Landscape Architecture Foundation

11th Street Bridge Park Landscape Performance Analysis: Environmental Metrics

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December 2016

Executive Summary

The following report provides background information and recommends that the environmental impacts of the 11th Street Bridge Park be measured in the following categories. Details on each can be found in the Environmental Performance Metrics section of this report.

Introduction

Landscape performance is rapidly emerging as a vital way to represent and articulate the value of excellent design, and to provide reliable and valid evidence to support design and management decisions. Landscape performance can be defined as a measure of the effectiveness with which landscape solutions fulfill their intended purpose and contribute to sustainability.

At its core, performance evaluation seeks to understand, manage, and improve the performance of a system. The results can demonstrate the success of a project and the contribution it makes toward environmental, social, and economic goals. Results may also show that certain goals or aspects of the design intent are not being met. In this case, performance evaluation helps to inform how a project and/or its ongoing management might be modified for better results. Understanding the performance of built landscapes will also lead to better informed choices on future projects thereby increasing our collective knowledge and capacity for sustainable development.

This report is the product of a partnership between the 11th Street Bridge Park and the Landscape Architecture Foundation and is intended to serve as a model for how landscape performance should be integrated into the design and development process. It represents an important first step in the performance evaluation process. The Landscape Architecture Foundation has worked with the 11th Street Bridge Park staff to document environmental performance goals and objectives, make recommendations to collect baseline information, and propose a set of metrics and methods that can be used to effectively evaluate the Bridge Park's performance once it is built and operating. Many of these metrics can also be used to test scenarios and inform the design of the space.

Measuring Performance

Performance evaluation should strive to measure outcomes not outputs. In landscape projects, outputs are things like the number of trees planted, the amount of area covered in highly reflective materials, or the length of protected bike lanes added. Outcomes are the impacts those things have, or essentially the benefits they provide. Landscape performance outcomes, therefore, include measurements like localized temperature improvements, the amount of carbon sequestered, or reductions in the number of bike accidents.

In order to evaluate the performance of a project, it is essential to understand the overall goals and design intent. Performance evaluation by definition requires that there are performance objectives to measure against. Since this is often not the case with landscape projects, performance is frequently measured against a baseline "before" condition or a comparable "conventional" landscape. To be most effective, measurable goals must be set and performance measurement considered throughout the design process. This allows different design concepts and iterations to be modeled and tested against those goals and it allows for the collection of relevant baseline information to show change over time.

Once the general areas of what to measure to gauge success have been determined, specific metrics and corresponding methods of evaluation must be chosen. These will depend largely on time, resources, and availability of information, so potential metrics and methods must be weighed based on their practical usefulness as well as their validity. It is important to explore a wide variety of data sources in addition to considering what can be collected through direct measurement. Publicly-available information can range from citizen science bird counts to property tax assessments to crime data. Metrics should also be selected to match the level of expertise of the intended audience so that the assessment results will be relevant and meaningful.

Data collection practices should be considered and a schedule established as part of a Performance Evaluation Plan. Ideally, performance evaluation should be an ongoing process with data collected at least once every few years to capture how performance changes over time. Optimal timing for an initial performance assessment is 1-5 years after construction is complete. This allows time for natural processes, site programming, and user behaviors to stabilize. Because the management, use, meaning assigned to space, and even the physical environment can evolve over time, each performance evaluation should also document these types of changes in narrative form. Above all, performance assessment needs to be included in the scope and budget for a project to ensure that the post-occupancy monitoring happens.

11th Street Bridge Park Background & Goals

The 11th Street Bridge Park will be Washington, D.C.'s first elevated public park and a new venue for healthy recreation, environmental education, and the arts. Expected to open by late 2019, the park will be located on the piers of the old 11th Street Bridge spanning the Anacostia River.

Overarching goals for the park are to:

- Create a healthy community by establishing a safe place for residents to exercise and play
- Connect the community with the Anacostia River
- Reconnect the neighborhoods of Anacostia / Fairlawn and Capitol Hill / Navy Yard
- Generate new jobs and economic activity

In October 2014, after extensive community outreach and a seven-month design competition, the winning team of OMA+OLIN was selected to design the 11th Street Bridge Park.

Though in the concept stage, the OMA+OLIN competition entry includes several design elements with direct environmental objectives. These include plantings and water-receiving landscapes that will capture, cleanse, and reuse stormwater. A proposed waterfall on the eastern side of the bridge will aerate water from the river and is linked to an active filtration system. Restoration of shoreline plantings are proposed to provide habitat and improve the ecological integrity of this portion of the river. A proposed pollinator garden will help provide forage for bees, butterflies, and other pollinators whose populations have been declining. The design also has the aim to mitigate climate extremes, using shade and shelter to encourage year-round use.

