Depave the Duwamish: A Site Suitability Analysis Using Multiple Criteria & Public Participatory GIS

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University of Washington – Geog 569 – Capstone Project

Recommended Course of Action

It is the recommended course of action that Sustainable Seattle acquire professional GIS assistance for site suitability and related project goals in an effort to convert impervious surfaces to green space. It is also recommended that Sustainable Seattle use systems thinking when considering criteria for sites in conjunctions with meeting funding standards and recommendations as attempted in this analysis. Skill-sets required to use the design and methods of the analysis outlined in this report entail experience and a level of understanding of scale and social-ecological systems using GIS in relation to the neighborhoods of South Park and Georgetown and reducing impervious surface. Continuance of the use of public knowledge using public participatory GIS services is also recommended. It is recommended a second phase of public participation occur after the suitable sites are known, giving the interested public a chance to voice their opinion as to where the new publically benefitting properties should exist. Without the use of the ArcGIS for Server account hosted by the University of Washington the second planned phase of public participation; the phase in which the public can recommend their choices for project sites will need to be done using one of these two open-source methods or another agency will need to host the data on their server account. Analysis results can be made into education and outreach efforts to help display how depaving a portion of underutilized pavement will benefit the neighborhood (Nyerges and Jankowski 2010). For future similar projects, a weighted analysis or pair-wise comparison may be a better methodology for projects where the remaining eligible parcels are not as similar in characteristics and criterion better differentiated them from one another.

It is recommended that project sponsors conduct an in-depth feasibility study to ensure potential sites are suitable for green space. When sponsors are able to identify suitable parcels and willing property owner participation, it is suggested to utilize the EPA's National

Stormwater Calculator and the USDA’s i-Tree Design tool for site feasibility (Rossman 2014, USDA Forest Service Center for Urban Forest Research n.d.). The EPA calculator is a tool used to review existing and proposed stormwater runoff of site conditions and the implementation of green stormwater infrastructure (GSI) for green space. The i-Tree Design tool estimates the benefits provided by individual tree related to greenhouse gas mitigation, air quality improvements, and stormwater interception. These tools combined will be a useful to defend the case for green space to local decision makers, community members, and property owners as well as a means to properly design a suitable site.

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Introduction

The two neighborhoods of study; Georgetown and South Park, are located along the lower Duwamish River, with jurisdictional boundaries by Seattle's Community Reporting Areas (City of Seattle n.d.). Residing among mixed use industrial landuse and residential, the neighborhoods share several topographical commonalities. The Duwamish River is one of their major identifying boundaries; western boundary for Georgetown and eastern for South Park. To the north, both neighborhoods boarder the Industrial District of Seattle, and both are situated at the base of hill ranges, Beacon Hill to the east of Georgetown and Delridge to the west. Southern boundary for both neighborhoods is the unincorporated areas of King County. State Route 99 and 509 run north-south through South Park and the railroad and Interstate 5 run north-south through Georgetown. The industrial portions of the neighborhoods have housed companies such as Boeing, and currently house the King County International Airport inhabiting the industrial and manufacturing spaces that abut residential space. In such an environment large swaths of impervious surface make the majority of the surface space, with minimal green infrastructure to balance. SEE TABLE with total impervious. The Duwamish River Clean-up Coalition identifies the neighborhoods as communities with high environmental burdens and low positive environmental benefits (Cummings 2013).

Socially, the people of these neighborhoods have been identified as some of lowest income earners, more likely to be sick, the most ethnically diverse, and have fewer environmental benefits than the rest of Seattle as previously stated (Cummings 2013). According to the 2010 census 27% of South Park's population falls below the poverty line Seattle total percent population below the poverty line is 15% for a comparison (Census 2014).

Historically the area was forest and farm land and the Duwamish meandered naturally through the area. Landuse change and industrial commerce, a railroad, and the re-routing of the river for ocean bound vessels carrying cargo in the 1900's drastically changed the area and made it what it is today; highly industrial and impervious. Residential use has remained and is intermingled with industrial areas of both neighborhoods (Wilma 2001).

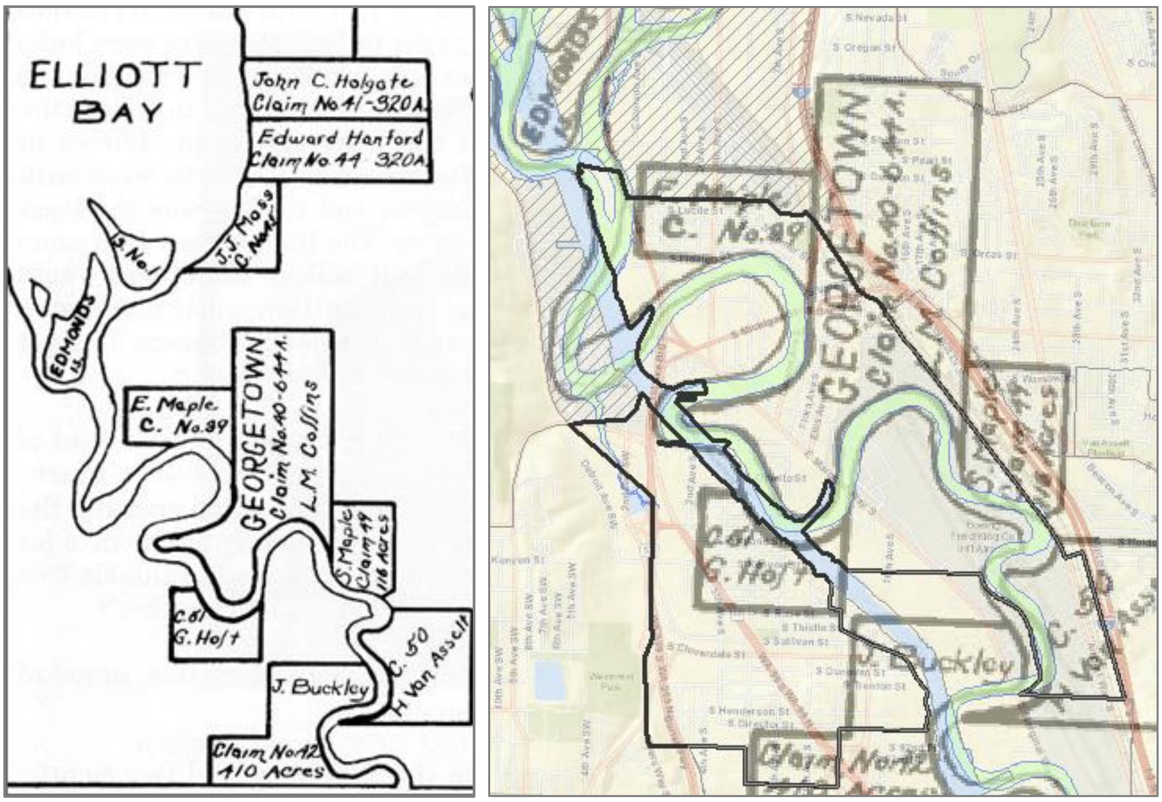

Figure 1: Historic Claims map, Historic Waterway & Current Neighborhood Boundaries

Sustainable Seattle with assistance from Urban Systems Designs, are working towards neighborhoods scale resiliency to climate change. Utilizing community participation of residents, business owners, and local land owners, they are working towards a common vision for reducing impervious surfaces and increasing green space in the Georgetown and South Park neighborhoods of Seattle; thereby reducing storm water runoff, providing accessible green space, providing CO2 sequestration, and less urban heat island effect to promote neighborhood resiliency. On a neighborhood scale, and using non-profit channels, the desired outcome for the project is reduced impervious surface, and increased pubic green space. With the reduction of impervious surface there is a reduction in storm water runoff, and reduced urban heat island effect; thereby helping create resiliency of climate change, and the increase in green space to take its place serving as a public benefit, and to serve potentially as a carbon sink.

The desired objectives of this project has been to provide data and knowledge about Georgetown and South Park, to assist in site selection that meet criteria for suitable locations for public green space, to provide a model or method for determining impervious surface totals, site suitability, hotspot, and current green space analysis results, a workflow for repeating the analysis by other GIS professionals in partnership with Sustainable Seattle, and a method for gathering public input in relation to the best site(s) for impervious-to-green space creation within the Georgetown and South Parks neighborhoods for Sustainable Seattle. The goal of this project entails using thresholds and standards for sustainability management, taking into account the social-ecological systems of the project, inviting public participation through interactive web map technology. Sustainable Seattle has emphasized pollution run-off abatement in under-utilized or abandoned parcels for top choice location(s). A method has been provides for public participation through internet sources, allowing the public to access information, provide feedback for, and choices on a web-map. Sustainable Seattle has been able to present to the public sites selected based on the criteria for best site locations in the form of scenarios. The final output for Sustainable Seattle includes web map technology for their in-house use allowing limited gaps in their project workflow, and a continuation of public input via GIS technology.

Problem Statement & Goals

The identification of sites at a parcel scale using GIS technology within the Georgetown and South Park neighborhoods of Seattle for impervious conversion to green space following the grant funding guidelines from King County Waste Water for site selection, while allowing public access and input to the project to promote social collaboration, thereby fostering social value in the sites selected. Supply Sustainable Seattle with total impervious surface percentage, identify criteria for site selection, create public participatory GIS services for Sustainable Seattle that can be used post- UW GIS help that is free and easy to use.

Scope

At the Duwamish water shed level, the aforementioned neighborhoods have been identified by the Duwamish River Clean-up Coalition as low income, high diversity, high impervious and low public green space. For this reason the neighborhoods have been selected by Sustainable Seattle for impervious to green space projects. At the King County level where funding from the project is coming from, the scope of the project includes identifying the specifications and stipulations required by King County Waste Water, much of which serves as exclusionary factors for converting impervious, industrial spaces to green spaces. GIS data from the county and collaboration with King County Waste Water, was necessary to ensure correct identification of the criteria. On the neighborhood scale, Sustainable Seattle is working with the public and landowners to identify sites for the impervious-to-green space project. GIS has assisted with this through interactive maps and feature services. The public or invited parties can log in to an ArcGIS online account and supply pictures, comments, and notes, about a particular site. Throughout the course of the project as the UW server has been available, a public feature service has served to collect local knowledge parcel data. Local knowledge of the area is particularly important as one of the main criteria most important to Sustainable Seattle is the use of under-utilized industrial space. "Under-utilized" is subjective and requires personal knowledge, or everyday observation of the area. Neighborhoods scale criteria pertinent to the Georgetown and South Park neighborhoods such as areas of drainage issues recorded by the city for each neighborhood, population locations in each neighborhood and concentrations, and sidewalk infrastructure, have supplied this neighborhood focal scale with data for the analysis. At the smallest scale, the parcel, the site suitability analysis with all associated criteria has been applied. Parcels that have not been excluded by the county criteria, and that have the highest number of matching criteria are selected for Sustainable Seattle's outreach campaign to contact residents and land owners of the parcels to educate an encourage impervious-to-green space conversion. GIS at the final site parcel level identifies the benefits associated with each final parcel if it is chosen for green space. The data is presented on public interactive web maps, with an editable feature that allows for public comment and input for each final site (see Appendix A: SES Table).

The workflow outlined in this report documents the design and methods of the project, describes results, discusses the intricacies of the process, provides the results of the analysis, and a business case for potential application. The Design and Methods section is structured in the following order:

- Public Participatory GIS
  - Identify Underserved Populations
  - Identify Populations that fall outside of the service area and use as a criterion
- Site Suitability Run
- Post Analysis Studies
  - Feasibility Study to Check Results: PPGIS
  - Final Service Area
- Second Tier Analysis
  - Scenarios
  - Recommended Sites

Design & Methods

Public Participatory GIS

The use of public participation has been stressed throughout this project as neighborhood scaled projects are specifically designed to provide a local voice using local knowledge, neighborhood togetherness, and provide ecological benefits as a community (see Appendix J). Project sites will be public benefiting green spaces and public participation helps ensure they are placed in the most suitable and useable locations. Public participation was used in the beginning of the multiple criteria suitability analysis through the use of an interactive web map, ArcGIS Server license and an SDE database feature class. A map was created for project sponsors and neighborhood contacts to assist data collection efforts by identifying known locations with underutilized impervious surfaces. The functionality of the web map included user-input of pinpoint placement, user contact information, notes and uploading of pictures. This initial phase of public involvement occurred over the course of one week. Data collected in this manner were used for two of the six criterion of the multiple criteria analysis. User input notes, sponsor feedback and aerial photography were used to further categorize these highlighted properties as consisting of parking lots or not parking lots. This distinction was made to separate the data into two criteria; underutilized parking lots and underutilized parcels. All user-input sites were considered underutilized parcels. During the one week of data collection twenty sites were identified as underutilized parcels, thirteen of which were categorized as underutilized parking areas.

Considerations were made with the onset of the project to include and test the use of free access GIS products for public participation, mapping, and sharing geographic information. This information can be easily used by non-GIS professionals and professionals alike to collect public input and feedback for the second phase of this project, or future projects. An ArcGIS online account was created and data was configured for the public input of site images, documents, notes and saved in the account. The service was tested and proven successful in a field study feasibility analysis during the project (see feasibility analysis). No further server, software, or professional GIS knowledge is necessary to use the service, and instructions and steps for adding and storing data in the service have been provided for Sustainable Seattle (See Appendix G).

It is recommended a second phase of public participation occur after the accessibility of suitable sites are known, giving the interested public a chance to voice their opinion as to which of the new publically benefitting properties should be constructed. This second phase will be done after project sponsors; Sustainable Seattle and Urban Systems Design, have made contact and gained permission from private property owners of the suitable sites. Analysis results will be made into education and outreach efforts to help display how depaving a portion of underutilized pavement will benefit the neighborhood. GIS will then be used to create and manage another interactive and publically editable web map with the properties that have agreed to allow their parcel to transform into these public benefitting spaces. The editable web maps not only enhance valuable feedback from a larger audience (Nyerges and Jankowski 2010) but they are also a means for education and outreach to increase support for sustainability management at the neighborhood level. Involving the public at varying phases of small scale projects has proven to improve acceptance and viability of such work (Nyerges and Jankowski 2010). One of the major objectives for the King County Waste Water Division grant is to increase awareness for the consequences of underutilized impervious surfaces on the environment and the further implications climate change brings.

Identify Underserved Populations

The methodology used for ParkScore, a Trust for Public Lands model, used to calculate and rank parks helped establish thresholds and standards for this analysis. These standards composed the major components of a green space. This includes the total acres of dedicated public space, and accessibility to the green space by the surrounding population based on a ½ mile of uninterrupted connectivity to the park, such as a sidewalk without barriers such as major roads, rivers, and fences (Trust for Public Lands 2013). The National Parks and Recreation Association shares similarities with the Land Trust model but indicates a threshold of a ¼ mile accessibility route, allowing for those unable to make longer journeys access to public green space as well (National Parks and Recreation Association 2014).

For the analysis, the two methods were combined and the ¼ mile accessibility distance along with park space per resident determined current deficiencies based on these suggested thresholds using Seattle sidewalk GIS data for a connectivity route. In addition, an example "best practice" was sought after to assure methodology validity. A white paper; Modeling Walkability, written by Arjun Rattan, Anthony Campese, and Chris Eden, published by ESRI in 2012 provides suggested best practices for using GIS to better understand the walkability of a city, region, or neighborhood. The main components outlined in the white paper are population, a spatial unit of measure to contain the population, population density, a sidewalk network, and the service locations of interest. In this instance the service locations of interest start with existing public access green space (Rattan, Campese and Eden, ESRI 2012).

The steps of the analysis are as follows:

1. Identify existing public green space
2. Identify population
3. Identify where existing green spaces falls in relation to sidewalk networks.
4. Identify underserved populations.

5. Visually identify on a parcel scale where the population resides for future analyses

Seattle City GIS supplied the green space GIS data used for the analysis. To identify residents that currently do not have ¼ mile sidewalk connectivity to an existing public access green space, a ¼ mile buffer from public greens space was created initially, then to collect better detailed population numbers a green space service area was created using ArcGIS Desktop with the Network Analyst extension and the data features listed below. The methodology used for the Green Space Pedestrian Analysis included the following data:

DATA	USE
Census block boundaries	Defines area of population counts
Total Population	Population within a census block
Sidewalk	Walkable access to public green space and connectivity
Green Space locations	Includes public green space currently in construction
Zoning	Current zoning of the area
Landuse	Landuse of the area
Buildings	All buildings in the neighborhoods
Buffer	As-the-crow-flies distance from public green space and boundary
Green Space Service Areas	¼ mile connectivity service area boundary

Table 1: Green Space Access Data

Data Preparation

Before the analysis could be conducted, data preparation was necessary to identify populations and densities on a neighborhood scale, and to determine residential housing locations in the mixed landuse environment of Georgetown and South Park. The 2010 Census was used to locate total population within census blocks, the smallest unit of measure found for this project. Though problematic for areal unit partitioning at the neighborhood scale for identifying population clustering or concentrations within neighborhoods, the census block level population data can be used in general to better ascertain population density (Lanford Unwin 1994). Obtaining census data with population information was done through King County GIS Center where total population per census block and number of housing units per block was readily available in a GIS format (KCGIS 2014). Density was calculated using *persons per acres* as the unit of spatial measure. Residential zoning GIS data was joined with buildings spatially. Though number of residents per house was not available, identifying the population in regards to the houses for which they live was used as a visual reference in the mapping of the data results in the analysis.

Data preparation of existing public green space was required to calculate total acres per park done in preparation of determining current green space deficiencies. Some post first iteration data preparation was done after the results of the first as-the-crow-flies distance analysis to green space were shared with the project sponsors. It was recognized that the GIS data did not include current public green space projects under construction. These projects were added and used in the second iteration of the analysis.

Analysis

The first iteration of the analysis, using ArcGIS Desktop software, used a simple ¼ mile spatial buffer applied to the green space feature, or 1,320 feet for the mapping data frame. Population falling within the buffer was selected to determine the total population falling within the corridor, or falling within a ¼ as-the-crow-flies distance from each green space. The total acres of green space, based on the National Parks and Recreation Standard 6.25 minimum to 10.5 acres maximum per 1,000 residents, was also applied to each neighborhood (National Recreation and Park Association 2012). The calculation for green space thresholds for each resident uses the following calculation:

6.25/1,000 = .00625 acres per person minimum

10.5/1,000 = .0105 acres per person maximum

First Analysis Iteration Results

Georgetown

Public Green Space	Georgetown Playfield 5.2 acres
	Oxbow Park .8 acres
Total Park Acres	6 acres
Total Population	1,306
Total Population Within Buffer	1, 056
Total Population Underserved	250
Total Green Space Deficiency Minimum Acres Considered	2.2
Total Green Space Deficiency Maximum Acres Considered	7.7

Table 2: Georgetown ¼ Mile Buffer Green Space Accessibility Results

Calculations

Total Population Underserved: 1,306 – 1,056 = **250 residence**
Total Green Space Deficiency:
(*1,306* * *.00625* = *8.2* acres) – *6* acres = ***2.2* acres minimum**
(*1,306* * *.0105* = *13.7* acres) – *6* acres = ***7.7* acres maximum**

South Park

Public Green Space	Cesar Chavez Park 1.7 acres
	Duwamish Waterway Park 1.5 acres
	Marra-Desimone Park 8.6 acres
	South Park Meadow 1 acre
	South Park Playground 5.5 acres
Total Park Acres	18.3
Total Population	4,135
Total Population Within Buffer	3,727
Total Underserved Population	408
Total Green Space Deficiency Minimum Acres Considered	7.5
Total Green Space Deficiency Maximum Acres Considered	25.1

Table 3: South Park ¼ Mile Buffer Green Space Accessibility Results

Calculations

Total Population Underserved: 4,135 - 3,727 = **408** residence
Total Green Space Deficiency:
(*4,135* * *.00625* = *25.8* acres) – *18.3* acres = ***7.5* acres minimum**
(*4,135* * *.0105* = *43.4* acres) – *18.3* acres = ***25.1* acres maximum**

