The Fish Passage Extension (FIPEX) for ArcGIS 10.x
User Manual

DISCLAIMER

Herein, the "AUTHORS" shall refer to any and all contributing authors to the Fish Passage Extension for ArcGIS™ (FIPEX) including but not limited to the individuals, organizations and institutions responsible for funding and development of this product.
Herein, the "SOFTWARE PRODUCT" refers to the Fish Passage Extension (FIPEX) "add-in" / extension for the ESRI™ ArcGIS™ Desktop™ Software Suite.
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Documentation created and updated:
Feb 11, 2014 by G. Oldford

Created by
Fisheries and Oceans Canada, Maritime Region, Habitat Management & Sustainable Development Division, 2007-2011

Additional Development
Parks Canada - DCI Integration and Upgrade from FIPEX version 2.3.x (for ArcGIS) 9.x to FiPEX version 10.x for (ArcGIS 10.x) – 2010-2012
Dalhousie University / NSERC / Nova Scotia Power Inc. / G. Oldford - Tool Refinement and Optimization Functionality – 2010 - 2014

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Preface

The extensive fragmentation of river systems due to damming, road construction, and other development is a problem that many governments, communities, and environmental groups are trying to solve. On the path to recovery of longitudinal connectivity (i.e., connectivity from headwaters to ocean / outflow) of river systems many questions arise, including:

How fragmented is a river system?
How much of the fragmentation is due to anthropogenic barriers?
How much does each barrier contribute to local fragmentation?
How much does each barrier contribute to system-wide fragmentation?
How much habitat will be restored or reconnected by a given project?
What kind of habitat will be made available?
How can limited funds be used most effectively?

River systems present unique challenges when attempting to assess the impacts of barriers and costs/benefits of habitat restoration and connectivity projects, making answering the above questions difficult, time consuming, or both. The Fish Passage Extension (FIPEX) is designed to help address these challenging questions. The toolset is designed as an integrated 'Add-in' to the Geographic Information System (GIS) software ArcGIS Desktop™ by ESRI™. It provides basic and advanced tools for assessing river systems with respect to their longitudinal connectivity and can assess individual and cumulative impacts of barriers to fish passage such as dams, weirs, and culverts. FIPEX can be differentiated from other toolsets for river / watershed network analysis in that it leverages the *geometric network* model provided with the ESRI ArcGIS Desktop™ suite.

FIPEX is made freely available courtesy of Fisheries and Oceans Canada and Parks Canada via the ESRI Code Gallery and www.thefishpassageextension.net (pending).

1. Timeline of Development

2007 - 2008

· Project initiated by Fisheries & Oceans Canada, Habitat Management (formerly Habitat Protection and Sustainable Development Division), Maritimes Region.

2009

· A sharealike[1] / attribution agreement is reached between Fisheries & Oceans Canada and Dalhousie University

2009

· Useability of toolset refined (funded by Fisheries & Oceans Canada)

2010

· A sharealike / attribution agreement is reached between Fisheries & Oceans Canada, Parks Canada, and Dalhousie University (Masters research of Greig Oldford).

· Funding contribution from National Science and Engineering Research Council of Canada (NSERC) for graduate research using FIPEX (G. Oldford).

· Nova Scotia Power Incorporated extends data sharing agreement for testing and refinement of toolset.

· Parks Canada funds further development.

· The DFO American Eel Decision Support Toolset is renamed the Fish Passage Extension (FIPEX).

2011

· Parks Canada funds further development.

· A Creative Commons Canada 2.5 (attribution) license is approved by Parks Canada and Fisheries and Oceans Canada.

· Free distribution of FIPEX software and source code over the web and via the ESRI Code Gallery is approved by Fisheries and Oceans Canada.

2012

· Parks Canada oversees upgrade of FIPEX to be compatible with ArcGIS 10.x, the integration of Dendritic Connectivity Index calculation, and refinement of system-level analyses.

· Logo redesign donated by Sebastian Harder (Sebazistan.com)

· Refinement of additional tools for river analysis by G. Oldford: 'distance to source', 'distance to sink', output table refinement (database normalization), options menu overhaul, 'visualize network' tool, code optimization and main algorithm overhaul.

· Standalone website created by G. Oldford, with server space donated by CVM Environmental Group Inc., to house documentation, installation files, and track usage and downloads (thefishpassageextension.net)

[1]Sharealike - all work shared freely between all parties involved; similar to Creative Commons terminology.

2. FIPEX overview

The Fish Passage Extension for ArcGIS (FIPEX) is a GIS toolset for assessing the effects of watercourse obstacles on the ability of fish to travel within a watershed, and the connectivity of a river system as a whole. The toolset was developed at Fisheries and Oceans Canada (Maritimes Region) by the Habitat Protection and Sustainable Development Division as a decision support tool to assist in the process of identifying sites where habitat restoration actions would provide the most benefit to eels and other fish species of concern.

FIPEX offers the ability to quantitatively assess the effects of real or anticipated barriers. The following main features are provided:

1. Summarize habitat quantity affected by one or many barriers, with *habitat affected* defined as one or all of:
    a) habitat immediately upstream of a barrier (until the next barrier or headwaters)
    b) habitat immediately downstream of a barrier (until the next barrier or headwaters)
    c) total habitat upstream of a barrier (ignoring all other barriers)
    d) total habitat downstream of a barrier (with the flow of the system, until the ocean / sink)
    e) total habitat downstream of a barrier (ignoring the flow of the system)
2. Define *habitat quantity* in one or many ways:
    a) As linear network (e.g., metres)
    b) As polygonal / area network (e.g., hectares)
    c) Including all features
    d) Excluding certain features (e.g., stillwater, wetland, lake 'spines')
3. Sub-categorize network using user-defined classes (e.g., lakes, river, wetland, urban area).
4. Exclude certain barriers (e.g., waterfalls) from analysis without a network rebuild.
5. Assess the contribution of one or many barriers to overall systemic connectivity using the Dendritic Connectivity Index (DCI).
6. Assess a whole watershed / river system for systemic connectivity using the Dendritic Connectivity Index (DCI).

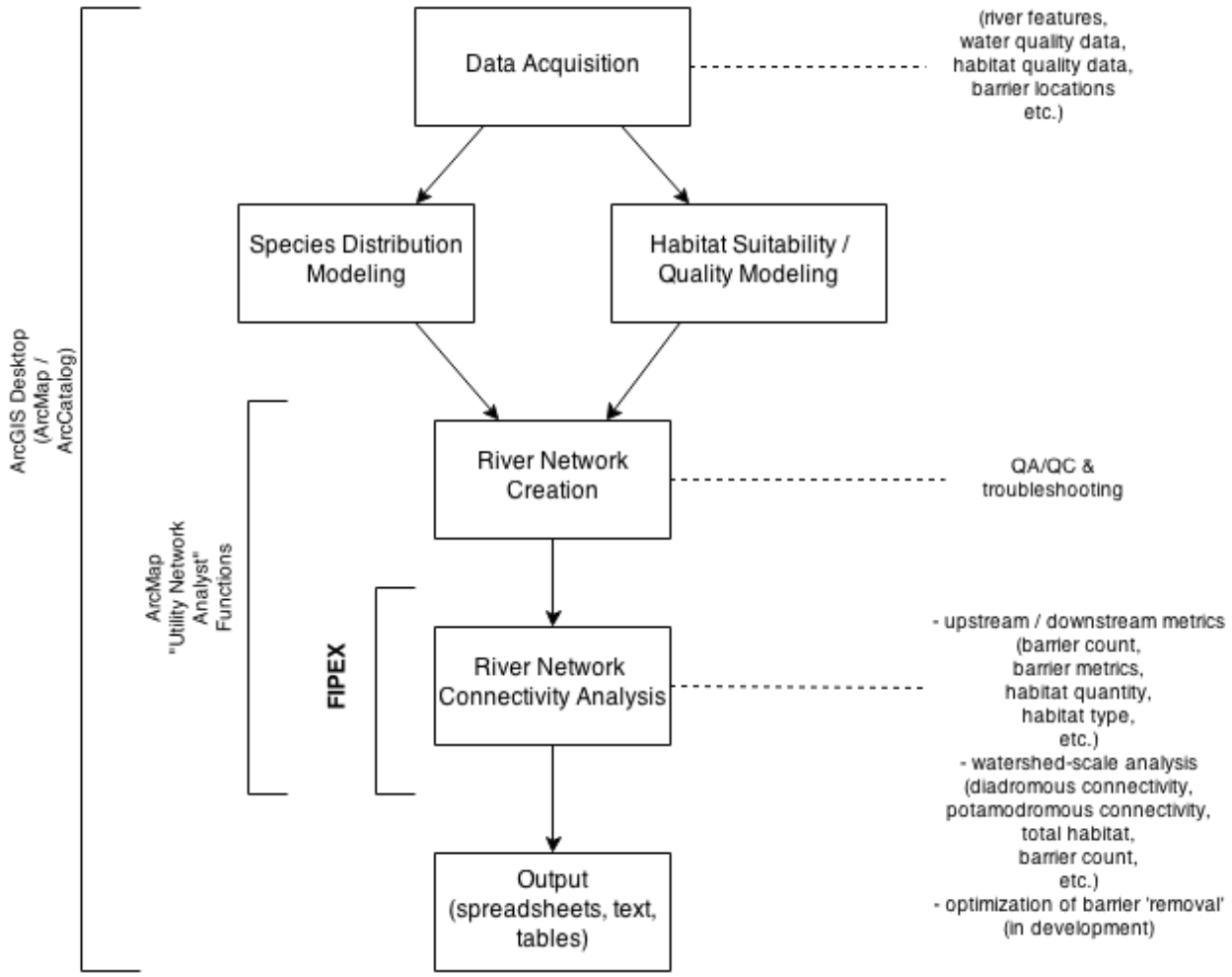

Figure 1: General Workflow Using FIPEX

Who is the Typical User of FIPEX?

Typically, the user of FIPEX is a GIS technician or GIS specialist familiar with the geometric network model (usage of the Utility Network Analyst toolbar).

The goal of FIPEX is to provide the everyday user with a decision support tool for fish passage and riverine connectivity assessment. However, as of version 10.1, FIPEX is suited for the intermediate to advanced user of ArcGIS™. After a river network is created, barriers are organized and labelled, quality assurance on the data is done, FIPEX is installed, options are set, and preliminary tests are done, a relatively unskilled user can conduct analyses using FIPEX. However, the flexibility offered by the toolset and advanced options such as coupling with the statistical software, 'R', mean that the typical user should have experience with ArcGIS and technical knowledge of windows-based software and operating systems.

3. The Geometric Network Model

FIPEX can be used with a hydrological dataset which is registered and modified as a *geometric network* by the ESRI ArcGIS™ program. As such, FIPEX requires the creation of a geometric network using the *Build Geometric Network Wizard* provided in the ArcCatalog™ program (a part of the ArcGIS Desktop™ suite). The geometric network is used for 'tree' or dendritic networks -- for example, water distribution, power distribution, or river networks. The *Utility Network Analyst Extension* / Toolbar is provided with the most basic ArcGIS Desktop™ license and contains many tools to perform simple tasks such as network tracing and connectivity troubleshooting. The geometric network model is *not* the same as the network model provided by ArcGIS™ for use with the *Network Analyst ™* extension which is used primarily for road network analysis and routing (an upgrade / add-in requiring an additional purchase from ESRI).

To create a geometric network requires a 'Standard' or 'Advanced' ArcGIS™ license:

> " Although geometric networks can be both created and edited in ArcGIS for Desktop Advanced andStandard, they are read-only in Basic." -- ESRI ArcGIS Resources Website, 2012

For more information on geometric network creation, editing, and troubleshooting:
http://resources.arcgis.com/en/help/main/10.1/index.html#//002r00000008000000
http://resources.arcgis.com/en/help/main/10.1/index.html#//00170000015t000000

4. Tool Installation

License

Prior to installation please read and accept the disclaimer and license. The FIPEX toolset is provided as is, where is (see DISCLAIMER). Code is provided under a Creative Commons Canada 2.5 (Attribution) License. For details of this license see http://creativecommons.org/licenses/by/2.5/ca/.

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> Fisheries and Oceans Canada (2011). The Fish Passage Extension for ArcGIS (FIPEX). Fisheries and Oceans Canada, Habitat Management, Maritimes Region.

Software Requirements

- Windows XP or Windows 7 Operating System (Windows Vista may work, but is untested)
- ArcGIS 10.x Desktop™ Installed (Standard level license preferred)
- The Microsoft .NET framework 3.5+ installed.

Hardware Requirements

- A PC Computer with 1Gb+ RAM
- 2.4Gb+ disk space (requirement for operation of ArcGIS)
- CPU Speed 2.2Ghz+

Prerequisites

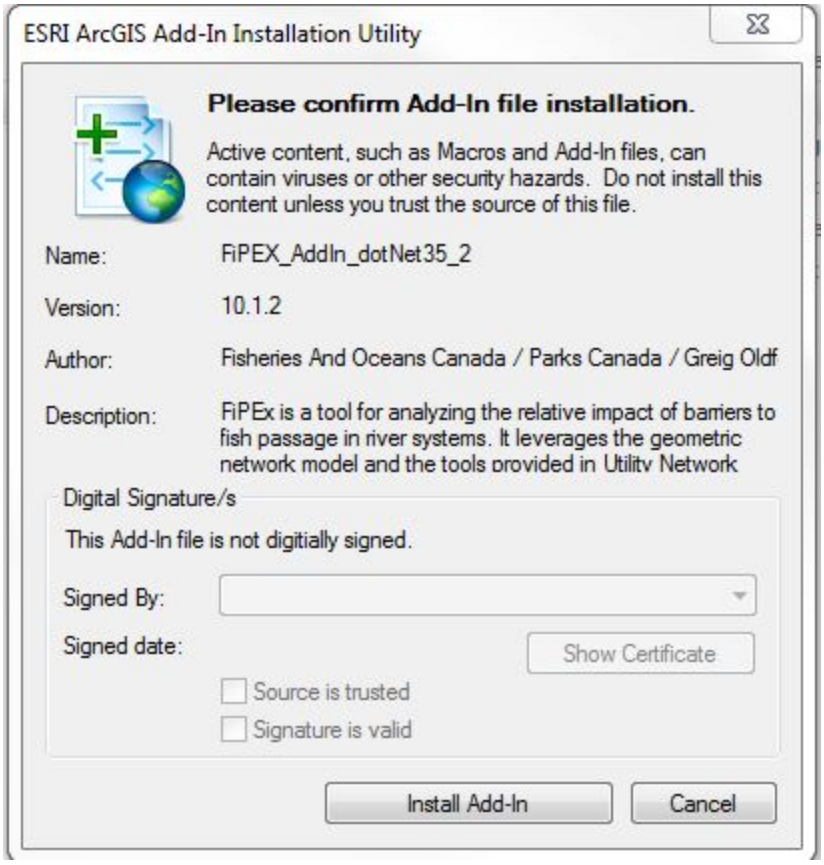
Prior to installation, ensure that the following requirements are met:

- ESRI™ ArcGIS™ 10.x is installed
- ArcMap™, ArcCatalog™ and all other ArcGIS™ products are not running.
- You have Administrator level privileges on your computer.

Installing FIPEX

(If there is a version of FIPEX already installed on your desktop computer, to remove previous version see Part 3.)

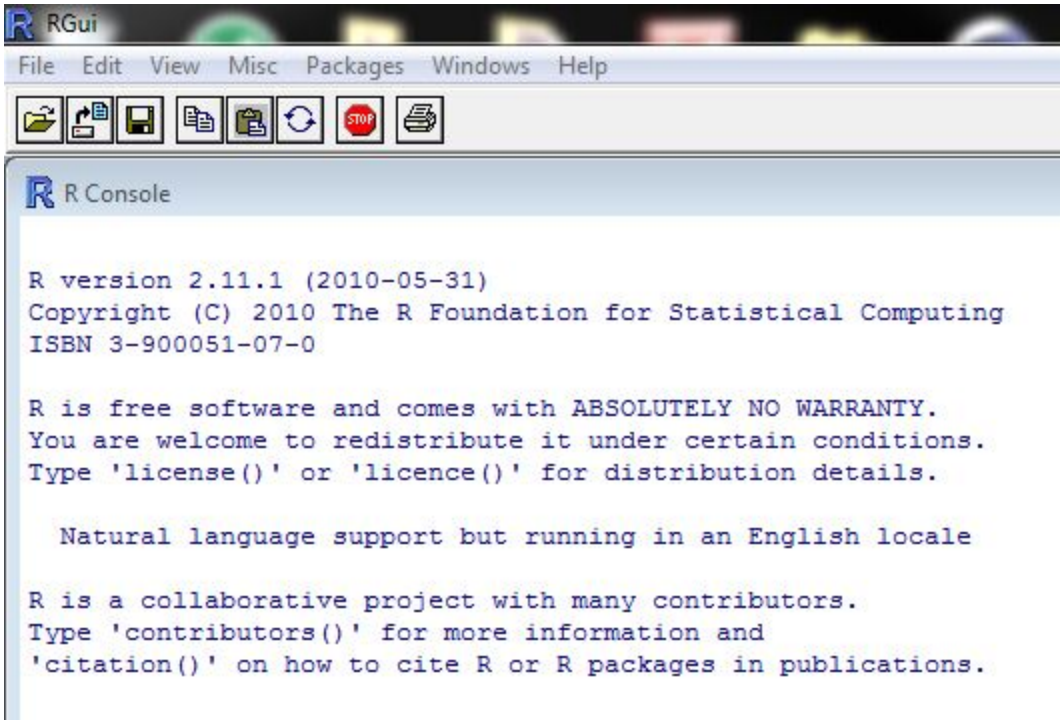
1. If you have downloaded a ZIP (compressed) file containing FIPEX, extract it to a secure directory on your local machine.
2. Navigate to that directory and double click the file with the esriAddIn file extension.



3. If you wish to calculate the **Dendritic Connectivity Index** (DCI), install the 'R' program (version 2.11.1) that is bundled and distributed with FIPEX follow these instructions, otherwise skip to step 4.