Various other aspects of the design could provide environmental benefits, depending on design decisions and materials choices that will be made as the design phase progresses. Examples include energy savings from efficient fixtures, water conservation from native plants and/or smart irrigation systems, shading and screening impacts of trees, and carbon sequestered in park plantings.

The environmental performance metrics in the following section are based on the 2014 OMA+OLIN competition entry and include suggestions that can be considered as the design is further developed and refined.

Resources for Data and Information

The District Department of Energy and Environment, Maryland Department of Natural Resource, Metropolitan Washington Council of Governments, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Army Corps of Engineers, as well as a number of nonprofit and advocacy groups, have long worked on Anacostia River health and restoration efforts. These include the Anacostia Watershed Society, Anacostia Riverkeeper, Earth Conservation Corps, and Living Classrooms (with facilities at Kenilworth Aquatic Gardens, Kingman Island Education Center, and The Yards). Reports and data from these entities are cited in the sections that follow.

In addition, reconstruction of the 11th Street vehicular bridges (2009-2013) spurred a number of data collection efforts and reports, and the 11th Street Bridge Park has led additional studies and data collection efforts, including the 2014 "Estimated Economic Impacts of the 11th Street Bridge Park," 2015 "11th Street Bridge Park Equitable Development Plan" and the 2016 "11th Street Bridge Park Baseline Health Assessment".

Finally, the Environmental Education Center proposed for the park will be an exceptional asset, and many of the data collection and analysis activities recommended in this report could be conducted by the center and nearby educational facilities such as the Anacostia High School.

Environmental Performance Metrics

The following sections provide recommendations for metrics and methods that can be used to quantify the environmental impacts of the 11th Street Bridge Park. Though beyond the scope of this report, a list of suggested social and economic performance metrics is provided in the final section.

For the 11th Street Bridge Park, one of the main challenges will be to distinguish the impacts of the park itself from the impacts of other changes happening nearby and throughout the watershed. To address this, the metrics recommended here focus on measuring direct impacts from specific design decisions. Another challenge is the lack of baseline data for many measures because the bridge piers are the only structures currently on the site. This makes before/after comparisons difficult. It will also be challenging to compare the 11th Street Bridge Park to a similar but more "conventional" landscape because the park is so unique.

The recommended metrics are environmental benefits that can all be measured on an ongoing basis in order to track performance over time. This report also includes suggestions about metrics that can be incorporated into the iterative process as the design is refined. There will also be one-time impacts from the park construction and materials choices, such as construction waste reduction or transportation energy savings from the use of local materials, which can be quantified.

As the 11th Street Bridge Park design process progresses, the environmental performance metrics will likely need to be adjusted to reflect changes in the design, materials, and/or intent. This is a natural part of the process, and this report can be modified to create a Performance Evaluation Plan based on the final design.

STORMWATER MANAGEMENT

Stormwater runoff is a major source of impairment for the Anacostia River, causing streambank erosion, combined sewer overflows, and carrying trash, bacteria, nutrients, and other pollutants into waterways. So as not to contribute to this problem, stormwater from the 11th Street Bridge Park should be managed onsite.

At a minimum, the 11th Street Bridge Park design and construction process will need to meet local regulations by following the DOEE 2013 Rule on Stormwater Management and Soil Erosion and Sediment Control[1]. How much stormwater needs to be retained onsite will depend on how the Bridge Park is classified – whether it is considered a "major land-disturbing activity" that disrupts 5,000 sf or more.

<u>DOEE 2013 Rule on Stormwater Management and Soil Erosion and Sediment Control</u>[2]
Major land-disturbing activity

- Retention standard: Retain the first 1.2" of rainfall on site or by combining on-site and off-site retention.
- Detention requirements: Maintain peak discharge:
  - From 2-year storm to pre-development conditions (meadow standard used).
  - 15-year storm to pre-project conditions.

Major substantial improvement activity

- Retain the first 0.8" of rainfall on site or through a combination of on-site and off-site retention.

The OMA + OLIN design incorporates water-receiving landscapes that will allow them to capture, cleanse and reuse stormwater. These include a substantial rain garden and waterfall feature on the Navy Yard side. The design team has indicated that they would like to go beyond the regulatory requirements and treat every drop of rain that falls. However, the stormwater management systems will not be sized until the detailed design work begins.

Annual Volume and Percent of Total Rainfall Retained Onsite

As the various stormwater management systems are sized, modeling should be done to determine how much of average annual rainfall is retained on-site. This can usually be done using the calculation method or modeling software that is used to design the systems and show that they meet regulations. Or alternatively the volume and percent of total rainfall retained onsite can be estimated using EPA's National Stormwater Calculator, which takes into account land cover and the impacts of various types of BMPs: https://www.epa.gov/water-research/national-stormwater-calculator. This calculator can also be used to compare different scenarios, including baseline and climate change scenarios, which incorporate changes in seasonal precipitation levels and effects of more frequent high-intensity storms.