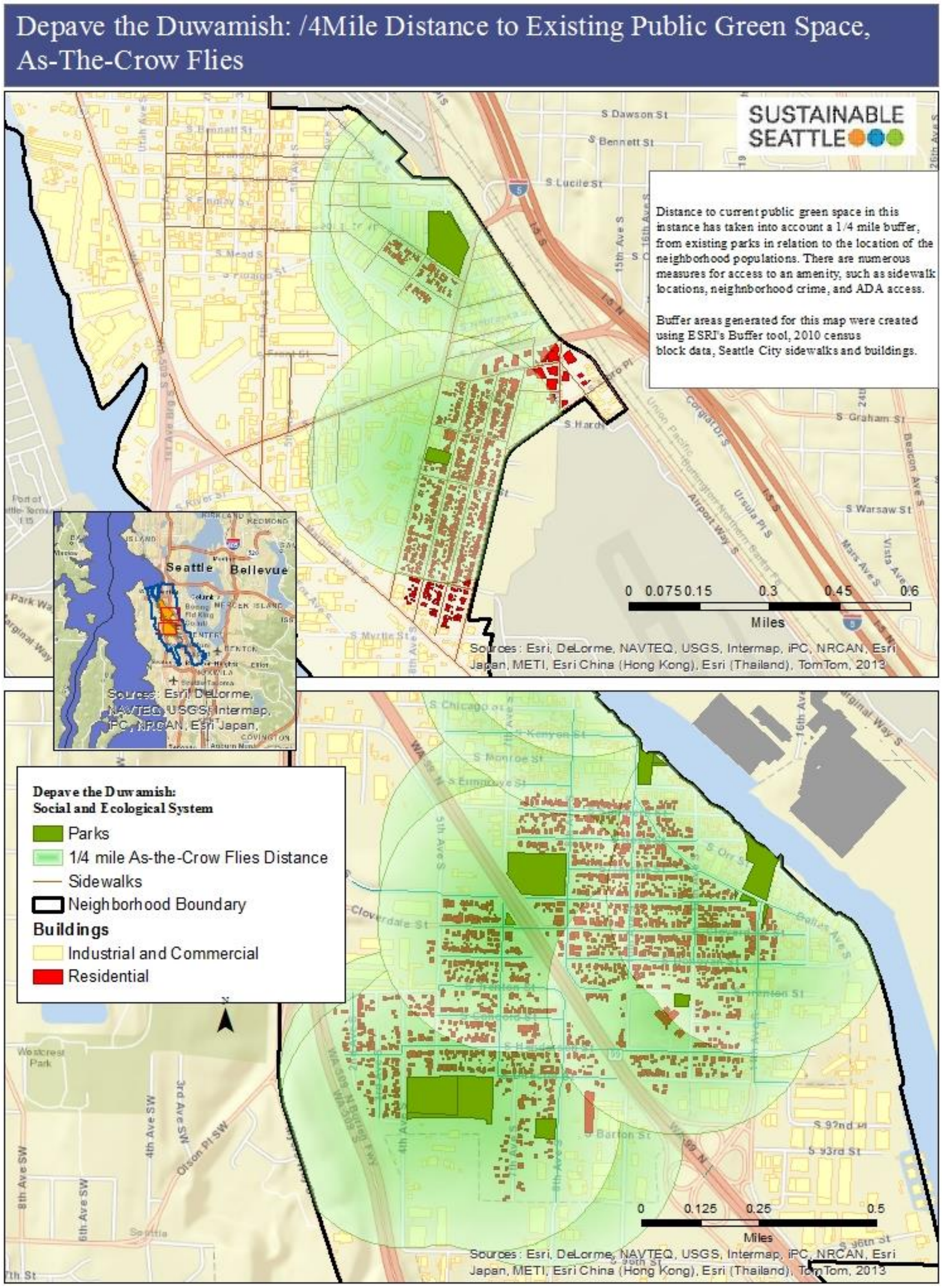

Figure 2: Existing Green Space

The initial as-the-crow-flies analysis was shared with project sponsors and its usefulness was determined. Further detail was added to the analysis with a “Service Area” rather than a simple buffer and a second analysis was completed to provide a network of connectivity and accessibility to public green space and residents of the neighborhoods within a ¼ mile distance as recommended by the NRPA (National Recreation and Parks Association 2012).

Second Iteration Analysis

Further accessibility analysis inclusive of a sidewalk network, additional green space sites provided by project sponsors, census blocks, and census block population totals was conducted to better determine deficiencies of access within the populations of Georgetown and South Park.

Using GIS tools a “service area” was created measuring the distance along the created sidewalk network ¼ mile to determine public access green space. Total population and total population within the service network, based on the 2010 census block data included in the ¼ mile service area was calculated. Additional data used for this analysis were sponsor provided green space data, sidewalk networks and zoned buildings, differentiating residential, industrial and commercial.

Second Iteration Analysis Results

Georgetown Results

Public Green Space	Georgetown Playfield 5.2 acres
	Oxbow Park .8 acres
	Riverside park .6 acres
Total Park Acres	6.6 acres
Total Population	1,306
Total Population Within Service Area	940
Total Population Underserved	367
Total Green Space Deficiency Minimum Acres Considered	1.6
Total Green Space Deficiency Maximum Acres Considered	7.1

Table 4: Georgetown ¼ Mile Service Area Green Space Pedestrian Accessibility Results

Calculations

Total Population Inaccessible by Sidewalk: 1,306 - 940 = **366 residence**
Total Green Space Deficiency:
(*1,306 * .00625 = 8.2* acres) – *6.6* acres = ***1.6* acres minimum**
(*1,306 * .0105 = 13.7* acres) – *6.6* acres = ***7.1* acres maximum**

South Park Results

Public Green Space	12th and Trenton .4 acres
	Cesar Chavez Park 1.7 acres
	Duwamish Waterway Park 1.5 acres
	Marra-Desimone Park 8.6 acres
	Park by the riverside .5 acres
	South Park Meadow 1 acre
	South Park Playground 5.5 acres
	South Park Plaza 3.47 acres
Total Green Space Acres	22.6
Total Population	4,135
Total Population Within Service Area	3,979
Total Population Underserved	156
Total Green Space Deficiency Minimum Acres Considered	3.2
Total Green Space Deficiency Maximum Acres Considered	20.8

Table 5: South Park ¼ Mile Service Area Green Space Pedestrian Accessibility Results

Total Population Underserved: 4,135 – 3,979 = **156** residence

Total Green Space Deficiency:
(*4,135 * .00625 = 25.8* acres) – *22.6* acres = ***3.2* acres minimum**
(*4,135 * .0105 = 43.4* acres) – *22.6* acres = ***20.8* acres maximum**

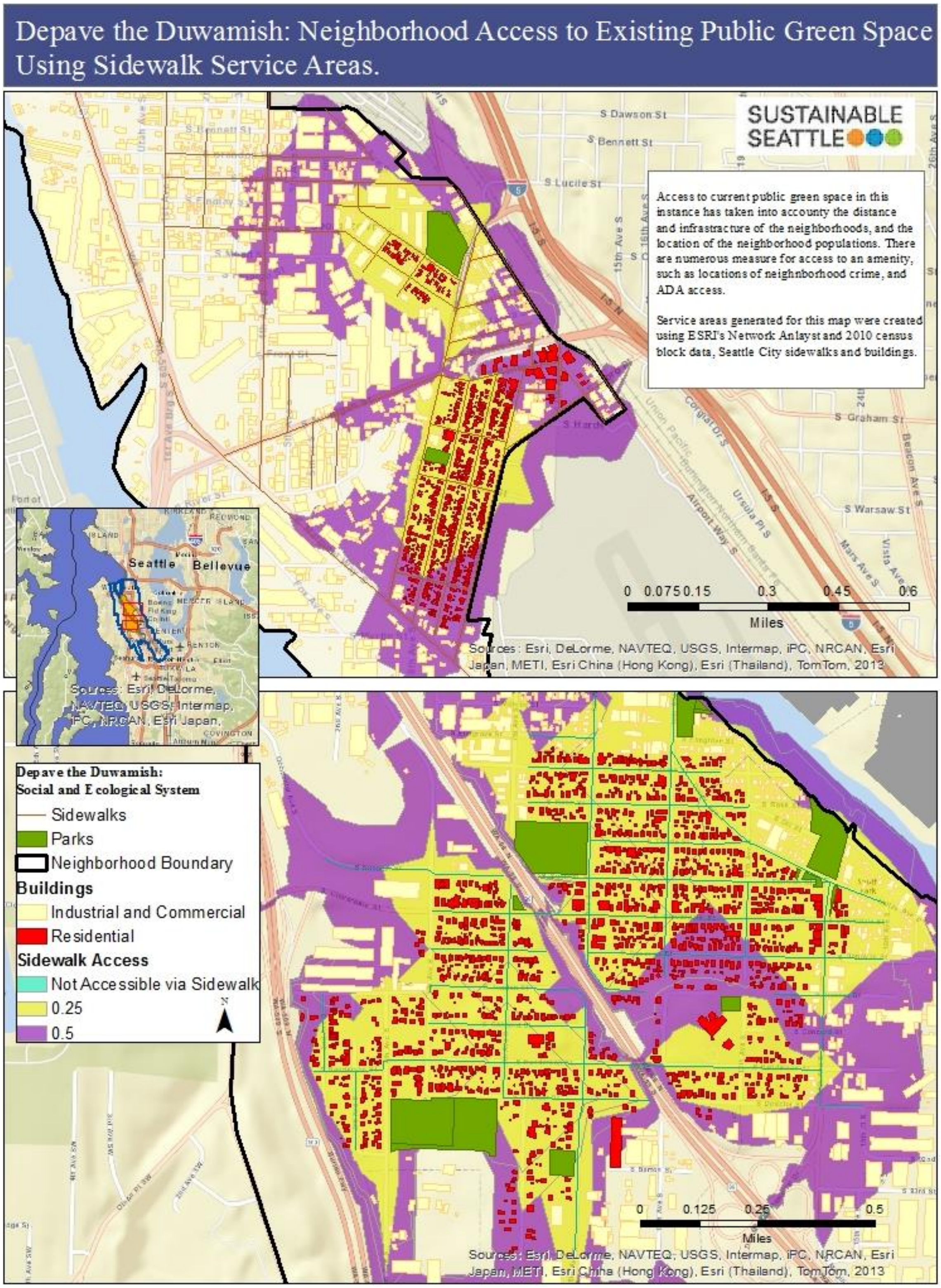

Figure 3: Existing Public Green Space Pedestrian Accessibility and Sidewalk Connectivity Analysis Results

The final Iteration

The final iteration of the pedestrian access analysis using the ESRI, ArcGIS Network Analyst, Service Area tool was used on the remaining 32 sites with sidewalk network connectivity within 100 meters of the network. Of the 32 sites, only 10 had sidewalk network connectivity, therefore only 10 of the 32 were included in the final service area analysis using the threshold of ¼ mile distance, the final sites in relation to population were analyzed.

Results

Results of the analysis using the 10 sites with pedestrian network connectivity show 2 sites have 0 residential populations falling within the service area. Three sites have 19 residents living within the service area of those three sites, two with 66, one with 1, and one with 354 residents.

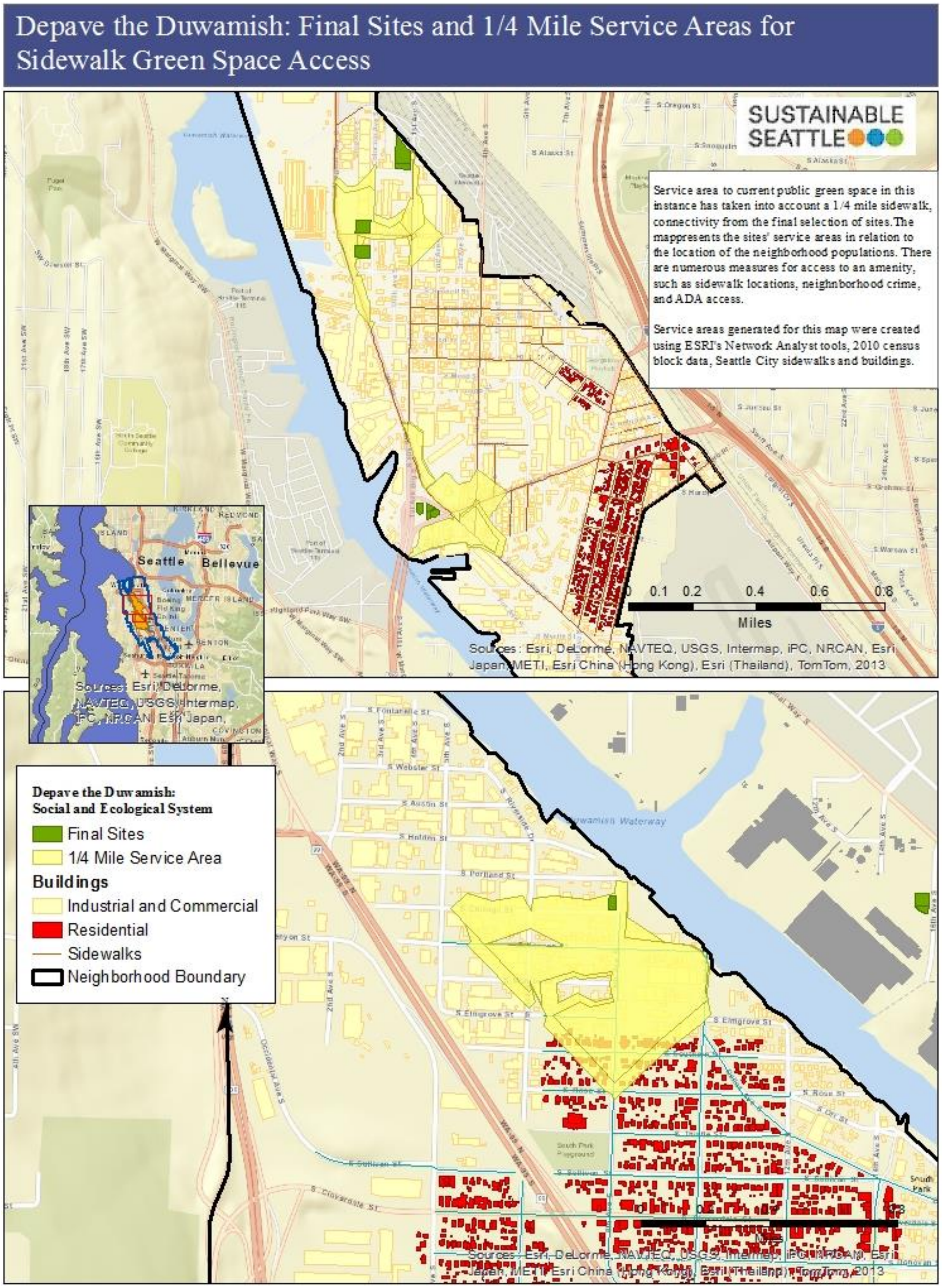

Figure 4: Final Sites and ¼ Mile Service Areas for Sidewalk Accessible Green Space

Pedestrian Accessibility Results

The results from the first iteration provide a general overview of who falls within the ¼ mile distance from each current green space. The second iteration has more detail and takes into account the mode of travel, walking on sidewalks, with additional data representing smaller scale population, though numbers are not available. The resulting spatial data show populations on the fringes of residential zoning falling outside of the service areas. These areas were then used on a parcel scale in the multiple criteria analysis as underserved populations that require a green space within proximity and accessible according to National Recreation and Parks Association standards (2012).

Pedestrian Accessibility Limitations and Simplifying Assumptions

Measuring accessibility to public green space in this study took into account three societal pedestrian infrastructure elements that can measure access; distance, available sidewalk, and sidewalk connectivity. There are numerous studies outlining social metrics of access, environmental measures of access, and the capabilities of all individuals to travel distances (Hutabarat 2009). Infrastructure access data relating to population locations was available for analysis, and therefore was utilized in this study. However, for a more detailed study of accessibility, social and environmental pedestrian measure data on the neighborhood scale, such as crime and safety, comfort and personal space, should be added (Hutabarat 2009).

Recommendations for Pedestrian Green Space Access

The focus of the analysis was to determine locations of underserved populations of Georgetown and South Park, Seattle by first locating populations that currently have sidewalk connectivity within a ¼ distance to public green space. Pedestrian level analyses in conjunction with infrastructure and population locations have provided a good understanding as to where the underserved populations of both neighborhoods reside. It is recommended for future access studies conducted by Sustainable Seattle that connectivity via sidewalk, bike paths, quality of infrastructure, and existing amenities all be taken into account. Time constraints prohibited this analysis from studying all afore mentioned measures. However, data has been provided to Sustainable Seattle in GIS form for future use. For the fastest results, using scientific methods of sustainability management practices, using a GIS professional to conduct future analysis will yield more accurate results using a Service Area analysis. This was done using the ESRI Network Analyst Service Area tool and requires a high level of GIS understanding to use. In the first iteration of the analysis a simple ¼ mile buffer was generated to generalize the populations that fall within the buffer and those that do not. Though this method is simple to use, the results are far less accurate or realistic. The second iteration using the Service Area tool calculated Euclidian distance with 100 meter buffer from sidewalks to determine the area for which each green space can be accessed via the sidewalk within ¼ mile.

Site Suitability Analysis

GIS was used to locate the most suitable sites for the depaving project. Eight data exclusions were determined, documented and spatially located to exclude the use of parcels residing within any of the eight exclusionary criteria. Table 6 describes these exclusions, data acquisition methods and data sources. Using the remaining parcels a multiple criteria site suitability analysis was conducted for six spatial characteristics. See Table 7 for a listing of the criteria, method of data acquisitions, and data sources of these. The criteria used in the analysis were decided in collaboration between GIS students and project sponsors to ensure the data used in the analysis both originated and satisfied the objectives described in the grant application. To further refine the resulting suitable parcels a second tier of criteria was included in an overlay analysis. Three different scenarios were based on project objectives. See Table 8 for the second tier of criteria used in the analysis. A quantitative value system counting the number of overlaying criteria per parcel was used, providing Sustainable Seattle a total number of criteria met per parcel(Safaripour 2012).

Criteria	Data Acquisition	Source
Industrial zoned only	Zoning GIS layer	King County GIS Department
Contains impervious surfaces	Impervious Surface GIS layer	King County GIS Department
Not connected to CSO	CSO GIS layer	King County GIS Department
Not used for residential	Landuse GIS Layer	Department of Ecology GIS
Not within unsuitable infiltration	Unsuitable Infiltration GIS layer	King County GIS Department
No superfunds on-site	Superfunds GIS Layer	Environmental Protection Agency GIS
No TRI (toxic release inventory) on-site	Toxic Release Inventory GIS Layer	Environmental Protection Agency GIS
No brownfields inventory on-site	Brownfields Inventory GIS Layer	Environmental Protection Agency GIS

Table 6: Exclusionary Criteria for Site Suitability According to Grant Requirements

Criteria	Data Acquisition	Source
Include Under-Utilized Parking Areas	Public participation web map (see Public participation section for details)	Public feedback from project sponsors and neighborhood contacts
Include Under-Utilized Parcels	Public participation web map (see Public participation section for details)	Public feedback from project sponsors and neighborhood contacts
Include Proximity to Residential (greater than 1/4 mile walking distance to green space)	1/4 Mile Service Area - see Walkability analysis section for details	
Avoid Natural Drainage Areas	Wetlands GIS layer	King County GIS Department, University of Washington WAGDA

Include Drainage Complaint/Problem areas (runoff, flooding, puddling)	Drainage Complaint GIS layer	King County GIS Department
Include Proximity to Most Densely Populated Areas	Population/square acre using census block groups	King County GIS Department, US Census Bureau

Table 7: Criteria used to Establish Suitable Parcels

Criteria	Data Acquisition	Source
Parcel minimum size of 3,333 square feet (1/3 total impervious in project)	Parcel GIS layer	King County GIS Department
Accessibility to sidewalks	Sidewalk GIS layer/Impervious GIS Raster	King County GIS Department
Population served with additional green space within 1/4 mile service area	1/4 Mile Service area - Walkability analysis	King County GIS Department/ ESRI ArcGIS Online
Estimated Available Amount of Runoff per Impervious Surface area	Impervious GIS Raster	King County GIS Department
Parcels with a Dept. of Ecology water quality facility located within 100ft	EIM GIS Layer	Department of Ecology

Table 8: Second Tier used to Establish Scenarios and Final Recommendations

The major project objectives were to create more green space benefitting the neighborhood while simultaneously creating a healthier watershed. This is to be done by installing green storm water infrastructure, promoting additional canopy cover and removing underutilized impervious surface to move the neighborhoods closer to becoming resilient to climate change. The three scenarios proposed for this were Greatest Green Space Pedestrian Accessibility Gains, Greatest Ecological Gains and Highest Overall Criterion Met. Groupings of the second tier criterion were developed and scored to determine the parcels most fitting for each scenario. The parcels found most suitable for the Greatest Green Space Pedestrian Accessibility Scenario were chosen by summing the greatest total criterion involving any population gaining green space access as identified in the analysis. Those among the choice parcels for the Greatest Ecological Gain Scenario involved those that had the largest number of spatially intersected criterion of Department of Ecology monitoring facilities and containing at least 3,332 square feet of impervious surface available for mitigation and therefore a large amount of estimated runoff. The Highest Overall Criteria Scenario was determined by finding the sites with the highest total of all the second tier criterion intersected through the overlay analysis.

In order to ensure transparency and repeatability, the workflow used for running the site suitability analysis was created through the use of five scripts. The entire analysis can be re-run using the same data, or data of the same type, in different neighborhoods. Scripts were written using Python 2.7 and then exported and described in ArcCatalog 10.2 as tools. Each input for each script has user-defined inputs and descriptions to help correctly run the tool. Exporting scripts as tools provided a means to be used for future similar projects with different data and to allow for iterative sensitivity analyses to be conducted.