Installing the R Statistical software for Windows

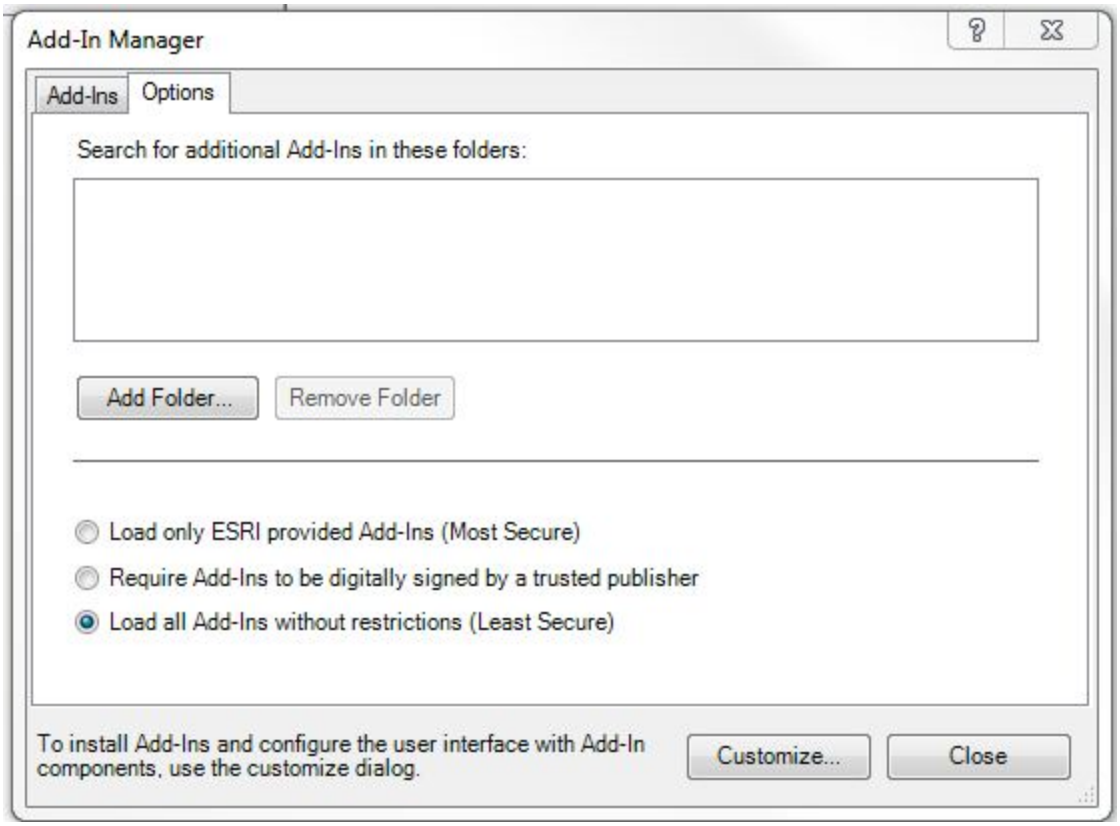
a) Double-click the **R-2.11.1-win32.exe** (do not install the 64bit version - ArcGIS is 32bit and will not be able to call a 64bit program).
b) Install the required **RBGL, Graph, rGraphViz,** & **BioCGraph** packages -->
c) Launch the **'RGui'** Program (In the **'Start Menu'** under '**R**', you should see the program R.2.11.1 - run this).



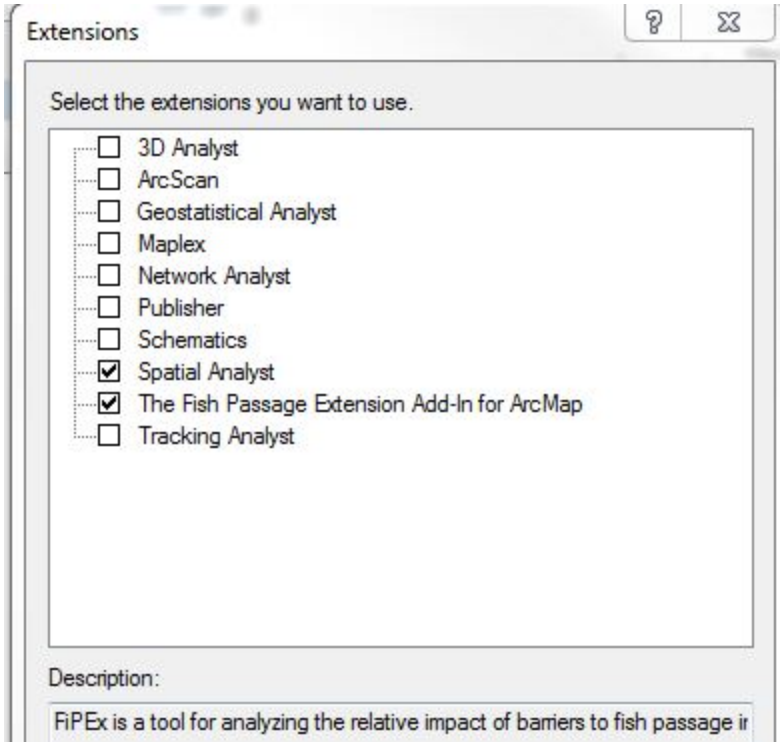
d) Go to the **'Packages'** Menu -> **'Install from Local ZIP File...'**
e) Select the ZIP files provided with the FIPEX Installation package.
f) **Important:** Cut and paste the entire ***DCI Model Files Directory*** to a permanent local directory in which you have 'write' permissions (e.g., /My Documents)

4. Open **ArcMap**
5. Go to the **'Customize'** Menu -> **'Add-In Manager'**
6. You should now see FIPEX in the manager (ignore digital signature warning)

7. Look at second tab **'Options'**: check that **'load all add-ins without restrictions'** is checked.



8. Go to **'Customize'** -> **'Extensions'** and check *The Fish Passage Extension Add-In for ArcMap.*



9. Go to **'Customize'** -> **'Toolbars'**
10. Check that the ***FIPEX*** Toolbar is activated. Also activate the ***Utility Network Analyst Toolbar***.
11. The FIPEX Toolbar should now be present but inactive. It will remain inactive until it detects a layer that is a member of a geometric network is present in the map document.

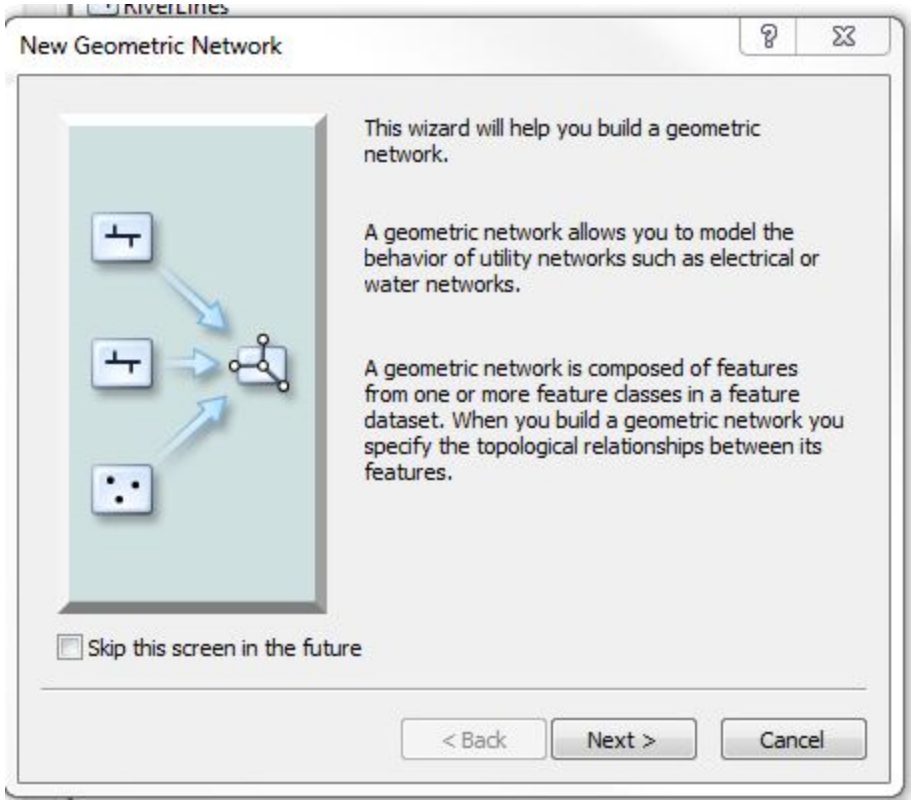
Configuring FIPEX - Network Build and Options Config Walkthrough

A demo dataset has been provided to help explain and configure FIPEX. In the directory that FIPEX was downloaded you should find an .MXD file (ArcMap document) and a geodatabase. This brief walkthrough will help set up the FIPEX 'Options' , demonstrate the construction of a simple geometric network (a requirement in order to set FIPEX Options), and do a simple analysis. Prior to opening this MXD, follow the instructions below for Network Creation.

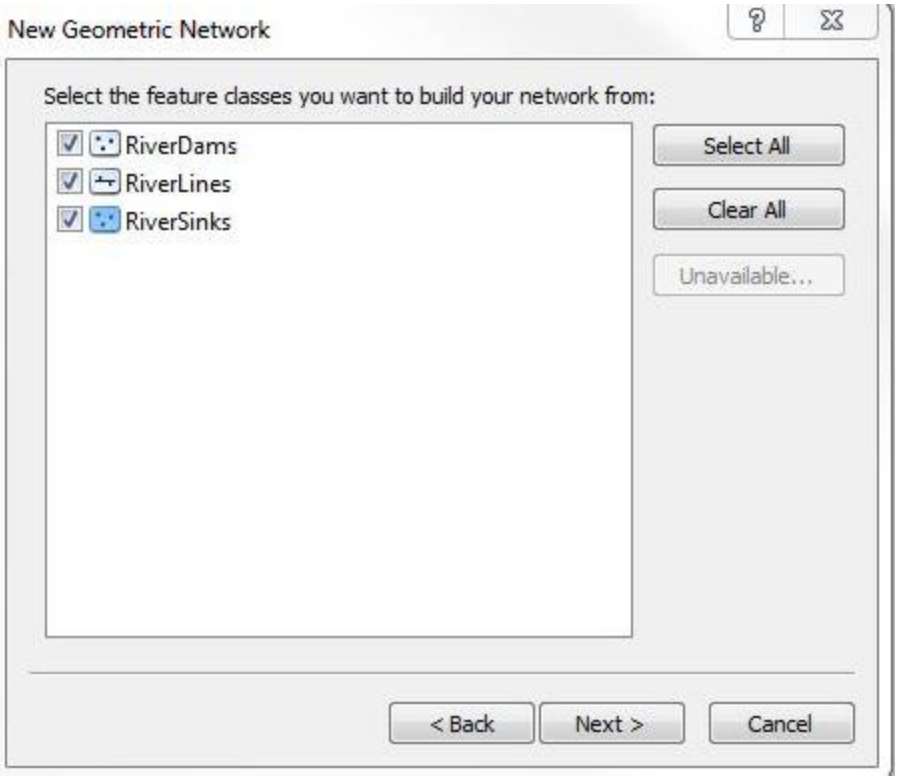
1. Close **ArcMap**
2. Open **ArcCatalog** (note: the full version, not from within ArcMap)
3. Navigate to the FIPEX install directory and into the demo geodatabase (named similar to *'FIPEX_DemoDataVer10_Dec1212.gdb'*)
4. Inside you should see the **'ForDemo'** dataset.
5. Inside the **'ForDemo'** dataset you should find three layers: **'RiverLines'**, **'RiverDams'**, and **'RiverSinks'**

Network Creation

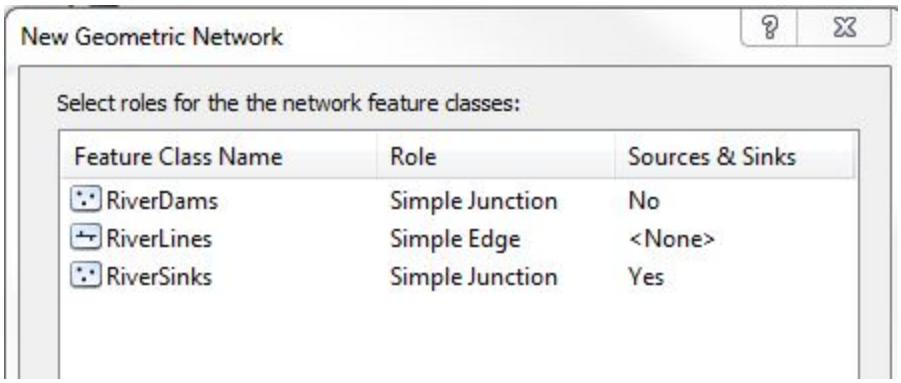
6. We will create a geometric network. You must have appropriate Standard-level ArcGIS Desktop™ License activated to continue. If you are unable to create a geometric network following the instructions here, it may be due to license restrictions.
7. Right-click anywhere in the **'Contents'** view of the ***'ForDemo'*** dataset (not on a layer)
8. Go to **'New'** -> **'Geometric Network'**. You should see the Wizard Screen.



9. Click **Next** (accept defaults; FIPEX uses SIMPLE networks only, not COMPLEX).
10. Check all three layers.

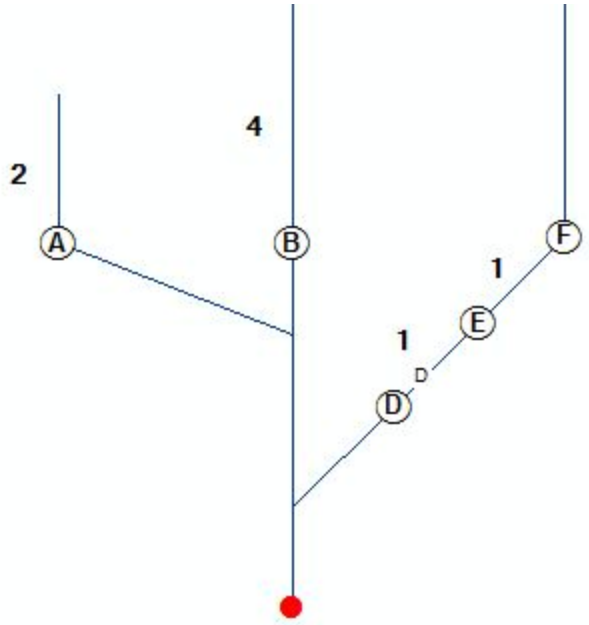


11. Click **Next**
12. Click **Next** (accept defaults)
13. Set the **'RiverSinks'** layer as **'Sinks'**=Yes



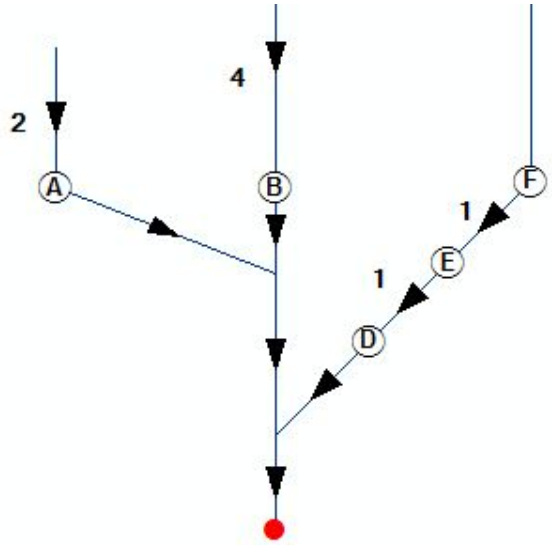
14. Click **Next**
15. Click **Next** (FIPEX does not use Network Weights)
16. Click **Finish**. The network should built. Notice that the geometric network wizard has built two additional layers: the 'junctions' layer, and a pseudo-layer called 'ForDemo_Net_Junctions.

17. Open **ArcMap**. Open the FIPEX_InstallDoc.mxd document.
18. You should see the three layers: RiverSinks, RiverDams, RiverLines. These layers now participate in the geometric network, 'ForDemo_Net_Junctions', so the FIPEX Toolbar is now active. The Utility Network Analyst Toolbar should also should the 'ForDemo_Net' network active.



19. Go to the FIPEX toolbar, **'Menu'** -> **'Display Arrows'**. Notice black circles positioned mid-line denote indeterminate flow. In a newly created geometric network this is normal.
20. Set the 'flow direction' of the geometric network. You will have to start an edit session to do this. In the 'List by Drawing Order' view of the Table of Contents, right-click any one of the layers and click **'Edit Features'** -> **'Start Editing'**
21. The **'flow direction'** is set using the **Utility Network Analyst Toolbar**. The **'Set Flow Direction**' button should now be active. Click this button.

22. The circles should now change to arrows.

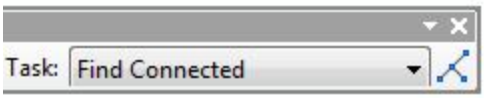


23. **Save Edits** and **Close Edit Session**. Note that barriers A thru F should be visible and labeled. The RiverDams layer contains these barriers. During network creation, these barriers would have 'broken' the river lines which they fall upon. The number labels represent line length (used next).

Quality Control

24. Do a quick quality control analysis with the Utility Network Analyst tools. Place a flag on the sink (colored red). Do this by clicking on the **'Add Junction Flag Tool'** (there is a similar tool in FIPEX, but use this one for now).

25. A green box (called the 'flag') should appear. This is a the analysis 'start point'. A number of options are now available in the Utility Network Analyst toolbar. Select **'Find Connected'**.



26. Click the **'Solve'** button next to it. All network elements connected to the flag will be highlighted red.

27. Clear the results. You can use the FIPEX menu to do this. Click **'Menu'** -> **'Clear results'**
28. Clear the flags. You can use the FIPEX menu to do this. Click **'Menu'** -> **'Clear Flags'**

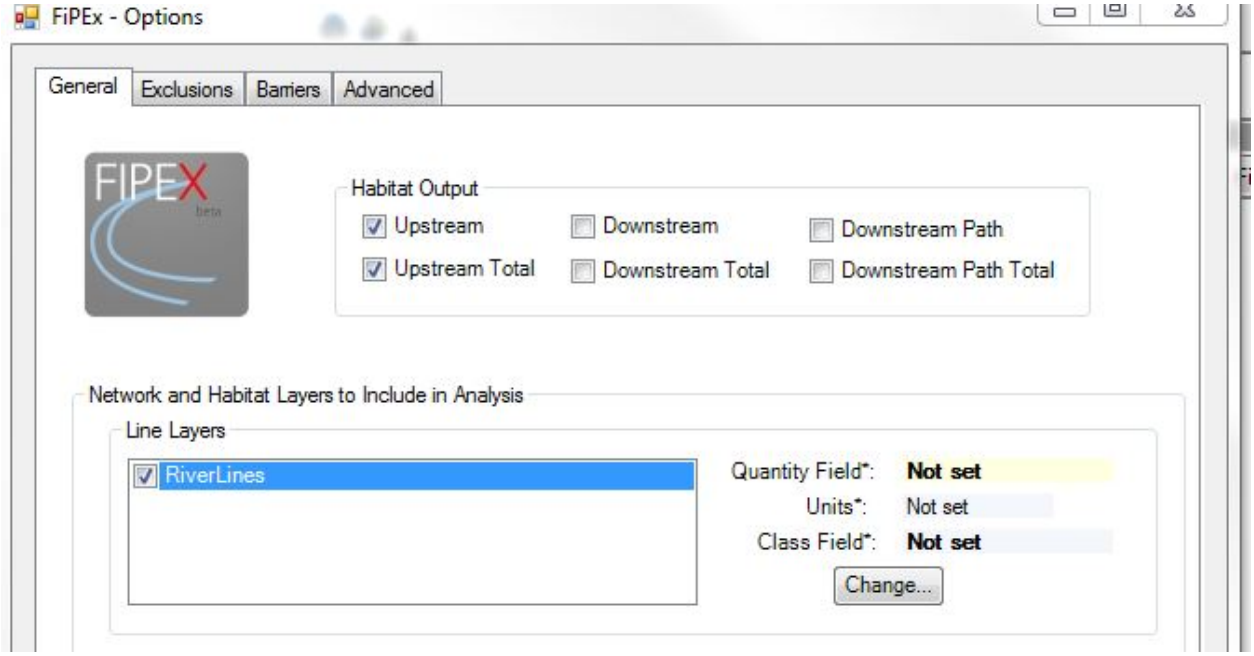
29. With the **'Set Junction Flag'** tool, flags can only be set, they cannot be cleared. They also remain unlabeled. The FIPEX **'Place / Remove Flag'** tool can alternatively be used, which can set, remove, and label the flag. Set the flag using this tool on the sink again.

