**Rapid Benefit Indicator (RBI) Spatial Analysis Toolset Manual**

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**Overview:**

The Rapid Benefits Indicators (RBI) approach consists of five steps and is outlined in **Assessing the Benefits of Wetland Restoration – A Rapid Benefits Indicators Approach for Decision Makers**,

<https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=325010>

hereafter referred to as the “guide”. The guide presents the assessment approach, detailing each step of the indicator development process and providing an example application in the “Step in Action” pages. The spatial analysis tool is intended to be used to analyze existing spatial information to produce metrics for many of the indicators developed in that guide. This spatial analysis tool manual gives you directions on the mechanics of the tool and its data requirements, but does not detail the reasoning behind the indicators and how to use results of the assessment; this information can be found in the guide.

**Requirements:**

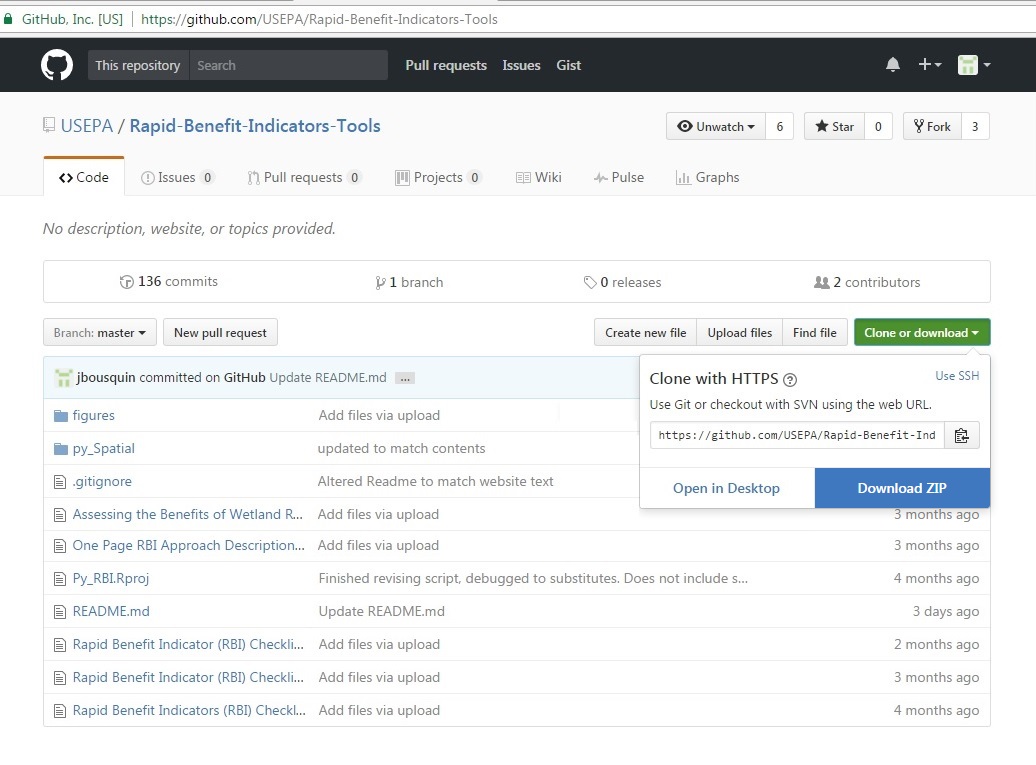
The Rapid Benefits Indicators (RBI) spatial analysis toolset is run using an ArcGIS Python toolbox. The toolbox must be used within ESRI’s desktop software versions 10.1 or newer. The toolbox is not yet compatible with ArcGIS Pro, and has only been tested on desktop versions 10.1 - 10.4. Operating system and hardware requirements for running this tool are the same as those for using ArcGIS desktop:

[http://desktop.ArcGIS.com/en/arcmap/10.3/get-started/system-requirements/ArcGIS-engine-system-requirements.htm](http://desktop.arcgis.com/en/arcmap/10.3/get-started/system-requirements/arcgis-engine-system-requirements.htm)

**Downloading the Toolset:**

The Python toolbox (.pyt extension) and associated files required to perform the spatial analysis can be downloaded as a package or copied as individual files:

Recommended: If downloading from github, go to the repository <https://github.com/USEPA/Rapid-Benefit-Indicators-Tools> and click the green “Clone or download” button, when the drop down window opens “Download Zip” will download all the associated files as a compressed zip file. Unzip the file to your desired file location.



Alternative: Depending on the requirements of your analysis, you may want individual files. The Python toolbox (.pyt) and standalone python scripts (.py) can be found in the repository subdirectory, py\_Spatial or py\_standaloneScripts respectively. Clicking the link for the desired file displays the file’s code. Clicking the “Raw” button and then right clicking and selecting “Save as…” will allow for the file to be saved directly. Renaming the file will not affect functionality as long as it has the appropriate extension (.pyt or .py). Associated data and map files have a download option. For full tool functionality you must save these files using the same name in the same location as the toolbox.

