Rapid Benefit Indicator (RBI)
Spatial Analysis Toolset Manual

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Disclaimer:

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**, 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 toolset 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 toolset manual gives 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 is 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, ArcMap or ArcCatalog, versions 10.1 or newer. The toolbox is not yet compatible with ArcGIS Pro, and has only been tested on desktop versions 10.1 - 10.5. Operating system and hardware requirements for running this tool are the same as those for using ArcGIS desktop:

https://desktop.ArcGIS.com/en/arcmap/10.3/get-started/system-requirements/ArcGIS-engine-system-requirements.htm

Table of Contents

Downloading the Toolset:

The RBI Spatial Analysis Toolset includes a Python toolbox file (.pyt extension) and the associated files required to perform the RBI spatial analysis. It is recommended that these files be downloaded as a package, but portions can alternatively be copied as individual files.

Recommended – Download from www.epa.gov/water-research/rapid-benefit-indicators-rbi-approach or the USEPA/Rapid-Benefit-Indicators-Tools GitHub repository. From the Code tab of GitHub (see Figure 1) click the green *Clone or download* button. In the window that appears click the blue *Download ZIP* button to download the toolset files as a compressed zip file. Unzip the file to your desired file location.
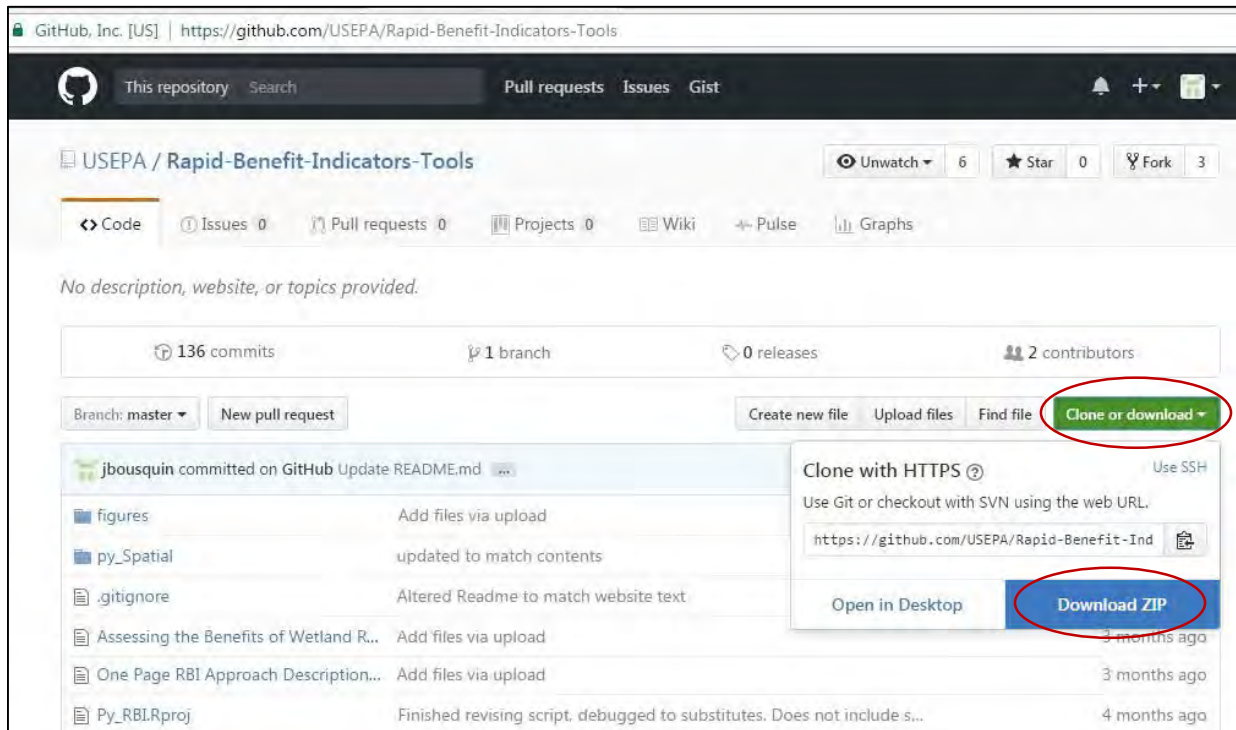
Figure 1 USEPA GitHub repository for RBI, found at https://github.com/USEPA/Rapid-Benefit-Indicators-Tools. To download the Spatial Analysis Toolset and all the associated files click "Clone or download" (circled in red) and the "Download ZIP" (circled in red).

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 (e.g., .pyt or .py). Associated data and map files have a download option. For full tool functionality you must save these files using the designated name and location relative to the toolbox file.

Components of the Toolset:

The focus of this manual is running assessments using the seven tools available in the Python toolbox. In addition to the toolbox file (.pyt) the toolset also includes standalone python scripts (.py) and additional files the toolbox uses for some functionality. The standalone python scripts perform the same processes as tools in the toolbox and 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.

Full functionality of the Python toolbox requires several other files found in the py_Spatial directory. These files help to streamline analysis. They include:

Help files (.xml) – eight files, each named after the tool they refer to, provide additional tool help when using the toolbox and each of the tools within the RBI Spatial Analysis Toolset. Without the .xml files the tools will not have the complete Tool Help including descriptive text for each tool parameter. These files do not otherwise impact tool performance.

NHDPlus files – files in the NHDPlusV21 subfolder are only used for Flood Risk Reduction indicators. The folder contains a File Geodatabase with three data files: BoundaryUnit – a Feature Class with the NHDPlus Boundary Units, Catchment – an empty Feature Class for catchments, and PlusFlow – an empty table for upstream/downstream relationships. The Part – Flood Data Download Tool is designed to use these files by default when downloading data from NHDPlus version 2: https://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php The Full Indicator Assessment Tool is designed to find the downloaded data in these default files, relative to the toolbox file. The Part – Flood Risk Reduction Tool allows alternative Catchment and/or Flow Table files or locations to be specified.

Mapfile (.mxd) – a map file is available for download with the tool that includes all the layout formatting required to produce PDF reports. The Full Indicator Assessment Tool is designed to automatically find these files in the py_spatial folder with the toolbox. The Part – Report Generation Tool allows the mapfile (.mxd) to be specified for alternative files or locations.

Installing the Toolbox:

Python Toolboxes are easy to install in ArcGIS (ArcMap or ArcCatalog) and operate like standard geoprocessing tools. To add the toolbox, click the *Geoprocessing* button on the *Standard* toolbar (Figure 2) and select *ArcToolbox* to open the ArcToolbox window (Figure 3).
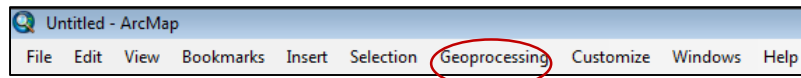

Figure 2 Click the Geoprocessing button circled in red and select "ArcToolbox" to open the ArcToolbox window.

