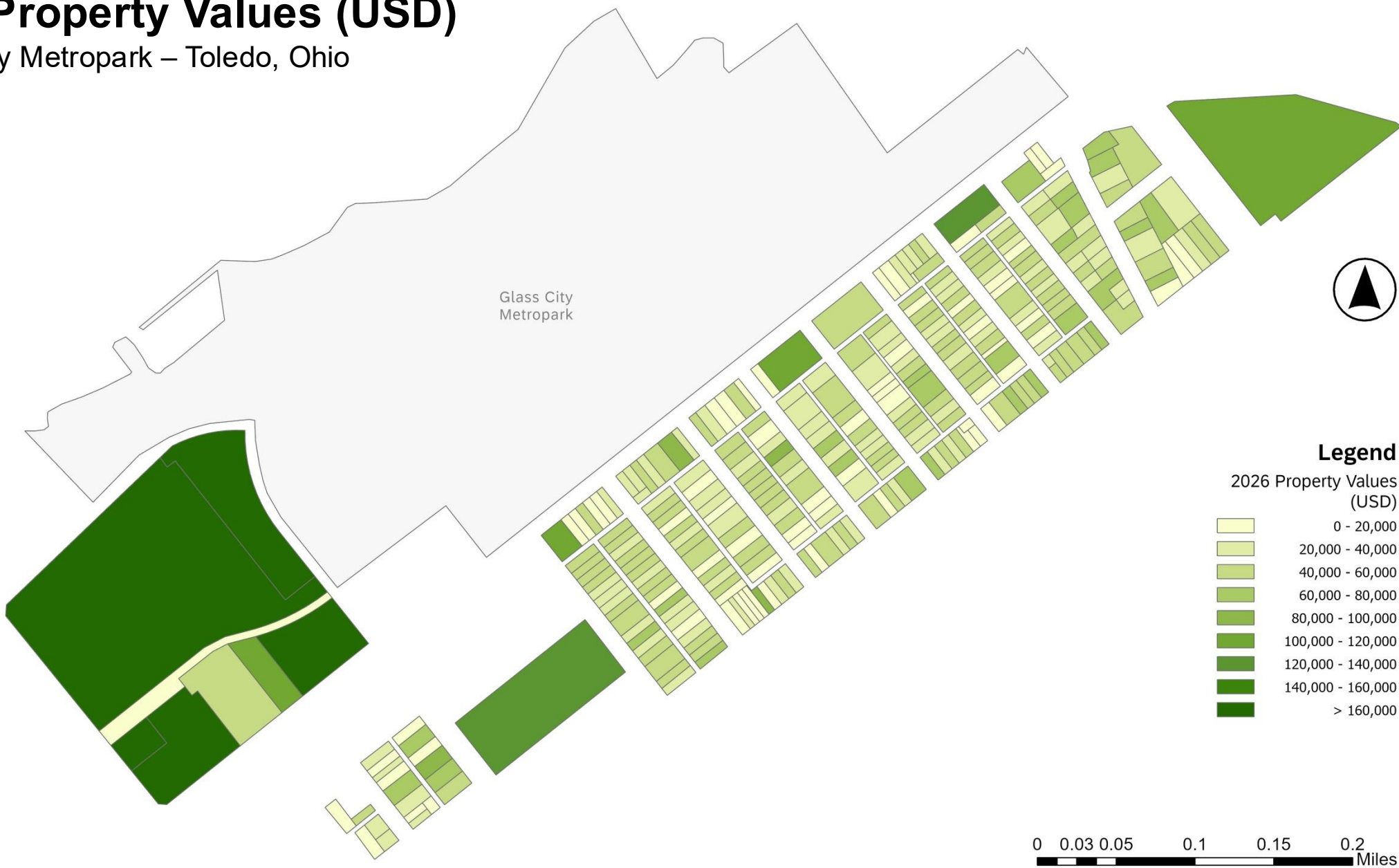
Glass City Metropark – Toledo, Ohio



0 0.03 0.05 0.1 0.15 0.2 Miles

2026 Property Values (USD)

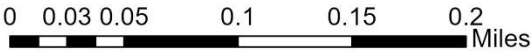
Glass City Metropark – Toledo, Ohio



Legend

2026 Property Values (USD)

	0 - 20,000
	20,000 - 40,000
	40,000 - 60,000
	60,000 - 80,000
	80,000 - 100,000
	100,000 - 120,000
	120,000 - 140,000
	140,000 - 160,000
	> 160,000



Findings

Glass City Metropark contributed to the surrounding property value increase of 23.5% from 2020 to 2026 when adjusted for inflation.

Number of Parcels: **323 Commercial or Residential**

Average Parcel Size: **0.22 acres**

2020 Median Property Value (with inflation): **\$36,256**

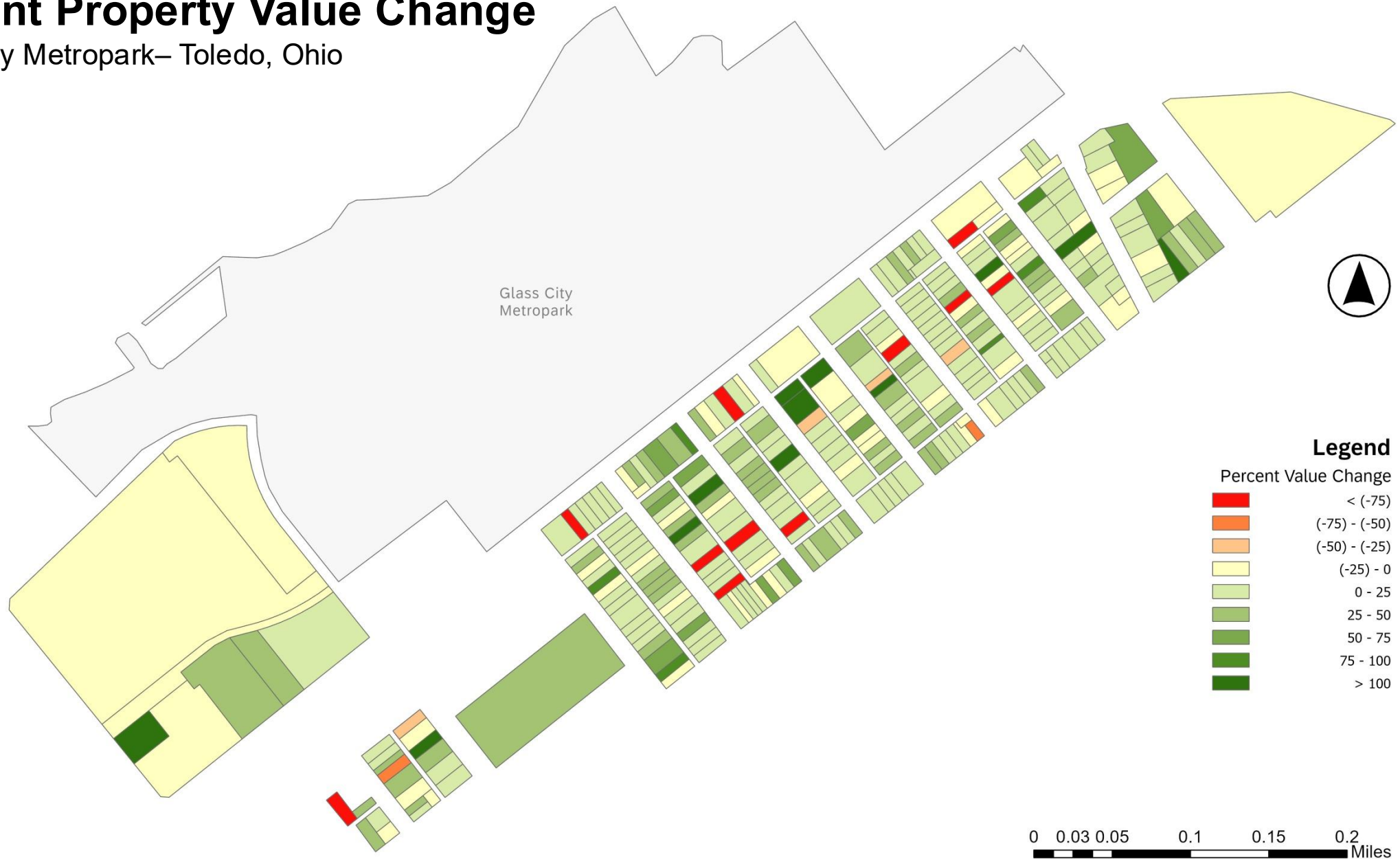
2026 Median Property Value: **\$39,800**

Average Percent Property Value Change: **23.5%**



Percent Property Value Change

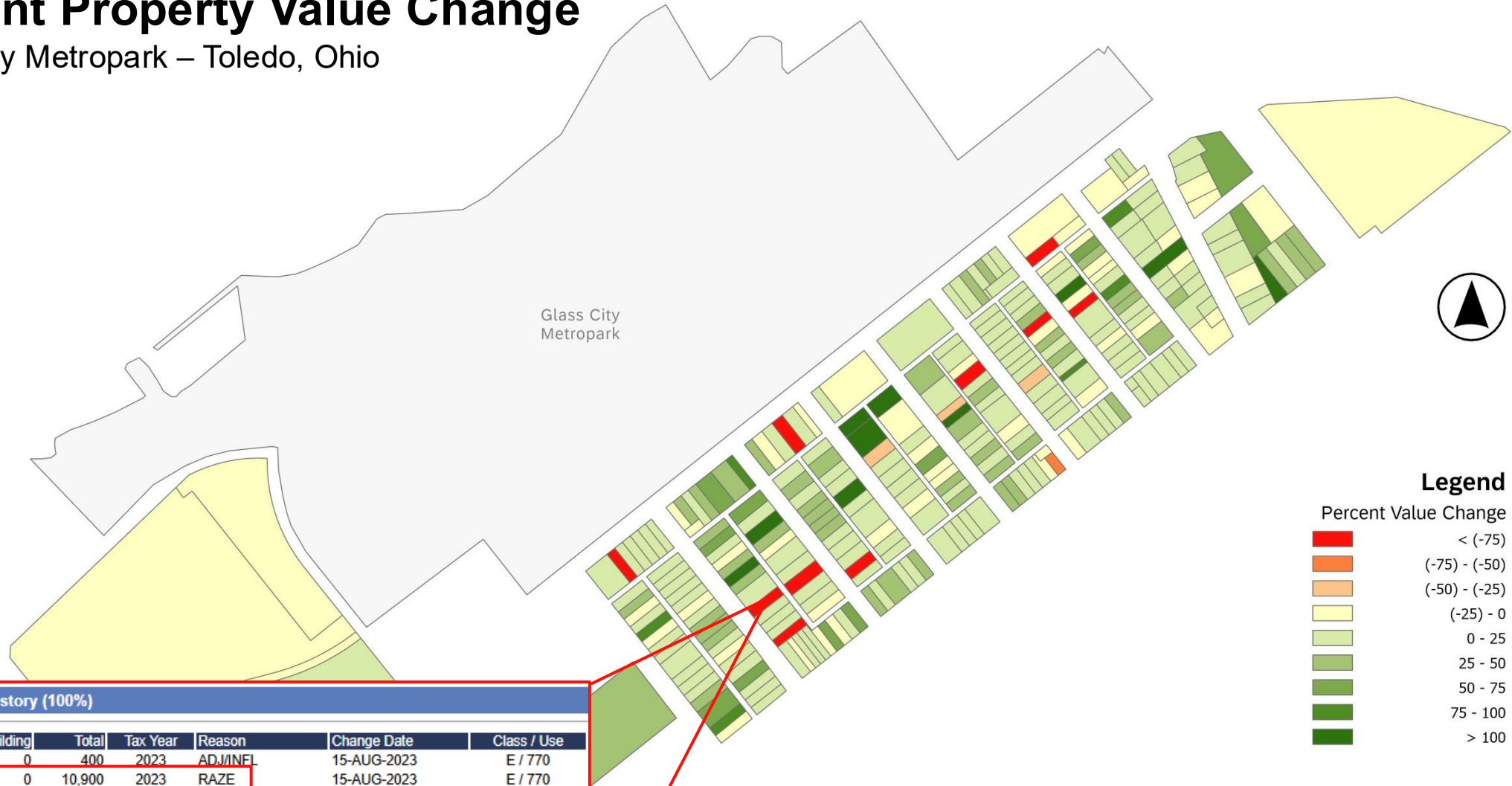
Glass City Metropark– Toledo, Ohio



Percent Property Value Change

Glass City Metropark – Toledo, Ohio

Value Change History (100%)						
Land	Building	Total	Tax Year	Reason	Change Date	Class / Use
400	0	400	2023	ADJ/MINEL	15-AUG-2023	E / 770
10,900	0	10,900	2023	RAZE	15-AUG-2023	E / 770
10,900	31,700	42,600	2022	D-EXEMPT	10-AUG-2022	E / 770
0	0	0	2022	D-EXEMPT	10-AUG-2022	R / 510
10,900	31,700	42,600	2021	TRI UPDATE	09-AUG-2021	R / 510
9,100	27,000	36,100	2018	REVAL	13-DEC-2018	R / 510
8,900	26,400	35,300	2015	TRIENNIAL	13-JUL-2015	R / 510
8,900	26,400	35,300	2015	TRIENNIAL	13-JUL-2015	R / 510
8,900	26,400	35,300	2015	TRIENNIAL	13-JUL-2015	R / 510



Relevance

The Zillow Home Value Index (ZHVI) for all zip codes in Toledo when adjusted for inflation has an average increase of **13.3%**



The study area’s assessed value increased faster than the average market trend measure.

ZIP Code	2020 ZHVI	2020 ZHVI Adjusted for Inflation (1.229)	2026 HVI	Percent HVI Change
43615	128701	158173	178327	11.3
43613	106026	130306	156540	16.8
43612	74158	91140	117053	22.1
43614	141124	173442	199500	13.1
43605	45202	55553	63674	12.8
43606	130481	160361	191112	16.1
43609	47724	58653	69826	16.0
43607	51532	63333	76377	17.1
43623	143218	176015	205185	14.2
43611	101671	124954	152371	18.0
43608	35595	43746	48149	9.1
43604	55675	68425	63243	-8.2
43617	239719	294615	326534	9.8
43610	40934	50308	61334	18.0

Limitations

- ① Property values collected from 2020 may be impacted by covid-19 pandemic
- ② Commercial properties were found to have much larger property values than residential parcels, which may have skewed or lessened the average property value change.
- ③ Parcels with building loss had significantly lower or negative property value change, which may have skewed or lessened the average property value change.



Discussion

- 1 Findings from this study support SmithGroup's design intent: Project plays a role as a catalyst for new private investment and economic activity in adjacent neighborhoods.
- 2 Although parcel property values are trending upward, the median property value remains very low making the neighborhood susceptible to gentrification challenges.
- 3 23.5% Average increase in property values within one block of Glass City Metropark supports the idea of urban parks as community assets.



References

- [1] City of Toledo. (n.d.). *Property dataset (Toledo, Ohio)*. <https://data.toledo.gov/datasets/>
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Glass City Metropark

Toledo, Ohio

April 27, 2026

Researchers:

Jess Le – Habitat Quality

Christopher Nosek – Stormwater Management

Sydney Zachos – Carbon Storage and Sequestration

Dr. Haoyue Yang

LA 883 Environmental Design Seminar

Michigan State University

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Performance Goals and Design Intent:

This research evaluated Glass City Metropark 6 years after its initial Phase 1 construction, and 3 years after Phase 2 construction. It is intended to assess the environmental benefits of the park and investigate if the design meets the primary objectives set before construction and completion. This investigation was conducted in collaboration with the design firm SmithGroup. SmithGroup's environmental design goals for this site design included prioritizing reforestation, improving water quality, and adhering to the 80/20 rule of park development.

The research involved collecting and reviewing both primary and secondary source data. This data consisted of collecting citizen science records on species biodiversity, calculating total runoff comparing current site conditions with former, and calculating carbon sequestration of trees planted on site.

The intended goals of this study are to quantify the park's ecological impacts, evaluate effectiveness of ecological design elements, identify key ecological benefits and limitations, establish basis for future ecological managements, and contribute to broader landscape performance assessment studies.

Benefit 1: Habitat Quality

Supports habitat for at least 159 bird species observed at Glass City Metropark, representing a 41.3% increase between Phase 1 and Phase 2 (December 2020-June 2023); bird population hotspot showed increased species richness and rising observation totals.

