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ZOFNASS PROGRAM
FOR SUSTAINABLE INFRASTRUCTURE
Graduate School of Design
Harvard University

Graduate School of Design
Harvard University
George Gund Hall
48 Quincy Street
Cambridge, MA 02138
June 10, 2019 - REV. 1

East Lake Park Water Quality Improvement Project

The Zofnass Program at Harvard University

Khumalo, W., Rodríguez, J., Prof. Pollalis, S. N.

June 10, 2019

Walburga Khumalo prepared this case study under the supervision of Judith Rodríguez and Prof. S.N. Pollalis as the basis for research and class discussion rather than to illustrate either effective or ineffective handling of the design, the construction, or an administrative situation of a project.

The authors would like to thank David Mason, Jane Madden, and Bernadette Kolb from CDM Smith, and the City of Chattanooga. This case study is part of the research on the business case for planning sustainable infrastructure, and has been developed by the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design http://research.gsd.harvard.edu/zofnass/. The program's mission is to develop and promote methods, processes, and tools that quantify sustainability for infrastructure. Its goal is to facilitate the adoption of sustainable solutions for infrastructure projects and systems, and expand the body of knowledge for sustainable infrastructure.

Executive Summary

The East Lake Park Water Quality Improvement Project is situated in the City of Chattanooga, Tennessee. The City of Chattanooga and Chattanooga Department of Public Works hired contractor CDM Smith to restore the park by improving its water quality and upgrading the recreational areas. For years, the pond has experienced severe eutrophication as algae flourish excessively, killing other life in it. Contractors have responded to this problem by recommending the dredging of the whole pond, cleaning it, then refilling it.

The project represents $15,000 per decade in savings by eliminating specific pond maintenance costs, while total design and construction costs amount to $2,172,520.[1] This includes the cost of constructing a boardwalk, outdoor classroom, and meadow walk, restoring the aquatic and land habitats, as well as restocking the pond with fish. The community surrounding East Lake Park has been heavily involved in the park's transformation. The meadow walk and boardwalk are among the features voted for by residents. These design features have been intended to enhance residents' and visitors' use of the park area, but a great deal of attention has been paid to the water and soil quality of East Lake Park. Design and implementation plans for water and soil quality restoration have been made to ensure the long-term health and sustainability of the East Lake area. Educational projects have been implemented, along with the pond cleaning to avoid future eutrophication, decreasing the total future costs of managing East Lake Park.

The project was analyzed using the five categories of the Envision checklist: *Quality of Life, Leadership, Resource Allocation, Natural World,* and *Climate and Risk.* The Envision evaluation was conducted to better analyze East Lake Park's overall sustainability performance. Of the five, the project performed best in the Leadership category, because of strong stakeholder engagement in decision-making and the foresight to design a spring and pond system that would not need to be continually dredged. The project's score was second best in the Natural World category, as considerable attention was paid to restoring aquatic and land habitats, improving water quality, and preserving greenfields. The Quality of Life category received the third-best score, because of attention paid to community engagement in the designing of the park as well as the park itself providing health and recreational improvements to the East Lake community. The category with the fewest credits achieved was Climate and Risk, because the project's documentation details did not involve climate adaptation. The Resource Allocation category achieved fewer than half the credits possible, as the local sourcing of materials could have received more attention during the construction of recreational elements, as could the designing of management systems to reduce the amount of excavation and wastewater during and after the project's completion.

[1] City of Chattanooga, Tennessee, East Lake Water Quality and Park Improvements, 60% Project Construction Cost Estimate.

Project Background Data

Project Name:	East Lake Park Water Quality Improvement Project
Sustainability Savings (avoided costs):	$15,000 every 10 years[2] saved from avoided dredging
Project Type:	Water quality improvement / park restoration
Location:	District 7, Chattanooga (TN)
Area / Length:	1.75-acre pond within an 18.5-acre park
Owner / Client :	City of Chattanooga; Chattanooga Department of Public Works
Project Team:	Contractor: TBD in the bidding process
	Engineer/designer: CDM Smith
	Facility/project manager: CDM Smith
	Consultants: CDM Smith
Project Lifespan	25-30 years[3]
Current Status:	Phase II: Engineering design in progress
Funding model:	$1,572,520 City of Chattanooga taxes; $600,000 crowdfunding from various organizations;[4] $800,000 donated by the Lyndhurst Foundation
Delivery Method:	Design-bid-build
Overall investment cost estimate:	$2,172,520[5]
O&M cost:	$5,000 annually, $15,000 every 10 years if pond needs to be dredged[6]

[2] Communications with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith, 29 October 2018.
[3] Ibid.
[4] Ibid.
[5] City of Chattanooga, Tennessee, East Lake Water Quality and Park Improvements 60% Project Construction Estimates, 2018.
[6] Communications with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith, 29 October 2018.

Introduction

The East Lake Park Water Quality Improvement Project is a water quality and park restoration project located in Chattanooga, Tennessee. The park was donated to Chattanooga City in 1896 and has been a public recreational area ever since. East Lake Park is located at the foot of Missionary Ridge, in a small formerly middle-class neighborhood that initially housed mill workers. It is Chattanooga's first park from land donated by businessman C. E. James. Many parts of the park, such as its walkways, are falling apart, and recreation areas have been regularly damaged when the pond's waters rise because they are too close to the pond area. Members of the Neighborhood Association hope the park upgrade will enhance neighborhood value, which currently features unkempt apartments, with an active gang and drug crime presence.