30. Place a single barrier (red 'X') on barrier D using the FIPEX **'Place/Remove Barrier'** tool. This effectively turns barrier D 'On'. (turn off **'display arrows'** in the FIPEX dropdown menu)

31. Do a second quick quality control test, again using the Utility Network Analyst toolbar trace 'Find Connected'. Select **'Find Connected'** and click **'Solve'**. All network 'beyond' barrier D should now be inaccessible and therefore not connected.

Set up the FIPEX Options

32. Click **'Menu'** -> **'Options'** on the FIPEX toolbar.
33. You will see four tabs. The menu is described in more detail in later sections. For now the **General Tab** settings determines which habitat layers are used in the analysis, and the **'Barriers Tab** contains settings for barriers used in the analysis.
34. In the **General Tab**, click the checkbox next to River Lines. Highlighting this layer will activate the **'Change'** button.



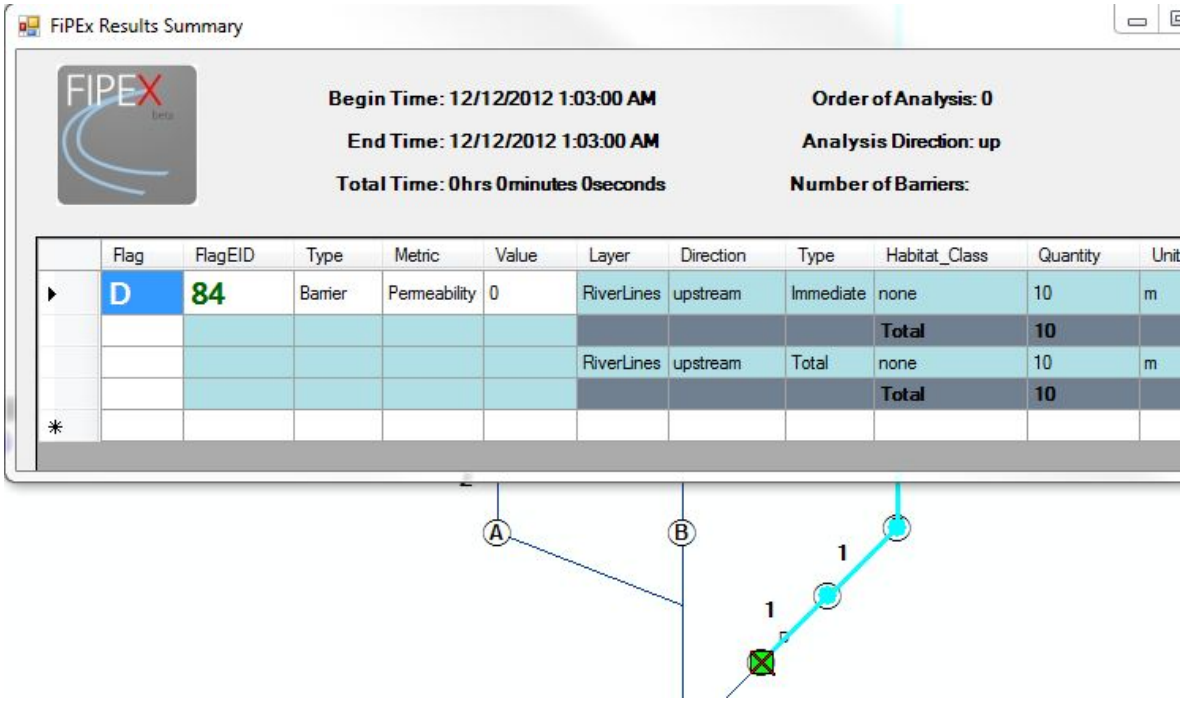
35. Click the **'Change'** button. Select *'LengthPrio_Demo'* as the **'Quantity'** -- this determines what field in the layer attribute table will be used to summarize habitat quantity. The simplest option is length. Select '*<none>*' for the **'class'** field. Select **'Metres'** for the **Units**. Click **'Save'**
36. Click the **'Barriers'** Tab. Check **'RiverDams'** as a barriers layer.
37. Select a field to use to uniquely identify barriers in analysis output. Click **'Change ID Field**' and select the field ***'Label'*** and click **'Save'**.

38. Click 'Save Settings'

Run a One-Click (One Barrier) analysis

39. The FIPEX **'One Click Analysis'** tool is meant for a quick assessment of a barriers. Select this tool from the toolbar.

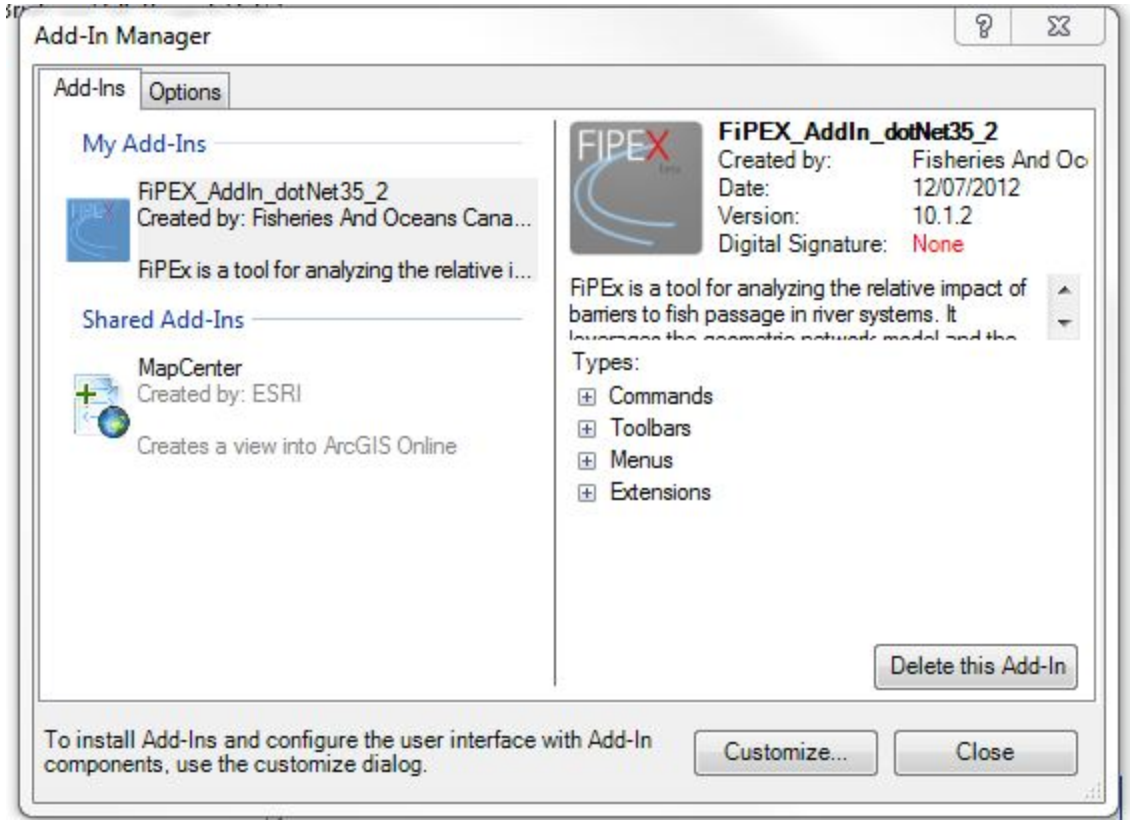
40. Click on a barrier in the network. You should see a brief analysis run followed by a FIPEX Results Summary Form.



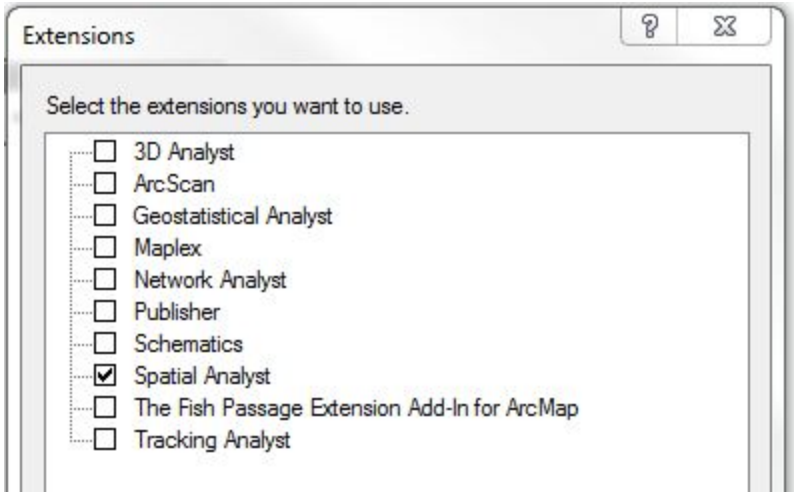
This was a first and general introduction to some of the FIPEX functionality and tools. Advanced analysis, multi-barrier analysis, Dendritic Connectivity Index calculation, and other analyses are discussed later.

Uninstalling FIPEX

1. FIPEX can be removed by opening ArcMap, clicking **'Customize'** -> **'Add-In Manager'**.
2. Under **'My Add-Ins'** select FIPEX_AddIN_dotNet35_2 (or similar) and click **'Delete this Add-In'**



3. Prior to closing ArcMap, click **'Customize'** -> **'Extensions'** and uncheck the Fish Passage Extension for ArcMap.



5. Overview of FIPEX Toolset

FIPEX is provided as a toolbar for ArcGIS. This toolbar contains a number of tools, scripts, menus, and commands which makes analysis of river systems with respect to their *longitudinal connectivity* easier.

Basic Features

Basically, FIPEX automates and 'batches' commands and analyses that are possible in ArcGIS without FIPEX but would take a long time. There are also other, more advanced features.

For example, if you wish to know what network lines are upstream of a barrier, grouped by feature type (from a code assigned to each line feature), *without* FIPEX you would need to:

(assuming a geometric network is built)

1. Place a flag on the barrier
2. Perform a **'Trace Upstream**' analyis with results returned as selection using the Utility Network Analyst.
3. Run a **'Summarize'** analysis on the feature type field in the attribute table.

With FIPEX you would:

(assuming FIPEX options are set)

1. Click on the barrier with the **One-Click Analysis** tool.

Another example: setting barriers 'on' in the geometric network. If you had 100 barriers, *without* FIPEX you would need to:

1. Click on the barrier with the **'Junction Barrier**' tool.
2. Repeat this 100 times.
3. Repeat this each time the map is opened

With FIPEX you would:

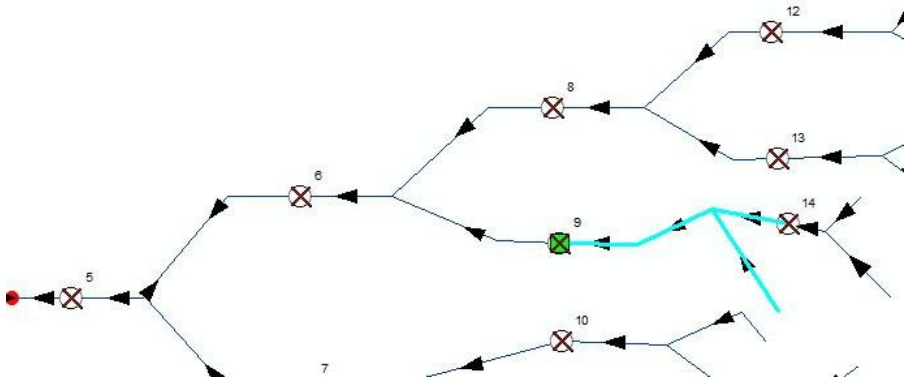
(assuming FIPEX options are set)

1. Select all barriers you wish set.
2. Click the **'Barriers on Selected'** button 
3. Save the map (barriers are saved in the MXD and do not need to be reset next time)

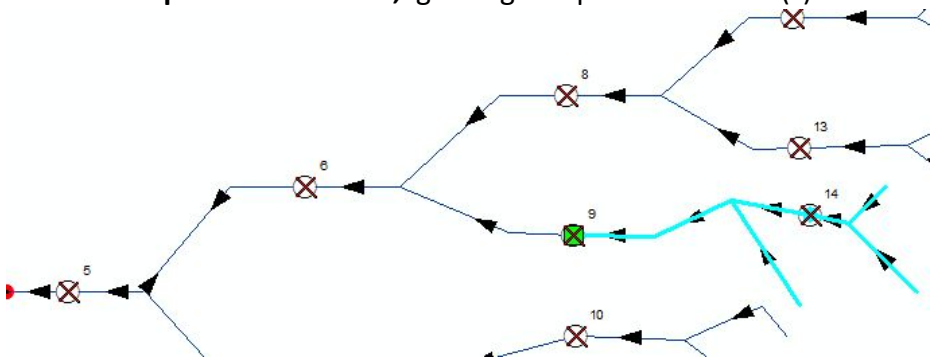
Analysis Types

FIPEX will perform analysis for a single barrier, presenting results in an output form and in non-spatial database tables. The standard metrics on each barrier are:

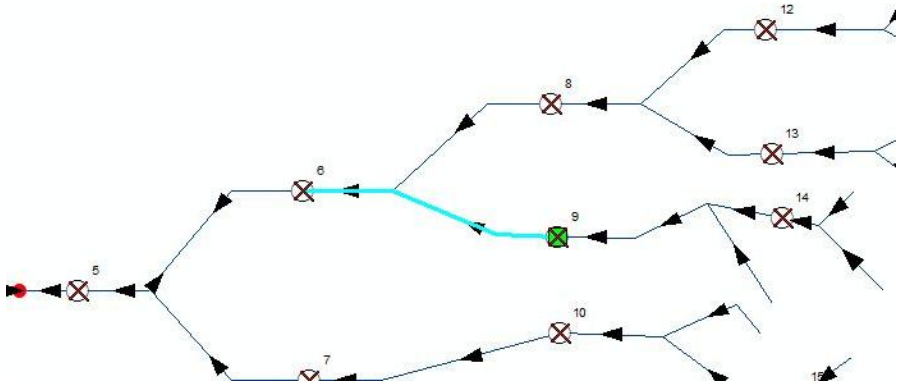
- **immediate upstream network,** until the next upstream barrier(s):



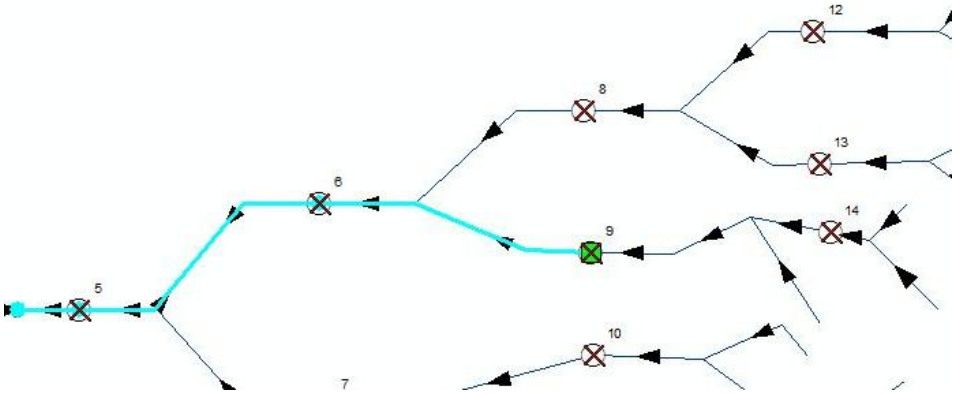
- **total upstream network,** ignoring all upstream barrier(s):



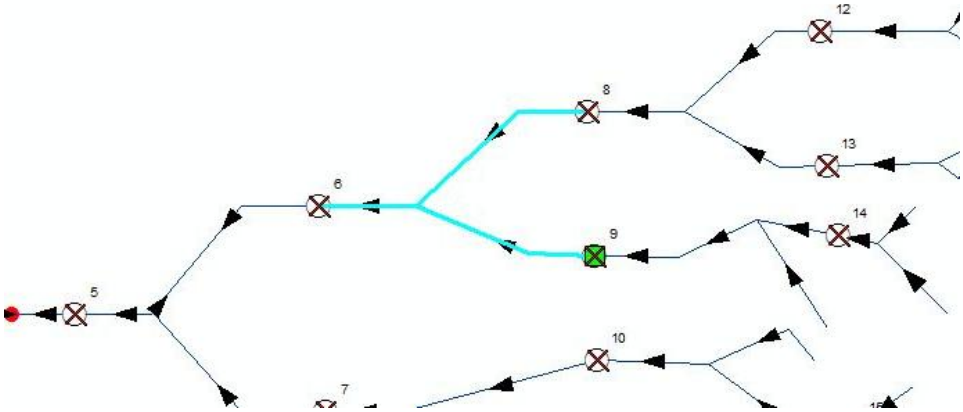
- **immediate downstream network with network flow**, until the next downstream barrier:



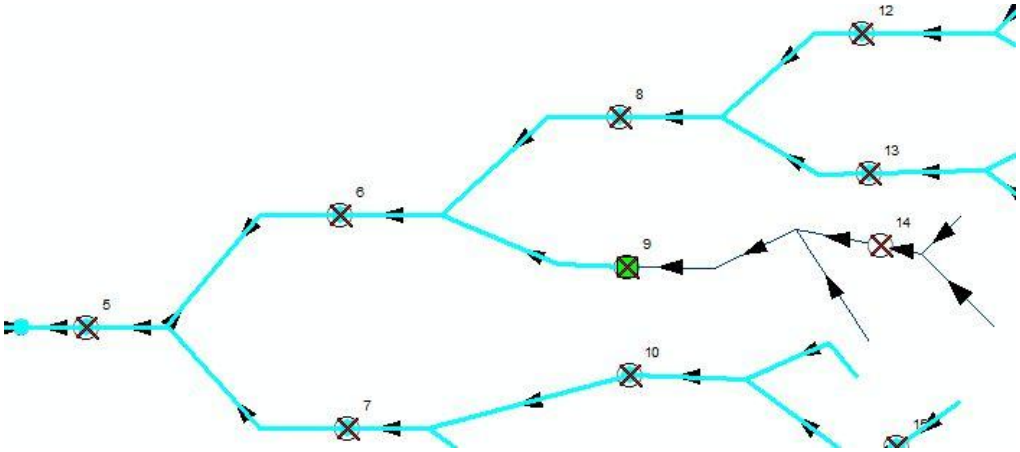
· **total downstream network with network flow**, ignoring the next downstream barrier:



· **immediate network downstream**, **ignoring network flow**, until the next barrier(s):



· **total network downstream**, **ignoring network flow,** ignoring the next barrier(s) encountered:



Classes

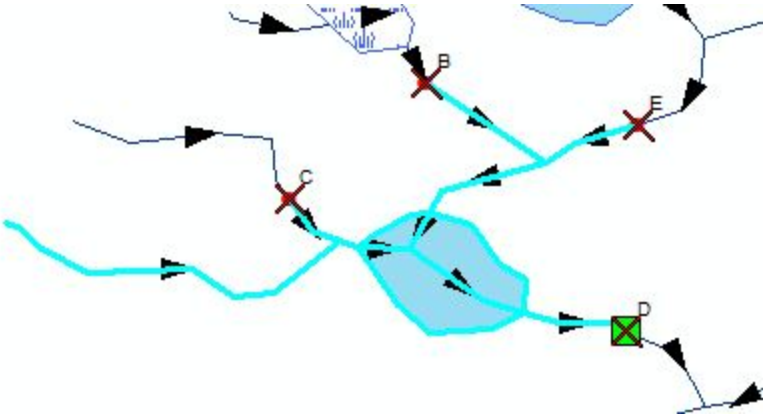
FIPEX offers the ability to define 'classes' for the output. This effectively summarizes network returned from the analysis. For example, river network may be summarized by 'large river', 'small river', or 'stream'. Alternatively, river network may be summarized by 'Stream order = 1', 'Stream order = 2', 'Stream order = 3' , etc.