**Included in the Toolset:**

The focus of this manual is running assessments using tools available in the Python toolbox (.pyt) within ArcGIS. In addition to the toolbox, the same functionalities of each tool are also included in standalone python scripts (.py). These scripts are intended for users with knowledge of python who wish to interact directly with the code, the scripts still require the arcpy libraries included with ArcGIS.

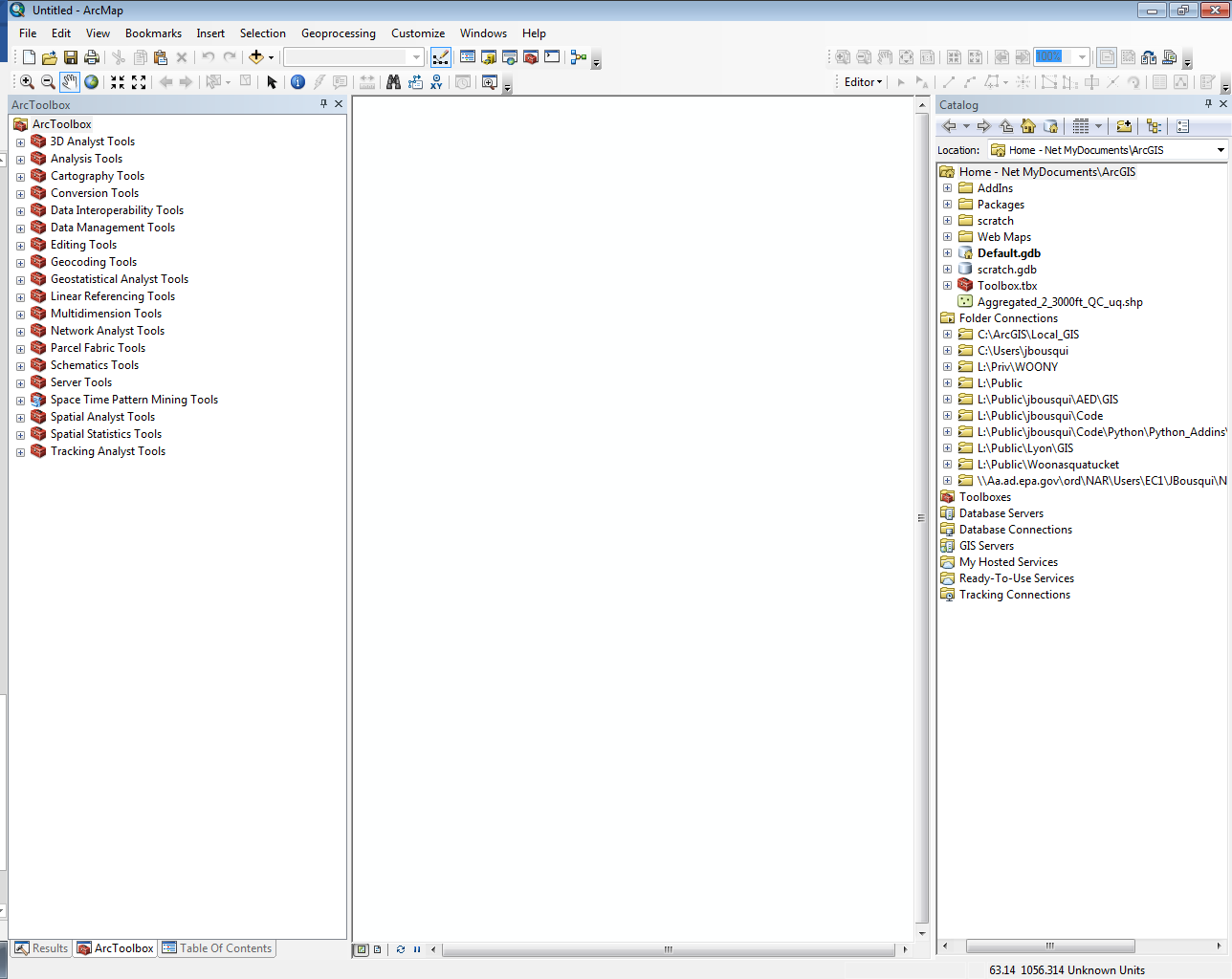
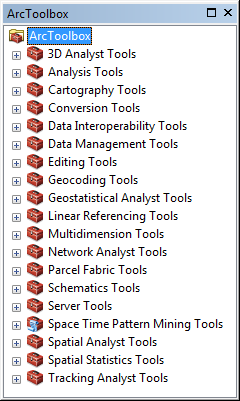
For the Python toolbox to have full functionality the toolset has several other “Associated Files” in the py\_Spatial directory. These files help to streamline your analysis. They include:

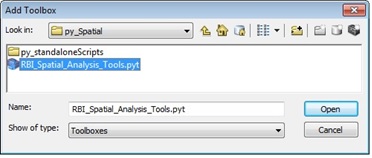
.xml files – five files, each named after the tool they refer to, provide additional tool help when using each of the tools within the RBI Spatial Analysis Toolset. Without the .xml files the tool will not have the complete Tool Help including descriptive help for each tool parameter. These files do not impact tool functionality.

