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Arc Hydro Stormwater Processing

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Table 1. Authors and Participants

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Table 2. Document Revision History

Version	Description	Date
1.0	First Version.	10/03/2017

Table 3. Related Documents

Description	Date

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1.0 Introduction

This document describes how to prepare the data required to support the Arc Hydro stormwater delineation tool.

1.1 System Environment

This workflow requires ArcGIS for Desktop 10.3.1 or greater with the Spatial Analyst Extension.

1.2 Arc Hydro Version

All processing may be performed using the versions of the Arc Hydro tools released after August 2017. Ensure you are using the Arc Hydro Tools Python toolbox, not the old Arc Hydro Tools, and not the Arc Hydro Tools menu bar:

1.3 Dataset

The dataset used as an example in this document is the Saint Louis combined storm sewer dataset provided by the USGS. An associated Stream dataset and Digital Elevation Model raster dataset were provided as well.

Figure 1 - CSS Data and Stream Datasets

1.4 Preprocessing Methodology

The data preprocessing is based on standard Arc Hydro terrain preprocessing tools.

1. All vector layers in the dataset must have HydroIDs assigned. The tools used in this document require geodatabase feature class layers as input and output data layers.
2. If errors are encountered, it is advised that users use a new ArcMap document to continue tasks.
3. Ensure that Target Locations are set in all new map documents.

2.0 Review Input Data

- Stormwater Network
- Stream
- DEM

2.1 Data Projection

The same projection must be used for raster and vector data. Projection must use a projected coordinate system that makes sense to support further analyses (area/length).

2.2 Digital Elevation Model

The DEM should be integer to speed up processing time.

Check units. If the DEM is in meters, convert it to centimeters. You can use the following map algebra expression in the Raster Calculator: Int(("floating_point_DEM" * 100) + .5)

The input dem_raw has values ranging from 22511 to 5899. The linear unit is meters, which means the elevation are in centimeters.

When looking at the projection information, the Coordinate System is “NAD_1983_Albers” but there is no Z unit defined. So the assumption is that the elevations are in meters.

The Define Projection tool may be used to correctly set the z-unit.

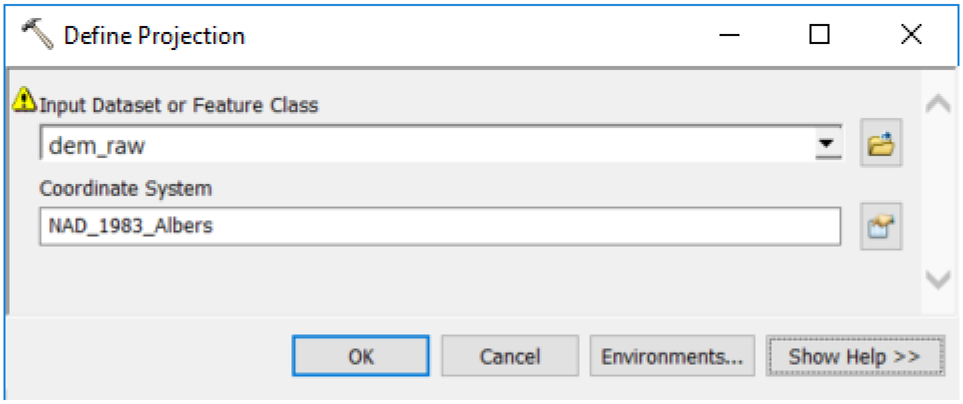


Figure 2 – Define Projection Tool

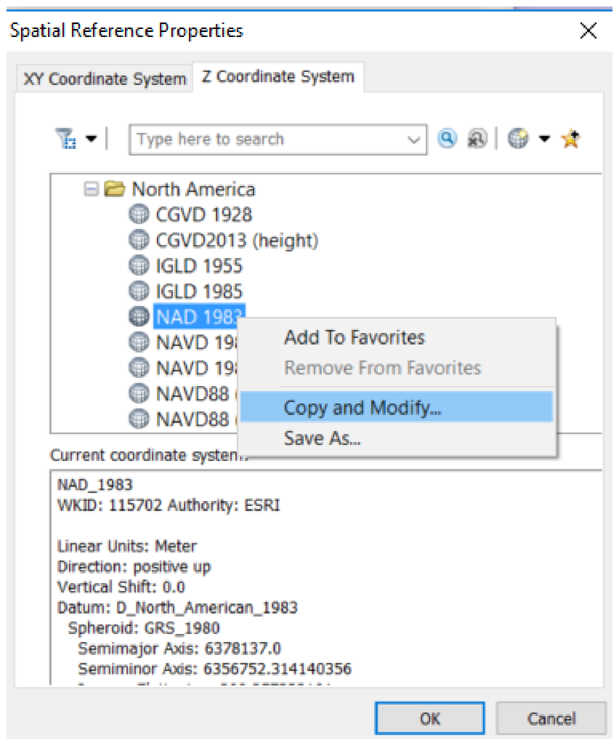


Figure 3 - Define Z Coordinate System

- Set the Linear Unit to centimeter and click Apply.

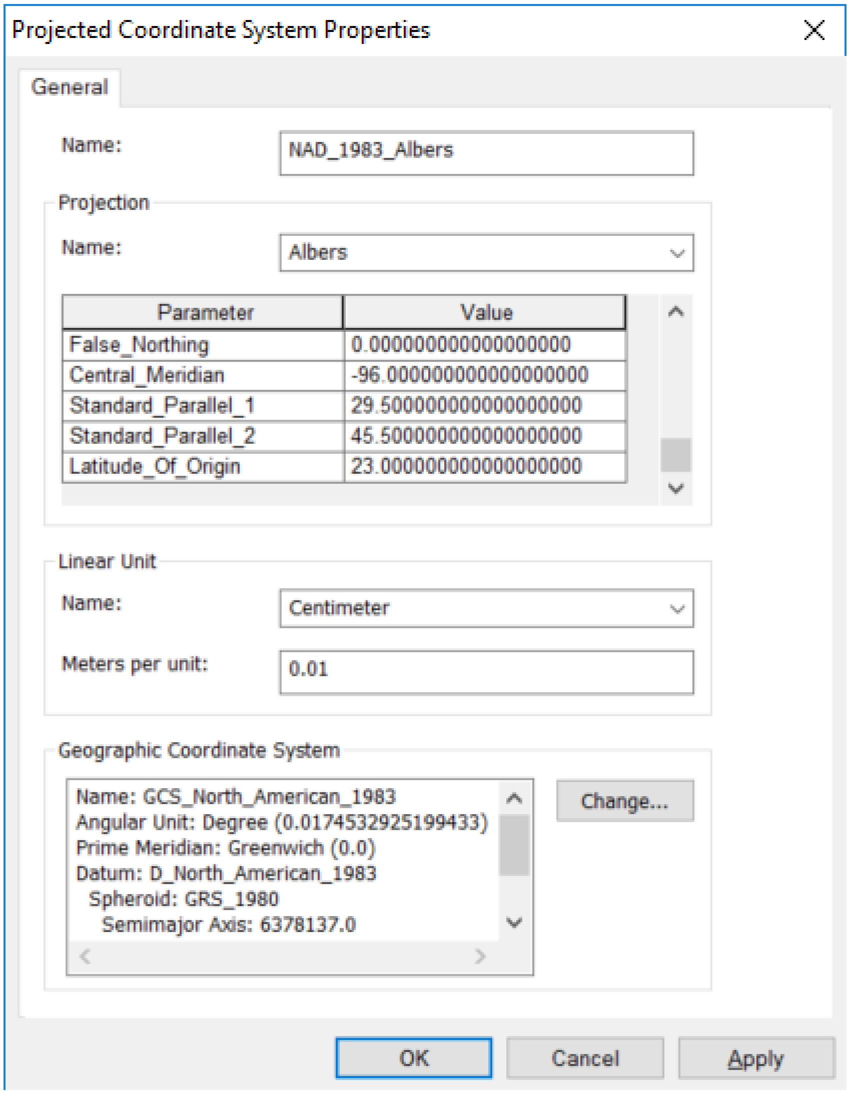


Figure 4 - Projected Coordinate System

```
Executing: DefineProjection dem_raw
PROJCS['NAD_1983_Albers',GEOGCS['GCS_North_American_1983',DATUM['D_North_Ame
rican_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich'
,0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Albers'],PARAMETER['Fal
se_Easting',0.0],PARAMETER['False_Northing',0.0],PARAMETER['Central_Meridian
',-
96.0],PARAMETER['Standard_Parallel_1',29.5],PARAMETER['Standard_Parallel_2',
45.5],PARAMETER['Latitude_Of_Origin',23.0],UNIT['Centimeter',0.01]],VERTCS['
NAD_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.25
7222101]],PARAMETER['Vertical_Shift',0.0],PARAMETER['Direction',1.0],UNIT['C
entimeter',0.01]]
Start Time: Thu May 11 15:48:44 2017
     Succeeded at Thu May 11 15:48:45 2017 (Elapsed Time: 0.04 seconds)
```

2.3 Identifying Stormwater Network Layers

2.3.1 Defining Layers Roles

The requirements for the network that will support the stormwater delineation process are as follows:

- Pipe line layer
- Stream line layer,
- HydroJunction: point location where the water may enter the closed pipe system via an inlet or seep into the ground via a sink. These HydroJunctions will be related to an associated SinkWatershed.

The input data must be reviewed to determine which input features will be used to create this network and to ensure proper connectivity when tracing through the network

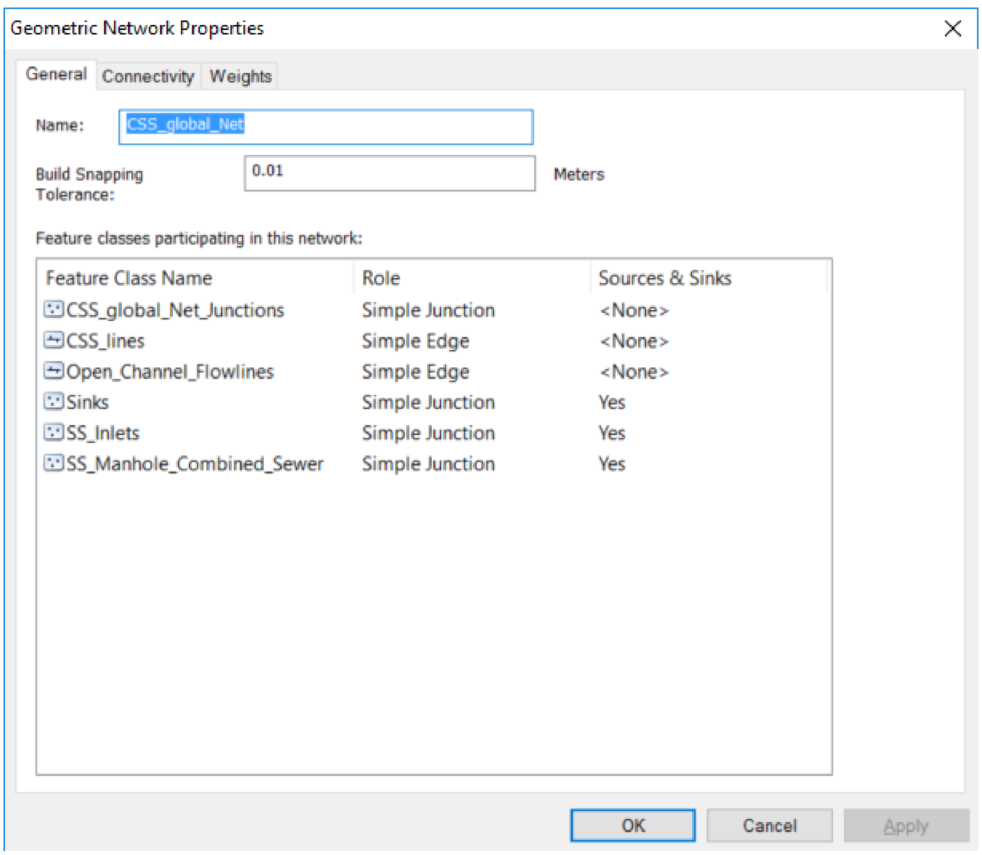


Figure 5 - Sample Input Geometric Network

For example, in the data shown above, the CSS_lines will be used to create the Pipe layer, Open_Channel_Flowlines to create the Stream layer and Sinks, SS_Inlets and SS_Manhole_Combine_Sewer will be combined to create the HydroJunction point layer.

2.4 Review Pipe Layer

Surface water enter the Pipe via a HydroJunction (Inlet).

A pipe may connect to another pipe or stream feature without requiring a HydroJunction (Inlet or Sink) at its end.

Pipe may end in a HydroJunction (Sink).

2.5 Review Stream Layer

If your input data is part of an existing network export the layer so that it does not belong to the network.

For example, in the CSS network, the Open_Channel network edge layer was exported to the layer Open_Channel_NoNetwork.

2.5.1 Remove pseudo nodes

Review the data and check whether there is only one feature between 2 confluences.

The input Open_Channel_NoNetwork has 47805 features.

Table

Open_Channel_NoNetwork

OBJECTID *	Shape *	ARCID	GRID_CODE	FROM_NODE	TO_NODE	Shape_Leng	Enabled	HydroID	Shape_Length
1	Polyline	128	1060	62	91	6	True	1248277	6
2	Polyline	128	1060	62	91	4.242641	True	1248278	4.242641
3	Polyline	128	1060	62	91	6.588341	True	1248279	6.588341
4	Polyline	128	1060	62	91	25.351636	True	1248280	25.351636
5	Polyline	128	1060	62	91	9.486833	True	1248281	9.486833
6	Polyline	128	1060	62	91	12.369317	True	1248282	12.369317
7	Polyline	128	1060	62	91	12.369317	True	1248283	12.369317
8	Polyline	128	1060	62	91	6.708204	True	1248284	6.708204
9	Polyline	128	1060	62	91	8.244992	True	1248285	8.244992
10	Polyline	128	1060	62	91	15.954601	True	1248286	15.954601
11	Polyline	128	1060	62	91	13.416408	True	1248287	13.416408
12	Polyline	128	1060	62	91	16.155494	True	1248288	16.155494

1 (0 out of 47805 Selected)

Open_Channel_NoNetwork

Figure 6 - Open_Channel_NoNetwork Attributes Table

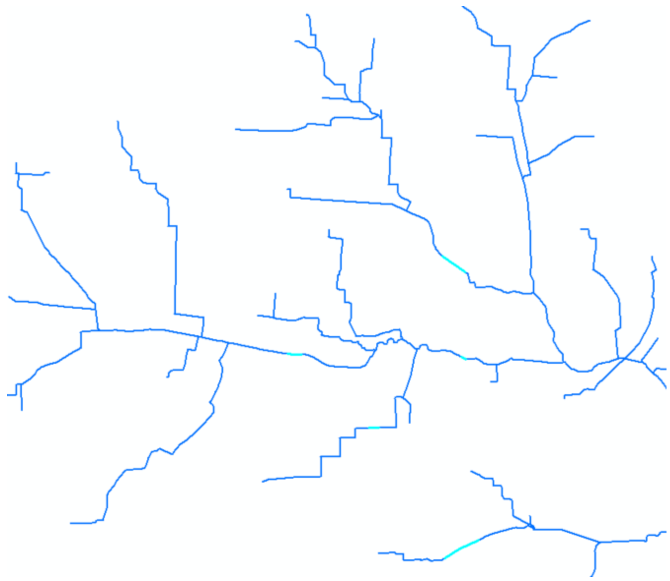


Figure 7 – Features with pseudo nodes

The tool Remove Pseudo Nodes is in the Arc Hydro Tools toolbox under the Watershed Processing > Line Processing toolset. Before running the tool, ensure that target locations are set and the following attributes are assigned in the input layer: HydroID, FROM_NODE, TO_NODE, NEXTDOWNID. Save map document.

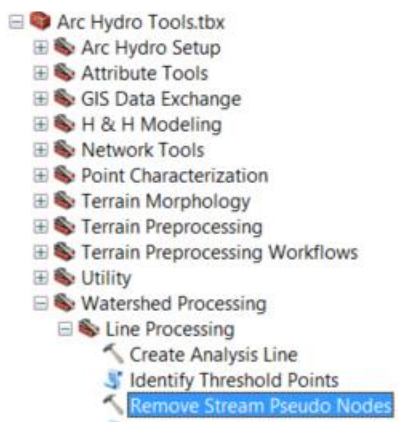


Figure 8 - Remove Stream Pseudo Nodes Tool

The processing time will depend on the number of existing pseudo nodes that need to be removed.

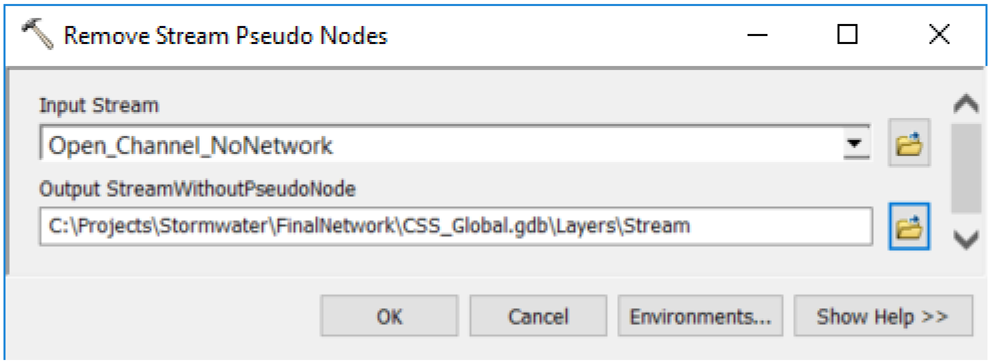
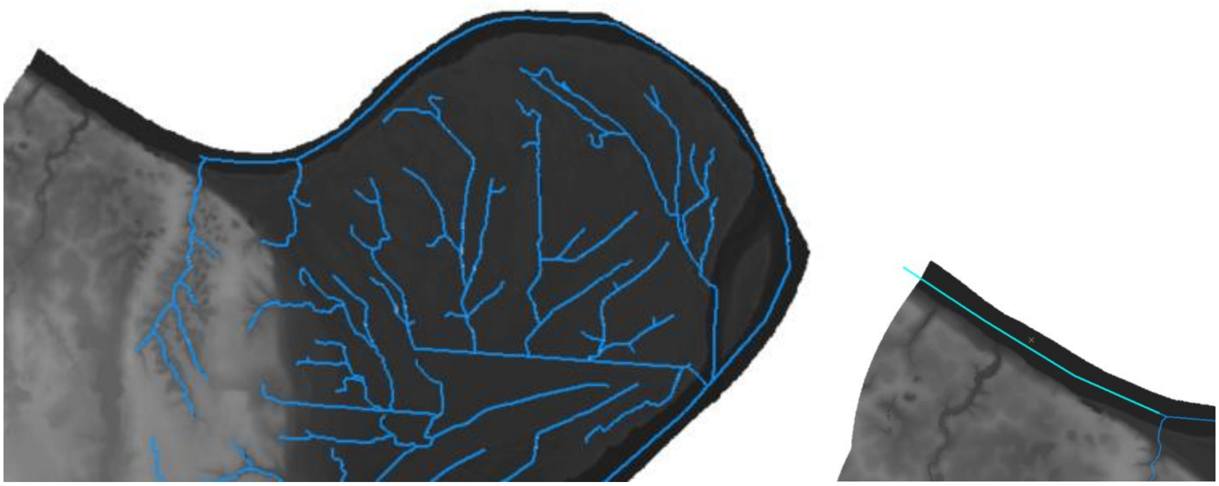


Figure 9 - Remove Stream Pseudo Nodes Tool

2.5.2 Extend lines outside of DEM extent

The Stream layer may need to be edited so that they cross the DEM's boundaries at the upstream and downstream end of Stream. Water needs to be able to enter and exit the DEM, either through a sink/inlet or by crossing the boundary.

Stream features will be burnt into the DEM during the processing, and the reconditioned DEM will be later filled back in if the water cannot "exit" the DEM. The water flowing through the stream must be able to flow out of the streams through a sink or an outlet.