Exclusions

Certain features may be excluded from analysis. For example, a common exclusion are lines features that run through waterbodies such as lakes. These are sometimes referred to as 'lake spines' and are unrepresentative of stream or river length. If they have been identified by a unique code in the layer's attribute table, then they may be excluded from the analysis.

Polygon Inclusion

Geometric networks are not able to accommodate inclusion of polygons -- they maintain only node-edge topology. FIPEX can optionally include polygonal layers and features into the analysis by 'intersecting' them with the lines features of the geometric network. For example, lakes may be included by setting this in the FIPEX options menu:



Resulting analyses will summarize lake surface area in the output:

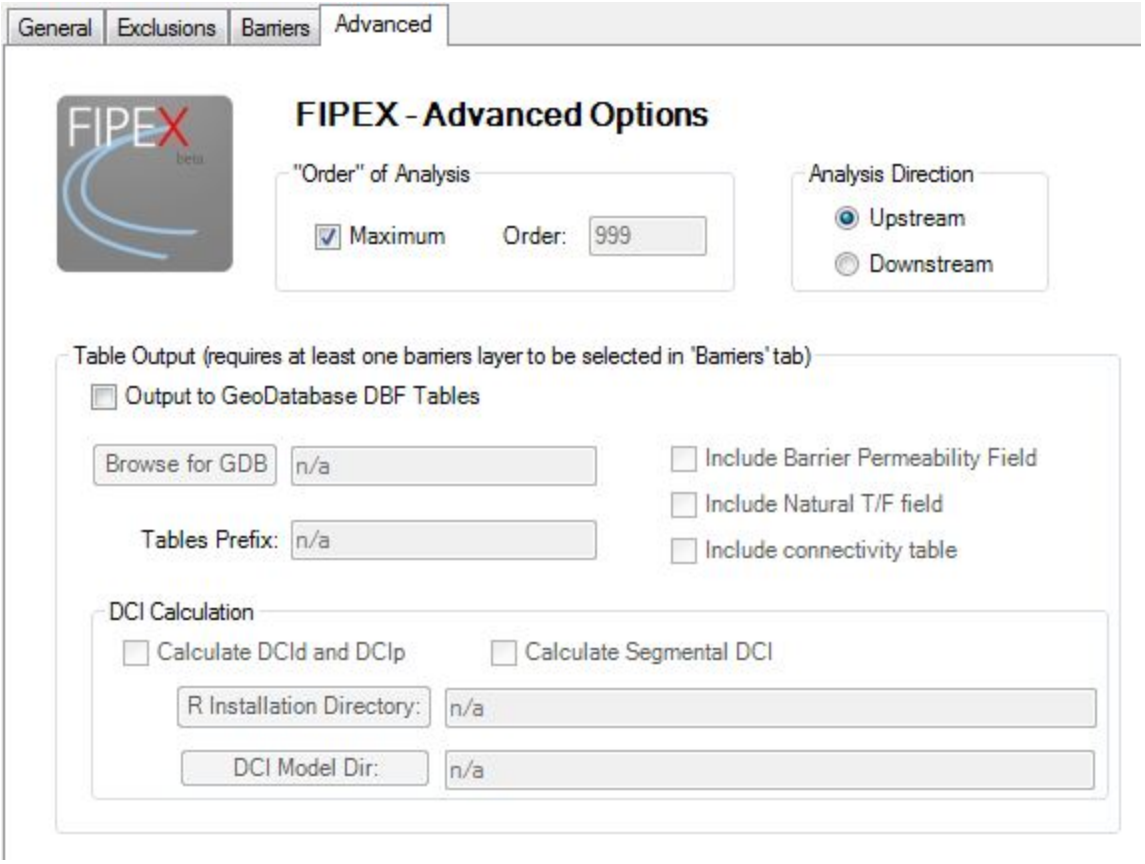
Flag	FlagEID	Type	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
D	19	Barrier	Permeability	0	RiverLines	upstream	Immediate	not set	76.79	m
								LakeSpine	18.23	
								Total	**95.02**	
					LakesAndWetlands	upstream	Immediate	Crater Lake	86.48	m^2
								Total	**86.48**	

Advanced Features

The most common 'Advanced' feature used with FIPEX is iteration of basic analyses like those described in the 'Basic Features' section. Typically, this is for a large number of barriers or an entire river system. By setting one flag on the 'sink' of the network, a user can run an **'Advanced Analysis'** on all barriers encountered on that river system (avoiding repetitive analysis of one barrier at a time).

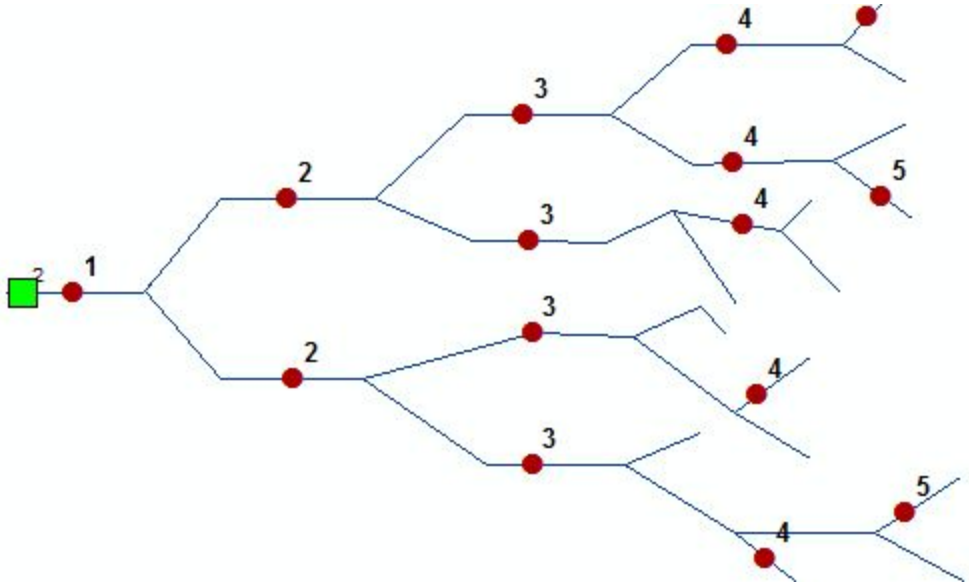
The Advanced analysis button: 

The Advanced Analysis Options Tab in the FIPEX Options menu:



"Order" of analysis

The "**Order**" of analysis is the limit of number of sibling barriers in the direction of analysis that the FIPEX algorithm will iterate in an 'Advanced Analysis.' In the image below, the orders of the barriers (red circles) with respect to the system sink (green square) are labeled.



Analysis Direction

Determines which direction from the flag the analysis iterates. For example, if the user was interested in how many barriers were between a barrier in the upper reaches of a watershed and the ocean, they may choose an iterative downstream analysis.

Output to DBF Tables

DBF Tables are non-spatial tables compatible with Microsoft Excel, stored here in an output geodatabase. Optionally, three tables are created: Connectivity, Habitat, and Metrics. These tables are designed to be relational (to each other or to barrier layers) and can be used for further analysis.

DCI Calculation

The Dendritic Connectivity Index (DCI) is a scaled index of connectivity (Cote et al., 2009[2]). It measures the likelihood that a fish can move from a point in the river system to any other point in the river system. There are three measures: the DCI for diadromous fish movement (movement between the river system and the ocean), the DCI for potadromous movement (for within the system only), and the segmental DCI (for the connectivity of individual reaches of river).

The DCI requires the R Statistical software program (http://www.r-project.org/). If R is installed on the local machine (see Installing the R Statistical software for Windows for

[2]Cote, D;, Kehler, D.G.; Bourne, C.; Wiersma, Y.F.. (2009) A new measure of longitudinal connectivity for stream networks. *Landscape Ecology* **24**:1, 101-113

details) then FIPEX can call upon R to calculate these statistics during the Advanced Analysis. The resulting DCI statistics are output to a form and to the Metrics table.

6. FIPEX Tools and Commands

A. Place / Remove Flag Tool

Places or removes a single junction flag on a point in the network. Also labels or removes the label for that flag. Labels are set based on the 'Barrier ID' selected in FIPEX Options.

B. Place / Remove Barrier Tool

Places or removes a single junction barrier on a point in the network. Also labels or removes the label for that barrier. Labels are based on the 'Barrier ID' selected in FIPEX Options.

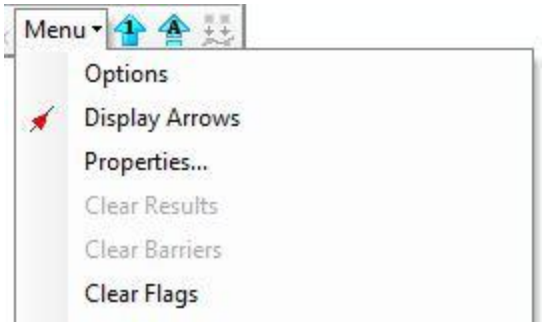
C. Place Flags on Selected

Places flags on all selected junctions / points that participate in the geometric network. Also labels flags. Labels are based on the 'Barrier ID' selected in FIPEX Options.

D. Place Barriers on Selected

Places barriers on all selected junctions / points that participate in the geometric network. Also labels barriers. Labels are based on the 'Barrier ID' selected in FIPEX Options.

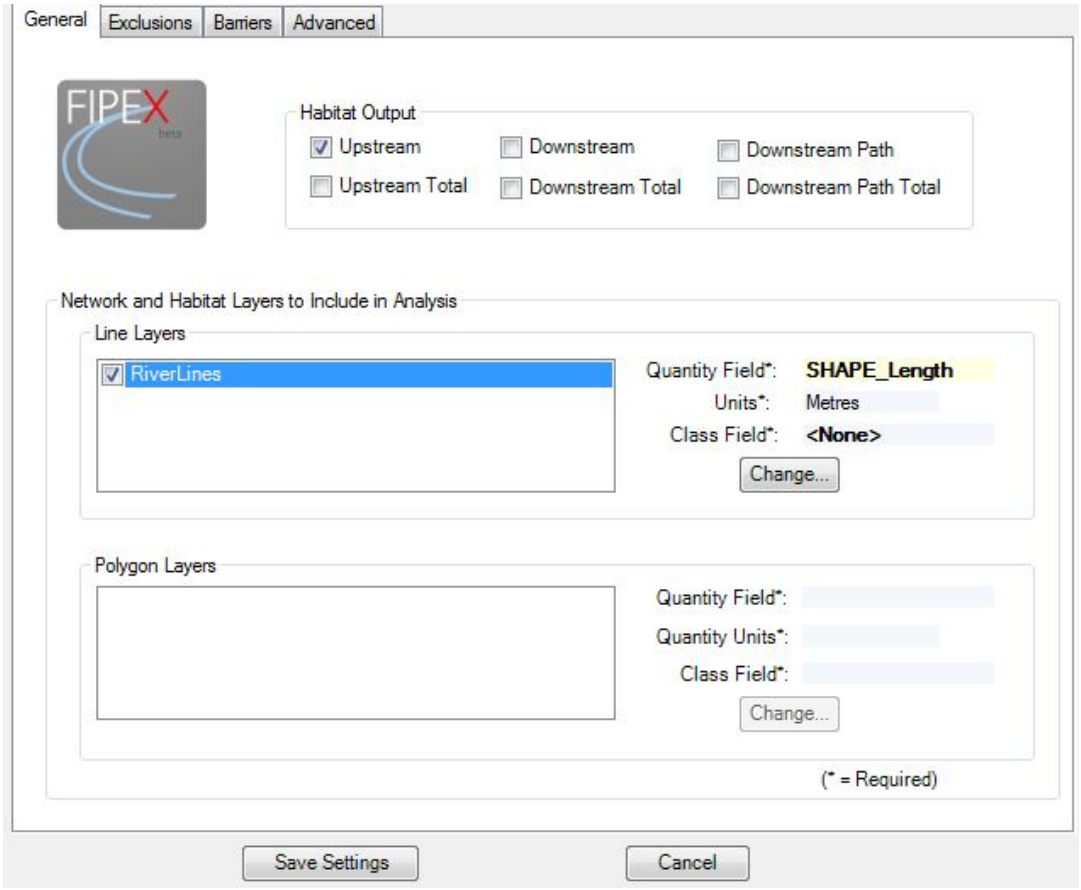
E. The FIPEX Menu



E1 FIPEX Options

The FIPEX Options Menu contains four tabs: General, Exclusions, Barriers, Advanced.

The General Tab



The settings in the FIPEX General Tab are essential to set prior to running any analysis. The ***Habitat Output*** checkboxes dictate the type(s) of traces performed in both the

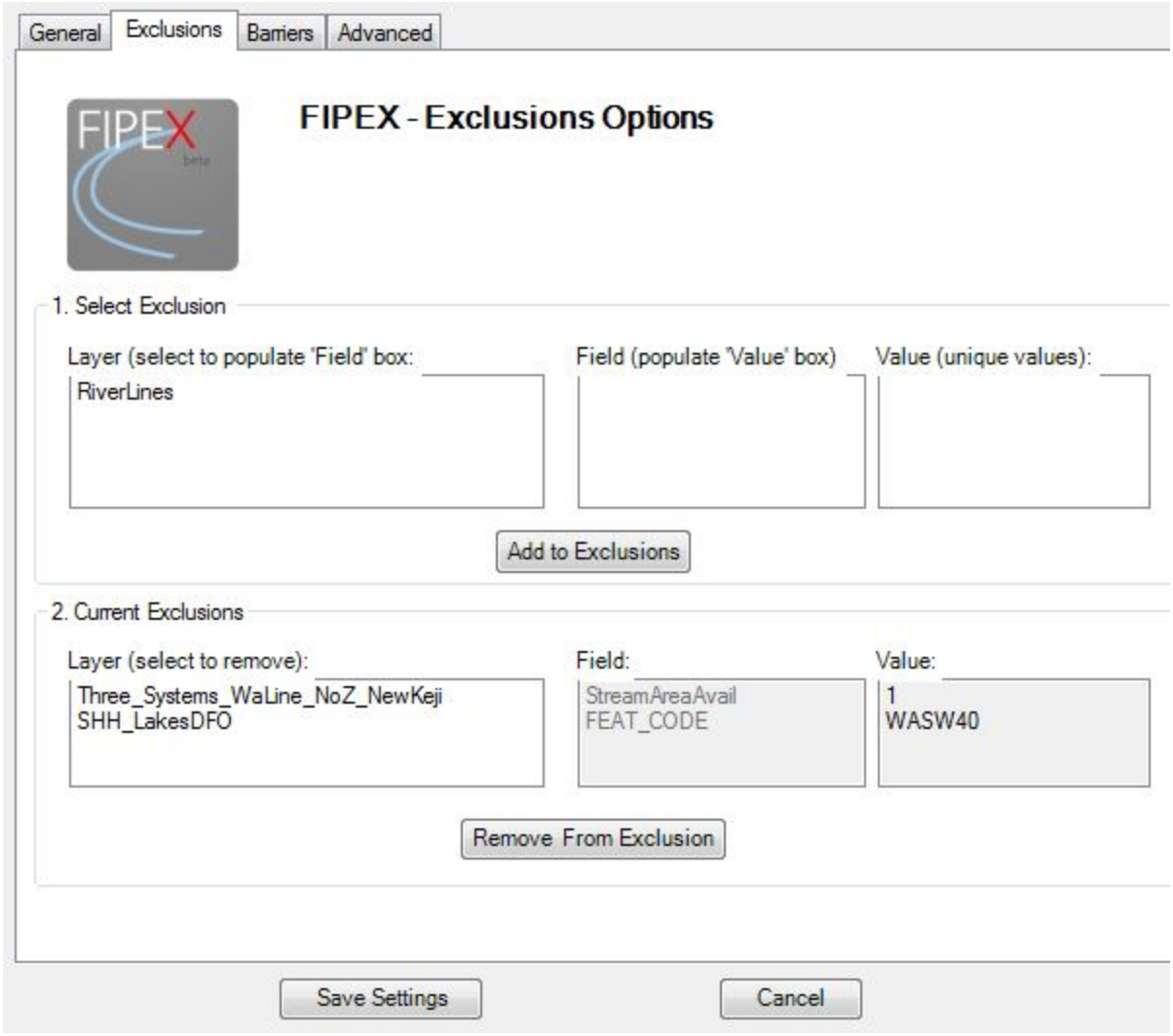
One-Click Analysis and the *Advanced Analysis*. For an explanation of each trace type see Analysis Types.

The ***Network and Habitat Layers to Include in the Analysis*** determines which layers will be used in the analysis to generate results. The '***Change**..'.* button will provide a pop-up window to select:

1. ***Quantity Field:*** The field used to total network quantity (this field should be of type 'Integer' or 'Double')
2. ***Units:*** This field specifies the units of the quantity field.
3. ***Class:*** The class field is used to separate and summarize output results. For example, this field may represent Stream Order or feature type (e.g., lake, stream, river).

The Exclusions Tab

The Exclusions Tab is used to set which features within the participating feature layers for the analysis will be excluded from the results. These settings apply to both the *One-Click Analysis* and the Advanced Analysis.