The project was approved over four years ago, with the community being promised upgrades during that time. Pressure from the residents living in the area has jump-started the project's revival.[7] The Neighborhood Association became involved with the project as residents became increasingly frustrated with its being given low priority. Miller Park, on the other side of town, began renovations first, even though the East Lake Park project was developed first.[8] One East Lake resident, Lisa Davis, said: "It's like the park doesn't matter, it's like East Lake doesn't matter, but we do matter. The people that live in East Lake do matter."[9]

The East Lake Neighborhood Association and East Lake homeowners and citizens are stakeholders interested in the overall neighborhood improvement that is possible through the project. Teachers at elementary schools in the neighborhood are also stakeholders who seek to benefit from the inclusion of an outdoor classroom in the park. The Lyndhurst Foundation has contributed to paying for the educational aspects of the project. The Chattanooga Parks and Recreation Division, as well as the City Open Space Group, have also been involved in upgrading the recreational aspects of the project.

The East Lake Park Water Quality Improvement Project is being led by Chattanooga's Public Works Department. The Department's Water Quality Program in the Water Quality Engineering Division has been directing efforts to mitigate the eutrophication of the pond. The pond is replenished by a natural spring and by stormwater from the higher elevation of Missionary Ridge, a drainage system that has not been renovated since the 1990s, causing large sediment build-up. The poor-quality replenishment source has gradually increased eutrophication and high turbidity in the pond, leading to the killing of fish and increased unpleasant odors around the park. Exotic plants have also invaded the pond area; there is a need to reestablish native vegetation. Improvements are needed in the pond's drainage area of about 6.9 acres, as shown in figure 1. The pond is not designed to provide flood control; recreational areas are also constantly flooding, indicating a lack of synergy between the park's ecosystem and the area's built infrastructure.

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[7] Tim Pham, WRCB TV, "Residents Near East Lake Park Waiting for Upgrades," 2018, accessed August 2018, http://www.wrcbtv.com/story/36023008/residents-near-east-lake-park-waiting-for-upgrades

[8] Ibid.

[9] Ibid.

Figure 1: East Lake Park drainage area map. Source: CDM Smith.

CDM Smith was hired by the City of Chattanooga to design water quality and pond restoration models. CDM Smith Project Manager David Mason notes:

> ***"The city put out a request for qualifications for consultants to submit. [CDM Smith] submitted and was accepted. We were selected to do this project by the water quality division, but ultimately, because of the drivers that the public brought out, the parks and recreation division got involved because we were making pretty big revisions to the park."***

The estimated cost of the project is $2,172,520.[10] The Lyndhurst Foundation has supported the project by contributing $800,000[11] to upgrade the park. In terms of cost, CDM Smith agreed to a $135,000 design fee. The assessment phase of the ecological quality of the park cost $100,000, and the park construction will cost $400,000.[12]

[10] City of Chattanooga, Tennessee, East Lake Water Quality and Park Improvements 60% Project Construction Cost Estimate, 2018.
[11] Ibid.
[12] Ibid.

The city and CDM Smith have divided the project into three phases. Phase I: Lake Assessment and Concept Plan Design saw an ecological assessment and community feedback. Physical and chemical sediment analysis was completed, in order to determine whether special considerations were necessary for the dredging of the pond. Water quality and overall hydrologic assessment were conducted to determine the capacities of hydraulic structures, including flood storage and water treatment capacity. In Phase II: Full Design Lake with GI Improvements and Constructability, green infrastructure will be installed to reduce roadway and parkway lots. A baffle box will also be installed to reduce sediment loads and floatables to the pond. Passive waterfowl control will be added, to limit the bird population. In Phase III: Water Quality and Park Improvements Dredging of Lake and Construction, the pond will be mechanically drained, with excavated dried sediment to be disposed offsite. A healthy and sustainable aquatic ecosystem, including warm water fishery and wetland vegetation, will be installed. A wetland will be installed upstream to provide nutrient filtering from runoff and denitrification.

Phase I involved scientific analysis of the water and soil quality of the pond in order to determine best practices necessary in the pond clean-up and improvement. The project's conceptual master plan is shown in figure 2.

Figure 2: East Lake Park conceptual master plan. Source: CDM Smith.
Phase II is notable for the great effort put into involving community members in designing the park upgrades.

> ***"When we had our public meetings, we had these design boards that we wanted the public to weigh in on. We had four different ones and assigned each one a color – red, yellow, blue, green – and red, yellow, blue, green***

boxes were brought and fake dollar bills. We asked, If you had one dollar tax revenue to spend on these projects, where would you spend it?"[13]

Phase III is the final project stage that requires the pond to be drained of water before construction and upgrading occur. The project's physical construction and redevelopment fall within this phase.

Sustainability milestones include the improvement of the pond's water quality and the upgrading of a wetland to provide a natural filtering system for the pond, along with the removal of exotic plants and their replacement by native plants. Other milestones include the design and completion of a rock amphitheater for educational purposes. Quite notably, fish stock will be added to the pond's aquatic habitat, restoring the aquatic life lost as a result of water eutrophication. The increasing of the fish population has also been encouraged to allow for sustainable recreational fishing. The project includes a boardwalk that will stretch into the pond and allow for fishing. There will be an outdoor classroom, in order to encourage further education about green infrastructure. The crumbling sidewalks will be replaced with more porous pathways, and wetlands will be created in order to improve water quality flowing into the pond. The project intends to tackle certain environmental challenges, with a focus on water quality improvement.

Project Development

As part of Phase I, the following studies and surveys were completed to assess the environmental quality of East Lake Park: a bathymetric survey conducted by the CDM Smith team to approximate the amount of sediment in the pond; a hydraulic assessment to approximate the capacity of hydraulic structures and existing water quality treatment capacity; and a water quality evaluation, with the city of Chattanooga, to measure the state of water quality and the svD e of eutrophication. Additionally, three processes will occur as a part of the whole project: (1) pond dredging and repair, (2) demolition, (3) overall site work.