NHD+ files – two data files are available for download with the tool, a table with catchments (Catchment) and a table with the upstream/downstream relationships (PlusFlow.dbf), both from NHD+ version 2: <http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php> These files are only used for Flood Risk Reduction indicators. Flood Risk Reduction calculations are designed to find these files in the same folder as the toolbox itself. Alternative catchments or NHD+ files you may wish to use can be specified using the “Part – Flood Risk Reduction” tool.

.mxd file – a map file is available for download with the tool that includes all the layout formatting required to produce pdf reports. The full tool is designed to automatically find these files in the same folder as the tool itself. In the “Part – Report Generation” tool you can specify the mapfile (.mxd) you want to use for formatting if you wish to move the file.

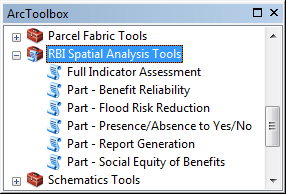
**Installing the Toolbox:**

Python Toolboxes are easy to install into ArcMap or ArcCatalog and operate just like other geoprocessing tools. If not already open, open the ArcToolbox window by clicking the “Geoprocessing” button on the main ribbon and selecting ArcToolbox from the drop down.

In the ArcToolbox window (A) right click and select “Add Toolbox…” to open the Add Toolbox window (B). Use this window to navigate to the py\_Spatial folder and select the “RBI Spatial Analysis Tools” you just downloaded and click “open”.

**B**

**A**

Once the toolbox is added it will appear in the ArcToolbox window (C) alongside other toolboxes, and individual tools within the toolbox can be selected just like other toolboxes.

**C**

**Using the toolbox:**

There are two ways to use the toolbox to run your spatial analysis: either by (1) using the individual “Part” tools in a stepwise process along with parts of the “Full Indicator Assessment” tool, or (2) by loading all of the data into the “Full Indicator Assessment” tool and running it once. Data requirements for each benefit you may choose to assess are described in the next section - **Data Requirements**. Then a description of the full tool is provided, followed by sections on each of the Part tools and how they differ from the Full Indicator Assessment tool.

**Data Requirements**

***Required Data***

**Restoration Site Polygons** - The area of the restoration site being assessed. All other input datasets will be re-projected based on the projection used for the restoration sites. All fields and spatial data in this feature layer will be copied from the sites to the output table. The output table from one partial analysis can be used as input to the next.

**Output –** A file name and location must be specified for the dataset that results from the analysis. It is recommended that users create a new file geodatabase and save their output there because the folder location of the output file is also used to save intermediate files. If files with the same names as the intermediates already exist in the specified location, they will be deleted and overwritten.

**Address Points** or **Population Raster** - People in the area around the restoration sites that could potentially receive benefits from site restoration. A buffer of 12 miles around the site will usually be enough, though the range may vary depending on the benefits chosen for assessment. Points representing individual homes should be entered as “Address Points.” Suggested sources include state provided E-991 address data. Grid format representations of population should be entered as "Population Raster." For the conterminous United States, the EnviroAtlas - Dasymetric Population dataset is recommended:

<https://catalog.data.gov/dataset/enviroatlas-dasymetric-population-for-the-conterminous-united-states>

***Optional Data***

The spatial analysis tool is designed to assess up to five (5) benefits that were developed for urban wetland restoration sites. Each of these has its own specific data requirements.

**Reduced Flood Risk** – Flood risk reduction benefits flow from where they are produced to downstream areas that would otherwise flood. Flood risk reduction indicator metrics include the number of beneficiaries in areas that flood downstream of the site. The“NHD+ Catchments” dataset is used to determine what catchments are within 2.5 miles of the site. The tool selects the catchment(s) in the “NHD+ Catchments” dataset that overlap the site, and makes a sub-selection of the catchments in 2.5 miles based on which catchments are downstream from those that overlap the site. Downstream catchments are identified using the “NHD Join Field“ field from the “NHD+ Catchments” dataset that matches the To/From COMID field in the “Relationship Table” dataset. Once a catchment falls completely outside of 2.5 miles of the site no further downstream catchments are included even if the stream network flows back into the area within 2.5 miles of the site. However, since the stream network may curve and loop around within 2.5 miles of the site, the length of the stream network included will typically exceed 2.5 miles. The “Flood Zone” dataset is used to define the area that floods, and gets clipped by the resulting catchments to determine where people may benefit downstream of the site. “Dams and Levees” and “Wetlands” are features that may act as substitutes, reducing flow risk. All substitute features in range are counted, regardless of being upstream or downstream.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Flood Zone Polygons | Dataset that defines flood zones (e.g. 100-yr or 500-yr) where flooding occurs | Feature Layer | FEMA, or NOAA |
| Wetland Polygons | Vector dataset that defines existing wetlands | Feature Layer | National Wetlands Inventory (NWI) |
| Dams/Levees | Point, line or polygon dataset defining flood prevention infrastructure | Feature Layer | USGS NHD+ |
| NHD+ Catchments | Dataset that defines catchments around the restoration sites | Feature Layer | Available with tool  (Catchment.shp) |
| NHD Join Field | Field that holds the ID associated with the catchment in the relationship table | Field | Available with tool  (FEATUREID) |
| Relationship Table | Table with to/from COMID fields corresponding to the NHD Join Field for upstream/downstream catchments | Table | Available with tool  (PlusFlow.dbf) |