Feasibility Study

A Feasibility Study, to objectively evaluate the condition of the selected sites, was conducted to visually verify suitable site location and to take notes about the site and surrounding area. Using a web map and map book that was created for public participation, sites were located, photographed and documented. This information was then applied to a PPGIS web map for the continued effort of including public participation in all phases of the depave project. The Feasibility Study was used to evaluate the potential of the suitable sites to support the decision making process. While extensive effort went into determining the suitability of sites through GIS analyses this preliminary study incorporated photos and notes to a web map. Figure 4 displays a parcel that has been selected in the web map. It shows the user defined information that a viewer can review per parcel. A "How to" list of instructions has been created so the sponsors may continue to present information about project status to the public as well as to obtain feedback.

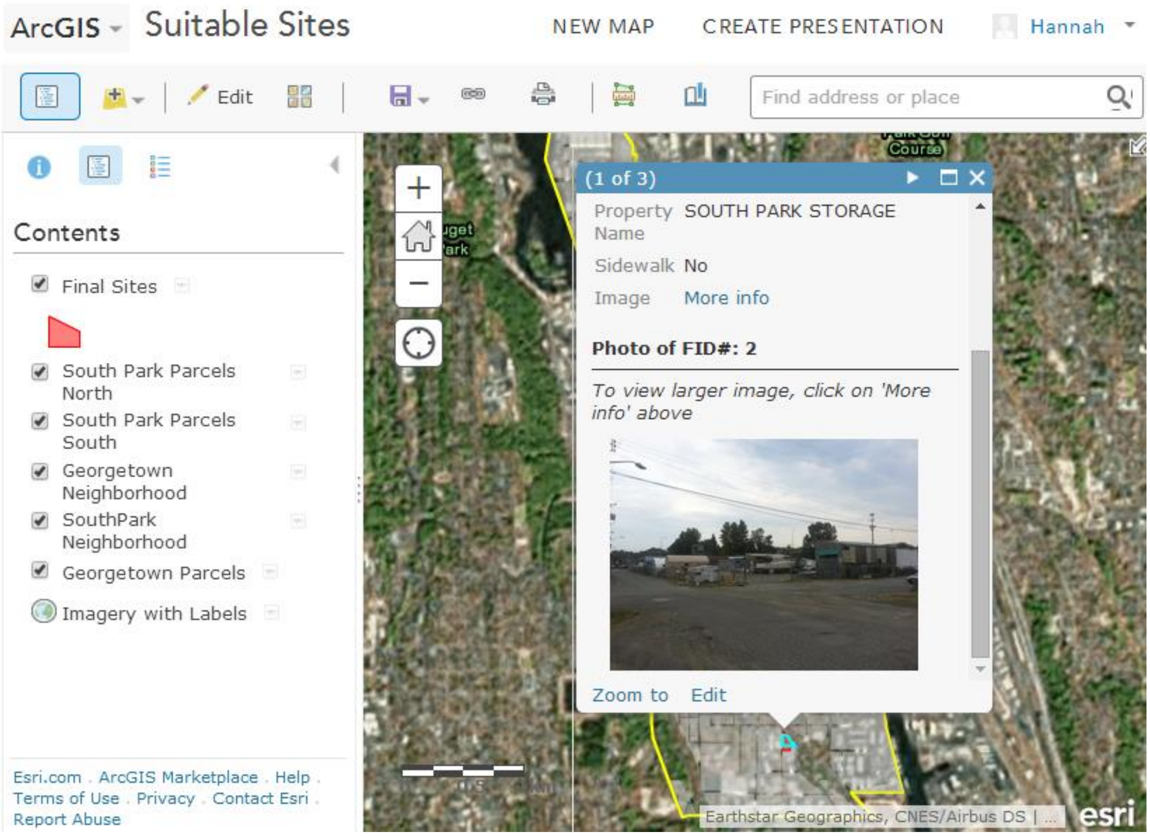

Figure 5: Web Map Interface

Results

Site Suitability Analysis

Thirty-two parcels were remaining after the exclusionary data was overlaid on the parcels within the Georgetown and South Park neighborhoods. After running the second tier criteria of ideal project site characteristics eight sites resulted in the highest appraisal scores. These sites were then chosen as parcels selected for the Highest Number of Criteria Met Scenario. The parcels containing the highest number of ecological criteria were selected for the Greatest Ecological Gains Scenario and the parcels with the highest number of overlapping characteristics pertaining to a gain in pedestrian accessibility to green space were selected for the Greatest Gain of Pedestrian Accessibility to Green Space Scenario (see Appendix F for resulting maps of each scenario). The resulting parcels from the Highest Number of Criterion Met Scenario were the same eight parcels resulting from the Greatest Gain of Pedestrian Accessibility to Green Space Scenario. Only one parcel had met both criteria used in the Greatest Ecological Gains Scenario, twenty-eight had met one criterion and three had met none. Using the parcels selected from each of the scenarios a recommendation was made for nine of the parcels to be endorsed for project sponsors, Sustainable Seattle and Urban Systems Design to concentrate their education and outreach efforts around.

Results have been documented through tables and maps, showing the analyses results and criteria met in establishing each scenario. Table 8 shows the results of the overlay analysis for each of the thirty-two suitable sites and the second tier criteria. Table 8 is categorized by storm water system and has columns for each of the scenarios with a mark to indicate whether or not the parcel was selected for each. The eight parcels with highest number of criteria met and greatest gain of green space pedestrian accessibility were among the twenty-eight sites ranked second highest for the Greatest Ecological Gains Scenario; the nine recommended parcels consisted of the eight parcels as well as the parcel with the highest appraisal score from the ecological scenario. These nine parcels are located within four separate storm water systems; this fulfills the grant requirement of selecting three sites from three different storm water systems. The nine recommended parcels are highlighted in Table 8. Resulting maps of the site suitability analysis are shown on Figures 5 and 6; Figure 5 shows the 32 resulting parcels from overlaying exclusionary data and Figure 6 shows the locations of the nine recommended parcels.

These results have also been made available as web maps for Sustainable Seattle to share them amongst community members. A link to a map comparing the scenarios and recommended sites can be found here: http://uw-geog.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=109336a46ff146a6ace585898df744ab.

Storm water System - Diagonal											
	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Resident-ial**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**High-est Ove-rall**	**Greatest Public Access**	**Greatest Eco-logical**
3573200005	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x
3573200040	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x
3573200135	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x

3573200920	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x

Storm water System - DUWR002 (Georgetown)

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
5367202410	High Residential	No Natural Drainage			DOE site	Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	3			x
5367200050	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x
5367200160	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x
5367200025	High Residential	No Natural Drainage	Sidewalk Access			Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	3			x
5367200029	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x

Storm water System - DUWR002 (SouthPark)

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
7327902490	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x

6871200100	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
7327906426	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
7327906525	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x

Storm water System - DUWR005

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
2433700135	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
2433700145	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
2433700156	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x

Storm water System - SouthPark001

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
7327903330	High Residential	No Natural Drainage	Sidewalk Access	Green Space Population Served		Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	4	x	x	x

7327904100	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
7327905940	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
7327906685	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
7327906636	High Residential	No Natural Drainage						0			
7327906750	High Residential	No Natural Drainage						0			

Storm water System - Unnamed003

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
2136200375	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x

Storm water System - Unnamed010

	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residential**	**No Natural Drainage**	**Sidewalk Connect-ivity**	**Added Green Space Access**	**DOE site**	**Lot Min SqFt**	**Est. Runoff**	**Second Tier Total**	**Highest Overall**	**Greatest Public Access**	**Greatest Eco-logical**
2924049056	High Residential	No Natural Drainage	Sidewalk Access			Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	3			x
2924049098	High Residential	No Natural Drainage	Sidewalk Access			Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	3			x

Storm water System -Unnamed015											
	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residenti al**	**No Natural Draina ge**	**Sidewal k Connec t-ivity**	**Added Green Space Access**	**DO E site**	**Lot Mi n SqF t**	**Est. Runoff**	**Secon d Tier Total**	**Highes t Overal l**	**Greate st Public Access**	**Greate st Eco-logical**
5367202270	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
5367202310	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
5367202380	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
5367202390	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
5367202400	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x

Storm water System -Unnamed054											
	First Tier Criterion (met)		***Second Tier Criterion***						***Scenarios***		
Parcel PIN	**High Density Residenti al**	**No Natural Draina ge**	**Sidewal k Connec t-ivity**	**Added Green Space Access**	**DO E site**	**Lot Mi n SqF t**	**Est. Runoff**	**Secon d Tier Total**	**Highes t Overal l**	**Greate st Public Access**	**Greate st Eco-logical**
5367202525	High Residential	No Natural Drainage				Lot Min SqFt 3,332 +	Min Impervious Surface Available 3,332+	2			x
5367202515	High Residential	No Natural Drainage						0			

Table 8: Site Suitability and Scenario Analyses Results

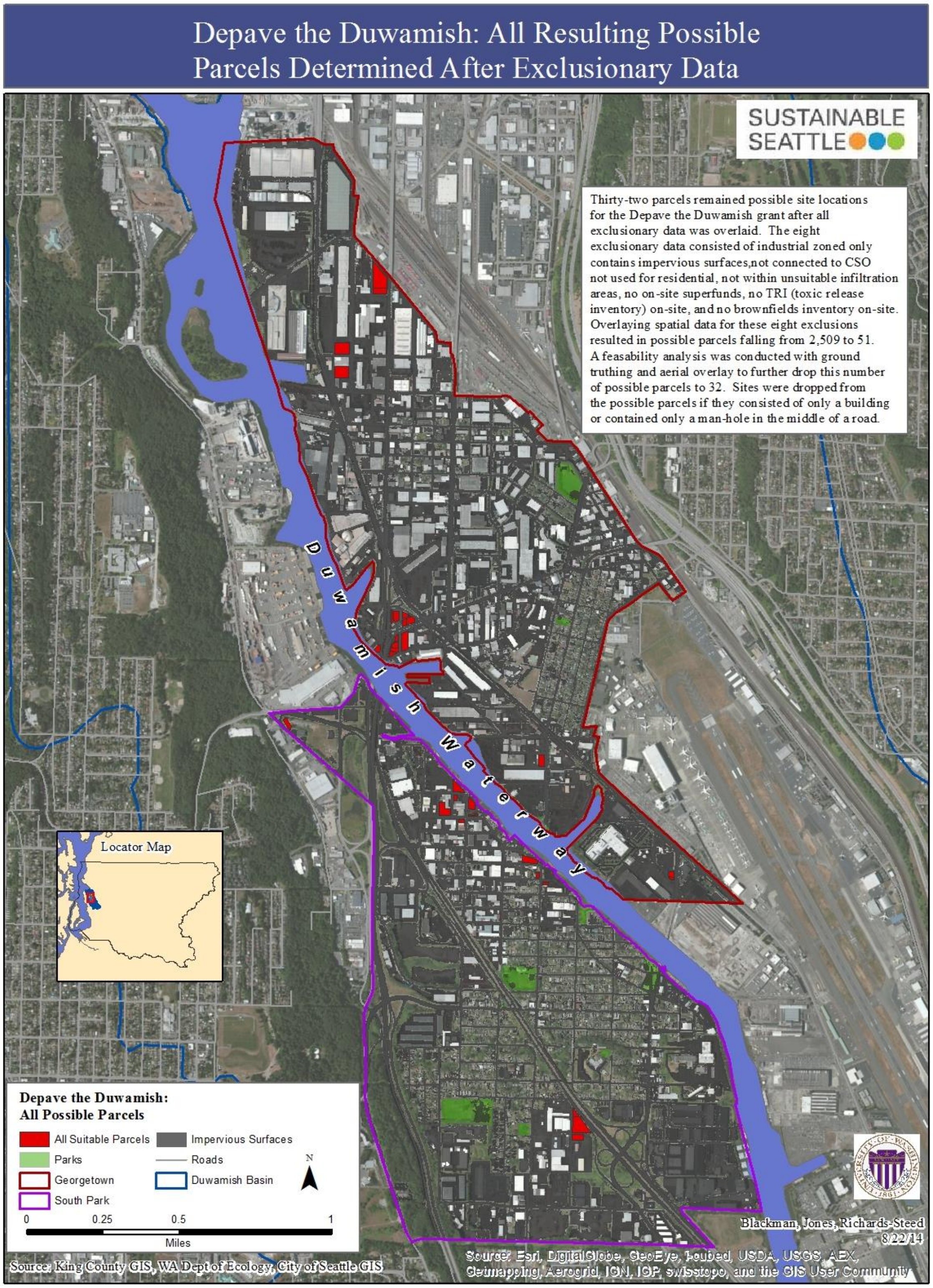

Figure 6: All Possible Parcels for the Depave the Duwamish Project

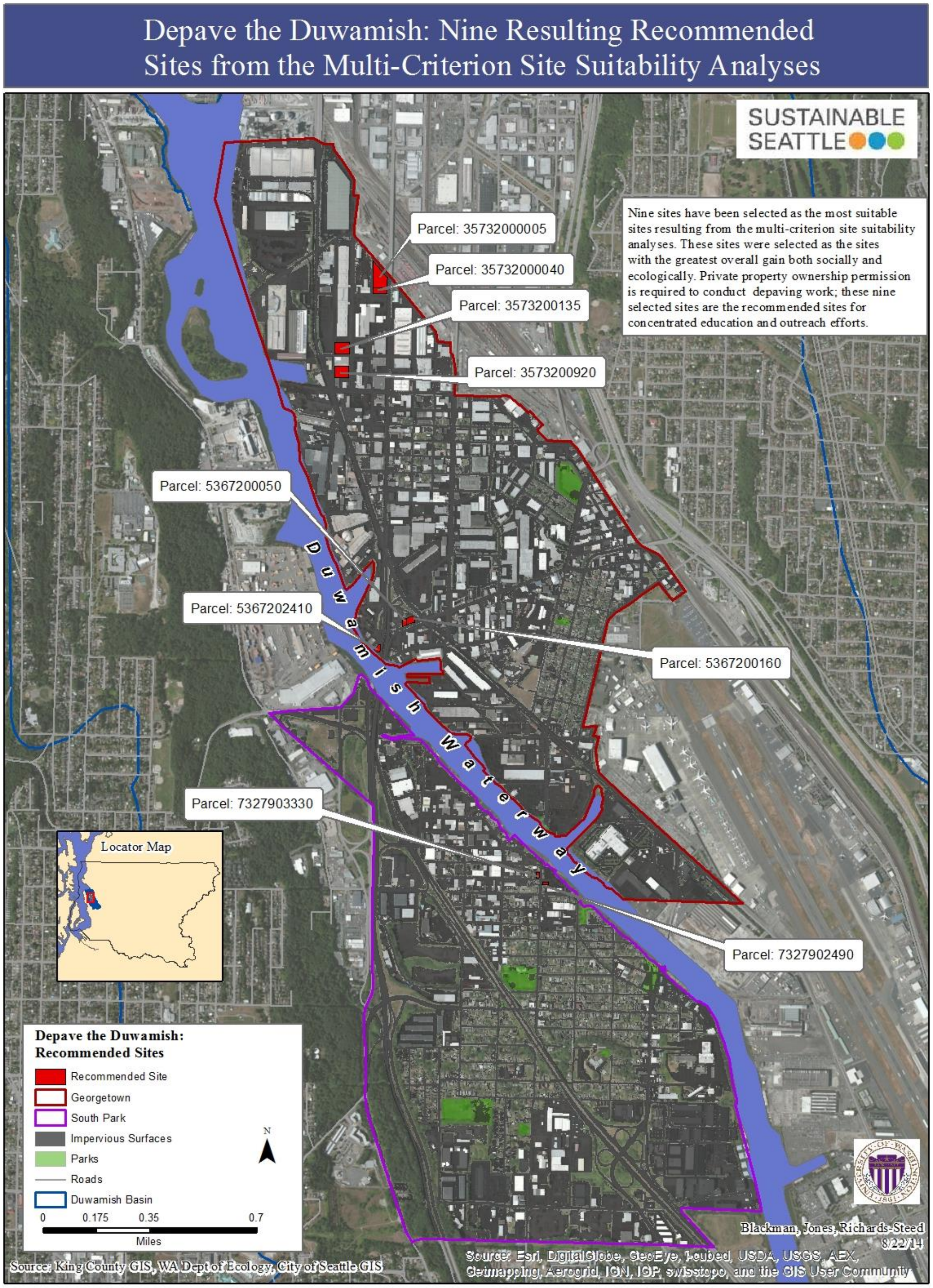

Figure 7: Nine recommended parcels for concentrated education and outreach efforts for the Depave the Duwamish Project

Discussion

Site Suitability

The multiple criteria suitability analyses resulted in narrowing down 2,509 possible parcels located in the area of interest to 32. Eight exclusionary datasets were analyzed using an overlay analysis due to the requirements of the 'Lower Duwamish Air and Water Quality Improvement Grant' in which this project is funded. Property owner permission is not only required but an agreement must also be made to work with community members to manage the newly depaved areas until plants are established. The second tier of criteria used in the analysis further refined the sites into groupings of the most suitable locations according to one of three scenarios. The scenarios used in this analysis were sites with the greatest gain for pedestrian accessibility to green space, greatest ecological gain and highest number of overall criterion met. Using the outcomes of the scenarios nine sites have been selected that best represent all three outcomes; representing the objectives of the grant and having the most suitable qualities of a project site regarding location and amenities it could provide. The purpose behind recommending nine sites is to give Sustainable Seattle specific locations where efforts should be targeted to gain the most valuable social and ecological benefits when selecting their three sites to work on.

Current conditions of Georgetown and South Park show 56.21% and 52.46% respectively of the neighborhoods to be impervious, excluding buildings. Literature reviews show environmental degradation begins when an area reaches 10% impervious ("Urban Nonpoint Source Fact Sheet", Frazer 2005). Streams show degradation occurs but are not heavily impacted until higher levels of impervious begin to persist. Percent impervious between 10 - 30% show impacted conditions (Klein 1979). Severe degradation begins when impervious surfaces reach levels higher than 30% ("Urban Nonpoint Source Fact Sheet", Klein 1979). Table 9 shows the amount of impervious surface both neighborhoods contain with current conditions, and the possible outcomes depaving 10,000 square feet will make. The table also includes the total square feet of depaving required to meet the 10% or 30% impervious thresholds.

		Current Conditions			*Impervious Surface to be Removed to Meet Thresholds (Square Feet)*		
	Total Square Feet	***Total Impervious Square Feet***	***Percent Impervious***	***If 10,000 Square Feet Depaved (All 3 Sites)***	***10% Impervious***	***30% Impervious***	***50% Impervious***
Georgetown	43,184,057.46	24,274,885.74	56.21%	56.19%	14,590,765.98	11,626,706.00	6,771,728.85
South Park	41,971,651.82	22,017,757.01	52.46%	52.43%	15,756,729.63	13,348,567.71	8,945,016.31
Both	85,155,709.28	46,292,642.75	54.36%	54.35%	30,347,495.61	24,975,273.71	15,716,745.16

Table 9: Impervious Surface Conditions

Environmental Impacts

As previously mentioned literature reviews cite environmental thresholds of impervious surfaces within watersheds are severely degraded past the 30% impervious threshold (Klein 1979, "Urban Nonpoint Source Fact Sheet"). This degradation begins with areas composed of 10% - 15% of a watershed ("Urban Nonpoint Source Fact Sheet", Frazer 2005). Very sensitive streams can begin degradation at even lower levels of percent impervious areas (Frazer 2005). Studies have shown channel stability weakens, fish diversity lessens and overall stream health weakens at the beginning stages of degradation (Delaware Sea Grant College Program 2005). At a threshold of 15% impervious surfaces nearly 60% of benthic macro invertebrate taxa may occur ("Impervious Surface: Water Quality Index"). While impervious surfaces alone do not cause water quality damage, they do halt soil infiltration, causing pollutants to load the waterways without an opportunity for soil or plant nutrient uptake. Streams can quickly turn into storm water conveyances with the emergence of impervious surfaces within a watershed.

Through the lack of infiltration and exponential increases in water, impervious surfaces severely damage the social ecological systems existing in nearby water bodies ("Impervious Surface: Water Quality Index", Delaware Sea Grant College Program 2005, Klein 1979). Klein compared the quality of water from urban runoff to raw sewage noting it could be 2-10 times as polluted (1979). Total phosphorus and nitrogen from urban area runoff compose the second highest pollutant loading rates from land use type (Klein 1979). Major types of contaminants found and conveyed over impervious surfaces in storm water are metals, pathogens, nutrients and organic chemicals ("Urban Nonpoint Source Fact Sheet").

