# Bridge Quality Assurance 1

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We start with a state-wide collection of National Bridge Inventory (NBI) points, and we wish to verify three things:

1. The bridge is connected to the correct TxDOT Roadway Inventory **road** line;
2. The bridge is connected to a **stream** that is forecast by the National Water Model;
3. The bridge has a satisfactory deck and stream **cross-section profile**, as obtained from the Tx-Bridge data.

The desired end result is an augmented NBI dataset that has ID's populated for the road line, the stream line and the Tx-Bridge profile, a field that says "Satisfactory" if the bridge passes all the tests, and a Comment field that contains space for an explanation if the bridge does not pass all the tests.

The assessment is done for all NBI bridges in a Maintenance Section.

In order to do this, we need a state-wide geodatabase containing all the necessary input information.

The ArcGIS Project and geodatabase from this exercise can be found at:
https://utexas.box.com/s/frn7a8ut8yxgsp2j91gqktzsbgee4cyp

## Building the State-wide Geodatabase

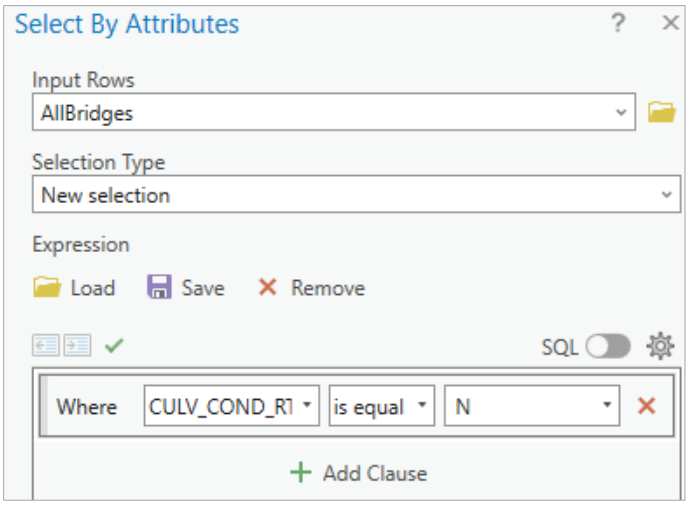
## 1. NBI Bridges

Start a new ArcGIS Pro project called **BridgeQualityAssurance.**

The TxDOT Bridges dataset, which contains National Bridge Inventory (NBI) bridges for Texas, is obtained from the TxDOT Open Data Portal: https://gis-txdot.opendata.arcgis.com/datasets/83af0d2957ca4c2eb340e4bd04a1046f_0/explore. Download these bridges, add them to the map, and export them into the BridgeQualityAssurance as feature class **AllBridges**.

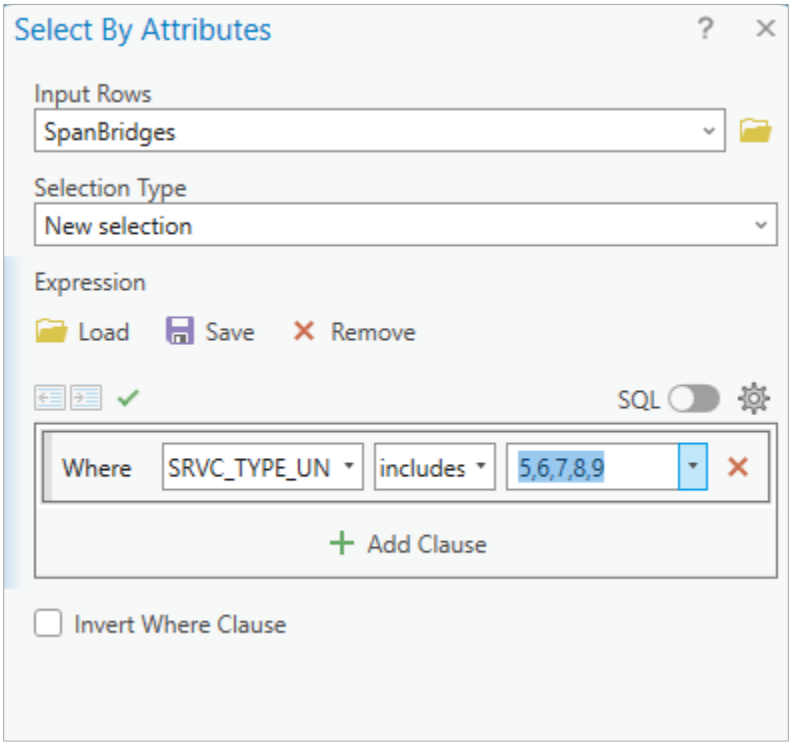
The NBI Bridges are of two types: **Span Bridges**, which have a deck supported on piers, and **Bridge-Class Culverts,** which are large multiple box culvert structures that are built into the road-bed and are designed to function satisfactorily even if they are overtopped.