Background:

Glass City Metropark, located along the Maumee River, serves as a critical habitat stopover for native migratory birds. Recent ecological enhancements, including riverfront stabilization and installation of a habitat island, have significantly improved habitat quality and increased use by waterfowl, herons, and raptors. The Grosbeak Adventure Play Area, inspired by a native migratory bird species, reinforces the park's identity as a habitat stopover through nature-based play. The park's connectivity to riparian corridors and regional trail networks strengthens its ecological function by linking habitat types such as native prairies, woodland edges, and wetlands. These features support a rich diversity of bird species and reinforce the site's role as a key node within the regional habitat system.



Figure 1.1. Grosbeak Adventure Play Area concept; bird species inspiration. Source: Earthscape

Performance Question:

How much has bird species richness increased after habitat improvements, compared to pre-design conditions in Glass City Metropark?

Methods:

For this study, eBird, a global user-generated biodiversity platform, was used to compile bird sighting data. Supported by a network of partner organizations, regional experts, and birding enthusiasts, and managed by the Cornell Lab of Ornithology, eBird provides an extensive dataset for tracking species presence and frequency. Glass City Metropark is a bird sighting hotspot. The study evaluated species diversity and observation frequency within the park through three tracked metrics: total species observed annually, annual counts of selected indicator species, and calculated percent change in species richness across defined project phases: pre-implementation (2018–December 2020), Phase 1 (2020–2023), and Phase 2 (2023–2025). This approach tracked changes in bird species richness and habitat use associated with the park’s development and ecological enhancements.



Figure 1.2. Images of bird species found at Glass City Metropark. Source: eBird website reference

Figure 1.2 highlights the diverse range of functional bird groups observed at Glass City Metropark, illustrating the ecological richness of the area. Notably, raptor species such as Cooper's Hawk and Bald Eagle are consistently present, reflecting the park's role as a suitable habitat for top predators. The images also showcase waterfowl and wading birds, emphasizing the importance of wetland and aquatic habitats.

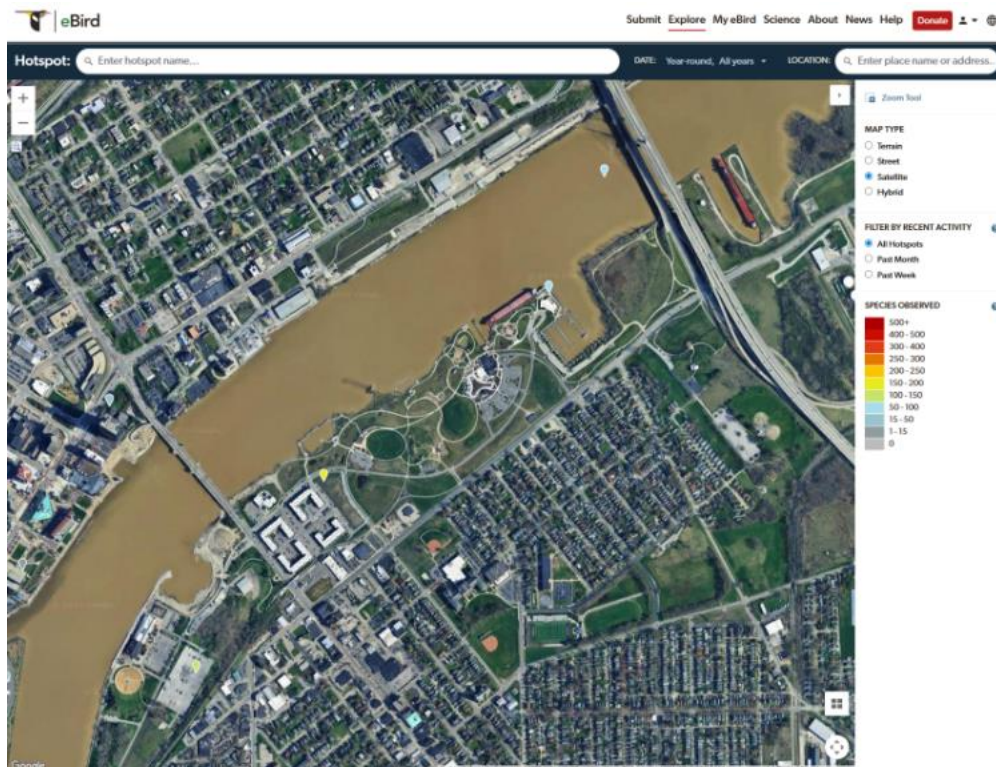


Figure 1.3. eBird Hotspot Map including Glass City Metropark. Source: eBird Hotspot

Figure 1.3 shows Glass City Metropark as a mid-sized birding hotspot, where 159 species have been recorded from 2013 to 2026. This highlights the park’s value for long-term avian monitoring and biodiversity tracking.

Calculations:

Table 1.1. Total species observed annually within Glass City Metropark (2020–2025). Source: eBird Bar chart with adaptations

Hotspot Observed Data	2020*	2021	2022	2023**	2024	2025
Bird Observations: total avian species observed within each year						
Glass City Metropark	59	63	76	125	148	131

*Phase 1 opened in December 2020

**Phase 2 opened in June 2023

Table 1.1 presents annual bird species richness at Glass City Metropark based on eBird data. From 2020 to 2024, the total number of species recorded shows a steady increase, rising from 59 species to a peak of 148 species. The most noticeable growth occurs between 2022 and 2024, where the number of species increases more rapidly from 76 to 125. In 2025, the total

drops slightly to 131 species but remains well above earlier years. Overall, the data indicate that the number of bird species observed at the site has increased over time, with the highest levels occurring in the most recent years.

Table 1.2. Total annual sightings of selected indicator species within Glass City Metropark. Species were selected based on suitability to represent avian functional groups. Source: eBird Bar chart with adaptations

Selected Indicator Species	Functional Group	2020*	2023**	2025
Totals: on eBird Bar Charts, the sum total of all counts from all observations for a species within a specified date range and region				
American Robin (<i>Turdus migratorius</i>)	Songbird (Passerine)	151	140	414
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Raptor	1	10	22
Canada Goose (<i>Branta canadensis</i>)	Waterfowl	22	392	1460
Double-crested Cormorant (<i>Nannopterum auritum</i>)	Waterfowl	2	104	1022
European Starling (<i>Sturnus vulgaris</i>)	Songbird (Passerine)	14	151	1356
Great Blue Heron (<i>Ardea herodias</i>)	Waterbird (Wader)	2	43	49
Great Egret (<i>Ardea alba</i>)	Waterbird (Wader)	0	7	9
Killdeer (<i>Charadrius vociferus</i>)	Shorebird	3	131	177
Osprey (<i>Pandion haliaetus</i>)	Raptor	0	3	39
Peregrine Falcon (<i>Falco peregrinus</i>)	Raptor	2	2	10
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	Songbird (Passerine)	0	382	674
Ring-billed Gull (<i>Larus delawarensis</i>)	Waterbird (Generalist)	333	514	3385

*Phase 1 opened in December 2020

**Phase 2 opened in June 2023

Table 1.2 records observation counts for selected bird species across key years and includes their functional group classifications. The species selected represent a range of groups, including songbirds, waterfowl, waterbirds, shorebirds, and raptors. A common trend observed is the increase in counts for water-associated species such as Canada Goose and Double-crested Cormorant, particularly between 2020 and 2025. Waterbirds like Great Blue Heron and Ring-billed Gull show higher observation numbers in later years. Songbirds such as American Robin and Red-winged Blackbird demonstrate increases as well, although with more variation across years. Raptors, including Bald Eagle and Peregrine Falcon, show lower overall counts but gradual increases over time. The data show that multiple types of species are recorded in greater numbers across the selected time periods.

Table 1.3. Distribution of bird species by conservation status within Glass City Metropark. Source: IUCN Red List

Species Classification	Count	Percent (%)
Species of Concern	9	5.7
Threatened	2	1.3
Endangered	2	1.3

Table 1.3 summarizes the number of bird species classified as species of concern, threatened, and endangered within the study area over all recorded years (2013-2026). A total of nine species of concern are recorded, as well as two threatened and two endangered species. Percentages are calculated based on the full dataset of 159 total bird species observed across the study period. The table shows that, in addition to commonly observed species, the dataset includes species across multiple conservation categories.

Table 1.4. Overall percent change of observed bird species between years. Source: eBird Bar chart with adaptations

Number of Bird Species Between January 2018 - December 2020 (Phase 1)	Number of Bird Species Between January 2021 – June 2023 (Phase 2)	Overall Percent Change (%)
43	75	74.4
Number of Bird Species Between January 2021 – June 2023 (Phase 2)	Number of Bird Species Between June 2023 – December 2025	Overall Percent Change (%)
75	106	41.3

Percent Change Formula:

(Number of Bird Species Between January 2021 to June 2023 – Number of Bird Species Between January 2018 – December 2020) / Number of Bird Species Between January 2018 to December 2020 x 100 =

$$(74 - 43) / 43 \times 100 = 74.4\%$$

(Number of Bird Species Between June 2023 to December 2025 – Number of Bird Species Between January 2021 – June 2023) / Number of Bird Species Between January 2021 to June 2023 x 100 =

$$(106 - 75) / 75 \times 100 = 41.3\%$$

Table 1.4 presents changes in species richness across defined time periods. From 2018–2020, a total of 43 species were recorded. This increases to 75 species between 2021 and June 2023, representing a 74.4% increase. From June 2023 to 2025, the number rises again to 106 species, with a 41.3% increase. The largest increase occurs between the first and second time periods, followed by continued growth at a slower rate in the final period. The data show a consistent increase in the number of species recorded across each project phase.

Findings:

Table 1.5. Field observations of avian and wildlife presence and behavior recording in 15-minute intervals during site visit to Glass City Metropark.

Time (Approx.)	Habitat Type	Observed Species	Number Observed	Observed Behavior
2:00–2:15 PM	Grassland / Open Field	Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	9	Perching, foraging
2:00–2:15 PM	Riverfront Edge	Canada Goose (<i>Branta canadensis</i>)	2	Flying, swimming, walking
2:00–2:15 PM	Riverfront Edge	Ring-billed Gull (<i>Larus delawarensis</i>)	18	Flying
2:00–2:15 PM	Grassland / Open Field	Horned Lark (<i>Eremophila alpestris</i>)	4	Flying
2:00–2:15 PM	Grassland / Open Field	American Robin (<i>Turdus migratorius</i>)	8	Flying, perching, foraging
2:15–2:30 PM	Grassland / Open Field	Killdeer (<i>Charadrius vociferus</i>)	7	Flying, nesting, resting
2:15–2:30 PM	Riverfront Edge	Double-crested Cormorant (<i>Nannopterum auritum</i>)	5	Flying, foraging
2:15–2:30 PM	Riverfront Edge	Bald Eagle (<i>Haliaeetus leucocephalus</i>)	1	Flying, perching, nesting
2:15–2:30 PM	Grassland / Open Field	Peregrine Falcon (<i>Falco peregrinus</i>)	1	Flying, foraging, vocalizing
2:30–2:45 PM	Grassland / Open Field	House Sparrow (<i>Passer domesticus</i>)	6	Flying, perching, Socializing
2:30–2:45 PM	Grassland / Open Field	European Starling (<i>Sturnus vulgaris</i>)	1	Vocalizing
2:30–2:45 PM	Riverfront Edge	Great Blue Heron (<i>Ardea herodias</i>)	1	Flying, wading
2:30–2:45 PM	Grassland / Open Field	American Crow (<i>Corvus brachyrhynchos</i>)	1	Flying
2:30–2:45 PM	Grassland / Open Field	Groundhog (<i>Marmota monax</i>)	1	Foraging
2:30–2:45 PM	Grassland / Open Field	Eastern Cottontail (<i>Sylvilagus floridanus</i>)	1	Foraging

Site visit observations recorded during a 30 to 40-minute field session provide supplemental qualitative data supporting eBird-derived trends in species richness and habitat use at Glass City Metropark. Observations were organized into 15-minute intervals to document activity across grassland/open field and riverfront edge habitats. A total of 15 species were recorded, representing multiple functional groups including songbirds, waterfowl, raptors, and terrestrial mammals.

Avian activity was distributed across both habitat zones, with the riverfront edge primarily supporting water-associated species such as Canada Goose, Ring-billed Gull, and Double-crested Cormorant. These species were observed engaging in high-mobility and foraging behaviors, including flying, swimming, and fishing. In contrast, grassland and open field areas supported a greater diversity of songbirds and edge species, including Red-winged Blackbird, American Robin, Killdeer, and House Sparrow, with observed behaviors dominated by perching, foraging, and nesting activity. Raptor species, including Bald Eagle and Peregrine Falcon, were present in low numbers but demonstrated wide-ranging movement and predatory behavior across habitat zones. Additionally, the presence of Groundhog and Eastern Cottontail in edge conditions indicates that terrestrial habitat structure contributes to broader ecological activity beyond avian populations.

Discussion and Implications:

The calculations and findings show an evident increase in bird biodiversity at Glass City Metropark. Species richness rose from 43 species in the pre-implementation phase to 106 species in the most recent phase. eBird data and field observations both support this trend, showing not only more species over time but also more varied behavioral activity. This suggests that the design interventions along the Maumee River have improved habitat quality and made the site more suitable for a wider range of species.

From a landscape design perspective, the results highlight the importance of varied habitat types. The mix of riverfront edges, grassland, and open areas support different functional groups of birds. The increase in water-associated species shows that river restoration and habitat island creation are working effectively. At the same time, it suggests the need for diverse shoreline and wetland designs to avoid over-supporting only a few dominant generalist species.

The increase in raptors such as Bald Eagle, Osprey, and Peregrine Falcon is especially important. These species sit higher in the food chain, so their presence suggests a healthier and more stable ecosystem overall. It indicates that lower-level species populations are also strong enough to support them. This shows the value of designing landscapes that support full ecological systems, not only individual species groups.

Overall, the calculations and findings suggest that phased ecological design and long-term habitat planning can significantly improve biodiversity in urban riverfront parks. They also show that ecological systems take time to develop and stabilize after construction. This reinforces the

importance of long-term monitoring and adaptive management, including tools like citizen science data, to guide future landscape design decisions.

Limitations:

- Bird observations are based on citizen science data, which may introduce some sampling bias and affect the accuracy of species records.
- The increasing popularity of birdwatching may lead to more observations being reported over time on platforms like eBird, which can influence trends.
- The COVID-19 pandemic may have reduced outdoor activity, leading to fewer observations and lower reported species counts beginning in 2020.
- Public access was limited during construction of Phase 1 and Phase 2, resulting in fewer recorded observations during these periods.

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Benefit 2: Stormwater Management

The redesign of Glass City Metro Park allowed for a 90% decrease in runoff during a 1-inch rainstorm event; preventing roughly 818,775 extra gallons of water runoff from entering the Maumee River compared to the previous site conditions.

Background:

Glass City Metroparks, located in Toledo, OH, occupies a formerly industrial waterfront site along the Maumee River. The property was formerly home to the Toledo Edison Acme Power Plant, which ceased operations in 1993. Due to the industrial nature of the site, much of the area

was heavily polluted from fly ash disposal associated with plant operations (Woodle, 2026). Plans to help the reinvigorate the site started in 2008 with private developers, though halted quickly due to the 2008 recession. Once sold to the Toledo Metroparks System, the site was able to enter into construction with a focus on remediation and creating a thriving ecosystem.

Due to the heavy pollution which effects both the Maumee River and subsequently Lake Erie, designers emphasized the importance of adding green stormwater infrastructure (GSI) that would help reduce the amount of on-site pollution from making its way into the river. Working on formerly polluted land, the construction first began with replacing the thin layers of clean fill, which was poured over the fly ash, with nutrient rich dredge (SmithGroup, 2024). Next, numerous strategies were incorporated with an intention to reduce runoff volume and improve water quality before discharge. These features include retention and detention of ponds, protected wetlands, rain gardens, green roofs, garden beds, and extensive native and naturalized plantings. The purpose of this test is to better understand if the added GSI is reducing runoff, especially when compared to the previous site's conditions.

Performance Question:

Will the added GSI placed throughout Glass City Metropark reduce the amount of runoff when compared to the previous site conditions? How many gallons of runoff will be reduced between the two cases?

Methods:

For this study, the stormwater performance was evaluated using ArcGIS Pro, which helped visualize and calculate land cover for both the existing and previous site. This was combined with the NRCS Curve Number Method, which is a widely used planning-level model that estimates the direct runoff from a rainfall event (USDA, 1986).