When water body conditions begin to decline it is not only the quality of water and its resident ecological systems but a significant increase in water quantity occurs as well (Frazer 2005). The abundance of water contributed by increases in impervious surfaces can cause wipeout conditions along stream banks and oftentimes, when caused by urbanization require new and expensive storm water systems to be installed. According to research from a the Natural Resources Defense Council when comparing the amount of runoff resulting from one acre of a paved parking lot to one acre of a meadow, runoff increases sixteen-fold (Frazer 2005, "Urban Nonpoint Source Fact Sheet"). Using the equation given for determining an estimated amount of runoff from one acre of paved parking lot resulting in 3,450 cubic feet and one acre of a meadow resulting in 218 cubic feet Table 10 shows estimated runoff (in cubic feet). Results are formulated for current impervious surfaces as well as the changes that could be estimated for the Georgetown and South Park neighborhoods, with a 10,000 square feet reduction of impervious and if enough impervious was removed to meet either the 10%, 30% or 50% thresholds ("The causes of urban stormwater pollution"). Although the comparable of a meadow in the urban Georgetown and South Park neighborhoods is challenging, Frazer states pavement contributes between ten and twenty times more runoff than grass (2005).

		Current Conditions				Estimated Runoff from 1 inch Rainstorm per percent impervious scenario (cf)		
	Total Square Feet	*Total Impervious Square Feet**	*Total Permeable Square Feet*	*Estimated Rainoff from 1 inch Rainstorm (cf)*	*Estimated Runoff After 10,000 Square Feet Depaved (cf)*	*10% Impervious*	*30% Impervious*	*50% Impervious*
Georgetown	43,184,057.46	24,274,885.74	18,909,171.72	2,017,230.38	2,016,488.41	934,646.46	1,154,569.36	1,514,791.73
South Park	41,971,651.82	22,017,757.01	19,953,894.81	1,843,691.71	1,842,949.74	674,597.35	853,274.56	1,180,002.71
Both Neighborhoods	85,155,709.28	46,292,642.75	38,863,066.53	3,860,922.08	3,860,180.12	1,609,243.81	2,007,843.92	2,694,794.44
Neighborhood (Focal Scale) Total Runoff Percent Change					**-0.02%**	**-58.32%**	**-48%**	**-30.20%**
*Impervious surface does not include buildings								

**Estimated runoff coefficients used are determined by amount of runoff calcuated on a one acre parking lot for impervious surfaces and amount of runoff calcuated on a one acre meadow for permeable surfaces. Figures used from research show 218 cubic feet of runoff on an acre of meadow and 3,450 cubic feet on an acre of parking lot. (Source: Natural Resources Defense Council - The Causes of Urban Stormwater Pollution, http://www.nrdc.org/water/pollution/storm/chap2.asp)

Table 10: Stormwater Runoff Conditions

Another direct environmental impact related to impervious surfaces is the urban heat island effect. The urban heat island effect is caused by dark, low albedo impervious surfaces and less canopy cover causing less reflective energy and more absorption energy from the sun. This results in increases in temperatures within cities with an abundance of these land cover characteristics (Giridharan and Kolokotroni 2008, "Community-Scale Environmental Measure and Urban Heat Island Impacts"). Several sources cite a drop in temperature of at least 1° Celsius from surrounding vegetation in urban environments (Bowler, Buyung-Ali, Knight and Pullin 2010, (Kleerekoper, van Esch and Salcedo 2012). Kleerekoper states vegetation in urban areas can cause anywhere between 1°-4.7° Celsius drop in temperature spreading between 100-1000 meters (2012). Table 11 shows the current area of each neighborhood benefiting from this urban heat island cooling effect as well as projected estimations for the additional area to be served with three additional sites within the neighborhood. These calculated estimates assume new sites will not have overlapping areas of cooling from existing parks or each other. A map depicting the current locations of parks, the nine recommended sites and the areas of urban heat island cooling that corresponds to 100-1000 meters of spreading is found in Figure 7.

			Current Conditions	
	Total Square Feet	*Total Area of Parks*	*Percent Area Served by Cooling Effect of 1000m Buffer of Parks*	*Percent Area Served by Cooling Effect of 3 Additional Sites (1000m Buffer)*
Georgetown	43,184,057.46	289,693.57	67.53%	67.55%
South Park	41,971,651.82	919,191.90	95.82%	95.84%
Both Neighborhoods	85,155,709.28	1,208,885.46	81.47%	81.48%
*At least a 1°C drop in temperature results from vegetation in urban areas (Giridharan et al. 2008; Zoulia et al.2009; Bowler et al. 2010). According to Schmidt (2006) an urban park can lower the temperatureany where between 1°- 4.7°C spreading across 100–1000 meters througout the urban area.				

Table 11: Urban Heat Island Effect

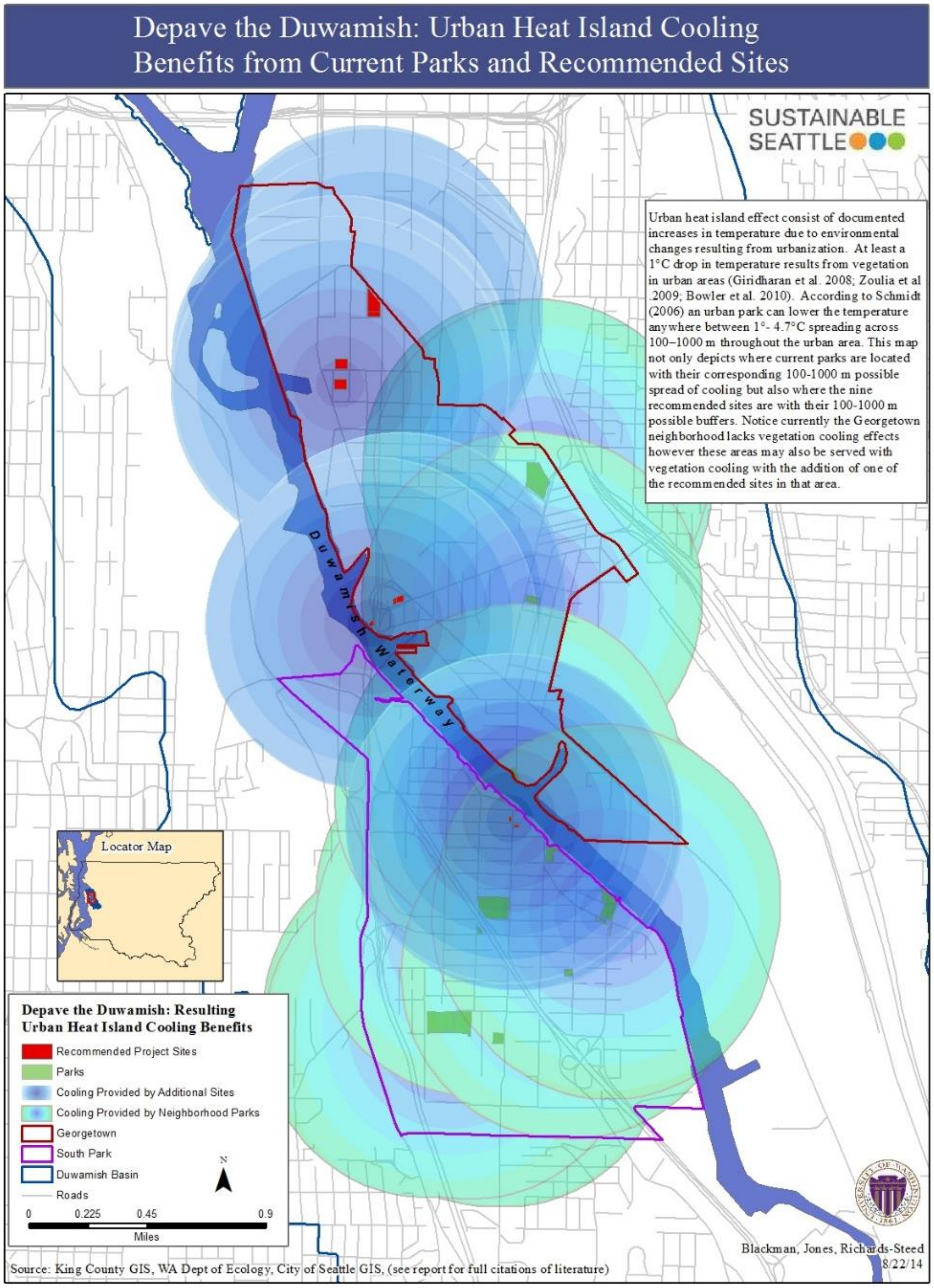

Figure 8: Urban Heat Island Effects

Although several other environmental impacts are caused from increases of impervious surfaces within watersheds, the last environmental impact to be discussed in this report is carbon sequestration. Sustainable Seattle expressed in their grant application their desire to create neighborhood scale climate resilience. Reducing impervious surfaces and replacing them with runoff mitigation through green space is one way to work towards this goal, in so doing carbon sinks for sequestration are also being created (Strobach 2011).

The US Department of Transportation Federal Highway Administration in partnership with the US Department of Research and Innovative Technology Administration, as a management intervention practice for climate change resilience, is studying green space for carbon sequestration (Federal Highway Administration 2010). Data from their findings in the project: Carbon Sequestration Pilot Program, or CSPP, has been applied to this project, and can inform Sustainable Seattle and landowners as to the estimated amounts of carbon sequestration that can be gained by implementing green space for the full 10,000 square feet, or .23 acres provided by the King County Wastewater Division grant funding.

Table 12 provides estimated carbon sequestration rates for .23 acres of converted impervious surface. Data in the table is based on the Federal Highway Administration's assumption that grasses on average can sequester carbon for 50 years, trees in general can sequester carbon for up to 120 years, using the average age of vegetation of 25 years. Wetland carbon sequestration rates were not supplied by the CSPP study and have been cited from the article in Science Daily, 2012, Temperate Water Wetlands are Forgotten Carbon Sinks. Much of the tabular data for wetlands was not available, thus empty spaces in the row.

10,000 Sq Ft	Total Acres for green space	Carbon Sequestration Rates (metric tons C/.23ac/yr)	Carbon Sequestration Rates (Pounds C/.23ac/yr)	Metric Tons of Carbon/Year in a Life Time	Pounds of Carbon/Year in a Life Time
Deciduous	.23	.00000104	.0023	.5	1102.3
Coniferous	.23	.00000177	.004	.52	1146.4
Mixed	.23	.00000933	.21	.51	124.3
Grasses	.23	.000000024	.00005	.161	355
Shrubs	.23	.000000136	.0003	.161	355
Total Unpaved	.23	.0000000155	.000034	.244	538
Wetlands	.23		632		
Impervious	.23	0	0	0	0

Table 12: Estimated Carbon Sequestration Rates of Converted Impervious Surface

Acres equivalent to 10,000 square feet are listed in the first two columns in Table 12 and the columns following list the estimated sequestration amounts in metric tons, pounds, and the amount of carbon stored over a lifetime of 120 years for trees and shrubs, and 50 years for grasses. Unpaved open space has been included in the table as well.

Using the CPSS figures in relation to Parks and Recreations recommended green space, the same carbon rates were applied to Georgetown and South Park for the total amount of deficient green space minimum of 6.25 acres per 1,000 people, and the maximum of 10.5 acres per 1,000 identified in the Pedestrian Accessibility Analysis (See page 20). Both neighborhoods fall short of these thresholds; Georgetown lacks a minimum of 1.6 acres, and a maximum of 7.1 acres, and South Park lacks a 2.8 acres minimum, and 20.8 acres maximum. The following table provides estimated carbon sequestration that can be gained by using grasses, trees, or both to reach the National Parks and Recreations Association's recommendations for green space in each neighborhood.

Georgetown

Potential Carbon Offset lbs/ac/yr	Grasses	Coniferous	Deciduous	Mixed
Deficiency Min 1.6 acres	.00008	.03	.02	1.4
Deficiency Max 7.1 acres	.0015	.123	.07	6.5

South Park

Potential Carbon Offset lbs/ac/yr	Grasses	Coniferous	Deciduous	Mixed
Deficiency Min 3.2 acres	.0007	.056	.032	2.9
Deficiency Max 20.8 acres	.005	.36	.21	19

Table 13: Estimated Carbon Sequestration Rates by Land Cover Type

According to Tufts University, Office of Sustainability, sequestrations rates for vegetation vary greatly according to the location, the age of the vegetation, and composition (Tufts Office of Sustainability 2014). With public green space implementation in the planning phase to incorporate carbon sequestration as a benefit requires consideration of what the green space will consist of and what type of maintenace emissions will result in the green space implementation and life of the green space. For instance, if the green space consists of turf grass that needs mowing, the emissions of the mower may offset any sequestration benefit gained by planting grass. The same principal applies to any vegetation put in place that may require a lot of maintence. According to Hostetler, Mark E, et al management practices that incorporate low maintenance green space produce far less CO2 as by product from maintenance than vegetation that requires consistant maintenance. Thus, urban open spaces with fertilized lawns and regularly pruned trees are a source of CO2 rather than a sink. The University of Florida found that a 4-hectare green space with 85% landcover in lawn produces 11 tons of C02 per year (University of Florida, EDIS 2013). To maximize the benefits of green space for carbon sequestration, best management practices include using long-lived, low maintence, fast growing species. In conjunction with maintence practices to prolong life and vitality, using trees as wood products to delay decomposition and release of C02 for furniture, building products, and reducing fossil fuel use in maintence activities as described in Sustainable Horitculture, April 2010 (Sustainable Horticulture 2010).

Social Impacts

The impact of community design and landuse choices in relation to impervious surfaces in urban studies, and social equity and well-being for sustainability is difficult to measure. However, it is documented that access to green space affects the usefulness of green space for public betterment and can serve to moderate inequalities (A.C.K. Lee 2010). High rates of impervious surface in relation to green space within the Georgetown and South Park neighborhoods is documented by the Washington Department of Ecology as extremely high, and green space extremely low (ECY 2014). Sustainable Seattle is working towards reducing impervious surfaces and replacing them with green space. The Duwamish River Clean-up Coalition, a project partner to Sustainable Seattle, has cited the Georgetown and South Park neighborhoods of Seattle as in need of public access green space to serve the neighborhood populations, with indication that such access can make their neighborhood populations more healthy. Outlined in their report; *Duwamish Valley Cumulative Health Impacts Analysis: Seattle, Washington*, written by the lead investigator BJ Cummings, it was reported that residence expressed concern that they lacked access to green space and places to play and exercise. Their concerns were expressed through a community based participatory research project which allowed local residents to share their opinions and worries (Cummings 2013).

In this project GIS technology has been used with sustainability management science to formulate a social component to green space infrastructure. Key elements noted in the green space and social well-being literature reviewed for this analysis mention two key social components; collaboration on site selection, and access to the space (Environmental Design

Research Association 2014). For the collaboration component the aforementioned PPGIS using web map services and interactive features was designed to supply a methodology and tool for the public of Georgetown and South Park for equal say and interaction for participation in the Sustainable Seattle project. The main limitation with the PPGIS is internet access. The issue of access to public green space by society, though complex in nature to measure, is a common theme in the study of green space in relation to social well-being (A.C.K. Lee 2010). In this analysis access is measured at the pedestrian scale, where car ownership and age do not define the mode of travel, making sidewalks the network of choice to model connectivity.

A social impact from impervious surface amounts was not the focus of the previously mentioned DRCC report. It is made clear that more green space would benefit these neighborhoods not just for the environmental purposes of catchments for runoff, but also for the social well-being of the communities and access to green space (Cummings 2013). According to calculations made to measure total impervious surface area found in Table 9, the total impervious surface area for Georgetown is 24,274,885, or 557 acres, and South Park comes in at 22,017,757, or 505 acres, with 6.6 acres of public green space in Georgetown, and 22.6 acres of public green space in South Park calculated using GIS.

EPA's National Stormwater Calculator

The EPA's National Stormwater Calculator was utilized to analyze suitable sites as a test for the next phase of Sustainable Seattle's Depave the Duwamish project. The EPA calculator is downloaded from EPA's website at http://www2.epa.gov/water-research/national-stormwater-calculator and runs on any version of Microsoft Windows (version 4 or higher). SWMM 5 is used as the National Stormwater Calculators computational instrument using a nonlinear reservoir model for surface runoff estimation and a GSI model for solving mass balance equations to express water volume change. It informs property owners and site developers of stormwater runoff estimates for different scenarios over long periods of time using historic rainfall data, localized soil conditions, slope, and land cover. Varying types of GSI practices are used to help determine the amount of rainfall that can be captured and retained on-site to reduce runoff (Rossman 2014).

Inputs of existing site conditions are selected to establish a Baseline Scenario. Soil characteristics are determined using a SSURGO database or manually entered, the amount of rainfall that can be infiltrated per soil class is determined based on the soils saturated hydraulic conductivity rate, site topography (slope) is used to determine the rate of stormwater runoff, historic hourly rainfall data from the National Weather Service's National Climatic Data Center is used to calculate precipitation and evaporation, and user defined land cover is used as percentages of the area being analyzed. A GSI Control Scenario is user defined to determine percent of sites treated impervious surface areas may also be used, and, finally, climate change scenarios can also be evaluated (Rossman 2014).

The results of the EPA calculator that were deemed significant to this project were percent runoff, percent evaporation, and percent infiltration for both the baseline existing scenarios and the GSI proposed scenarios for each of the suitable parcels. All sites had reduction in runoff and increase of infiltration at varying degrees, and all but one site has an increase in evaporation. (See Figure 9) These results are to be evaluated as a site specific before/after comparison as each site varies in size therefore GSI designs are unique to each parcel. See Appendix H for more information about design and methods, specific results and calculator limitations.

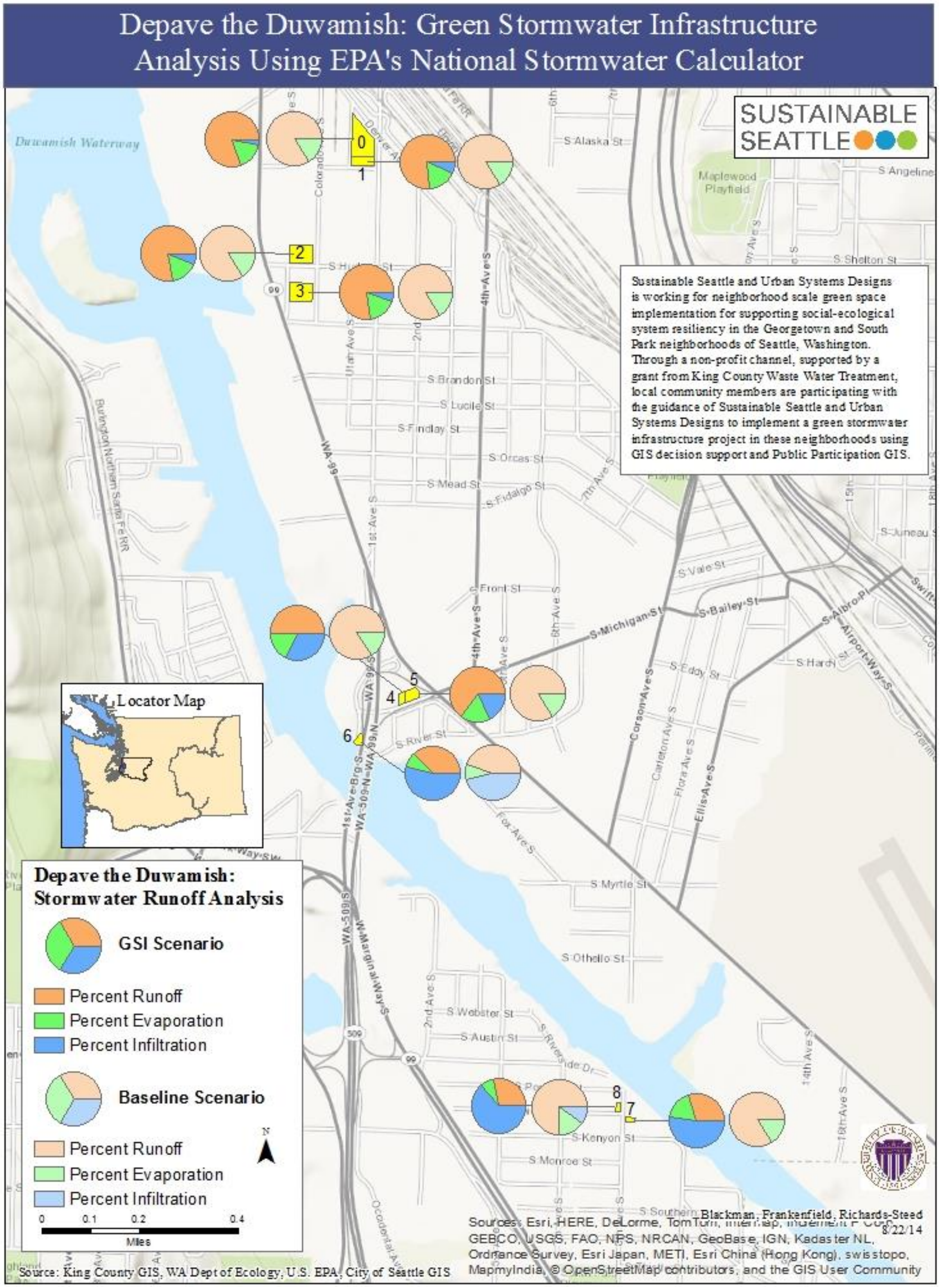

Figure 9: Stormwater Runoff Analysis results

Business Case & Implementation Plan

Using an overlay analysis supported by a pedestrian sidewalk access study resulted in 32 sites chosen as the most suitable for Sustainable Seattle to move forward with their Depaving the Duwamish project. The 32 sites were chosen to include a variety of locations for Sustainable Seattle to start contacting landowners for interest. GIS analysis conducted up until this point will provide the visual and factual support to help explain the importance of the public's cooperation and leverage related educational outreach campaigns. Continued public involvement through public participatory GIS (PPGIS) is recommended as this project specifically targets neighborhood level involvement and will benefit by using local knowledge and feedback to ensure a successful and feasible project is completed.