(1) Pond dredging and repair process
The plan is to first drain the pond of water and install erosion control products, such as blankets and silt-fencing, around the designated area. Different sediments will be identified and separated as either substandard material or usable material. Then sediments will be removed from the pond using light construction equipment such as skid steers or front-end loaders and stockpiled in a designated area away from the pond. The pond lining will be inspected and repaired as needed. Regrading of the southwest corner of the pond will be done to create a beach access area. A boardwalk/fishing platform with railing and associated lighting will be constructed as a part of the pond. Next, wetland beds will be constructed around the pond fringe, and submerged fish habitat structures as well as spawning substrates will be installed while the pond is dry. Wetland plantings will be installed in the constructed wetland beds. Some plantings will be installed at specified water levels during refilling of the pond. The pond will then be refilled as directed in plan, and the pond will be stocked with warm water fish.[14]

[13] Interview Call with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith, 28 September 2018.
[14] Tennessee Department of Environment and Conservation. East Lake Park CN-1091 Application for Aquatic Resource Alteration Permit and State 401 Water Quality Permit, p 12.

(2) Demolition process
Mechanisms used to prevent soil erosion will be installed around the pond. Concrete liner and rim in the southwest corner of the pond for beach access area will be demolished, as well as footpaths, tennis court, and other items per demolition plan. Lastly, demolished items and substandard material will be removed from the site.[15]

(3) Site work
New swale and adjacent floodplain planting areas will be constructed using the soil already on site, followed by regrading of the site as shown in the plan. New footpaths and footbridges will be constructed as well as a new playground, beach access, and outdoor classroom area. Landscaping elements including upland plantings will be installed, and park light posts and electrical wiring will be relocated. Railing around the pond will be constructed and new park signage will be added. Excess soil material will be removed from the site and disturbed areas will be sodded and seeded per plan. Finally, erosion control measures will be removed from the site.[16]

Total construction costs for the entire park added up to $2,172,520, including the cost of permits, taxes, and insurance ($120,000), contractor fees ($330,000), and construction contingencies (15% for $275,000). With regard to general site clearing, a total of $84,740 was spent on site clearing, pipe disposal, sediment control, seeding, traffic control, and local drainage modification. Miscellaneous site improvements were the most expensive, totaling $467,000. These costs include repairing the concrete lining inside the pond, demolishing the non-porous walkways and tennis courts, electrical lighting upgrades, and adding a railing to the walkways.

Sustainability Features

The sustainability and longevity of the pond and the park are prioritized in the project strategy. Key components were incorporated into the pond and park redesign in order to make sure the park would become an environmental asset that could benefit the neighborhood's ecosystem and property values.

The sustainability objectives of the East Lake Park project prioritize the improvement of the water quality of the pond, as well as the maintenance and improvement of the native fish population. The project also increases native vegetation around the pond while removing exotic plant life. The upgrading of a natural filter system (wetland) is a major objective, in order to decrease eutrophication in the pond. The following project features are considered to be the sustainability features of the project: pond restoration, spring restoration, community participation, outdoor classroom, replacing impervious surfaces with pervious ones, and improving aquatic and terrestrial environments and habitats.

a. Pond Restoration

[15] Ibid.
[16] Ibid.

The entire pond will be dredged, meaning all the water will be removed and the sediments will be filtered, in order to improve the overall soil and water quality of the pond. A wetland will be constructed as a means of naturally filtering the water that enters the pond. The increase of plant life as a part of the restoration project will serve to increase the efficiency with which the wetland sustainably filters water entering the pond. Parts of the pond will also be reconstructed to create a beachfront area, increasing the recreational value of the pond. Importantly, the native fish, animal and plant species will be restored to historical accuracy as a part of the environmental conservation and improvement goals.

The main economic aim of the project is to increase the pond's recreational and environmental value while reducing the cost of maintaining the project. The focus on dredging the pond as well as daylighting the spring is intended to reduce the costs of maintaining and cleaning the pond annually and every decade or so. Lake habitat restoration, which includes fish stocking, planting, wetland zoning, and fish habitat design, costs $68,450. Lake sediment removal incurred a higher cost, at $129,250, with costs going toward the actual sediment extraction as well as the dewatering of the pond before the necessary removal. Sediment control and local drainage control take up $25,000 of the budget each.

b. Spring Restoration

The daylighting of the spring is vital for ensuring that water in the pond stays clean and of high-quality. It will be designed as a natural channel that captures and filters stormwater before the water enters the pond. The changing of the manmade infrastructure, especially in rebuilding pathways using pervious surfaces, also contributes to the improvement of the park's ecology and water quality, as more water can be filtered through soil and enter the water table, forming part of the natural water cycle.

In the daylighting process, the spring will be redirected from the drainage system and allowed to flow in its natural state, through soil and foliage into the pond. The design of natural channel features to convey water to the pond improves the overall water quality entering the pond as well as the captured stormwater to maintain water levels and sufficient native vegetation. A meadow walk around the daylighted spring will also be included, as a means of increasing recreational space for people.