The ***Select Exclusion*** section is where the particular feature code can be selected. To set an exclusion:

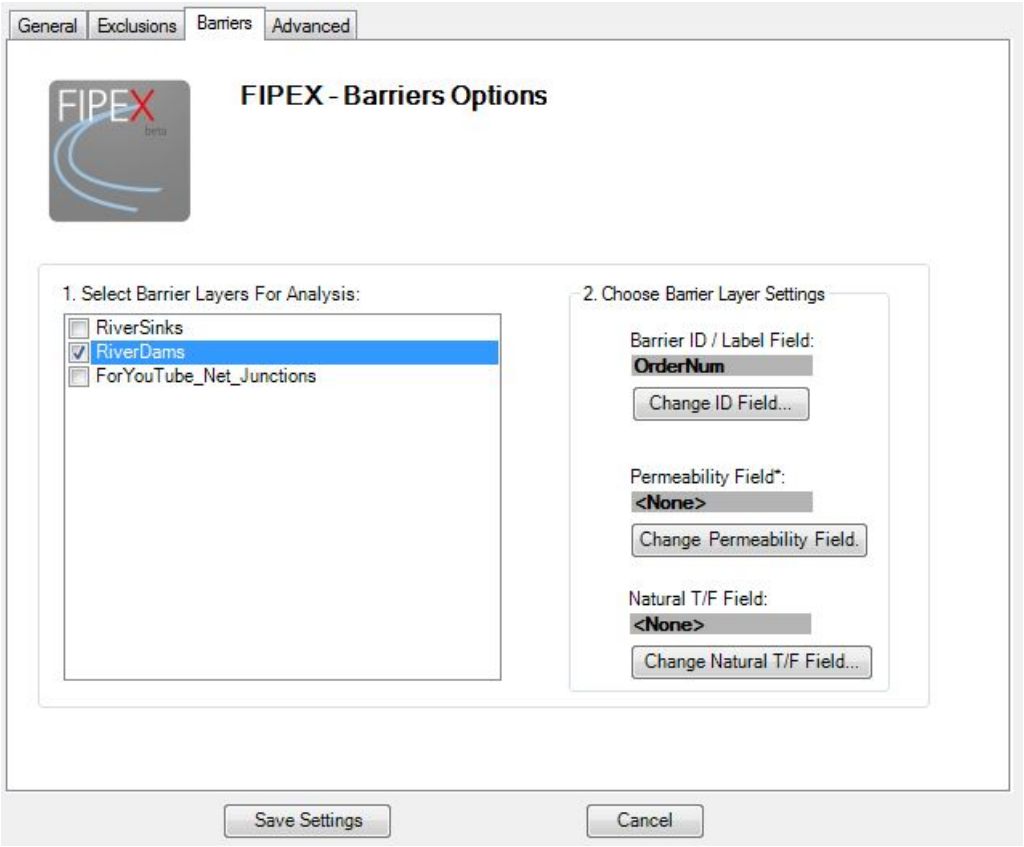
1. Select the layer in the ***Layer*** box of section 1.
2. Select the field in the ***Field*** box of section 1.
3. Select the unique value from that field in the ***Value*** box of section 1.
4. Click ***'Add to Exclusions'*** .
5. Click 'Save Settings'.

To remove an exclusion:

1. Click the layer in the **Layer** box of section 2. Corresponding Field and Value should highlight.
2. Click **'Remove From Exclusion'**
3. Click **'Save Settings'.**

The Barriers Tab

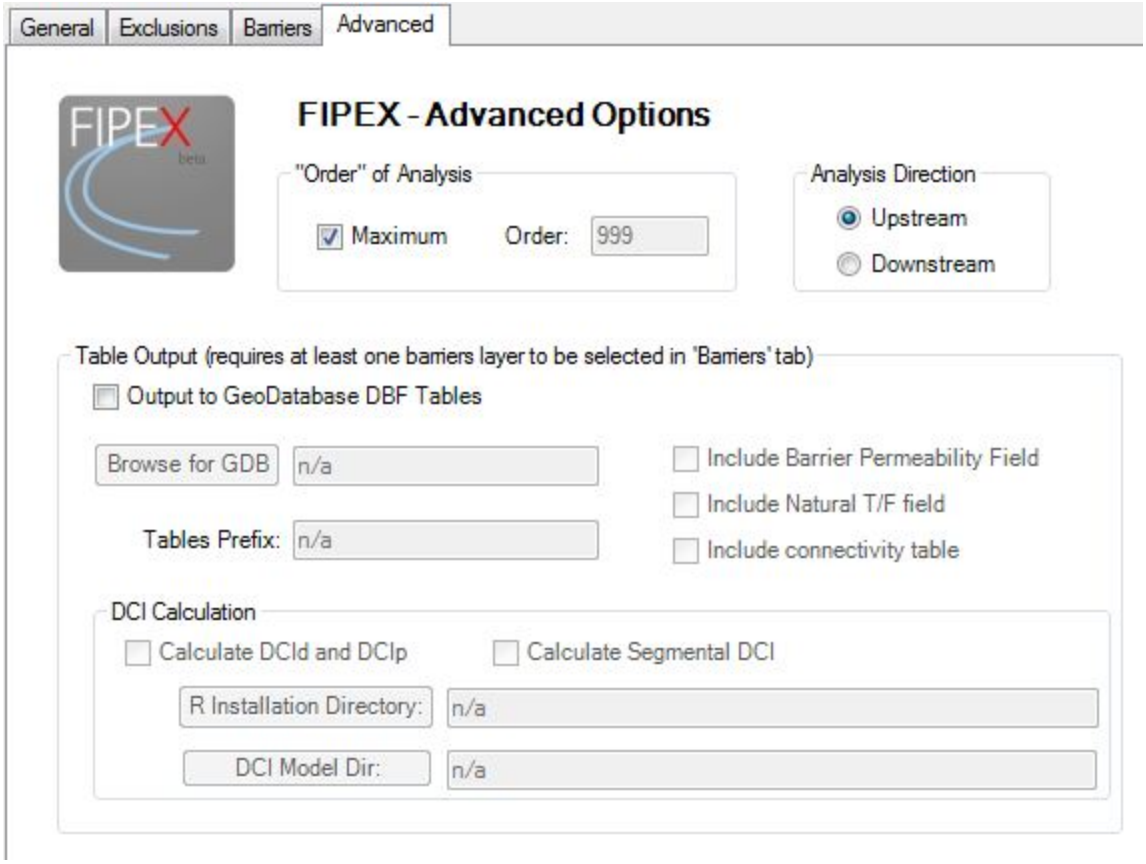
The Barriers Tab is used to determine which barriers get reported in the results. It is also used to select the 'Barrier ID' (used for labels and output identification), the 'Permeability' field (used in *Advanced Analysis*), and the 'Natural T/F' field (used in *Advanced Analysis*).



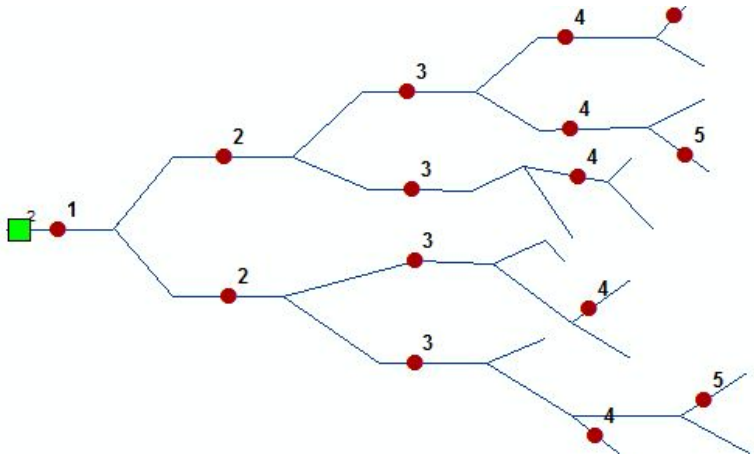
To select the 'Barrier ID', 'Permeability', and 'Natural T/F', buttons that provide a pop-up form that allow you to select from the available fields in the attribute table of the layer selected in ***Select Barrier Layers For Analysis*** section.

The Advanced Tab

The Advanced Tab sets options that are only used in the *Advanced Analysis* of FIPEX.



The ***"Order" of Analysis*** section sets the maximum number of iterations in the direction of the analysis (set in the *Analysis Direction* section) that the FIPEX *Advanced Analysis* algorithm will proceed.



In the image above, the order of the barriers (red circles) upstream of the sink (green square) are labeled. If the ***Maximum*** checkbox is checked, the traces in the analysis direction will proceed until the end(s) of the network are reached.

The ***Analysis Direction*** is the direction from the flag(s) (i.e. start point(s)) that the Advanced Analysis algorithm will proceed. This direction is based solely on flow direction as set in the geometric network.

The ***Table Output*** section sets parameters for the output from FIPEX *Advanced Analysis* to non-spatial geodatabase tables.

· ***Output to Geodatabase DBF Tables*** checkbox: Determines whether these tables will be generated.

· ***'Browse for GDB'*** button: Provides a pop-up window to select the output geodatabase. ***'Tables Prefix'***: the user-determined prefix for the output table names.

· ***Include Barrier Permeability Field***: determines whether output tables will include the barrier permeability which must be specified in the Barriers Tab.

· ***Include Natural T/F Field***: determines whether this parameter will be included in the output tables.

· ***Include Connectivity Table***: determines whether a table containing the connectivity of barriers on the network will be generated.

The ***DCI Calculation Section*** determines whether the Dendritic Connectivity Index (DCI; Cote et al., 2009) will be calculated and output. The R Statistical Software (See Installing the R Statistical software for Windows**)** must be installed on the computer in order to calculate the DCI. The three checkboxes in the above section (for Barrier Permeability, Natural T/F Field, and Connectivity table) must also be checked to enable this section.

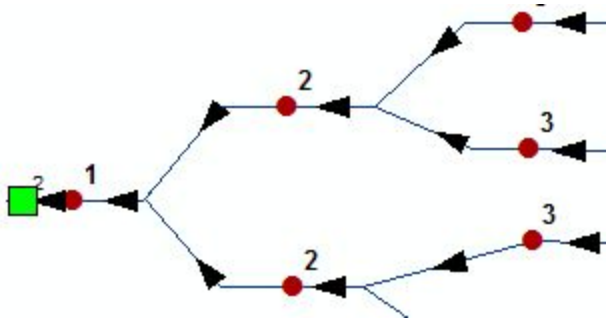
In brief, the DCId and DCIp are measures of the longitudinal connectivity of the system. The DCI Segmental is a measure of the relative connectivity of segments within the system. The statistics are provided as an index from 0 - 100 with 100 being 100% connected. For an explanation and walkthrough see 9. A DCI Calculation Walkthrough.

The ***R Installation Directory*** button sets the location of the R program on the local system. As is specified in the Installing the R Statistical software for Windows Section the current version used for DCI Calculation is R 2.11.1. The button provides a pop-up window to navigate to the R installation directory. Select this directory.

The ***DCI Model Directory*** button provides a pop-up browse window to locate the directory of the DCI Model files provided with FIPEX. *You must have read/write access to this directory.*

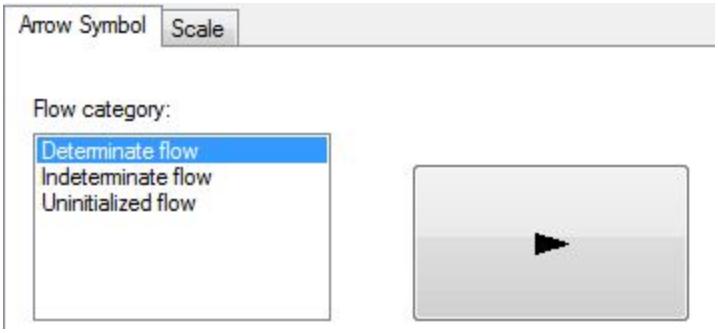
E2 Display Arrows

The Display Arrows button will toggle display of network flow arrows. This button is identicle to the one provided with the Utility Network Analyst toolbar.



E3 Properties

The **Properties** menu in the FIPEX dropdown menu allows you to set the style of the network flow arrows. This menu is identical to the one provided in the Flow dropdown menu of the Utility Network Analyst toolbar.



E4 Clear Results

The Clear Results button in the FIPEX dropdown menu will clear all highlighted results returned by an analysis. This button is identical to the one on the Utility Network Analyst Toolbar.

E5 Clear Barriers

The Clear Barriers button will clear all network barriers. It also clears the labels for the barriers.

E6 Clear Flags

The Clear Flags button will clear all network flags. It also clears the labels for the flags.

F. One-Click Analysis Tool

With the ***One-Click Analysis*** tool a quick analysis can be done for a single barrier or non-barrier junction on the network. This tool uses the settings found in the General tab, the Barriers tab, and the Exclusions tab of the FIPEX Options Menu. It does not use the settings in the Advanced tab. See 7. A 'One-Click Analysis' Walkthroughfor a walkthrough of a One-Click Analysis.

G. Advanced Analysis Command

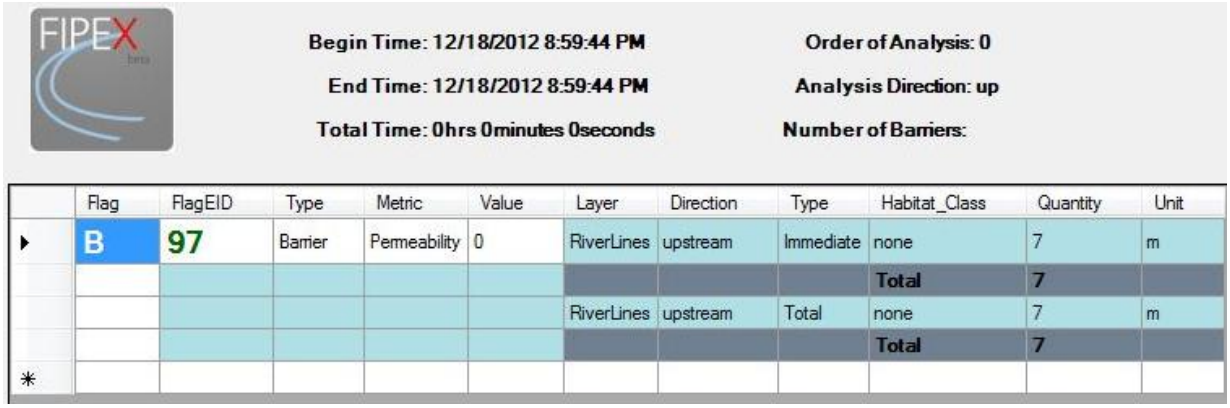
The ***Advanced Analysis*** command will start an iterative analysis for multiple barriers and multiple flags. This command uses the settings from the Advanced Tab of the FIPEX Options (see The Advanced Tab). Output will be optionally sent to non-spatial geodatabase tables (for an explanation of table output see FIPEX Output Tables). The DCIp, DCId, and DCI segmental will optionally be calculated (DCI Calculation).

H. Batch Snap Barriers to Points

The **'Batch Snap Barriers to Points'** button will snap points to lines based on snapping settings in ArcMap. This command operates using an active edit session, a selection of point features, and the settings in the **Snapping Window** of the **General Editing Options**. See 'Clean' the Dataset Prior to Building the Network for a description and walkthrough.

FIPEX Output Form

The FIPEX Output form is created after both the **'One Click Analysis'** or '**Advanced Analysis**' is run. The form creates a 'datagrid' similar to an excel worksheet that varies in length and width depending on the options selected.



Begin Time: 12/18/2012 8:59:44 PM
End Time: 12/18/2012 8:59:44 PM
Total Time: 0hrs 0minutes 0seconds
Order of Analysis: 0
Analysis Direction: up
Number of Barriers:

Flag	FlagEID	Type	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
B	97	Barrier	Permeability	0	RiverLines	upstream	Immediate	none	7	m
								Total	**7**	
					RiverLines	upstream	Total	none	7	m
								Total	**7**	

Figure 2: The summary output from a One-Click Analysis.

The output columns:

Flag - The flag ID (user-set)

FlagEID - The unique geometric network element ID (hidden from attribute tables)

Type - Can be 'Sink', 'Barrier', or 'Flag - Node'. In a One-Click Analysis this will refer to the node which the user clicks (may or may not have a barrier marker on it). In an Advanced Analysis, this will identify the flag(s) of the analysis.

Metric - contains barrier or flag specific metrics such as permeability, DCIp and DCId (for an Advanced Analysis. System-wide metrics; available for flags only), or DCI segmental (For an Advanced Analysis. Barrier-specific).

Value - the value of the specific metric

Layer - the participating layer name

Direction - the direction of trace used in analysis on the layer in the 'Layer' column. Can be 'upstream' or 'downstream'. Determined in the FIPEX Options General Tab.

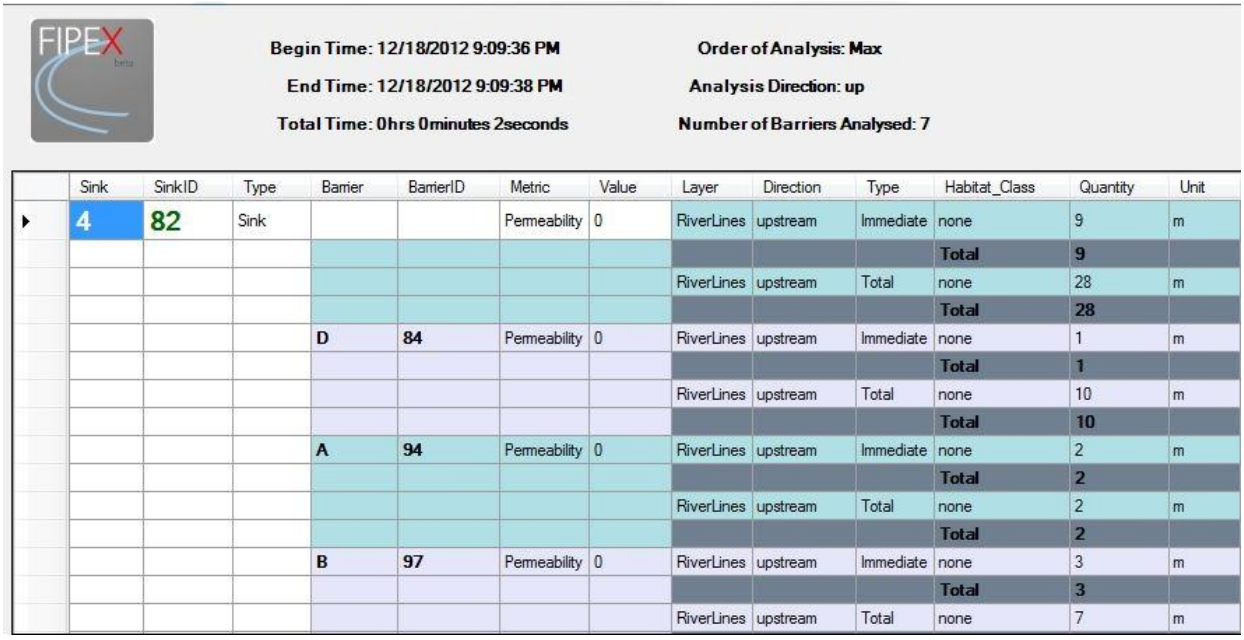
Type - the type of trace used in analysis on the layer in the 'Layer' column in the direction specified in the 'Direction' column. Can be 'Immediate', 'total', or 'path'. Determined in the FIPEX Options General Tab.