**Scenic Views –** Scenic view benefits flow from aesthetically pleasing landscapes outward to surrounding areas. Residents in the surrounding area and people moving through, assessed using “Trails” and “Roads” route datasets, may receive benefits. The existing “Wetlands” features are considered substitutes that may already benefit people. However, other types of greenspace, the “Landuse/Greenspace” dataset, are complements where greater landscape variety increases view value. The user has the flexibility to choose what field and values represent value adding greenspace in the Landuse/Greenspace dataset.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Trails (hiking, biking, etc.) | Point, line or polygon dataset that defines other places people may receive benefits | Feature Layer | NPS, State agency, or NGOs |
| Roads (streets highways, etc.) | Point, line or polygon dataset that defines other places people may receive benefits | Feature Layer | Tiger, ESRI, Google, or E911 |
| Wetland Polygons | Vector dataset that defines existing wetlands | Feature Layer | National Wetlands Inventory (NWI) |
| Landuse/Greenspace Polygons | Vector dataset that defines alternative greenspace that may add value | Feature Layer | State agencies, NOAA, or National Land Cover Database (NLCD). |
| Greenspace Field | Field identifying greenspace landuse | Field | user specified |
| Greenspace Field Values | Values in the field which are greenspace | Values | user specified |

**Environmental Education –** Environmental education benefits are the only ones that can be assessed without a population dataset (addresses or population raster). The “Educational Institutions” dataset is used instead and can include public schools as well as early education institutions like pre-k or daycare. The existing “Wetlands” features are considered substitutes that may already benefit people.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Educational Institution Points | Point dataset that defines education institutions that may receive benefits | Feature Layer | State department of education |
| Wetland Polygons | Vector dataset that defines existing wetlands | Feature Layer | National Wetlands Inventory (NWI) |

**Recreation –** Recreation benefits require people to travel to the site where recreation opportunities are to benefit. People within walking or driving distance of the site are assumed to be able to benefit. The presence of “Trails” or “Bus Stops” dataset features also increase who could benefit by making the site accessible by alternative modes of transportation. The existing “Wetlands” features are considered substitutes that may already benefit people. However, other types of green or open space adjacent to the restoration site are complements, as these may increase the types of recreational opportunities available.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Trails (hiking, biking, etc.) | Point, line or polygon dataset that defines trails that help people access benefits | Feature Layer | NPS, State agencies, or NGOs |
| Bus Stop Points | Point, line or polygon dataset that defines bus stops that help people access benefits | Feature Layer | State department of transportation |
| Wetland Polygons | Vector dataset that defines existing wetlands | Feature Layer | National Wetlands Inventory (NWI) |
| Landuse/Greenspace Polygons | Vector dataset that defines alternative greenspace that may add value | Feature Layer | State agencies, NOAA, or National Land Cover Database (NLCD) |
| Greenspace Field | Field identifying greenspace landuse | Field | user specified |
| Greenspace Field Values | Values in the field which are greenspace | Values | user specified |

**Bird Watching** – Bird watching benefits flow from where birds are located outward to surrounding areas where people can see them. Bird Watching benefits can be received in the surrounding area by residents or by people moving through on trails or roads (“Trails” and “Roads” datasets).

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Trails (hiking, biking, etc.) | Point, line or polygon dataset that defines other places people may receive benefits | Feature Layer | NPS, State agencies, or NGOs |
| Roads (streets highways, etc.) | Point, line or polygon dataset that defines other places people may receive benefits | Feature Layer | Tiger, ESRI, Google, or E911 |