The span bridges are identified by the query **CULV_COND_RATING = 'N'**




Some of the span bridges are bridges for one road crossing another road or a road crossing a railroad. The span bridges over water are identified by the query

**SRVC_TYPE_UNDER_BRDG includes the values 5, 6, 7, 8, 9**




Export these bridges to feature class **NBIBridgesWater.**

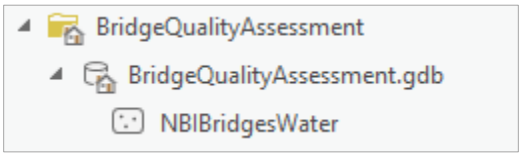
These two queries have reduced the number of bridges to be considered as shown in Table 1, which applies for data downloaded on 10 October 2024 (the number of bridges changes as new bridges are built and old ones are taken off-line).

| Bridges | Number |
|---|---|
| **All Bridges** | **57,955** |

| | |
|---|---|
| **Span Bridges** | **36,434** |
| **NBI Bridges over Water** | **25,046** |

Table 1. Number of bridges in each class

Delete the AllBridges, and SpanBridge feature classes from the BridgeQualityAssurance geodatabase to leave just the feature class that we want to deal with: **NBIBridgesWater**




**Delete Unneeded Fields**

The NBI database contains a large number of fields that are not needed for our project. These can be deleted by using the geoprocessing tool Delete Field, selecting "Delete All" which checks all the fields to be deleted, and then unchecking the fields that are to be retained. The result yields the set of fields shown below.

| Visible | Read Only | Field Name | Alias | Data Type |
|---|---|---|---|---|
| ☑ | ☑ | OBJECTID | OBJECTID | Object ID |
| ☑ | ☐ | Shape | Shape | Geometry |
| ☑ | ☐ | BRDG_ID | Bridge ID | Text |
| ☑ | ☐ | STATE_HWY_DEPT_DIST | STATE_HWY_DEPT_DIST | Text |
| ☑ | ☐ | MAINT_RSPNBL | MAINT_RSPNBL | Text |
| ☑ | ☐ | OWNR | OWNR | Text |
| ☑ | ☐ | MAINT_SECT_NBR | MAINT_SECT_NBR | Text |
| ☑ | ☐ | SRVC_TYPE_UNDER_BRDG | SRVC_TYPE_UNDER_BRDG | Text |
| ☑ | ☐ | MEMB_TYPE | MEMB_TYPE | Text |
| ☑ | ☐ | LNGTH_MAX_SPAN | LNGTH_MAX_SPAN | Double |
| ☑ | ☐ | STRUC_LNGTH | STRUC_LNGTH | Double |
| ☑ | ☐ | LT_SDWALK_WIDTH | LT_SDWALK_WIDTH | Double |
| ☑ | ☐ | RT_SDWALK_WIDTH | RT_SDWALK_WIDTH | Double |
| ☑ | ☐ | BRDG_RDWAY_WIDTH_CURB_CURB | BRDG_RDWAY_WIDTH_CURB_CURB | Double |
| ☑ | ☐ | DECK_WIDTH_OUT_OUT | DECK_WIDTH_OUT_OUT | Double |
| ☑ | ☐ | CULV_COND_RTNG | CULV_COND_RTNG | Text |

The definition of these attributes is given at:
https://www.caee.utexas.edu/prof/maidment/StreamflowII/Documents/Bridge_Data_Dictionary.pdf
and their Coding Guide is given at:
https://www.caee.utexas.edu/prof/maidment/StreamflowII/Documents/BridgeCodingGuide.pdf

The **MAINT_RSPNBL** and **OWNR** specifies who owns and maintains the bridge and if these values = 1, it means that TxDOT does that.