Habitat Class - the unique class, if specified in FIPEX options, that the results in the 'Quantity' column belong to (specific for the Layer, Direction, and Type)

Quantity - the total amount of habitat for this analysis class, type, direction, layer, and barrier.

Unit - the unit of the quantity reported.

In the FIPEX results from an Advanced Analysis the horizontal shading will alternate for each barrier or flag (see below image).



Begin Time: 12/18/2012 9:09:36 PM
End Time: 12/18/2012 9:09:38 PM
Total Time: 0hrs 0minutes 2seconds
Order of Analysis: Max
Analysis Direction: up
Number of Barriers Analysed: 7

Sink	SinkID	Type	Barrier	BarrierID	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
4	82	Sink			Permeability	0	RiverLines	upstream	Immediate	none	9	m
										Total	**9**	
							RiverLines	upstream	Total	none	28	m
										Total	**28**	
			D	84	Permeability	0	RiverLines	upstream	Immediate	none	1	m
										Total	**1**	
							RiverLines	upstream	Total	none	10	m
										Total	**10**	
			A	94	Permeability	0	RiverLines	upstream	Immediate	none	2	m
										Total	**2**	
							RiverLines	upstream	Total	none	2	m
										Total	**2**	
			B	97	Permeability	0	RiverLines	upstream	Immediate	none	3	m
										Total	**3**	
							RiverLines	upstream	Total	none	7	m

Figure 3: The summary output from an Advanced Analysis.

FIPEX Output Tables

Optionally, an Advanced Analysis will output to non-spatial geodatabase tables. These tables are easily exported to XLS, CSV, DBF or other common formats. The tables are designed to be joined or related (either with each other or with spatial layers).

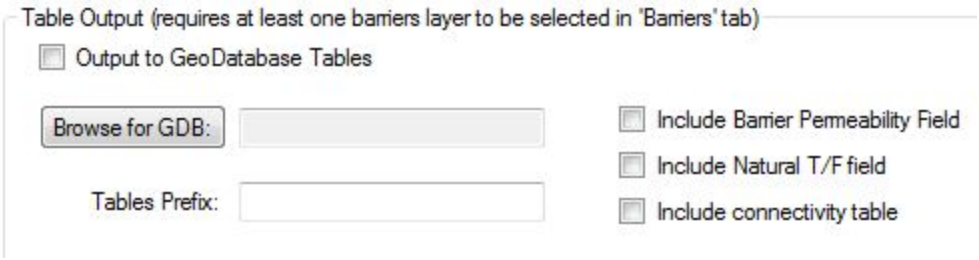


Figure 4: The table output section in the Advanced Tab

The following tables can be created: Connectivity, Habitat, and Metrics tables. These tables will be output to the geodatabase specified in the FIPEX Options Advanced Tab.

The Habitat Table

The Habitat table contains network quantity results returned for each barrier and sink used in the Advanced Analysis. The following fields are used

ObjectID - Unique object ID for each row in the table.

Sink ID - The unique ID of the flag / sink. The ID field used is set to the ObjectID in the sink layer.

Sink EID - The unique 'Element ID' of the sink. The EID is a hidden ID created and used by the geometric network.

bID (Barrier ID) - The barrier ID set by the user in FIPEX Options Barriers Tab.

barrEID (Barrier EID) - The unique 'Element ID' of the barrier. The EID is a hidden ID created and used by the geometric network.

Node Type - Determined by the presence / absence of a barrier marker. Can be 'Barrier', 'Sink', or 'Flag - Node.'

Habitat Layer - The layer of the output quantity for this row in the table.

Direction - The direction of the trace for this row. Can be 'upstream' or 'downstream'. Determined in the FIPEX Options General Tab.

Trace Type - The type of trace for this row. Can be 'Immediate', 'total', or 'path'. Determined in the FIPEX Options General Tab.

Habitat Class - the unique class, if specified in (FIPEX Options General Tab), that the results in the row belong to (specific to the Layer, Direction, and Type).

Habitat Class Field - reports the field used for the layer in this row (if specified in FIPEX Options General Tab) for the unique class designation.

Habitat Quantity Field - reports the quantity of network for this sink/barrier, layer, direction, trace type, class (optional).

Unit Measure - the unit of measure for the ***Habitat Quantity Field***.

The Metrics Table

The Metrics table contains one or many metrics for the sinks / barriers encountered during an Advanced Analysis. The following fields are used:

ObjectID - Unique object ID for each row in the table.

Sink ID - The unique ID of the flag / sink. The ID field used is set to the ObjectID in the sink layer.

Sink EID - The unique 'Element ID' of the sink. The EID is a hidden ID created and used by the geometric network.

bID (Barrier ID) - The barrier ID set by the user in FIPEX Options Barriers Tab.

barrEID (Barrier EID) - The unique 'Element ID' of the barrier. The EID is a hidden ID created and used by the geometric network.

Node Type - Determined by the presence / absence of a barrier marker. Can be 'Barrier', 'Sink', or 'Flag - Node.'

Metric Name - The name of the metric for this row (currently limited to 'permeability', 'DCIp', 'DCId', and 'DCI Segmental'.

Metric - The metric value (type 'double').

The Connectivity Table

The connectivity table contains the barrier-barrier topology of the network, as analyzed by FIPEX. This table can be useful in troubleshooting network connectivity; it should help ensure that any given barrier has only one downstream barrier (maintaining dendritic topology). The columns include:

ObjectID - Unique object ID for each row in the table.

BarrierFlagID - The unique 'Element ID' of the barrier. The EID is a hidden ID created and used by the geometric network.

Downstream Barrier/Sink - The unique 'Element ID' of the immediately downstream barrier.

7. A 'One-Click Analysis' Walkthrough

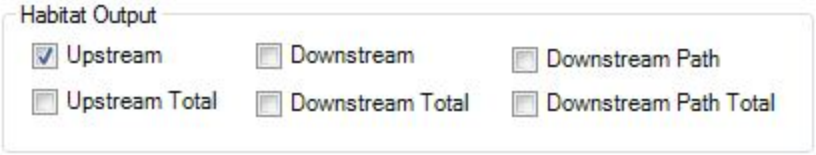
This walkthrough will lead you through conducting a **One-Click Analysis** with FIPEX. Prior to this walkthrough you should have a geometric network created (see Network Creation) using the MXD and dataset provided.

The One-Click Analysis

1. For a simple **One-Click Analysis** using network lines (no classes):

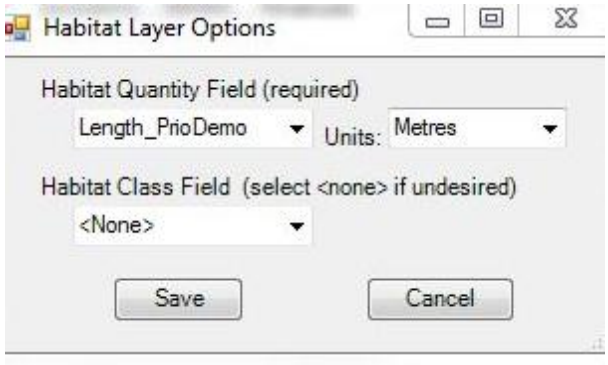
2. Open **FIPEX Options** (Menu -> Options)

3. In the **General Tab**, under **Habitat Output** check **'Upstream'**.



4. In the **Network and Habitat Layers to Include in Analysis** section check **'RiverLines'**.

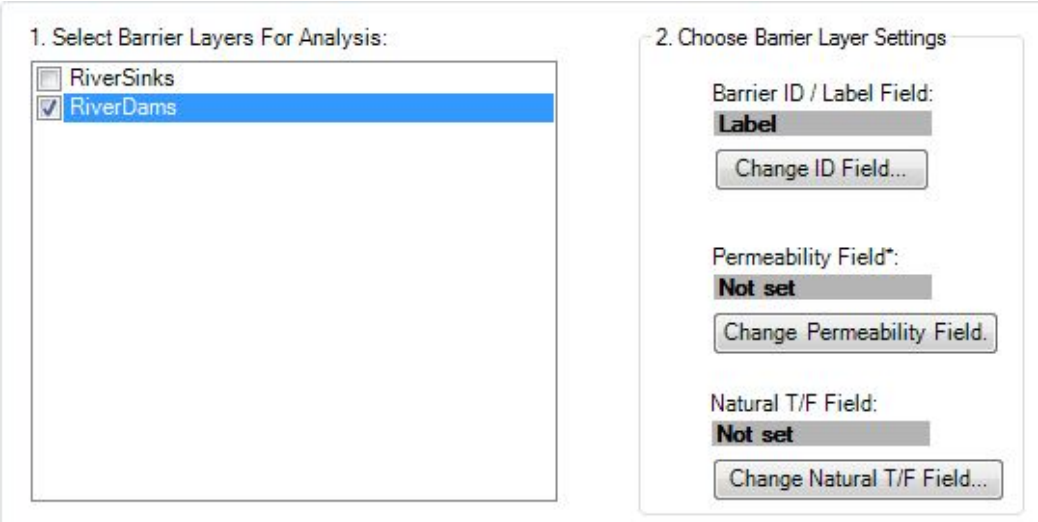
5. Use the **'Change**...' button to set the **Habitat Quantity Field** for *RiverLines* to the *Length_PrioDemo* field. Set the **Units** to Metres and the **Habitat Class Field** to <None>.



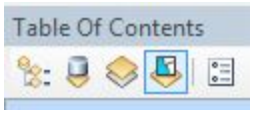
6. Go the **Barriers Tab**. Check *'RiverDams'*.

7. Use the '**Change ID Field'** button to select the *Label* field as the ID field. This specifies which field will be used in output ID's (i.e., the 'user set ID'). Leave the **Permeability Field** and the **Natural T/F** Field not set.

8. Click **'Save Settings'**

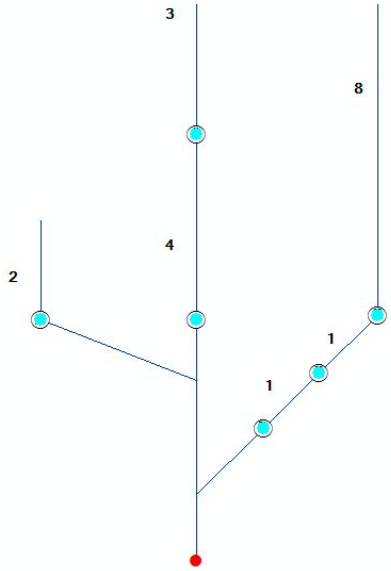


9. Add barrier markers to all barriers in the network. This can be done with the **'Set Barriers on Selected'** or the **'Place / Remove Barrier'** tool. To use **'Set Barriers on Selected'**, go to the **'List by Selection'** Tab of the Table of Contents in ArcMap.



10. Right-click the **'RiverDams'** layer and click **'Make this the only selectable layer'**

Use the **'Select Features by Rectangle'** tool to select all barriers.

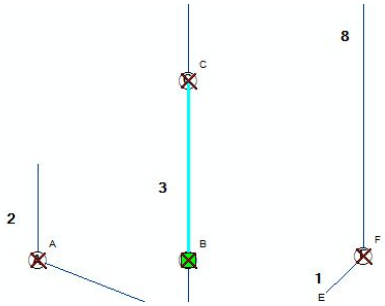


11. Click the **'Set Barriers on Selected'** button.

12. Barriers should be set and labeled on barriers A, B, C, D, E, & F.

13. Use the **One-Click Analysis** tool to perform a quick analysis starting at any barrier or the flag. At any barrier results should appear similar to this:

	Flag	FlagEID	Type	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
▶	B	97	Barrier	Permeability	0	RiverLines	upstream	Immediate	none	3	m
									Total	**3**	
*											



Notice if you click the network sink, the 'Type' in the results changes to 'Sink.'

8. An 'Advanced Analysis' Walkthrough

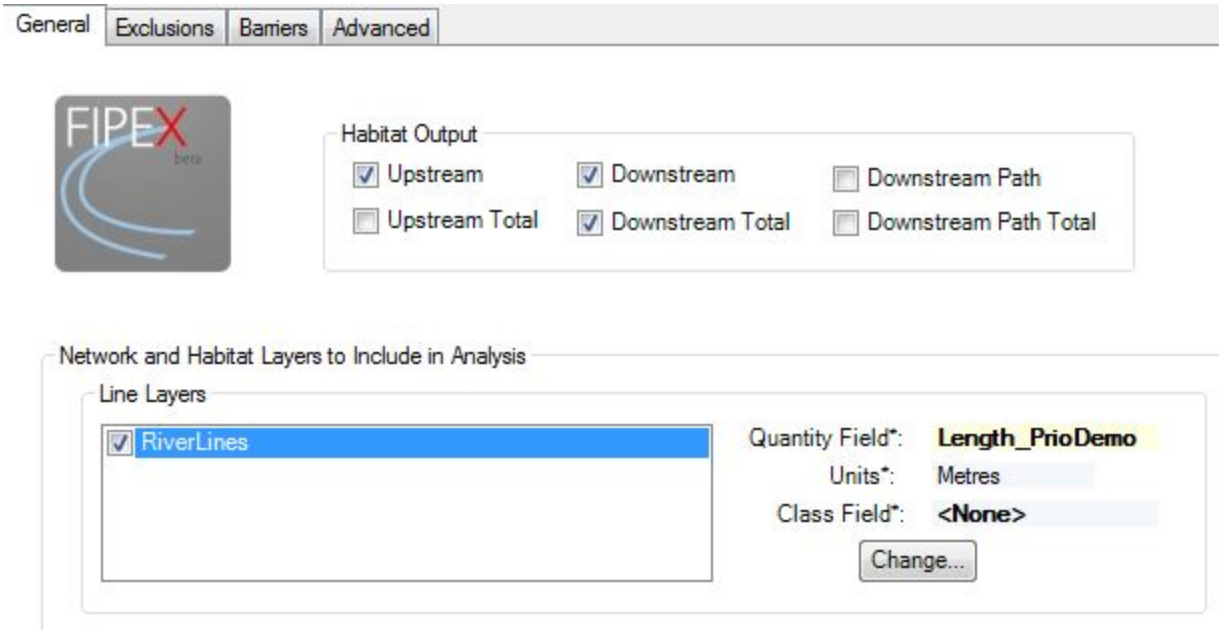
This walkthrough will lead you through conducting an **Advanced Analysis** with FIPEX.

Prior to this walkthrough you should have a geometric network created (see Network Creation) using the MXD (*FIPEX_InstallDemo.mxd*) and dataset provided. You should also have completed the One-Click Analysis Walkthrough (7. A 'One-Click Analysis' Walkthrough).

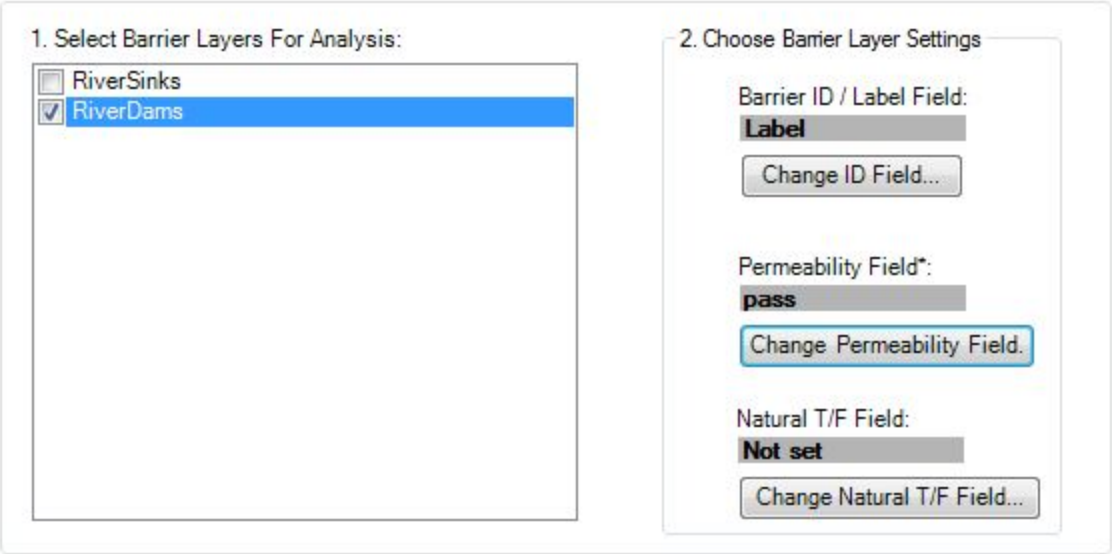
An Advanced Analysis is used to analyze one or many barriers on a given network. It is triggered by clicking the Advanced Analysis button on the FIPEX toolbar .

The Advanced Analysis uses the settings in the Advanced Tab of the FIPEX Options menu (as well as the settings in the General, Exclusions, and Barriers).

1. Open the **FIPEX Options** menu. Make sure the **General Tab** looks like this (check 'Upstream', 'Downstream', 'Downstream Total' and / or any other Habitat Output you wish):

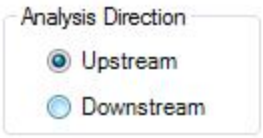


2. In the **Barriers Tab**, highlight **'RiverDams**.' For the **Barrier ID / Label Field**, select the *Label* field using the **'Change ID Field...**' button. Choose the 'Permeability Field', setting it to the *pass* field using the 'Change Permeability Field' button. Make sure the **Barriers Tab** looks like this:



3. In the **Advanced Tab**, in the **"Order" of Analysis**, check "**Maximum**." This setting ensures the analysis will iterate through all barriers encountered between the flag and the end(s) of the network in the Analysis Direction.