Monetary Value of Stormwater Retention Credits (SRCs)

If the 11th Street Bridge Park retains more stormwater than is required by regulation, it could earn Stormwater Retention Credits (SRCs), which are privately tradable. One SRC is equal to one gallon of retention for one year. The credits are determined by calculating the difference between the regulated retention amount (generally 1.2 inches of rainfall) and the additional retention amount (up to a ceiling of 1.7 inches) of rainfall. In 2016, the average purchase price for SRC was $1.85[3].

Calculating the projected or actual purchase price any SRCs generated by this project would be a great way to monetize the value of any additional stormwater retention capacity.

WATER CONSERVATION

The benefits of water conservation practices include water utility cost savings, reducing demand on local water sources (in this case, the Potomac River, which is the source of drinking water for Washington, D.C.), energy savings from reduced pumping and treatment, and reducing the amount of runoff and/or wastewater.

A primary way that landscapes can conserve water is through selection of plant species that are native or well-adapted to a site's climate, soil conditions, exposure, and slope in order to reduce or eliminate the need for irrigation. Other landscape-based strategies for water conservation include efficient irrigation systems, water features that recirculate water, and systems that capture and reuse stormwater, grey water, or wastewater on-site. The only explicitly-stated water conservation strategy in the OMA+OLIN competition entry is the use of captured stormwater and river water in the park's waterfalls.

The most straightforward way to quantify a reduction in water use is to use water bills to determine annual consumption. This can then be compared to consumption prior to the project or to that of a conventional landscape. Because the 11th Street Bridge Park is so unique, it may be difficult to find a comparable site, and because nothing is currently on the site, baseline water consumption will be zero. Therefore, it is recommended that the contribution of individual elements be estimated, in combination with monitoring the park's actual water use over time to ensure that the site is being operated in accordance with the design intent. Installing separate water meters for the different systems (irrigation, water features, indoor water use) could assist in tracking and identifying any issues.

Reduction in Potable Water Use for Landscape Irrigation

Because the OMA+OLIN design includes lawn areas, it is assumed that the 11th Street Bridge Park will include a permanent irrigation system. Potable water use for irrigation could be reduced through plant species selection, the type of irrigation system, and if captured stormwater, river water, or recycled greywater is used. This reduction in potable water use compared to a more conventional landscape can be estimated.

The EPA Water Sense Budget Tool is one tool that estimates water savings compared to a baseline case: https://www3.epa.gov/watersense/water_budget/. This is the method used in the Sustainable Sites Initiative (SITES) v2 rating system. The tool includes broad categories for plant types and irrigation type, and it can factor in the use water from nonpotable sources. The tool compares the designed landscape to a baseline case, which is 70% of the amount of water that would be needed if the entire landscape was covered by a well-maintained expanse of average-height green grass.

Reduction in Potable Water Use in Water Features

The OMA+OLIN competition entry includes two waterfalls on the bridge deck and a splash pad in Anacostia Park on the east shoreline. Descriptions state that captured stormwater will be used in the waterfall on the west side and filtered river water will be used in the waterfall on the east side. As the design progresses, these waterfalls and the proposed splash pad may also use systems that collect and recirculate the water to further reduce potable water use.

It should be possible to estimate the reduction in potable water use based on the systems used in the final design. The reduction can be translated into financial savings using the current utility rate from DC Water: https://www.dcwater.com/customercare/rates.cfm

Reduction in Potable Water Use from Low-Flow Fixtures

Facilities in the 11th Street Bridge Park café, environmental education center, restrooms, and any other out buildings can be equipped with faucets, toilets, and other fixtures that conserve water without compromising performance. The reduction in potable water compared to conventional fixtures can be estimated base on anticipated use. This can be translated into financial savings using the current utility rate from DC Water: https://www.dcwater.com/customercare/rates.cfm

If captured stormwater or greywater will be reused for toilet flushing or washing activities, this savings can also be estimated based on the anticipated amount of water available.

WATER QUALITY

The 8.5-mile Anacostia River has 13 major tributary creeks and streams and a watershed that covers 176 square miles in Maryland and Washington, D.C. The river is a tidal estuary with sluggish flow and numerous sources of contaminants, nutrients, and trash. Throughout the watershed, numerous efforts are underway to clean and restore the river. One of the most significant is DC Water's Anacostia River tunnel, which is slated to come online in 2018 and is part of a series of improvements that will reduce combined sewer overflows into the river by 98%.

DOEE maintains real-time water quality monitoring locations at Benning Road (upstream of the 11th Street Bridge) and South Capitol, taking readings every 15 minutes. A number of other groups, including the Anacostia Watershed Society, do periodic sampling.