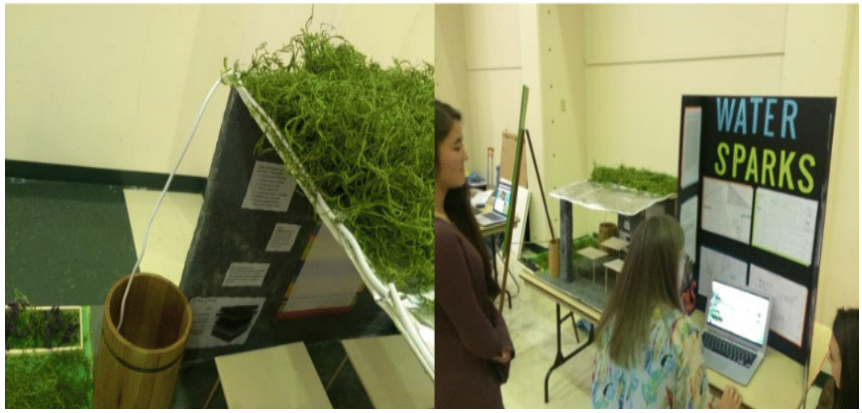
The main goal of the project is to stabilize the ecosystem of the park, especially its pond. Economically, reestablishing the natural ecosystem is a part of the plan, in order to avoid the cost of regularly removing sediments within the pond every 10 years. The spring restoration work, as well as the construction of a wetland, will be the main components that reduce dredging costs, as these systems will work to naturally filter stormwater into the pond, preventing eutrophication.

c. Community participation

The project team collaborated with teachers to design a rock amphitheater, used designs drawn by children to inspire the amphitheater design, gathered feedback from people and the Neighborhood Association about park and pond upgrades, and set up a booth in the park seeking informal ideas from the public, including a funny money game (putting "funny money"

bills into buckets representing different possible improvements – e.g., boardwalk).[17] The boardwalk cost totals $167,500. The meadow walk totals $144,800, including several bridges amounting to $77,000 that create a continuous path through the meadow.

In 2015, the Tennessee Stormwater Association awarded the City of Chattanooga Water Quality Program $10,000 for a Green Development Grant Project. The project, referred to as Partnership for LID Student Education, is a student competition in which students designed green infrastructure models in order to raise awareness about stormwater and green infrastructure among the community and students, as shown in figures 3-4. Four middle school teams were challenged to design an outdoor classroom for East Lake Park in order to further educate the public about green infrastructure and water quality.[18] These middle school learners were taught by the design-thinking team Bright Spark about water quality and green infrastructure. The learners were then taken to the park site, where they could ask community members questions as well as immerse themselves in the parts of the park where design intervention was needed. Their prototypes received feedback from design professionals, and ideas such as a "green infrastructure" lesson plan at the outdoor amphitheater have been incorporated into the East Lake Park management and planning development. The sustainability features included in the East Lake plans have been collaborative, as the community has been heavily involved with what they would like to see in the park.



Figures 3-4: Green Development Grant Project; Best Water System Prototype. Source: CDM Smith.

d. Outdoor Classroom

The recreational outdoor classroom and boardwalk through the pond increase the value of the park for the surrounding community. The project developers can be commended for their deliberate inclusion of all stakeholders – mostly the community members of the East Lake

[17] Interview call with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith, 28 September 2018.
[18] Tennessee Stormwater Association Green Development Grant Green Sparks: Outdoor Classroom Design Competition, p. 2.

Park area. Most of the sustainability features address the needs and desires of the community, because of the collaborative processes during the planning and designing of the East Lake Park upgrades. The outdoor classroom design went a step further by involving school learners and teachers in the project development. The East Lake Park Neighborhood Association regularly invited teachers to the cafe in the park for free coffee as a way of strengthening the relationships between parents and teachers as well as to encourage teachers to contribute their ideas and share their needs during the park designing process. CDM Smith's David Mason shared thoughts on the relevance of teacher engagement, noting:

> ***"The teachers are engaged, because there is the education component, and that education component was brought in by the Lyndhurst Foundation who were providing funding to the city for the project."***

The outdoor classroom will provide the East Lake Elementary School with space to conduct lessons on environmental education. The restoration provided an opportunity to educate learners on forest ecology, wetland ecology, nature hiking, and dendrology (the study of trees).[19] The park's play area was previously situated in a part of the park prone to flooding. In the redesign, the recreational area for children will be moved to another location and will include a rock amphitheater, which will serve as an outdoor classroom to educate school learners about the environment and other academic topics chosen by their teachers. The teachers at the school have also been heavily involved in the design choices included in the rock amphitheater. The cost of constructing the outdoor classroom is $12,500.

e. Replacing impervious surfaces with pervious surfaces

Numerous walking paths around the daylighted spring and the rock amphitheater are included in the design to increase the park's recreational use. About 70-80% of the impervious surfaces will be replaced with materials and soils that allow water to filter through into the ground, to increase the natural water quality and drainage management throughout the park. Figure 5 shows the areas around the pond and paths where pavement will be upgraded to pervious surfaces. The addition of pervious pavement is the second largest incurred cost, totaling $253,400.

[19]CDM Smith, City of Chattanooga, East Lake Park TVA & USACE NWP Application, p. 83.

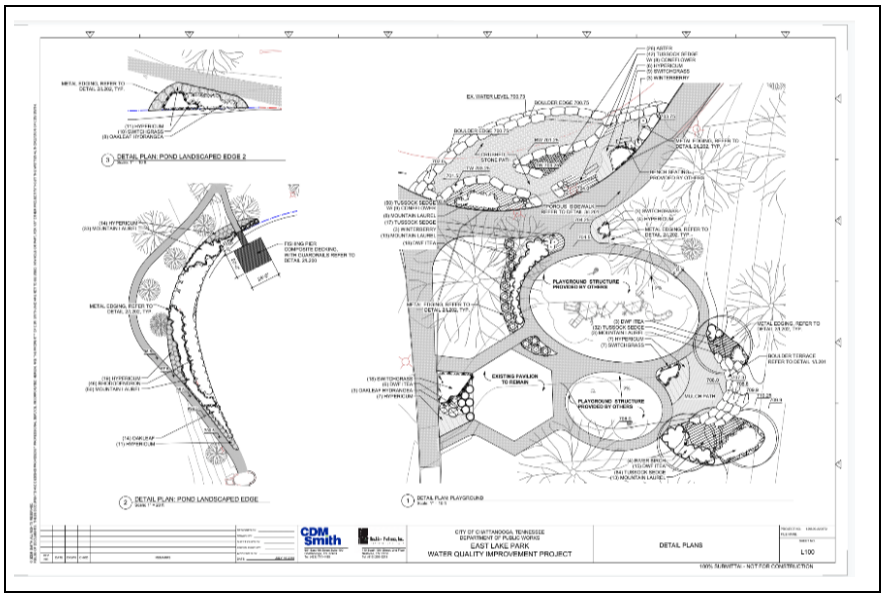


Figure 5: Detail plan showing hardscapes and pond's edges, proposed park design. Source: CDM Smith.