To begin, the site boundary was traced according to the 'phase one' and 'phase two' construction plans on GIS. This means that any landcover of the commercial space located West of the site, or the Great Lake's Museum property located just Northeast of the site was not included. The landcover types separated into multiple feature classes; classifying each as either plant beds, green stormwater infrastructure (GSI) retention/detention basins, forested space, impervious surface, or pervious paving (see Figure 2.2).



Figure 2.1: Different land cover types (in order: left to right, up to down): 1. Turf, 2. Garden Beds, 3. Stormwater Infrastructure (GSI), 4. Pervious Gravel Paths, 5. Impervious Concrete/Asphalt Paths, and 6. Dense Tree Plantings. Source: 1-5 taken on site April 10, 2026, Photo 6 Source: Google Earth



Figure 2.2: Digitized GIS map displaying boundary of study and the separate land cover categories for the Current Metropark. Turf is not traced exactly since it is the predominant land cover; it will be left as the residual land cover and calculated after the other land covers are shown. Source: ArcGIS Pro.

Using the data provided, overall acreage was calculated, as well as each land cover's percentage. The remaining turf space was calculated as the remaining park area after subtracting mapped pervious, impervious, planted, forested, and water-management surfaces from the overall acreage (see Table 1). A similar tracing method was repeated to figure out the former industrial site's land cover; though only splitting that into two categories. One category for the impervious industrial development formerly found on the site and another for the disturbed turf and industrial open space (see Figure 2.3 and Table 2.2).

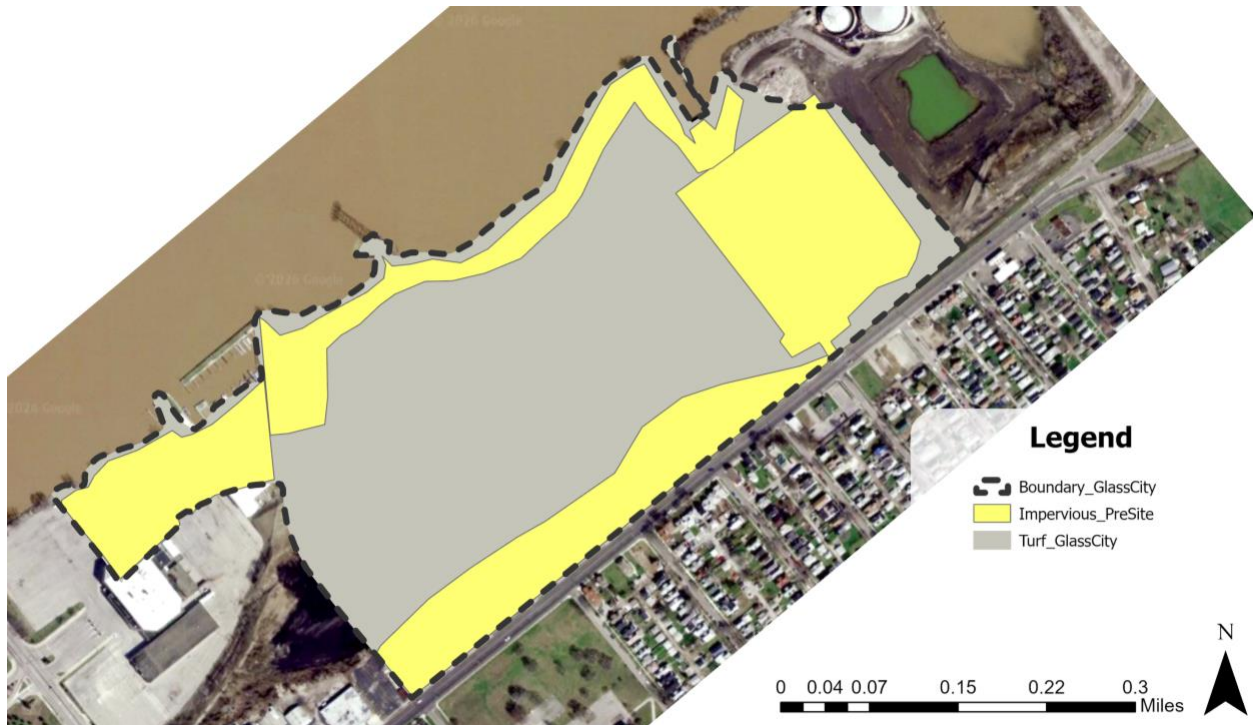


Figure 2.3: Digitized GIS map displaying boundary of study and the separate land cover categories for the former industrial site. Turf is not traced exactly since it is the predominant land cover; it will be left as the residual land cover and calculated after the other land covers are shown. Source: ArcGIS Pro.

Table 2.1: Current Metropark's acreage and land cover percentage for each surface type.

Current Site Land Cover (2026)		
Land Cover Type	Acreage	Percentage
Impervious	11.47	18.14%
Pervious	1.69	2.67%
Garden Bed	2.5	3.95%
Retention Basin	3.87	6.12%

Forested	12.19	19.28%
Turf	31.72	50.17%
Total	63.44	

Table 2.2: Previous industrial acreage and land cover percentage for each surface type.

Previous Site Land Cover (2006)		
Land Cover Type	Acreage	Percentage
Impervious	31.16	49.12%
Turf/open land	32.28	50.88%
Total	63.44	

With the land cover mapped out and percentage types identified, the NRCS Curve Number Method could begin. The equation for this method is:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

- Q = runoff (in)
- P = rainfall (in)
- S = potential maximum retention after runoff begins (in)

To find 'S, or the maximum retention after runoff begins (in), the weighted curve number for each version of the site must be identified. With the soil contents throughout the site primarily being made up of 'dredge', the hydrologic soil group can be inferred as group 'C' as based off information given by the Soil Conservation Service (USDA, 1986). With this group identified, each land cover type's curve number was identified (see Tables 2.3 and 2.4).

Table 2.3: Current land cover and curve number for the total site (weighted).

Current Metropark: Calculated Curve Weight and Soil CN			
Land Cover Type	Soil Type 'C' CN	Percentage	Weighted Curve Number (% x CN)
Impervious	98	18.14%	.1814 x 98 = 17.7772
Pervious	74	2.67%	.0267 x 74 = 1.9758
Garden Bed	74	3.95%	.0395 x 74 = 2.923

Retention Basin	70	6.12%	.0612 x 70 = 4.284
Forested	70	19.28%	.1928 x 70 = 13.496
Turf	74	50.17%	.5017 x 74 = 37.1258
Current			77.5818 = 78

- Current Metropark's overall CN = **78**

Table 2.4: Previous land cover and curve number for the total site (weighted).

Former Industrial: Calculated Curve Weight and Soil CN				
Land Cover Type	Acreage	Soil Type C CN	Percentage	Weighted Curve Number (% x CN)
Impervious	31.16	98	49.12%	.4912 x 98 = 48.1349
Disturbed turf/open land	32.28	91	50.88%	.5088 x 91 = 46.3033
Total	63.44			94.4382 = 95

- Former Industrial Site's overall CN = **95**

Both weighted curve numbers were then entered into the equation to find 'S':

$$S = \frac{1000}{CN} - 10$$

- Current Metropark = (1000 / 78) - 10 = **2.8205**
- Former Industrial Site = (1000 / 95) - 10 = **.5263**

For 'P', a 1-inch rain event will be calculated into the equation for 'Q'. This was chosen to keep all

Findings:

Through calculating a 1-inch rainstorm on the current site, it was found that only **0.05 inches of rain runs off** into the Maumee River. This, compared to the former industrial site which had around 0.5 inches of runoff during the same 1-inch storm. To better visualize the reduction, the inch of rain across the site was converted into gallons to accurately see the decrease in runoff post-construction. Converted to acres, a 1-inch rainstorm over an acre is around 27,154 gallons.

- Current Park = 0.0538 x 63.44 x 27,154 = 92678.5571 = **92,679 gallons of runoff**
- Former Industrial Site = 0.5291 x 63.44 x 27,154 = 911453.988 = **911,454 gallons of runoff**

Table 2.5: Total findings of research comparing the amount of total runoff and water retention between the former industrial site and the current metropark.

Findings: Industrial vs Current conditions				
	Curve Number	Water Retained S	Runoff (in) Q	Runoff (gallons)
Current Metropark	78	2.8205	0.0538 in	92,679 gallons
Former Industrial	95	.5263	0.5291 in	911,454 gallons
Results	-17	+2.29 in	-.4753	-818,775

In total, the redesign of Glass City Metro Park allowed for a **90% decrease** in runoff during a 1-inch rainstorm event, preventing roughly **818,775 extra gallons of water runoff** from entering the Maumee River, compared to the previous site's conditions.

Discussion and Implications:

Through the findings, the benefits of reclaiming polluted industrial areas and converting them to multi-use parks are shown. The conversion of Glass City Metropark substantially improved the amount of water runoff that enters the Maumee River, even on relatively low-infiltrating soils. The large amount of land that was designated for green space, garden beds, and stormwater retention and detention allowed this park to reduce the amount of stormwater runoff, further helping to reduce pollution by holding and filtering water on-site. For cities like Toledo, which are home to major industrial plants and are built around major river systems like the Maumee, this reduction is important. Untreated urban runoff can transport sediment, nutrients, metals, oils, and debris into important water bodies. By retaining more rainfall on site, the park likely helps reduce pollutant loading to the Maumee River. Retaining water on-site also aids infrastructure and cost-reduction by decreasing stress on municipal drainage infrastructure. This test of runoff proves the importance of green infrastructure and how it aids both recreational activities and high-performing green infrastructure systems.

Limitations:

- Former industrial land-cover conditions were modeled based on historic site use rather than detailed archival mapping.

- Though cross checked with modern imagery, land-cover for current site was mapped off of older imagery, meaning some areas labeled as one land cover could have changed.
- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.
- Soil conditions were interpreted from publicly available mapping and may vary locally.
- The model estimates runoff volume only and does not account for peak flow timing, water quality treatment, or subsurface drainage infrastructure.
- Modeled rainstorm amount does not represent the site's ability to handle water during extreme or historic rain events; site performance may vary depending on rainfall intensity, seasonal moisture, and maintenance conditions.

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Benefit 3: Carbon Storage and Sequestration

Sequesters an estimated 33,180 lbs of CO₂ annually in 1,149 newly planted trees and is projected to sequester over 663,600 lbs of carbon over the next 20 years.

Background:

The design of Glass City Metropark integrates large-scale reforestation as a central strategy for ecological restoration and user experience enhancement on a formerly industrial waterfront site. A total of 207 trees were planted during Phase 1 in 2020, followed by an additional 942 trees in Phase 2 in 2023, contributing to the establishment of over 17 acres of new forest habitat. Planted at a density of approximately 500 trees per acre, these trees are part of a broader effort to reintroduce native plant communities reflective of the region's historic mixed oak forest ecosystem (Woodle, 2026).

Beyond their ecological role, the trees are strategically distributed throughout the park to improve pedestrian comfort and spatial quality by providing shade along trails, gathering spaces, and activity areas. As the canopy matures, these plantings are expected to enhance microclimatic conditions, reduce urban heat island effects, and contribute to long-term environmental performance through carbon sequestration, stormwater interception, and habitat creation. This reforestation effort supports the project’s goal of transforming a degraded brownfield site into a resilient, multifunctional landscape that prioritizes both environmental sustainability and community use (SmithGroup, 2024).

Performance Questions:

How does planting new tree species influence carbon sequestration in the area?

How could carbon sequestration be predicted for 20 years from now?

Methods:

For this study, trees planted on site from both Phase 1 and Phase 2 of the design were measured. Trees were measured using standard diameter measurement at breast height (DBH) of roughly 4.5 feet from the base of the tree. Additional data was sourced from the firm’s planting plan.

A carbon sequestration analysis was conducted using the iTree Eco tool V6, generally used to collect data from both single trees and complete inventories. On site measurements were used as sample data to inform DBH values for the complete planting plan. Species name, DBH, percent of crown dieback, and land use type were imported into iTree Eco, resulting in values indicating the annual carbon sequestration of trees by species.

Calculations:

Table 3.1 - Site Measurements taken on 4/10/2026 of diameter breast height of trees.

Glass City Site Measurements – 4/10/2026		
Phase	Tree Species	DBH (inches)
1	Crabapple	6
1	Red Sunset Maple	7.5
1	London Planetree	12
1	Bald Cypress	7.25
1	Elm	7.5
2	Red Maple	6.25
2	Kentucky Coffee tree	8
2	Redbud	7
2	Hawthorn	6

Site Measurements were taken on select trees around the site. Trees selected were commonly planted species on the site, determined from the planting plan provided by the firm. DBH was

measured at 4.5 feet above the ground using a soft measuring tape, which is the standard measurement method (City of Portland, n.d.).

Table 3.2 - Calculations for DBH Weighted Average.

DBH Weighted Average Calculations			
Phase	Average DBH Value	DBH at Planting	DBH Weight
Phase 1	7.06	1.5	3.71
Phase 2	6.81	1.5	3.54
London Planetree*	12	1.5	7

*London Planetree was excluded from average DBH calculations as the growth rate for this tree species is considered faster than average (Yiesla, 2026).

Each species was given a size at planting noted from the planting plan provided by the firm. An average DBH at planting value was determined from the caliper size at planting. The caliper size at planting is commonly 2 inches, resulting in a DBH of roughly 1.5 inches (OpenAI, 2026; U.S. Department of Agriculture, 1993). The DBH at planting was multiplied by the DBH weight values determined from Phase 1 and Phase 2 site measurements. This resulted in a DBH value used and imported into iTree Eco for reporting.

DBH Weight Formula:

(Average DBH from site measurements – DBH at planting) / DBH at planting) = DBH Weight

Phase 1: $(7.06 - 1.5) / 1.5 = 3.71$

Phase 2: $(6.81 - 1.5) / 1.5 = 3.54$

Table 3.3 – Annual Carbon Sequestration for Phase 1 of the design.

Annual Carbon Sequestration of Trees by Species – Phase 1		
Species	Gross Carbon Sequestration (ton/yr)	CO₂ Equivalent (ton/yr)
Ironwood	0.01	0.05
Amur Maple	0.06	0.23
Red Maple	0.12	0.43
Serviceberry spp	0.12	0.45
Downy Hawthorn	0.03	0.11
Black Gum	0.04	0.13
Honeylocust	0.05	0.19
Kentucky Coffee tree	0.03	0.12
Witchhazel spp	0.01	0.02
Japanese Flowering Crabapple	0.07	0.24

American Sycamore	0.03	0.10
Swamp White Oak	0.08	0.29
Bur Oak	0.03	0.11
Redbud	0.03	0.12
Common Linden	0.03	0.11
Elm spp	0.05	0.19
TOTAL	0.79	2.90

CO₂ Equivalent Carbon Sequestration can be converted to pounds per year through this equation:

(CO₂ Equivalent in tons x 2000 lbs) = CO₂ Equivalent carbon sequestration in pounds per year =
 (2.90 x 2000) = **5,800 lbs CO₂/year for Phase 1.**

Table 3.4 – Annual Carbon Sequestration for Phase 2 of the design.

Annual Carbon Sequestration of Trees by Species – Phase 2		
Species	Gross Carbon Sequestration (ton/yr)	CO₂ Equivalent (ton/yr)
Ironwood	0.04	0.13
Red Maple	0.45	1.67
Sugar Maple	0.15	0.55
Serviceberry spp	0.46	1.68
American Hornbeam	0.09	0.31
Downy Hawthorn	0.24	0.89
Black Gum	0.58	2.13
Honeylocust	0.16	0.59
Kentucky Coffee tree	0.04	0.14
Witchhazel spp	0.09	0.32
Tuliptree spp	0.20	0.73
Japanese Flowering Crabapple	0.13	0.47
Norway Spruce	0.12	0.43
Serbian Spruce	0.07	0.24
London Planetree	0.44	1.63
Redbud	0.05	0.19
Bald Cypress	0.11	0.39
Common Linden	0.24	0.89
Elm spp	0.08	0.31
TOTAL	3.73	13.69

The CO₂ equivalent carbon sequestration in pounds per year:

(13.69 x 2000) = **27,380 lbs CO₂/year for Phase 2.**

To forecast carbon sequestration over the next 20 years, the annual sequestration value is multiplied by 20 years; assuming sequestration stays constant.