Before After

Figure 10 - Adding Stream entering the DEM

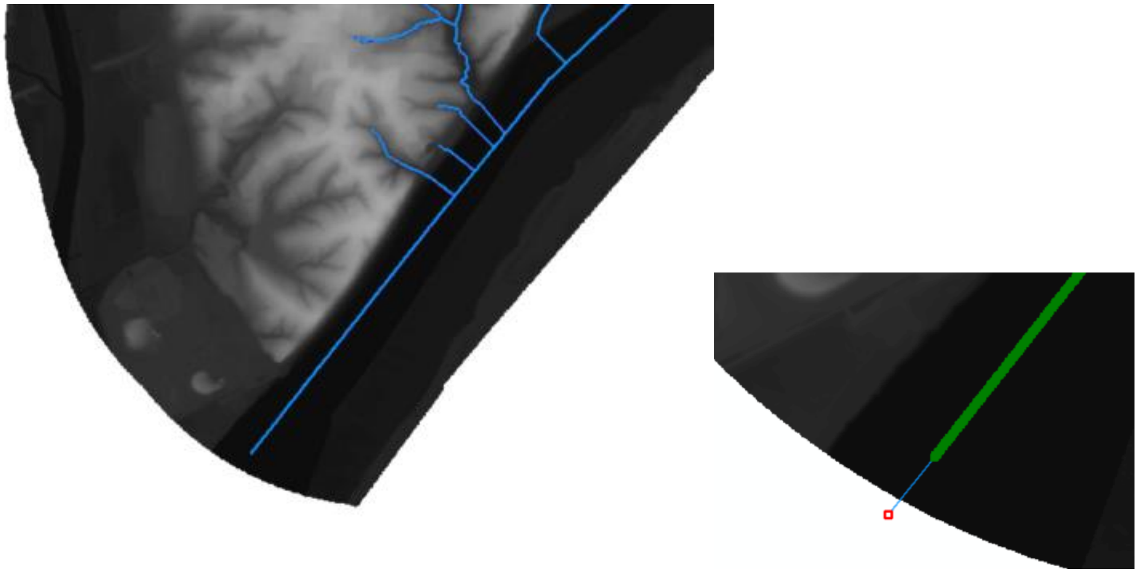


Figure 11 – Adding Stream leaving the DEM

2.5.3 QC Stream Geometry

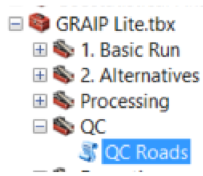


Figure 12 – QC Roads Tool

QC input lines with the following checks:

- Zero length lines

- Multipart lines

- Overlapping lines

- Lines with From_Node = To_Node

Ran this tool and corrected bad geometry, then re-ran the tool and got clean geometry:

```
Executing: QCRoads Streams_no_pseudonodes
F:\project_work\StreamStats_MO_CSS\from_Rodney\ESRI_040617\ESRI_040617\CSS_g
lobal.gdb\CSS_global\Stream_QC_Geometry2
Start Time: Thu Jul 20 12:53:16 2017
Running script QCRoads...
Total number of input features:          2641
Number of features with zero length:     0
Number of single part features:          2641
Number of multipart input features:      0
Number of features in output:            2641
Number of features with overlap:         0
Number of features with loops:           0
Number of features with end loops:       0
2641 record(s) updated on
F:\project_work\StreamStats_MO_CSS\from_Rodney\ESRI_040617\ESRI_040617\CSS_g
lobal.gdb\CSS_global\Stream_QC_Geometry2. The HydroID values ranged from
263560 to 266200.
Completed script QCRoads...
Succeeded at Thu Jul 20 12:53:42 2017 (Elapsed Time: 26.38 seconds)
```

2.5.4 QC Streams

The QC Streams tool may be used to review the geometries of the input Stream in association with the DEM.

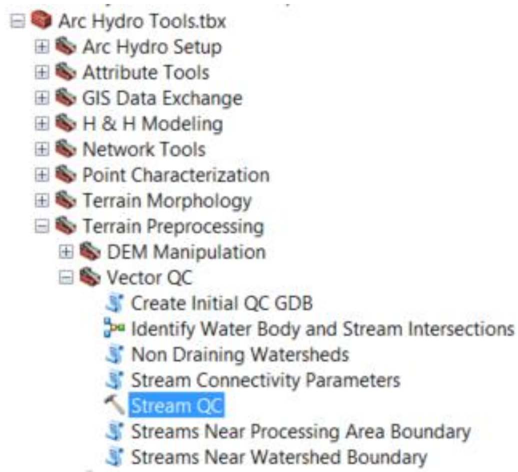


Figure 13 – QC Streams Tool

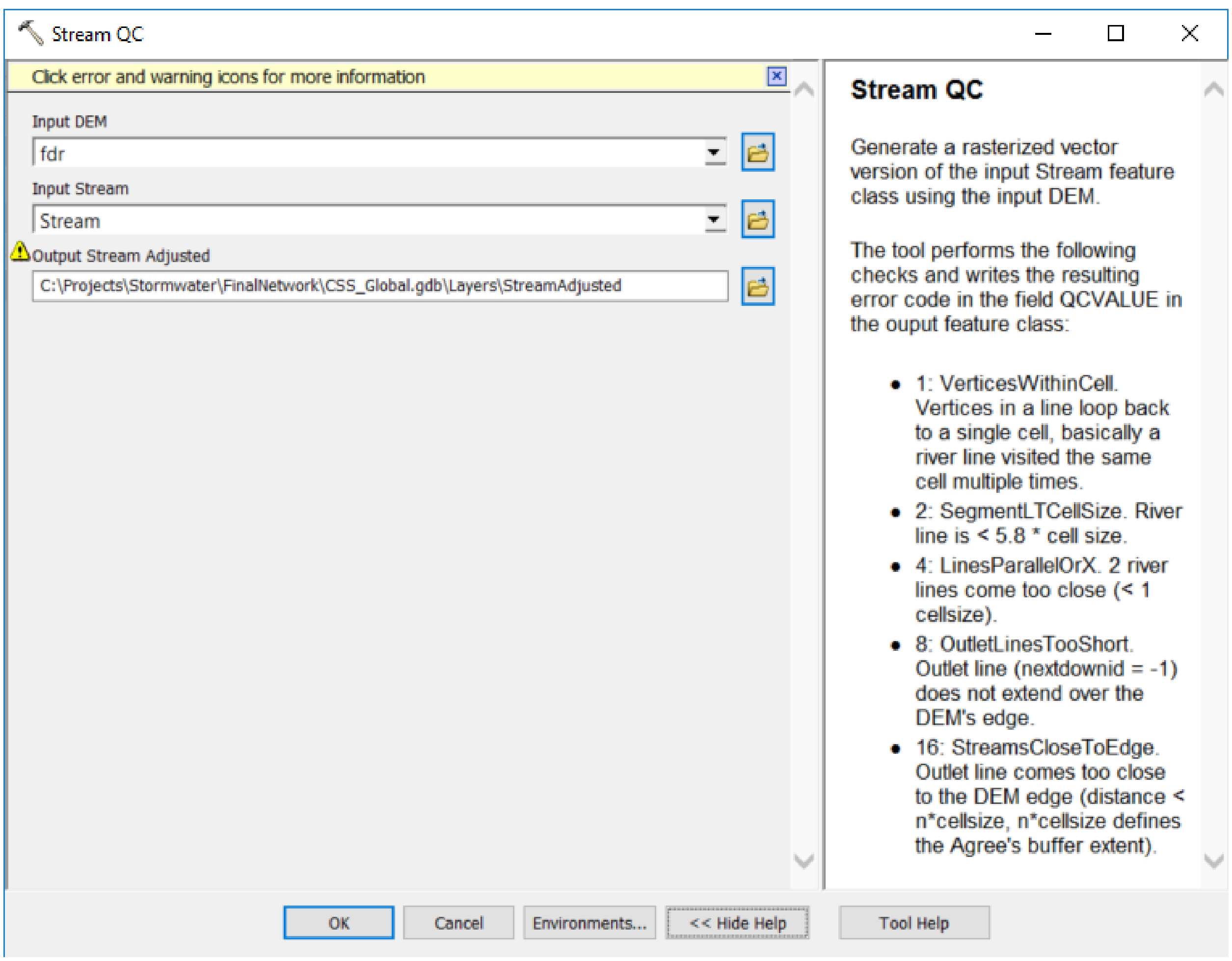


Figure 14 - Stream QC Interface

Review the lines with QCVALUE > 0.

Table

StreamAdjusted

OBJECTID *	Shape *	ARCID	GRID_CODE	Shape_Leng	Enabled	HydroID	FEATUREID	From_Node *	To_Node *	NextDownID *	QCVALUE	GRIDID	Shape_Length
2023	Polyline	828	1006	3.824632	True	4696733	2564909	2026	1936	4696643	2	<Null>	6
2193	Polyline	0	0	3.566998	True	4696903	2565079	2196	2195	4696902	2	<Null>	4.242641
2194	Polyline	0	0	2.272254	True	4696904	2565080	2197	2195	4696902	2	<Null>	3
2213	Polyline	0	0	0	True	4696923	2565099	2216	2214	4696921	2	<Null>	6
2326	Polyline	0	0	0	True	4697036	2565212	2332	2331	4697035	2	<Null>	7.242641
2327	Polyline	0	0	0	True	4697037	2565213	2333	2331	4697035	2	<Null>	10.242641
2341	Polyline	0	0	0	True	4697051	2565227	2348	2347	4697050	2	<Null>	6
2344	Polyline	0	0	0	True	4697054	2565230	2351	2350	4697053	2	<Null>	3
2346	Polyline	0	0	0	True	4697056	2565232	2353	2352	4697055	2	<Null>	6
2370	Polyline	0	0	0.015095	True	4697080	2565256	2392	2390	4697079	2	<Null>	0
2372	Polyline	0	0	0.015095	True	4697082	2565258	2394	2392	4697080	2	<Null>	0
2400	Polyline	0	0	7.487966	True	4697110	2565286	2422	2396	4697084	2	<Null>	3
2401	Polyline	0	0	0	True	4697111	2565287	2423	2395	4697083	2	<Null>	9
2402	Polyline	0	0	19.946291	True	4697112	2565288	2394	2392	4697080	2	<Null>	0
2403	Polyline	0	0	2.103646	True	4697113	2565289	2392	2390	4697079	2	<Null>	0
2415	Polyline	0	0	0	True	4697125	2565301	2436	2435	4697124	2	<Null>	10.242641

0 (0 out of 2437 Selected)

Stream | StreamAdjusted | Open_Channel_NoNetwork | RoadClean_overlap | RoadClean

Figure 15 - Streams in same cell

Blue line in same cell -> need to move the lower line (pink and blue) so that they connect in the same cell.

Figure 16 - Streams collapsed

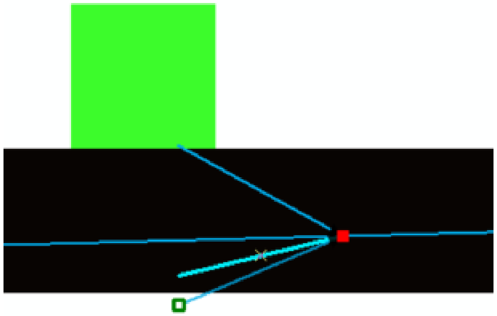
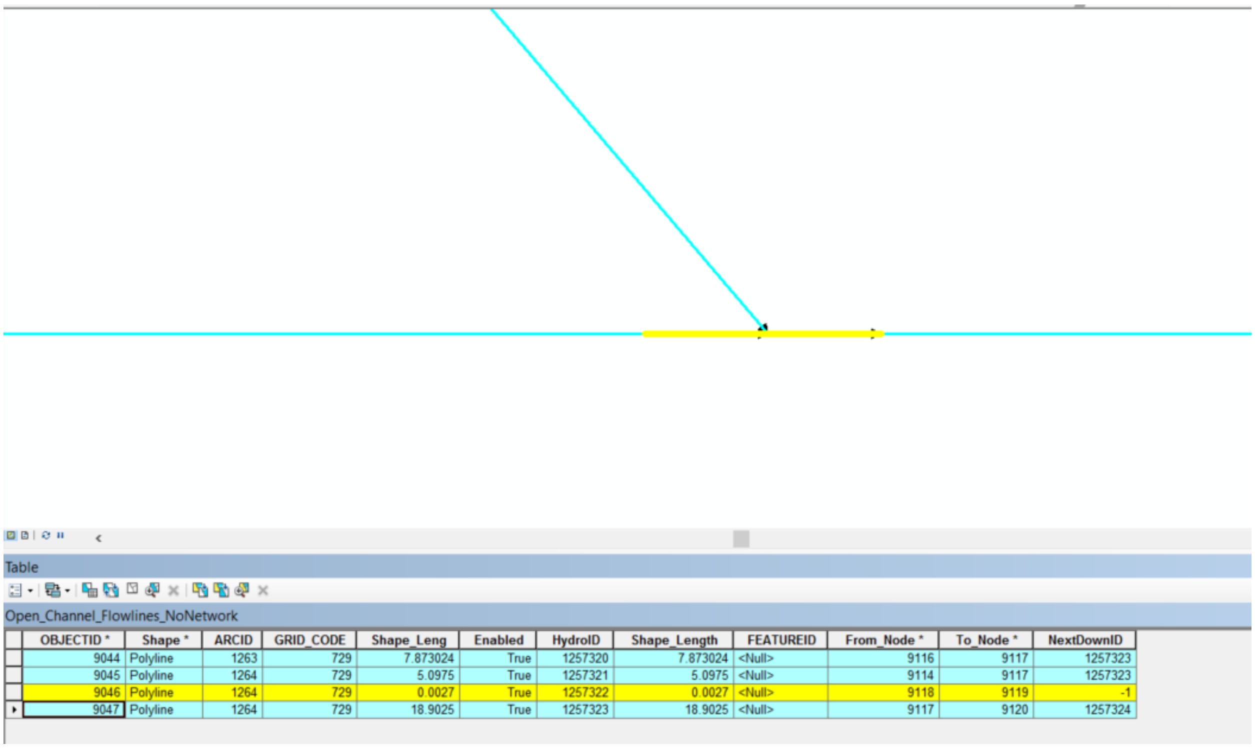


Figure 17 – Streams in same cells

Figure 18 - Streams moved to another cell



OBJECTID *	Shape *	ARCID	GRID_CODE	Shape_Leng	Enabled	HydroID	Shape_Length	FEATUREID	From_Node *	To_Node *	NextDownID
9044	Polyline	1263	729	7.873024	True	1257320	7.873024	<Null>	9116	9117	1257323
9045	Polyline	1264	729	5.0975	True	1257321	5.0975	<Null>	9114	9117	1257323
9046	Polyline	1264	729	0.0027	True	1257322	0.0027	<Null>	9118	9119	-1
9047	Polyline	1264	729	18.9025	True	1257323	18.9025	<Null>	9117	9120	1257324

Figure 19 - Overlapping streams

2.6 Review HydroJunction used as Inlet/Sinks

2.6.1 Add Pipe Inlet/Sink HydroJunctions

All features identified as potential Inlet/Sink points need to be combined into a new HydroJunction point feature class. The various input layers may be combined using the Merge geoprocessing tool.

2.6.2 Identify Required Sinks at end of terminal Streams

The end of terminal streams,i.e. streams not connected to another downstream stream feature, must either be located outside the boundary of the DEM or coincide with a HydroJunction representing an Inlet or a Sink.

Figure 20 shows an example of missing HydroJunction at the end of a terminal Stream (blue line) connecting to a Pipe feature (purple line).

Figure 20 - Missing HydroJunction at end of Terminal Stream

Figure 21 - Missing HydroJunction at end of Terminal Stream

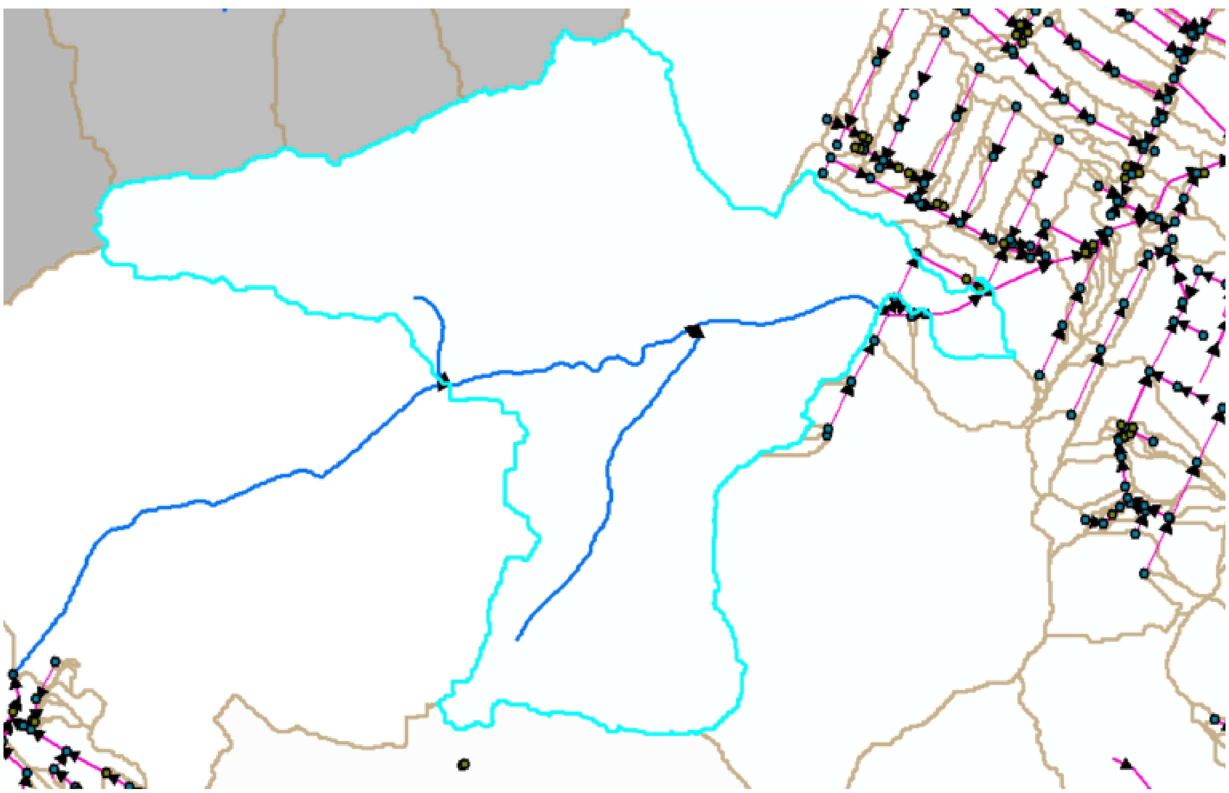


Figure 22 - Missing Catchments due to filled in stream

Connectivity issue at end of drainage line – not connected to css via inlet/sink in HydroJunction → results in lines being filled in and only one catchment created instead of one catchment for each stream segment.

The Create Sinks for Line Structures may be used to identify the locations where HydroJunctions must exist.

Use Create Sinks for Line Structure to identify the location where the sinks/inlets should be created and check whether there are existing HydroJunction features existing in the HydroJunction feature class.

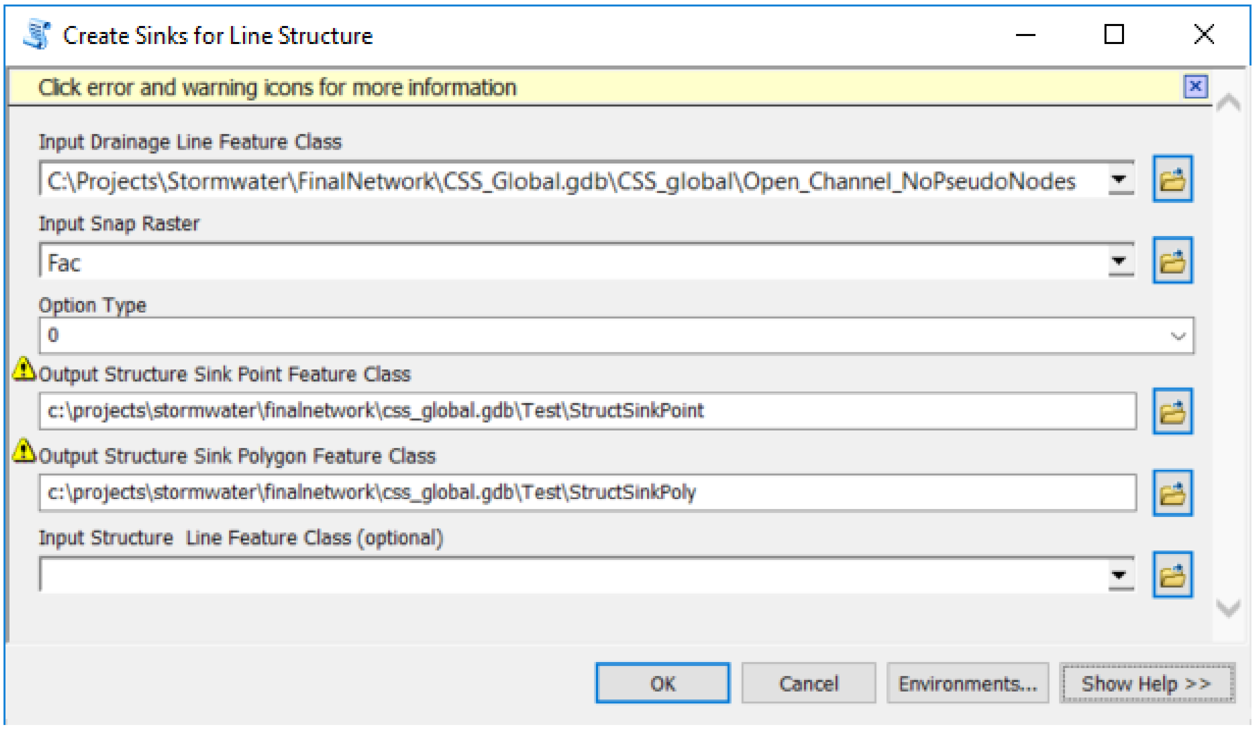
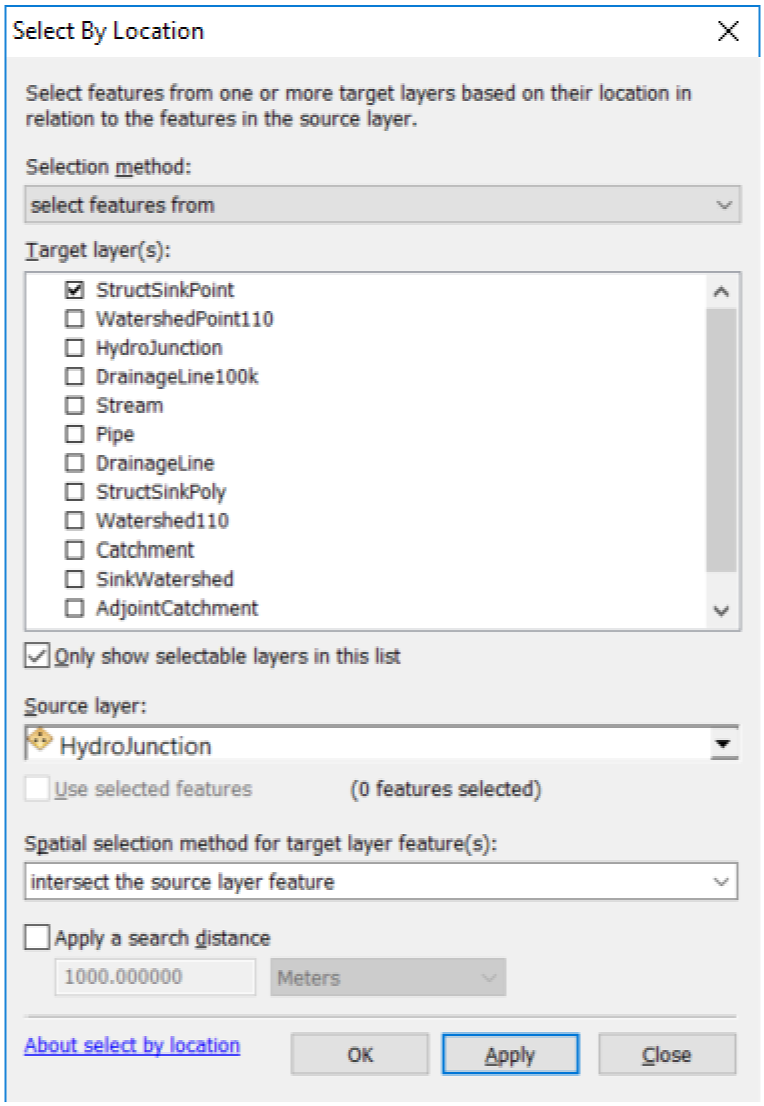