Right click inside the *ArcToolbox* window and select *Add Toolbox…* to open the Add Toolbox dialog (Figure 4). Use this dialog to navigate to the toolset download subfolder py_Spatial, select the toolbox file (.pyt) and click *Open*.
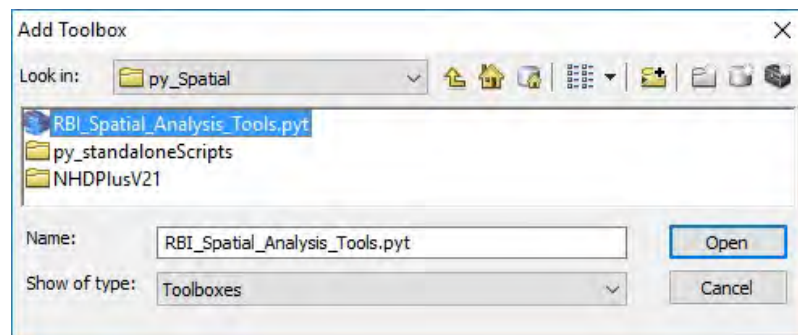
Figure 4 *Add Toolbox* dialog, used to navigate to and open the toolbox.
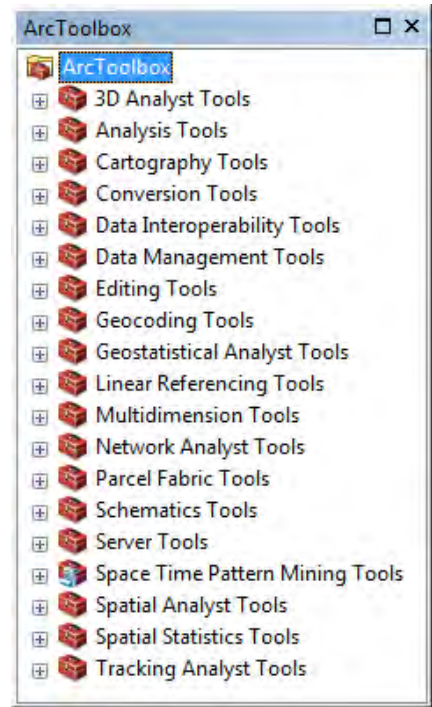
Figure 3 *ArcToolbox* window.

Once added, the toolbox will appear in the *ArcToolbox* window (Figure 5) alongside other toolboxes, and individual tools within the toolbox will be accessible just like tools inside standard toolboxes.
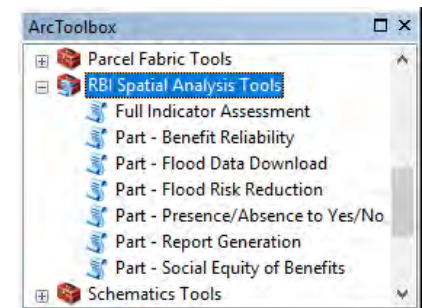
Figure 5 *ArcToolbox* window with RBI Spatial Analysis Tools Added.

ArcGIS Recommended Settings

The RBI Spatial Analysis toolbox runs in ArcGIS (ArcMap or ArcCatalog). Background geoprocessing should be disabled to help ensure proper functioning. To do this, access the *Geoprocessing Options* window by clicking *Geoprocessing > Geoprocessing Options* on the *Standard* toolbar. In the *Background Processing* section uncheck *Enable*. In the *General* section, *Overwrite the outputs of geoprocessing operations*, may be unchecked, but be aware the toolbox overrides this setting. See the Output description in the Data Requirements section for ways to avoid overwriting pre-existing files. For more information on these two geoprocessing settings see:

http://desktop.arcgis.com/en/arcmap/10.3/analyze/executing-tools/using-geoprocessing-options-to-control-tool-execution.htm

Using the Toolbox:

The toolbox is set up to assess five benefits (Reduced Flood Risk, Scenic Views, Environmental Education, Recreation, and Bird Watching) mainly using the Full Indicator Assessment Tool. "Part" tools are also available to help with acquiring input data (e.g., Part – Flood Data Download Tool helps download NHDPlus data), to run individual benefits assessments with added options (e.g., Part – Benefit Reliability Tool has the added option to specify the buffer used) or to perform specific functions on the assessment result data tables (e.g., Part – Report Generation Tool generates a PDF report from the results data table, and the Part – Presence/Absence to Yes/No Tool fills in existing fields in the results data table as "Yes" or "No" based on features of interest being within a specified range of each site).

This *Using the Toolbox* section has two parts. The first part of this section, Data Requirements, describes the datasets used for assessment of each benefit including the defaults used in the Full Indicator Assessment Tool. Descriptions can also be found in the Tool Help for each parameter field. The second part of this section describes running each of the seven tools.

Data Requirements

Required Data

> ***Restoration Site Polygons*** – The restoration site area 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 dataset will be copied to the output. 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 output file folder location is also used to save intermediate files. If a file saved in the specified location shares a name with any intermediate it is 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. The suggested source is the state E-991 address data. Grid format representations of population should be entered as Population Raster. The suggested source for the conterminous United States is the EnviroAtlas - Dasymetric Population dataset: 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 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. People and structures in areas that flood (defined by Flood Zone Polygons), are downstream (defined using Catchments), and within range (within 2.5 miles of site) may receive benefits. Tools are designed to determine downstream areas using the NHDPlus files downloaded with the toolset. Before these files can be used, they must be populated using the Part – Flood Data Download Tool. The Full Indicator Assessment Tool assumes NHDPlus files have been saved to a default location relative to the toolbox file (~NHDPlusV21\NHDPlus_Downloads.gdb). If these data are not in the default location or alternative datasets are used, they must be specified using the Part – Flood Risk Reduction Tool.

For each site, determining the area potentially receiving benefits starts with catchments within 2.5 miles of the site. These catchments are then subset to only those downstream of the catchment(s) containing the site. This relationship is determined using Catchment Join Field values, where a row in the Flow Table has a "FROMCOMID" field value for the upstream catchment and a "TOCOMID" field value for the downstream catchment. As downstream catchments are added to the subset their downstream catchments are added as well. However, only the initial catchments are considered, meaning once a catchment falls completely outside 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. Since the stream network may curve and loop around within 2.5 miles of the site, the stream network included often exceeds 2.5 miles. Both Dams/Levees and Wetlands are features that may also reduce flood risk. Only downstream Dams/Levees are counted. All wetlands within a 2.5-mile range are considered.

Table 1 Optional inputs for assessing Reduced Flood Risk Benefits. Default datasets are in ~NHDPlus_Downloads.gdb

Parameter	Explanation	Data Type	Suggested Source
Flood Zone Polygons	Polygons that define flood zones (e.g. 100-yr or 500-yr) where flooding occurs	Feature Layer	FEMA, and/or NOAA
Dams/Levees	Point, line or polygon dataset defining flood prevention infrastructure	Feature Layer	USGS NHDPlus, and/or FEMA
Wetland Polygons	Polygons that define existing wetlands	Feature Layer	National Wetlands Inventory (NWI)
Catchments	Polygons that define catchments around the restoration sites	Feature Layer	Default: Catchment
Catchment Join Field	Field in the specified Catchment file that corresponds to a COMID field in the Flow Table	Field	Default: "FEATUREID"
Flow Table	Table with "FROMCOMID" and "TOCOMID" fields corresponding to the specified Catchment Join Field.	Table	Default: PlusFlow

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. Existing wetland features are considered substitutes that may already benefit people. However, other types of greenspace, defined using the Landuse/Greenspace dataset, are complements where greater landscape variety increases a view's value. The user has the flexibility to choose what field and values represent value adding greenspace in the Landuse/Greenspace dataset.