$(5800 \text{ lbs} + 27380 \text{ lbs}) \times 20 \text{ years} = \mathbf{663,600 \text{ lbs CO}_2 \text{ over the next 20 years.}}$

Findings:

Through calculating and estimating the DBH of newly planted tree species on site, it was determined that these trees sequester an estimated 33,180 lbs of CO₂ annually. Compared to the former industrial site that was generally barren with trees, this level of carbon sequestration is a major improvement. While carbon sequestration changes as the growth and health of maturing trees change, we can estimate that the site will sequester well over 663,600 lbs of CO₂ over 20 years.

Discussion and Implications:

The findings show that the design's reforestation strategy produces meaningful ecological value beyond visual improvement. The 1,149 planted trees provide measurable carbon sequestration and storage while also supporting shade, habitat creation, and a more resilient microclimate. Especially given the former industrial waterfront, this design shows that the landscape can function as a restorative infrastructure solution. Effectively transforming degraded land into a multifunctional public landscape that has large environmental benefits.

This park highlights the importance of designing with long-term ecological performance in mind. Especially through native and regionally appropriate plant palettes, strategic tree placement, and an understanding of how canopy growth changes site performance over time.

Limitations:

- Not every tree included in the planting plan was measured on-site individually. Real DBH measurements and estimated DBH measurements used in iTree Eco could vary.
- Some specific tree varieties were not listed under iTree Eco's tree inventory database and were substituted for similar varieties for calculations. This could have shifted the carbon sequestration results slightly.
- DBH at planting values used in the complete inventory were determined from standard and average values taken from other sources. There is potential for inaccuracy.
- The 20-year projection of carbon sequestration is based on a constant sequestration value. Trees grow and sequester more carbon over time, making the projection a rough estimate and not biologically grounded.

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Glass City Metropark, Toledo, Ohio

Landscape Performance Assessment - Option B: Detailed Research Plan and Instrument

Research Fellow:

Samia Tasnim Faiza

4th year, Landscape Architecture

Michigan State University

Course Instructor: **Dr. Haoyue Yang**

Assistant Professor, Landscape Architecture

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Overview: The Glass City Metropark is a large public park situated next to the Maumee River. The park was created to allow outdoor activities and make waterfront access easier for everyone. The park features open lawns, walking paths, benches, and a children's playground. It offers great views of the river and allows gatherings that bring people closer together. The main aim of the design is to create a place where socialization and leisure can take place safely and comfortably. Visitors enjoy walking, working out, and being with their families and friends at the park.

Table of Contents:

1. Project Goals and Design Objective – Key design goals and intended outcomes.
2. Performance Questions – The performance questions guiding my analysis.
3. Methods and Metrics – The metrics selected and the methods used to calculate or evaluate them.
4. Performance Findings – Results from analysis, or initial data collection.
5. Limitations – Data limitations and uncertainties.
6. Discussion and Implications – Interpretation of findings.
7. References – Sources of tools used in the analysis.

Acknowledgements: I would like to sincerely thank Dr. Haoyue Yang (Professor) and Brandon Woodle for their guidance and support throughout this project. Their suggestions helped me better understand landscape performance and improve my analysis. I also appreciate the opportunity to visit Glass City Metropark, which allowed me to observe and collect valuable data for this study.

I am grateful to my team member, Adam Hershner, for his collaboration during the project. Lastly, I acknowledge the use of observation methods and tools such as SOPARNA, which helped structure the behavioral analysis in this study.

Research Strategy: This study uses a behavioral observation approach to evaluate social performance at Glass City Metropark. The SOPARNA toolkit is applied to systematically observe how visitors use different areas of the park and how social interactions occur.

Site objective → SOPARNA Method → Zone Selection → Observation → Data Collection → Analysis → Visualization → Findings

Metric Title: Assessment of Social Interaction and Activity Patterns

Project Goal and Objective: The goal of this project is to focus on social performance analytics and evaluate how well “Glass City Metropark” supports community gathering, recreation, social interaction, and user activity through behavioral observation. It also focuses on how people use different spaces, what activities they do, and how they interact with each other.

Performance Questions: This study asks; How do visitors use different spaces within the park? Which areas of the park support more social interaction? What type of activities are most common in the park?

Methods and Metrics: I used behavioral observation to evaluate how people use the park. I collected data like how many people were in different areas, the age groups, and interaction levels. I have also used a timer to record short activities of how much time they were spending in an activity.

Performance Findings: I observed areas at the **Boardwalk (Across the Glass City Pavilion)**, **Prairie and Pollinator Discover Play Area**, and **Glass City Metro Park Slides**. The observed areas were engaging and interactive. Since they were playground areas, it was mostly occupied with children and parents.

- All the observation zones show high levels of social interaction, especially among children and families.

- Riverwalk areas show mixed interaction levels, supporting both movement and casual social use.
- Larger group sizes are concentrated in play zones, while smaller groups dominate linear spaces.

Limitations: The observations were done for a limited period of time so it may not show full patterns. Findings will be different at different times and days of the week which is challenging as it may not fully understand visitor reasons just by observing.

Discussions and Implications: The study suggests that the space is actively engaging. It brings together communities and supports social interaction, biodiversity, and well being.

Social Performance

Overall Method (SOPARNA Behavioral Observation): The study used direct observation to record how people use the park. The site is divided into three key zones such as the Boardwalk (Across the Glass City Pavilion), Prairie and Pollinator Discover Play Area, and Glass City Metro Park Slides. Observations are conducted through repeated visual scans, where data on activity type, group size, age range, and interaction level are recorded.

Data Collection:

Data is collected during specific times of the day to capture variations in park use. For each observation:

- Activity type (walking, playing, sitting) is recorded
- Group size (individual, pair, group) is noted
- Age group is estimated
- Interaction level (low, medium, high) is observed

This structured method allows comparison between zones and helps identify patterns of social use.

Key Social Performance Indicators:

Social Interaction Level → Measures how actively people engage with others.

Group Activity → Identifies whether spaces support group use.

Age Distribution → Shows which age groups use different areas.

Activity Type → Indicates how the space is used (active vs passive).

Interpretation:

- Play structures and flexible spaces encourage group interaction.
- Pathways support movement and moderate interaction.
- Seating and open spaces allow for passive and social use.

Conclusion:

The study shows that Glass City Metropark supports strong social interaction, especially in play areas where group activities are common. Spaces like the riverwalk provide more flexible use, allowing both movement and casual interaction. The findings highlight that design elements such as play structures, seating, and open spaces influence how people gather and interact. Overall, the park successfully promotes social engagement, but further data collection would provide a more complete understanding of user behavior.

Behavioral Observation Sheet: SOPARNA (System for Observing Physical Activity and Recreation in Natural Areas)

Observer name: **Samia Tasnim Faiza**

School: **Michigan State University**

Course instructor: **Dr. Haoyue Yang**

Date: **10th April, 2026**

Day: **Friday**

Observation Time: **Afternoon (1 - 3PM)**

Weather: **Gloomy**

Site: **Glass City Metropark, Toledo, Ohio**

Overview of the Park: The Glass City Metropark is a large public park situated in Toledo, Ohio. The park was created to allow outdoor activities and make waterfront access easier for everyone. The park features open lawns, walking paths, benches, and children's play areas. It offers great views of the river and allows gatherings that bring people closer together. The main aim of the design is to create a place where socialization and leisure can take place safely and comfortably. Visitors enjoy walking, working out, and being with their families and friends at the park.

Purpose of "SOPARNA": SOPARNA toolkit was used to systematically observe and record user behavior, activity types, and social interactions across different park zones. Observations were conducted at a specific time of the day, and behavior mapping was used to identify patterns of use and social engagement.

Observation Zone:



Figure: Aerial map of Glass City Metropark showing three different observation areas

❖ **Zone 1: Glass City Riverwalk**

❖ **Zone 2: Glass City Metropark Slides**

❖ **Zone 3: Prairie and Pollinator Discover Play Area**

Behavioral Observation Data

Table: Overall Data

Observation Zone	Group Size	Activity Type	Age Range Group (y/o)	Interactive Level	Duration (minutes/seconds)	Notes
Glass City Riverwalk (Boardwalk across Pavilion) - 1	2 adults	Playing, Socializing	(18 - 20)	Interaction: High, Active	Recorded time: 4:53	Two young adults were playing and running after one another on the boardwalk bridge. The interactive rope bridges are an attraction of the park which is used by all age groups of people.
Glass City Riverwalk (Boardwalk across Pavilion) - 2	2 adults	Dog strolling	(30 - 35)	Interaction: Medium, Moderately active	Recorded time: 9:11	One man and a woman were strolling a dog near the boardwalk area. They both took a break after 9 minutes 11 seconds, hence that was the amount of time I could record.
Glass City Metropark Slides	11 children	Playing, Socializing, Running	(2 - 12)	Interaction: High, Active	Recorded time: 7:53	Three groups of families were present in the area where each of the families were busy playing and interacting with their children. Family 1: 4 members, Family 2: 4 members, Family 3: 3 members
Prairie and Pollinator Discover Play Area	9 children	Playing, Socializing, Running	(2 - 10)	Interaction: High, Active	Recorded time: 5:23	A total of 9 children were playing, waiting for their turns to use the slides, eating, running , and socializing with each other.

Fig: Table shows overall data collection during the entire observation time

Bar graph 1:

→ Metropark Slides and Prairie and Pollinator Discover Play Area have larger group sizes, whereas Glass City Riverwalk has smaller group size.

→ This shows family/group activity vs individual use spaces.

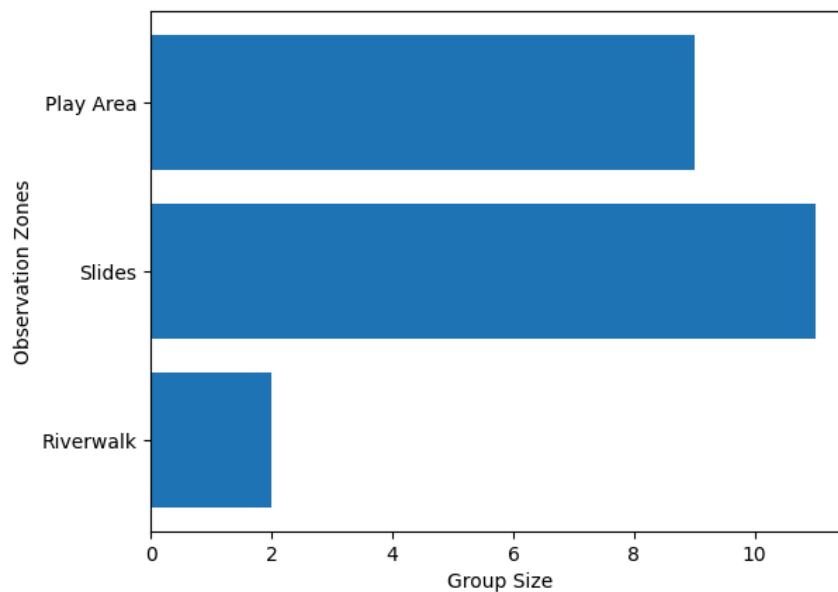


Fig: Bar graph showing the Group Size vs Observation Zones

Bar graph 2:

- Prairie and Pollinator Discover Play Area and Metropark Slides show only high interaction, meaning these spaces strongly support social activity.
- The riverwalk shows both medium and high interaction, indicating a mix of social and individual use.
- This suggests that design features like play equipment encourage stronger social engagement, while walkways support more flexible use.

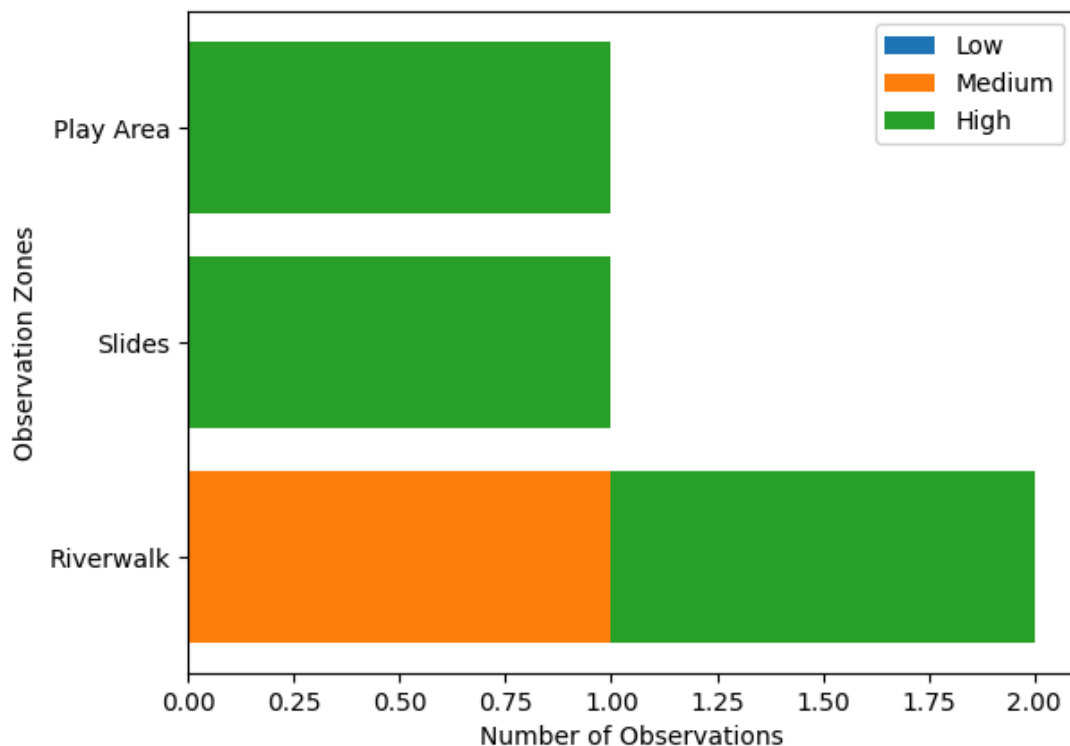


Fig: Bar graph showing Social Interaction Levels vs Observation Zones

Observation notes: All the three observation zones were interactive and engaging, however, the Glass City Metro Park Slides was highly active as most children were gathered in the same area and interacting among themselves.

Conclusion: From the observations made, it can be seen that each zone in the park encourages different forms of social interactions. In the play zones and

slides, people engage highly socially, but in other parts like the riverwalk, it is possible to either socialize or act alone.

Planned Methods Document: Glass City Metropark

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Overview

The Glass City Metropark is a park built in downtown Toledo, Ohio, being a riverside park along the Maumee River. Before formation, the site was entirely within the river, before the addition of the Toledo Edison Acme Power Plant in 1918, where industrial waste and fly ash was deposited into the river, building up landmass. The power plant ran until 1993, where the site sat undeveloped until the firm SmithGroup was chosen to redesign it. The result is Glass City Metropark, a currently Phase II riverside park with a larger Riverwalk project still in development.

Project Objectives and Goals

Overall, the Glass City Metropark sought to create a recognizable sense of place from an industrial wound near the heart of the city, turning a negative into a positive. Within the framework of social benefits, this expressed itself as a focus on creating a new addition to Toledo's interconnected Metropark system, built along the Maumee River.

Notable social benefit goals include:

- Create a variety of amenities for all seasons.
 - Reconnect the east bank of the Maumee River to the western downtown of Toledo in order to return waterfront access to Toledo.
 - Create an extension of Toledo's existing and vibrant culture within the site.
 - Create unique opportunities that are not found in other parks.
 - Create the titular "best" riverside park.
 - Focus on Discovery Play, Water Play, and Winter Play as the three most critical program elements.
 - Create regional interconnectivity within both surrounding neighborhoods and all of northwest Ohio.
 - Establish a strong foundation for future phases of the Riverwalk project.
-

Performance Questions

Has community engagement and visitor numbers increased across different phases of development?

This question relates to the overall phasing of Glass City Metropark; while two phases have been completed thus far, this is only a quarter of the entire planned Riverwalk. As such, analyzing success metrics throughout the process will allow for design adjustments and adaption for future development.

Which amenities are being most utilized, and which are being underutilized?

In a pairing to the above question, this seeks to better understand use of the site for the sake of future development, allowing for plan refinement for similar planned amenities or upgrading to those previously made.

Do users of Glass City Metropark have a positive opinion of the park?

The driving factor of social benefits and repeated use of a particular site. This can be best measured by ratings, surveys, and consistency of return visits, being critical for determining a project's overall success within the eyes of its users.