The purpose of this project was to aid Sustainable Seattle with their grant deliverables for phase 1 of the King County Wastewater grant funded project. Phase 2 involves the post analysis activities of documenting selected sites during rain events to collect measurable data, outreach to selected site owners, and to educate the public on the program and environmental processes involved. Project support will be needed from private property owners in order to implement depaving underutilized property in the neighborhoods for environmental and social benefits to be gained. Data collection efforts will help guide evidence for the business case of depaving, particularly at the neighborhood scale where few published data exists. Several state owned Department of Ecology (DOE) collection points exists within the project area. It is recommended contact is made to DOE to collaborate on data collection efforts.

The technical nature of the analysis, with its multiple steps and components, along with the public participatory web maps and features requires a high level proficiency in GIS. The analysis is applicable to numerous scales of governance and allows diversity in usage by selforganizing associations such as Sustainable Seattle which works with local partners to inform, educate, and take action on a neighborhood community scale for improved environmental and social well-being. The recommended usage is therefore at the non-profit level where the ground work and public participation is at its foundation, thereby empowering landowners, residents, and local business owners to use GIS to participate in their neighborhood improvement activities. In so doing, with the combination of local knowledge inputs and GIS technical capabilities, site selection time is decreased by months, allowing Sustainable Seattle to contact local land owners more quickly, and provide parcel benefits created by the analyses and tools, thereby bolstering the process to a green space landuse. It is a top priority for Sustainable Seattle to locate land, contact landowners, and working with the communities, convert that land to green space (See Appendix J).

	Associated Costs	Benefits
Personnel Salary	$57,000 yearly salary	Highly skilled GIS Analyst
Hardware	$3,000	Hardware capable of using GIS specialized software and processes
Software	ArcDesktop License: $1,500 ArcServer License: $5,000 Network Analyst: $2,500 Spatial Analyst: $2,500 Python: Open Source	Highly specialized software that can assist in decision making processes, cutting overall time and associated costs.
Data	Data sharing agreement	Expansion of knowledge base about the social-ecological system. Intangible benefit may include greater relations between levels of governance.
Web Map Service	Single User: Free	A free service up to one administrator that allows information via map display that can serve to inform the public, organizations, agencies, and policy makers.

Table 14: Cost and Benefit Table

The average salary according to Indeed.com for a non-profit employee working in Seattle is $53,000 yearly (Indeed, Non-Profit Salary 2014). The average salary for a GIS professional in Seattle is $61,000 depending on the level of skill (Indeed, GIS 2014). The average between the two was used in the Associated Costs column (See Table 14. Cost and Benefit Table). The cost for the personnel cited in Table 14 does not account for insurance and other benefits. The data costs cited assumes a data sharing agreement that allows for a financial cost-free transaction and thereby avoiding incurring costs for needed information from other agencies and groups. The costs in the table also assume that all data needed to run the analyses can be acquired from county and city agencies and organizations without cost (Appendix K). Web mapping data display via a web map service can be published by a single service administrator for free by ESRI's ArcGIS Online, with an open-source access to the public (ESRI 2014, "Features"). The same service can publish results from Network Analyst (service area) via shapefiles uploaded to the cloud service, avoiding the cost of the ArcServer license. However something for the non-profit to consider is the ease of data sharing ArcServer provides, both between and among groups and agencies if a data sharing agreement is reached. It also allows for additional application development for public use and interaction, such as a phone application not covered in this report (ESRI 2013, ArcServer). The costs associated with the analysis may not have a balanced associated financial benefit for the non-profit salary (Table 14 Data sources: UCD 2014, ESRI 2014, ArcServer, Python 2014, ESRI 2014, ArcDesktop, ESRI 2014, Agent Analyst, CostHelper 2014, Salaries.com 2014, ESRI 2014, Features.) However, with a highly skilled analyst working internally with the data received and then generated by the analysis, significant knowledge is gained from outputs, inclusive of public access to green space, runoff and infiltration percent, and gaining public knowledge through GIS tools. Whereas business as usual, focusing on the ground survey, checking multiple data sources such as the county or city parcel data using tables and paper maps takes a significant amount of time. The workflow for implementation has been captured in Appendix E.

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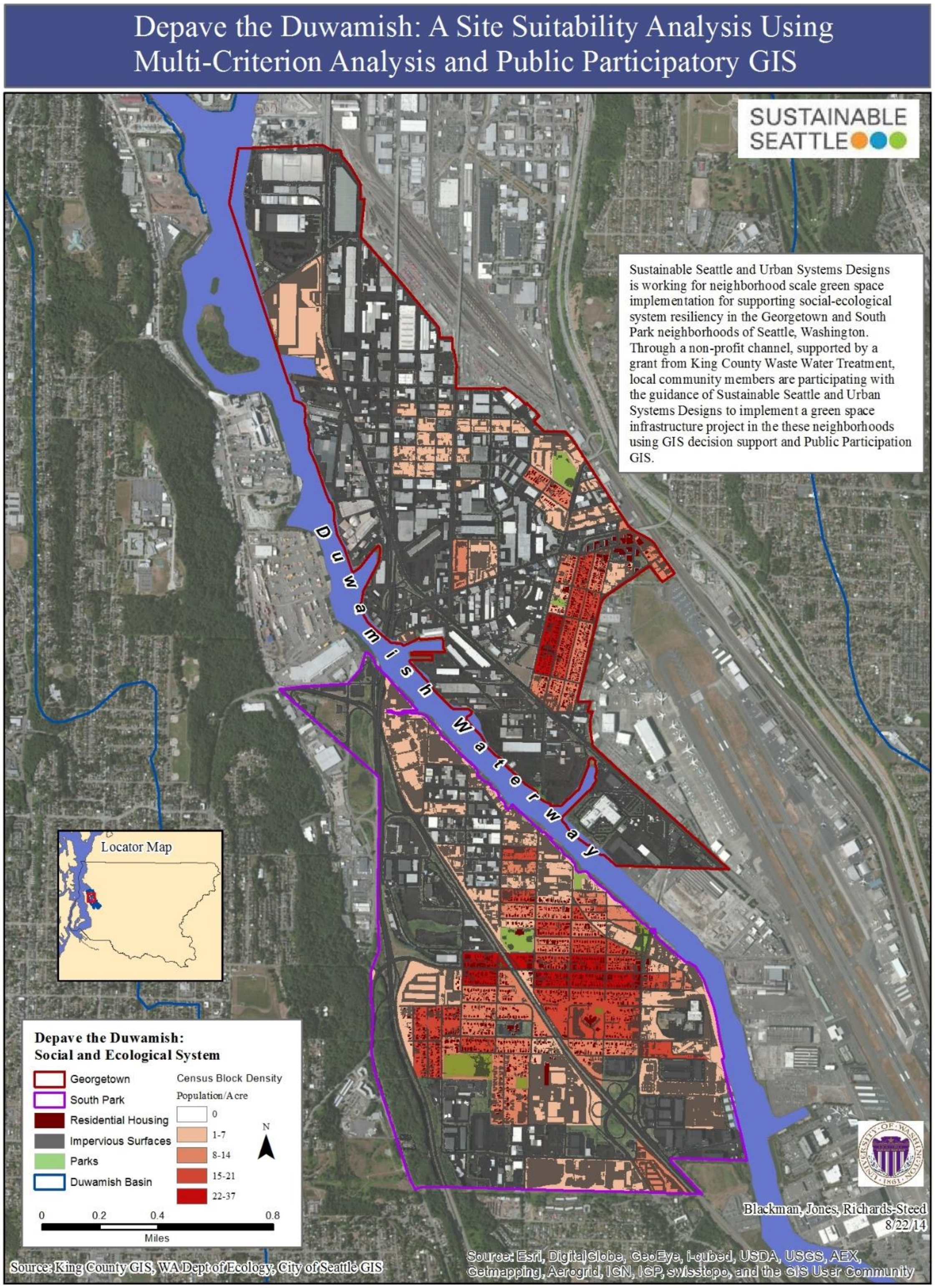
Appendix

Appendix A: SES Table

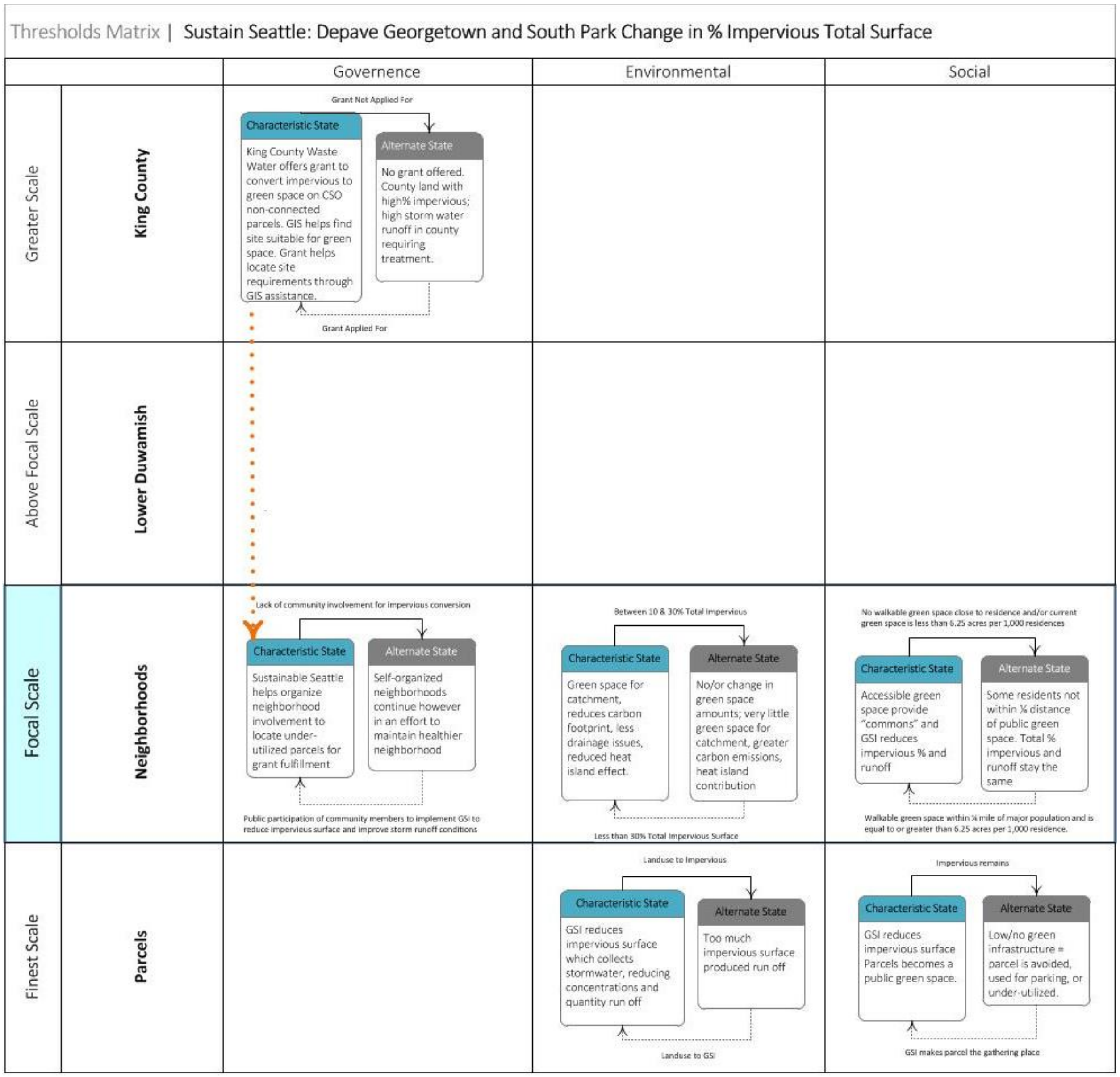
Social-Ecological Systems Table | *Sustainable Seattle; GIS for Decision Support and Public Participation to Depave the Duwamish in Georgetown and South Park Neighborhoods, Seattle.*

	Map	Goverance	Environmental	Social
King County		Grant to fund impervious-to-green space requires only CSO basin non-connected parcels. GIS identifies these parcels for criteria		
Duwamish		Duwamish River Clean-up Coalition self organizes to identify Georgetown and South Park neighborhoods to be lacking green space and have high amounts of impervious surfaces, galvanizing Sustainable Seattle to seek UW GIS decision support.		
Neighborhoods		Georgetown and South Park residents galvanize to decrease impervious and participate in green space site selection by identifying key criteria through an interactive web map.	Sustainable Seattle wants to decrease impervious surfaces in Georgetown and South Park neighborhoods to decrease neighborhood runoff, and lessen urban heat island.	Sustainable Seattle wants to decrease impervious surfaces and increase public accessibility to green space in the Georgetown and South Park neighborhoods.
Parcels		Sustainable Seattle collaborates with Georgetown and South Park self organized systems using site analysis results to contact and share results with landowners via static maps and web map application picking their top sites for further site study.	Parcels within neighborhoods are identified as potential green space based on environmental criteria: high impervious, under-used, unconnected to CSO, and are away from toxic release inventoried parcels.	Parcels within neighborhoods are identified as potential green space based on social criteria: close to population densities, walkable distance for residents, and fall outside the service area of existing green spaces, complaint areas