Table 2 Optional inputs for assessing Scenic View Benefits.

Parameter	Explanation	Data Type	Suggested Source
Trails (hiking, biking, etc.)	Point, line or polygon dataset that defines trails where people may access benefits	Feature Layer	NPS, state agencies, and/or NGOs
Roads (streets highways, etc.)	Point, line or polygon dataset that defines roads where people may access benefits	Feature Layer	Tiger, E911 and/or OpenStreetMap
Wetland Polygons	Polygons that define existing wetlands	Feature Layer	National Wetlands Inventory (NWI)
Landuse/Greenspace Polygons	Polygons that define landuse or greenspace	Feature Layer	State agencies, and/or NOAA
Greenspace Field	Field categorizing landuse types	Field	User specified
Greenspace Field Values	Values in the field which are greenspace	Values	User specified

Environmental Education – Environmental education benefits are the only benefits 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. Existing wetland features, the Wetland Polygons dataset, are considered substitutes that may already benefit people.

Table 3 Optional inputs for assessing Environmental Education Benefits.

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	Polygons that define 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. Existing wetland 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.

Table 4 Optional inputs for assessing Recreation Benefits

Parameter	Explanation	Data Type	Suggested Source
Trails (hiking, biking, etc.)	Point, line or polygon dataset that defines trails where people may access benefits	Feature Layer	NPS, state agencies, and/or NGOs
Bus Stops	Point, line or polygon dataset that defines bus stops where people may access benefits	Feature Layer	State agencies or OpenStreetMap
Wetland Polygons	Polygons that define existing wetlands	Feature Layer	National Wetlands Inventory (NWI)
Landuse/Greenspace Polygons	Polygons that define landuse or greenspace	Feature Layer	State agencies, and/or NOAA
Greenspace Field	Field categorizing landuse types	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 outward to surrounding areas where people can see them. Bird Watching benefits can be received in the area surrounding a site by residents (Population Dataset) or by people moving through on trails or roads (Trails and Roads Dataset).

Table 5 Optional inputs for assessing Bird Watching Benefits.

Parameter	Explanation	Data Type	Suggested Source
Trails (hiking, biking, etc.)	Point, line or polygon dataset that defines trails where people may access benefits	Feature Layer	NPS, state agencies, and/or NGOs
Roads (streets highways, etc.)	Point, line or polygon dataset that defines roads where people may access benefits	Feature Layer	Tiger, E911 and/or OpenStreetMap

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. The default Buffer Distance considered in the Full Indicator Assessment Tool varies depending on the benefits being assessed. If no benefit is selected the default is 2.5 miles; then the farther people are able to receive one of the selected benefits the farther the default Buffer Distance. The default Buffer Distance for Scenic Views is 100 meters, for Bird Watching it is 0.2 miles, for Environmental Education it is 0.25 miles, for Recreation it is 0.33 miles, and for Flood Risk Reduction it is 2.5 miles.

Table 6 Optional inputs for assessing the social equity of benefits.

Parameter	Explanation	Data Type	Suggested Source
Social Vulnerability	Polygon dataset defining the social vulnerability of different areas	Feature Layer	Social Vulnerability Index (NOAA, CDC or census)
Vulnerability Field	Field categorizing vulnerability	Field	User specified
Vulnerable Field Values	Values in the field which are vulnerable	Values	User specified
Buffer Distance	Buffer distance around the restoration site that will be considered to determine the social equity of benefits delivery from each site	Distance	Variable 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. Many factors can influence how long a site will persist; here we suggest using conservation protections on the site and immediate area as an indicator. The default Buffer Distance for the immediate area is 500 feet.

Table 7 Optional inputs for assessing the reliability of benefits.

Parameter	Explanation	Data Type	Suggested Source
Conservation Lands	Polygon dataset defining areas to be conserved or otherwise protected against future threats and development	Feature Layer	State planning organizations
Conservation Field	Field categorizing conservation areas	Field	User specified
Conservation Types	Values in the field which are protected	Values	User specified
Buffer Distance	Distance around the restoration site that will be considered to determine the reliability of benefits from each site	Distance	500 feet

Generic Tool Functionality

Tools in the RBI Spatial Analysis Tools Toolbox execute in the same way as other ArcGIS tools:
http://desktop.arcgis.com/en/arcmap/latest/analyze/executing-tools/a-quick-tour-of-tool-dialogs.htm

Datasets (feature layer selections, features in a geodatabase or shapefiles) are added by dragging and dropping a layer into the fillable space, typing in the file name or by navigating the tool to the dataset using the corresponding browse icon to the right (Figure 6). After a dataset is specified, a user may need to select a field in that dataset using a drop down list of the available fields. After a field is specified, a user may need to select values in that field using check boxes. When the complete toolset is downloaded (see Help Files in Components of the Toolset) all tools have a *Show Help>>>* button that opens help guidance on the tool and parameters (1). Tools do not have html reference pages (accessed by Clicking *Tool Help* when *Show Help>>>* is open). Spatial outputs (2) are saved as either a shapefile or feature class in a geodatabase.

Full Indicator Assessment Tool

The Full Indicator Assessment Tool is used for the bulk of the benefits assessment (Figure 6). This tool streamlines the analysis, allowing datasets entered once to be used as input for multiple processes/benefits (see Data Requirements for each benefit) and assuming certain default files are available (Table 8).

Restoration Site Polygons (3) and an Output (2) are required for the tool to run. The output table contains several fields that may help when interpreting results (Table 9) in addition to the fields that correspond to RBI indicators (Table 10). Either Address Points or a Population Raster (4) are required to run the analysis, and once one is entered the other will become gray and non-fillable. To reverse this, delete the entry.

Check boxes are clicked to select which benefits will be assessed (Reduced Flood Risk, Scenic Views, Environmental Education, Bird Watching, Recreation) and if additional site metrics (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 the data requirements of your desired analysis. When optional datasets or default files are missing the tool will execute, but it will skip metrics requiring those inputs.