Because so many factors influence water quality in the Anacostia River, it is unlikely that the impacts of the 11th Street Bridge Park can be isolated when looking at changes in overall water quality. However, it may be possible to measure the localized impacts of particular systems.

Localized Increase in Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen found in water. It is an important measure of water quality because low DO levels can stress aquatic organisms like fish and shellfish. DO levels vary with the water temperature (colder water can hold more oxygen) and pollutant loads because microorganism use oxygen in the decomposition process (biochemical oxygen demand). Because of this, it is most important to monitor DO during the summer months, especially during times of high pollutant load, such as combined sewer overflows.

In the Anacostia River, DO levels have been steadily improving, though levels are lower in the downstream (Washington, D.C.) sections of the river.[4,5] During intense rain events, dissolved oxygen levels in the DC sections can get very low. However, starting in 2018, the DC portion should see a significant improvement in DO levels from DC Water's Anacostia River tunnel to control sewer overflows.

On the east side of the 11th Street Bridge Park, the OMA + OLIN design proposes an aeration waterfall on the lower level that can serve to oxygenate water in the river. Dissolved oxygen (DO) levels could be measured upstream and downstream of the waterfall. The impact of the aeration waterfall will be very localized, so the downstream measurements will need to be taken very close to the waterfall itself. According to the DOEE[6], DO levels should range from 4.0 to 6.0 mg/L or greater, depending on the time of year.

Localized Improvement in Turbidity

Turbidity, a measure of the relative clarity, is another important water quality indicator. In the Anacostia River, the average depth of visibility is about 3-6 inches[7], due to sediment and other particles entering the river and its tributaries through streambank erosion and stormwater runoff. While other water quality indicators have trended toward improvement, water clarity in the Anacostia has remained relatively static.[8] Aside from the aesthetic aspects, the murkiness of the water absorbs heat and blocks sunlight, preventing the growth of submerged aquatic vegetation, which supplies oxygen and filter the water.

Several elements of the 11th Street Bridge Park design could work to address water clarity issues and may have localized impacts that are measurable. These include the "active filtration system" that is linked to the proposed east side lower waterfall, new wetland areas proposed adjacent to the bridge piers, and any restoration efforts along the shoreline.

Turbidity can be measured directly with a turbidity meter/sensor, or indirectly with a secchi disk by measuring the depth at which the disk ceases to be visible from the surface. Turbidity could be measured in the immediate vicinity of the proposed improvements and compared with turbidity further upstream.

HABITAT CREATION AND RESTORATION

Although it is a highly urbanized watershed, the Anacostia River supports 188 species of birds and nearly 50 species of fish.[9] Wildlife in and along the river include bullhead catfish, bald eagles, beavers, white perch, ospreys, striped bass, cormorants, crayfish, herons, turtles, egrets, otters, herring, red fox, shad, and kingfishers. The entire river is a corridor for wildlife, and the southern end of the river has great potential for habitat restoration. Land reclamation efforts that created Kingman Island, the RFK Stadium grounds, Poplar Point, Hains Point, and much of Anacostia Park greatly reduced the historic extent of the Anacostia River and its tidal emergent wetlands.[10]

A number of government agencies and nonprofits engage in habitat restoration and wildlife monitoring. Every 10 years, DOEE develops a Wildlife Action Plan with the latest version released in 2015.[11] The

U.S. Fish and Wildlife Service and U.S. Geological Survey conduct ongoing studies of birds, fisheries, and other wildlife in the DC portion of the Anacostia River. The Anacostia Watershed Society and Earth Conservation Corps also collect wildlife data.

When examining larger wildlife trends, it is unlikely that the impacts of the 11th Street Bridge Park can be isolated. However, monitoring could be done in the park itself to determine the success of particular design elements. This monitoring requires periodic fieldwork and could be done by partnering with agencies or nonprofit organizations, through programming at the education center, or by engaging citizen scientists. It may also be important to track the presence of any nuisance species that the park attracts, such as rats and seagulls.

Species Richness/Abundance in Pollinator Garden

A proposed pollinator garden is one of the ecological strategies in the OMA + OLIN design. Field observations can be used to track the success of this garden over time by recording the type number of species observed. Species richness, the number of different species present in an ecological community or landscape, is often used as an indicator of biodiversity. If there is a particular species of interest the abundance of that species (measured by presence, number of individuals observed, density, or frequency) can be tracked over time.

Species Richness/Abundance in River Installations

The OMA + OLIN competition entry proposed the creation of floating wetlands around the 11th Street Bridge piers and the creation of wetlands along the Anacostia Park shoreline. These areas can be observed periodically to determine whether they are providing habitat for wildlife. As with the pollinator garden, species richness can be used a proxy for biodiversity, and abundance can be used for particular species of interest, such as rare or threatened species.