Proposed Social Benefits

Proposed Benefit: Year-Round and Diverse Programming

- **Offers a range of recreational activities throughout all seasons of use.**
-

Background

Due to the project site originally being an industrial brownfield without usable amenities, there is little existing data on whether the site experienced much social recreational before construction completion. Prior visit and use numbers were not obtained. Due to the metropark being a phased project, attention was paid to the divisions of times open, with Phase I being opened to the public on December 10th, 2020, and Phase II being opened to the public on June 9th, 2023.

Methods

All Google Reviews were gathered, with the final collection date being April 22nd, 2026. In total, 545 reviews were analyzed, with the earliest being from December 11th, 2020, exactly one day after the Phase I project was opened. The latest review was from April 22nd, 2026. The five-star rating average was 4.8.

Figure 1.1: Screenshot of the initial loading page on Google Reviews for Glass City Metropark.

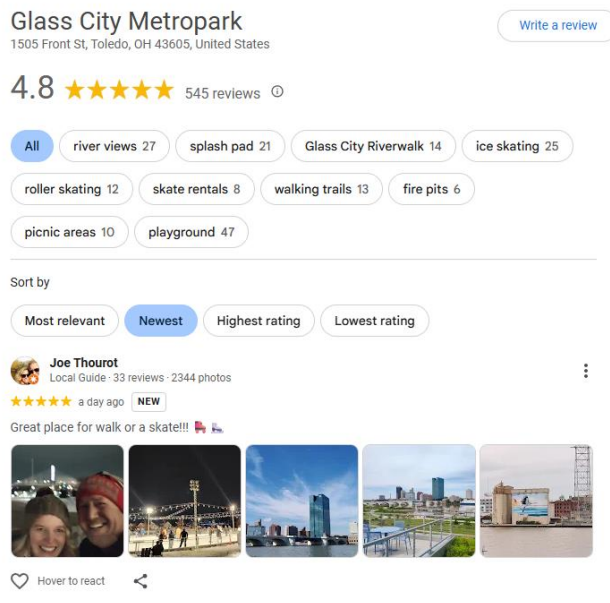
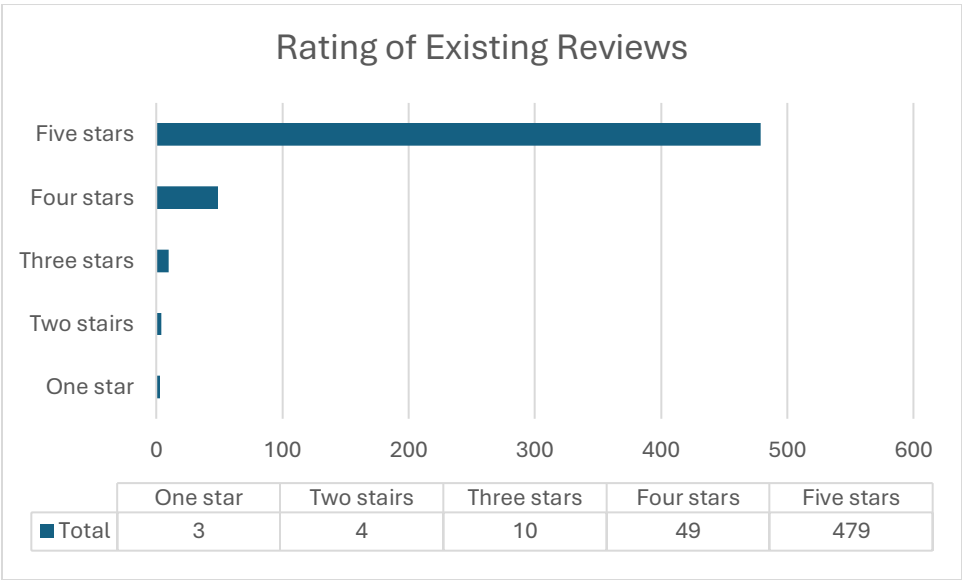
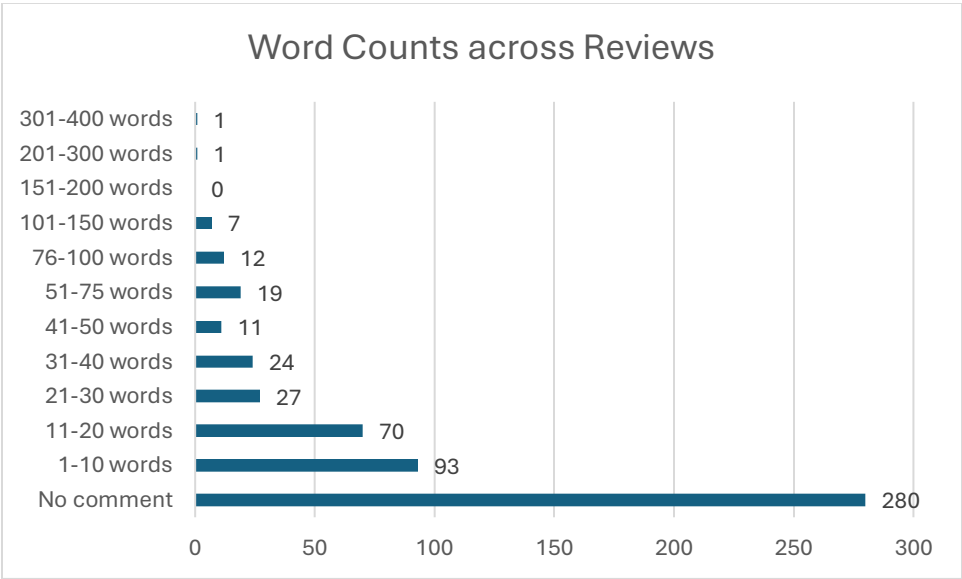


Figure 1.2: Total average rating across 545 reviews by users of Glass City Metropark.



Of the 545 collected reviews, 280 were left without attached words.

Figure 1.3: Word counts across all Google Reviews by users of Glass City Metropark.



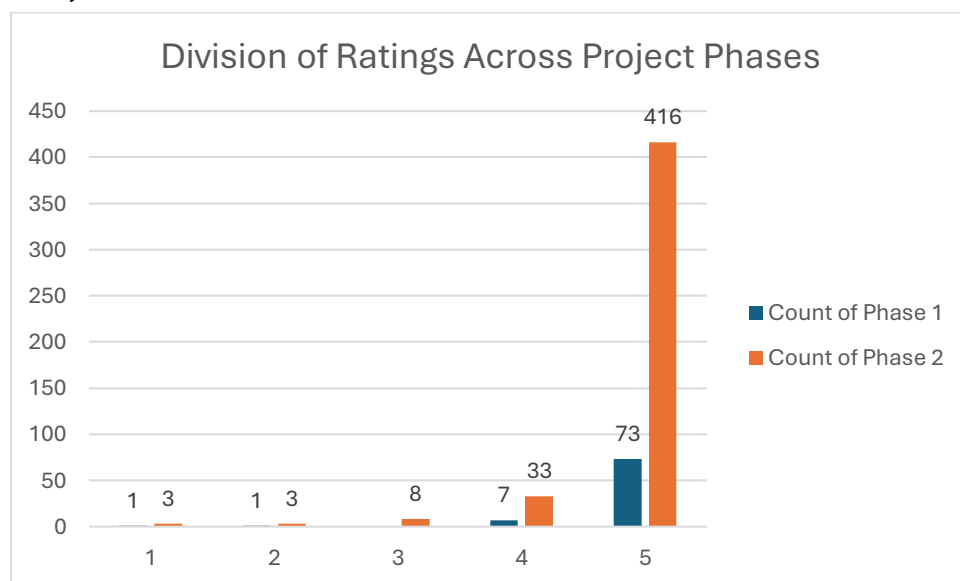
Calculations

Calculations were completed in Excel, utilizing Pivot Tables and graphs to best visualize the collected data. Straight data counts were completed based on data input. Additional data was collected through comparable case studies, research papers, and information provided by SmithGroup during their project brief.

To estimate overall amenity use throughout the site, all reviews with written attachments were consolidated into a third-party cloud program that sought out repeating words (**Figure 2.2**) and assembled them into a notated list per mention (**Figure 3.1**). Particularly of note where reviews mentioned specific elements or amenities by name (**Figure 3.2**), with the most numerous being skate / skating / ice skating with 64 mentions, playground with 53 mentions, and river with 35 mentions, divided into 25 mentions of specifically the Maumee River and 10 of the riverwalk amenity. This equates to **82.9%** (218 out of 263 reviews with comments) of unique reviews mentioning the use, excellence, or existence of amenities, implying them being a key element and factor of enjoyment throughout the site.

A secondary analysis was done through dividing reviews into those published while the project had released only Phase I (being all reviews before June 9th, 2023) and those in Phase II, where multiple additional amenities were introduced. As seen, the number of reviews increases from 82 left within a two and a half year period to 463 left within a two years period, displaying a dramatic increase in overall users of the site through phasing changes.

Figure 1.4: Division of star ratings with divisions made between reviews made before June 9th, 2023, and reviews made after.



Sources

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“Glass City PARK, Toledo, OH - Reviews, Ratings, Tips and Why You Should Go – Wanderlog.” *Wanderlog*, 2025, [wanderlog.com/place/details/8205864/glass-city-metropark](https://www.wanderlog.com/place/details/8205864/glass-city-metropark).

“Glass City Riverwalk | Toledo OH.” *Facebook.com*, 2026, www.facebook.com/glasscityriverwalk/.

Limitations

- All Google Reviews are self-initiated, which necessitates outside factors to inspire someone to leave one; this tends towards either highly positive or highly negative responses, which is not indicative of the average experience of the site.
- Reviews can be completed at any time; as such, while it can be consolidated to roughly the correct time period for when the review was left, it is equally likely that the collected dates are inaccurate to when the user actually visited the site.
- The number of reviews (545) is incomparable to the number of estimated visitors to the site within the past two years (500,000), leading to probable differences to the average user.

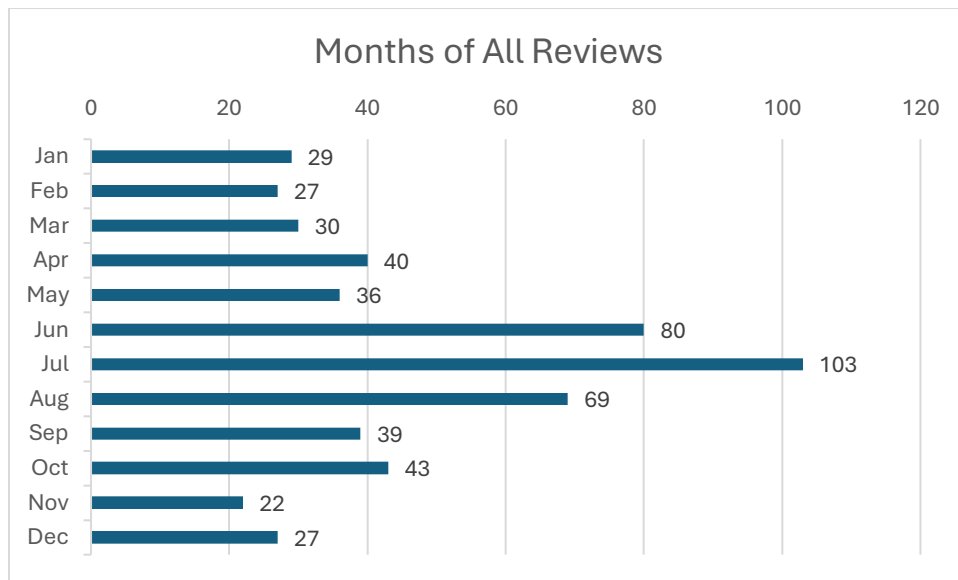
Further Study

Due to all data currently gathered being insubstantial in terms of raw numbers and accurate scaling, additional will need to be gathered. While one visit to the site was made, it was of a limited timeframe and did not involve interaction with users of the site. As such, the suggested continuation of this study would be that of an intrapersonal anonymous survey.

In taking directives from a similar CSB study done at Rainier Beach Urban Farm and Wetlands, they noted an exceptionally higher rate of completion for paper surveys over digital, with a ratio of 57 completed paper surveys and 3 digital surveys. As such, it would be advantageous to offer both options, ideally in combination with an on-site activity, such as one of their numerous festivals or volunteering events. The digital survey can be shared online, such as the existing *Glass City Riverwalk* or *Metroparks Toledo* Facebooks.

To further increase potential answers, Glass City Metropark’s existing Google Reviews were analyzed for periods of high activity, utilizing the days and months of posting. As shown, there is a significant spike during the months of June, July, and August, increasing potential for answers, with the next highest months being September and October.

Figure 2.1: All Google Reviews by users of Glass City Metropark sorted into months of posting.



According to a research study by Brent Chudoba with additional research from PubMed Central, a public-facing survey should be under ten minutes to maximize completion and responses rate, with a potential question range of 11-25, requiring that all be multiple choice instead of open-ended. To ensure ease of the paper survey, it should be a single piece of paper to minimize difficulty for both volunteers handing it out and participants taking it, further improving chances of completion.

With that question limit in mind, the category of social benefits to focus on is the previously analyzed, being **Year-Round and Diverse Programming**. Notable questions to consider include:

- How often do you visit the site?
 - o With answers divided into first visit, a few times per year, a few times per month, and a few times per week.
- When did you first visit the site?
 - o With answers divided into first visit, since the release of Phase II, or prior to Phase II.
- What amenities do you most often use?
- What are your favourite parts of the site?
- Do you feel that the site has a good variety of amenities?
- How would you rate your overall experience at the site?

To consolidate experiences with those of the Google Reviews for attempted clarity, the most-repeated words can be assembled into a word cloud attached to the survey, with a question asking if these words are equivalent to what the survey taker feels about Glass City Metropark. This question could also be limited to the digital version to save on size and ink costs for the paper version.

Figure 2.2: An assembled Word Cloud taken from attached comments to Google Reviews by users of Glass City Metropark.

Appendices

Figure 3.1: Consolidated words from Google Reviews by users of Glass City Metropark.

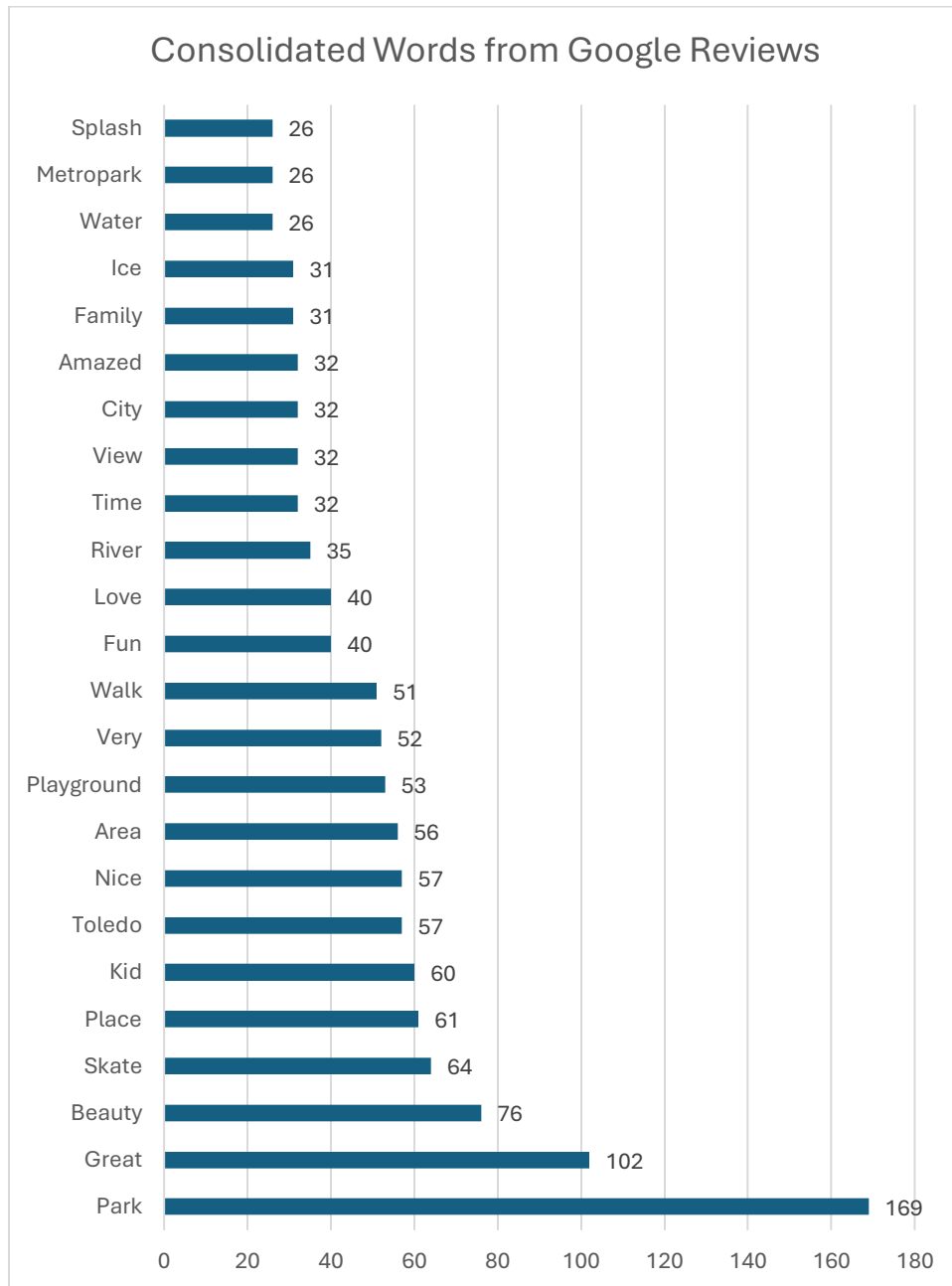


Figure 3.2: Specific amenities mentioned by name in Google Reviews by users of Glass City Metropark.