Figure 23 - Create Sinks for Line Structure tool

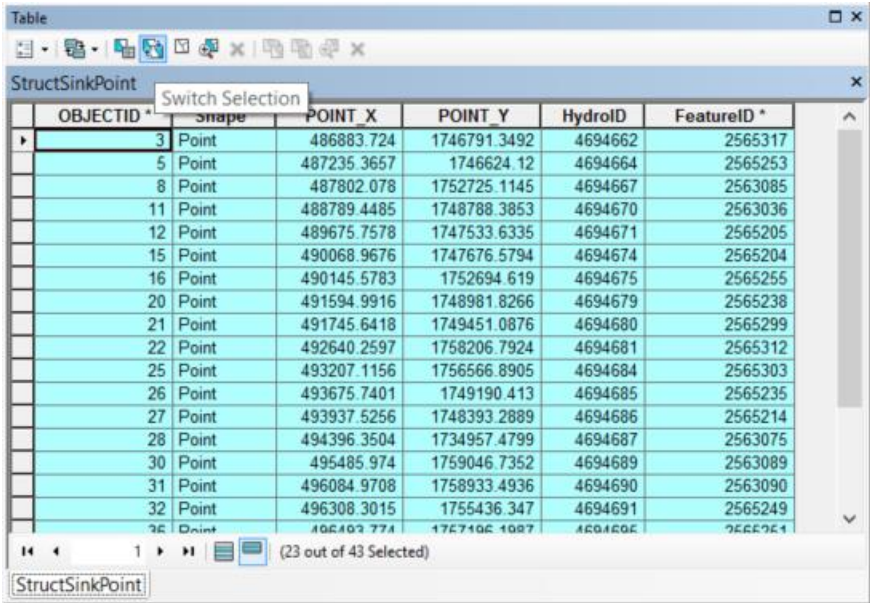
Identify the StructSinkPoint that are missing in HydroJunction.

- Use Select by Location to identify StructSinkPoint that have a corresponding HydroJunction.



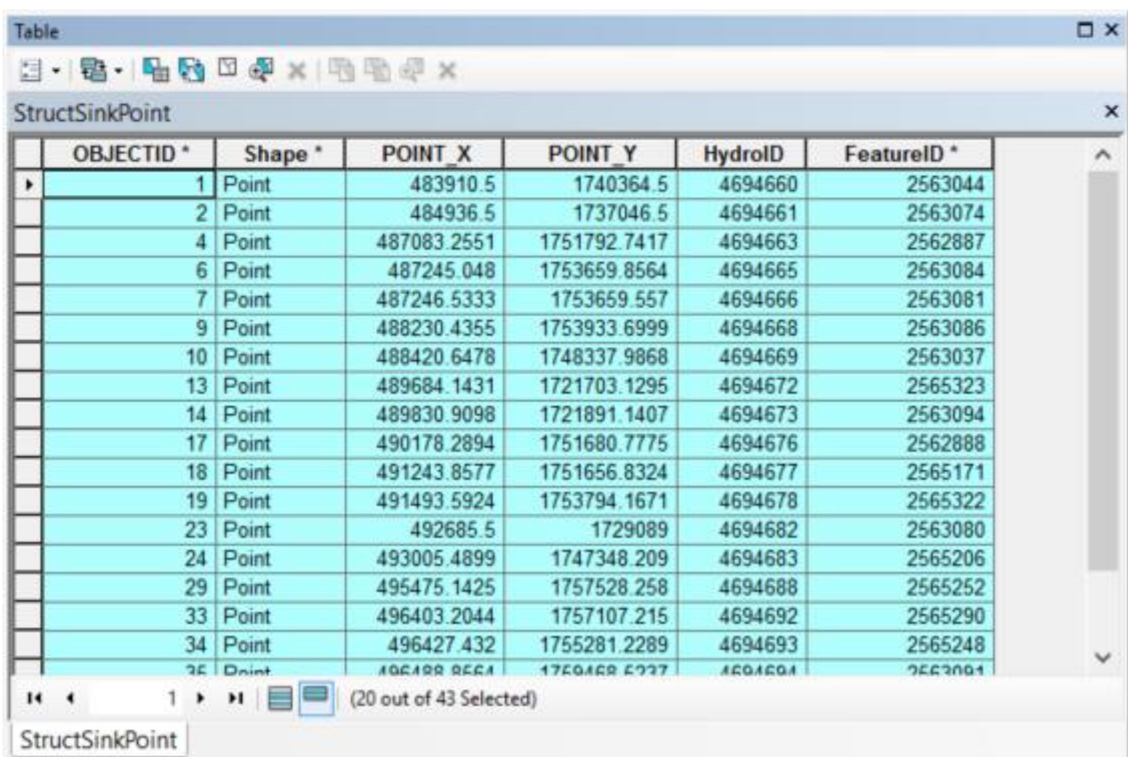
- Switch the selection to identify the missing HydroJunction and append to HydroJunction feature class.

- Copy the associated StructSinkPoly to LineDraftSinkPoly and populate JunctionID for the new features.



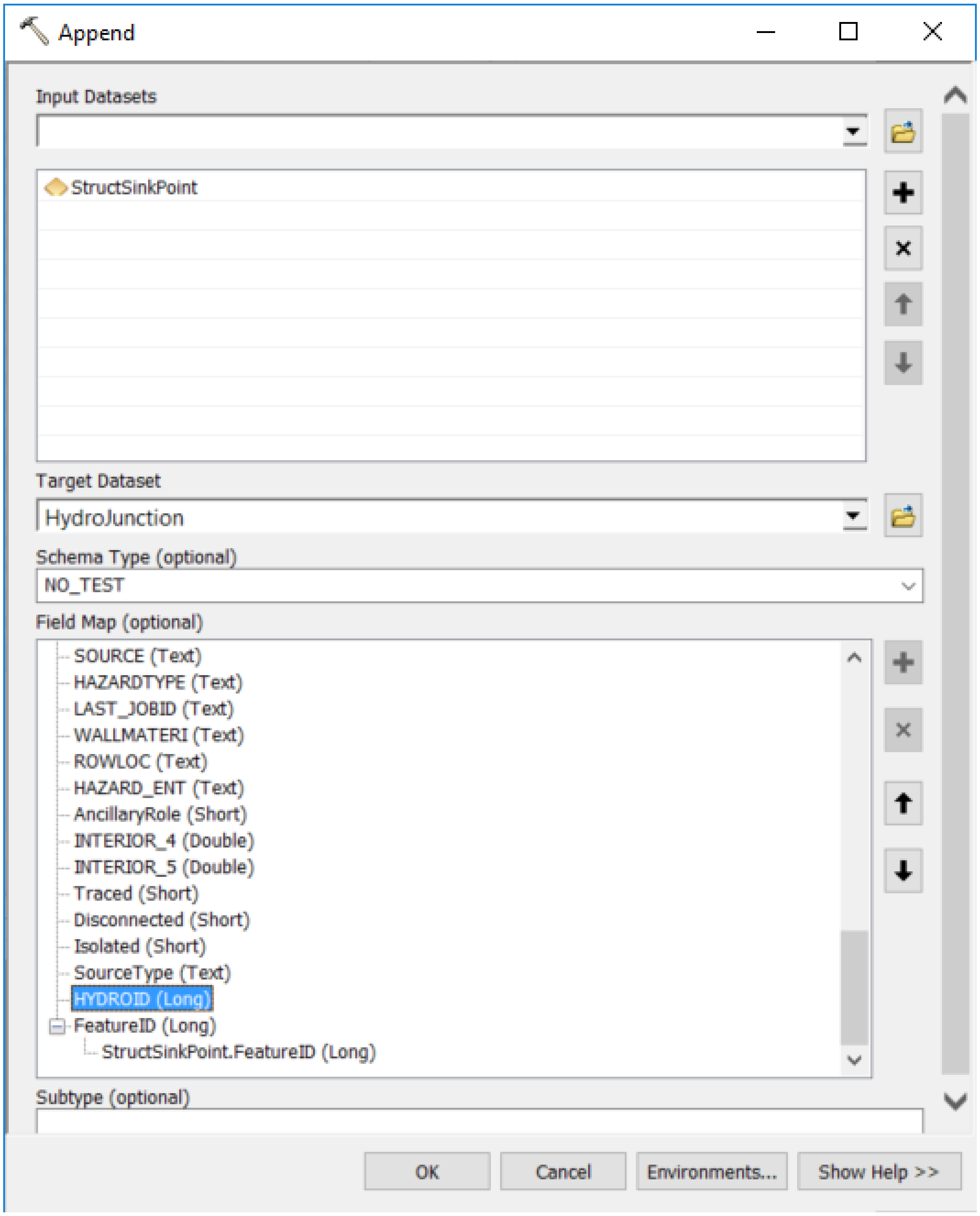
OBJECTID *	Shape	POINT_X	POINT_Y	HydroID	FeatureID *
3	Point	486883.724	1746791.3492	4694662	2565317
5	Point	487235.3657	1746624.12	4694664	2565253
8	Point	487802.078	1752725.1145	4694667	2563085
11	Point	488789.4485	1748788.3853	4694670	2563036
12	Point	489675.7578	1747533.6335	4694671	2565205
15	Point	490068.9676	1747676.5794	4694674	2565204
16	Point	490145.5783	1752694.619	4694675	2565255
20	Point	491594.9916	1748981.8266	4694679	2565238
21	Point	491745.6418	1749451.0876	4694680	2565299
22	Point	492640.2597	1758206.7924	4694681	2565312
25	Point	493207.1156	1756566.8905	4694684	2565303
26	Point	493675.7401	1749190.413	4694685	2565235
27	Point	493937.5256	1748393.2889	4694686	2565214
28	Point	494396.3504	1734957.4799	4694687	2563075
30	Point	495485.974	1759046.7352	4694689	2563089
31	Point	496084.9708	1758933.4936	4694690	2563090
32	Point	496308.3015	1755436.347	4694691	2565249

FeatureID allows relating back to the input line feature but also allow joining the StructSinkPoint to its related StructSinkPoly.

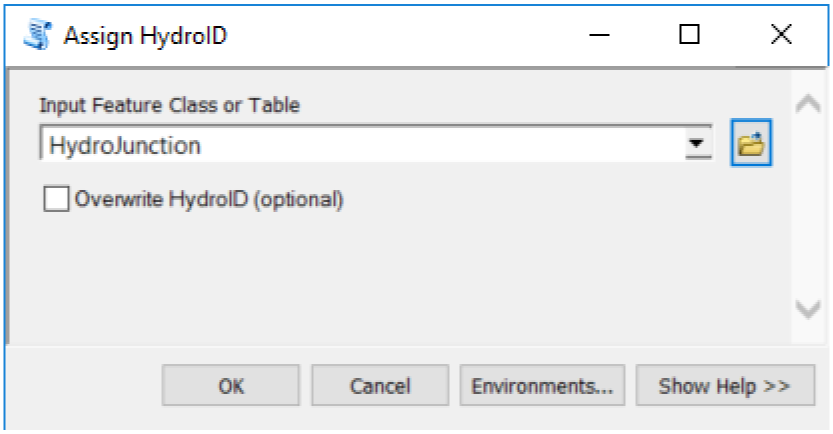


OBJECTID *	Shape *	POINT_X	POINT_Y	HydroID	FeatureID *
1	Point	483910.5	1740364.5	4694660	2563044
2	Point	484936.5	1737046.5	4694661	2563074
4	Point	487083.2551	1751792.7417	4694663	2562887
6	Point	487245.048	1753659.8564	4694665	2563084
7	Point	487246.5333	1753659.557	4694666	2563081
9	Point	488230.4355	1753933.6999	4694668	2563086
10	Point	488420.6478	1748337.9868	4694669	2563037
13	Point	489684.1431	1721703.1295	4694672	2565323
14	Point	489830.9098	1721891.1407	4694673	2563094
17	Point	490178.2894	1751680.7775	4694676	2562888
18	Point	491243.8577	1751656.8324	4694677	2565171
19	Point	491493.5924	1753794.1671	4694678	2565322
23	Point	492685.5	1729089	4694682	2563080
24	Point	493005.4899	1747348.209	4694683	2565206
29	Point	495475.1425	1757528.258	4694688	2565252
33	Point	496403.2044	1757107.215	4694692	2565290
34	Point	496427.432	1755281.2289	4694693	2565248

- Add field FeatureID to HydroJunction if it does not exist.
- Append selected missing StructSinkPoint. Do not upload HydroIDs (Right-click and delete the mapping).



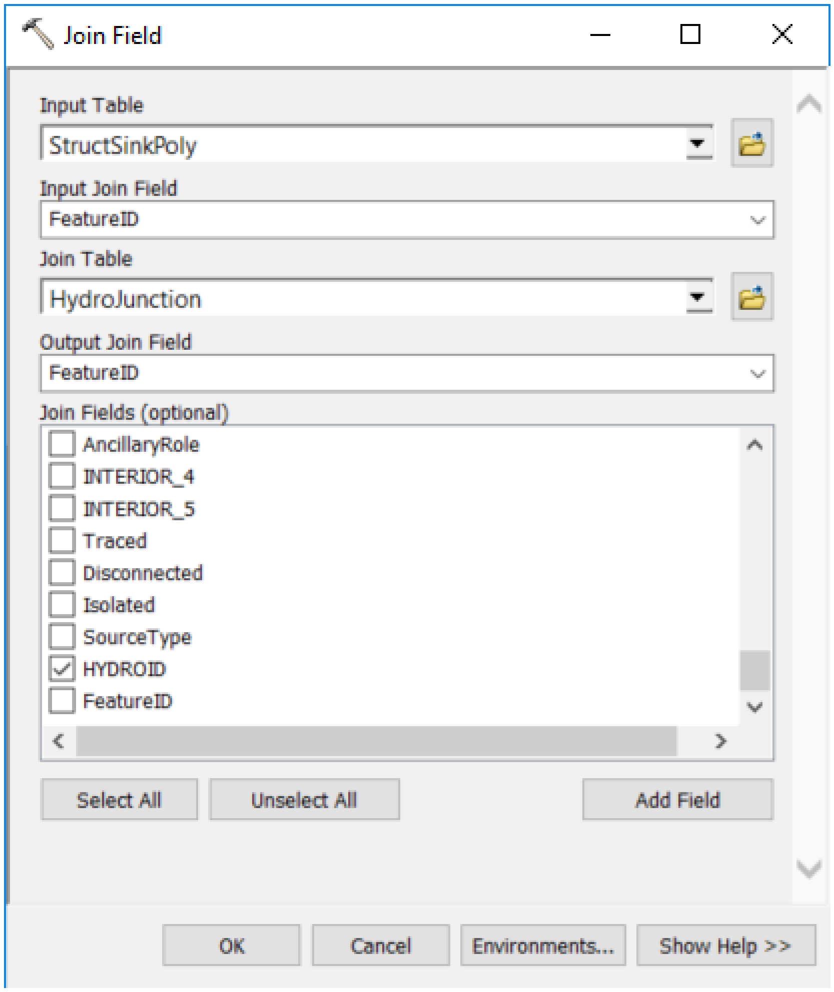
- Assign missing HydroIDs (uncheck option to overwrite).



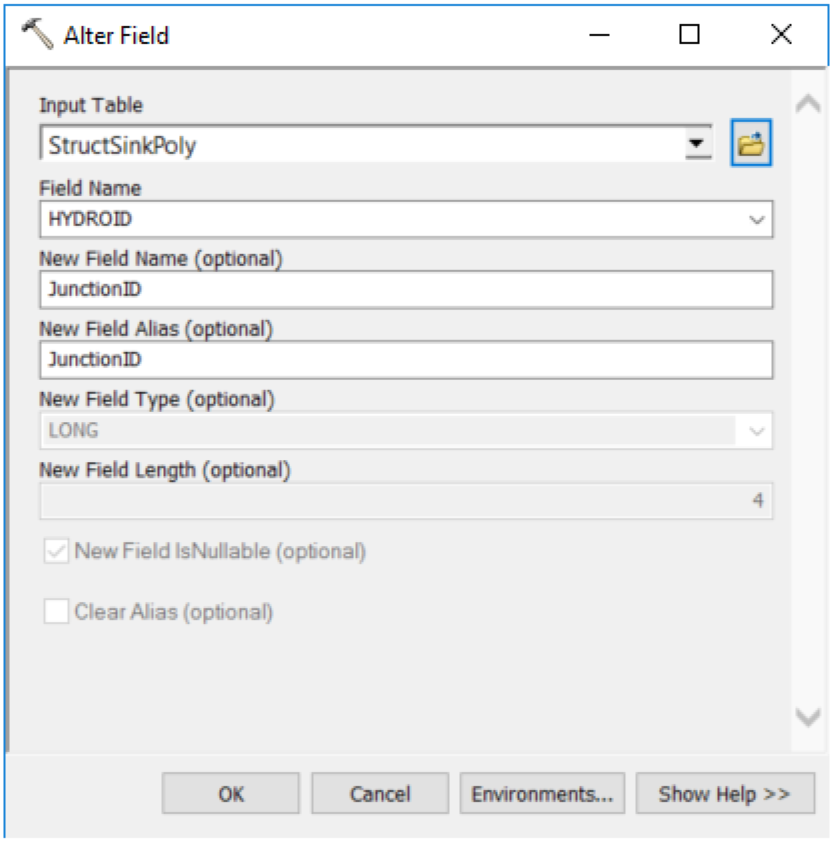
- Select StructSinkPoly intersecting the selected StructSinkPoint features.

Only 19 polygons for 20 points. Due to small line located within another sink polygon. Need to review data and eliminate this line/point.

- Join HydroJunction and StructSinkPoly on FeatureID to add the HydroID of the HydroJunction



- Rename HydroID field JunctionID



- Append selected StructSinkPoly features to DraftSinkPolyReview Stormwater Network Connectivity

Create a geometric network, set the flow direction in the digitized direction and test the connectivity. Identify the disconnected features and whether the connectivity needs to be modified. Delete disconnected HydroJunction if needed.