While not part of the OMA + OLIN proposal, another practice that could be considered is the creation of artificial reefs for oysters and mussels that filter river water. Mussels have been observed near Buzzard Point.[12] The same or similar species could be planted near the 11th Street Bridge Park and monitored over time to determine if conditions are suitable for further restoration efforts. The bioaccumulation of different contaminants in the mussels could also be studied to assess water quality.

Increase in Ecological Integrity of Shoreline Vegetation

In designed landscapes, plant species selection and organization play a key role in creating or restoring habitat. The OMA + OLIN design includes an array of ecological communities on the east shore in Anacostia Park, including tidal marsh, emergent wetlands, meadow grasses and woodland. This area is currently grass with clusters of trees on the slopes and volunteer vegetation along the river's edge.

The habitat quality of plant communities can be assessed using one of several rating indices that assign a coefficient to each plant species. These are all based on the Floristic Quality Assessment Index (FQAI) methodology. The Universal Floristic Quality Assessment Calculator (http://universalFQA.org) is a free, open-source web-based tool that offers access to over 30 databases of plants for different regions across the United States and Canada.

The Plant Stewardship Index (PSI) is a variant of the FQAI developed for the Piedmont region of Pennsylvania and New Jersey: http://www.bhwp.org/plant-stewardship-index.htm. The PSI incorporates the presence and impact of non-native plants for its calculation, making it preferable for sites where invasive species are an important management issue, as is the case along the Anacostia River.[13] The PSI plant databases can be accessed on the Universal FQA Calculator site by selecting the "Pennsylvania Piedmont 2006" or "New Jersey 2006" FQA database in the dropdown menu. The PSI database is recommended if the majority of plant species used in the 11th Street Bridge Park restoration areas are in the database.

A list of plant species present on the site is input into the calculator to determine the FQI score. An inventory of existing conditions should be conducted to get a baseline score. The FQI can then be determined immediately after installation of the 11th Street Bridge Park project based on the as-built plant list. Every year or two, fieldwork should be done to inventory plant species on the site and calculate the FQI. This will account for plant survival, succession, and invasive species colonization, showing how the ecological integrity changes over time. This information can be used as part of the adaptive management of the site. Strong plant identification skills are needed for this type of assessment.

TEMPERATURE & URBAN HEAT ISLAND EFFECTS

Washington, D.C. is infamous for its hot, humid summers, with an annual average of 36 days in which the temperature reaches 90°F or higher.[14] Climate conditions are exacerbated by the urban heat island effect, a phenomenon in which developed areas are significantly warmer than surrounding rural areas. A 2014 report by Climate Central ranked Washington, D.C. as sixth out of 60 U.S. cities in terms of the intensity of its summer urban heat island.[15]

Because urban heat islands depend on surface materials, vegetative cover, wind, waste heat, and geometric effects like topography and building heights, it is very difficult to quantify the impact that individual sites have on overall temperatures. Collecting surface and localized air temperatures on a site is a much more direct and measurable way to assess its impact.

For the 11th Street Bridge Park, the OMA+OLIN competition entry includes a stated aim to mitigate climate extremes, using shade and shelter to encourage year-round use. The renderings include green roofs, vegetated areas, and light-colored materials, which are an effective way to counter the urban heat island effect at the site scale. Based on this, the primary reasons to monitor temperatures on the site are to gauge: 1) the park's overall contribution to the urban heat island, and 2) the thermal comfort of park users.

Reduction in Surface Temperatures (Weighted Average)

Once the 11th Street Bridge Park is built, an infrared thermometer can be used to measure actual surface temperatures. On a hot, sunny day, temperature can be measured for each major type of surface (walkway, lawn, plaza, green roof, etc.), with measurements taken to represent both shaded and unshaded areas. Using the area of each type of surface (as determined from the plans or field measurements), a weighted average can be determined for entire Bridge Park. This can be compared to the weighted average of a hypothetical "conventional" scenario or to the weighted average at comparable park – perhaps the adjacent Anacostia Park, which is primarily composed of turf and asphalt paths.

While the park is still in the design phase, solar reflectance (SR), solar reflectance index (SRI), or albedo values can be used to determine a weighted average and test different scenarios. These types of calculations are included in both the Sustainable Sites Initiative (SITES) v2 rating system (Soil + Vegetation Credit 4.9) and LEED NC-v4 (Sustainable Site Credit SSc5).

Thermal Comfort of Park Users

Because the park will be designed to encourage year-round use, the creation of microclimates will be key. For this, the OMA + OLIN design includes the shade and shelter provided by the bridge's x-shaped platforms, trees, green walls/hanging vines, and the cooling impacts of the waterfalls. Other strategies that could be considered are wind breaks, mist systems, and surface materials design to reflect or radiate heat.