The Landuse/Greenspace, Social Vulnerability, and Conservation Lands datasets each require a field and relevant values in that field to be specified. This increases flexibility and limits pre-processing by allowing the user to specify a subset of the dataset for use. For example, the tool only uses greenspace features from the Landuse/Greenspace dataset, but most landuse
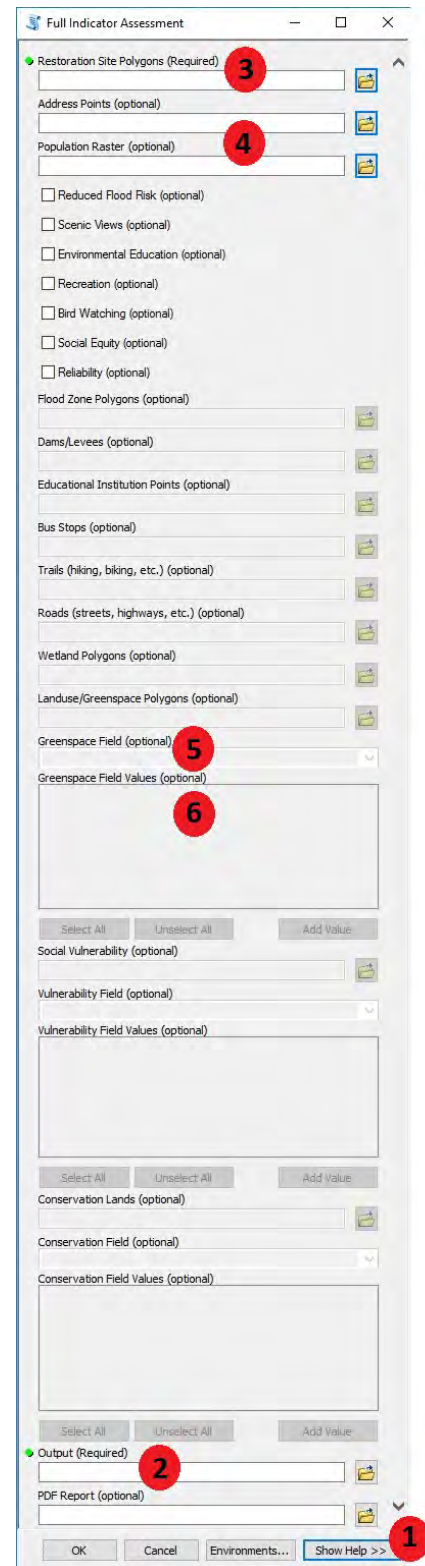

Figure 6 Full Indicator Assessment Tool.

datasets include non-greenspace features (e.g. residential). The user selects a (5) Greenspace Field within the dataset and checks the (6) Greenspace Field Values within that field that are classified as greenspace (e.g., forested).

An optional PDF file report is generated from fields in the Output table (Table 10) when a PDF Report file name is specified. The layout of the PDF report is based on a Mapfile (report_layout.mxd) with the report layout in it that is downloaded as part of the toolset to the same file directory as the toolbox (see Mapfile in Components of the Toolset). An example PDF report page that results from using the default layout is shown in Figure 12 of the section on the Report Generation Tool.

Table 8 Full Indicator Assessment Tool Defaults. These defaults can be changed in Part tools that correspond to each benefit/function.

Benefit	Parameter	Default
Benefit Reliability	Buffer Distance	Variable (0.25-2.5 miles)
Flood Risk	NHDPlus Catchments	~NHDPlusV21\NHDPlus_Downloads.gdb\Catchment
Flood Risk	NHDPlus Join Field	"FEATUREID"
Flood Risk	NHDPlus Flow Table	~NHDPlusV21\NHDPlus_Downloads.gdb\PlusFlow
Social Equity	Buffer Distance	500 ft.
PDF Report	.mxd format file	~py_Spatial\report_layout.mxd

Table 9 Field names in the output table results that are 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
vulnerability values	Percent area around site which is features in the social vulnerability layer that aren't selected for the "Vul_High" indicator field. If there are no more than six unique values each is captured in a new field named using the value.
Threatene	Percent area around site which is features in the conservation lands layer that aren't selected for the "conserved" indicator field. The new field is named "Threatene" due to a nine-character field name limitation.

Table 10 Indicator field names in the output table results.

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

Part - Benefit Reliability Tool

The Benefit Reliability Tool calculates the reliability of site benefits in the same way as the Full Indicator Assessment Tool. The difference is this tool has an added Buffer Distance parameter (Figure 7). Using this parameter, the user can alter the buffer distance around the restoration site that will be considered to determine the reliability of benefits from each site. The default used in the Full Indicator Assessment is 500 feet.
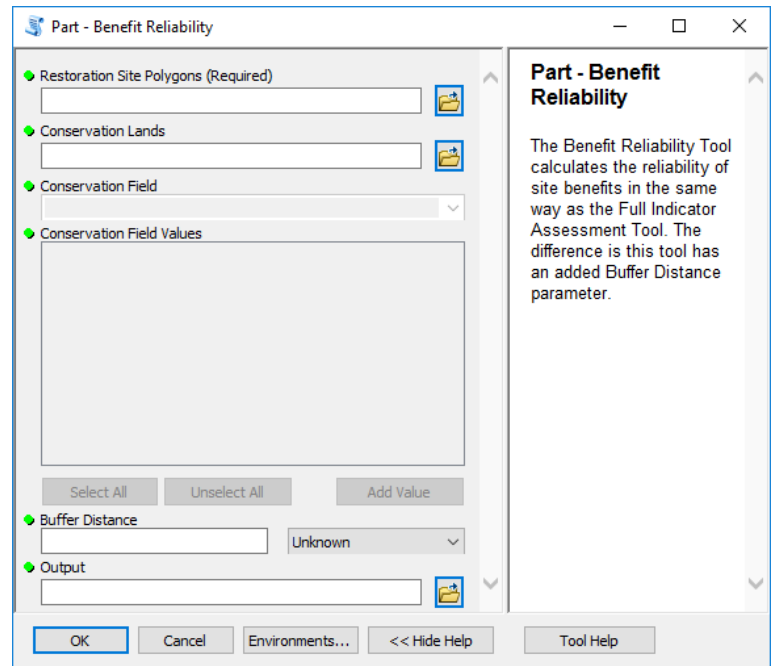

Figure 7 Part – Benefit Reliability Tool. This tool calculates the reliability of site benefits

Part – Flood Data Download Tool

The Flood Data Download Tool downloads the NHDPlus data needed to assess Flood Risk Reduction Benefits for the users' Restoration Site Polygons (Figure 8). The NHDPlus Vector Processing Unit polygons define the NHDPlus regions where data is available. These are compared to the Restoration Site Polygons to determine the name and web location of needed NHDPlus files. If no dataset is specified, the tool will default to using the

Figure 8 Part – Flood Data Download Tool. This tool downloads NHDPlus data based on the users' restoration sites.