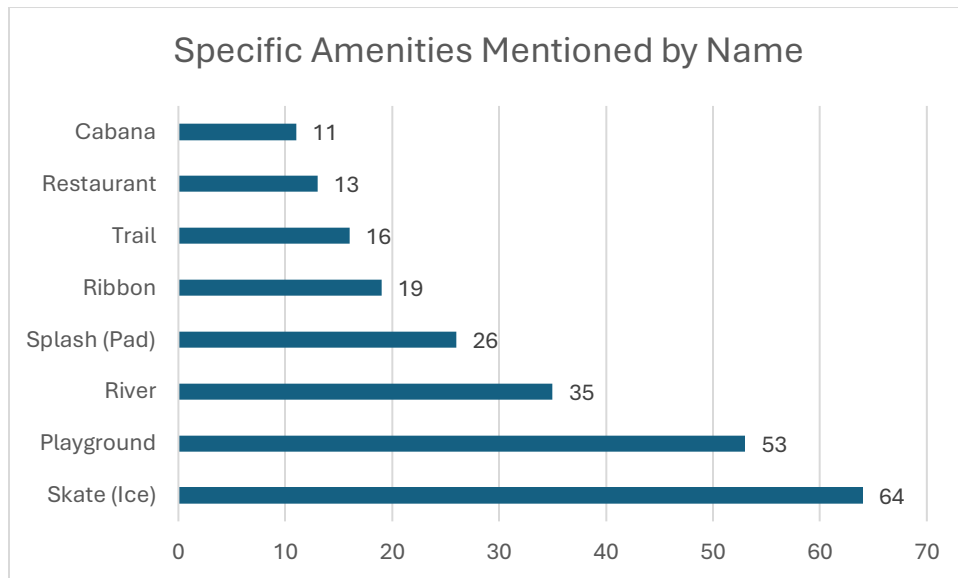
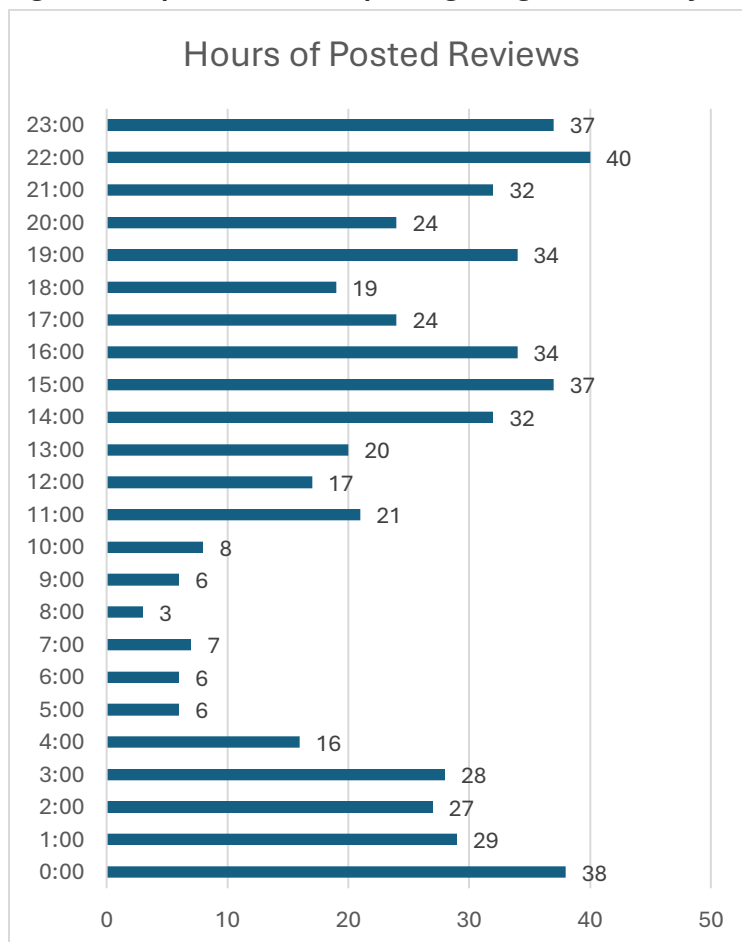


Figure 3.3: Specific hours of posting Google Reviews by users of Glass City Metropark in UTC.



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Glass City Metropark Methods

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This study was conducted as part of the Landscape Performance Assessment Final Project. Students evaluated how the park contributes to economic value. The project followed the structure and methods used in the Landscape Architecture Foundation Case Study Investigation (CSI) program, which evaluates built landscape projects using measurable performance metrics. Students worked collaboratively in small teams to analyze one category of landscape performance and produce a case study report and presentation.

Economic Performance

- **Generates approximately \$482,00 in direct annual revenue.**

The goal of this analysis is to evaluate the ability of Glass City Metropark to generate direct operational revenue through its design and programming. This means understanding how different park elements like event spaces, concessions, and recreational amenities contribute to financial performance. The intended outcome is to quantify total annual revenue and identify which design features are most economically productive.

Method:

Revenue data were collected from Metroparks Toledo financial records and staff-provided estimates. Only revenue retained by Metroparks Toledo was included, excluding total gross sales from vendors.

Revenue was categorized into:

- Facility rentals
- Concessions and vendor agreements
- Programs and recreation

This categorization aligns with Landscape Architecture Foundation (LAF) CSI methods, allowing for analysis of how different systems contribute to economic performance.

Calculation:

Specific Revenue Element	Apx. Revenue Generated Annually
Glass City Pavillion	\$100,000
Grosbeak Shelter	\$4,000
Pollinator Shelter	\$1,000
Kayak Share Locker Rental	\$10,000
Permit Fees	\$50,000
Total	165,000
The Garden	\$100,000
Hajjar Hospitality (Catering)	\$30,000
Brenner 75 Marine	\$10,000
Jupmode	\$5,000

Total	\$145,000
Ice Skating Rental & Admission	150,000
Roller Skating Rental	20,000
Modest Program Fees	2,000
Total	\$172,000
Grand Total	\$482,000

Approximately \$482,000 in direct annual revenue. Programs and recreation generate the most revenue, indicating that they are the primary economic driver within the park.

Limitations:

- Revenue values are estimated and may not reflect exact audited totals.
- Some concession data are approximate and based on agreements rather than fixed returns.
- Revenue is sampled from only 2025.
- The analysis does not account for indirect economic impacts such as nearby business activities.

Sources:

- Metroparks Toledo financial data
- **Generates approximately \$0.58 in revenue per visit.**

The goal of this analysis is to evaluate the economic efficiency of the park relative to its level of use. By calculating revenue per visit, this metric assesses how effectively the park converts visitation into financial return while maintaining its role as a publicly accessible space.

Methods:

Total annual revenue / Total annual visits = Revenue per visit

PLACER DATA:

Day	Total Visits
Monday	66887
Tuesday	65522

Wednesday	67204
Thursday	62282
Friday	100796
Saturday	150060
Sunday	115212
Total Visits Annually	657,963

$\$482,000 \text{ annual revenue} / 657,963 \text{ annual visits} = \text{\$0.73 per visit}$

Revenue per visit was calculated by dividing total annual revenue by total annual visits. Total visits were used instead of unique visitors to reflect actual park usage frequency.

The low revenue per visit reflects the park's design being a public accessible space. However, this does not mean poor performance. It highlights the trade-off between public accessibility and revenue generation.

Limitations:

- Total visits include repeat users and do not represent unique individuals.
- Visitation data are estimated and may vary seasonally.
- This metric does not account for broader visitor spending within the park.

Sources:

- Metroparks Toledo financial data
- **Saves approximately \$130,335 annually through reduced mowing and ecological design.**

The goal of this analysis is to evaluate how landscape design strategies contribute to long-term cost efficiency. Specifically, the study examines how reduced mowing and naturalized landscapes lower maintenance costs compared to conventional turf management.

Methods:

Maintenance cost data were used to compare the current reduced mowing strategy with a full-maintenance scenario.

Steps:

1. Calculate cost per acre using mowing data
2. Apply cost per acre to total site area (23.6 acres)
3. Compare full mowing cost to current mowing cost

Mowing cost annually / Acres mowed = mowing rate per acre

Mowing rate per acre x Mowable acres = Total mow cost

Total mow cost – Mowing cost annually = Savings

Total mowing cost = \$35,036 annually

Total mowing area = 5 acres

Mowing rate = \$35,036 / 5 acres = \$7,007 per acre

Total mow cost = \$7,007 x 23.6 acres = \$165,371

\$165,371 - \$35,036 = **\$130,335 saved**

This finding demonstrates that ecological design strategies can significantly reduce long-term operational costs. By limiting mowing to high-use areas, the park avoids over \$130,000 in annual expenses.

This shifts the understanding of economic performance from revenue generation alone to include cost avoidance as a critical factor. For landscape architecture practice, this highlights the importance of designing landscapes that are not only functional and ecological, but also financially sustainable over time.

Limitations:

- Assumes uniform cost per acre across the entire site.
- Only mowing costs are included; other maintenance activities are excluded.
- Naturalized landscapes may require alternative maintenance not captured here.

Sources:

- Metroparks Toledo Natural Resources maintenance cost data (2025)
- Glass City Metropark site area data (Phase 1 & 2)

Glass City Metropark Landscape Performance Methods

Ava Yon

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Economic Benefits

- ***Glass City Metropark contributed to the surrounding property value increase of 23.5% from 2020 to 2026 when adjusted for inflation.***

Background

Toledo, Ohio, carries a long history of industrial activity that drives the workforce in its neighborhoods. East Toledo used to be home to industrial employers such as railroads, oil refineries, utilities, and shipyards (Michaels & Mauter, 2006). Most notably Libbey Glass, a glass manufacturing company that gave Toledo its nickname, Glass City. Glass City Metro park itself used to be a steel mill and power plant (Peng, 2021). Many of these businesses were abandoned in the later half of the 20th century, leaving a long-lived impact on Toledo's neighborhoods and economy (Peng, 2021).

Garfield neighborhood, the home of Glass City Metropark, has since had a consistent history of low incomes, housing burdens, and service fragmentation (University of Toledo, Center for Urban & Regional Studies, 2019). The overall decline in the city has sparked change in within Toledo's neighborhoods. Since the Covid-19 Pandemic efforts to revitalize heavily impacted communities have grown. Glass City Metropark is part of the initiative followed by the Garfield Community Plan (Toledo Design Collective, 2021).

Glass City Metropark, designed by SmithGroup, opened the first phase of the park in 2020 and the second phase in 2023. SmithGroup's design intent was to design the park as a catalyst for new private investment and economic activity in adjacent neighborhoods.



Figure 1.0. Housing directly adjacent to the Glass City Metropark. Image captured on April 10, 2026.

Performance Question

How has the development of Glass City Metropark in Toledo, Ohio affected the local economy through changes in property values?

Study Overview

In conjunction with SmithGroup's design intent, this study aims to evaluate economic activity in adjacent neighborhoods by identifying changes in residential and commercial property values within one block of the park.

Property values are gathered from the Lucas County real estate website, AREIS. The property report cards identify land values and building values, combining them for the total property value. These values are determined by the Lucas County mass appraisal system. This becomes important when looking at property value changes when parcels have drastic changes in the presence or alterations of buildings. In alignment with the parks opening dates, this study uses property values from 2020 and 2026. These values were consistently available and provide insight on property value changes since the first opening of the park.

Overall data relevant to this study includes Toledo parcel boundaries and numbers, zoning ordinances gathered from The City of Toledo website. Additionally, property values are obtained from the AREIS Lucas County real estate website. The Bureau of Labor Statistics is used to understand inflation rates and applications. Lastly, the Zillow Home Value Index is taken from the Zillow housing data website. The structure of this study was guided by a Landscape Architecture

Foundation Case Study Investigation based in Raleigh, North Carolina which evaluated property values (Delcambre & Dominguez, 2023).

Study Area

This study only considered parcels with either commercial or residential zoning codes within one block of the park. This includes regional commercial, multi-dwelling residential, duplex residential, and mixed commercial-residential zones (Table 1.0). Industrial parcels are not included in this study due to their high property values and little to no property value change. Figure 2.0 shows the 323 parcels included in the study area color coded by the corresponding zone ordinance.



Figure 2.0. The 323 parcels within the study area and their corresponding zones.

Zone Code	Zone	Number of Parcels
CM-PUD	Mixed Commercial Residential	4
CR	Regional Commercial	48
RD6	Duplex Residential	20
RM36	Multi-Dwelling Residential	251

Table 1.0. Number of parcels in each zone within the study area.

Property Value Collection

To determine the property values for 2020 and 2026, a parcel report was downloaded for each parcel from the Lucas County Real Estate Data website, AREIS. Each parcel was searched by parcel ID, which was collected from the study area using s City of Toledo parcel feature layer in ArcGIS Pro. Figure 3.0 shows a sample property report and the values taken from the report outlined in red. Full market property values were documented in Appendix A.

Parcel ID: 17-03434		KATIE MOLINE - LUCAS COUNTY AUDITOR		RESIDENTIAL/AGRICULTURAL									
Owner: JONES CRYSTAL D ETAL (OR SURVTC) 136 OSWALD ST		Card 1 of 1 Assr #: 08292014		Market Area: 802R DTE #: 00300 - TOLEDO CITY - TOLEDO CSD									
				Tax Year: 2026 LUC: 520 - 2FAM-PLAT									
GENERAL INFORMATION													
Topo: 1 - Paved		Spec Use: 520-2 Family-Plat											
Street: 22 - City Water / City Sewer		Traffic: 6-Resside											
Utilities: 0-Missing		Corner Lot: No											
Legal: YONDOTA NEW PLAT LOT 167 NE 36 FT & 168...S													
ADMINISTRATIVE													
DATE	SOURCE	ENTRY	ADMIN	DATA ENTRY	REVIEWER								
02/29/12	7-lfr	8-Road	237-Final Value Review	9990	670								
09/09/09		0-Missing	240-Bor/Appeal Review	920	670								
 													
1703434 2/8/2024													
LAND INFORMATION													
TYPE	CODE	FRONT	DEPTH	SQFT	AC								
1	01-Residential Land	30	80	2,400	.0551								
INFL1: 1-None INFL2: 1-None													
Total SF: 2,400 Total AC: .0551													
PERMITS													
DATE	TAXYR	PERMIT #	PURPOSE	STATUS	% COMP								
SALES/TRANSFER HISTORY													
DATE	CONV #	# OF PARCELS	DEED	VALIDITY	TYPE	PRICE							
08/11/21	21204154	1	FD	X - Exempt Transfe	2 - Land & Building								
08/22/00	00203857	21	WD	8 - Unrevd	2 - Land & Building								
08/14/96	96106793	1	ST	0 - Validvac / L&B	2 - Land & Building	5,000							
CONDO COMPLEX													
COMPLEX #	COMPLEX NAME	YR DECLARED	# BLDGS	# UNITS									
VALUE HISTORY													
CLASS	2026	CLASS	2025	CLASS	2024	CLASS	2023	CLASS	2022	CLASS	2021	CLASS	2020
100% L	8,200	100% L	8,200	100% L	8,200	100% L	6,800	100% L	6,800	100% L	6,800	100% L	5,600
B	34,300	B	34,300	B	34,300	B	23,100	B	23,100	B	23,100	B	19,000
T	42,500	T	42,500	T	42,500	T	29,900	T	29,900	T	29,900	T	24,600
35% L	2,870	35% L	2,870	35% L	2,870	35% L	2,380	35% L	2,380	35% L	2,380	35% L	1,960
B	12,010	B	12,010	B	12,010	B	8,090	B	8,090	B	8,090	B	6,650
T	14,880	T	14,880	T	14,880	T	10,470	T	10,470	T	10,470	T	8,610

Figure 3.0. A sample property report card used to determine the property values from 2020 and 2026.