The bridge thickness is defined for our project from the attributes **MEMB_TYPE** and **LNGTH_MAX_SPAN**, using a set of rules specified at: https://www.caee.utexas.edu/prof/maidment/StreamflowII/ReferenceDocs/0-7095-TM5B-Final.pdf on pp. 9-12.

**Additional Fields**

In order to store the results of the Bridge Quality Assessment, two additional fields are included in the NBIBridgesWater feature class: **Satisfactory (Long Integer)** where **Satisfactory = 1** means the bridge is acceptable, and **Satisfactory = 0** means that it is not acceptable. The field **Comment (Text)** is there for explanation of what was determined for this bridge during the assessment.

| IRB | DECK_WIDTH_OUT_OUT | CULV_COND_RTNG | Satisfactory | Comment |
|---|---|---|---|---|
| 43 | 46 | N | <Null> | <Null> |
| 36 | 44 | N | <Null> | <Null> |
| 51 | 66 | N | <Null> | <Null> |
| 48 | 56 | N | <Null> | <Null> |
| 65 | 76 | N | <Null> | <Null> |
| 40 | 50 | N | <Null> | <Null> |

## 2. Roads

The roads are obtained from the TxDOT Open Data Portal at: https://gis-txdot.opendata.arcgis.com/datasets/843ebe994c114961a855ec76ddcde086_0/ Download these and load them into the project.

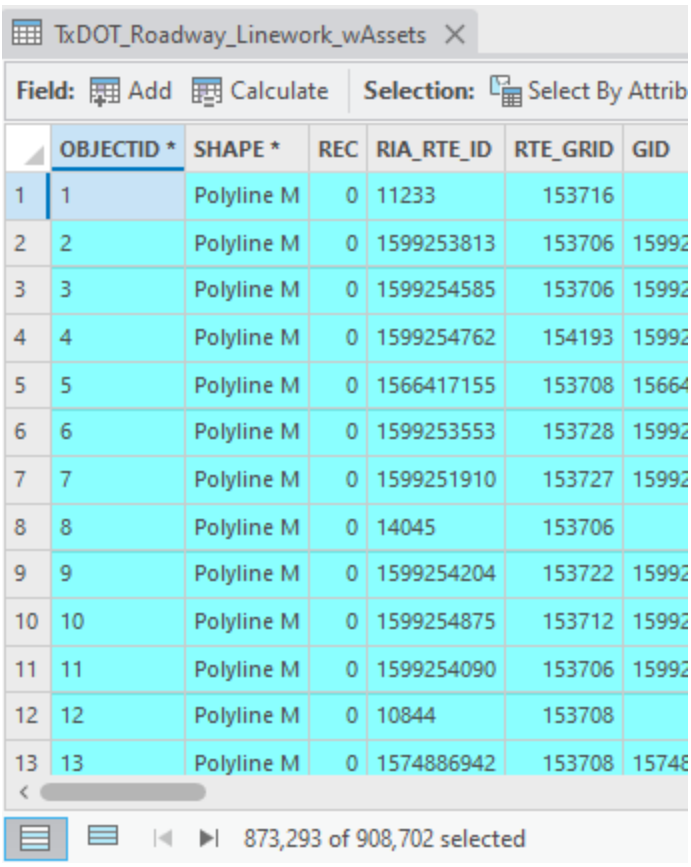
Some of these road lines are for a line down the median of a multilane highway, and we don't need these median lines, so filter them out by selecting the roads we want to keep with this query:

RDBD_ID IN ('GS', 'RG', 'AG', 'BG', 'LG', 'MG', 'PG', 'SG', 'XG', 'YG', 'TG')

OR (RDBD_ID = 'KG' And (MED_TYPE = 0 Or HWY_DES NOT IN (0, 3, 4, 5)))

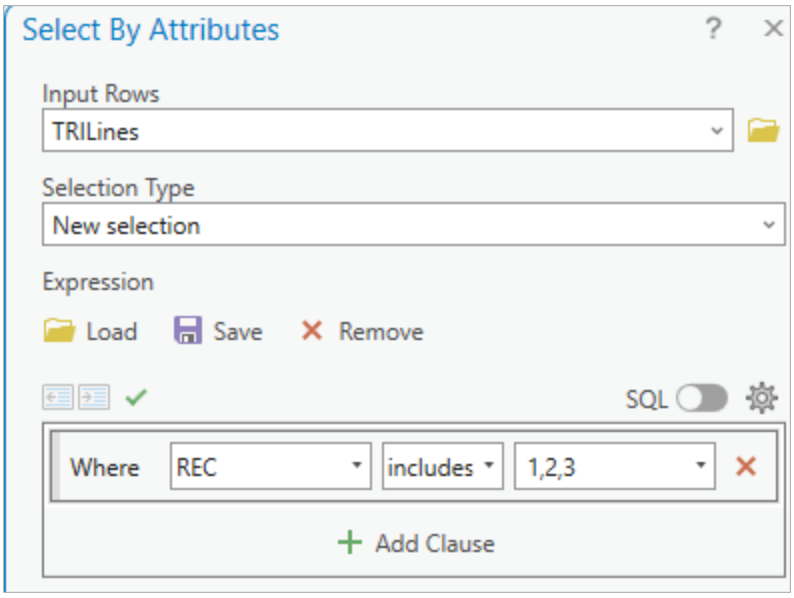
OR HSYS IN ('LS','CR')