~\NHDPlus_Downloads.gdb\BoundaryUnit file downloaded as part of the toolset (see NHDPlus files in Components of the Toolset). If no dataset is specified and the default dataset is not in the expected location this tool will fail to run. The Download Folder is where the tool will download NHDPlus .7z data files. If left blank, the default is within the Spatial Analysis Toolset NHDPlusV21 folder ~\Rapid-Benefit-Indicators-Tools\py_Spatial\NHDPlusV21. Once downloaded, WinZip is used to unzip the files to the Download Folder (see Common Errors). The Part - Flood Data Download Tool then merges the newly downloaded data into existing "Catchment" or "PlusFlow" files in a file geodatabase in the Download Folder (example default is ~\NHDPlusV21\NHDPlus_Downloads.gdb\Catchment). If a non-default Download Folder is specified, or the download is not merged with the expected files, the Part - Flood Risk Reduction Tool must be used for Flood Risk Reduction Benefit analysis instead of the Full Indicator Assessment tool. The downloaded dataset is merged to ensure that files are in the expected location even when the scope of the assessment overlaps multiple NHDPlus unit boundary polygons. Alternatively, NHDPlus data can be downloaded manually from: http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php
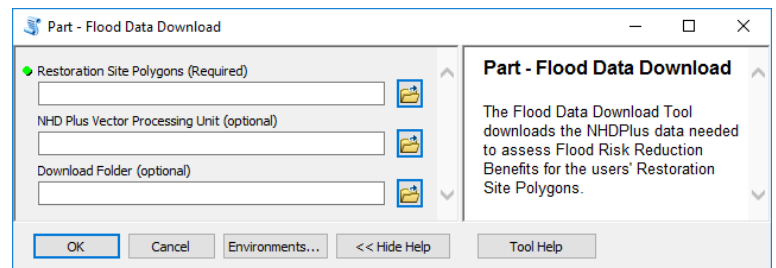
Part – Flood Risk Reduction Tool

The Flood Risk Reduction Tool calculates indicator metrics for flood risk reduction benefits in the same way as the Full Indicator Assessment Tool, but with added Catchment, Catchment Join Field and Flow Table parameters (Figure 9). These parameters are useful when different hydrologic data is being used or data have been saved in non-default locations. The Catchment parameter is the polygons that define catchments around the restoration sites. If left blank, the tool default is the NHDPlus Catchment file downloaded as part of the toolset and populated by the Part – Flood Data Download Tool, ~\Rapid-Benefit-Indicators-Tools\ py_Spatial\NHDPlusV21\ NHDPlus_Downloads.gdb\Catchment. The Catchment Join Field is the field in the specified Catchment file that corresponds to a COMID field in the Flow Table. If left blank, the tool default field is "FEATUREID." The Flow Table stores the upstream/downstream relations for the catchments. The table must have "FROMCOMID" and "TOCOMID" fields corresponding to the specified Catchment Join Field. If left blank, the tool default is the flow table downloaded as part of the toolset and populated by the Part – Flood Data Download Tool ~\Rapid-Benefit-Indicators-Tools\py_Spatial\NHDPlusV21\ NHDPlus_Downloads.gdb\PlusFlow.
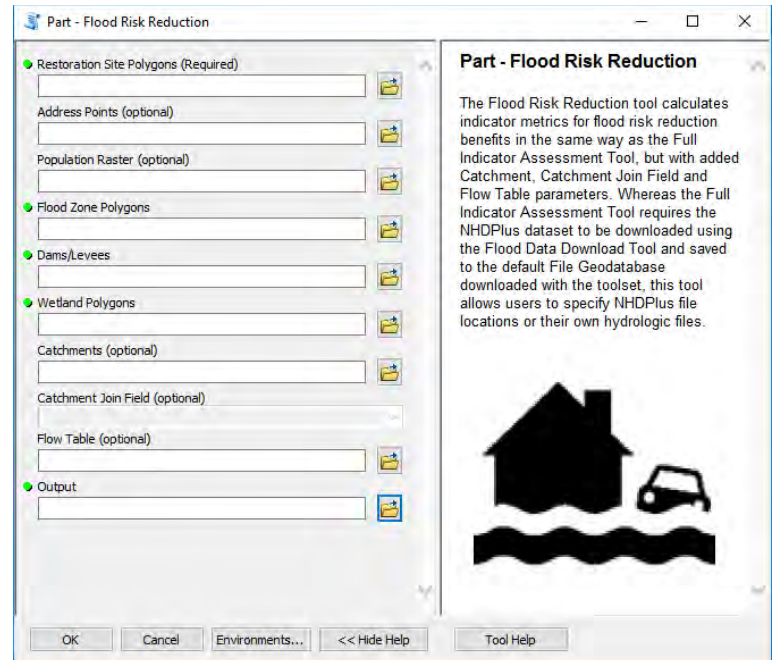
Figure 9 Part – Flood Risk Reduction Tool. This tool is used to assess Flood Risk Reduction benefits using catchment and flow data.

Part – Presence/Absence to Yes/No Tool

The Presence/Absence to Yes/No Tool parameterizes a specified indicator field as "Yes" based on the presence of at least one feature from a Features of Interest dataset occurring within a specified Buffer Distance of each Restoration Site Polygon. Sites without a feature within that distance are parameterized as "No" (Figure 10). There are several indicators that are measured as Yes or No (see Table 11), and although the Full Indicator Assessment Tool creates these fields it is not able to populate them. The Presence/Absence to Yes/No Tool is designed to be run after the Full Indicator Assessment Tool to assign metrics to these indicators. The Field Name is a field from the Restoration Site Polygons dataset that will be updated with Yes/No results of the tool. The recommendation is to run the Full Indicator Assessment Tool first and then to use the output dataset from that as the Restoration Site Polygons. All the fields in Table 11 can be populated using the Presence/Absence to Yes/No Tool. Use caution when selecting a field to populate as any previous values will be overwritten.
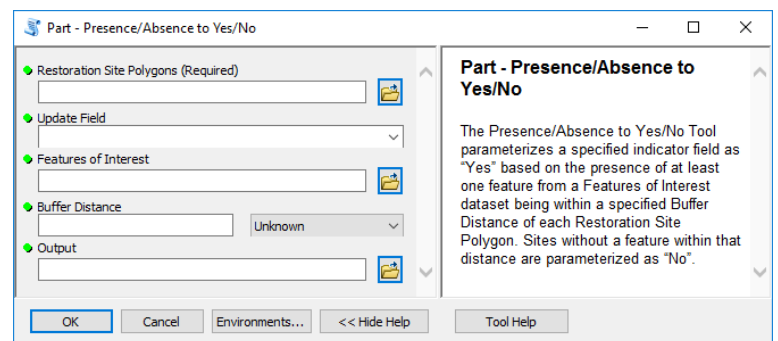
Figure 10 Part – Presence/Absence to Yes/No Tool. This tool is used to assess if any features in a specified dataset are within a specified range of each site.

Features of interest are the vector dataset containing features of interest to compare to restoration sites. If any feature in this dataset intersects the specified area around the site (Buffer Distance) the field value for that site will be Yes, otherwise it will be No. The Buffer Distance is the distance and units for the area around each site to search for intersecting features.

Although the Full Indicator Assessment Tool uses the same functionality as the Presence/Absence to Yes/No tool that functionality is not directly accessible. For example, for recreation benefits, this same functionality is used to determine if there are Features, bike paths, within a Buffer Distance, 1/3 miles, of each restoration site. If the bike paths dataset passes within the 1/3 mile-buffer around a site the Field "R_2_03_tb" gets a "YES", otherwise it gets a "NO."