Adjustments for Inflation

To accurately compare the property values from 2020 to 2026, inflation must be considered. According to U.S Bureau of Labor Statistics, the inflation rate from 2020 to 2026 was 22.9%. This inflation rate was applied to the 2020 property values before calculating the absolute change and percent property value change. See Appendix A for the full calculation table, including the 2020 property values, 2026 property values, 2020 property values adjusted for inflation, absolute change, and percent property value change for each parcel.

Inflation Rate Calculation

$(\text{CPI 2026} - \text{CPI 2020}) / \text{CPI 2020} = \text{Inflation Rate}$

CPI 2020 = 258.8 [1]

CPI 2026 = 318 [2]

Inflation Rate = 22.9%

Finding the Percent Property Value Change

The final metric used to understand the impact of Glass City Metropark is the percent of property value change. This allows us to see the change in values over time. The following sample shows the calculation used to determine that change.

Sample Percent Property Value Change Calculation

136 Oswald St

2020 Value: \$24,600

2026 Value: \$42,500

Inflation Multiplier: 1.229

Absolute Value Change: $[42,500 - (24,600 \times 1.229)] = \$12,267$

Percent Value Change: $\{ [42,500 - (24,600 \times 1.229)] / 42,500 \} \times 100 = 40.6\%$

Findings

Figure 4.0 provides a choropleth map of the 2020 property values when adjusted for inflation. It identifies low property values for most residential parcels, and high property values for mixed-use and commercial parcels. Figure 5.0 visualizes the 2026 property values. It is notable that parcels near the central residential area see property value increases when compared with the 2020 values. Mixed-use and commercial areas remain with high property values. For this study, all property values over \$160,000 are symbolized in the darkest green. This symbology choice was made not to skew the visualization of property values since there are few parcels with property values nearing \$4 million.

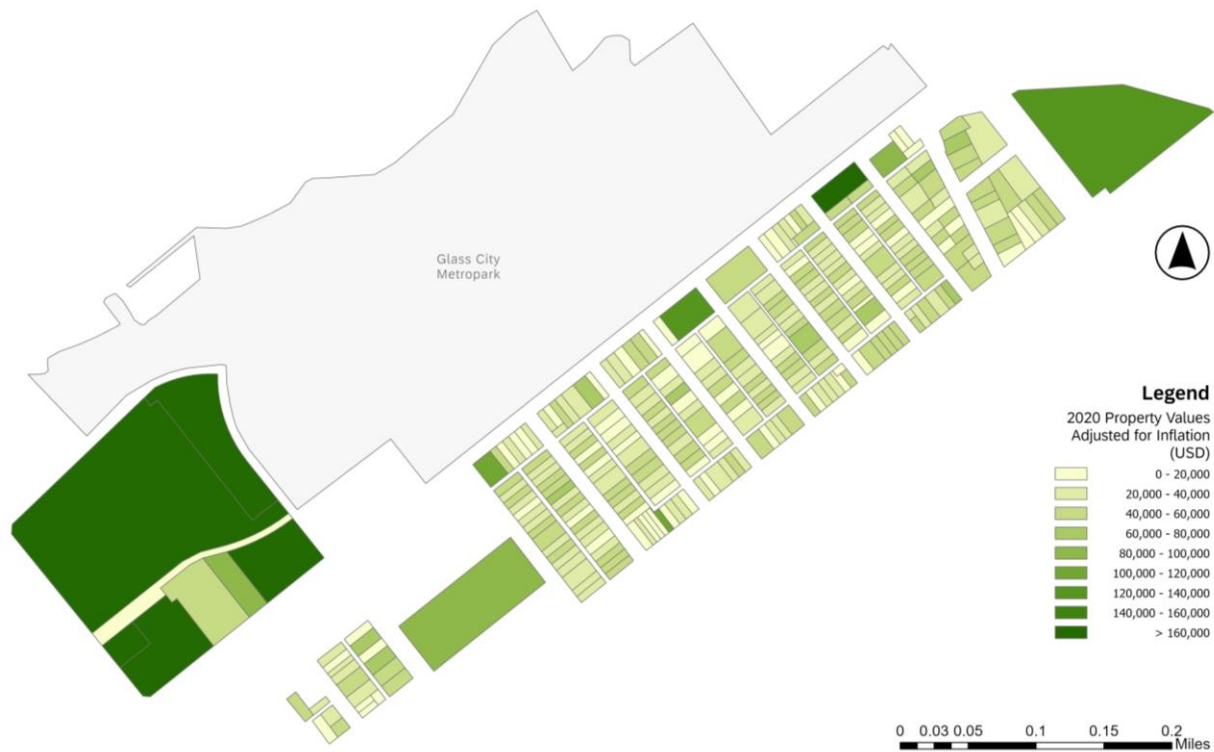


Figure 4.0. Choropleth map of 2020 poverty values (USD) adjusted for inflation for residential and commercial parcels within one block of Glass City Metropark.

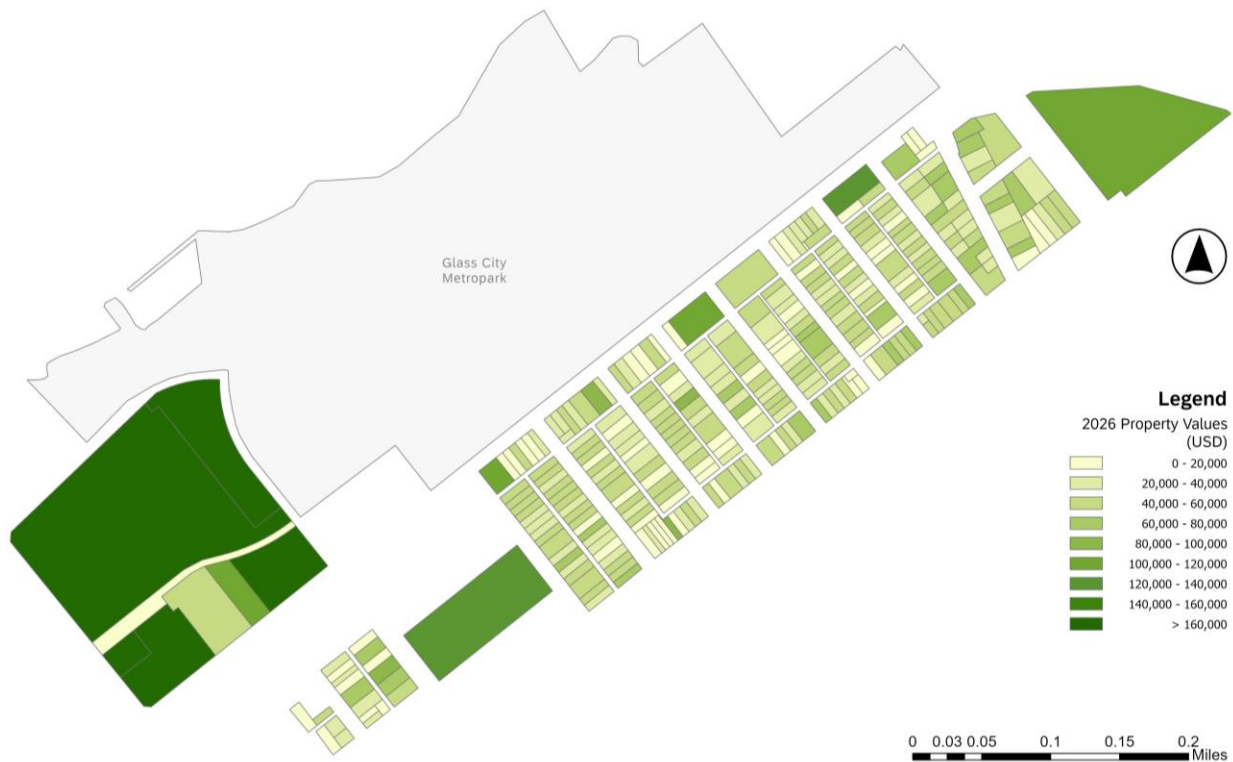


Figure 5.0. Choropleth map of 2026 poverty values (USD) for residential and commercial parcels within one block of Glass City Metropark.

The results of the data collection and calculations find an average percent property value increase of 23.5%. This property value increase supports the implementation of Glass City Metropark to have a positive effect on the adjacent communities. Additionally, it supports SmithGroup’s design intent for the park to work as a catalyst for new private investment and economic activity in adjacent neighborhoods. Overall, the findings are positive and open the door to further discussion about urban parks and the changes that come with rising property values.

Figure 6.0 shows the percent property value change for each parcel within the study area. Most residential parcels see an increase in property value. Parcels in yellow represent properties that saw no change or slightly negative change. A pattern can be recognized that these parcels are mostly mixed-use or commercial where the property values were much higher than the residential properties in 2020 and were similar in 2026. Lastly, red parcels are scattered throughout the residential area. Upon investigation, it is found that the majority of these parcels were documented to have a reduction in building value because a building was either removed or demolished. This is where the definition of property value becomes important, as it is the combination of building and land values.

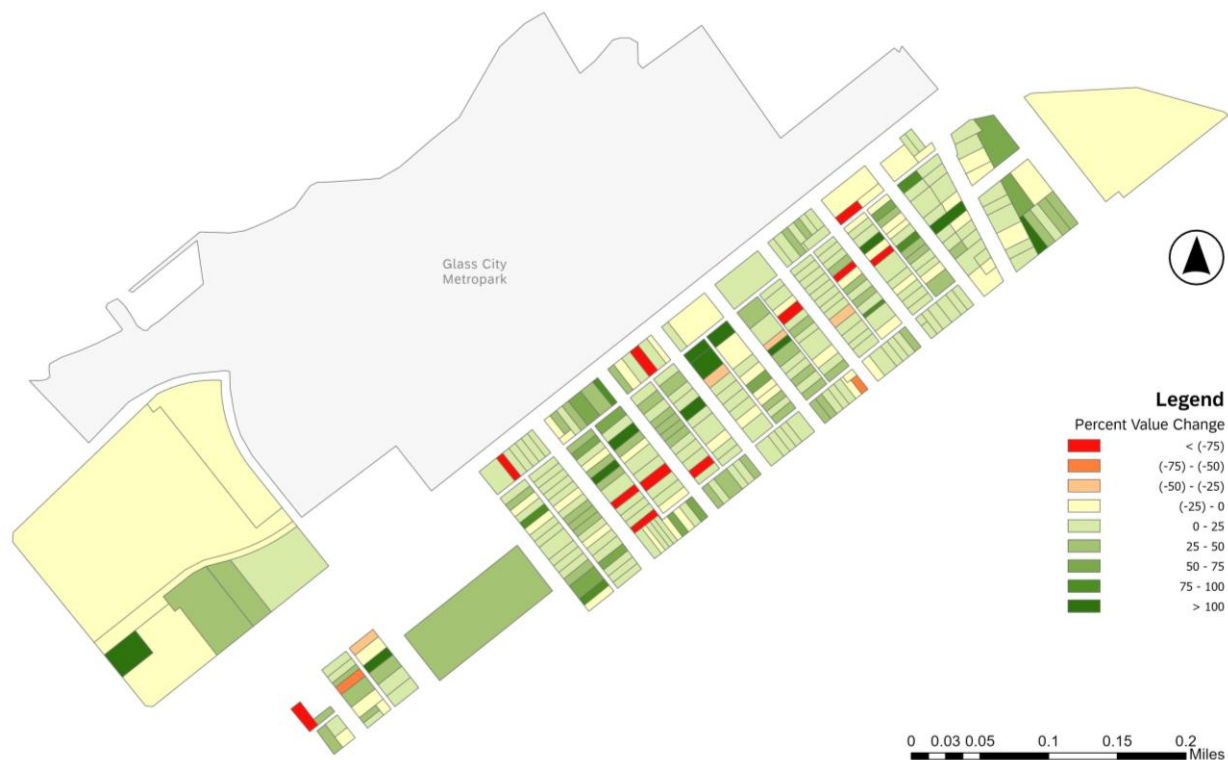


Figure 6.0. Choropleth map of percent property value change from 2020 to 2026 when adjusted for inflation.

Relevance

For additional comparison, this study looks at the Zillow Home Value Index (ZHVI) to identify adjacent economic changes in the City of Toledo. Table 2.0 shows the changes in ZHVI for each zip code within city limits, with the zip code containing Glass City Metropark highlighted in green. The ZHVI identifies average market housing trends and is not a completely equal comparison to property values. However, it reveals that the assessed value of parcels within one block of Glass City Metropark has increased faster than the average market trends.

ZIP Code	2020 ZHVI	2020 ZHVI Adjusted for Inflation (1.229)	2026 HVI	Percent HVI Change
43615	128701	158173	178327	11.3
43613	106026	130306	156540	16.8
43612	74158	91140	117053	22.1
43614	141124	173442	199500	13.1
43605	45202	55553	63674	12.8
43606	130481	160361	191112	16.1
43609	47724	58653	69826	16.0
43607	51532	63333	76377	17.1
43623	143218	176015	205185	14.2
43611	101671	124954	152371	18.0
43608	35595	43746	48149	9.1
43604	55675	68425	63243	-8.2
43617	239719	294615	326534	9.8
43610	40934	50308	61334	18.0

Table 1.0. All ZHVI values for the zip codes within Toledo city limits from 2020 and 2026.

Limitations

- Property values collected from 2020 may be impacted by covid-19 pandemic.
- Commercial properties were found to have much larger property values than residential parcels, which may have skewed or lessened the average property value change.
- Parcels with building loss had significantly lower or negative property value change, which may have skewed or lessened the average property value change.
- Baseline property values from years prior to the first opening of the park could strengthen the findings. Since the park had already opened its first phase in 2020, the property values may have already been impacted by the park's development.

Discussion

- Findings from this study support SmithGroup’s design intent: Project plays a role as a catalyst for new private investment and economic activity in adjacent neighborhoods.
- Although parcel property values are trending upward, the median property value remains very low, making the neighborhood susceptible to gentrification challenges.
- 23.5% Average increase in property values within one block of Glass City Metropark supports the idea of urban parks as community assets.