This yields 873,293 roads selected of 908,702 total

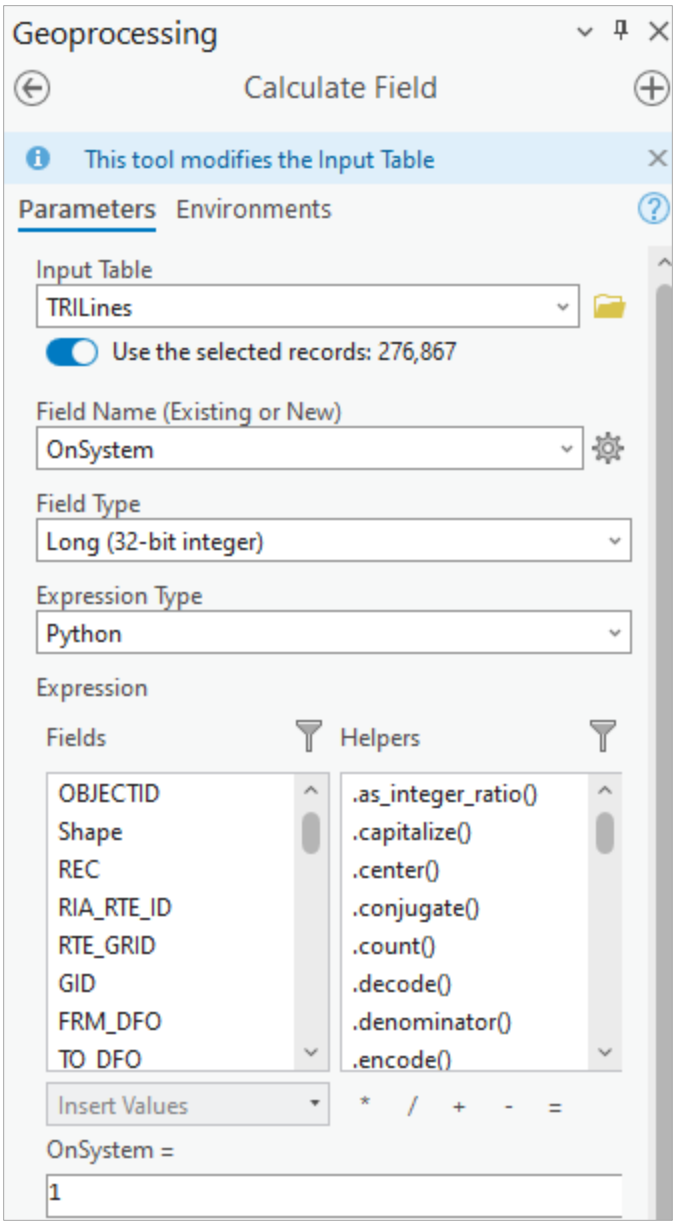



With the desired roads selected, export them to a new feature class **TRILines**


There are couple of classes of road lines of particular interest. The first of these are the On-System road lines, which are the ones that TxDOT owns and maintains.

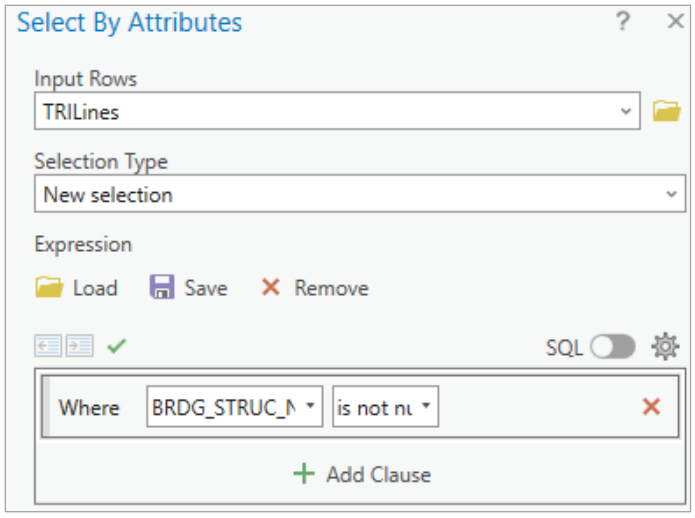



There are 242,210 records of 873,293 that satisfy that criterion. For these records, Calculate a new field, OnSystem = 1, as shown below.