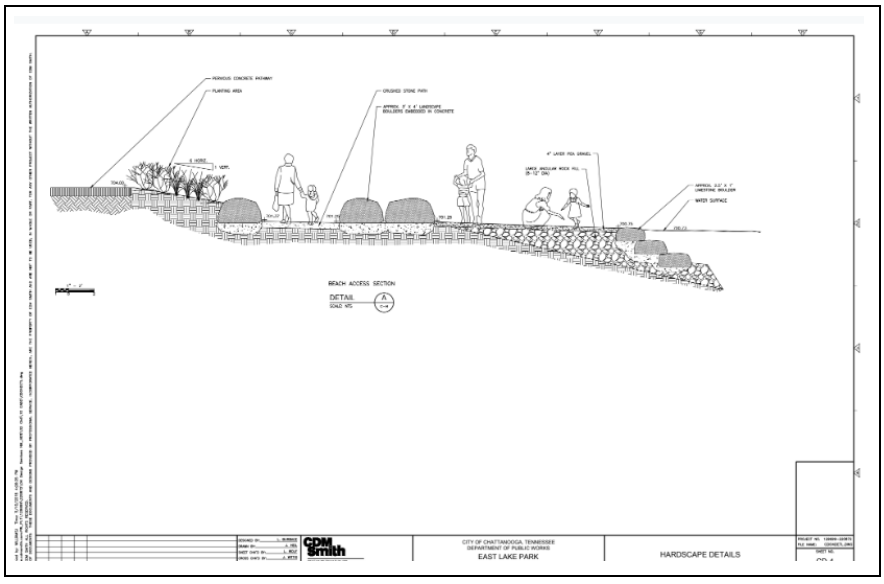


Figure 6: CDM Smith hardscape details: beach access. Source: CDM Smith.

f. Improving aquatic and terrestrial environments and habitats

The upstream wetland naturally filters nutrients from runoff, reducing sediments from stormwater flowing into the pond and increasing water quality. More native plant species will be replanted to balance the ecosystem overtaken by exotic species that need to be eliminated. Figure 6 shows in section the planting beds and the design of a more naturalized water edge for the pond. Waterfowl species have been identified as the dominant pollution source of the pond. Maintaining high-quality water management is unlikely so long as the waterfowl population remains high. Consequently, the waterfowl population will be relocated. Additional precautions had been taken prior to the beginning of project construction to ensure that waterfowl and other animal species are not negatively impacted by the project.[20]

The replenishment of fish life is the biggest habitat upgrade. CDM Smith Project Manager David Mason discussed this in an interview:

> ***"as part of [the] design, [they] are adding several fish structures, a spawning bed in the lake and are restocking the lake with native fish."***[21]

The aquatic life already in the pond includes koi and bluegill fish. Canadian geese, mallard ducks, Muscovy ducks, American Pekin ducks, the belted kingfisher, and the great blue heron are bird species identified within the area.[22] The koi fish, Muscovy ducks, and Pekin ducks are among the non-native species present in and directly around the pond in East Lake Park. The large presence of these bird species has contributed to the high rate of eutrophication occurring in the pond waters. Educational signage encouraging civilians not to feed these animals or throw bread into the pond will form part of the entire sustainability initiative, as a means of eliminating the recurring eutrophication.

Birds closer to areas with more trees and shrubs include the blue jay, catbird, mourning dove, house finch, mockingbird, robin, song sparrow, and bluebird. Birds that specifically prefer the woodlands include woodpeckers, the great-crested flycatcher, the titmouse, woodthrush, and wrens. The woodthrush was the only bird species listed under conservation concern.

Native trees, shrubbery, and wildflowers will be planted around the wetland, pond, and throughout the rest of the park, in order to supplement the existing hardwood trees occupying the space. East Lake Park already has a considerable population of large hardwood trees, primarily oaks, cypress, elm, hackberry, magnolia, and chestnut. The chestnut trees were likely planted as part of the Chattanooga Chestnut Tree Project as a way of restoring the American chestnut in the Southern Appalachian and Cumberland Plateau regions.[23] These trees will be preserved, while the new plants will serve to diversify the ecosystem and restore native plant life to the area.

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[20] CDM Smith, City of Chattanooga, East Lake Park TVA & USACE NWP Application, p. 29.
[21] Interview call with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith, 28 September 2018.
[22] CDM Smith, City of Chattanooga, East Lake Park TVA & USACE NWP Application, p. 82.
[23] Ibid, p. 83.

The neighborhood group seeks to engage more of the community by utilizing the park and its upgraded resources. There is a possibility for WiFi service to be supplied in the park, in order to have after-school study programs. The neighborhood group will have access to the pavilion and plans to use it to open a coffee shop in the mornings to better engage with teachers. The effort put into making East Lake Park more sustainable has also been increasingly educational, for the benefit of the East Lake residents and their schoolchildren. The collaborative nature of the project has been coordinated with the goal of increasing East Lake Park's longevity. The cafe inside the park is not for profit. There are no profit-generating projects inside the park. Added costs include the potential addition of a boat launching ramp after the park is reopened, but that is still a matter of discussion for the project.