4. Set the **Analysis Direction** to '**Upstream**.'

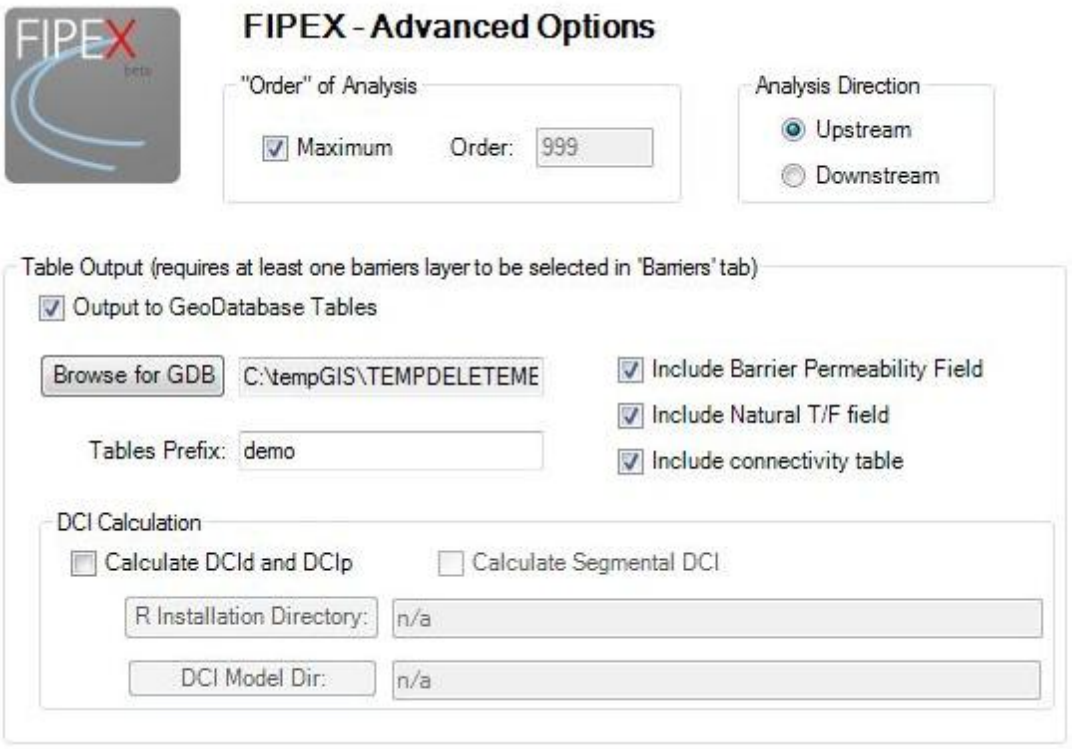


5. Check **'Output to GeoDatabase Tables'**.

6. Click **'Browse for GDB'** and select a geodatabase for output (File Geodatabase preferred). You may choose to use the geodatabase provided with FIPEX (*FIPEX_DemoDataver10_[date].gdb*).

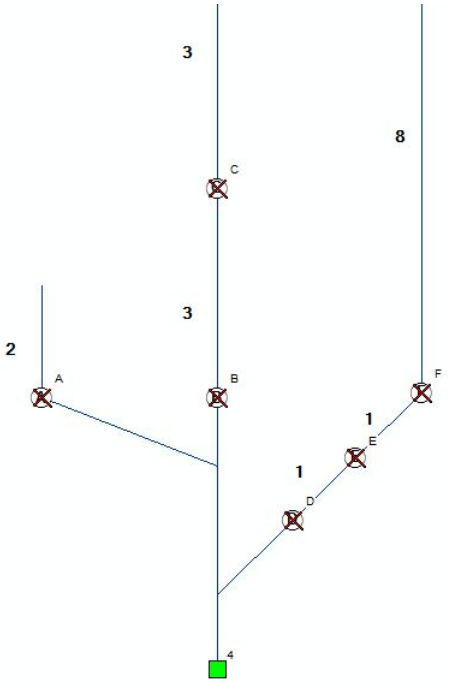
7. In tables prefix enter **'demo'** (or another prefix of your choosing).

8. Check **'Include Barrier Permeability Field'**, **'Include Natural T/F field'**, and **'Include Connectivity Table'**. Make sure your Advanced Tab looks generally like this:



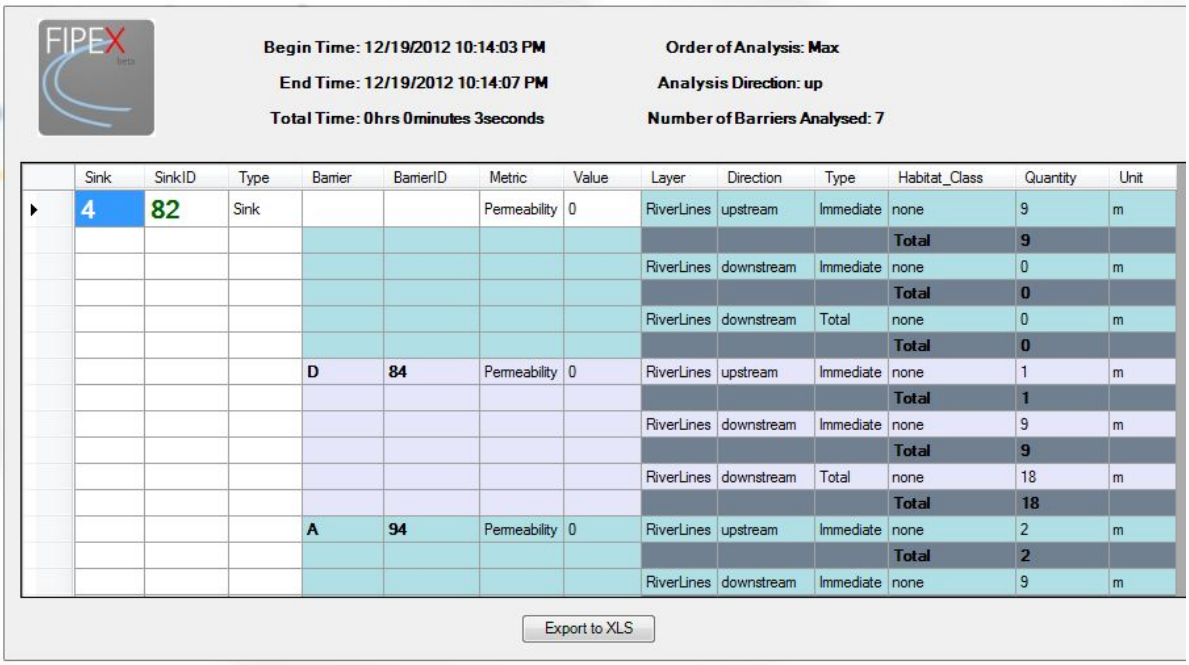
9. Click **'Save Settings'**.

10. In the *FIPEX_InstallDemo.mxd* in ArcMap, place a flag on the sink of the network (use the **Place/Remove Flag tool**), place barrier markers on barriers **A,B,C,D,E, & F** (if you have not used the **'Set Barriers on Selected'** tool see steps 9 thru 12 of the **One Click Analysis Walkthrough)**. Make sure your network looks like this:



11. Click the **Advanced Analysis** button  . This will pop-up the FIPEX Options menu (for review). Click **'Run'**.

12. The output should look similar to this:



Begin Time: 12/19/2012 10:14:03 PM **Order of Analysis: Max**

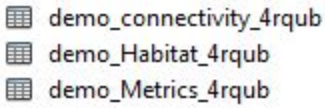
End Time: 12/19/2012 10:14:07 PM **Analysis Direction: up**

Total Time: 0hrs 0minutes 3seconds **Number of Barriers Analysed: 7**

Sink	SinkID	Type	Barrier	BarrierID	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
4	82	Sink			Permeability	0	RiverLines	upstream	Immediate	none	9	m
										Total	**9**	
							RiverLines	downstream	Immediate	none	0	m
										Total	**0**	
							RiverLines	downstream	Total	none	0	m
										Total	**0**	
			D	84	Permeability	0	RiverLines	upstream	Immediate	none	1	m
										Total	**1**	
							RiverLines	downstream	Immediate	none	9	m
										Total	**9**	
							RiverLines	downstream	Total	none	18	m
										Total	**18**	
			A	94	Permeability	0	RiverLines	upstream	Immediate	none	2	m
										Total	**2**	
							RiverLines	downstream	Immediate	none	9	m

Export to XLS

You should also see three tables output in the Table of Contents (the 'List Layers by Source' view should now be active).



Notice in the output form the highlighting alternates between barriers. The first result listed is for the network found immediately accessible to the sink. Subsequent results (barriers D and A in the image) are reported next. The Permeability Metric is included for each. The Total is specific for each layer, each direction, and each trace type. There is only one item summed for each 'total' in this case because we have no habitat 'classes' specified.

For an explanation of the output tables see FIPEX Output Tables.

9. A DCI Calculation Walkthrough

This walkthrough will lead you through conducting an **Advanced Analysis** with Dendritic Connectivity Index (DCI) output. Prior to this walkthrough you should:

1. Have a geometric network created (see Network Creation) using the MXD (*FIPEX_InstallDemo.mxd*) and dataset provided.
2. Have completed the One-Click Analysis Walkthrough (7. A 'One-Click Analysis' Walkthrough).
3. The setup for the FIPEX Options is similar to that of the Advanced Analysis Walkthrough (8. An 'Advanced Analysis' Walkthrough). Performing that is recommended.
4. The 'R' Statistical software is needed during the analysis and so steps 3a - 3k of Installing the R Statistical software for Windows should be done.

The DCI analyses calculate metrics of connectivity for a river system or segments of a river system. The DCId characterizes *diadromous* connectivity, that is, the connectivity of the ocean / sink to the river system and vice versa. This metric may be used to characterize the system's accessibility for diadromous migratory fish such as salmon or the American Eel, for example. The DCIp characterizes potadromous connectivity -- the connectivity between sections of a river system and other sections of a river system. The DCIp characterizes the ease with which resident fish may move within the system. The DCI segmental is specific for individual reaches of river and is a measure of the connectivity of that segment (or 'reach') to the other reaches of river. At a basic level, the DCI metrics reflect the probability that a fish may move through the system. The DCI is given on a 0-100 index, with a DCI=100 being 100% connected.[3]

[3]The DCI's are semi-structural, in that they incorporate some biological data in determining barrier passabilities, but do not consider other biological aspects, such as movement motivation.

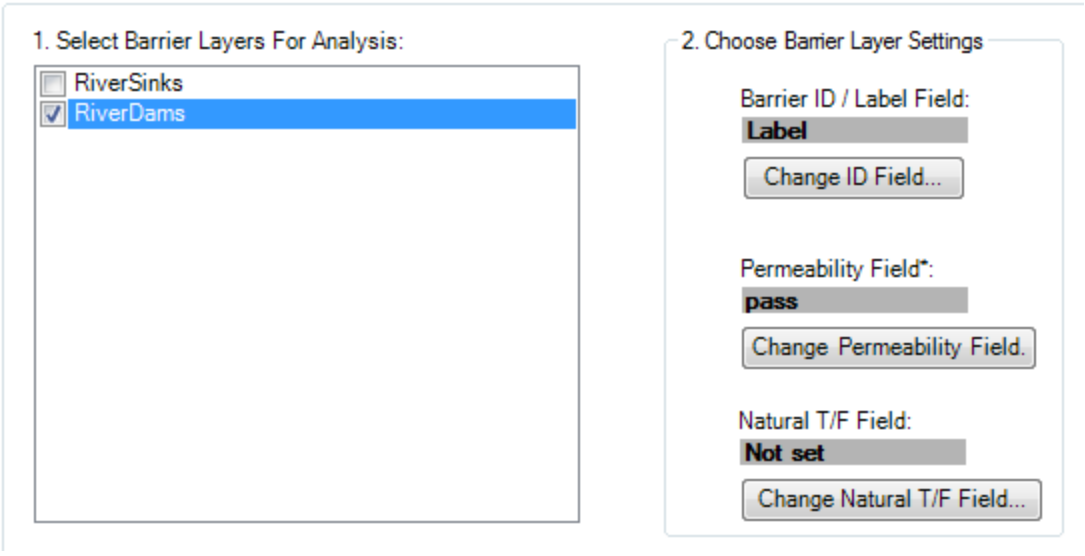
The DCI metrics rely on a parameter called permeability (*p;* sometimes referred to as *passability* or *passage efficiency*) of barriers. This parameter is the degree to which a barrier impedes passage or connectivity. In FIPEX analyses, permeability is a 0-1 index, with *p*=1 being 100% passable. The permeability of a barrier reflects *the probability that a fish will successfully pass a barrier*. Another way to define permeability is: *the proportion of a given fish population that will successfully pass a barrier.*

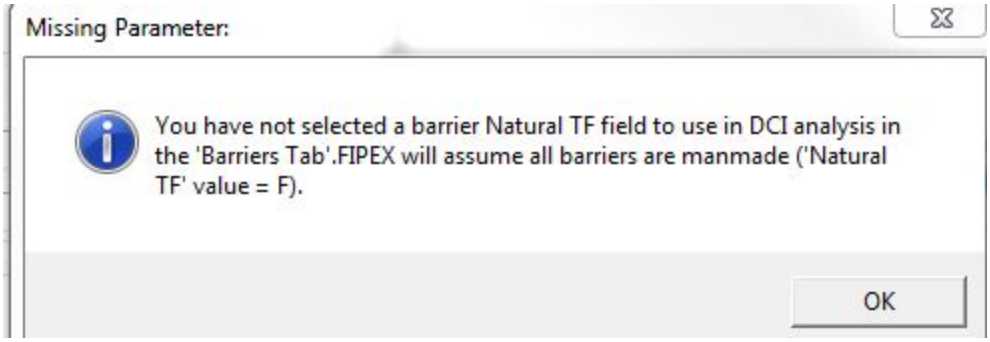
For FIPEX to calculate the DCI's, a *permeability* field must be chosen for each barrier layer included in the analysis. This can be found in the FIPEX Options Barriers Tab.

To set the permeability field open the FIPEX Options menu and go to the Barriers Tab.

1. Highlight the RiverDams layer.

2. Click the **'Change Permeability Field'** button. Choose the *pass* field. Click **'Save'** to close the pop-up. The settings should look like this:

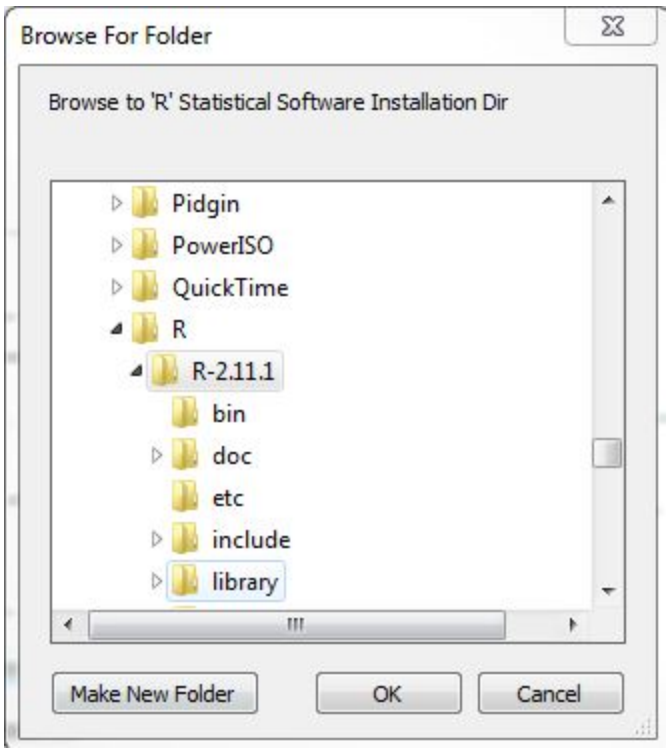




3. Go to **FIPEX Options Advanced Tab**. Check **'Include Barrier Permeability Field'**, **'Include Natural T/F Field'**, and **'Include Connectivity Table'**. The DCI Calculation section should now be visible.

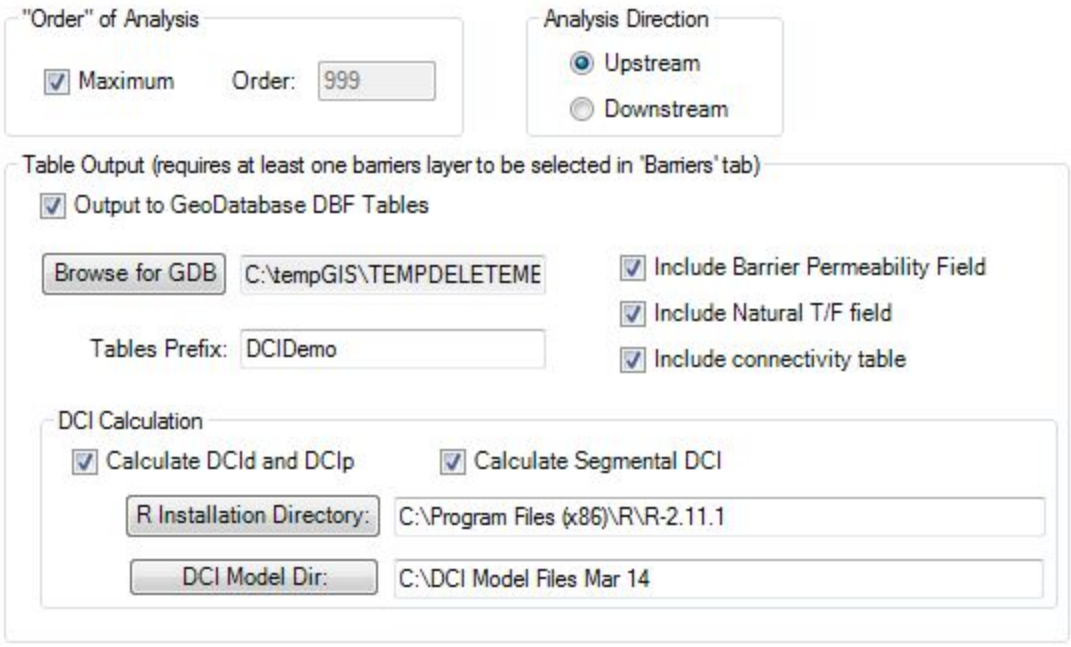
4. Check **'Calculate DCId and DCIp'** and '**Calculate Segmental DCI'**.

5. Click '**R Installation Directory'**. Navigate to the location of the R Statistical Software. Select the directory and click **'OK**.'



6. Click the '**DCI Model Dir'** button. Navigate to and select the directory provided with the FIPEX add-in. The name will be similar to: *DCI Model Files Mar 14*. **You must have read / write permissions to this directory.**

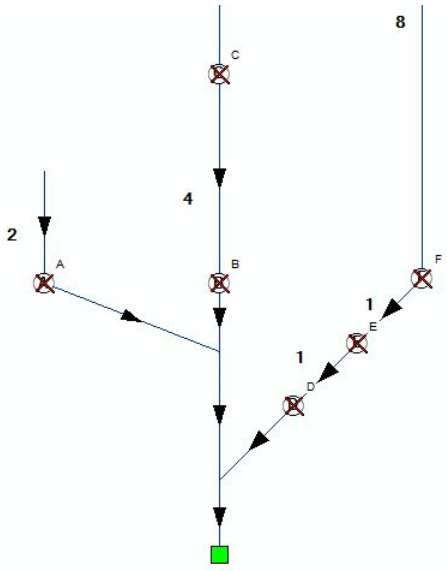
Make sure that the final setup looks similar to this:



7. Click '**Save Settings**'.

8. Review the network. You should be using the demo MXD provided with FIPEX. There should be barrier markers on each of the network barriers. A green flag should be on the sink of the network.