2.7 Fix network connectivity issues

2.7.1 Move junction to be on line features

- Use advanced editing → connect to split the line after moving the junction

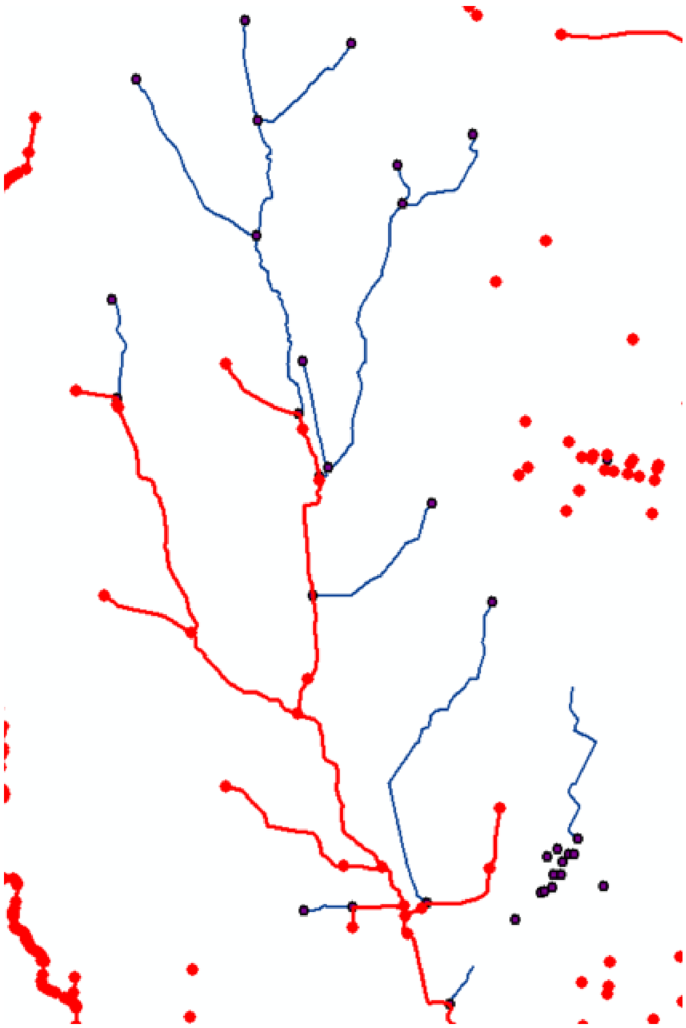


Figure 24 - Identifying Disconnected Network Features

2.7.2 Fix connectivity issues for Stream features -> Lines must connect through end points.

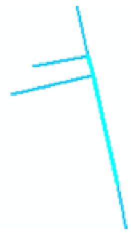


Figure 25 - Line not connecting to end point

2.7.3 Use Find Disconnected trace and Connect

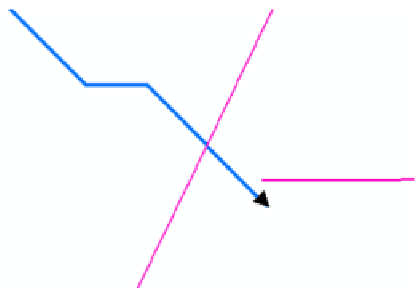


Figure 26. Identifying Disconnected Features

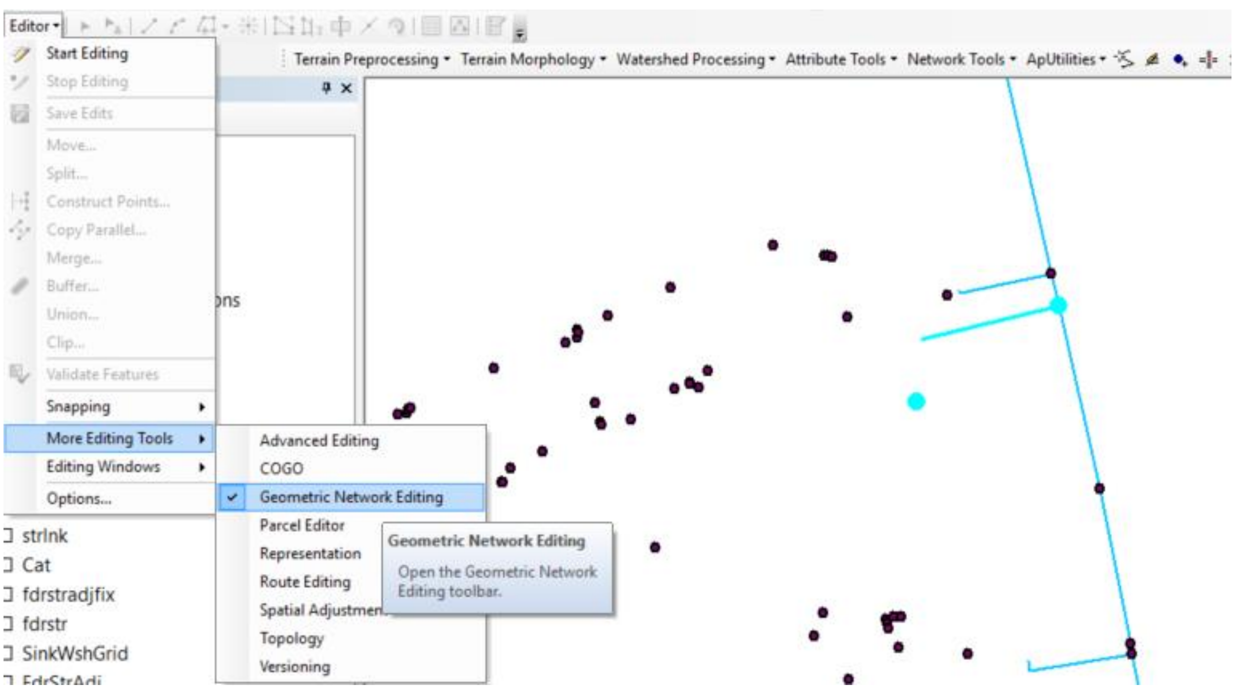


Figure 27. Selecting Network Features to Connect

- Click Connect after doing a Find Disconnected trace.

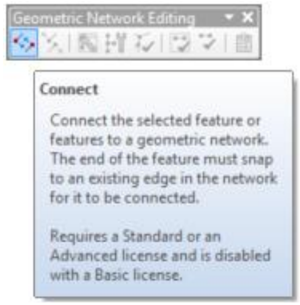


Figure 28 – Connect Tool

- Reassign HydroIDs after cleaning up.
- Update NEXTDOWNID in Streams layer.

3.0 Create Input Draft Sink Polygon

3.1 Create Sink Polygons for defined HydroJunctions

3.1.1 Using Buffering

Given the number of features, the sink polygons were created by buffering the HydroJunctions.

- Reselect connected HydroJunctions (should all be connected).

Dem is 3 cell size. So use 4.5m m for buffering.

If using 3m will end up with one cell SinkPoly and those are not considered sinks.

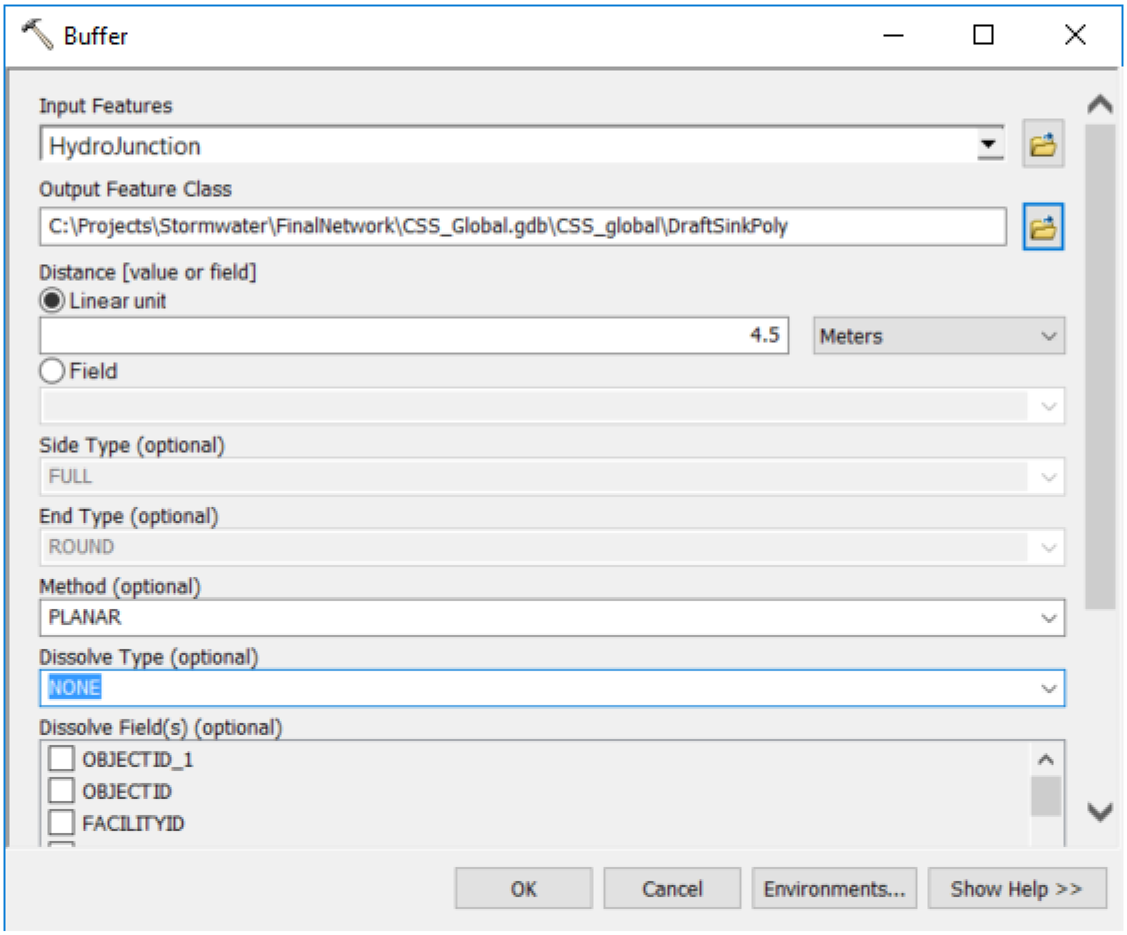
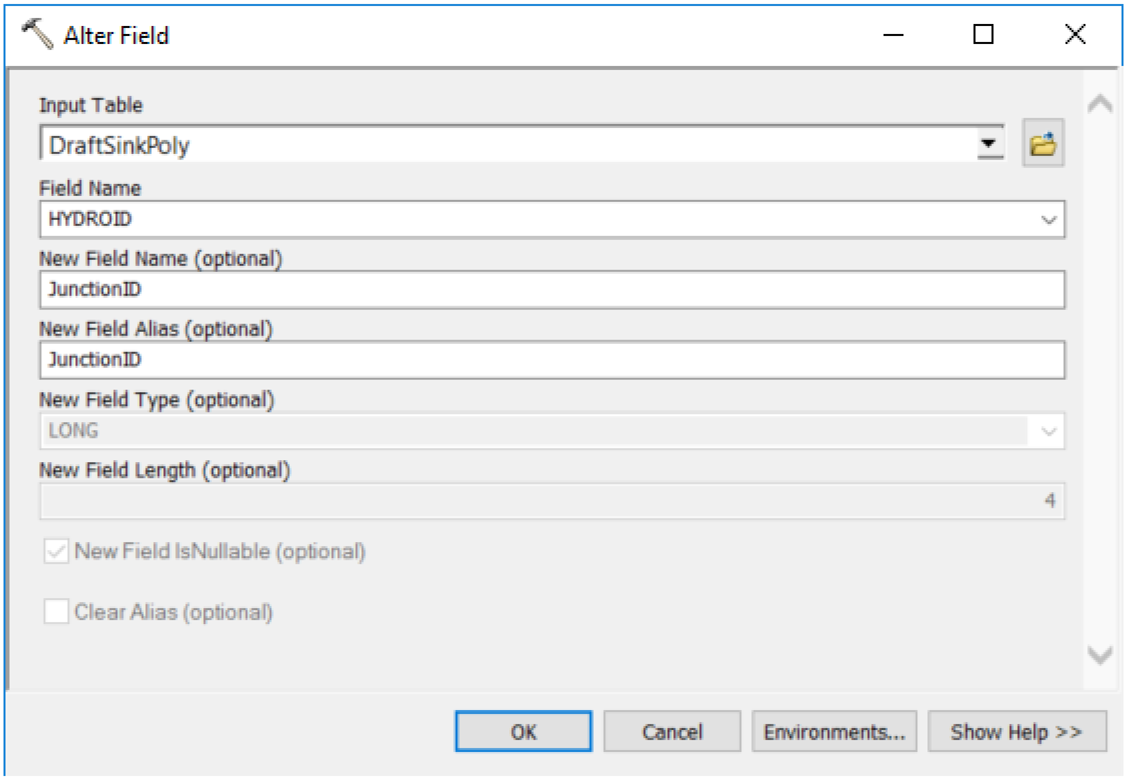


Figure 29. Buffer Tool

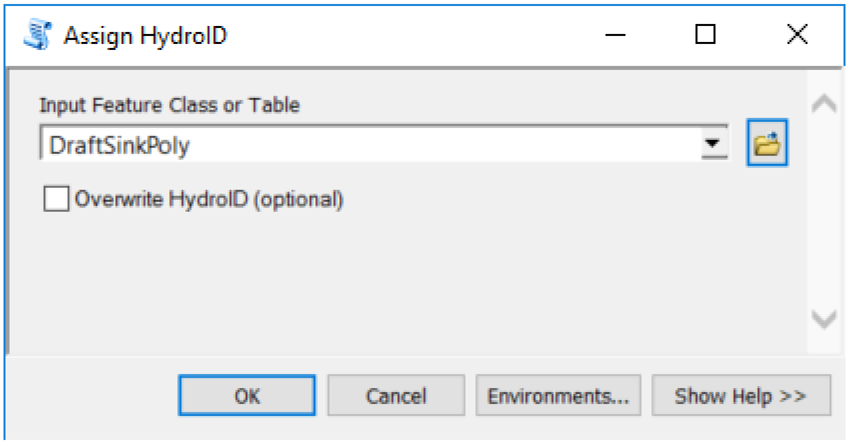
```
Executing: Buffer HydroJunction
C:\Projects\Stormwater\FinalNetwork\CSS_Global.gdb\CSS_global\DraftSinkPoly
"4.5 Meters" FULL ROUND NONE # PLANAR
Start Time: Thu May 25 07:45:04 2017
Succeeded at Thu May 25 07:45:22 2017 (Elapsed Time: 17.86 seconds)
```

- Rename HydroID field to JunctionID in output DraftSinkPoly feature class.




```
Executing: AlterField DraftSinkPoly HYDROID JunctionID JunctionID LONG 4
NULLABLE false
Start Time: Thu May 25 07:48:34 2017
Succeeded at Thu May 25 07:48:34 2017 (Elapsed Time: 0.34 second
```

- Assign HydroID to DraftSinkPoly.



Potential Sinks created. HydroID will be used by the tool Create Sink Structures.

```
Executing: AssignHydroID DraftSinkPoly OVERWRITE_NO
Start Time: Thu May 25 07:50:13 2017
Reading Input Parameters...
 Executing: AddField DraftSinkPoly HYDROID LONG # # # # NULLABLE
 NON_REQUIRED #
 Start Time: Thu May 25 07:50:13 2017
 Adding HYDROID to DraftSinkPoly...
 Succeeded at Thu May 25 07:50:13 2017 (Elapsed Time: 0.15 seconds)
Assigning HydroID...
The HYDROIDs ranged from 4214930 to 4282715.
Succeeded at Thu May 25 07:50:24 2017 (Elapsed Time: 11.14 seconds)
```

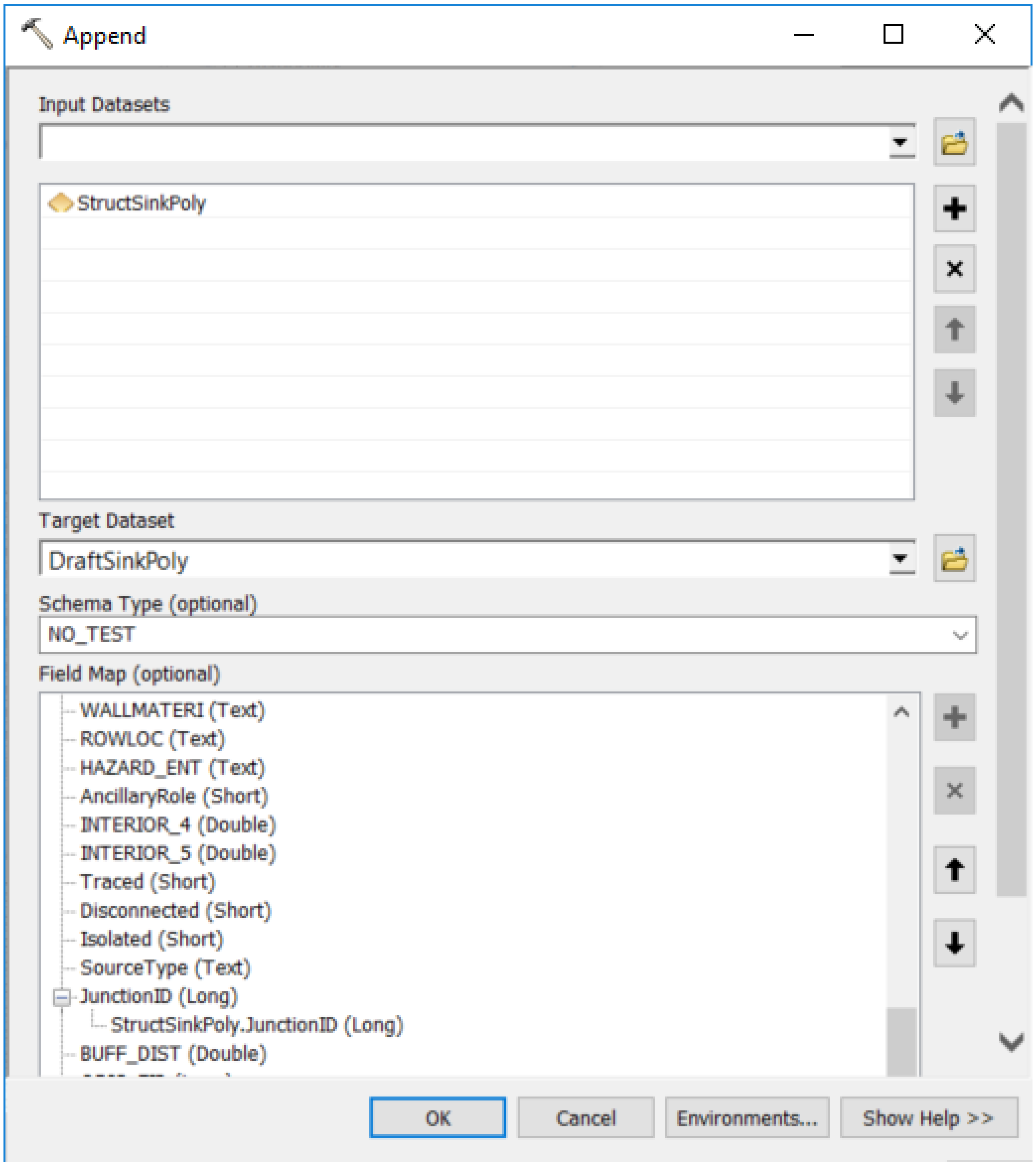
- Run Assign HydroID. Will be use to populate FeatureID in SinkPoly when using Create Sink Structures.

3.1.2 Alternative: Use Create Sinks for Point Structure

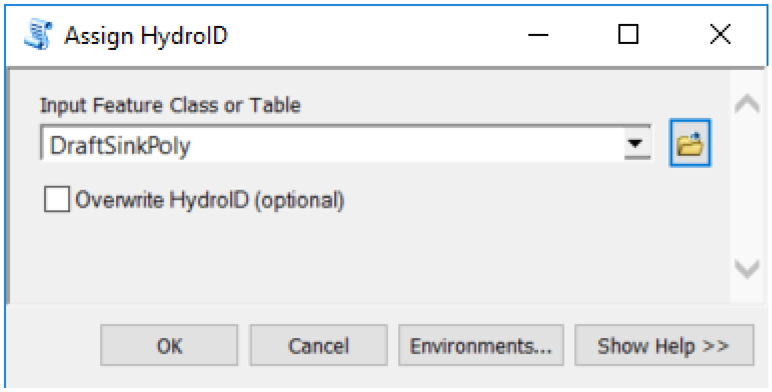
To do. Performance issue with CSS data.

3.2 Add Sink Polygons associated to Stream

The LineDraftSinkPoly features created in step 2.6.2 need to be appended to the DraftSinkPoly features.



- Assign HydroIDs to Null value



- Remove the junctions that are not connected so that they are not burnt in (unless you want to have terrain sinks).
- Assign HydroID to HydroJunction

4.0 Processing Steps

4.1 Required Inputs

The required inputs are the following:

- Pipe line feature class
- Stream line feature class
- DraftSinkPoly polygon feature class
- HydroJunction polygon feature class
- DEM

4.2 Outputs Supporting the Stormwater Delineation process

The following outputs will support the stormwater delineation process:

- Flow Direction
- Stream Link
- Snap Stream Raster
- Catchment
- Adjoint Catchment
- Pipe
- Stream
- Sink Watershed
- HydroJunction

4.3 Summary and Processing Times

Table 4. Processing Steps Table.

Step	Tool	Description	Processing Time (CSS dataset)
1	Create Drainage Line Structures	Create rasterized vector representation of the input streams as Drainage Line features.	11mn5s
2	Create Sink Structures	Create Sink Points and Polygons associated to DraftSinkPoly and HydroJunction. Note Review the data and make sure that the sink points are not located on the stream grid. If they are, edit the input streams to avoid this and rerun steps 1.	6mn23s
3	DEM Reconditioning from Stream Grid	Burn the stream grid generated in step 1 in the DEM to enforce the location of the streams and force water near the streams to flow toward the closest stream.	3mn46s
4	Level DEM	Level DEM within terrain and structure sink polygons using the lowest elevation along the sink polygon boundary – 10000 offset.	4mn50s
5	Fill Sinks	Fill the DEM at all locations except within the sink polygons (both terrain and structure).	5mn31s
6	Flow Direction	Generate flow direction grid.	1mn14s
7	Adjust Flow Direction in Sinks	Modify flow direction within sink polygons so that water flows toward the sink point in the sink polygon.	1mn15s
8	Adjust Flow Direction in Stream	Modify flow direction in the streams so that the water flows in the digitized direction along the streams.	39s
9	Combine Stream Link and Sink Link	Combine link grids generated from the streams and from the sinks.	24s
10	Catchment Grid Delineation	Delineate catchments for each link.	1mn55s
11	Catchment Polygon Processing	Convert catchment grid to vector.	1mn59s

12	Adjoint Catchment Processing	Generate Adjoint Catchment associated to each input Catchment and set the connectivity between Catchments.	2mn36s
13	Sink Watershed Delineation	Delineate watershed associated to terrain sinks.	4mn32s
14	Link Sink Watershed to HydroJunction	Create and populate JunctionID in SinkWatersheds with HydroID of associated HydroJunction. Create relationship.	3mn57s
15	Create Stormwater Network	Create geometric network from HydroJunction, Pipe and Stream layers and set flow direction in digitized direction.	43s
16	Flow Accumulation	Create Flow Accumulation to support next step, Create Snap Data.	8mn47s
17	Create Snap Data	Create snap raster to support snapping when delineating.	1mn54s

4.4 Create Drainage Line Structures

This tool will use the existing From_Node and To_Node fields if they exist.