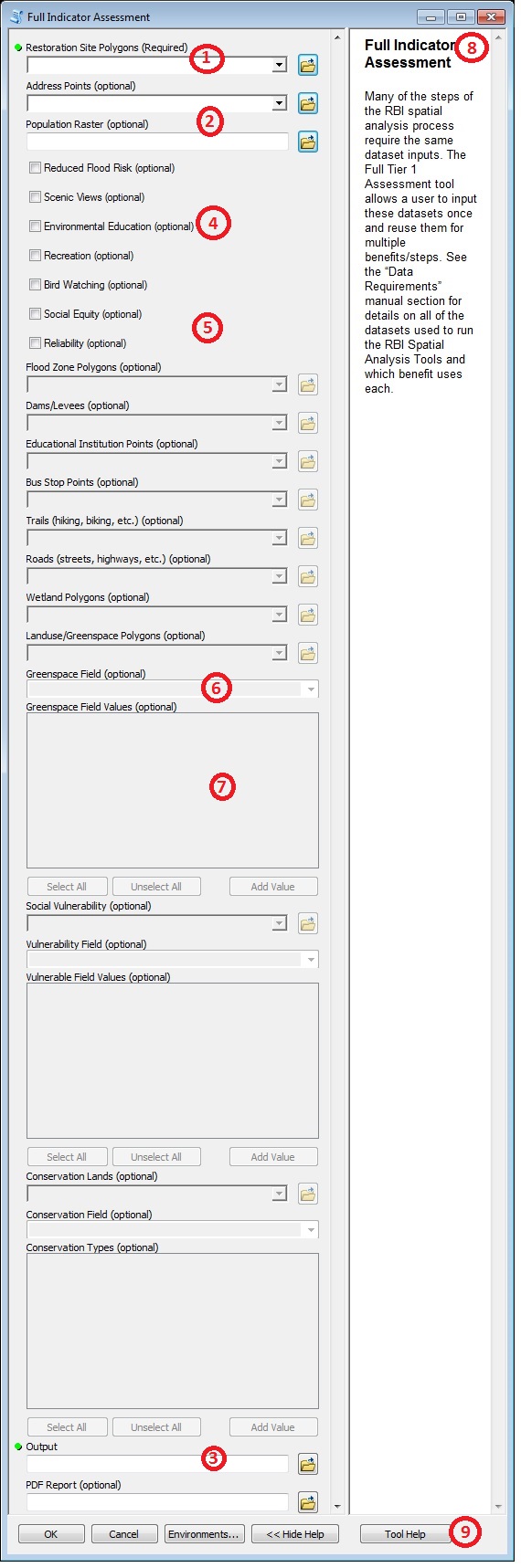
In addition to the five optional benefits that can be assessed, the restoration site can also be assessed for its potential to deliver benefits in a socially equitable way and reliably into the future.

**Social Equity** – The social equity of restoration sites can be compared for each benefit based on who is expected to benefit, but these will typically be similar across different benefits so it is recommended that users run social equity once for each site.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Social Vulnerability | Dataset that defines the social vulnerability of different areas | Feature Layer | Social Vulnerability Index (NOAA, CDC or census) |
| Vulnerability Field | Field designating population vulnerability | Field | user specified |
| Vulnerable Field Values | Values in the field which are vulnerable | Values | user specified |
| Buffer Distance | Value and units | Distance | Default |

**Reliability –** A restoration site that will persist further into the future is rated as higher priority than a comparable site that is not expected to persist into the future.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explanation** | **Data Type** | **Suggested Source** |
| Conservation Lands | Vector dataset defining areas to be conserved or otherwise protected against future threats and development | Feature Layer | State Planning Organizations |
| Conservation Field | Field designating protected areas | Field | user specified |
| Conservation Types | Values in the field which are protected | Values | user specified |
| Buffer Distance | Value and units | Distance | 500 ft |

**Using the Full Indicator Assessment Tool**

Many of the steps of the RBI spatial analysis process require the same dataset inputs. The Full Indicator Assessment tool allows a user to input these datasets once and reuse them for multiple benefits/steps. See the “Data Requirements” manual section for details on all of the datasets used to run the RBI Spatial Analysis Tools and which benefit uses each.

Datasets are added either by dragging and dropping a layer into the fillable space or by navigating the tool to the dataset using the corresponding open icon to the right.

(1) **Restoration Site Polygons**, (2) **Address Points** or **Population Raster**, and the (3) **Output** file must always be specified for the tool to run. Either Address Points or the Population Raster are needed to run the analysis, and once entered the other will become gray and non-fillable.

Check boxes are clicked to select which benefits will be assessed (4: Reduced Flood Risk, Scenic Views, Environmental Education, Bird Watching, Recreation) and if additional site metrics (5: Social Equity, Reliability) will be calculated. As boxes are checked, the datasets required for each will go from gray to fillable. This feature of the tool helps to clarify what the data requirements of your desired analysis. If a dataset is not entered or associated files are not available the tool will execute, but skip some metrics.

Flood Zone, Dams/Levees, Educational Institutions, Bus Stops, Trails, Roads, Wetlands, Landuse/Greenspace, Social Vulnerability, and Conservation Lands datasets can be in a geodatabase, shapefile, or feature layer selection.

The Landuse/Greenspace, Social Vulnerability, and Conservation Lands datasets each require certain values in certain fields to be specified. This increases flexibility and limits pre-processing. For example, in Landuse/Greenspace the tool only uses greenspace classified features. The classification (6) **Field** within your landuse dataset and its selected greenspace (7) **Values** are user-specified, allowing for different datasets and greenspace classifications.

In addition to the output table, the tool can also create a pdf report when a new PDF Report file name is entered.

All tools have (8) Help guidance and a (9) Tool Help sheet when downloaded as part of the tool package.