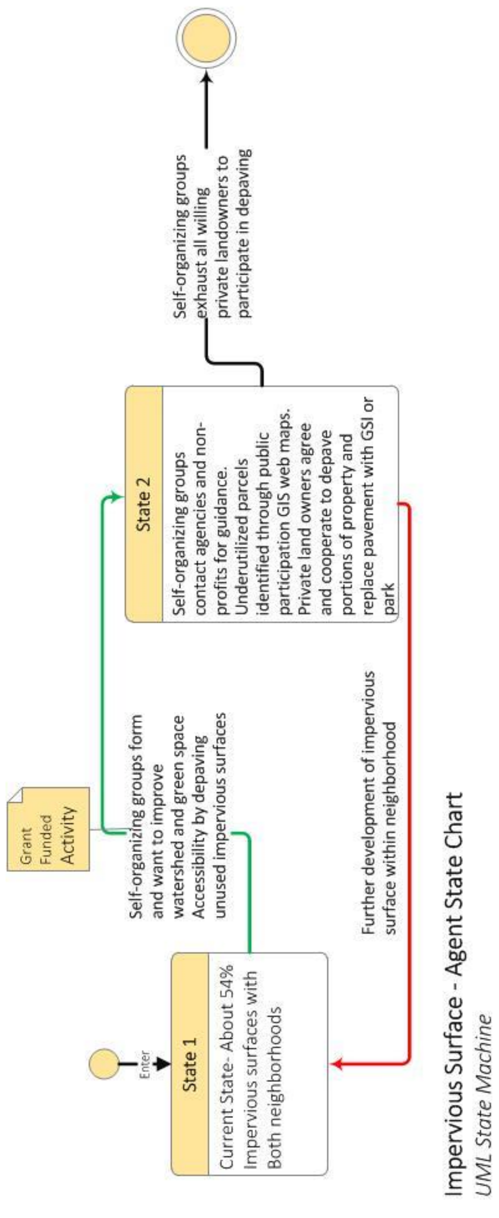
Appendix B: Social Ecological Map

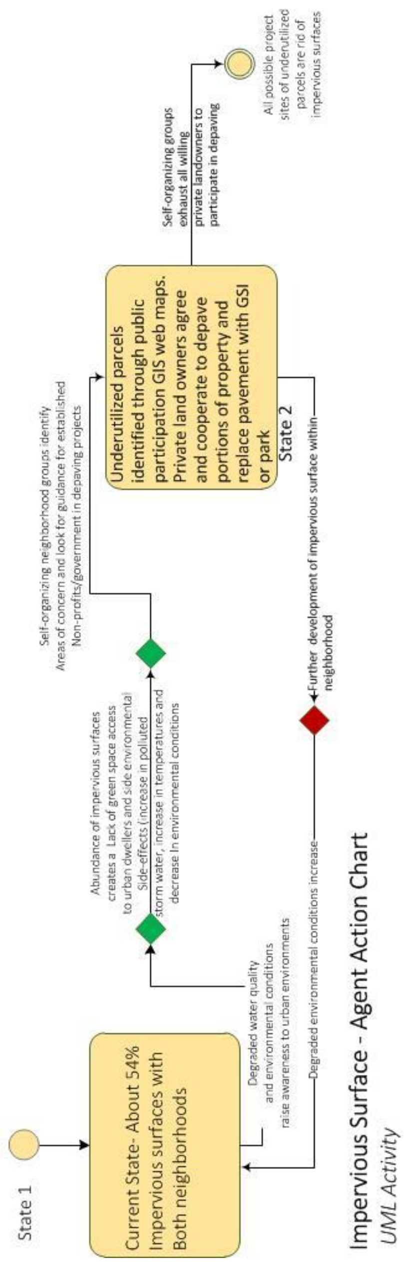


Appendix C: Thresholds Matrix

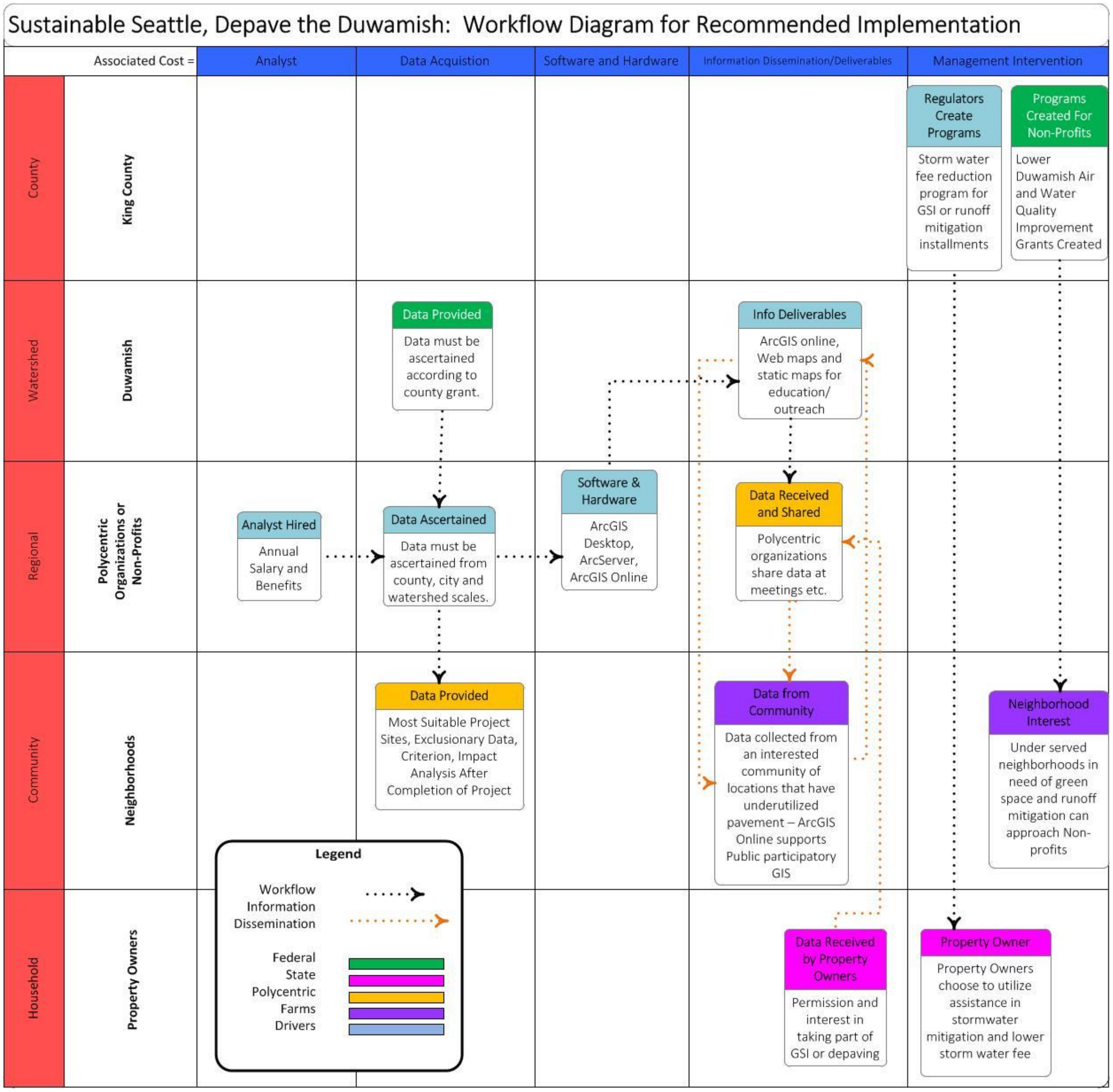


Appendix D: Action State Change and Action Change

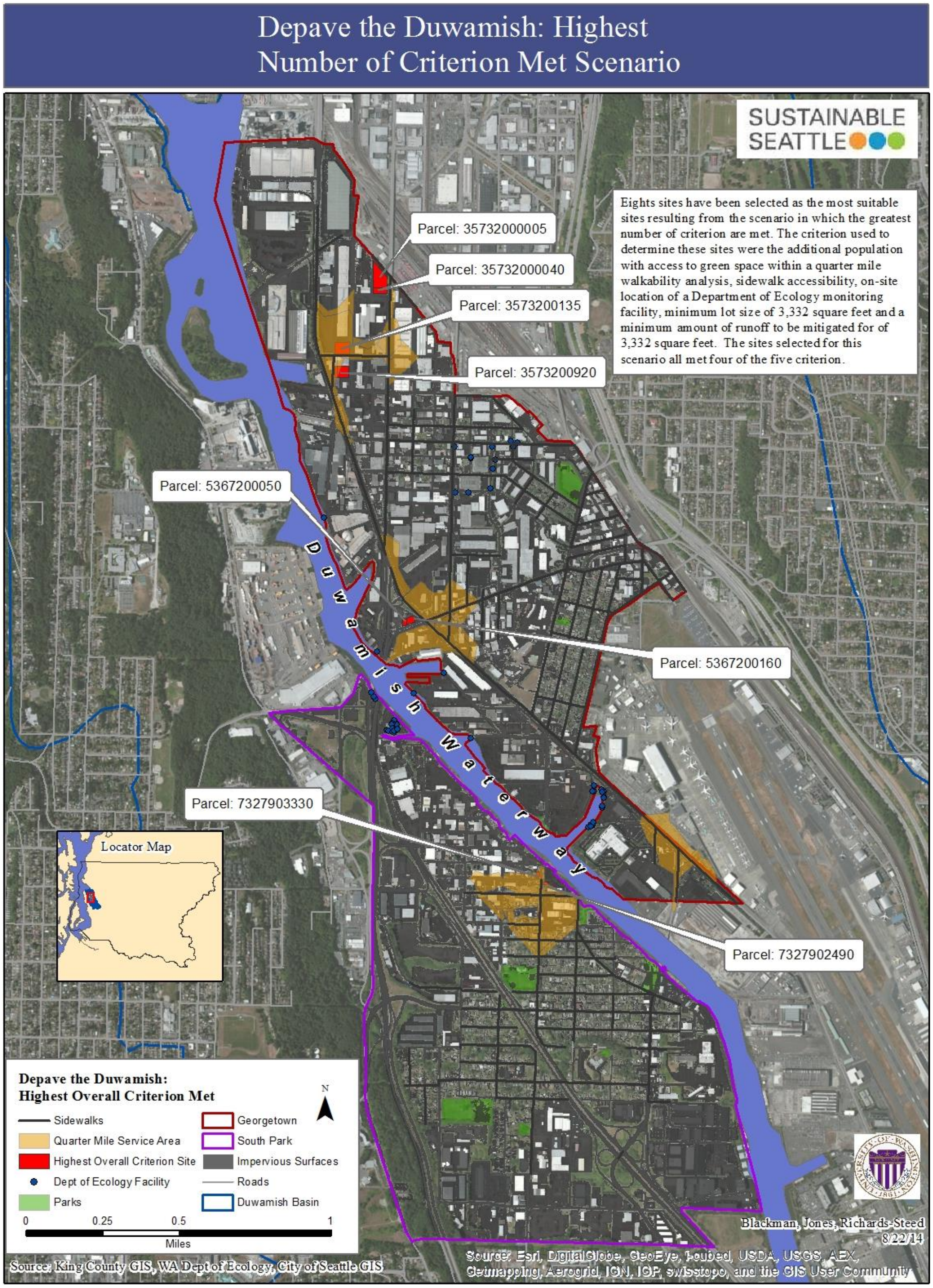




Appendix E:

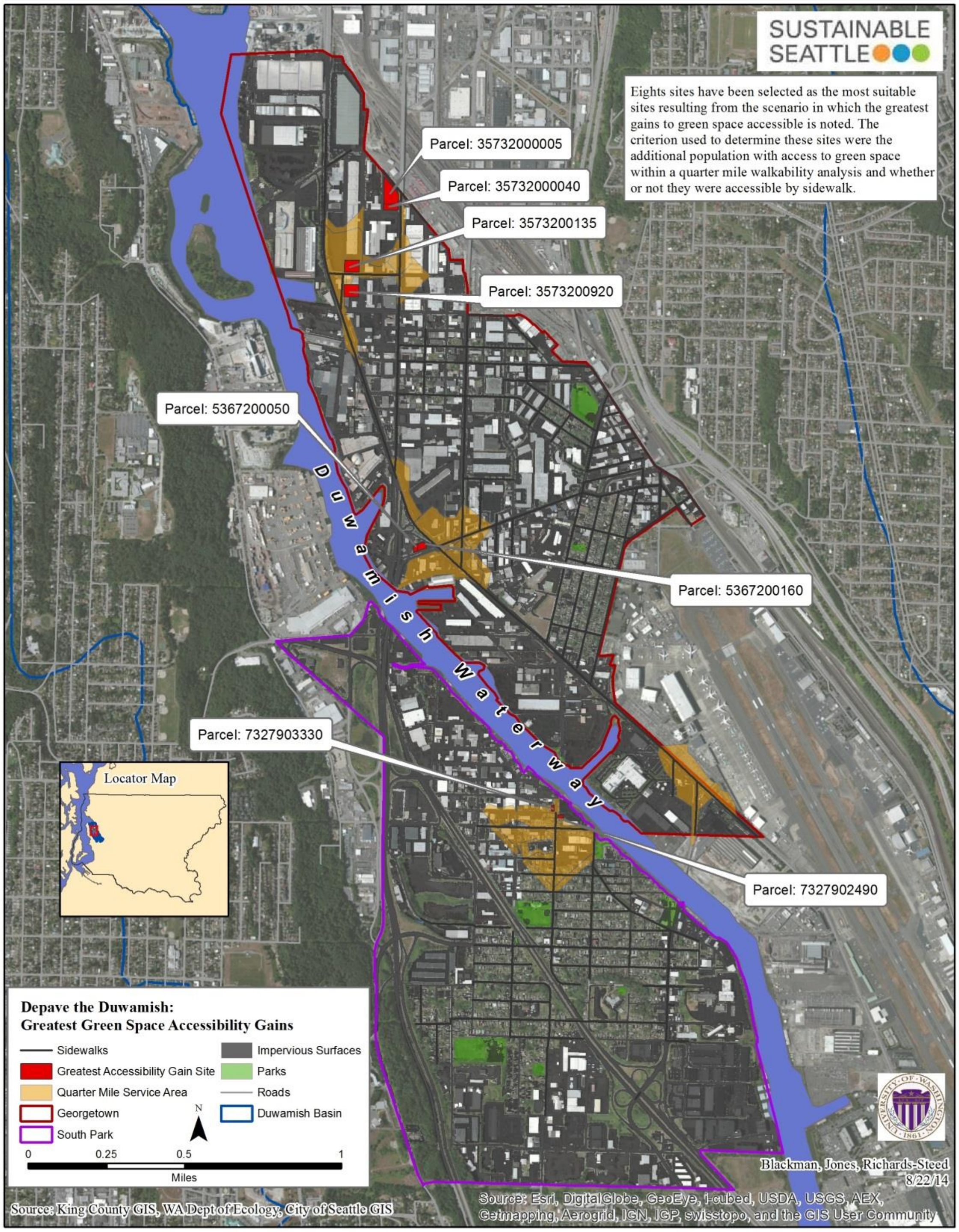

Sustainable Seattle, Depave the Duwamish: Workflow Diagram for Recommended Implementation
Associated Cost =
Analyst
Data Acquistion
Software and Hardware
Information Dissemination/Deliverables
Management Intervention
County
King County
Watershed
Duwamish
Regional
Polycentric Organizations or Non-Profits
Community
Neighborhoods
Household
Property Owners
Regulators Create Programs
Storm water fee reduction program for GSI or runoff mitigation installments
Programs Created For Non-Profits
Lower Duwamish Air and Water Quality Improvement Grants Created
Data Provided
Data must be ascertained according to county grant.
Info Deliverables
ArcGIS online, Web maps and static maps for education/ outreach
Analyst Hired
Annual Salary and Benefits
Data Ascertained
Data must be ascertained from county, city and watershed scales.
Software & Hardware
ArcGIS Desktop, ArcServer, ArcGIS Online
Data Received and Shared
Polycentric organizations share data at meetings etc.
Data Provided
Most Suitable Project Sites, Exclusionary Data, Criterion, Impact Analysis After Completion of Project
Data from Community
Data collected from an interested community of locations that have underutilized pavement – ArcGIS Online supports Public participatory GIS
Neighborhood Interest
Under served neighborhoods in need of green space and runoff mitigation can approach Non-profits
Legend
Workflow
Information Dissemination
Federal
State
Polycentric
Farms
Drivers
Data Received by Property Owners
Permission and interest in taking part of GSI or depaving
Property Owner
Property Owners choose to utilize assistance in stormwater mitigation and lower storm water fee

Appendix F

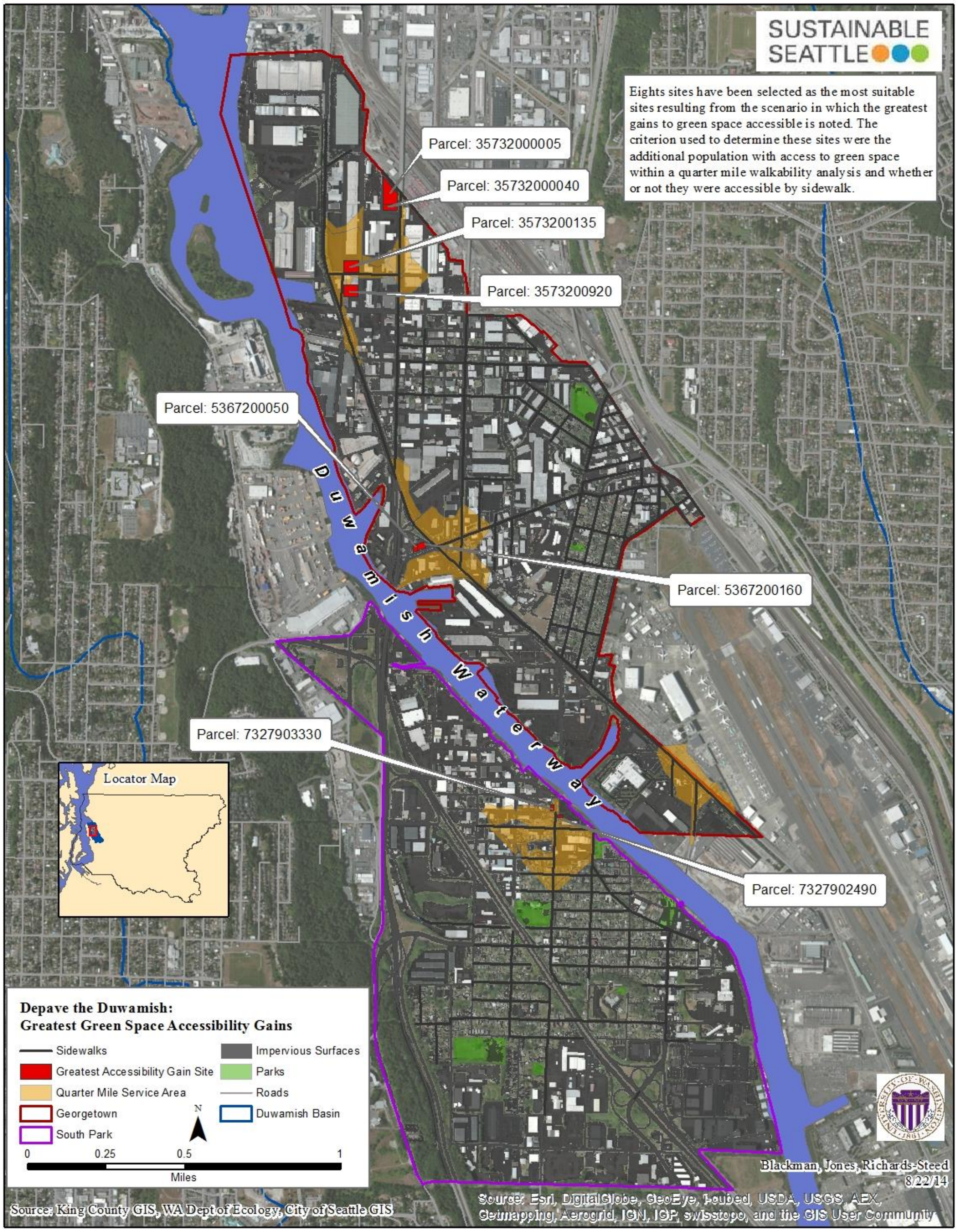


Depave the Duwamish: Highest Number of Criterion Met Scenario
SUSTAINABLE SEATTLE
Eights sites have been selected as the most suitable sites resulting from the scenario in which the greatest number of criterion are met. The criterion used to determine these sites were the additional population with access to green space within a quarter mile walkability analysis, sidewalk accessibility, on-site location of a Department of Ecology monitoring facility, minimum lot size of 3,332 square feet and a minimum amount of runoff to be mitigated for of 3,332 square feet. The sites selected for this scenario all met four of the five criterion.
Parcel: 35732000005
Parcel: 35732000040
Parcel: 3573200135
Parcel: 3573200920
Parcel: 5367200050
Parcel: 5367200160
Parcel: 7327903330
Parcel: 7327902490
Duwamish Waterway
Locator Map
Depave the Duwamish:
Highest Overall Criterion Met
Sidewalks
Quarter Mile Service Area
Highest Overall Criterion Site
Dept of Ecology Facility
Parks
Georgetown
South Park
Impervious Surfaces
Roads
Duwamish Basin
N
0
0.25
0.5
1
Miles
Source: King County GIS, WA Dept of Ecology, City of Seattle GIS
Blackman, Jones, Richards-Steed
8/22/14
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depave the Duwamish: Greatest Gain of Pedestrian Accessibility to Green Space Scenario



Depave the Duwamish: Greatest Gain of Accessibility to Green Space Scenario



Appendix G

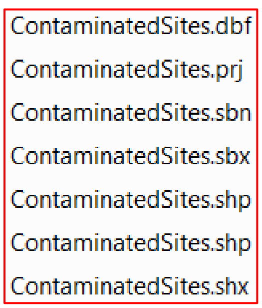
Public Account Instructions

Go to ArcGISonline.com

To open and view the existing maps that have been created, login and click on the MY CONTENT tab at the top of the viewer.

MY CONTENT:

MY CONTENT allows access to maps and data that have been saved from this project, make new maps, and it also allows you to upload zipped shapefiles and GPS data from your computer. The maps that have been created for you on your account should be in a visible list. Many of the neighborhood scale shapefiles created for you in the SS_Shapefile folder can be added to MY CONTENT by zipping them first, clicking the + Add Item tab, and choosing the file. Each shapefile contains 6 files. The files look like this in a regular desktop folder:



Notice the file extensions; .dbf, .prj, .sbn, .sbx, .shp (2), .shx. All files must be included in the zipped file in order for the file to work.

Making a Map

There are two ways to create a map: Click on MAP at the top of the window and a new map with a topographic basemap will open, or click on MY CONTENT, then Create Map tab by the + Add Item tab and a new map with a topographic basemap will open. The 

tab at the top of the map viewer allows you to add zipped files you have saved in MY CONTENT, from the web, or from your computer. To select zipped shapes from your computer when the drop-down opens select Add Layers From a File. To add layers from MY CONTENT select from the drop-down menu Search for Layers, and in the In box, from the drop-down, select MY CONTENT. As you go through these steps you will find multiple sources for adding data to your map.

**Note: Shapefiles in a .zip file can be added to a new map, or an existing map.*

To add files to an existing map, the same steps apply. To change the basemap, click in the Basemap tab at the top of the map viewer. Here you will find options for your map's basemap. Click on the basemap that best suits your purposes. It will automatically update to your selected basemap.

Change Symbols and Making Edits

Once you have data displayed on your map, you may wish to change symbols, make new features, or edit existing features. On the left side of the map viewer the contents of the map are listed when the Contents  icon is selected. The contents when viewable are checked next to their name. To make them un-viewable uncheck the box.

To change the symbols of your data make sure the Contents icon is selected. Notice the dropdown arrow by the data files added to the map. Within the dropdown options you will notice that you can re-name your file, move it up or down, and numerous other options. Making symbols viewable, and changing the default symbol can be done by selecting the Change Symbols option. Click on this option and you will see a use with another dropdown to change the symbol from a single symbol representing all the geographic data in the file, to unique symbols to represent different information contained within the fields of the spatial data, to colors choices, and sizes.

Making files editable starts in the same dropdown menu for each file as described previously. Click on the 

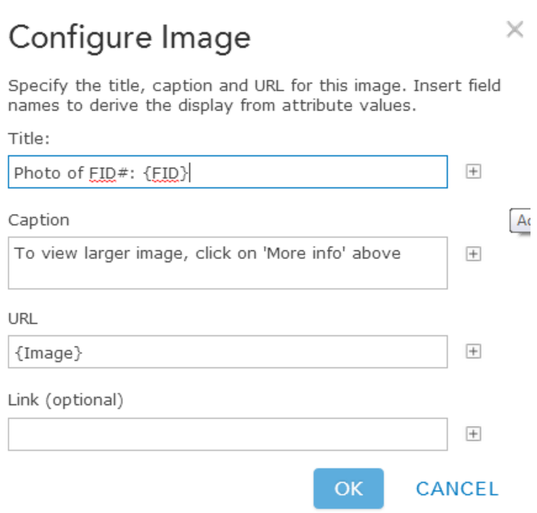
option. An Edit button appears at the top of the map viewer. Click on the Edit button when ready to edit the data that has been enabled to edit. An editing window will appear click on the icon of the data to be edited and then click the map to create the data.

Double click the map to stop editing. A small box will appear and the data for this newly created feature goes here. Fill in the data and cycle through the window by using the down arrow on your keyboard. When you are finished click on the Edit button. Editing will stop. To the save the newly created features, click the dropdown box for the file layer and select the Save Layer. The file will be saved in your MY CONTENT tab.

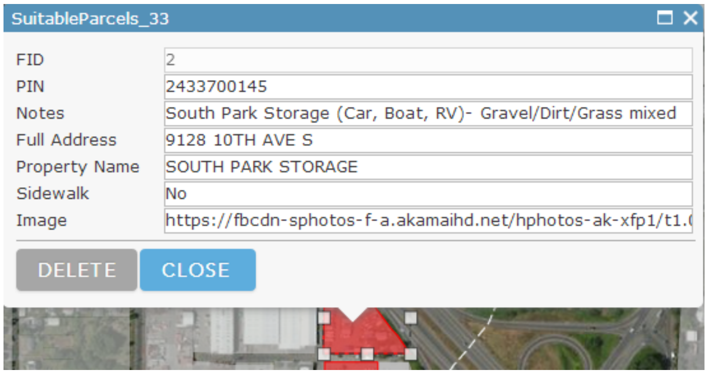
*If a file in the map is enabled for editing and the map is Shared with other groups or individuals, they can edit the feature. For instance if you are in need of collecting local knowledge data about an area you can enable a file for editing and share it with certain groups to edit.

To add or view images, there must be an 'Images' field within the original added shapefile that is to have viewable images. This can be a blank field that is used to gather images through the Map or the images can already be within the shapefile to share with the map audience. To display images within a popup there are two options: add all images while configuring the pop up for the parcels or adding images to the appropriate field so that the images are site specific. The first option is easy and useful if only dealing with a few sites (i.e., up to 10 parcels) as long as they are named something meaningful so the viewer can find the connection between an image and the parcel it represents. To do this, click on the (drop-down) arrow next to the desired feature and select the Configure Pop-up option. When the Pop-up Properties menu opens (see image below), there are several options. Configure Attributes can be selected to check the fields you want to display and edit, select a field to change its alias/displayed name, its order, etc. Make sure the Image field is checked so that it can be viewed within the map. Under Pop-up Media, select the ADD button and choose Image. Change the default title to something meaningful that will help the viewer to understand the connection between the image and the parcel (i.e., ID #: or Photo:) then click on the symbol to add the attribute you would like to use to reference the image and parcel. A caption can also be added. We used the caption "To view larger image, click on 'More info' above. And finally, the URL field name can be a copy of the URL where the image is being stored. The URL box must contain paths to images that are stored on a publicly-accessible server, such as your account on a photo-sharing site (i.e., a Facebook account). Several images can be added, but all images will be displayed for all selected parcels. For instructions on how to have site specific images, see below.