Make sure they are correctly populated if they do exist.

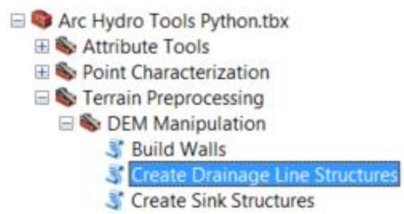


Figure 30 - Create Drainage Line Structures

- Run Create Drainage Line Structures (11mn).

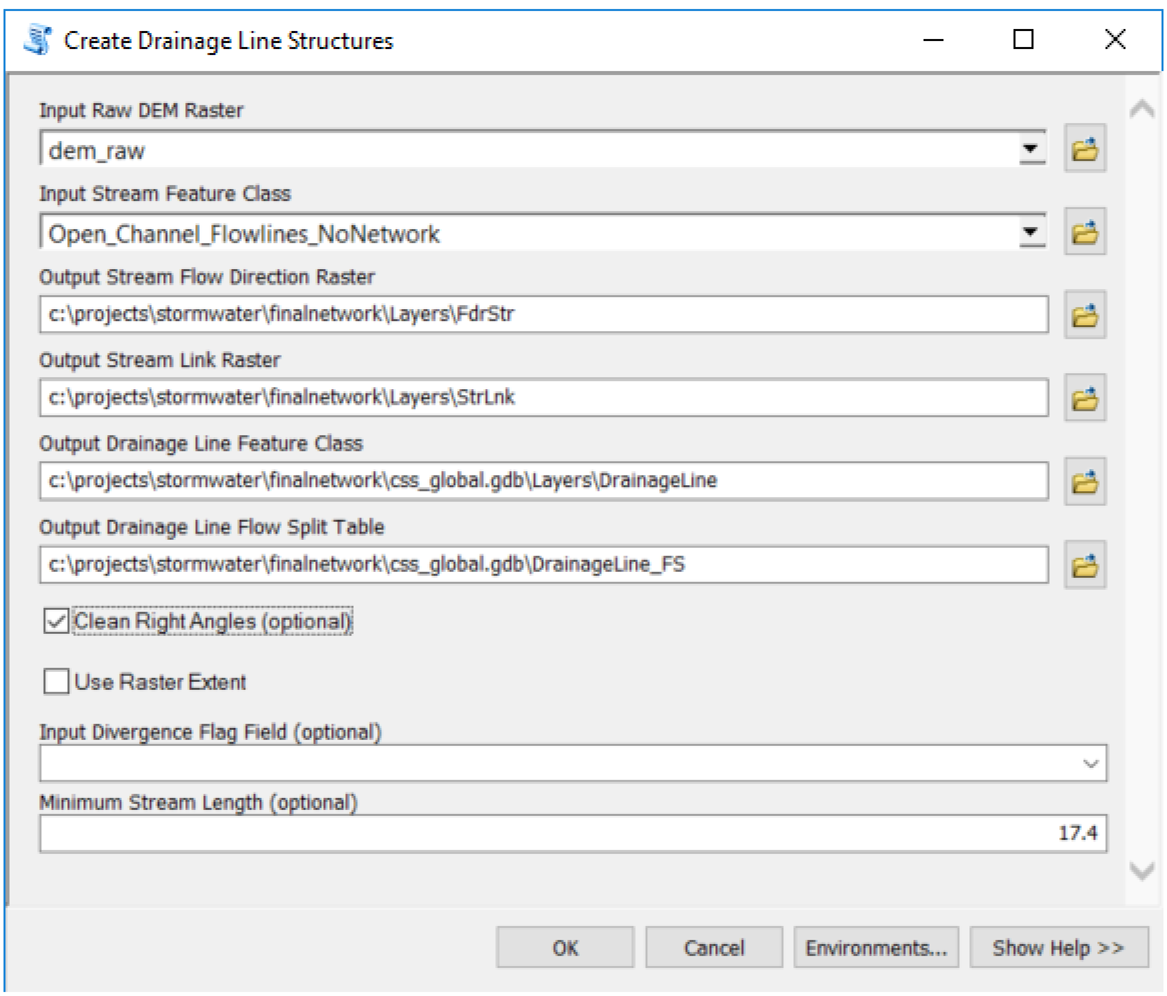


Figure 31 - Create Drainage Line Structures Interface

4.5 Create Sink Structures

HydroJunction is the point feature class storing all the junctions used as inlets or sinks.

Input Deranged Polygon feature class is the DraftSinkPoly polygon feature class created by buffering and running Create Sinks for Line Structures. Contains field HydroID and JunctionID which is the HydroID of the associated HydroJunction.

- Run Create Sink Structures (6mn).

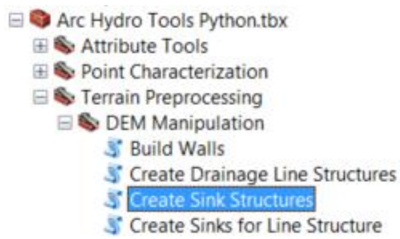


Figure 32 - Create Sink Structures Tool

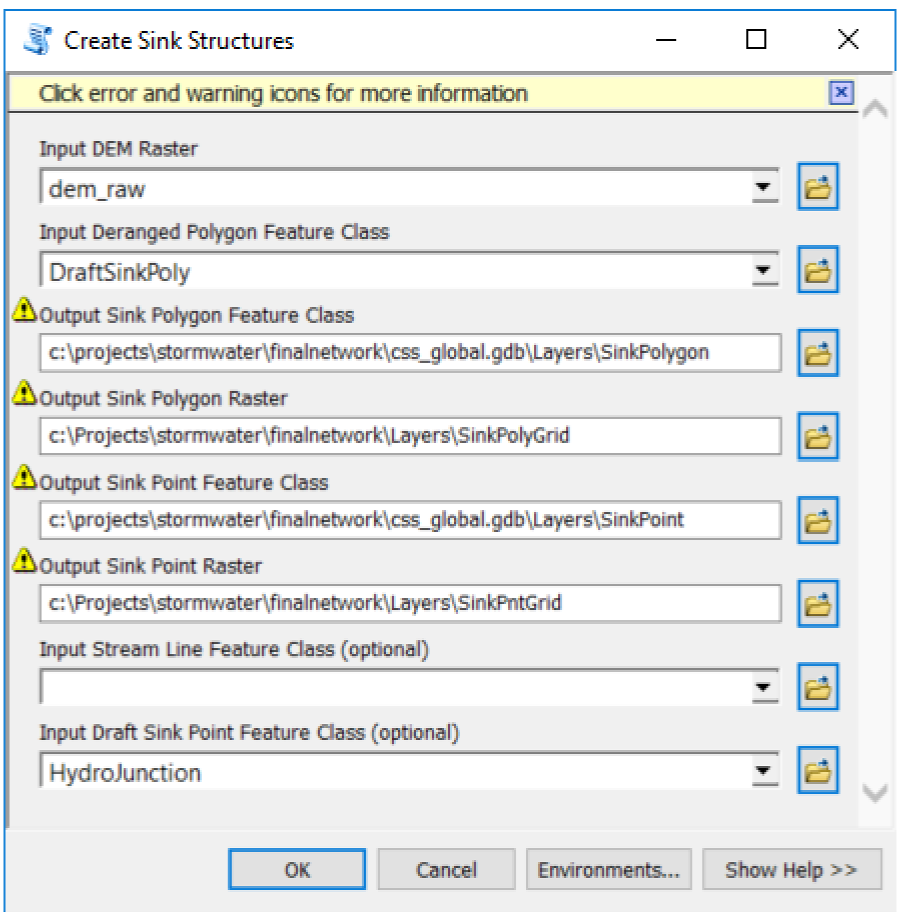


Figure 33 - Create Sink Structures Interface

After running the tool, review the data and make sure that there are no sink point features located on top of stream grid cells. You can use the ExtractMultiValuesToPoints tool to identify those locations. If any points are located on streams, edit the input Stream layer so that the stream grid moves to a neighboring cell and rerun the previous step, Create Drainage Line Structures.

4.6 DEM Reconditioning

- Run DEM Reconditioning (3mn).

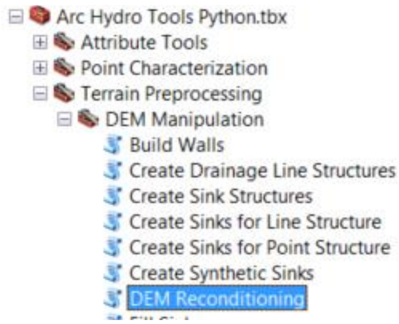


Figure 34 - DEM Reconditioning Tool

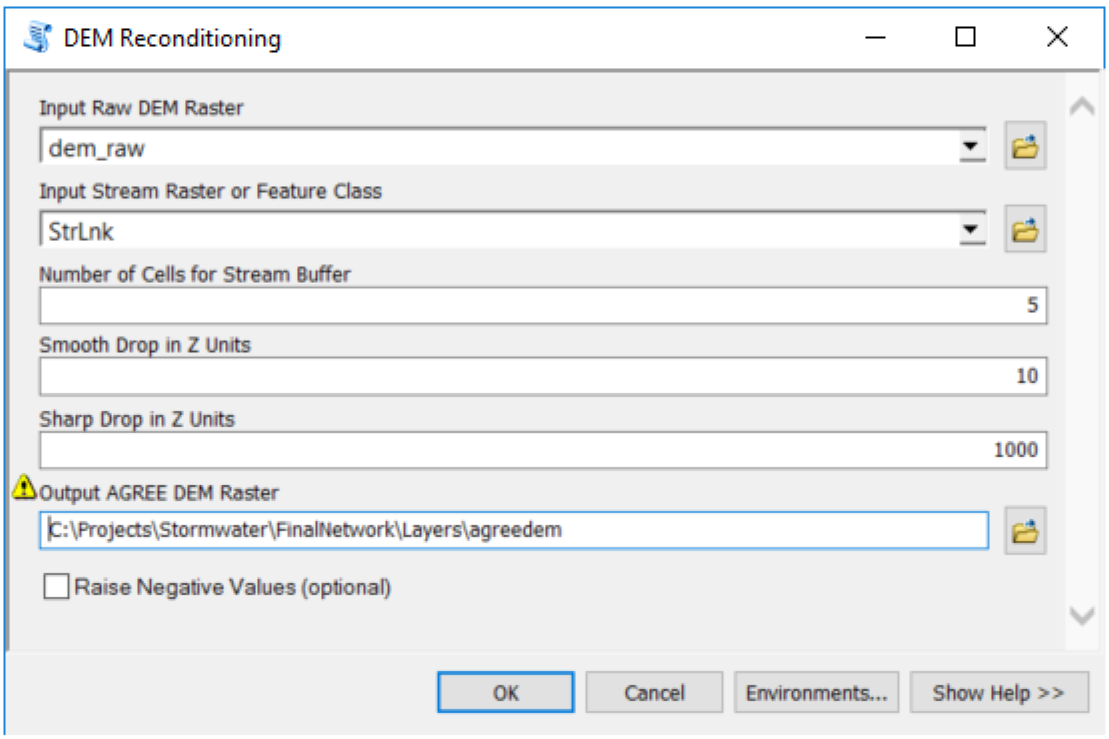


Figure 35 - DEM Reconditioning Interface

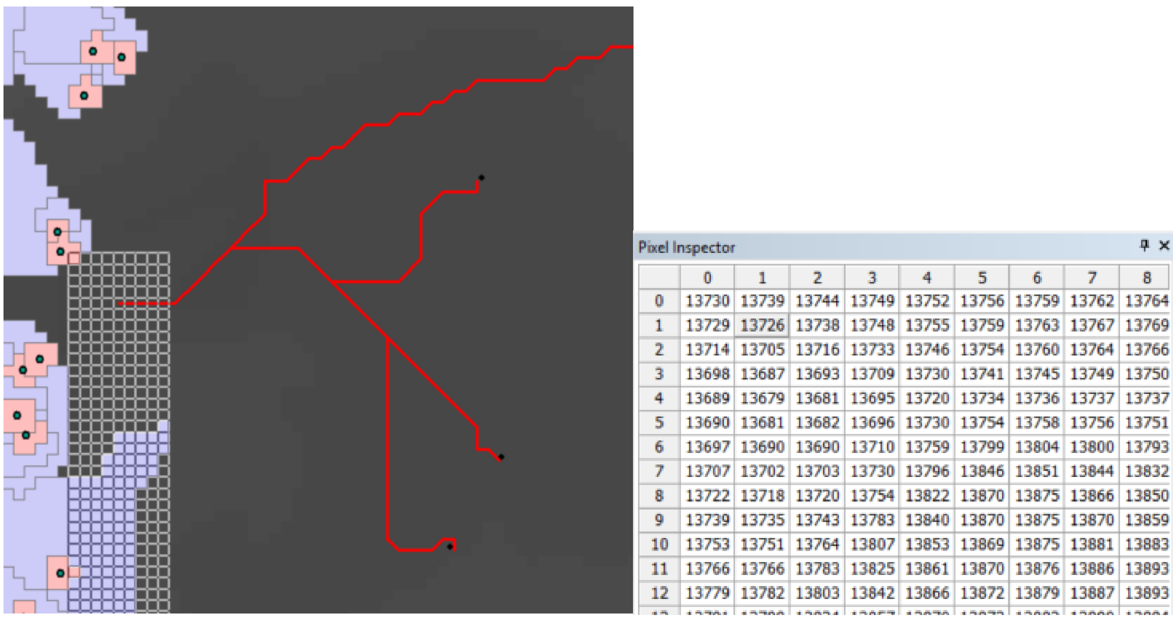
4.7 Level DEM

Levels the DEM by filling the SinkPoly features up to their FillElev - offset value. This ensure that the SinkPoly really acts as sinks by setting all elevations in the SinkPoly features much lower than the elevations in the surrounding areas, so that the SinkPoly features act as a magnet for water.

Note

Make sure to use a large value to ensure that the leveled elevation is lower than any surrounding cell.

When using 10 below the problem still occurs because the z factor is not set so the tool assumes that the elevations are in linear units, whereas in fact they are in cm. So to avoid any issue, use a big number for the Offset (e.g. 1000).



	0	1	2	3	4	5	6	7	8
0	13730	13739	13744	13749	13752	13756	13759	13762	13764
1	13729	13726	13738	13748	13755	13759	13763	13767	13769
2	13714	13705	13716	13733	13746	13754	13760	13764	13766
3	13698	13687	13693	13709	13730	13741	13745	13749	13750
4	13689	13679	13681	13695	13720	13734	13736	13737	13737
5	13690	13681	13682	13696	13730	13754	13758	13756	13751
6	13697	13690	13690	13710	13759	13799	13804	13800	13793
7	13707	13702	13703	13730	13796	13846	13851	13844	13832
8	13722	13718	13720	13754	13822	13870	13875	13866	13850
9	13739	13735	13743	13783	13840	13870	13875	13870	13859
10	13753	13751	13764	13807	13853	13869	13875	13881	13883
11	13766	13766	13783	13825	13861	13870	13876	13886	13893
12	13779	13782	13803	13842	13866	13872	13879	13887	13893

Figure 36 - Leveling Sensitivity

The leveled sink has an elevation of 13730 while the lowest point in the neighboring area is lower. So the enforced sink is not the lowest area and the connected cells will not be filled in, resulting in a missing catchment and an additional unwanted sink.

- Run Level DEM (5mns).

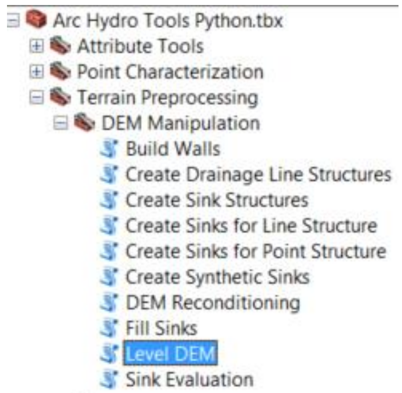


Figure 37 – Level DEM Tool

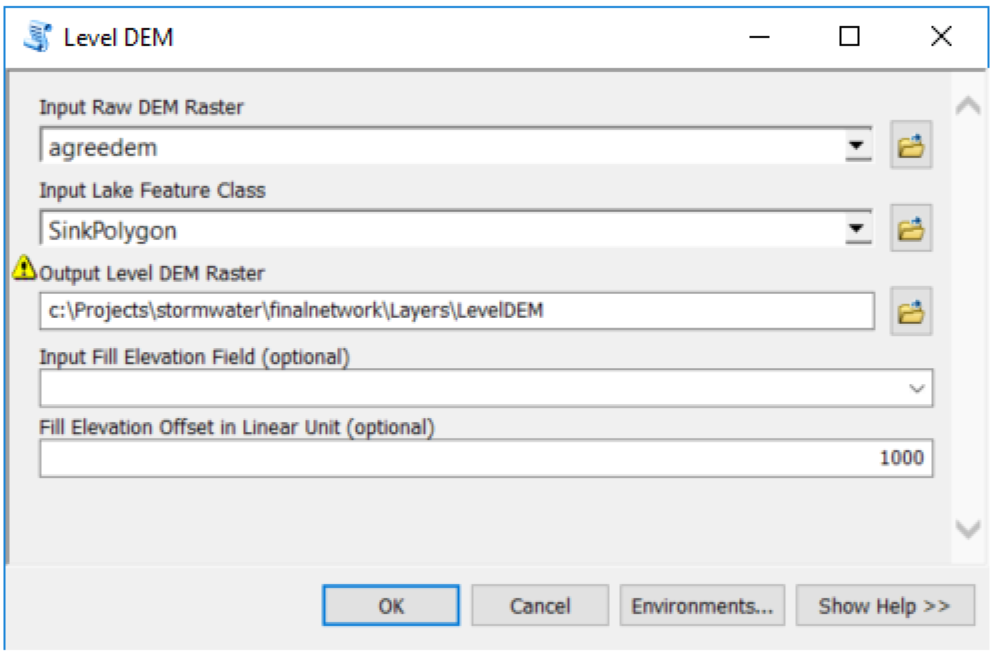


Figure 38 – Level DEM Interface

```
Executing: LevelDEM agreedem SinkPolygon
c:\Projects\stormwater\finalnetwork\Layers\LevelDEM # 1000
Start Time: Thu May 25 08:04:34 2017
Running script LevelDEM...
Using zUnitFactor= 1.0
Elevation field not set.
Assigning Level Elevation to the lakes...
Identifying point inside...
Extracting values under points...
Calculating fields...
Completed script LevelDEM...
Succeeded at Thu May 25 08:09:24 2017 (Elapsed Time: 4 minutes 50 seconds)
```

4.8 Fill Sinks

- Run Fill Sinks (5mn).

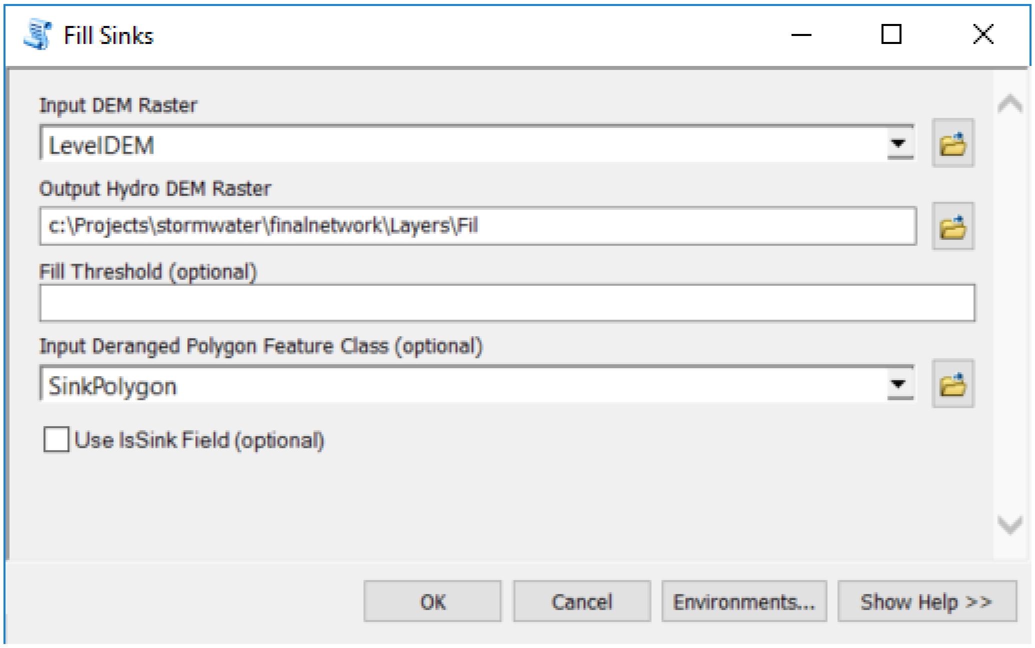


Figure 39 - Fill Sinks Tool

```
Executing: FillSinks LevelDEM c:\Projects\stormwater\finalnetwork\Layers\Fil
# SinkPolygon ISSINK_NO
Start Time: Thu May 25 08:10:49 2017
Running script FillSinks...
--Identifying Deranged Polygons before filling...
--Filling the DEM...
--Updating the fill DEM with sink values of original DEM...
Completed script FillSinks...
Succeeded at Thu May 25 08:16:21 2017 (Elapsed Time: 5 minutes 31 seconds)
```

4.9 Flow Direction

- Run Flow Direction.