**Table relating indicators to the field name in the output table**

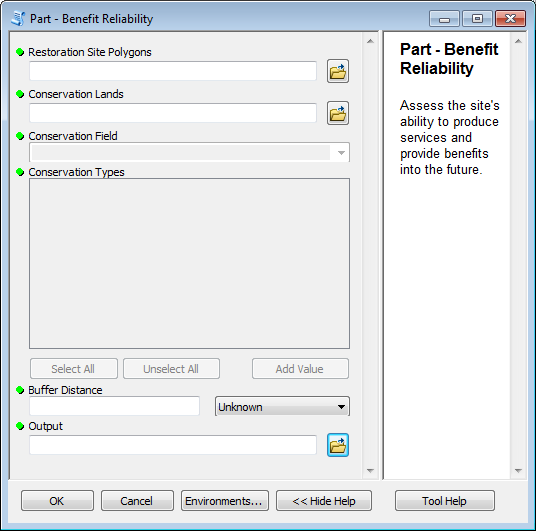
|  |  |  |  |
| --- | --- | --- | --- |
| **Benefit** | **Indicator** | **Text** | **Field Name** |
| Flood Risk | How Many Benefit? | 2.5 mi downstream of site and in flood zone | FR\_2\_cnt |
| Flood Risk | Service Quality | Area of restoration site (acres) | FR\_3A\_acr |
| Flood Risk | Service Quality | Features that increase retention volume? | FR\_3A\_boo |
| Flood Risk | Scarcity | Dams and levees 2.5 mi downstream? | FR\_3B\_boo |
| Flood Risk | Scarcity | Wetlands within 5 mi (number or % area) | FR\_3B\_sca |
| Flood Risk | Preferences | Are people worried about flood risk? | FR\_3D\_boo |
| Scenic Views | How Many Benefit? | Number within 160 ft of site | V\_2\_50 |
| Scenic Views | How Many Benefit? | Number within 160-325 ft of site | V\_2\_100 |
| Scenic Views | How Many Benefit? | Weighted number who benefit (70/30) | V\_2\_score |
| Scenic Views | How Many Benefit? | Are there roads or trails within 325 ft of site? | V\_2\_boo |
| Scenic Views | Service Quality | Aesthetic features or characteristics? | V\_3A\_boo |
| Scenic Views | Scarcity | Wetlands or water within 650 ft (number or %) | V\_3B\_scar |
| Scenic Views | Complements | Natural land use types within 650 ft (types) | V\_3C\_comp |
| Scenic Views | Preferences | Will people find it aesthetically pleasing? | V\_3D\_boo |
| Environmental Education | How Many Benefit? | Educational institutions within 0.25 mi of site | EE\_2\_cnt |
| Environmental Education | Service Quality | Features/habitat/wildlife of educational interest? | EE\_3A\_boo |
| Environmental Education | Scarcity | Wetlands within 0.5 mi of the site | EE\_3B\_sca |
| Environmental Education | Complements | Educational facilities or infrastructure on site? | EE\_3C\_boo |
| Environmental Education | Preferences | Will people prefer characteristics of the site? | EE\_3D\_boo |
| Recreation | How Many Benefit? | Number within 1/3 mi of the site | R\_2\_03 |
| Recreation | How Many Benefit? | Are there bike paths within 1/3 mi of site? | R\_2\_03\_bo |
| Recreation | How Many Benefit? | Are there bus stops within 1/3 mi of site? | R\_2\_03\_b2 |
| Recreation | How Many Benefit? | Number within 0 to 0.5 mi of site | R\_2\_05 |
| Recreation | How Many Benefit? | Number within 0.5 to 6 mi of site | R\_2\_6 |
| Recreation | Service Quality | Total area of green space around site | R\_3A\_acr |
| Recreation | Scarcity | Green space within 2/3 mi of site | R\_3B\_sc06 |
| Recreation | Scarcity | Green space within 1 mi of site | R\_3B\_sc1 |
| Recreation | Scarcity | Green space within 12 mi of site | R\_3B\_sc12 |
| Recreation | Complements | Infrastructure supporting recreational activities? | R\_3C\_boo |
| Recreation | Preferences | Are there additional features on the site? | R\_3D\_boo |
| Bird Watching | How Many Benefit? | Number within 0.2 mi of site | B\_2\_cnt |
| Bird Watching | How Many Benefit? | Are there roads or trails within 0.2 mi of site? | B\_2\_boo |
| Bird Watching | Service Quality | Will the site support rare or unique species? | B\_3A\_boo |
| Bird Watching | Complements | Supporting infrastructure or habitat on site? | B\_3C\_boo |
| Bird Watching | Preferences | Will people be interested in birds at the site? | B\_3D\_boo |
| Social Equity | Percent area of buffer with selected vulnerable field value | | High |
| Reliability | Percent area of buffer with selected conserved field value | | Conserved |