Envision Rating System Assessment: Summary by Category

The Envision Rating System checklist is a quick self-assessment tool to give an overview of the sustainability performance of a project. These questions are specific to the criteria of each individual credit found in Envision version 2. Envision v2 organizes the credits into five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk.

The assessment consisted of a series of "Yes", "No," and "Non-applicable" questions that were answered by Project Manager David Mason from CDM Smith during interviews. In total, 7 of 60 credits were considered non-applicable.

Of the five categories, the project performed best in the Leadership category. The second best was the Natural World Category. The Quality of Life Category placed third, while the Resource Allocation and Climate and Risk categories were fourth and fifth, respectively.

The Leadership category focuses heavily on collaboration between stakeholders as well as management and planning of the project by stakeholders. This project fared best in the Leadership category because a lot of attention was paid to ensuring community members' needs and ideas were integrated into all stages of the project's design. CDM Smith and the City of Chattanooga proved very dedicated to designing for sustainability. Lastly, long-term management systems were researched and organized as a way of ensuring the park's longevity and high environmental quality (in ecosystem quality and community value) for years to come.

The East Lake Park is already a very impressive green project, and it did very well in the Natural World category because considerable effort was put in by the team to ensure that the environmental and natural quality of the park remained a priority. The water and soil quality were heavily researched, with plans to improve their conditions for the long term by creating a wetland that will assist in the filtering of water that continuously enters the pond.

The Quality of Life Category saw the third-best performance overall. The East Lake citizens have been heavily involved with the planning of the East Lake Park upgrade. Attention to the interests of the community was prioritized, as indicated by the inclusion of an outdoor

classroom and boardwalk in the final design plans. Historical restoration of the park was also an important addition in the Quality of Life category, through the replenishment of aquatic life that existed in the pond before the increased eutrophication of its waters.

The Resource Allocation category saw the second-lowest performance overall, as there was insufficient information about the net embodied energy of the materials used in the park upgrade. More could have been done to improve energy savings and water management during and after the upgrade, but the project did well in ensuring that limited waste material would leave the construction site.

The Climate and Risk category had the lowest performance because there was insufficient documentation on how the park upgrade could be integrated into the climate mitigation framework. More life cycle assessments focused on the materials used to upgrade the site and manage the pond could have been completed.

Figure 7: Overall performance in Envision v2 self-assessment. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

Quality of Life

			Y	N	NA	
QUALITY OF LIFE	PURPOSE	QL1.1 Improve Community Quality of Life	3	0	0	3 of 3
		QL1.2 Stimulate Sustainable Growth and Development	1	2	0	1 of 3
		QL1.3 Develop Local Skills and Capabilities	1	2	0	1 of 3
	COMMUNITY	QL2.1 Enhance Public Health and Safety	0	1	0	0 of 1
		QL2.2 Minimize Noise and Vibration	0	1	0	0 of 1
		QL2.3 Minimize Light Pollution	1	0	0	1 of 1
		QL2.4 Improve Community Mobility and Access	1	2	0	1 of 3
		QL2.5 Encourage Alternative Modes of Transportation	0	2	0	0 of 2
		QL2.6 Improve Site Accessibility, Safety and Wayfinding	2	1	0	2 of 3
	WELLBEING	QL3.1 Preserve Historic and Cultural Resources	2	0	0	2 of 2
		QL3.2 Preserve Views and Local Character	2	0	0	2 of 2
		QL3.3 Enhance Public Space	2	0	0	2 of 2
		TOTAL	15	11	0	15 of 26

Figure 8: Performance in Quality of Life. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

In the Quality of Life category, the project performed well in 6 out of 12 credits. Overall, the Quality of Life category sits right in the middle in terms of performance among the five categories.

In the Purpose subcategory, the project performed the best in QL1.1 Improve Community Quality of Life, as the community and Neighborhood Association were directly involved in design decisions. According to interviews with the Project Manager, door-to-door surveys were performed and they tried their best to integrate the desires of the East Lake community. They could improve their performance in QL1.2 Stimulate Sustainable Growth and Development (the project does not contribute to local employment or productivity, but pond restoration makes the community more attractive to real estate investors and businesses) as well as 1.3 Develop Local Skills and Capacity (they could improve skills capability by hiring and training more local workers, but the city prefers using local nurseries and contractors to complete the project).

The Community subcategory had the lowest performance of the three subcategories, as more attention could be paid to improving the project's use of materials during construction. 2 of the 6 credits scored high. QL 2.1 Enhance Public Health and Safety performed poorly because the use of new materials and technologies during construction was regulated by standard requirements, with little effort to go above the status quo. QL2.2 Minimize Noise and Vibration performed poorly because the project chose to use a business-as-usual approach to sound pollution during the construction phase. QL2.3 Minimize Light Pollution did well, as the design decision to have lights along the park railing, as opposed to having overhead spotlights, reduces the light filtering out of the park into the East Lake Neighborhood. The project could use improvement on the credit QL2.4 Improve Community Mobility and Access, as the park only provides walking paths, with little consideration of connecting to transport infrastructures outside the park area.

The Wellbeing subcategory performed the best, with all 3 credits achieving the highest scores. QL 3.1 Preserve Historic and Cultural Resources excelled as the historic nature of the pond is being restored, including the replenishment of fish that were once a part of the park's fabric in its earliest days. The designing of a rock amphitheater and addition of a boardwalk upgrade the park's atmosphere; as expected, QL 3.2 Preserve Views and Local Character as well as QL 3.3 Enhance Public Space scored perfectly.