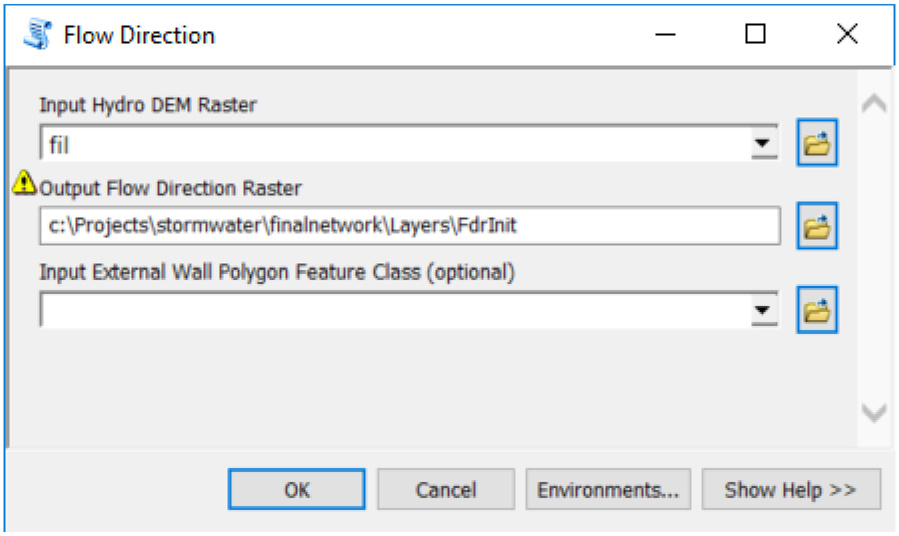


Figure 40 - Flow Direction Interface

```
Executing: FlowDirection Fil
c:\Projects\stormwater\finalnetwork\Layers\FdrInit #
Start Time: Thu May 25 08:21:02 2017
Running script FlowDirection...
--Calculating Flow direction...
--Saving c:\Projects\stormwater\finalnetwork\Layers\FdrInit...
Completed script FlowDirection...
Succeeded at Thu May 25 08:22:16 2017 (Elapsed Time: 1 minutes 14 seconds)
```

4.10 Adjust Flow Direction in Sinks

- Run Adjust Flow Direction in Sinks.

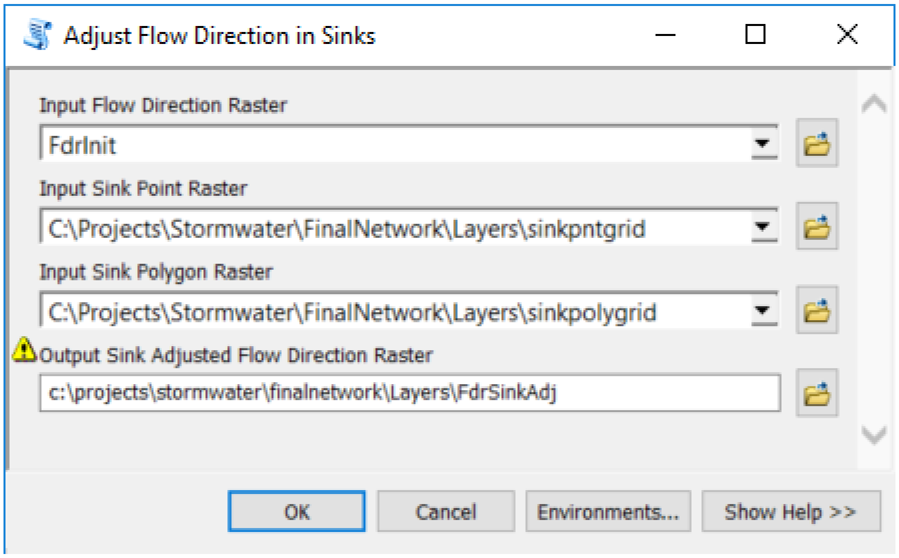


Figure 41 - Adjust Flow Direction in Sinks Interface

```
Executing: AdjustFlowDirectioninSinks FdrInit SinkPntGrid SinkPolyGrid
c:\projects\stormwater\finalnetwork\Layers\FdrSinkAdj
Start Time: Thu May 25 08:24:59 2017
Running script AdjustFlowDirectioninSinks...
--Adjusting flow direction in sinks...
Completed script AdjustFlowDirectioninSinks...
Succeeded at Thu May 25 08:26:14 2017 (Elapsed Time: 1 minutes 15 seconds)
```

4.11 Adjust Flow Direction in Streams

- Run Adjust Flow Direction in Streams.

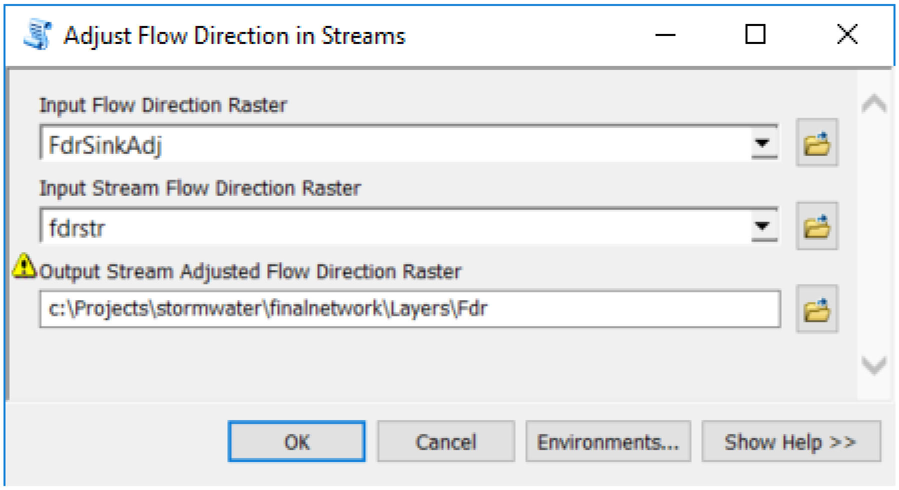


Figure 42 - Adjust Flow Direction in Streams

```
Executing: AdjustFlowDirectioninStreams FdrSinkAdj fdrstr
c:\Projects\stormwater\finalnetwork\Layers\Fdr
Start Time: Thu May 25 08:29:41 2017
Running script AdjustFlowDirectioninStreams...
Completed script AdjustFlowDirectioninStreams...
Succeeded at Thu May 25 08:30:20 2017 (Elapsed Time: 38.61 seconds)
```

4.12 Combine Stream Link and Sink Link

- Run Combine Stream Link and Sink Link.

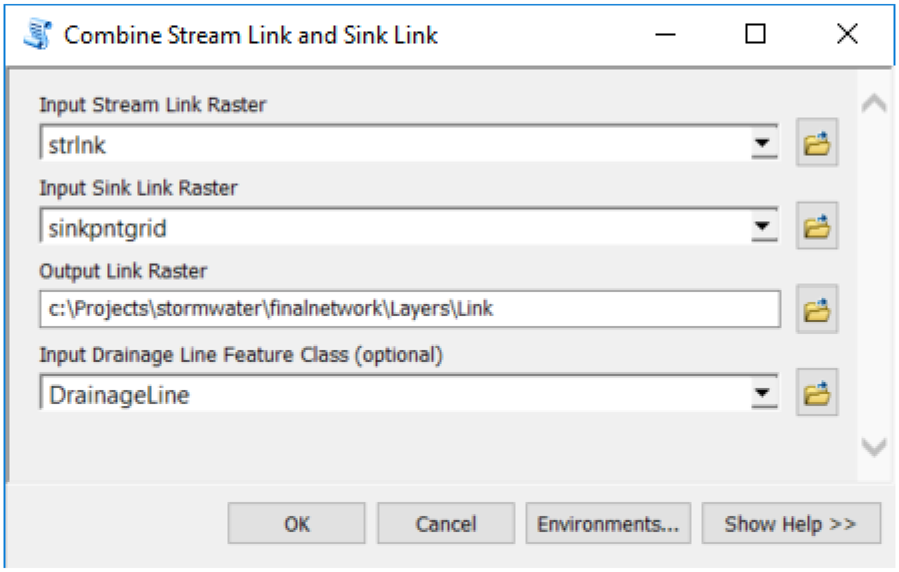


Figure 43 - Combine Stream Link and Sink Link Interface

```
Executing: CombineStreamLinkandSinkLink strlnk
C:\Projects\Stormwater\FinalNetwork\Layers\sinkpntgrid
c:\Projects\stormwater\finalnetwork\Layers\Link DrainageLine
Start Time: Thu May 25 14:37:35 2017
Running script CombineStreamLinkandSinkLink...
Min GridID in DrainageLine:7212964, Minimum value in streamlink: 2862463
Increment: 0
--Updating GridID in drainage lines...
--Updating link grid with sink links...
Completed script CombineStreamLinkandSinkLink...
Succeeded at Thu May 25 14:37:58 2017 (Elapsed Time: 23.55 seconds)
```

4.13 Catchment Grid Delineation

- Run Catchment Grid Delineation.

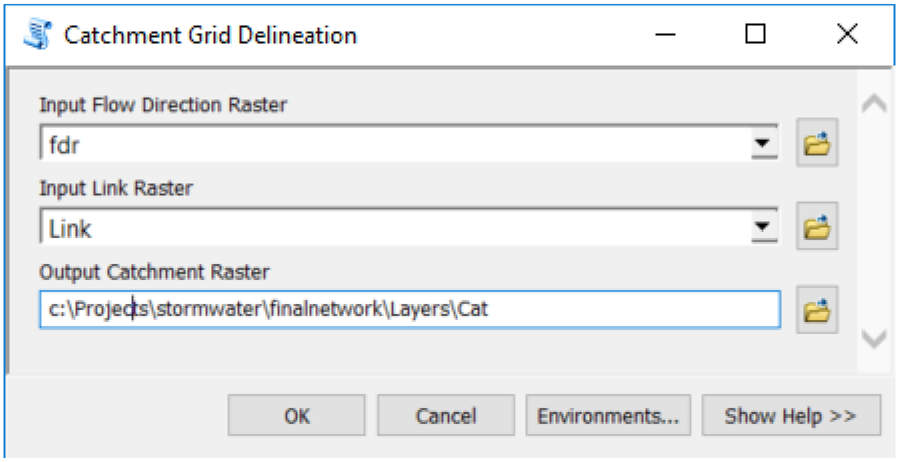


Figure 44 – Catchment Grid Delineation Interface

```
Executing: CatchmentGridDelineation fdr link
c:\Projects\stormwater\finalnetwork\Layers\Cat
Start Time: Wed May 24 16:21:42 2017
Running script CatchmentGridDelineation...
Completed script CatchmentGridDelineation...
Succeeded at Wed May 24 16:23:38 2017 (Elapsed Time: 1 minutes 55 seconds)
```

4.14 Catchment Polygon Processing

- Run Catchment Polygon Processing.

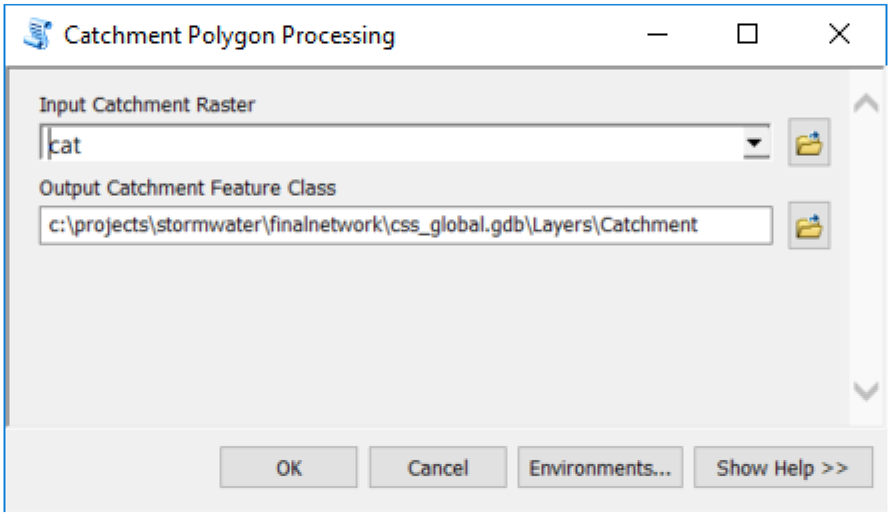


Figure 45 - Catchment Polygon Processing

```
Executing: CatchmentPolygonProcessing Cat
c:\projects\stormwater\finalnetwork\css_global.gdb\Layers\Catchment
Start Time: Thu May 25 10:28:15 2017
Running script CatchmentPolygonProcessing...
--Converting raster to polygons...
       - Conversion completed in 13.6 seconds.
Dissolving features...
       - Dissolve completed in 88.9 seconds.
Renaming field to GridID...
       - Renaming field completed in 0.2 seconds.
Assigning HydroIDs...
70009 record(s) updated on
c:\projects\stormwater\finalnetwork\css_global.gdb\Layers\Catchment. The
HydroID values ranged from 4418104 to 4488112.
       - Assigning HydroIDs completed in 8.8 seconds.
Adding attributes indices...
       - Adding attributes indices completed in 4.1 seconds.
Cleaning up...
Completed script CatchmentPolygonProcessing...
Succeeded at Thu May 25 10:30:15 2017 (Elapsed Time: 1 minutes 59 seconds)
```

4.15 Adjoint Catchment Processing

- Run Adjoint Catchment Processing.

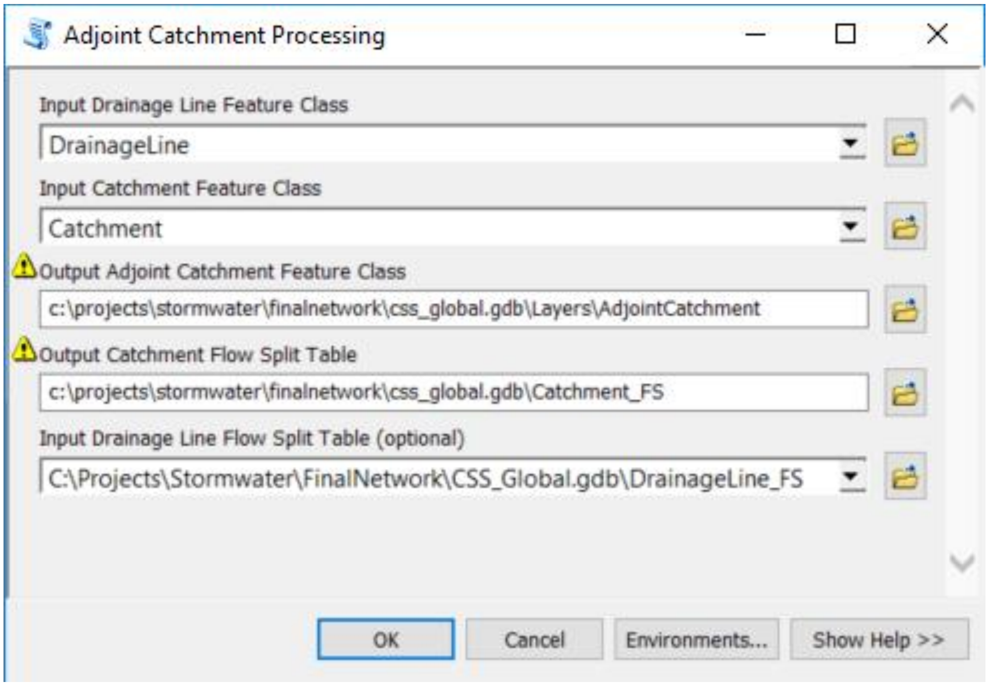
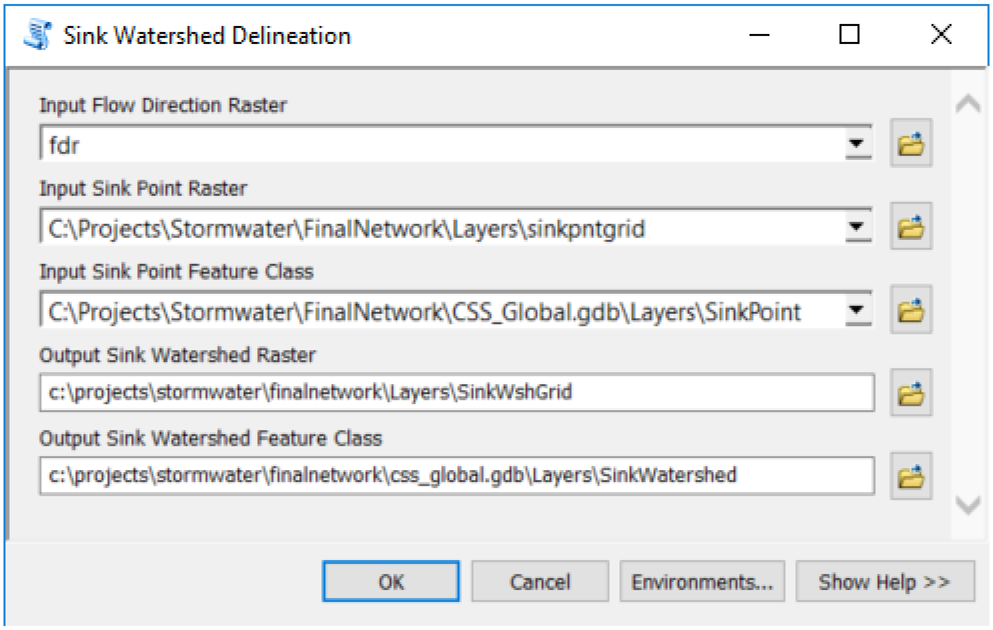


Figure 46 - Adjoint Catchment Processing Interface

4.16 Sink Watershed Delineation

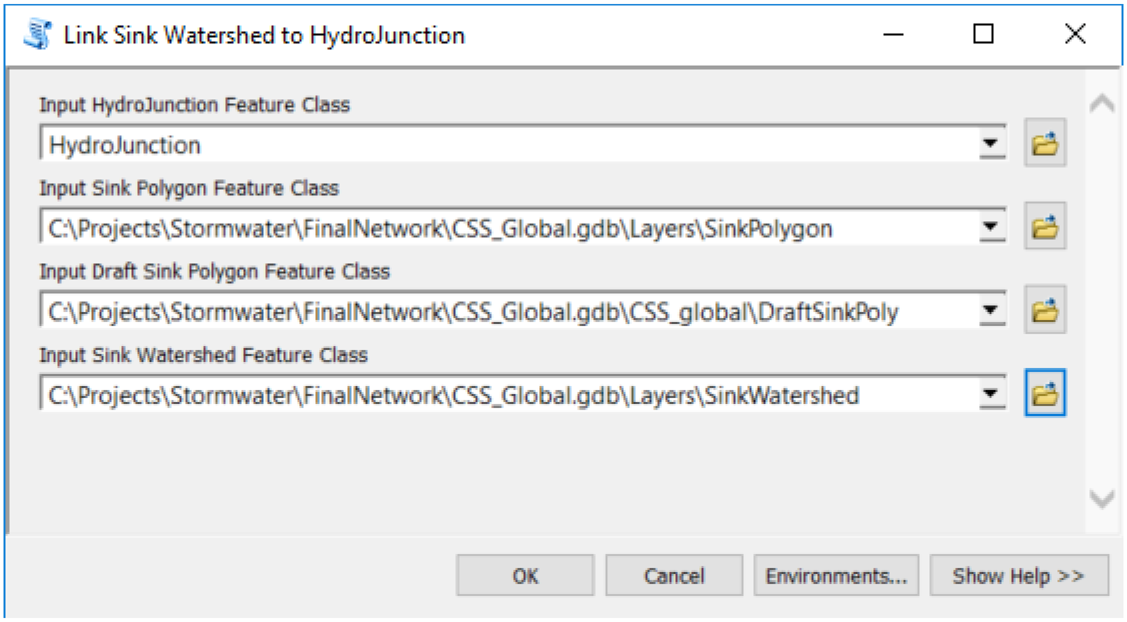
- Run Sink Watershed Delineation.




```
Executing: SinkWatershedDelineation fdr SinkPntGrid SinkPoint
c:\projects\stormwater\finalnetwork\Layers\SinkWshGrid
c:\projects\stormwater\finalnetwork\css_global.gdb\Layers\SinkWatershed
Start Time: Thu May 25 15:25:01 2017
Running script SinkWatershedDelineation...
  Delineating sink watersheds...
      Delineating sink watersheds completed in 158.44 seconds.
  Vectorizing sink watersheds and populating attributes...
67601 record(s) updated on
c:\projects\stormwater\finalnetwork\css_global.gdb\Layers\SinkWatershed. The
HydroID values ranged from 4559306 to 4626906.
      Vectorizing sink watersheds and populating attributes completed in
110.24 seconds.
Cleaning up...
Completed script SinkWatershedDelineation...
Succeeded at Thu May 25 15:29:34 2017 (Elapsed Time: 4 minutes 32 seconds)
```

4.17 Link Sink Watershed to HydroJunction

- Run Link Sink Watershed to HydroJunction.