Table 11 Field names in the results table that correspond 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 Tool

The Report Generation Tool creates a PDF Report from the Results Table the same way the Full Indicator Assessment Tool uses its Output table. The difference is this tool has added Mapfile (.mxd) and Site Name Field parameters (Figure 11).
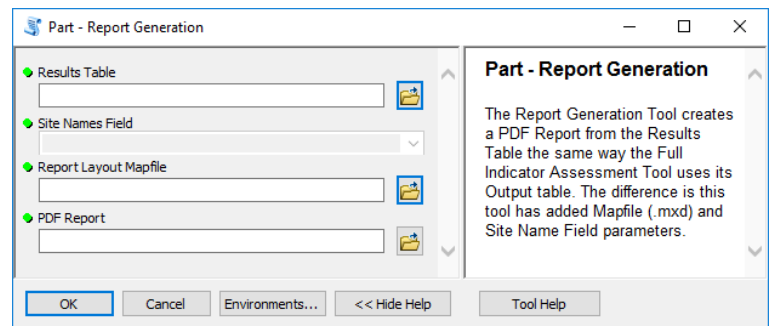
Figure 11 Part – Report Generation. This tool is used to create a formatted summary PDF report of indicator results.

The Results Table is the Output table with all desired indicators. The Site Names Field is a field in the Results Table that contains site names for the report. The Report Layout Mapfile is an .mxd file with the report layout in it. The default is downloaded as part of the toolset to the same file directory as the toolbox and saved as "report_layout.mxd" (see Mapfile in Components of the Toolset). The PDF Report is the file name that will be used to save the PDF Report. An example PDF report page that results from using the default layout is shown in Figure 12. The site names for this dataset were the OBJECTID, "2" and "5."

Step 4	Summarize the Indicators		Site	
Benefit		**Indicators**	Site 1 2	Site 2 5
Flood Risk	3.2 How Many Benefit?	2.5 mi downstream of site and in flood zone	86	135
	3.3.A Service Quality	Area of restoration site (acres)	1.36	0.58
		Features that increase retention volume?		
	3.3.B Scarcity	Dams and levees 2.5 mi downstream?	Yes	Yes
		Wetlands within 5 mi (number or % area)	9.92	10.44
	3.3.C Complements	NA	NA	NA
	3.3.D Preferences	Are people worried about flood risk?		
Scenic Views	3.2 How Many Benefit?	Number within 160 ft of site	2.0	2.0
		Number within 325 ft of site	7.0	11
		Weighted number who benefit	3.5	4.7
		Are there roads or trails within 325 ft of site?	Yes	Yes
	3.3.A Service Quality	Aesthetic features or characteristics?		
	3.3.B Scarcity	Wetlands or water within 650 ft (number or %)	9.5	6.8
	3.3.C Complements	Natural land use types within 650 ft (types)	3.0	3.0
	3.3.D Preferences	Will people find it aesthetically pleasing?		
Environmental Education	3.2 How Many Benefit?	Education institutions within 0.25 mi of site	0	0
	3.3.A Service Quality	Features/habitat/wildlife of education interest?		
	3.3.B Scarcity	Wetlands within 0.5 mi of the site	7.7	5.4
	3.3.C Complements	Educational facilities or infrastructure on site?		
	3.3.D Preferences	Will people prefer characteristics of the site?		
Recreation	3.2 How Many Benefit?	Number within 1/3 mi of the site	360	372
		Are there bike paths within 1/3 mi of site?	Yes	No
		Are there bus stops within 1/3 mi of site?	Yes	Yes
		Number within 0 to 0.5 mi of site	274	350
		Number within 0.5 to 6 mi of site	85,118	91,459
	3.3.A Service Quality	Total area of green space around site	1,215	1,214
	3.3.B Scarcity	Green space within 2/3 mi of site	46.6	50.7
		Green space within 1 mi of site	51.9	51.5
		Green space within 12 mi of site	42.3	42.8
	3.3.C Complements	Infrastructure supporting recreational activities?		
	3.3.D Preferences	Are there additional features on the site?		
Bird Watching	3.2 How Many Benefit?	Number within 0.2 mi of site	169	98
		Will the site support rare or unique species?	No	No
	3.3.A Service Quality	Will the site support rare or unique species?		
	3.3.B Scarcity	NA	NA	NA
	3.3.C Complements	Supporting infrastructure or habitat on site?		
	3.3.D Preferences	Will people be interested in birds at the site?		
	3.4 Social Equity	Score	11.94	11.24
	3.5 Reliability	Score	19.82	20.93

BLACK = No entry; GRAY = NA; BLUE = Above Average/Yes; RED = Below Average/No (reverse for scarcity)

Figure 12 Example PDF report output page. In this example the values in the Site Names Field were "2" and "5". Values that are better than average are in blue, which for scarcity metrics means these values are lower. When viewing results realize that the averages used for color coding are from all pages of the report.

Part – Social Equity of Benefits Tool

The Social Equity of Benefits Tool calculates the social equity of site benefits in the same way as the Full Indicator Assessment Tool. The difference is this tool has an added Buffer Distance parameter (Figure 13). Using this parameter, the user can alter the buffer distance around the restoration site that will be considered to determine the social equity of benefits delivery from each site. The distance from which people are able to receive benefits depends on the benefit. Because of this the default distance in the full tool varies based on the benefits assessed. The default is the largest reasonable distance someone receiving one of the selected benefits could be from the site and still receive benefits. For Scenic Views it is 100 meters, for Bird Watching it is 0.2 miles, for Environmental Education it is 0.25 miles, for Recreation it is 0.33 miles, for Flood Risk Reduction it is 2.5 miles, and if no benefits are selected it is 2.5 miles.
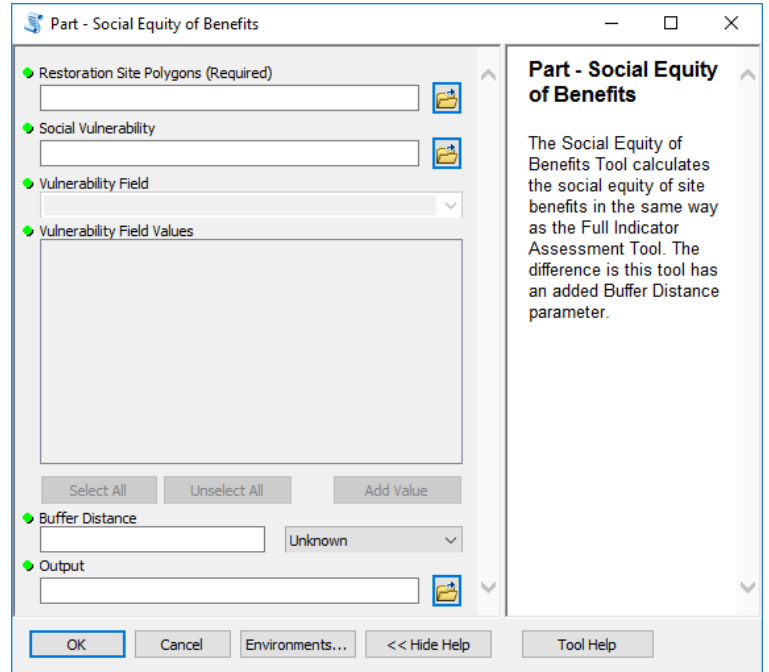

Figure 13 Part – Social Equity of Benefits. This tool is used to assess the social vulnerability of those benefitting to identify social equity issues.