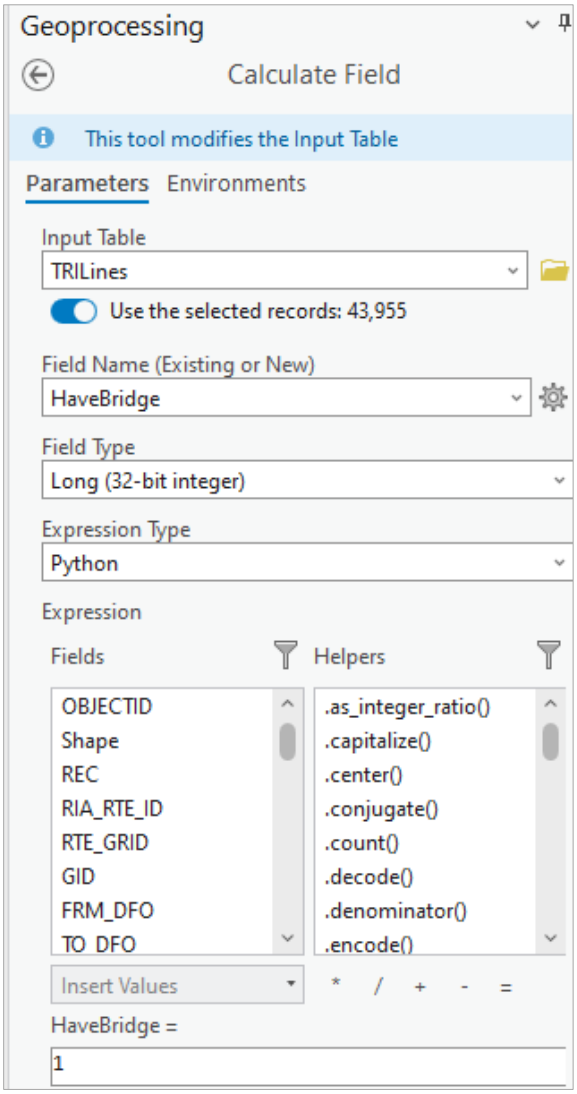



This yields an attribute OnSystem with values of 1 for OnSystem roads and <null> for OffSystem roads. Use **Select by Attributes** for OnSystem is null and Calculate Field **OnSystem = 0** for these roads.

Another set of TRI lines are those that have a bridge identified on them. These can be selected using the query BRDG_STRUC_NBR is not Null (these lines have an NBI Bridge ID attributed for them). There are 41,448 out of 873.298 TRI road lines. This is an encouraging number but less than the number of NBI bridges in total, 57,955, so there are about 14,000 NBI bridges that do not have an associated bridge line in the TxDOT Roadway Inventory. Of the 43,955 TRI road lines that have bridges, 43,036 are located On-System (98%) and 919 Off-System (2%). This shows that the On-System bridges are well located on the TxDOT Roadway Inventory but not so for the Off-System bridges.