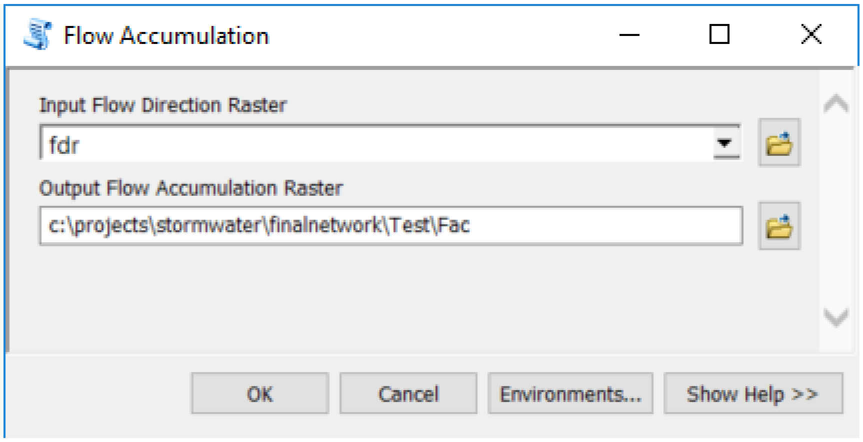

```
 Executing: linksinkwatershedtohydrojunction HydroJunction
 C:\Projects\Stormwater\FinalNetwork\CSS_Global.gdb\Layers\SinkPolygon
 C:\Projects\Stormwater\FinalNetwork\CSS_Global.gdb\CSS_global\DraftSinkPoly
 C:\Projects\Stormwater\FinalNetwork\CSS_Global.gdb\Layers\SinkWatershed
 Start Time: Fri May 26 16:15:26 2017
 Running script linksinkwatershedtohydrojunction...
 Deleting field FeatureID from SinkWatershed.
 Deleting existing relationship between SinkWatershed and HydroJunction
 Deleting field JunctionID from SinkWatershed.
 Joining Sink Watershed with SinkPolygon...
 Creating index FeatureID_Index...
 Joining Sink Watershed with DraftSinkPoly...
 Creating relationship class between SinkWatershed's JunctionID and
 HydroJunction's HydroID...
 Cleaning up...
 Completed script linksinkwatershedtohydrojunction...
Succeeded at Fri May 26 16:19:23 2017 (Elapsed Time: 3 minutes 57 seconds)
```

4.18 Create Stormwater Network

- Run Create Stormwater Network.

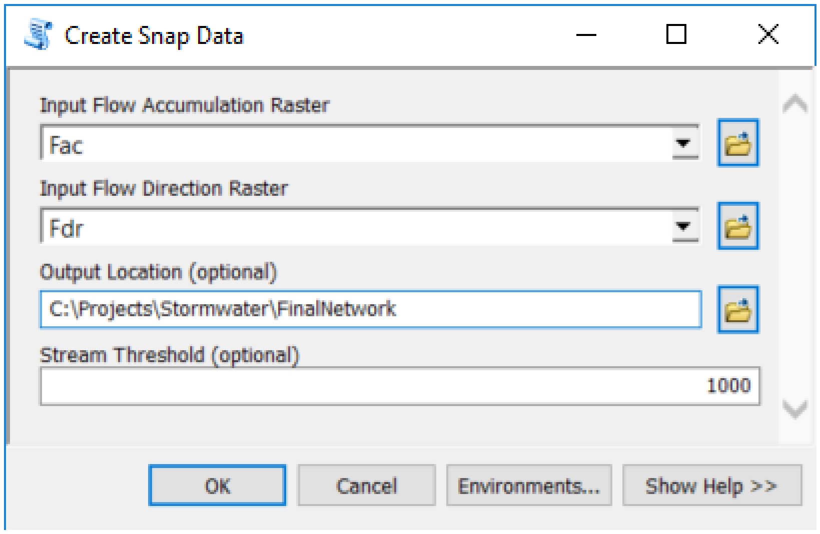
The tool creates a geometric network from Pipe, Stream and HydroJunction and set the flow direction in the lines to the digitized direction.

4.19 Flow Accumulation




```
Executing: FlowAccumulation fdr c:\projects\stormwater\finalnetwork\Test\Fac
Start Time: Tue May 30 09:50:17 2017
Running script FlowAccumulation...
Creating output directory c:\projects\stormwater\finalnetwork\Test.
Performing flow accumulation using INTEGER option.
Building raster attribute table.
Completed script FlowAccumulation...
Succeeded at Tue May 30 09:59:27 2017 (Elapsed Time: 9 minutes 9 seconds)
```

4.20 Create Snap Data




```
Executing: CreateSnapData Fac Fdr C:\Projects\Stormwater\Run1 1000
Start Time: Mon Jun 05 14:44:53 2017
Running script CreateSnapData...
--Calculating stream definition...Mon Jun 05 14:44:56 2017
Using threshold = 1000 cells.
--Calculating stream segmentation...Mon Jun 05 14:45:14 2017
--Creating drainage lines...Mon Jun 05 14:45:30 2017
--Replacing flow direction in sinks with 0...
Executing Stream to Feature...
       - Stream to Feature completed in 36.4 seconds.
Copying C:\Users\chri3244\Documents\ArcGIS\scratch\scratch.gdb\tmpdl0 into
feature dataset...
       - Copying completed in 4.8 seconds.
Cleaning completed: 0 line(s) deleted.
       - Cleanup completed in 1.2 seconds.
--Adding GridID as a field...
--Adding and assigning HydroID...
36053 record(s) updated on
C:\Projects\Stormwater\Run1\Run1.gdb\Layers\DrainageLine1k. The HydroID
values ranged from 349163 to 385215.
       - Adding and assigning HydroID completed in 4.4 seconds.
--Populating NextDownID...
       - Populating NextDownID completed in 10.3 seconds.
Cleaning up...
Cleaning up...
Completed script CreateSnapData...
Succeeded at Mon Jun 05 14:46:48 2017 (Elapsed Time: 1 minutes 54 seconds)
```

5.0 Stormwater Delineation

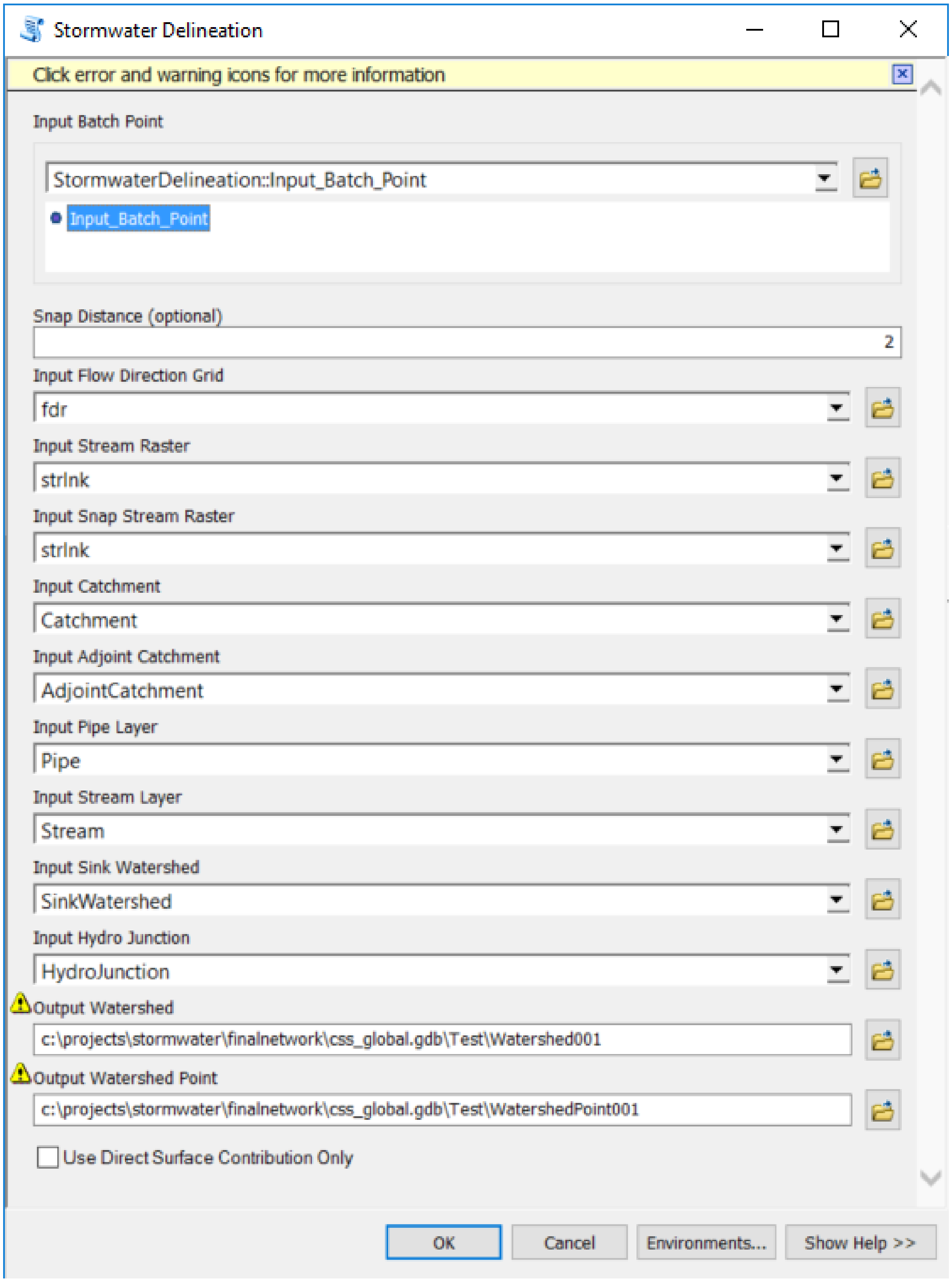


Figure 47 – Stormwater Delineation Tool

6.0 Troubleshooting the Resulting Dataset

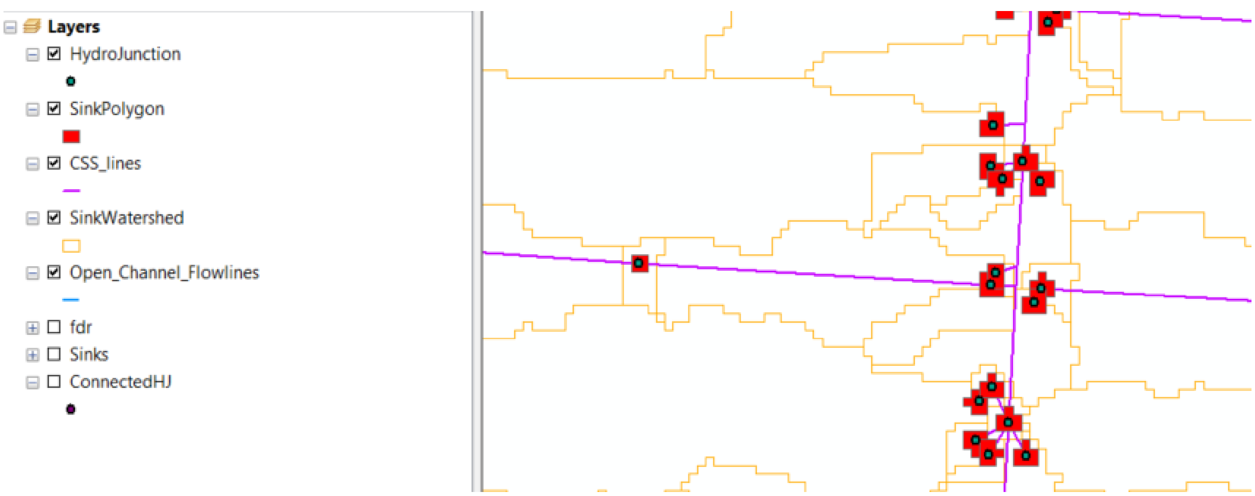
- Open Map document Stormwater.mxd.

Network

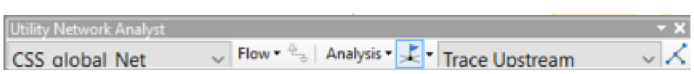
1. HydroJunction → related to SinkWatershed via DrainID/HydroID: should at least contain all Junctions related to sinks (and maybe all except default junctions) . Created from initial junctions: Sinks, SS_Inlets, SS_Manhole_Combined_Sewer.
2. CSS_lines
3. Open_Channel_Flowlines

Related layers

- SinkWatershed: associated to HydroJunction via DrainID
- Fdr: flow direction
- ConnectedHJ: connected junctions in initial network used to burn in sinks (Sinks, SS_Inlets, SS_Manhole_Combines_Sewer)
- Catchment: catchment associated to inlet and drainage lines



Set trace to use Selection: Analysis > Options > Results



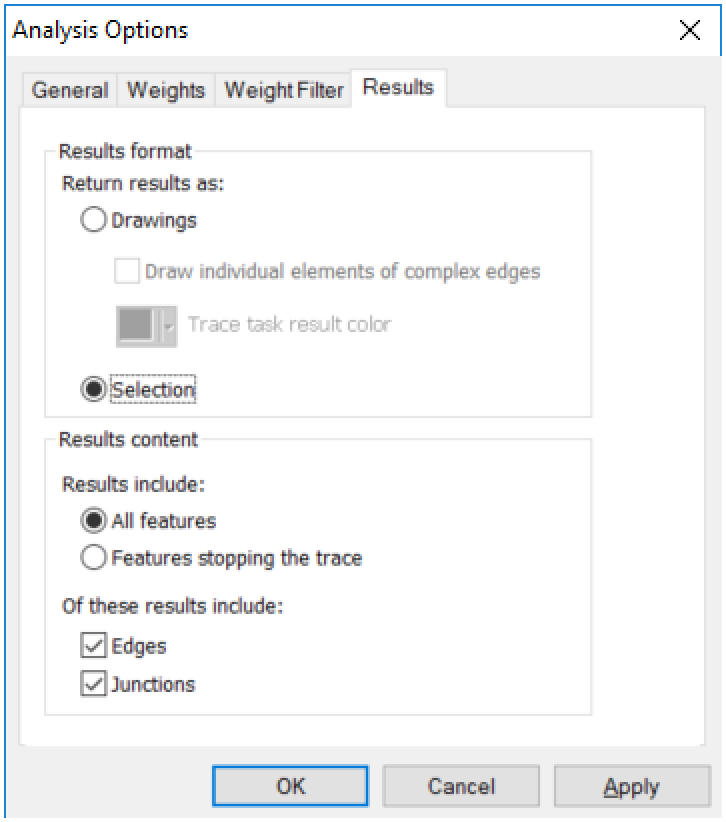
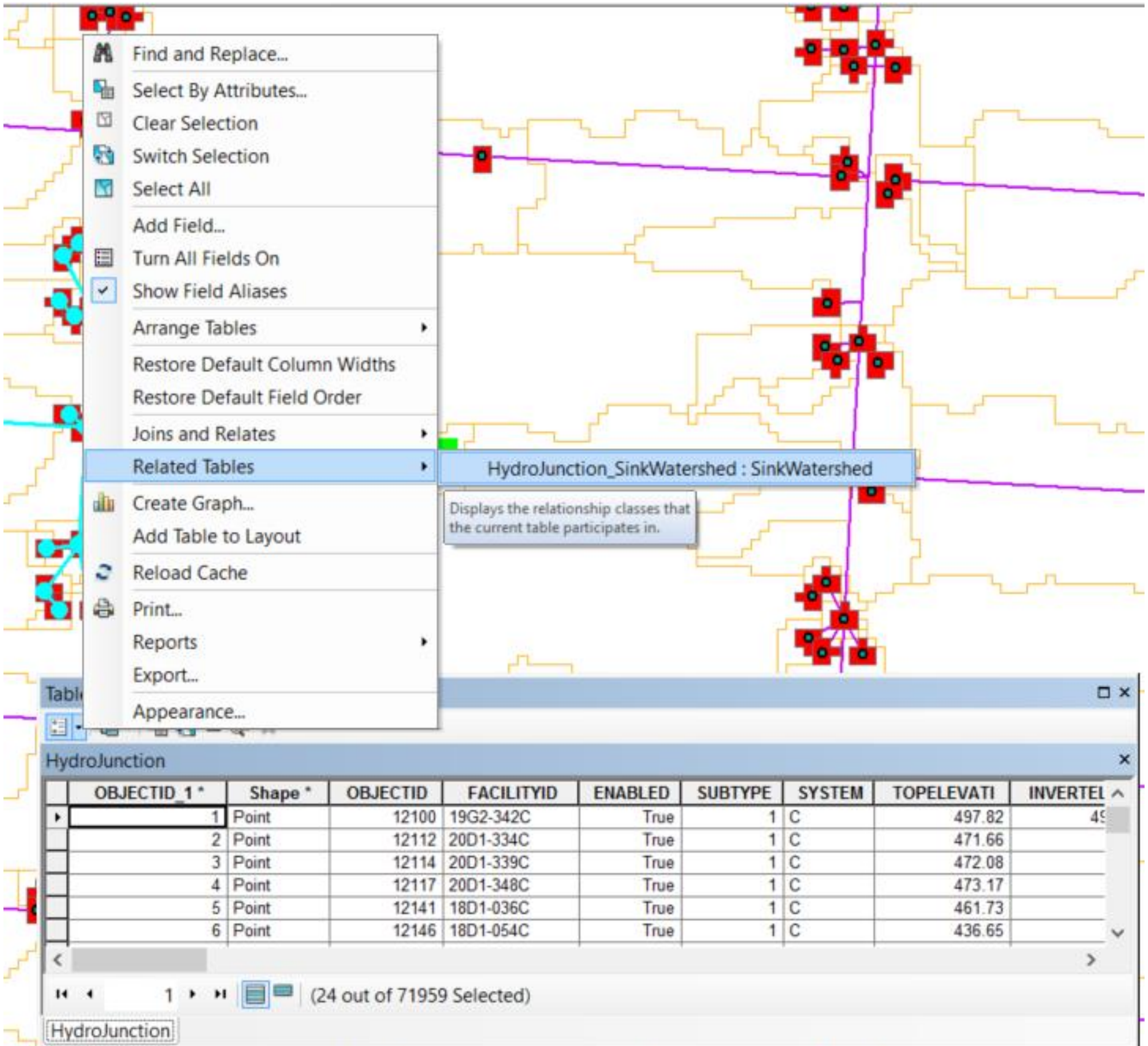
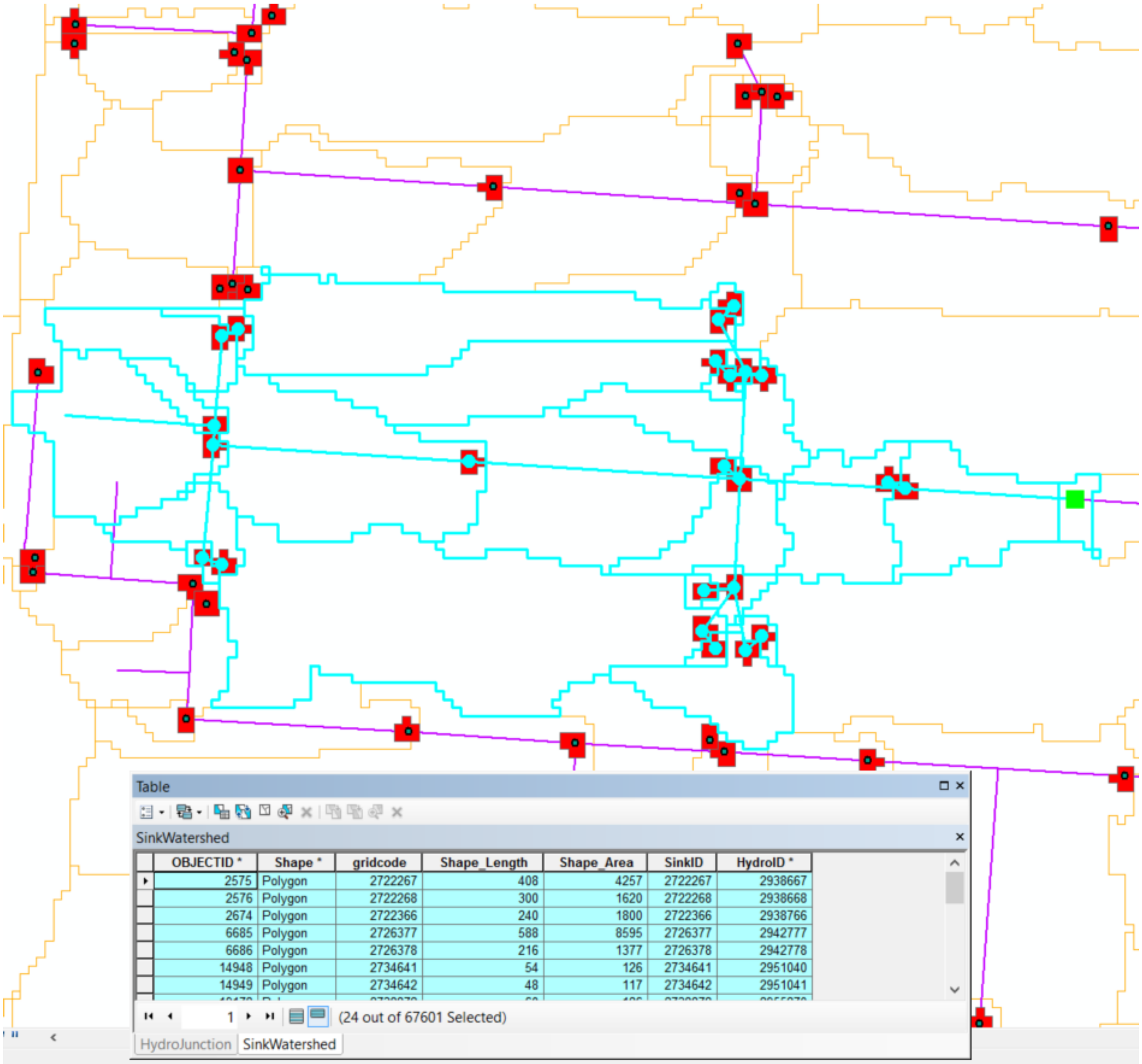


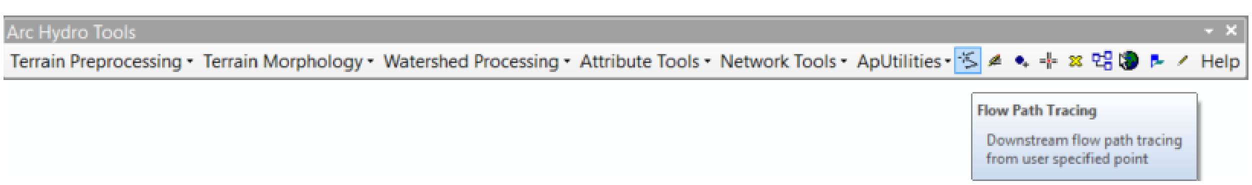
Figure 48 – Trace Analysis Options

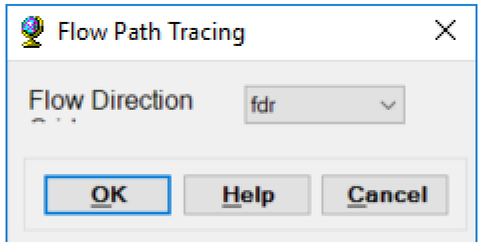
- Put a junction flag and perform an upstream trace.
- Open the attributes table of HydroJunction and select Related Tables > HydroJunction_SinkWatershed to select the SinkWatershed related to each traced HydroJunction.