Air temperatures can be measured in key areas where these design strategies are implemented in the climate conditions that they are designed to address. Temperature should be measured 4-6 feet above the surface plane, making sure to shade the thermometer itself. This method can be used to test the impact of design strategies under extreme conditions or, if readings can be taken over time, to show that certain spaces are maintained within a comfortable temperature range for a certain number of hours per day or certain number of days per year. These readings could also be compared to temperatures on the exposed pedestrian path on the adjacent 11th Street vehicular bridge.

Surface temperatures also have importance for the thermal comfort of park users. On a hot, sunny day, surface temperatures can be measured for equipment like café tables, benches and playground installations and compared to equipment made of conventional materials and/or located in full sun. Alternatively, these temperatures can be compared to a certain threshold: for example, all play surfaces maintained at a temperature below 130°F, the temperature at which children's skin can burn.[16] Conducting user surveys is another way to gauge the thermal comfort of Bridge Park users.

While the park is still in the design phase, a number of predictive tools and models can be used to inform design by estimating the projected change in thermal sensation.[17]

ENERGY USE AND EMISSIONS

While non-renewable energy consumption is most commonly associated with buildings, sustainable site design also plays an important role. Landscape elements can shade, screen, and insulate buildings; use or generate renewable energy; and require less energy to operate and maintain.

Reduction in Annual Energy Use

While the OMA + OLIN competition entry does not specifically include energy conservation strategies, these may be incorporated during the detailed design process. Both LEED NC-v4 and the Sustainable Sites Initiative (SITES) v2 rating system include credits for reductions in energy use compared with a baseline scenario. The LEED Optimize Energy Performance credit uses building energy simulations or ASHRAE Advanced Energy Design Guide compliance. SITES v2 Operations + Maintenance Credit 8.5 includes guidance for calculating a reduction in outdoor energy consumption based on a baseline case using lowest cost comparable fixtures. These methods can be used to compare scenarios and report expected reductions.

Since the electricity used by the 11th Street Bridge Park will be metered, actual energy use can be tracked by monitoring the park's utility bills. Energy use can be tracked over time and compared to a baseline case or to a similarly programmed but more conventionally designed park. Reductions can be translated into financial savings using the current utility rate from Pepco: http://www.pepco.com/my-business/choices-and-rates/district-of-columbia/rate-schedules/

If the park chooses to offset its emissions or switch to a green energy source for all or part of its energy use, this reduction could be reported.

CARBON SEQUESTRATION AND AVOIDANCE

Reducing carbon emissions and sequestering carbon are important tools in the global fight against climate change. Because the 11th Street Bridge Park is not disturbing an existing greenfield, providing a missing transportation link, or supplying parking for park visitors, its primary carbon impacts (not related to construction) will be those from park energy use, service/delivery vehicles, maintenance equipment, and the carbon sequestered in park plantings.

Reduction in Carbon Emissions from Energy Savings

Annual energy use can be converted into greenhouse gas emissions using a simple online calculator like the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. The calculator reports the emissions in weight of Carbon Dioxide Equivalent and a variety of other equivalencies, such as pounds of coal burned or miles driven by an average passenger vehicle. The emissions can be tracked over time and compared to emissions from a baseline case or a similarly programmed but more conventionally designed park.

Carbon Sequestration by Trees and Shrubs

Carbon sequestration is the capture and long-term storage of carbon dioxide from the atmosphere. Plants take carbon dioxide from the atmosphere and convert it into the material of their leaves, stems, and roots. Trees and shrubs, in particular, lock up large amounts of carbon in their woody biomass as they grow. Soil is also a carbon storehouse, but measuring soil carbon requires sampling, lab testing, and statistical analysis; and soil carbon can be highly variable over time.

The OMA + OLIN competition entry incorporates trees and shrubs. As detailed design is done and the planting plan is finalized, the carbon benefits of these woody plants can be estimated using iTree, a set of straightforward tools from the USDA Forest Service: http://www.itreetools.org/. iTree Design (web-based) or iTree Eco (desktop application) both estimate the carbon sequestered by trees and shrubs annually, based on species, size, and location. Both tools can also forecast future benefits based on projected tree growth over time. These tools can be used to test scenarios in the design phase, to determine the benefits of the completed park following installation using the as-built planting plan, and to track changes over time using actual field measurements for tree species and size.

AIR QUALITY

In the last few decades, air quality in the Washington, D.C. region has greatly improved, though the region is still classified as a non-attainment area because it does not meet the National Ambient Air Quality Standard (NAAQS) for 8-hour ground-level ozone (O_3).[18] Fine particulate matter ($PM_{2.5}$) is another air pollutant of interest. Because the region was previously a non-attainment area for $PM_{2.5}$, it must demonstrate that it continues to meet the standard. Air quality issues in the District are primarily due to emissions from vehicles and air pollution transported from other states.[19]

Ground-level ozone is not emitted directly into the air, but rather is formed by reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Because of this, ozone levels increase during the hotter, drier days of the year when there is little wind. In 2015, the Washington, D.C. region experienced 14 days in which ozone levels were either unhealthy for sensitive groups or unhealthy for everyone.