Leadership

LEADERSHIP	COLLABORATION	LD1.1 Provide Effective Leadership and Commitment	3	0	0		3 of 3
		LD1.2 Establish a Sustainability Management System	0	1	0		0 of 1
		LD1.3 Foster Collaboration and Teamwork	3	0	0		3 of 3
		LD1.4 Provide for Stakeholder Involvement	3	0	0		3 of 3
	MANAGEMENT	LD2.1 Pursue By-product Synergy Opportunities	1	0	0		1 of 1
		LD2.2 Improve Infrastructure Integration	3	0	0		3 of 3
	PLANNING	LD3.1 Plan for Long-term Monitoring and Maintenance	1	1	0		1 of 2
		LD3.2 Address Conflicting Regulations and Policies	0	2	0		0 of 2
		LD3.3 Extend Useful Life	1	0	0		1 of 1
		TOTAL	15	4	0		15 of 19

Figure 9: Performance in Leadership. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

The project performed best in the Leadership category. Overall, the East Lake Park Project scored perfectly in 6 of the 9 credits in this category, with the Collaboration subcategory achieving highest scores in 3 of the 4 credits.

Leadership in charge of the park upgrades include the City of Chattanooga, Chattanooga Department of Public Works, and CDM Smith. The project performed perfectly in LD 1.1 Provide Effective Leadership and Commitment, as leadership continues to regularly update news services about the park renovations. CDM Smith hired ecologists, and Phase I of the project included chemical and physical assessments of the sediments, water quality, and water network of the pond and park, in order to better understand how water quality could be improved. These pre-project assessments indicate an interest in sustainability as the project's upgrades were made context-specific to the quality of the park's ecology. LD 1.2 Establish a Sustainability Management System needs improvement. No post-upgrade plan was made, despite the pond having previously suffered because no such plan was made after its previous renovation the 1990s. LD 1.3 Foster Collaboration and Teamwork scored perfectly. The city managers and contractors engaged with the many stakeholders involved in the park upgrade. These stakeholders included residents of East Lake Park, the Neighborhood Association, and teachers. Consequently, those who would be using the park often became a part of the decision making. The teachers using the rock amphitheater for educational events and the Neighborhood Association were invited to participate in meetings between the city and contractors. LD 1.4 Provide for Stakeholder Involvement also scored perfectly as residents of East Lake were identified. They were continually brought out and were encouraged to contribute to design decisions, such as the inclusion of a boardwalk. Fun fair events were held at the park, encouraging people to play games as a part of deciding what they wanted to see improved in the park.

The Management subcategory scored the highest, with both of its credits scoring perfectly. LD 2.1 Pursue By-Product Synergy Opportunities did well as materials dredged from the pond require testing and reuse on site. LD 2.2 Improve Infrastructure Integration scored perfectly as the Project Leaders are working to redesign and improve the wetland near the pond as a way to ensure the maintaining of high-quality water and less eutrophication of the pond. The moving of the playground to a park area with no flooding improves the relationship between ecosystem and built infrastructure in the area.

In the Planning subcategory, 1 of the 3 credits scored perfectly. LD 3.1 Plan for Long-term Maintenance and Monitoring did reasonably well, as there are vegetation and fishery plans, but the plans are not well-detailed, nor has there been agreement on who will manage and execute these plans. LD 3.2 Address Conflicting Regulations and Policies did poorly because no consideration was put into how existing policies within the city might limit the potential for the project to be sustainable, nor is there any plan to research or approach the city with potential policy-related limitations. LD 3.3 Extend Useful Life scored perfectly as natural infrastructure will be restored and improved in order to avoid repeated dredging in the future.

Resource Allocation

Figure 10: Performance in Resource Allocation. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

The project scored perfectly in 3 of the 13 credits in the Resource Allocation category, and reasonably well in 2 others. More can be done to better understand the materials and tools used during the upgrading process. Overall, the Resource Allocation category did not perform as well as the other categories, only performing better than Climate and Risk.

The Materials subcategory had 2 out of 7 credits achieve high accreditation, 1 score average, and the remaining 4 score poorly. RA1.1 Reduce Net Embodied Energy left room for improvement. There is insufficient information about the net embodied energy created during construction and operation. RA1.2 Support Sustainable Procurement Practice did poorly, as it is unknown where the virgin materials and tools used in the project will be obtained. RA 1.4 Use Regional Materials did well, as the project intends to source over 30% locally produced materials. Plants, lumber, fish, and rocks are sourced from within the region. RA 1.5 Divert Waste from Landfills scored poorly because waste will be created when the playground demolition occurs; although it is not a major part of the project, a lot of the materials will not be recycled. RA 1.6 Reduce Excavated Materials Taken Off-Site scored perfectly. Specs were written in a way that requires testing of dredged material as much as possible. The material is nutrient-rich and can be mixed with lower-grade topsoil to contribute to a healthier, high-quality ecosystem within the pond. RA 1.7 Provide for Deconstruction and Recycling did poorly, as there will be no assessment of which products can be recycled upon project completion.

The Energy subcategory achieved 0 of the 3 credits listed. RA 2.1 Reduce Energy Consumption left room for improvement; despite changing light bulbs, there has been no study done on energy use reduction. RA 2.2 Use Renewable Energy performed poorly because the project owners have not taken renewable energy use into consideration. RA 2.3 Commission and Monitor Energy Systems scored poorly because no system will be put in place to monitor how energy systems perform once the upgrades have been completed.

The Water subcategory also left room for improvement. RA 3.1 Protect Fresh Water Availability can improve, as the water quality would be assessed and protected under the project. This is because water refilling the pond during upgrading isn't all coming from the spring. Freshwater withdrawal of receiving waters is non-applicable because there is no withdrawal during project operations. RA 3.2 Reduce Potable Water Consumption could be

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improved by considering the type of water source to refill the pond during the upgrade. RA 3.3 Monitor Water Systems could also be improved by implementing water monitoring post-construction. Strategies to monitor and detect leaking during operations was non-applicable.