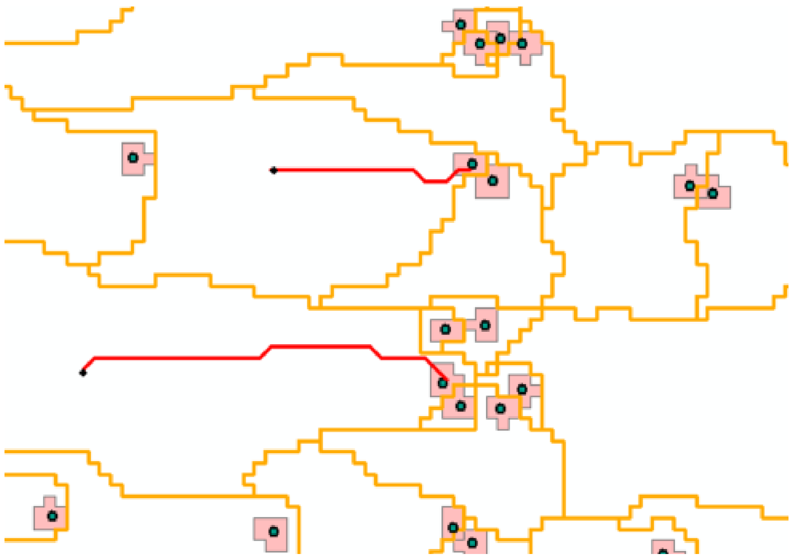




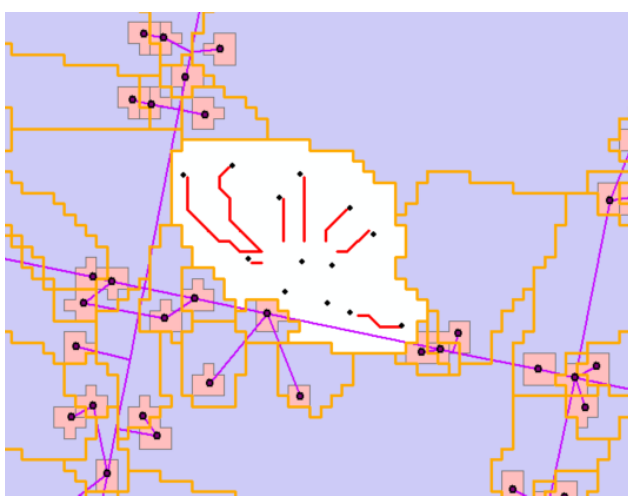
- Use the Flow Path Tracing tool to trace using the Fdr raster.
- Click the tool, click on the map and select Fdr if prompted (first time).
- Then click on the map to perform traces.



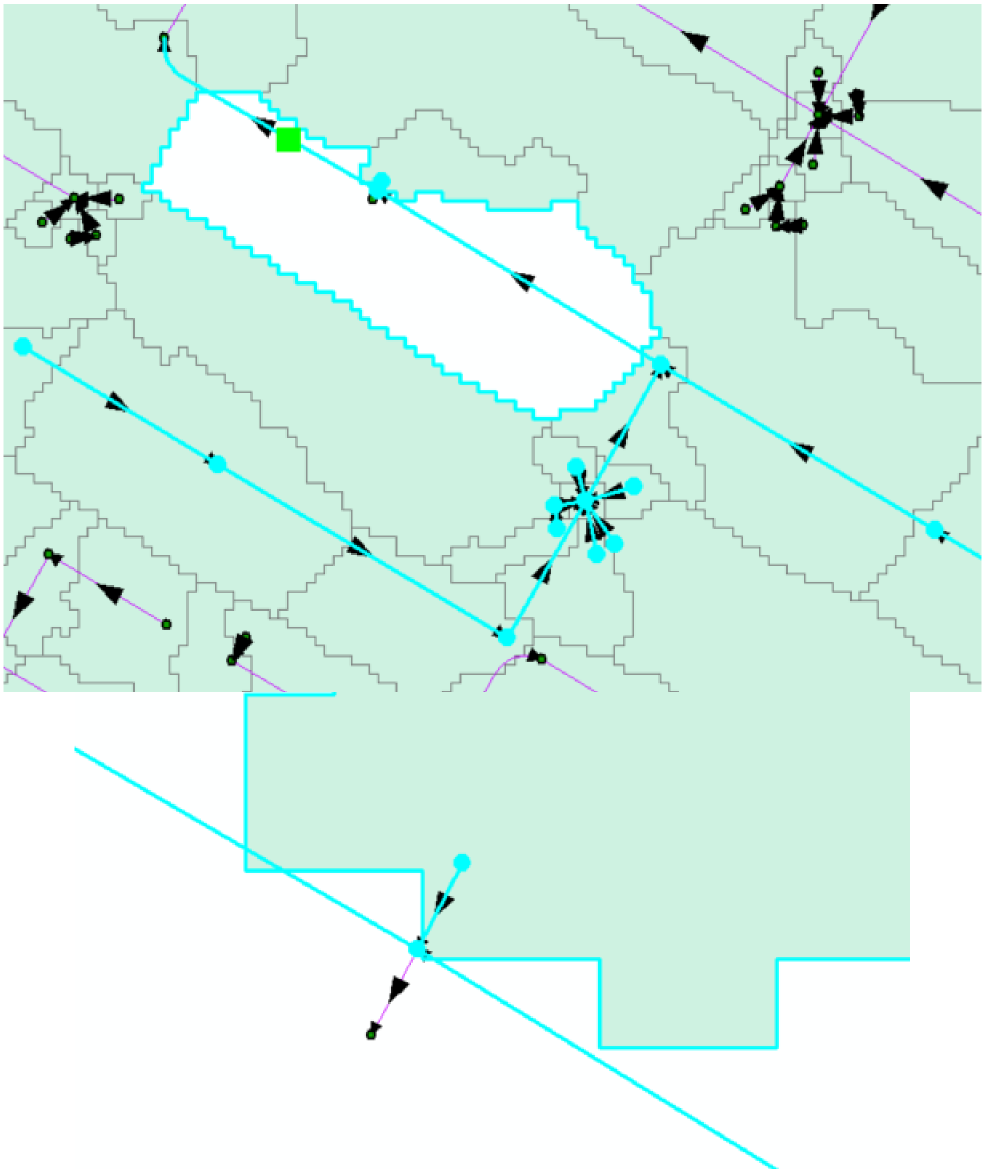




- Review Catchment to identify problem areas: looks like area was not correctly filled (probably because it connects to a neighboring sink – need to check)

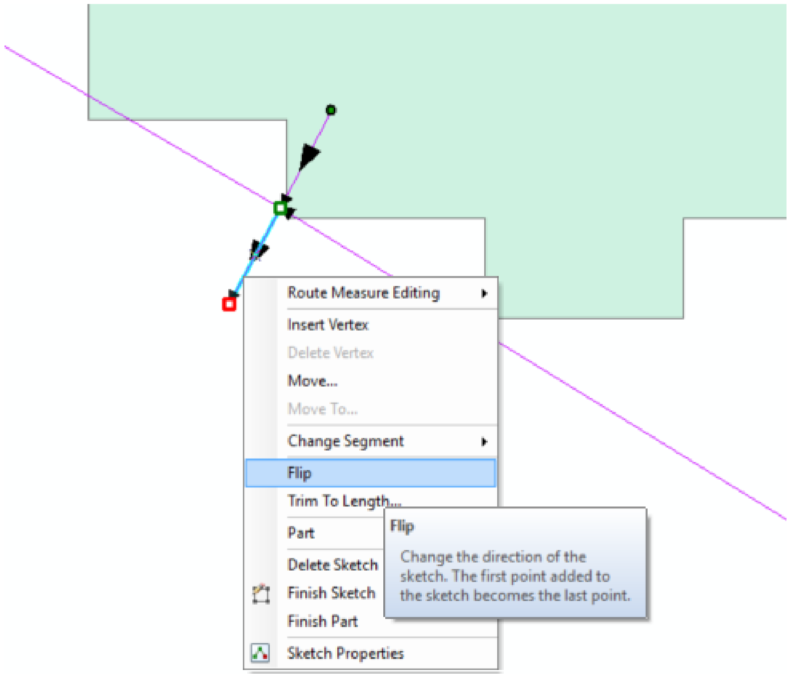


Problem was offset in Level DEM was to small (the z factor was not set properly. To avoid this issue, use a large value for the offset to make sure the elevations in the sink are much lower than any neighboring elevations.



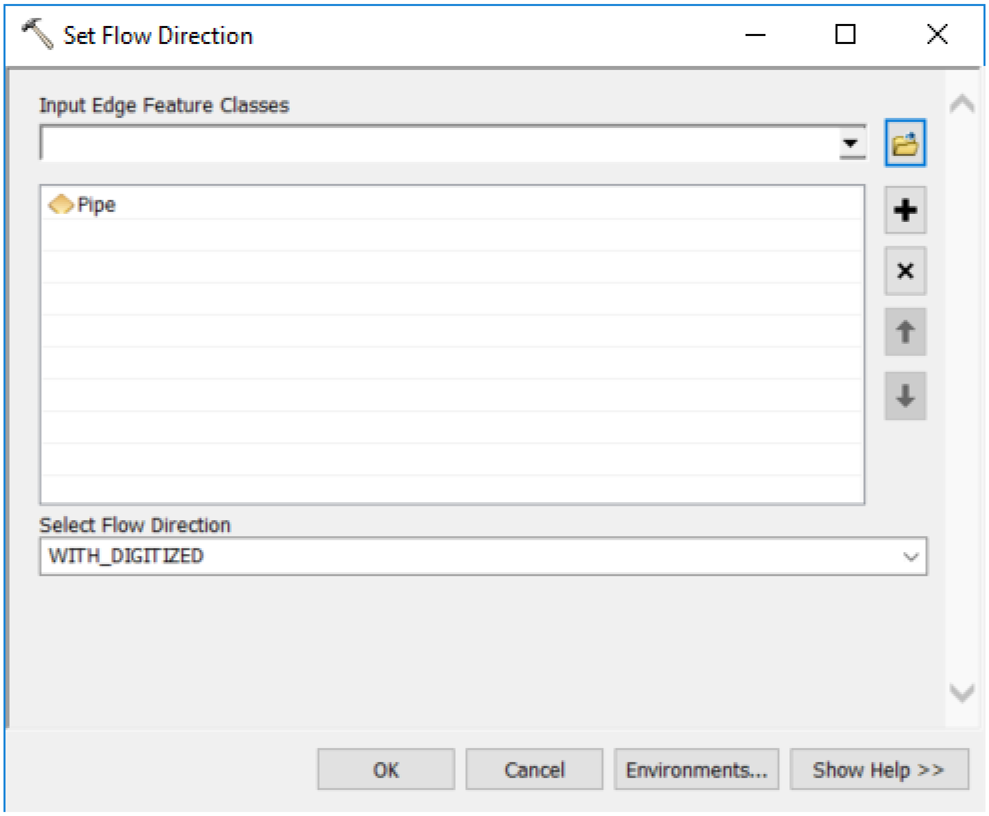
Hole in the watershed cause by wrong flow direction. Need to reverse the direction of the line to fix this issue so the water goes from the lower HydroJunction towards the main pipe instead of away from it.

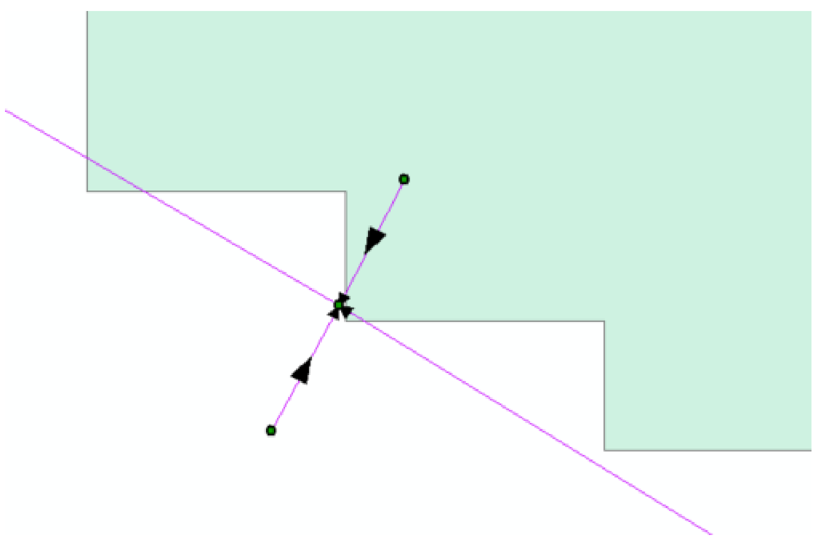
- Start Editing – Double click the line to edit, right-click and Select Flip.

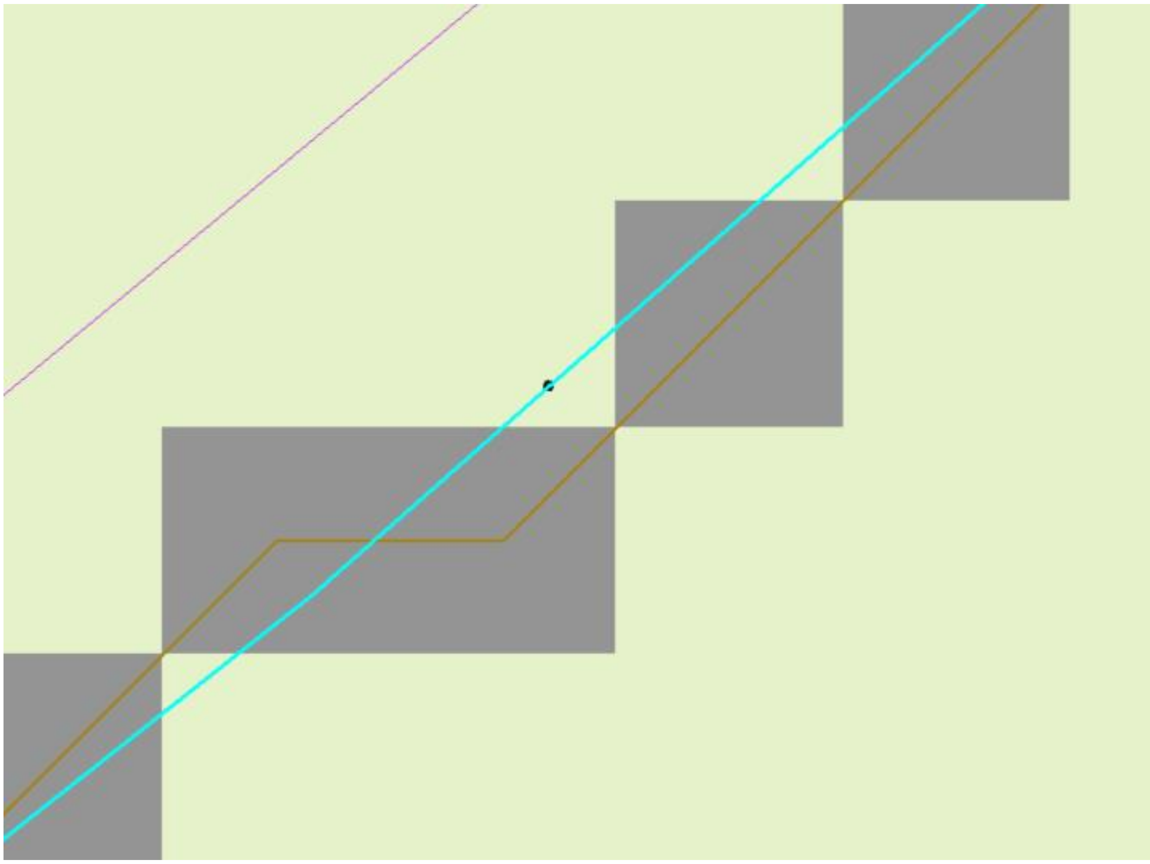


The flow direction is now uninitialized.

- Stop editing.
- Select the line you just edited and reset the Flow Direction in the digitized direction.

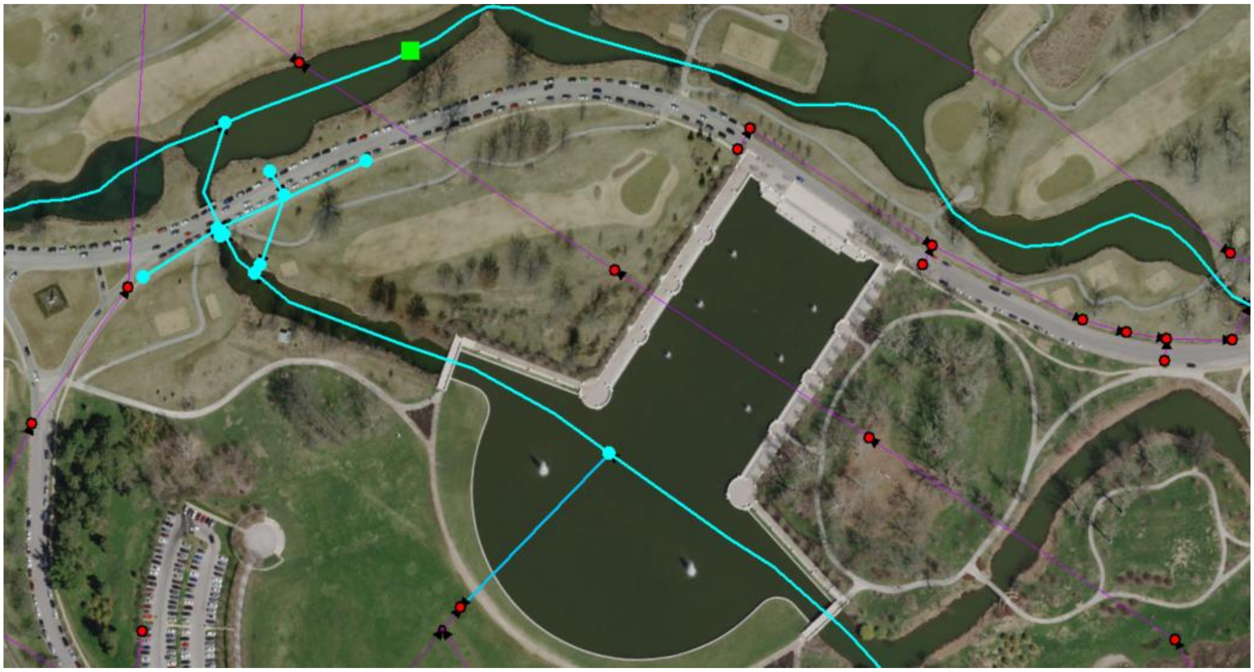

Set Flow Direction
Input Edge Feature Classes
Pipe
Select Flow Direction
WITH_DIGITIZED
OK
Cancel
Environments...
Show Help >>





Stream does not match DrainageLine/StrLnk perfectly. But if point is snapped to line for tracing, it should also be snapped to the stream grid for local delineation (snap to closest stream cell).

- Review direction of blue line.



Missing HydroJunction at the end of the blueline.

Figure 49 - Example of missing Hydrojunction at end of Stream