**Table listing field names in the output table not included as indicators**

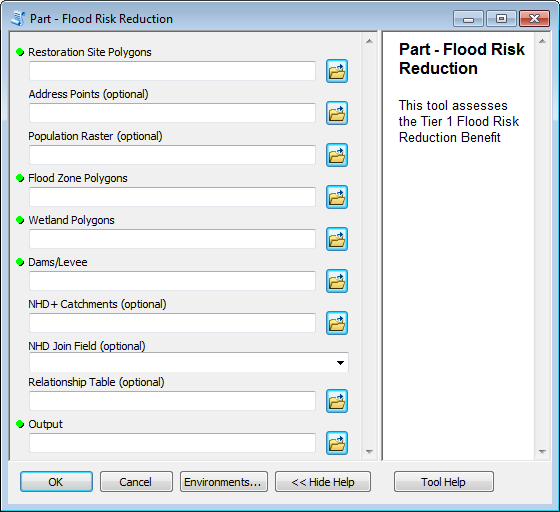
|  |  |
| --- | --- |
| **Field Name** | **Description** |
| FR\_zPct | Percent area around site that is flood zone |
| FR\_zDown | Area of downstream flood zone |
| FR\_zDoPct | Percent flood zone in area which is downstream |
| FR\_sub | Count of substitute features in FR\_3B\_boo |
| “SOVI values” | A field is created for each unique value that isn’t selected as vulnerable |
| Threatened | Features in the conservation layer that aren’t selected as “conserved” |

**Using Partial Assessment Tools**

The Full Indicator Assessment tool allows a user to run an assessment from start to finish but is streamlined with certain defaults. The “Part” assessment tools perform processes within the Full Indicator Assessment, but allow the user more flexibility to specify additional parameters or inputs.

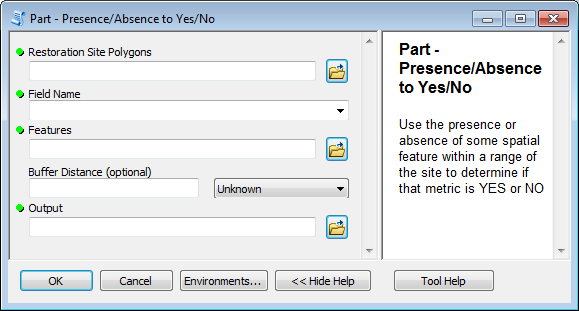
**Part - Benefit Reliability**

The Benefit Reliability tool calculates the reliability of site benefits in the same way as the Full Indicator Assessment Tool, but the user can designate a custom buffer distance around the restoration site that will be considered to determine the reliability, instead of the default 500 ft used in the Full Indicator Assessment.



**Part – Flood Risk Reduction**

The Flood Risk Reduction tool calculates indicator metrics for flood risk reduction benefits in the same way as the Full Indicator Assessment Tool, but the user is able to specify the catchment dataset to use and the field in that dataset that corresponds to a COMID field in the specified relationship table. Whereas the Full Indicator Assessment assumes the NHD+ dataset was downloaded and saved with the tool package, this partial assessment tool lets users specify their own catchments.

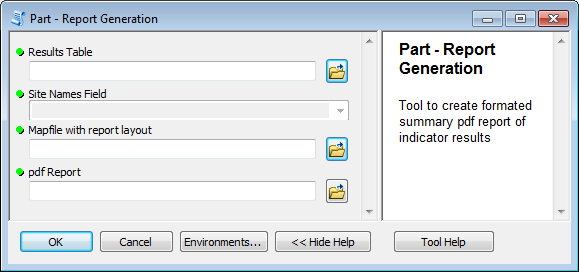
**Part – Presence/Absence to Yes/No**

The Full Indicator Assessment tool uses the same functionality as the Presence/Absence to Yes/No tool, but that functionality is not directly accessible. For example, for recreation benefits, this same functionality is used to determine if there are bike paths within 1/3 miles of the site. If the “Trails” dataset passes within the 1/3 mile-buffer around a site the “R\_2\_03\_tb” field gets a “YES”, otherwise it gets a “NO.”

There are several indicators that are measured as yes or no (see table below). The Presence/Absence to Yes/No tool is designed to work with vector datasets to put metrics to these indicators and populate the output table where the Full Tier Assessment tool does not.