To add site specific images, a similar approach is taken as previously mentioned. We were able to create an 'Image' field in the shapefiles attribute table and copied URLs to the attribute table directly. In doing so, we were able to set up the Configure Image box as seen below. We used 'Photo of FID#:' and added the {FID} field as a descriptor so that when the parcel FID25 was selected, the image would be labeled 'Photo of FID#: 25'. And again, we used the caption field to bring note to the fact that the More Info tab could be used to view a larger image. Lastly, we were able to add the {Image} field to the URL box directly.



But this can be done through the Map as well, as long as there is a blank 'Image' field created in the shapefile being used. Select a parcel to view its Pop-up (see below).



As long as the Image field (in the Configure Attributes window) checked to the editable, a URL can be added directly to the 'Image' field. The URL box (above) will still need to reference the 'Image' field, but the image doesn't need to be previously saved in the shapefile.

A helpful online help page is available at: http://learn.arcgis.com/en/projects/get-started-with-arcgis-online/lessons/configure-pop-ups/

Sharing Your Map

Once you have created a map to suit your purposes save the map and click on the Share tab. A URL is provided for open source, online viewing if you check the Everyone (public) box, to embed in a website or social media site like Facebook, click on the EMBED IN WEBSITE button and HTML is provided. The HTML can be copied and pasted directly to the host. To create a web application you can click on the MAKE A WEB APPLICATION. From here you choose a template to feature your map in. Click the Publish drop-down to download the template for immediate use, or preview your map before you download. To keep the map within a group, such as yourself and project partners, you can create a group

Creating Groups

Sharing data with the public, especially edit-enabled data maps, opens to door to unwanted changes, unless the changes have been suggested or directed by you. You can keep your map edits and changes within a group context by creating a group to share your map(s) with. Log in to your argisonline public account and click on GROUPS at the top of the page. Click on the

CREATE A GROUP icon. You can create your group title, description, and summary. You can invite people to join your group by sending them an e-mail request by clicking the INVITE USERS icon and adding e-mails to the INVITE USERS window. You will see that a Sustainable Seattle group has been created for you (groups members have not been added). You can create multiple groups and share some or all of your maps and data with any one group, are all groups.

What You Can Do with This Public GIS Account

Your arcgisonline public account has a lot of functionality for project management and decision support. The most basic feature is the mapping feature and adding and editing data for a project. You can request a zipped shapefile from Washington County GIS of your project area boundary, obtain data from ESRI's free, open source data files, create apps, and store important project data. Dive in and start using the application, even just for testing its use in order to get use the service. For more information and help with your account visit the following link:

http://www.esri.com/software/arcgis/arcgisonline/features/public-account

Public accounts have major limitations that will impact your mapping. The account has a 2G size storage limit. With multiple projects, or the archiving of projects in the account may be problematic, but taking project data off the account once finished with the project and storing it on a personal computer can remedy the storage size limitations. Files uploaded to the account for any purpose must have no more than 1000 features contained within them. An example of this is housing units in a neighborhood. If a neighborhood contains more than 1000 houses within a shapefile the file will not u

Appendix H

EPA's National Stormwater Calculator

Inputs of existing site conditions are selected to establish a Baseline Scenario. Several user defined or calculator defined inputs were used for each of these suitable sites. Every site has its own spatial location and size (in acres rounded to the nearest tenths place) entered by the user. Soil type can be derived from the calculator, if available, or entered manually. The soil types available are: A – low runoff potential, B – moderately low, C – moderately high, and D – high runoff potential. Table 4 displays the definitions of the soil types used by the EPA calculator. Soil type was not available for the focal area of this project and also could not be located using the Web Soil Survey operated by the USDA Natural Resources Conservation Service as soil survey data is generally used for farming and agricultural planning. (USDA 2013) The majority of the sites analyzed are classified as having high runoff potential (D) as the majority of the parcels are mostly if not completely covered with impervious surface. Sites that are not 100% impervious were given a C rating as they have undertaken high industrial usage such as construction equipment traffic and storage that have compacted soils not allowing for much infiltration. (Rossman 2014)

Group	Meaning	Saturated Hydraulic Conductivity (in/hr)
A	Low runoff potential and high infiltration rates when thoroughly wetted. Consisting mainly of deep, well to excessively drained sands or gravel.	≥ 0.45
B	Low/moderate infiltration rates when thoroughly wetted and consisting mainly of fine to moderately coarse textures (shallow loess, sandy loam).	0.30 – 0.15

C	High/moderate infiltration rates when thoroughly wetted and consisting mainly of moderately fine to fine textures (clay loams, shallow sandy loam).	0.15 – 0.05
D	High runoff potential and slow infiltration rates when thoroughly wetted. Consisting mainly of clay soils with high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material.	0.05 – 0.00

Table of Definitions of Hydrologic Soil Groups (EPA)

The same is true for soil drainage. If soil survey data is not available, as is the case with the focal area of this project, the user defines the rate at which standing water drains from the site into the soil in inches per hour and a default of 0.4 inches/hour is provided. If this data is available, however, it is displayed with four (4) symbolized classifications: ≤ 0.01 inches/hour, > 0.01 to ≤ 0.1 inches/hour, > 0.1 to ≤ 1.0 inches/hour, and > 1 inch/hour. Of the sites analyzed, six (6) sites fell within the D HSG group due to their high level of impervious surface to total area ratios with the other three (3) sites in the C group. As a result, calculator default values of 0.01 was selected for the sites in the D group and 0.04 for the remainder in the C group. (Rossman 2014)

Topography (or slope) is calculator or user defined input using percent. If the data is not available, the user has the option to select the following inputs: flat (2% slope), moderately flat (5% slope), moderately steep (10% slope), and steep (above 15% slope). All sites analyzed have a flat (2%) topography. (Rossman 2014)

Some inputs are selected by the user with calculator defined options. The EPA calculator uses precipitation and evaporation in this analysis and provides a list of local rain gage and weather stations. For this project, the Seattle-Tacoma Airport station was used for its proximity to the area of interest. The user also selects land cover for the site selecting percent of pervious cover of forest, meadow, lawn, and desert with the remaining balance automatically calculated by the calculator as impervious. The EPA calculator limits land cover percent inputs to whole numbers including zero (0). (Rossman 2014)

FID	PIN	Property Name	Sq. Ft.	Acres	Soil Type	Soil Drainage
0	3573200005	Bartell Drugs	79476.83	1.8245	D-high runoff	0.01
1	3573200040	Bloch Steel	24635.12	0.5655	D-high runoff	0.01
2	3573200135	All City Fence Co	49322.03	1.1323	C-mod/high	0.04
3	3573200920	Lux Lyfe	49333.08	1.1326	D-high runoff	0.01
4	5367200050	Cascade Pacific vacant	8445.47	0.1939	D-high runoff	0.01
5	5367200160	Cascade Pacific	16158.83	0.3710	D-high runoff	0.01
6	5367202410	Vacant (WSDOT)	8532.77	0.1959	C-mod/high	0.04
7	7327902490	Vac Land	4999.24	0.1148	D-high runoff	0.01
8	7327903330	Morton Marine	5001.03	0.1148	C-mod/high	0.04

Table of Baseline Scenario Inputs (Existing Site Conditions)

*Note: All sites had Flat (2%) slope site conditions and the SeaTac Airport was also used for all sites as the rain gauge and weather station, so, therefore, not presented in the above table.

GSI controls are also user defined as percent of the site's impervious area to be treated and are selected to establish a Proposed Site Scenario.. And like land cover inputs, the EPA calculator limits GSI control percent inputs to whole numbers. The options for GSI controls are: disconnection, rain harvesting, rain gardens, green roofs, street planters, infiltration basins, and porous pavement. (Rossman 2014) Many simplifying assumptions had to be made when selecting the type and amount of GSI controls to select. For example, all sites with the exception of one had the minimum requirements for available space to install GSI/green space, so all parcels received GSI/green space design for 3500 sq. ft. while the other could only receive 2400 sq. ft. GSI design. And with the absence of soil types and soil drainage information, educated deductions had to be made, as defined previously. The table below displays the calculator inputs for the suitable sites analyzed. Selected GSI design elements that are used in the stormwater analysis have been generalized as property owner participation has not yet been established by Sustainable Seattle. All GSI design specifications used are set to default values as each sites design will

FID	GSI Total Sq. Ft.	Percent of Parcel	GSI Controls
0	3500	4.404%	2705sf permeable pavement (3%) & 795sf street planters (1%)
1	2400	9.740%	2150sf permeable pavement (9%) & 250sf street planter (1%)
2	3500	7.096%	3000sf permeable pavement (6%) & 500 sf of street planter (1%)
3	3500	7.095%	3000sf permeable pavement (6%) & 500sf rain garden (1%)
4	3500	41.442%	3000sf permeable pavement (35%) & 500sf rain garden (6%)
5	3500	21.660%	500sf rain garden (3%) & 3000sf pavement (19%)
6	3500	41.018%	2050sf rain garden (23%), 900sf pavement (10%) & 550sf lawn (6%)
7	3500	70.011%	500sf rain garden (10%) & 3000sf pavement (60%)
8	3500	69.986%	500sf rain garden (10%) & 3000sf pavement (60%)

Table of Proposed Site Scenario (using GSI controls)

The results of the EPA calculator that were deemed significant to this project were percent runoff, percent evaporation, and percent infiltration for both the baseline existing scenarios and the GSI proposed scenarios for each of the suitable parcels. Because the value zero (0) has no measurable quantity, magnitude, etc., the percent difference formula was used to determine the difference between baseline percentages and GSI scenario percent results. (Furey 2011) Percent difference is the absolute value of the difference over the mean times 100 and the formula used is : Percent Difference = $((|E_1 - E_2|) \div (\frac{1}{2}(E_1 + E_2))) * 100$. (Percent Difference – Percent Error n.d.) Percent change was also considered, but the formula for this calculation is not applicable for situations with a zero (0) value that represents the "old" value, as is the case of infiltration for the majority of our sites. (Pierce 2014) All sites had reduction in runoff and increase of infiltration at varying degrees, and all but one site has an increase in evaporation. These values are displayed in Tables 8.A & 8.B and is visually represented in the Stormwater Runoff Analysis results.

FID	**Avg Annual Runoff Baseline**	**Avg Annual Runoff GSI**	**Percent Runoff Baseline**	**Percent Runoff GSI**	**Runoff Percent Difference**
0	30.78	29.79	0.84	0.81	**-0.04**
1	30.78	27.94	0.84	0.76	**-0.10**
2	30.78	28.78	0.84	0.78	**-0.07**
3	30.78	28.61	0.84	0.77	**-0.09**
4	30.78	18.76	0.84	0.50	**-0.51**
5	30.78	24.11	0.84	0.65	**-0.26**
6	16.68	13.58	0.45	0.37	**-0.20**
7	30.78	11.21	0.84	0.30	**-0.95**
8	27.8	10.46	0.75	0.28	**-0.91**

FID	Percent Evaporation Baseline	Percent Evaporation GSI	Evaporation Percent Difference	Percent Infiltration Baseline	Percent Infiltration GSI	Infiltration Percent Difference
0	0.16	0.17	**0.06**	0.00	0.03	**2.00**

1	0.16	0.17	**0.06**	0.00	0.07	**2.00**
2	0.16	0.16	**0.00**	0.00	0.06	**2.00**
3	0.16	0.17	**0.06**	0.00	0.06	**2.00**
4	0.16	0.18	**0.12**	0.00	0.32	**2.00**
5	0.16	0.17	**0.11**	0.00	0.18	**2.00**
6	0.09	0.09	**0.00**	0.46	0.54	**0.16**
7	0.16	0.18	**0.17**	0.00	0.52	**2.00**
8	0.15	0.08	**-0.61**	0.10	0.63	1.45

Table of EPA Calculator Results

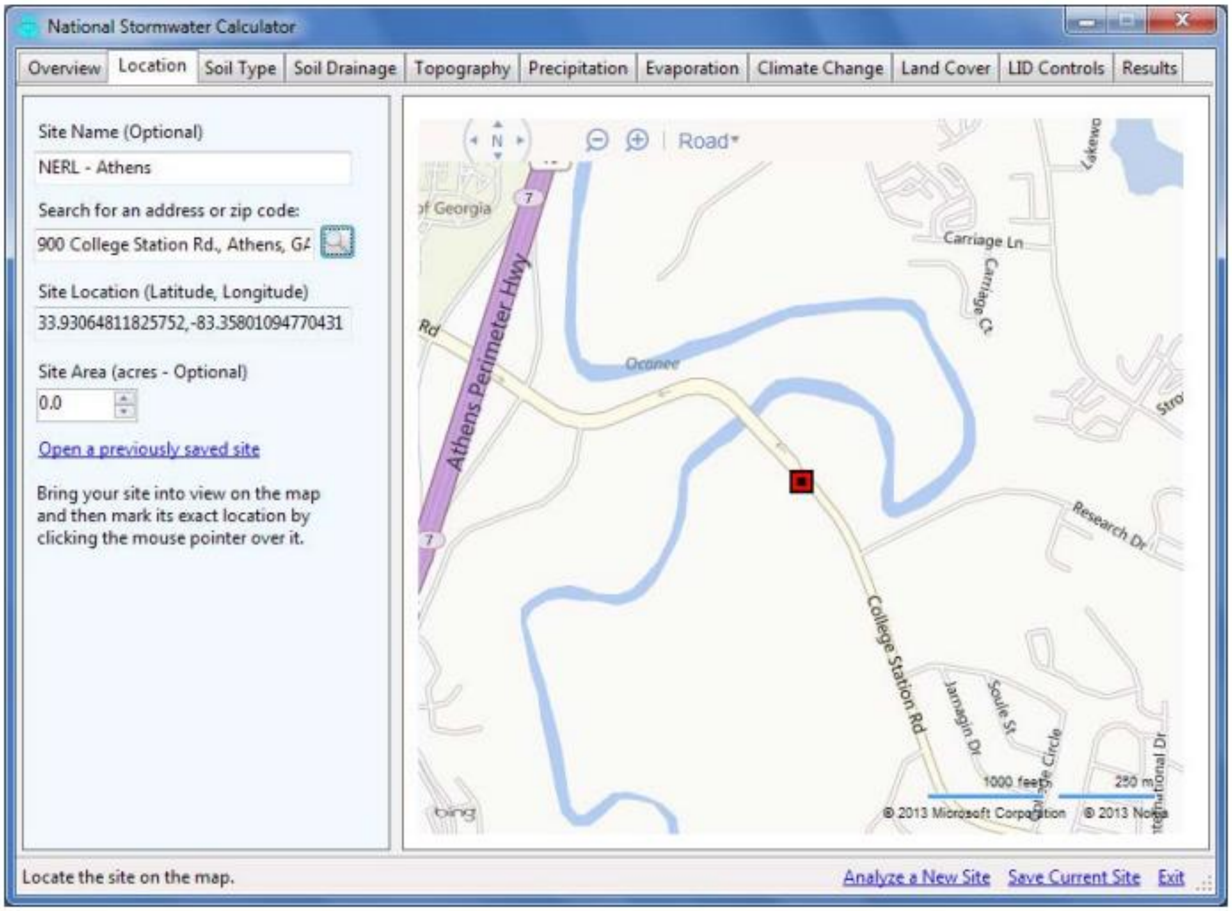
*Note: Negative symbols were applied to percentages that represent a decrease in values for easy classification and decimal equivalents of percentages were used.

EPA Calculator Limitations

All models and calculators of this kind have limitations in one form or another. Scientific phenomena cannot be explained in perfect detail by a model or calculator. (Annenberg n.d.) Predictive models, when used properly, allow users to analyze highly complex systems and events. Simplifying assumptions are made in order for the model or calculator to highlight areas of concern, interest or topic that is being evaluated. (UNR 2012) While the user has the benefit of location and size specific property inputs, the property size is displayed as a circular boundary around the location point rather than detailed physical boundaries (i.e., property lines). Soil type and drainage information is limited by the sources that provide the data, SSURGO and National Weather Service's National Climatic Data Center. Land cover inputs are limited to five (5) types and GSI controls are limited to nine (9). Lastly, as mentioned earlier, land cover and GSI controls are limited to whole number percent inputs which can have dramatic effects on some

GSI control inputs, especially on large parcels implementing a small green space in comparison for parcel size.

EPA National Stormwater Calculator User Interface

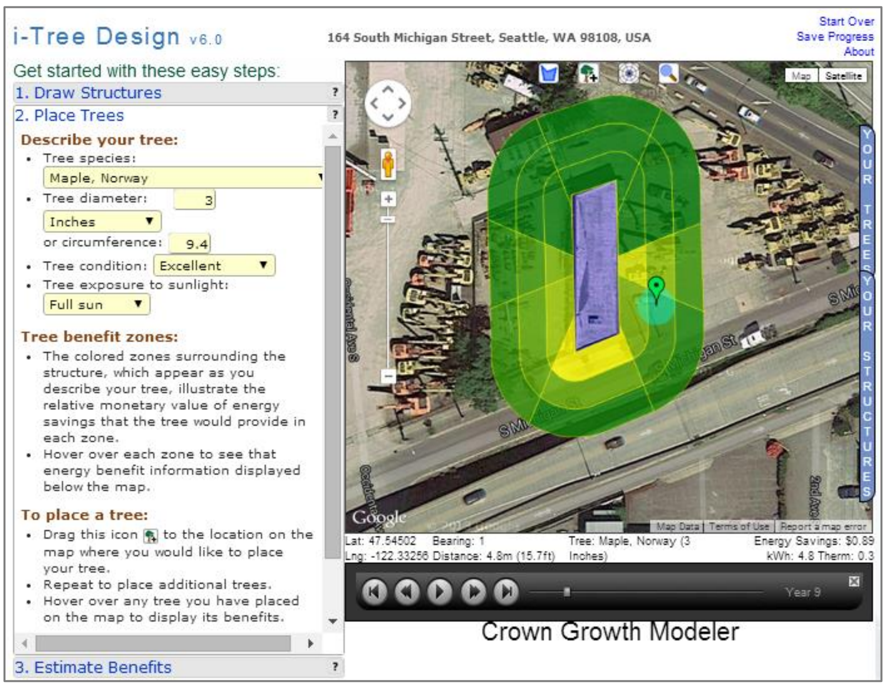


EPA Calculator can be downloaded at: http://www2.epa.gov/water-research/national-stormwater-calculator

Appendix I

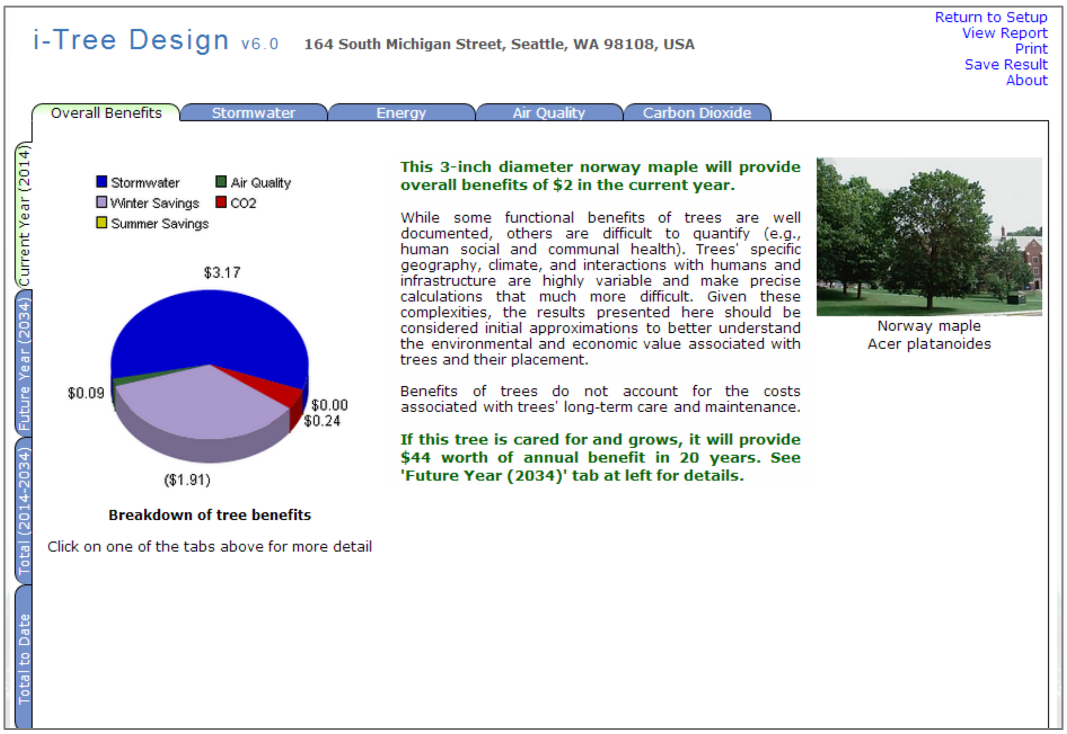
i_Tree Design tool

Part of the USDA Forest Services i-Tree software suite, i-Tree Design uses location, species, tree size, and condition as inputs to evaluated tree benefits related to greenhouse gas mitigation, air quality improvements, and stormwater interception are estimated. The effects of trees on building energy use can also be reviewed by adding virtual trees and the additional step of drawing a building footprint. (i-Tree n.d.)