Natural World

SITING	NW1.1 Preserve Prime Habitat	3	1	1	3 of 4
	NW1.2 Protect Wetlands and Surface Water	3	0	0	3 of 3
	NW1.3 Preserve Prime Farmland	1	0	0	1 of 1
	NW1.4 Avoid Adverse Geology	3	0	0	3 of 3
	NW1.5 Preserve Floodplain Functions	4	0	2	4 of 4
	NW1.6 Avoid Unsuitable Development on Steep Slopes	0	0	2	0 of 0
	NW1.7 Preserve Greenfields	2	0	0	2 of 2
LAND & WATER	NW2.1 Manage Stormwater	0	2	0	0 of 2
	NW2.2 Reduce Pesticide and Fertilizer Impacts	2	3	0	2 of 5
	NW2.3 Prevent Surface and Groundwater Contamination	3	1	0	3 of 4
BIODIVERSITY	NW3.1 Preserve Species Biodiversity	3	1	0	3 of 4
	NW3.2 Control Invasive Species	1	2	0	1 of 3
	NW3.3 Restore Disturbed Soils	1	1	0	1 of 2
	NW3.4 Maintain Wetland and Surface Water Functions	5	0	0	5 of 5
	TOTAL	31	11	5	31 of 42

Figure 11: Performance in Natural World. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

The Natural World Category achieved perfect scores in 6 of the 13 applicable credits and did fairly well in another 4. Overall, the Natural World category achieved the second best accreditation, behind the Leadership category.

The Siting subcategory did the best, achieving perfect scores in 5 of the 6 applicable credits. NW 1.1 Preserve Prime Habitat only struggled in improving the synergy of surrounding habitats. The inclusion of a 300 ft natural buffer between the site and habitats was non-applicable because it is a park area that engages directly with the natural habitats. NW 1.2 Protect Wetland and Surface Water was fully credited, as development on the wetlands and degrading of preexisting buffer zones were strictly avoided. NW 1.3 Preserve Prime Farmland remains non-applicable, as the site has no farmland on or near it. NW 1.4 Avoid Adverse Geology was non-applicable, as the research team did boring studies under the pond and the spring but located no adverse geology. NW 1.5 Preserve Floodplain Functions scored perfectly. The area has been FEMA-registered as low risk, so protecting infrastructure against flooding has been considered. NW 1.6 is non-applicable because the site has no steep slopes. NW 1.7 Preserved Greenfields was perfectly accredited, as the park itself is a large greenfield, and nothing is being built on top of the green areas. Pavings that were previously greyfield will be made more porous.

The Land and Water subcategory left room for improvement, achieving fairly well in 1 of the 3 credits. NW 2.1 Manage Stormwater scored poorly as no attention will be given to the reduction of stormwater runoff to pre-development conditions, and water storage capacity will not be improved in any way either. Credit NW 2.2 Reduce Pesticides and Fertilizer Impacts scored poorly because little attention has been paid to designing a plan that reduces the amount of fertilizer the park will use. NW 2.3 Prevent Surface and Groundwater Contamination achieved ¾ of the credit, with the prevention of spills and leaks being the only feature that will

not be incorporated. Preventing future contamination is already a part of the design plan, as educational information will be provided, making park-goers aware not to feed the geese. This awareness will be done with the goal of reducing eutrophication of the pond.

The Biodiversity subcategory achieved perfect accreditation in only 1 of the 4 credits. NW 3.1 Preserve Species Biodiversity scored almost perfectly, but no design ideas were put into creating wildlife movement corridors. NW 3.2 Control Invasive Species did poorly because no comprehensive management plan will be put into controlling, eliminating, and preventing the spread of invasive species. The future encroachment of invasive species could also be better anticipated and planned for. NW 3.3 Restore Disturbed Soils was only partially accredited because less than 100% of the soil disturbed before the pond's development will be restored. NW 3.4 Maintain Wetland and Surface Water Functions scored perfectly, as assessment and management plans have been implemented to maintain water quality, hydrologic connection, and maintain existing habitat.

Climate and Risk

Figure 12: Performance in Climate and Risk. Source: Zofnass Program for Sustainable Infrastructure, and interviews with David Mason, Project Manager and Associate Water Resources Engineer, CDM Smith.

Overall, the project achieved the least number of credits (none) in the Climate and Risk category. The subcategory Emissions was uncredited because no life cycle carbon assessment was conducted for the fulfillment of CR 1.1 Reduce Greenhouse Gas Emissions. CR 1.2 Reduce Air Pollutant Emissions was also uncredited because dust and odor reduction specifications were not included in the project design.

The Resilience subcategory was uncredited because climate impact assessment and adaptation plans were not created; consequently, CR 2.1 Assess Climate Threat remained unfulfilled. An analysis of the project's long-term risks and vulnerabilities was not completed, leaving CR 2.2 Avoid Traps and Vulnerabilities unfulfilled. CR 2.3 Prepare for Long-term Adaptability remained uncredited because possible environmental changes were not considered in the project's life cycle.

Next Steps

The next steps for the project involve the bidding for its construction. In conclusion, the project's golden achievement is ensuring the water that enters the pond can self-clean, saving the city thousands of dollars in dredging costs and more importantly revitalizing the natural ecosystem within and around the pond. The consistent and creative ways in which the city and project developers engaged with the neighborhood created a design that serves to

improve the value of East Lake socially and economically. CDM Smith's David Mason had this to say:

"We want to design and develop a sustainable infrastructure system that can function on its own, without us having to interfere every couple of years."

This project, overall, was planned and designed with self-sufficiency and sustainability of the water system in mind. Other components, such as fauna and foliage restoration, serve to enhance this initial goal, revitalizing the whole urban landscape in East Lake Park, Chattanooga, Tennessee.

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