**Table of fields corresponding to Yes/No indicators**

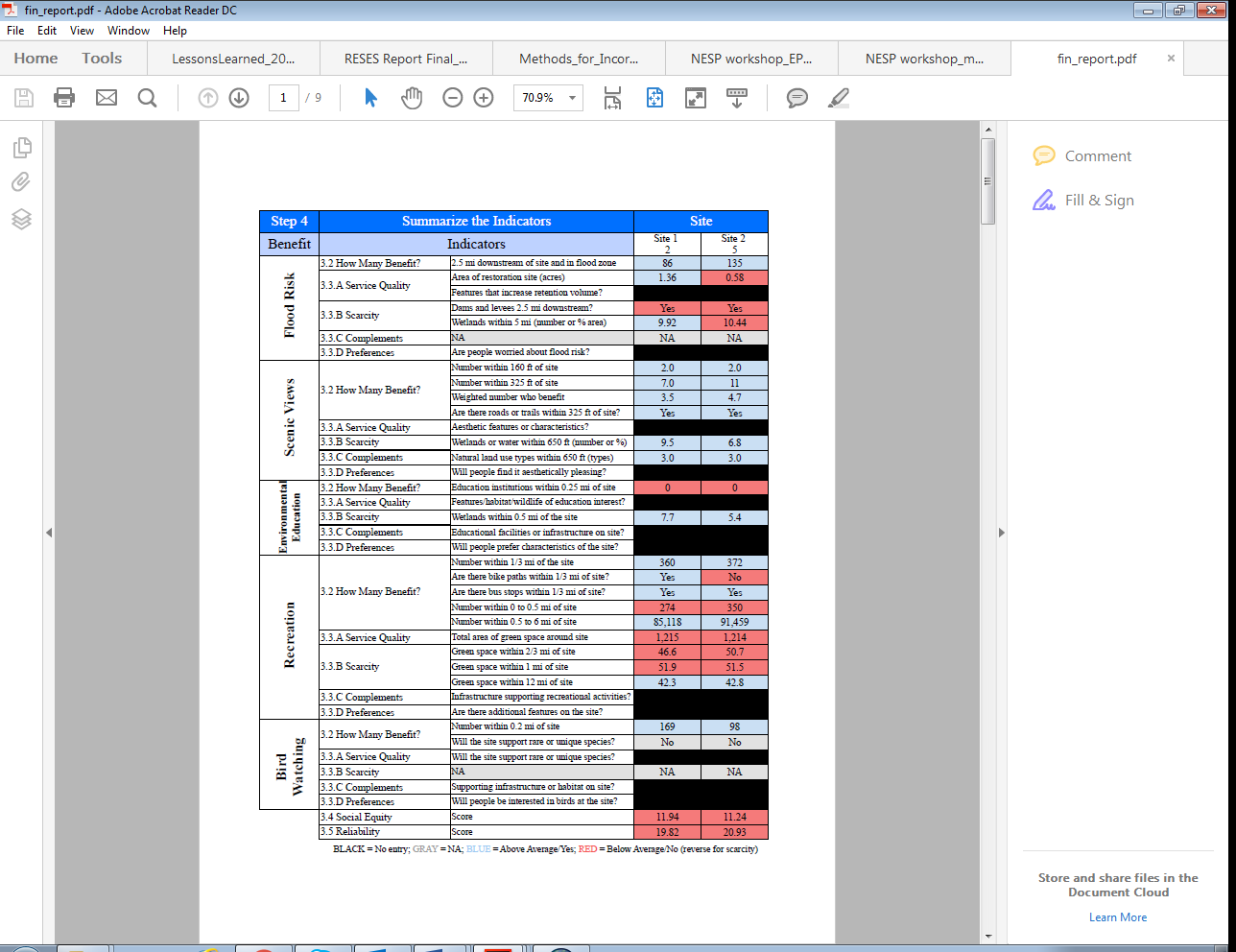
|  |  |  |  |
| --- | --- | --- | --- |
| **Benefit** | **Step** | **Indicator** | **Field** |
| Flood Risk | Service Quality | Features that increase retention volume? | FR\_3A\_boo |
| Scenic Views | Service Quality | Aesthetic features or characteristics? | V\_3A\_boo |
| Environmental Education | Service Quality | Features/habitat/wildlife of educational interest? | EE\_3A\_boo |
| Environmental Education | Complements | Educational facilities or infrastructure on site? | EE\_3C\_boo |
| Recreation | Complements | Infrastructure supporting recreational activities? | R\_3C\_boo |
| Bird Watching | Service Quality | Will the site support rare or unique species? | B\_3A\_boo |
| Bird Watching | Complements | Supporting infrastructure or habitat on site?” | B\_3C\_boo |

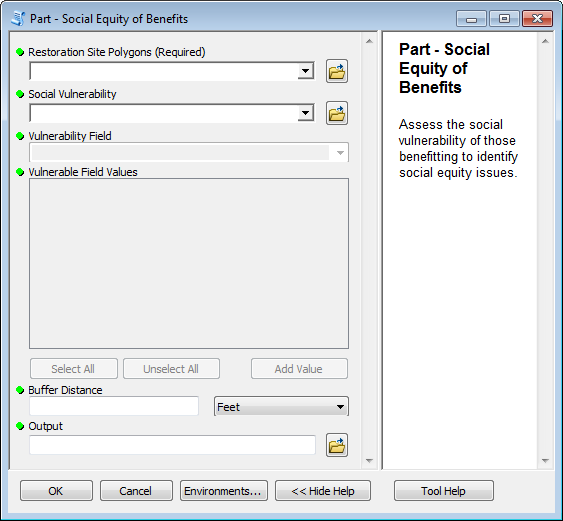


**Part – Report Generation**

The Report Generation tool uses the Results Table (Output from other tools) to create a PDF Report in the same way as the Full Indicator Assessment Tool, but the user is able to specify the Mapfile (.mxd) with the report layout in it. The user is also able to specify a field in the results table with names for the sites.

**Example PDF Report Format**



**Part – Social Equity of Benefits**

The Social Equity of Benefits tool calculates the social equity of site benefits in the same way as the Full Indicator Assessment Tool, but users are able to designate their own buffer distance around the restoration site that will be considered to determine the reliability instead of the default. The default used by the Full Indicator Assessment is the largest reasonable distance someone receiving one of the selected benefits could be from the site and still receive benefits [flood risk = 2.5 miles, recreation = 0.2 miles, bird watching = 100 meters, etc.].