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Appendix A

Parcel ID	2020 Property Value	2020 Prop Value Adjusted for Inflation	2026 Property Value	Absolute Change	Percent Value Change
1703627	46,600	57271	60,400	3,129	5.5
1703631	49,400	60713	85,900	25,187	41.5
1703434	24,600	30233	42,500	12,267	40.6
1703514	27,200	33429	35,200	1,771	5.3
1703641	6,800	8357	5,600	-2,757	-33.0
1703637	57,100	70176	69,100	-1,076	-1.5
1703547	600	737	700	-37	-5.1
1703504	900	1106	1,400	294	26.6
1703497	33,200	40803	39,500	-1,303	-3.2
1703541	16,100	19787	20,700	913	4.6
1703511	29,500	36256	37,700	1,445	4.0
1703421	45,000	55305	1,000	-54,305	-98.2
1703524	31,100	38222	18,000	-20,222	-52.9
1703517	700	860	900	40	4.6
1703537	6,100	7497	10,000	2,503	33.4
1703521	23,100	28390	38,700	10,310	36.3
1703534	27,700	34043	32,600	-1,443	-4.2
1703621	39,800	48914	50,300	1,386	2.8
1703531	45,800	56288	75,300	19,012	33.8
1703634	800	983	6,500	5,517	561.1
1017171	39,200	48177	51,300	3,123	6.5

400397	40,600	49897	44,500	-5,397	-10.8
1016954	40,900	50266	56,200	5,934	11.8
1017311	30,700	37730	54,100	16,370	43.4
1016864	36,200	44490	50,400	5,910	13.3
1016781	34,300	42155	39,000	-3,155	-7.5
1016957	37,000	45473	56,200	10,727	23.6
1017341	26,900	33060	34,800	1,740	5.3
966821	15,300	18804	37,500	18,696	99.4
1016877	11,200	13765	27,000	13,235	96.2
1887756	346,000	425234	346,000	-79,234	-18.6
400337	34,700	42646	54,300	11,654	27.3
400381	39,300	48300	52,600	4,300	8.9
1887746	468,000	575172	468,000	-107,172	-18.6
1017237	36,600	44981	55,300	10,319	22.9
1016674	35,600	43752	44,800	1,048	2.4
1017094	40,600	49897	66,100	16,203	32.5
739824	48,400	59484	66,700	7,216	12.1
1016987	300	369	700	331	89.9
1017067	500	615	600	-15	-2.4
1016937	36,700	45104	55,400	10,296	22.8
966894	28,200	34658	38,400	3,742	10.8
1016884	44,100	54199	47,300	-6,899	-12.7
1017451	11,800	14502	30,600	16,098	111.0
1016977	1,200	1475	1,400	-75	-5.1
1017027	800	983	1,100	117	11.9
1016907	37,400	45965	55,400	9,435	20.5
1017121	27,600	33920	43,900	9,980	29.4
739864	50,500	62065	65,300	3,235	5.2
1017031	40,800	50143	54,100	3,957	7.9
1017044	35,900	44121	53,700	9,579	21.7
400311	16,300	20033	21,100	1,067	5.3
739987	36,500	44859	56,900	12,042	26.8
1016664	25,000	30725	36,300	5,575	18.1
966867	1,100	1352	1,300	-52	-3.8
1017194	18,500	22737	23,100	364	1.6
739834	24,300	29865	31,400	1,535	5.1
1017107	40,300	49529	46,100	-3,429	-6.9
1017017	25,600	31462	32,900	1,438	4.6
400324	40,500	49775	55,500	5,725	11.5
1016787	14,900	18312	20,300	1,988	10.9
966744	28,700	35272	34,900	-372	-1.1

966891	37,700	46333	52,200	5,867	12.7
1017407	31,300	38468	46,600	8,132	21.1
1887757	142,600	175255	2,062,600	1,887,345	1076.9
1016797	48,400	59484	66,900	7,416	12.5
1017037	20,700	25440	30,000	4,560	17.9
1017374	29,600	36378	46,000	9,622	26.4
1017317	26,000	31954	41,600	9,646	30.2
1016964	33,500	41172	44,000	2,829	6.9
1017324	28,800	35395	37,300	1,905	5.4
1016700	132,200	162474	138,300	-24,174	-14.9
1017351	24,400	29988	35,500	5,512	18.4
966901	15,400	18927	600	-18,327	-96.8
1016834	30,500	37485	45,100	7,616	20.3
400354	25,900	31831	37,400	5,569	17.5
400327	40,300	49529	58,500	8,971	18.1
400394	31,700	38959	47,900	8,941	22.9
1887753	0	0	0	0	0.0
1016997	14,500	17821	19,900	2,080	11.7
1017387	27,000	33183	38,600	5,417	16.3
739867	47,800	58746	65,200	6,454	11.0
966887	36,100	44367	400	-43,967	-99.1
1016756	17,400	21385	26,600	5,215	24.4
1016607	111,600	137156	115,800	-21,356	-15.6
1017447	23,600	29004	38,700	9,696	33.4
739991	20,400	25072	25,500	428	1.7
1017201	1,700	2089	2,400	311	14.9
966911	29,600	36378	35,200	-1,178	-3.2
1017294	22,700	27898	35,800	7,902	28.3
400401	31,600	38836	48,800	9,964	25.7
1017331	800	983	800	-183	-18.6
1017204	33,400	41049	50,500	9,451	23.0
1016744	16,400	20156	38,400	18,244	90.5
1016577	1,000	1229	1,300	71	5.8
1016807	25,100	30848	30,800	-48	-0.2
1016734	5,700	7005	7,000	-5	-0.1
966864	46,000	56534	57,800	1,266	2.2
400364	30,800	37853	39,800	1,947	5.1
1016881	34,400	42278	46,100	3,822	9.0
400344	900	1106	1,400	294	26.6
739931	23,300	28636	49,200	20,564	71.8
1017434	18,200	22368	22,900	532	2.4

1017051	41,400	50881	38,000	-12,881	-25.3
1017301	44,800	55059	55,100	41	0.1
1017081	29,700	36501	44,000	7,499	20.5
1017064	900	1106	1,200	94	8.5
1016994	17,600	21630	27,100	5,470	25.3
1017271	25,200	30971	38,100	7,129	23.0
1016897	33,200	40803	36,700	-4,103	-10.1
1017231	21,200	26055	43,200	17,145	65.8
1017134	26,500	32569	39,000	6,432	19.7
1017234	16,900	20770	19,700	-1,070	-5.2
1017057	28,500	35027	40,900	5,874	16.8
1017177	27,000	33183	37,600	4,417	13.3
1016761	42,500	52233	61,300	9,067	17.4
1017181	22,700	27898	35,100	7,202	25.8
1016574	23,500	28882	24,000	-4,882	-16.9
1016961	44,600	54813	61,500	6,687	12.2
400391	14,300	17575	32,500	14,925	84.9
1016774	15,000	18435	51,200	32,765	177.7
966854	30,000	36870	32,200	-4,670	-12.7
1017124	25,200	30971	36,900	5,929	19.1
1016871	24,700	30356	39,000	8,644	28.5
400387	25,100	30848	30,300	-548	-1.8
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1016714	65,100	80008	65,100	-14,908	-18.6
1017101	35,600	43752	56,700	12,948	29.6
1016947	40,100	49283	64,800	15,517	31.5
400304	700	860	900	40	4.6
1017344	15,000	18435	56,700	38,265	207.6
966917	1,700	2089	2,400	311	14.9
739997	1,000	1229	11,400	10,171	827.6
739817	7,300	8972	9,700	728	8.1
1016677	31,600	38836	39,900	1,064	2.7
400334	17,200	21139	24,300	3,161	15.0
966904	4,500	5531	5,900	370	6.7
1016671	12,900	15854	20,200	4,346	27.4
1017336	33,300	40926	48,100	7,174	17.5
1016921	24,200	29742	400	-29,342	-98.7
966877	32,300	39697	50,700	11,003	27.7
1016657	19,500	23966	30,000	6,035	25.2
1017391	37,100	45596	54,400	8,804	19.3
1016767	29,500	36256	35,800	-456	-1.3

1016727	5,600	6882	6,900	18	0.3
966844	33,700	41417	50,100	8,683	21.0
400314	33,500	41172	46,500	5,329	12.9
1017274	43,300	53216	65,200	11,984	22.5
400347	41,900	51495	62,800	11,305	22.0
400341	26,200	32200	41,100	8,900	27.6
1017197	31,300	38468	40,600	2,132	5.5
1017397	10,300	12659	15,000	2,341	18.5
1017217	38,900	47808	55,900	8,092	16.9
400307	700	860	1,000	140	16.2
1017047	28,300	34781	43,000	8,219	23.6
1016917	500	615	600	-15	-2.4
966851	30,100	36993	36,600	-393	-1.1
1017327	1,900	2335	2,900	565	24.2
1016647	3,500	4302	5,000	699	16.2
1017277	14,220	17476	21,600	4,124	23.6
1016941	12,780	15707	19,460	3,753	23.9
1016934	20,100	24703	18,800	-5,903	-23.9
400377	46,500	57149	59,400	2,251	3.9
1017427	40,600	49897	1,600	-48,297	-96.8
1016971	5,700	7005	5,900	-1,105	-15.8
966921	1,800	2212	2,500	288	13.0
1017011	29,200	35887	45,700	9,813	27.3
1017061	32,600	40065	49,800	9,735	24.3
1016831	45,000	55305	55,500	195	0.4
1016581	37,200	45719	5,600	-40,119	-87.8
1016581	37,200	45719	5,600	-40,119	-87.8
966897	36,200	44490	48,300	3,810	8.6
739984	36,800	45227	56,900	11,673	25.8
966861	19,400	23843	40,500	16,657	69.9
1016584	33,300	40926	47,100	6,174	15.1
400317	30,000	36870	40,100	3,230	8.8
1017174	33,000	40557	51,900	11,343	28.0
1017257	10,200	12536	35,100	22,564	180.0
1017104	30,500	37485	38,200	716	1.9
966757	19,700	24211	39,200	14,989	61.9
1017364	32,500	39943	50,200	10,258	25.7
1016944	21,000	25809	26,400	591	2.3
1016824	55,800	68578	71,700	3,122	4.6
1017454	1,000	1229	1,300	71	5.8
1017361	41,400	50881	56,000	5,119	10.1

739937	38,900	47808	72,600	24,792	51.9
400284	81,900	100655	107,300	6,645	6.6
1016667	34,700	42646	51,900	9,254	21.7
1016874	28,500	35027	44,000	8,974	25.6
1887748	455,200	559441	635,600	76,159	13.6
1016914	9,000	11061	27,300	16,239	146.8
1017127	35,100	43138	600	-42,538	-98.6
1017377	33,900	41663	53,800	12,137	29.1
1017394	35,400	43507	1,900	-41,607	-95.6
1017131	35,700	43875	39,200	-4,675	-10.7
739827	44,600	54813	51,300	-3,513	-6.4
1017021	37,000	45473	55,900	10,427	22.9
1016567	30,500	37485	48,900	11,416	30.5
1016814	42,300	51987	49,700	-2,287	-4.4
1017414	9,700	11921	20,000	8,079	67.8
1016731	5,700	7005	7,100	95	1.4
966841	16,800	20647	26,500	5,853	28.3
1016594	4,100	5039	5,300	261	5.2
739851	35,700	43875	42,700	-1,175	-2.7
966827	51,400	63171	82,300	19,129	30.3
1887755	67,700	83203	115,900	32,697	39.3
400321	22,800	28021	31,200	3,179	11.3
1017157	4,100	5039	19,700	14,661	291.0
1016847	35,500	43630	47,600	3,971	9.1
1017071	35,500	43630	16,900	-26,730	-61.3
1017137	28,400	34904	42,500	7,596	21.8
400367	41,500	51004	62,700	11,697	22.9
966747	43,600	53584	60,300	6,716	12.5
1017384	37,000	45473	55,200	9,727	21.4
1017424	29,300	36010	42,000	5,990	16.6
1017281	47,900	58869	65,800	6,931	11.8
1017267	30,700	37730	23,500	-14,230	-37.7
1017117	44,900	55182	60,500	5,318	9.6
1017314	700	860	1,000	140	16.2
1016794	38,800	47685	50,900	3,215	6.7
1017411	25,000	30725	28,700	-2,025	-6.6
1017087	31,200	38345	40,800	2,455	6.4
1016621	42,700	52478	55,500	3,022	5.8
966924	1,800	2212	2,600	388	17.5
1017167	17,300	21262	22,700	1,438	6.8

1016867	35,500	43630	53,700	10,071	23.1
1017004	34,700	42646	41,600	-1,046	-2.5
1017154	20,600	25317	16,100	-9,217	-36.4
1016904	33,100	40680	49,000	8,320	20.5
1016754	50,300	61819	65,800	3,981	6.4
1017417	1,200	1475	1,400	-75	-5.1
1016861	42,200	51864	47,800	-4,064	-7.8
1016777	20,500	25195	31,500	6,306	25.0
966847	15,200	18681	24,200	5,519	29.5
1017007	32,500	39943	1,300	-38,643	-96.7
1016751	39,900	49037	55,800	6,763	13.8
966754	32,600	40065	41,000	935	2.3
1017224	25,600	31462	30,000	-1,462	-4.6
1017304	17,200	21139	23,100	1,961	9.3
1016841	33,300	40926	45,700	4,774	11.7
1017014	26,400	32446	34,500	2,054	6.3
1017221	33,900	41663	52,200	10,537	25.3
1017041	19,400	23843	25,300	1,457	6.1
966751	41,800	51372	56,700	5,328	10.4
1017421	28,800	35395	42,800	7,405	20.9
1016851	21,600	26546	29,800	3,254	12.3
739841	47,000	57763	64,900	7,137	12.4
739994	900	1106	1,400	294	26.6
1016931	24,800	30479	34,200	3,721	12.2
1017247	47,800	58746	56,500	-2,246	-3.8
1016587	5,900	7251	7,000	-251	-3.5
739947	19,800	24334	24,100	-234	-1.0
400371	20,500	25195	30,000	4,806	19.1
1016984	49,600	60958	74,000	13,042	21.4
400361	24,500	30111	42,800	12,690	42.1
1017161	11,300	13888	19,000	5,112	36.8
1017254	6,000	7374	23,900	16,526	224.1
1017114	54,000	66366	74,800	8,434	12.7
1017077	700	860	800	-60	-7.0
1017143	31,400	38591	54,200	15,609	40.4
1867714	73,600	90454	122,700	32,246	35.6
400297	700	860	1,000	140	16.2
1017457	17,700	21753	37,800	16,047	73.8
400301	31,400	38591	47,600	9,009	23.3
1017431	42,600	52355	58,100	5,745	11.0
1017284	1,300	1598	1,400	-198	-12.4

1017357	33,600	41294	42,500	1,206	2.9
1017024	27,300	33552	40,100	6,548	19.5
1016801	22,200	27284	30,300	3,016	11.1
1016784	38,800	47685	47,900	215	0.5
966837	28,700	35272	53,200	17,928	50.8
1016697	42,500	52233	47,900	-4,333	-8.3
1016901	36,700	45104	45,000	-104	-0.2
739861	34,800	42769	39,200	-3,569	-8.3
1016894	27,500	33798	51,600	17,803	52.7
1017091	15,000	18435	23,300	4,865	26.4
1016887	16,200	19910	17,400	-2,510	-12.6
1017261	7,700	9463	30,400	20,937	221.2
1016791	15,800	19418	25,200	5,782	29.8
1017347	65,000	79885	98,500	18,615	23.3
1016857	40,600	49897	68,400	18,503	37.1
966857	25,200	30971	39,900	8,929	28.8
966914	88,300	108521	92,200	-16,321	-15.0
1016681	38,400	47194	1,200	-45,994	-97.5
1017401	13,000	15977	26,000	10,023	62.7
1017367	27,900	34289	35,900	1,611	4.7
400331	52,200	64154	57,600	-6,554	-10.2
1017371	33,400	41049	52,600	11,551	28.1
1017287	23,000	28267	29,300	1,033	3.7
1016661	200	246	300	54	22.1
1017084	27,000	33183	34,900	1,717	5.2
400404	38,700	47562	58,200	10,638	22.4
1017054	37,300	45842	50,000	4,158	9.1
1016844	27,100	33306	40,800	7,494	22.5
1017214	19,800	24334	31,300	6,966	28.6
966871	33,500	41172	52,400	11,229	27.3
1016891	23,600	29004	39,600	10,596	36.5
1016924	36,200	44490	52,000	7,510	16.9
400357	900	1106	1,300	194	17.5
1016654	5,100	6268	7,400	1,132	18.1
1016771	45,700	56165	62,100	5,935	10.6
1016747	27,200	33429	39,500	6,071	18.2
1017184	43,200	53093	64,900	11,807	22.2
1017354	3,900	4793	6,500	1,707	35.6
400384	25,800	31708	32,100	392	1.2
1017147	29,400	36133	39,700	3,567	9.9
739844	34,000	41786	47,000	5,214	12.5

1017227	33,300	40926	31,500	-9,426	-23.0
1017001	21,400	26301	34,000	7,699	29.3
1016991	39,200	48177	58,600	10,423	21.6
966881	30,700	37730	46,200	8,470	22.4
1017441	1,200	1475	1,400	-75	-5.1
1017034	37,300	45842	53,600	7,758	16.9
966874	4,100	5039	25,500	20,461	406.1
400351	26,600	32691	31,000	-1,691	-5.2
966737	27,800	34166	53,500	19,334	56.6
966741	25,600	31462	56,800	25,338	80.5
1600036	521,200	640555	532,800	-107,755	-16.8
1627988	106,100	130397	106,100	-24,297	-18.6
1887745	1,410,200	1733136	1,410,200	-322,936	-18.6
1800053	39,786,500	48897609	39,857,000	-9,040,609	-18.5
1887749	301,600	370666	301,600	-69,066	-18.6
1800086	35,100	43138	55,800	12,662	29.4