In the District, DDOE's Air Quality Division maintains a network of six monitoring sites.[20] Air sampling at these sites measures criteria air pollutants, fine particulates, certain chemicals and toxics, and ozone its precursor pollutants. For most pollutants samples are taken hourly, though for some, like particulates, samples are taken every 1-6 days. Two of the monitoring stations (River Terrace and the Anacostia Freeway Near-Road Station) are located 2.5 miles upriver from the 11th Street Bridge and one site (Hains Point) is located one mile downriver. The Hains Point site only monitors particulates, while the River Terrace and Anacostia Freeway stations focus on particulates and ozone/precursors to ozone.

Because air quality is a regional issue, it is challenging to isolate the impacts of 11th Street Bridge Park. However, the benefits of individual systems can be estimated using predictive models. Since the park is adjacent to a major freeway, organizers may want to consider establishing an air quality monitoring station within the park to give better information on the health of the air for park users

Pollution Removal by Trees and Shrubs

Urban vegetation can directly and indirectly impact local and regional air quality. As they intake air, trees and plants remove some air pollutants. Vegetation can also intercept and temporarily retain airborne particles, which are then washed off by rain, dropped to the ground, or re-suspended. Because lower summer air temperatures can reduce ozone formation, the cooling impacts of trees and vegetation can also affect air quality.[21]

However, plants also emit volatile organic compounds (VOCs), which can mix with NO_x to form ozone. Emission rates vary widely by species and have been estimated for common tree and shrub genera in the U.S.[22] Because motor vehicles are a primary source of NO_x, it may be prudent to avoid planting high VOC-emitting trees along streets with heavy traffic.[23] Since the 11th Street Bridge Park is adjacent to I-695 and its interchange with the I-295/Anacostia Freeway, designers will want to carefully consider the tree species that are planted in the park.

As detailed design is done and the planting plan is finalized, air quality benefits of trees and shrubs can be estimated using iTree: http://www.itreetools.org/. The web-based iTree Design gives only a graph with the estimated monetary value of annual removal and avoidance (from reduced energy needs) for five pollutants: O_3, VOCs, NO_2, SO_2, and PM_{10}. The desktop application iTree Eco gives hourly air quality improvement for O_3, NO_2, SO_2, CO, and PM_{10}; results are displayed in line chart and table formats. Both tools can also forecast future benefits based on projected tree growth over time. These tools can be used to test scenarios in the design phase, to determine the benefits of the completed park following installation using the as-built planting plan, and to track changes over time using actual field measurements for tree species and size.

Pollution Removal by Surface Coatings

Titanium dioxide, which is used as a whitening agent in paints and surface coatings, also acts as a photocatalyst that breaks down nitrogen oxides (NO_x), volatile organic compounds (VOCs), and other air pollutants in the presence of sunlight. It has been used as coating on roofs, panels and other surfaces to reduce air pollution.

While the OMA + OLIN competition entry does not specifically incorporate these coatings, it does include many light-colored surfaces that could be candidates for their use. As detailed design is done, titanium dioxide coatings should be considered. The potential reduction could be estimated based on removal rates from previous studies.[24]

WASTE REDUCTION

Waste management is a challenge in any public open space, but it will be particularly important for the 11th Street Bridge Park. Trash is such a persistent problem in the Anacostia River that in 2010 the U.S. Environmental Protection Agency, the District of Columbia, and the state of Maryland established a Total Maximum Daily Load (TMDL) for trash, making the Anacostia the first interstate river in the nation with such a trash limit.[25] Trash enters the river and its tributaries through urban storm drain systems and illegal dumping.

The design and operation of the 11th Street Bridge Park must be considered carefully in order not to exacerbate the trash problem. Onsite waste reduction, collection, and recycling strategies should be explored for the various facilities and event spaces.

It may also be possible to compost landscape waste onsite, and possibly food waste from the café and/or events. This compost could then be used in landscape areas, particular those used for urban agriculture. If composting is not possible onsite, the waste could be collected and sent to an offsite composting facility. On its "Sustainable Management of Food" webpages, the U.S. EPA offers a number of tools to asses and reduce food waste: https://www.epa.gov/sustainable-management-food/tools-assessing-wasted-food

To most accurately measure impacts, waste generation and reduction strategies at the 11th Street Bridge Park should be tracked on an ongoing basis by estimating how much and how often waste is collected and disposed of. Protocols for this data collection should be developed and conveyed to operations and maintenance staff. Since the park is envisioned to accommodate numerous special events, it will be important to track waste during these peak times. "Smart" waste and recycling systems, such as Bigbelly, can capture data on how often receptacles are emptied and can improve efficiency for maintenance staff.