Example Workflows:

Complete assessment with no blank indicators on the report and utilizing defaults as much as possible:

1. Download NHDPlus Data using the Flood Data Download Tool.
   Parameters: Restoration Site Polygons is the only required dataset.

2. Assess all five benefits, and the reliability and social equity of those benefits using the Full Indicator Assessment Tool.
   Parameters: All parameters should be filled in (see Data Requirements for information on these parameters) except PDF Report. Remember the Output file and location.

3. For each of the seven blank fields in the Output (Table 11) run the Presence/Absence to Yes/No Tool
   Parameters: Use the Output file from the Full Indicator Assessment (Step 2) for Restoration Site Polygons when populating the first field. Each subsequent time using the tool, use the Output file produced from populating the previous field as the Restoration Site Polygons (i.e. Output from Run 2 as input to Run 3, Output from Run 3 as input to Run 4, etc.). Look at the Rapid Benefit Indicator Approach Guide for example Buffer Distances and Feature datasets as these tend to be based more on local characteristics.

4. Produce a PDF report using the Report Generation Tool.
   Parameters: use the Output from the last run of the Presence/Absence to Yes/No Tool (Step 3).

Complete assessment with no blank indicators on the report and utilizing NHDPlus data manually downloaded to a non-default directory:

1. Assess Reduced Flood Risk benefits using the Flood Risk Reduction Tool.
   Parameters: datasets are the same as those used in the Full Indicator Assessment Tool (see Data Requirements) except the Catchment, Catchment Join Field and Flow Table must all be set according to where these files were downloaded.

2. Continue complete assessment starting with Step 2 above, but do not check Reduced Flood Risk
   Parameters: leave Reduced Flood Risk unchecked. Use the Output from Step 1 as the Restoration Site Polygons.

Running Benefit Reliability with a 500-m buffer area after having previously run a Full Indicator Assessment, including reliability of benefits based on the default 500 feet:

1. Assess reliability of benefits using the Benefit Reliability Tool.
   Parameters: Use the Output from the previous Full Indicator Assessment as the Restoration Site Polygons. Be sure to specify 500 and Meters as the Buffer Distance. The previous values for percent area conserved and threatened (polygons from the Conserved Lands dataset not checked as Conservation Values) will be overwritten with the new results.

Running Social Equity of Benefits with a 1-mile buffer area before running a Full Indicator Assessment:

1. Assess reliability of benefits using the Social Equity of Benefits Tool.
   Parameters: Use original Restoration Site Polygons and specify a Buffer Distance of 1 and Miles.

2. Continue analysis (i.e. Full Indicator Assessment Tool).
   Parameters: Use Output from Step 1 as Restoration Site Polygons in subsequent steps. Do not check Social Equity in the Full Indicator Assessment Tool or results of Step 1 will be overwritten.

Frequently Asked Questions:

Do I have to know GIS to run the RBI Spatial Analysis Tools?

It is not mandatory to have a high level of GIS training to begin working with the tool, but a basic familiarity with ArcGIS may help avoid more common mistakes.

At what scales can the tool be applied?

The tool was initially designed to be used to compare wetland restoration sites within the same watershed. The rapid nature of the indicators allows for differences between watersheds to be lost, so although the tool may function on larger scales the analyst should be cautious when comparing those results.

How many sites will the tool run at once?

The tool is set up to run on one or more sites. The PDF Report requires at least two sites for proper color coding since it is based on an average value of all sites. The maximum number of sites is only limited by the ArcGIS desktop capabilities and the run time required for processing.

How long will it take to perform the assessment?

There are many factors that influence the length of time the assessment takes. Usually assembling and pre-processing the datasets to run in the assessment tool is the most time consuming step. Run time for the tool varies depending on the size of analysis, size of input datasets and specifications of the computer system being used. Some pre-processing of input datasets, including re-projecting all inputs to one uniform projection and clipping datasets to only the required extents, may help speed up the tool processing time.

Do I need an internet connection to run the RBI Spatial Analysis Tools?

An internet connection is required to initially download the toolset and to download NHDPlus data using the Part – Flood Data Download Tool, but this data is only required to assess flood risk reduction benefits and only has to be downloaded once.

Do I need the spatial analyst extension?

The spatial analyst extension is only required if using a population raster dataset. Make sure the extension is enabled (*Customize>Extensions*) if using this functionality.

What radius around the site does the Full Indicator Assessment Tool use for reliability of benefits?

The Full Indicator Assessment Tool uses a default Buffer Distance of 500 feet.

What radius does the Full Indicator Assessment Tool use for social equity of benefits?

The default distance (also used for Buffer Distance if the parameter is not specified in the Part – Social Equity of Benefits Tool) is determined based on the selected Benefits being assessed. When a benefit with longer delivery pathways is assessed the Buffer Distance used is farther. For Scenic Views it is 100 meters, for Bird Watching it is 0.2 miles, for Environmental Education it is 0.25 miles, for Recreation it is 0.33 miles, for Flood Risk Reduction it is 2.5 miles, and if no benefits are selected it is 2.5 miles.

I am running an assessment of coastal sites, what happens when the coast is within 2.5 miles downstream?

Coastal wetlands may require some special considerations since people interact with them in different ways. However, in the NHDPlus data coastal catchments are often connected as upstream/downstream from one another. Although this means people in some neighboring coastal catchments may be included as benefitting from the wetland this is limited by the 2.5 miles ensuring the entire coastline will not be included.

I ran the Flood Data Download tool without optional inputs, where did the files I downloaded go?

When the tool is downloaded as part of the Toolset as recommended, several files are downloaded in a geodatabase in a NHDPlus Folder in the same directory as the toolbox file. Files are downloaded and unzipped to the NHDPlus Folder, but these files are deleted after being merged into the geodatabase.

I am running an assessment again on the same sites, do I need to download the NHDPlus Data?

NHDPlus data only has to be downloaded for a region once. If the data is downloaded a second time the entries will be duplicated but assessment results will not be impacted unless an updated version of the dataset has become available (see Solutions to Common Errors).

What if I don't have WinZip?

If WinZip is not installed in the expected location on your machine (C:\Program Files\WinZip) or is unable to be run from the command line (see Solutions to Common Errors) the Open Source 7-Zip can be used instead to manually unzip the NHDPlus files.

What units are indicators measured in?

In the report (Figure 12), units for the 20 quantitative indicators are dealt with in a variety of ways. Some indicators are labeled with their units (e.g., Natural land use types within 650ft are counted as the number of types). Areas are measured in acres (e.g., "Area of restoration site" is in acres). The majority (nine) of the quantitative indicators count the number of people who benefit (3.2 How Many Benefit?) using units defined by their dataset. Most of these are based either on an Address Points dataset that represents homes or other structures (i.e. the indicator is a count of homes), or on a Population Raster dataset that has grid cells representing the population count in that area (i.e. the indicator is a count of people). Six scarcity indicators (3.3.B Scarcity) are measured as a percent of the surrounding area (e.g., for "Wetlands within 0.5 mi of the site" the number is the percent of the area with 0.5 miles that is identified as existing wetlands). The Social Equity and Reliability of benefits is measured in a similar way, where the result is the percent of the area considered (i.e. within the default or user specified buffer) that met the user-specified criteria (e.g., Conservation Field Values for Reliability of Benefits). The units for the indicator assessment are left somewhat open so that users who are not using the Spatial Analysis Toolset can still collect the necessary information in a rapid manner. As long as the same units are used for the indicator at each site the indicator results will be comparable across sites.