To test the i-Tree Design tool, one parcel was selected that had a building on site. The parcel address was entered, the building was drawn, and the inputs were entered using a 20 year projection to track tree growth and benefits. The inputs entered were: Norway Maple (a common street tree in the Seattle urban forest) with a 3 inch diameter in excellent condition and exposed to full sun. The tool provides “tree benefit zones” symbolized yellow (for poor) to dark green (for best) and when a zone is hovered over, energy benefit information is provided. (i-Tree n.d.) For this test, one tree was placed on the site as seen in Figure H.1.

i-Tree Design Overall, Stormwater, Energy, Air Quality, and Carbon Dioxide (CO2) results are displayed for the current year, future year, total years, and total to date. Based on the inputs used on our sample site, this year the addition of one Norway Maple would intercept 114 gallons of stormwater and reduce atmospheric CO2 by 25 pounds. In addition to these benefit results, the trees crown growth (canopy cover) can be modeled over a 60 year period to determine the possibility of required maintenance for building and utility interference.



Users are also provided a tool for the assistance in tree selection with i-Tree Species. By means of user defined tree functions based on a 0-10 ranking scale and geographic area by city and state, the tool compares user's inputs to approximately 1,600 tree species.

Appendix J

Lower Duwamish Air and Water Quality Improvement Grants
King County Wastewater Treatment Division

2014 GRANT APPLICATION

Please submit grant applications electronically by June 2, 2014, at 5:00 pm to karen.bergeron@kingcounty.gov. Please put in the subject field "Green Grants". Proposals submitted by email must by less than 10MB (megabytes).

Note: Shaded fields will expand as you type

Applicant: **Sustainable Seattle**		
Project title: **Depave the Duwamish**		
Contact: **Hannah Kett**	Phone: **206-622-3522**	Fax:
E-mail: hannahk@sustainableseattle.org	Web Site: **www.sustainableseattle.org**	
Address: **1501 E. Madison St, Suite 400**		
City: **Seattle**	State: **WA**	Zip: **98103**
Body of water or watershed of project: **Duwamish RIver**		
Community where project is located: **Georgetown and South Park**		
Street location or address of project:		
Alternate contact: **Cari Simson**	Phone: **206-234-5102**	E-mail: **cari@urbansystemsdesign.com**
Brief Project Statement (3 short sentences max.) Depave the Duwamish aims to support King County's GSI goals and build a healthy and vibrant Duwamish Valley by transforming impervious surfaces on private property into public benefit green spaces. The project will increase the communities' awareness of the impact of impervious surfaces and enable them to identify priority sites for potential depaving. A successful project will empower residents and catalyze 3 concrete projects with private land owners in separated stormwater systems in the Georgetown and South Park neighborhoods.		
Request: $ 22,875 Date of request: **6/2/2014**		

Be sure to include and checkmark the following prior to sending your application:

☒ The project narrative (see below; 3 pages maximum)
☒ A cover letter signed by a person allowed to approve a legal agreement with King County
☒ Map indicating project location and showing street names

OPTIONAL: A fact sheet or brochure on your organization describing its history and accomplishments, etc.
Which one of the following grant funds are you applying for?
Pleases note that each one will have different requirements regarding project location, type of project, project activities, spending and match.

There is a maximum grant award of $50,000 per applicant.

Which of the following describes your organization?

☐ SCHOOL
☐ TRIBE
☐ LOCAL GOVERNMENT
☒ PRIVATE NON-PROFIT ORGANIZATION OR ASSOCIATION
☐ INDIVIDUAL (Duwamish Water Quality Improvement grants only)
☐ BUSINESS IN DUWAMISH AREA (Duwamish Water Quality Improvement grants only)

PROJECT NARRATIVE

Instructions: Please answer the following questions in the boxes below. The boxes will expand as you type. ***This section is limited to no more than 3 pages.***

PROJECT BACKGROUND

Briefly explain the history of the problem you are addressing in this project. How has the problem been addressed to date and by whom?

The Duwamish Valley is home to an EPA Superfunded Site where the clean-up plan involves residential, industrial, and muncipal stakeholders. Through efforts of the Duwamish River Clean-up Coalition (DRCC), the EPA-led plan includes the voice of the community. King County Wastewater and Seattle Public Utilities are also implementing major capital projects to reduce the overflows of combined stormwater and sewage into the Duwamish River, through the use of gray (treatment and additional pipes) and green infrastructure (trees, rain gardens or permeable pavement).

However, even with this effort underway, this community will remain one of low-tree canopy, high impermeability, and a lack of buffers between residential and industrial uses. These gaps have a significant impact on the overall health of the community as identified in the Cumulative Health Impact study published by DRCC. Specifically, lack of tree canopy can have an adverse effect on air quality and cause asthma, specfically in vulnerable populations like children and elderly. Excessive paved areas also cause "heat islands" where temperatures rise over areas with pavement or other hard surfaces. Duwamish Valley residents have higher rates of disease such as lung cancer, more acute asthma attacks, and shorter life expectancies than elsewhere in the county. In addition, the communities in Duwamish Valley, specifically Georgetwon, South Park, and adjoining neighborhoods will see the effects of climate change sooner than the rest of Seattle, including higher tides, increased runoff, and impacts on utility infrastructure. A coordinated effort of reducing impervious surfaces and widespread tree plantings enables private property owners to reduce polluted runoff and improve air quality. Community leaders have prioritized improved air quality in the setting of their goals for the spending the Duwamish Opportunity Fund, which will be managed by the Department of Neighborhoods.

Sustainable Seattle, in partnership with Urban Systems Designs and multiple community-based groups, proposes to develop a Depave plan in the Duwamish Valley, to identify excessive impervious surfaces through data and map analysys and following-up through 'ground truthing' with students and other volunteers. The aim is to engage private property owners to strategically reduce these surfaces and replace them with native trees and shrubs creating small green spaces that provide long-term benefits for the public. The design solutions could take the form of green infrastrucutre systems like Splash Boxx, Filterra tree pits, native trees and plants, picnic tables, benches, public art and more.

Through a grassroots engagement of residents and local property owners, we will activate neighborhood-scale change that will support climate change resiliency. Residential engagement is already underway in South Park with over 20 homes installing RainWise rain gardens, positively impacting water quality and building initial community vibrancy. Now, there is an opportunity to use momentum to push the more industrial areas to turn pavement into a green space for public benefit. A central focus of this project will be building a collaboration between the industrial sector, residents, and additional stakeholder to build a common vision for reducing impervious surfaces and increasing green spaces.

This Depave effort will build on the successful model built in Portland and piloted in Highland Park, a project funded by King County Green Grants. With support from King County, the project partners will engage the public around the purpose and potential for Depave as well as set priorities for initial Depave projects. Construction funds will be sought from alternative grants and matched by engaged businesses.

RATED QUESTIONS

1. Project objectives and description of activities and project outputs (50 points; 41 points minimum required)

Describe the project objectives:

- **Increase awareness with residents and workers about climate change, "heat island effect," polluted runoff and air quality issues in the Duwamish Valley** residential-industrial areas, and the cost-effective impact of asphalt removal and tree planting on improving overall environmental health, and how a proactive project gets immediate results.
- **Identify and reduce the amount of impervious surfaces on private properties in separated stormwater drainage areas** in Georgetown, South Park, and other Industrial areas surrounding the Duwamish River; currently the Duwamish Valley is estimated to be at least 85% paved or other impervious surfaces, based on preliminary map analysis.

The following objectives will be incorporated into Phase 2 with additional funding:

- **Replace impervious surfaces with tree canopy, native plants, and "people habitat" on private properties;** currently the Duwamish industrial area, including South Park and Georgetown has approximately 13% tree canopy – well below the 30% target for Seattle.
- **Charismatically document the story** to expand the number of industrial sites engaging in the Depave Process

Describe the activities that will carry out your objectives and their tangible outputs (e.g., plantings, culvert removal, water reuse demonstration, publications, learning activities).

- Research and collate existing maps, neighborhood plans developed by Georgetown and South Park community groups, and active projects from Georgetown, South Park, and connected industrial areas to provide a base picture of need in the neighborhood.
- Collaborate with the University of Washington GIS team to create maps that build on existing resources – including King County's detailed analysis - to identify private parcels in the Duwamish Valley where a reduction of asphalt would have multiple benefits
- Cross-reference this data with EPA and Department of Ecology Toxic Site Inventory lists to identify parcels that would not be safe to disturb
- Combine maps with on-the-ground knowledge built in the first task to identify priority sites for Depave and green transformation. Ground -truthing will be carried out to assess the accuracy of GIS data analysis.
- Form collaborative working group comprised of Sustainable Seattle, Stewardship Partners, Urban Systems Design, and key neighborhood stakeholders; hone existing marketing materials based on previous Depave success stories in Portland, OR; Tacoma, WA; and Highland Park (Seattle), WA;
- Utilize this material and list of priority sites to engage with neighborhood and business organizations, including the Manufacturing Industrial Council, South Park Neighborhood Association, Georgetown Community Council, Duwamish River Cleanup Coalition, and more; identify additional people to join working group, including industry leaders like McKinstry, CleanScapes, and Georgetown Brewing Company, and the Boeing Company, as well as the Port of Seattle and City of Tukwila.

The following activities will be incorporated into Phase 2 with additional funding:

- Compile photographs of properties during rain events; collect other data like temperature, runoff flows, or other measurable qualities of the existing asphalt;
- Conduct outreach to identified property owners; identify at least one and up to four property owners who are willing to participate; work with selected property owners to identify and coordinate funding as well as organize a team who will lead construction and planting on site(s); in partnership with the private property owners.
- Facilitate the digital storytelling process working with students, afterschool youth programs or other entity to share the Depave process.

Describe how you will measure the success of your project.

- We will track the effectiveness of the marketing material through measuring interest in workshops, inquiries, and distribution of material.
- We will qualitatively track the success of the collaboration built through this project, providing reports of the collaborative results achieved through meetings, development of GIS based maps and more.
- We will also quantify success by the number of businesses participating, the number of volunteers, and the number of partners in our collaborative working group.

The following successes will be measured in Phase 2 of this project:

- We will also be able to quantify success by calculating air and water quality, air temperature adjacent to buildings, CO2 reductions and other measurable climate change metrics.
- We will also be able to quantify success by calculating air and water quality, air temperature adjacent to buildings, CO2 reductions and other measurable climate change metrics.
- We will also capture the visual changes of the neighborhood through video and photography. This, combined with the interviews, will help illustrate the success of the project to the broader public.
- We will be able to quantify success by the number of depave projects that enter the pipeline for implementation.

2. Community support (20 points; 17 points minimum required)

How does your project include community participation and build support for salmon habitat or water quality protection and restoration? What will the community learn from or about this project and through what means? (e.g., press releases, posters, project signage, presentations). Please describe any project partners and what they are bringing to this project (0-20 points).

At its core, this project is seeking to address community concerns and interests. In the first objective, the team will be focused on engaging the community in the purpose of the project – educating through broad written communications as well as one-on-one engagement to educate people about the impacts of climate change and heat islands and how "Depave"-ing can reduce this impact. A portion of this education will be done through dedicated canvassing. We will partner with groups like Georgetown Community Council, ECOSS, South Park Neighborhood Association, and DRCC to ensure a broad range of constituents are accessing the education and able to participate in the development of a Depave vision.

These organizations, along with the process of working through neighborhood plans, will ensure the community learns about water protection through a hands-on project. Long-term learning will be conveyed through the digital storytelling as well as through project participants – including the high school students and elementary students – that can be the spokespeople for the project in the community. In addition to the groups listed above, we will be partnering with:

- Veterans Conservation Corps to provide construction support
- EarthCorps to support the ground-truthing and GIS efforts
- Stewardship Partners to incorporate the project into the regional Depave efforts
- Urban Systems Design and Cari Simson to provide overall project management, incorporating it into existing and potential projects in the neighborhood.
- Sustainable Seattle to provide on-the-ground project management, outreach implementation, and grant administration
- Green Infrastructure Partnership is a strong resource for this project, providing an opportunity to share and learn best practices and leverage efforts by connecting with other ongoing projects.

Please describe any matching funds. Matching funds are not required; however, applications will receive additional points for providing a sponsor match (up to five bonus points).

This project will work in coordination with other on-going efforts, including the RainWise outreach. The project partners will be seeking additional funds from: King Conservation District, Department of Neighborhood, and others to fund the construction of the Depave projects to address the priorities and vision identified in this project. In-kind support will be provided through the Department of Geography at the University of Washington. Sustainable Seattle is requesting a team of 2 to 3 students to develop initial impervious surfaces and target areas for the Duwamish Valley.

3. Certainty of Success (30 points; 25 point minimum)

Why is your project important to do now? Please describe how you are capable of implementing the project.

Climate change is already happening and proactive neighborhood planning is needed for Seattle's low-income residential-industrial shoreline neighborhoods. We have a once-in-a-lifetime opportunity to develop a bigger vision focused on urban resilience while the efforts to remediate the Duwamish River Superfund site continue, to recover salmon habitat, and improve community health. This project is part of a much larger need for a visionary, overarching planning and synthesis process to develop a resilient strategy for the Duwamish Valley, including Region 10 EPA, Department of Ecology, NOAA, WRIA-9, Emergency Management, and more.

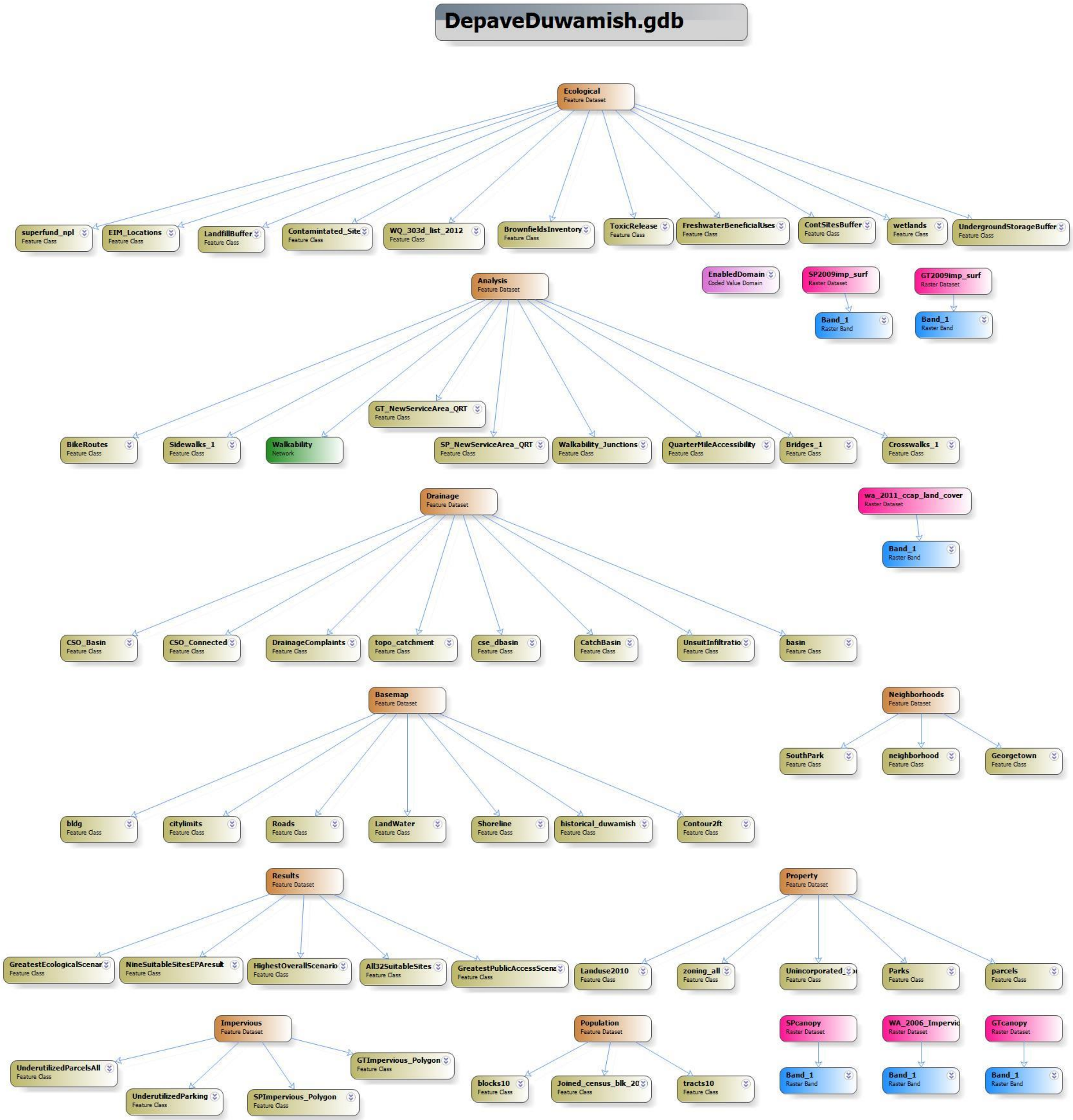
Sustainable Seattle and Urban Systems Design have been working in South and West Seattle to build support for Green Infrastructure. Most recent projects include voluntary roadside rain garden projects in South Park implemented by Cari Simson's team and a Depave project at Highland Park Improvement Club resulting in a permeable pavement courtyard and multiple rain gardens. Both of these projects were the result of close collaboration with a diverse group of residents, non-profits, municipalities, and community-based groups. The design, education and research-based team proposing this effort brings an unmatched perspective for the process to engage and involve people where they live, work and play. Their collaborative work has developed ground-breaking and award-winning projects across the Duwamish valley that connect equity, urban design, health, public art, green infrastructure, and climate resilience through multi-stakeholder teams.

These successes, as well as the groundswell of efforts around green infrastructure emerging from the Green Infrastructure Partnership, provide a strong foundation for the implementation of this project. In addition, these projects will work in coordination with targeted efforts to build climate resiliency and tree planting leadership in these neighborhoods.

BUDGET TABLE

BUDGET ITEM	GRANT REQUEST	CASH MATCH	IN-KIND MATCH	SOURCE OF MATCH	STATUS OF CASH MATCH
Salaries & benefits **Hannah Kett, 4875 Michelle Ruiz (communications), 2500**	7375	5000		Cash - King Conservation District	☐Received ☒Pending
Freelance workers and consultants **Cari Simson, 6000 Amir Sheikh 500 Aaron Clark, Stewardship Partners, 1000 Eric Rosewell, Depave, 1000 Canvassing, 2,500**	11000	5000		Cash – King Conservation District	☐Received ☒Pending
Sub	**18375**	**10,000**			
Project supplies, materials and equipment	1000	20,250	5000	KCD Minimum Expected Match from Business Participants	☐Received ☒Pending
Commercial services (e.g., printing, backhoe)	500	12,250	5000	KCD Minimum Expected Match from Business Participants	☐Received ☒Pending
Transportation					☐Received ☐Pending
Office expenses (broken down unless requesting a blanket overhead rate) **15% of total cost**	3000	7500		KCD	☐Received ☐Pending
Real estate-related costs					☐Received ☐Pending
Other costs					☐Received ☐Pending
Sub	**4500**	**40,000**	**10,000**		

Appendix K:


DepaveDuwamish.gdb
Ecological
Feature Dataset
superfund_npl
EIM_Locations
LandfillBuffer
Contamintated_Site
WQ_303d_list_2012
BrownfieldsInventory
ToxicRelease
FreshwaterBeneficialUses
ContSitesBuffer
wetlands
UndergroundStorageBuffer
Feature Class
Analysis
EnabledDomain
Coded Value Domain
SP2009imp_surf
GT2009imp_surf
Raster Dataset
Band_1
Raster Band
GT_NewServiceArea_QRT
BikeRoutes
Sidewalks_1
Walkability
Network
SP_NewServiceArea_QRT
Walkability_Junctions
QuarterMileAccessibility
Bridges_1
Crosswalks_1
Drainage
wa_2011_ccap_land_cover
CSO_Basin
CSO_Connected
DrainageComplaints
topo_catchment
cse_dbasin
CatchBasin
basin
Basemap
Neighborhoods
SouthPark
neighborhood
Georgetown
bldg
citylimits
Roads
LandWater
Shoreline
historical_duwamish
Contour2ft
Results
Property
NineSuitableSitesEPAresult
HighestOverallScenario
All32SuitableSites
Landuse2010
zoning_all
Parks
parcels
Impervious
Population
SPcanopy
GTcanopy
UnderutilizedParcelsAll
GTImpervious_Polygon
UnderutilizedParking
SPImpervious_Polygon
blocks10
tracts10

Appendix L