9. Click the Advanced Analysis button. Notice the FIPEX Options appears again. This is provided to double-check settings. Click the **'Run'** button.



10. Results returned should look similar to:

Sink	SinkID	Type	Barrier	BarrierID	Metric	Value	Layer	Direction	Type	Habitat_Class	Quantity	Unit
4	82	Sink			Permeability	0	RiverLines	upstream	Immediate	none	9	m
					DCIp	22.45				**Total**	**9**	
					DCId	32.14	RiverLines	upstream	Total	none	28	m
					DCI Sectional	32.14				**Total**	**28**	
			D	**84**	Permeability	0	RiverLines	upstream	Immediate	none	1	m
					DCI Sectional	3.57				**Total**	**1**	
							RiverLines	upstream	Total	none	10	m
										Total	**10**	
			A	**94**	Permeability	0	RiverLines	upstream	Immediate	none	2	m
					DCI Sectional	7.14				**Total**	**2**	
							RiverLines	upstream	Total	none	2	m
										Total	**2**	
			B	**97**	Permeability	0	RiverLines	upstream	Immediate	none	3	m
					DCI Sectional	10.71				**Total**	**3**	
							RiverLines	upstream	Total	none	7	m

Notice the DCIp and DCId are reported only in the row associated with the sink / flag. This is because these metrics are associated with the entire river system. The DCI Sectional is reported for each barrier (and the sink). The 'Section' referred to is the immediately upstream section of river from the barrier to the next barrier(s) in the network. The DCI Sectional is also given for the segment immediately upstream from the sink / flag which will always match the DCId (somewhat redundant).

There is an extra table created and visible now in the Table of Contents. This is titled 'DCI', prefixed with the characters you chose in the FIPEX Options and suffixed with a random five character code. This table contains exactly what was sent to the R Model to calculate DCI.

ObjectID *	BarrierID	Habitat Quantity Field	Barrier Permeability Field	Barrier Natural TF Field
1	Sink	9	0	F
2	84	1	0	F
3	94	2	0	F
4	97	3	0	F
5	98	1	0	F
6	100	4	0	F
7	99	8	0	F

This completes the walkthrough

10. Getting Started -- Network Building Tips

Building geometric networks and conducting quality assurance can be time consuming. Here are a few pointers and tips to help.

Use a 'File Geodatabase'

With FIPEX, a File Geodatabase as opposed to a Personal Geodatabase is more extensively tested. Choosing a File Geodatabase to store and work with data is recommended.

'Clean' the Dataset Prior to Building the Network

The Build Geometric Network Wizard has a 'snapping' feature, but it rarely worked as expected. ESRI recommends 'cleaning' the dataset prior to geometric network creation. In this case, 'cleaning' the dataset means that barrier points fall exactly on top (are coincident with) river network lines. ESRI recommends using Topology rules in the geodatabase to achieve this:

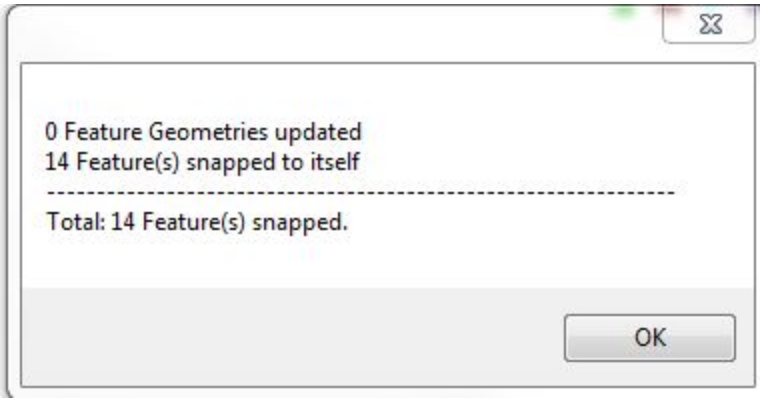
http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//002r00000008000000
http://gis.stackexchange.com/questions/35270/arcgis-10-sp-3-geometric-network-which-features-are-moved

There are a number of ways to do this, and topology can be complicated. If you choose not to use topology, FIPEX contains a tool called 'Batch Snap Points to Lines.'

This tool operates using an active edit session, a selection of point features, and the settings in the Snapping Window of the General Editing Options. It will snap points to lines based on snapping settings in ArcMap.

To Snap Points to Lines
1. Select all point features you wish to have snapped to lines. The **'Batch Snap Points to Lines**' command should now activate on the FIPEX Toolbar.
2. Click on the **'Batch Snap Points'** command.

3. Click **OK**.
4. Results should be reported.



5. Save Edits: **'Editor'** -> **'Save Edits'**. Do not end the edit session.
6. The changes in the barrier locations must now be registered with the geometric network. Use the **Geometric Network Editing Toolbar** to do this. Click the **'Connect'** button on the toolbar.

7. **Save Edits**, **End Edit Session**.

Use a Temporary Network to Help 'Clean' the Dataset

Creating a geometric network with points and lines as they are (imperfect) will be useful because the tools provided with the Utility Network Analyst Toolbar provide means to troubleshoot the network. After troubleshooting and editing, the network can be deleted and rebuilt (if need be).

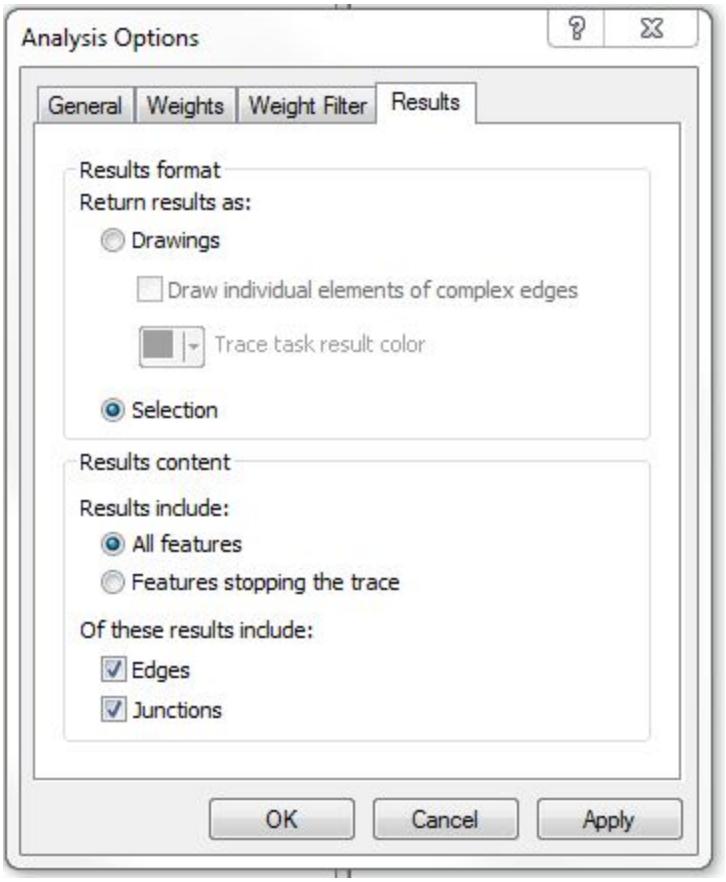
Specific tools provided with the Utility Network Analyst Toolbar that can be used to help troubleshoot a network are:

- **Find Connected**
- **Find Disconnected**
- **Find Loops**

By setting the Analysis Options on the Utility Network Analyst Toolbar to return results as a selection, using Find Disconnected can be useful in identifying which barriers are not currently participating in the network. A useful process is combining this functionality with the 'Bulk Snap Points to Barriers' command provided with FIPEX. The general process is:

1. Start an edit session by right-clicking the barrier features you wish to snap in the Table

of Contents. **'Edit Features'** -> **'Start Editing'**
2. Set a junction or edge flag using the **Utility Network Analyst** tools
3. Set the Analysis Options (**'Analysis'**->**'Options'**) to trace on all features and trace indeterminate flow: **General Tab**, check **'Directed trace tasks include edges with indeterminate and uninitialized flow'**.
4. Set the results to return a selection: **Results Tab**, **'Selection'** radio button.



4. In the **'List by Selection**' tab of ArcMap's **Table of Contents**, right click your barrier(s) layer and click **'Make This the Only Selectable Layer'**.
5. Select a Trace Task in the dropdown of the **Utility Network Analyst Toolbar**.
6. Click the **'Solve'** button. Only disconnected barrier features should be returned.
7. Click the **'Bulk Snap Points to Barriers'** button (be sure to follow instructions from earlier on setting Snap Tolerances). The barriers should snap to lines.

8. (see above note) Click **'Connect'** on the **Geometric Network Editing Toolbar**.
9. Save your edits. **'Editor'** -> **'Save Edits'**
10. Re-run trace results and see what barriers are still unconnected.

Problem Lines or Points may Cause Other Features to be

Disconnected

If a **'Find Disconnected'** trace reveals lines or points to be unexpectedly disconnected from the geometric network a select few of these lines or points may be causing the others to remain disconnected -- fixing these few may fix the others.

TIP: When first building and troubleshooting a network, simply selecting points and lines and clicking the 'connect' button on the Geometric Network Editing toolbar (with an edit session started) may fix some of these errors.

Check the table of Network Build Errors for Error Codes

During network creation, a number of build errors may occur. The Geometric Network Editing Toolbar can help identify the problem features. In an edit session you can use the Network Build Errors command of this toolbar to highlight problem features. For more information, see:
http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//002r0000000z000000

The build errors are also stored in a table identified as the geometric network's name appended with _BUILDERR. The table is found in the root of the geodatbase. As of December, 2012, the codes refer to:

Error Code	Error description
10	The feature has an empty geometry.
11	The feature's geometry has multiple parts.
12	The feature's begin and end vertex are the same.
13	The feature has a geometry with zero length.
14	The edge feature is associated with the same from–to junction feature.
15	The junction is coincident with an edge–feature vertex having a different z-value.
16	The junction is not connected to any other edge feature.
17	Edge features prevented from collapsing on themselves because their length is near the snapping tolerance.

-- from
http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//002r00000006000000

Deal with 'Loops' or 'Braids' on a Case-by-Case Basis

The geometric network determines flow direction based on the 'tree' structure of a river network. When that structure is broken - as is the case with segments of river that are braided or in a river delta - the direction of flow as seen by the network is categorized as 'indeterminate'.

Currently, the only way to handle 'Loops' and 'Braids' is on a case-by-case basis. In the case of smaller braids with no barrier present on any of the braids, they may be ignored. In the case of braids over large areas of network or in braids that contain a barrier, a decision will have to be made. If it is decided that the flow and subsequent FIPEX analyses should be forced 'through' the barrier, network line elements may be 'disabled' in the attribute table.

'Disabling' a network element means that network traces may not pass through the element. To 'disable' a network element:
1. Start an edit session for the layer containing the network element (line, usually) you wish to disable.
2. Go to the '***Enabled***' field and change the value for that feature to ***'false'***.
3. Click **'Connect'** on the **Geometric Network Editing Toolbar'**.
4**. Save Edits. End Edit Session**

The 'enabled' or 'disabled' setting is saved in the attribute table of the network layer. This is useful if the network needs to be rebuilt, as the state of the feature is saved.

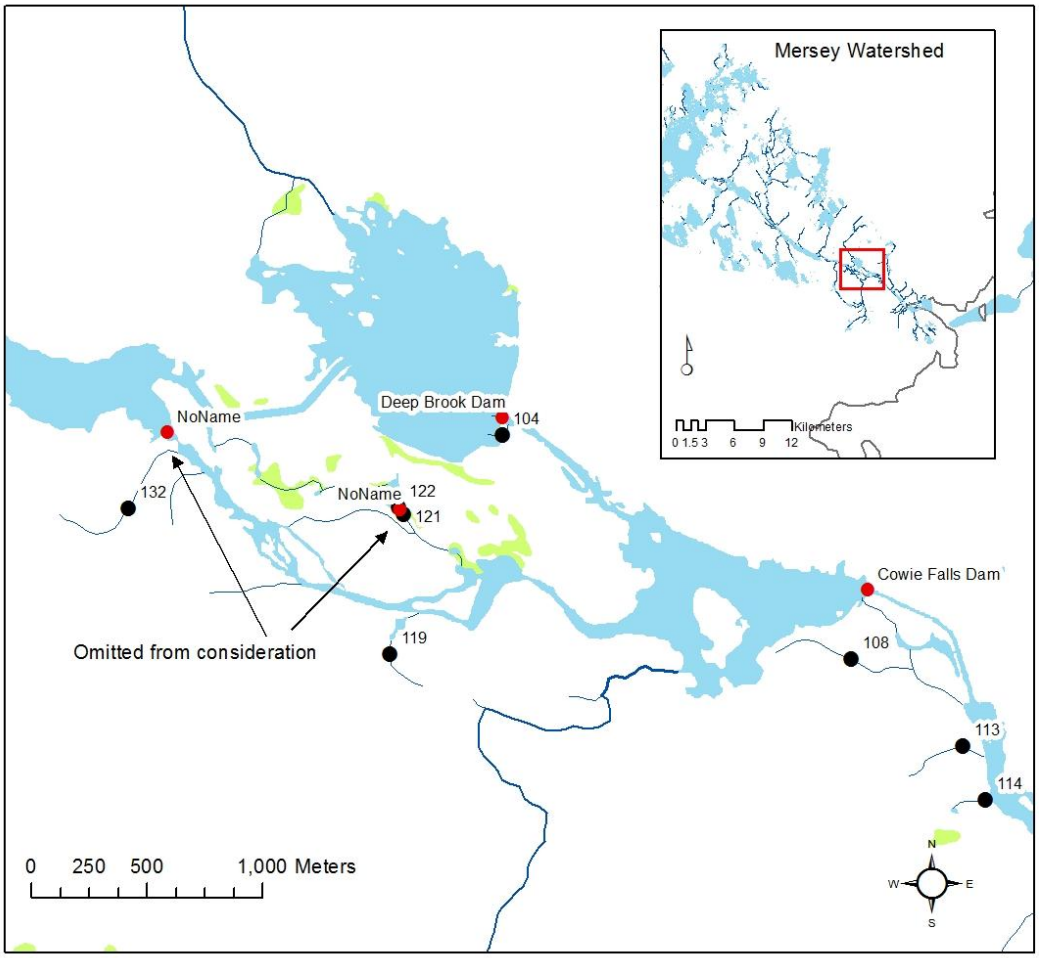


Figure 5: In the case of a braided section of this river, the barrier features titled 'NoName' were disabled, forcing analysis traces through Deep Brook Dam.

Thoroughly Check for Duplicate (i.e. stacked) Barriers

In many circumstances, barriers can be 'stacked' on top of each other. This can cause problems when 'setting' these barriers.

Currently, there is no easy way to clean these duplicate barriers. Scripts may be available with other extensions or on the Internet. Alternatively, manually check for duplicates after all other checks have been done. A 'Find Disconnected' search with Utility Network Analyst will help identify potential problems.

Check with the Data Provider for Hydrographic Specifications

Most regions have a government authority who manages spatial data including a hydrographic dataset. These datasets are increasingly maintained with adherence so some basic hydrographic standards. One key standard, for example, is the continuance of river network lines through lakes and large water bodies to maintain network connectivity throughout. Knowledge of what standards your data already meet will be helpful during network analysis with FIPEX.

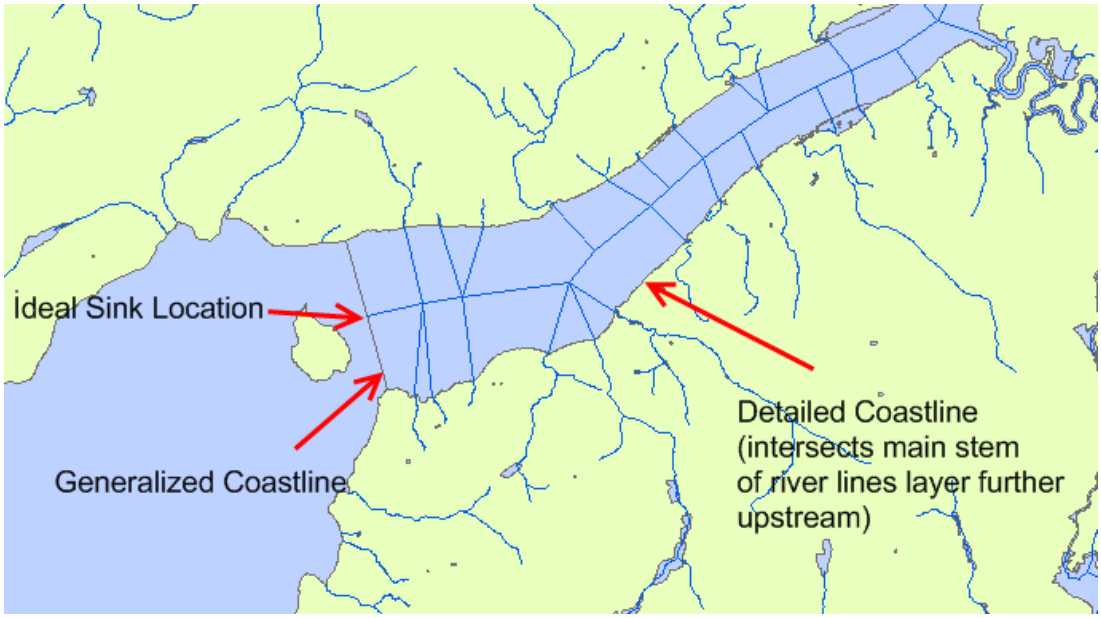
Create a separate 'Sinks' layer

A sink represents the outflow of a river system. The function of the sink is to determine network flow in the geometric network -- everything connected to the sink flows towards it. A separate sinks layer is a good idea and it is recommended for using FIPEX (in FIPEX Options you will choose a layer to be used as a 'barriers' layer by FIPEX. Combining a 'sinks' layer with a 'barriers' layer may have unintended consequences.).

Create a single sink for multiple watersheds

To minimize time spent locating and creating sinks for many river systems, you can create a single sink for multiple networks by editing network lines to connect multiple river systems. These lines are unrepresentative of actual river network and therefore serve a function similar to lake 'spines,' for example. In similar practice, an attribute can be assigned to these features to use in the Exclusions tab of the FIPEX Options menu.

It is possible to use a coastline layer of a region to intersect with rivers. Using a tool like Hawth's Tools "Intersect Lines (Make Points) Tool" (http://www.spatialecology.com/htools/tooldesc.php) you can create points at the intersection of two lines layers. This method does not always yield the desired results because large coastal rivers often are segmented by tributaries (see example below) and therefore a custom generalized coastline layer often must be created to properly place a sink along large rivers.


Ideal Sink Location
Generalized Coastline
Detailed Coastline
(intersects main stem
of river lines layer further
upstream)