It may also be possible to monitor trash accumulation downstream of the 11th Street Bridge Park to demonstrate whether the park is having any negative impacts on trash in the river. It is unclear who maintains the trash traps along the Navy Yard piers, in Yards Park, and near Diamond Teague Park, but accumulation could be spot checked to determine if the 11th Street Bridge Park is a source of trash, particularly after events.

Amount of Municipal Solid Waste Recycled

Recycled waste can be estimated as an annual weight, volume, or percent of total waste based on data collected by operations and maintenance staff. The percent of the waste stream that is recycled could be compared to a regional or national average[26] or to recycling rates at nearby Yards Park or other similarly programmed public space.

Amount of Landscape and Food Waste Composted

The amount of landscape waste and/or food waste that is composted onsite or offsite can be estimated as an annual weight, volume, or percent of total waste based on data collected by operations and maintenance staff. The percent of the waste stream that is composted could be compared to a regional or national average.[27] To quantify landscape waste, maintenance staff will need to log the type and frequency of their site maintenance activities like mowing and pruning.

Reduction in Carbon Emissions due to Waste Reduction Strategies

If the type and weight is known for each material that is source reduced, recycled, landfilled, or composted, the web-based EPA Waste Reduction Model (WARM) can be used to estimate greenhouse gas emission reductions from these waste management practices: https://www3.epa.gov/warm/Warm_Form.html. The model compares a baseline and an alternate scenario.

SOCIAL AND ECONOMIC FACTORS

While not explicitly part of the scope of this report, many social and economic factors are related to the environmental performance metrics outlined above. The 11th Street Bridge Park Health Impact

Assessment[28] and Equitable Development Plan[29] capture baseline data and outline a number of strategies for measuring many social and economic impacts of the park. The following are recommendations for additional performance measurements that should be considered given the overarching goals and stated intent of the OMA + OLIN design.

Increase in Crossings and/or Interactions with Residents on the Other Side of the River

To address the goal of connecting the neighborhoods on either side of the river, surveys could be conducted to estimate how many and how often residents currently cross the river and/or interact with residents from the other side. Once the Bridge Park is complete, the same survey could be conducted periodically to determine whether the park is indeed helping to connect the two sides.

Increase in Interactions with the River

To address the goal of connecting the community with the Anacostia River, surveys or observations could be conducted to determine how many users of current parks (Yards Park and Anacostia Park) engage with the river itself. Once the Bridge Park is complete, the same survey or observations could be conducted for 11th Street Bridge Park users. Alternatively, the survey could be undertaken for residents of the neighborhoods in the vicinity of the 11th Street Bridge Park, comparing results from before and after the park is complete.

Health and Well Being

In addition to tracking the neighborhood level data outlined in the Baseline Health Assessment, surveys and site observations could be used to assess if the 11th Street Bridge Park is providing users with needed places for respite, social interaction, and physical activity.

Safety

Safety in the vicinity of the 11th Street Bridge Park could be measured by tracking actual crime using police reports to compare the number and type of incidents before, during, and after the park is completed. Additionally or alternatively, surveys could be conducted to gauge the perception of safety by park users and nearby residents.

Educational Value

The Environmental Education Center that is included in the OMA + OLIN design will have many impacts. Protocols should be established to collect data on the number and demographics of the people it serves, volunteer efforts, and research conducted. If the urban agriculture component includes public programs similar data should be collected there. The design also includes installations for more passive educational experiences, such as demonstration projects and signage. Surveys could be used to understand whether these installations are increasing the environmental literacy of park users and program participants.

Food Production

Protocols should be established to track how much food is being produced in the urban agriculture section of the park and how it is being used. For example, will it be used in the café, sold at a farmers market, or donated to a local food pantry?

Noise Mitigation

In 2014, a study of noise levels was conducted around the proposed location of the 11th Street Bridge Park.[30] Using this data as a baseline, actual sound levels in the park could be measured at key points of interest, such as performance spaces, contemplative spaces, or spaces where design elements are introduced to screen noise. User surveys could be used to gauge perceptions about noise, which may be as important as actual sound levels. For example, spaces near a waterfall may be perceived as peaceful even though the measured sound level is high. New research has shown that in the presence of vegetation, people are less stressed and perceive noise levels as being lower than they are.[31]

Scenic Quality

While aesthetics and beauty are somewhat subjective, the visual quality of the 11th Street Bridge Park and the views to and from it will greatly impact the overall public perception of the park. Surveys could be used to determine perceptions of visual quality using renderings or before/after photos of the site from various locations.

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