Solutions to Common Errors:

Invalid archive

NHDPlus data files are periodically updated and given new version numbers. If an old version number is used the toolbox will not be able to download and unzip the catchment or flow table correctly and an error will occur when the toolbox tries to open the file (Figure 14). The toolbox is periodically updated with new version numbers so downloading a newer version may resolve the issue. Otherwise the file can be downloaded manually from: www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php
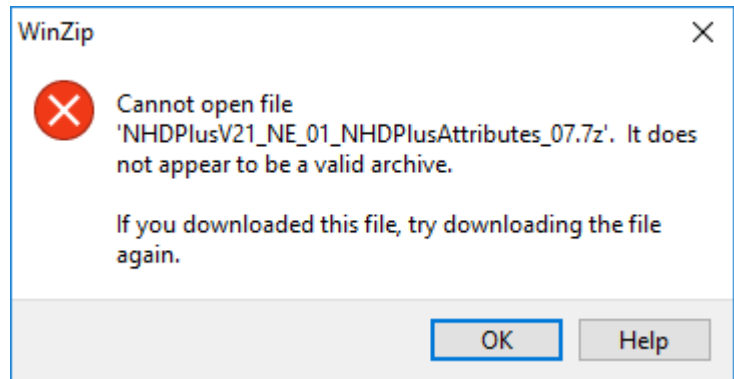
Figure 14 WinZip error pop-up that occurs when a downloaded NHDPlus file is invalid. This is often because a new version of that dataset has been released.

Winzip is unavailable or unable to unzip the downloads

If the Part – Flood Data Download Tool is able to download the data but unable to unzip the files you may not have WinZip installed in the expected location on your machine (C:\Program Files\WinZip) or the version may not be able to be run from the command line. Operating system patches available through regular updates may help resolve this issue. The files can alternatively be manually unzipped to the default folder. If WinZip is not available on your machine the free utility 7-Zip can be used instead to manually extract the NHDPlus files (www.7-zip.org/download.html).

The tool fails when generating a PDF Report

When either the Full Indicator Assessment Tool or the Part – Report Generation Tool is generating a PDF report it creates 1 page at a time and then adds that page to the rest of the report. After each page is added to the complete report it is deleted. This error will appear if the PDF file for the single page is unable to be deleted.
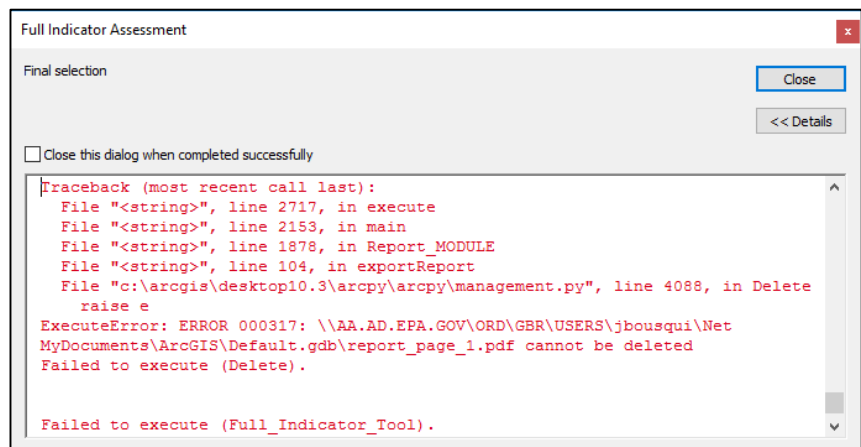

Figure 15 Tool Error Message that appears during PDF Report generation when an intermediate PDF page cannot be deleted

The tool doesn't produce Flood Risk Reduction Benefit Indicators or fails

Both the Full Indicator Assessment Tool (Figure 16) and the Part – Flood Risk Reduction Tool (Figure 17) start by checking the Catchment and Flow Table files. If these files do not pass checks for the Full Indicator Assessment Tool the flood risk reduction benefits are not assessed, but the tool continues analysis of the other benefits. In the Part – Flood Risk Reduction Tool if the files do not pass checks the tool will fail. For both tools first make sure the Part – Flood Data Download has already been run. Next check that the default files being used by the tool are correct and populated with the data that has been downloaded. If the files are in a non-default location use the Part – Flood Risk Reduction Tool to redirect the tool to these files. If the files still do not pass checks, try manually downloading the files.
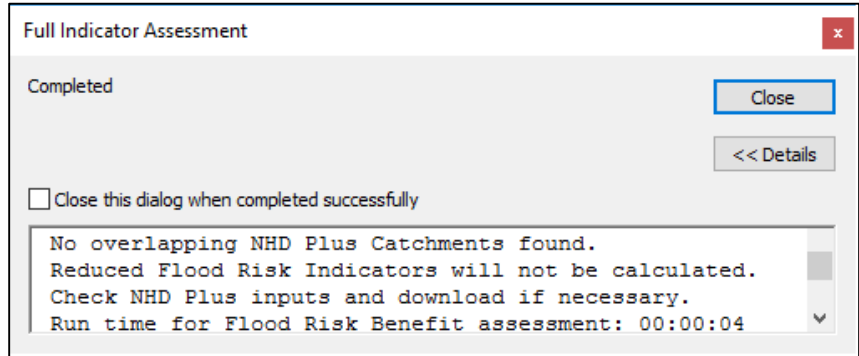

Figure 16 Message that appears when the Full Indicator Assessment Tool is unable to find the Catchment file in the default location.
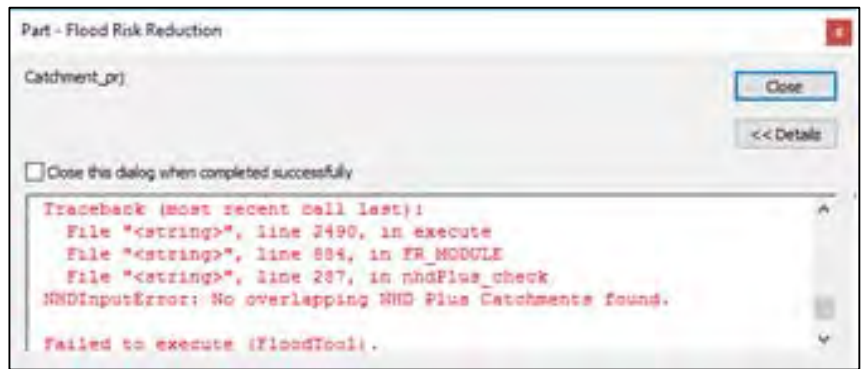

Figure 17 Tool Error Message that appears when the Part – Flood Risk Reduction Tool is unable to find the Catchment.