Calculate a new attribute HasBridge = 1 for these selected lines

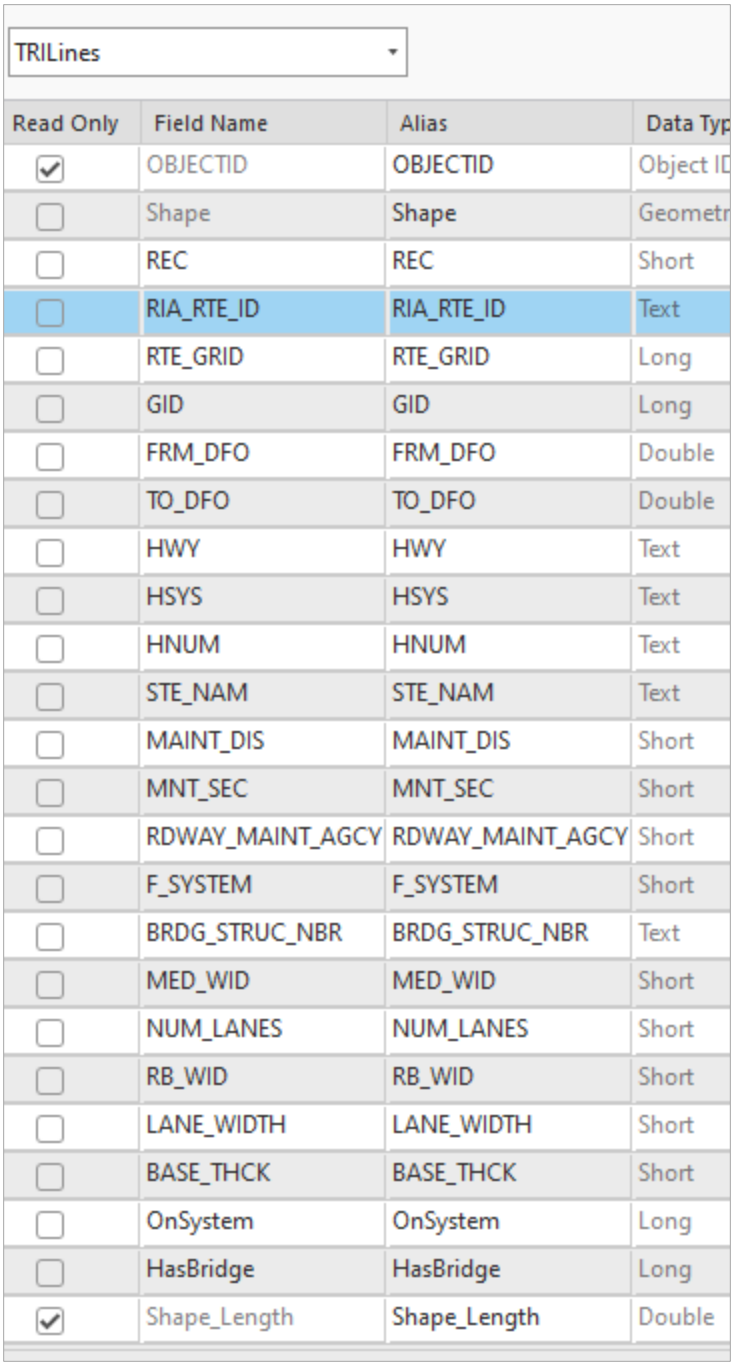


So now we have identifiers that tell us if we have an On-System road and also if the road line has a bridge on it.

| )VMT | DTRKVMT | Shape_Length | OnSystem | HasBridge |
|---|---|---|---|---|
| 3133.508 | 48.72 | 1448.888763 | 1 | <Null> |
| 288.672 | 98.064 | 89.389333 | 1 | <Null> |
| 2231.485 | 21.534 | 185.594051 | 1 | <Null> |
| 228.72 | 1.976 | 15.341408 | 1 | 1 |
| 21.735 | 1.8 | 83.664587 | 1 | <Null> |
| 14.08 | 1.628 | 81.779548 | 1 | 1 |
| 15 | 1.42 | 18.240078 | 1 | 1 |
| 66.465 | 13.545 | 597.043193 | 1 | <Null> |

**Delete Fields**

Similar to the NBI Bridges, there are many fields in the TxDOT Roadway Inventory that do not relate to our project. These have been deleted to leave the remaining attributes, shown below. The description of these attributes is given at:
https://www.caee.utexas.edu/prof/maidment/StreamflowII/Documents/TxDOT_Roadway_Inventory_Specifications_2020.pdf

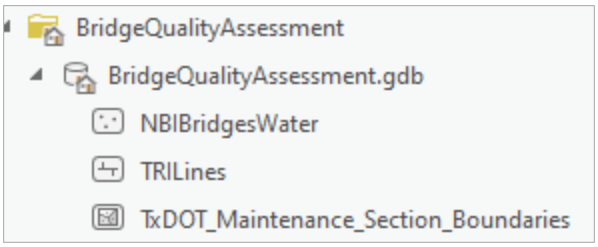


TRILines

| Read Only | Field Name | Alias | Data Typ |
|---|---|---|---|
| ☑ | OBJECTID | OBJECTID | Object ID |
| ☐ | Shape | Shape | Geometr |
| ☐ | REC | REC | Short |
| ☐ | RIA_RTE_ID | RIA_RTE_ID | Text |
| ☐ | RTE_GRID | RTE_GRID | Long |
| ☐ | GID | GID | Long |
| ☐ | FRM_DFO | FRM_DFO | Double |
| ☐ | TO_DFO | TO_DFO | Double |
| ☐ | HWY | HWY | Text |
| ☐ | HSYS | HSYS | Text |
| ☐ | HNUM | HNUM | Text |
| ☐ | STE_NAM | STE_NAM | Text |
| ☐ | MAINT_DIS | MAINT_DIS | Short |
| ☐ | MNT_SEC | MNT_SEC | Short |
| ☐ | RDWAY_MAINT_AGCY | RDWAY_MAINT_AGCY | Short |
| ☐ | F_SYSTEM | F_SYSTEM | Short |
| ☐ | BRDG_STRUC_NBR | BRDG_STRUC_NBR | Text |
| ☐ | MED_WID | MED_WID | Short |
| ☐ | NUM_LANES | NUM_LANES | Short |
| ☐ | RB_WID | RB_WID | Short |
| ☐ | LANE_WIDTH | LANE_WIDTH | Short |
| ☐ | BASE_THCK | BASE_THCK | Short |
| ☐ | OnSystem | OnSystem | Long |
| ☐ | HasBridge | HasBridge | Long |
| ☑ | Shape_Length | Shape_Length | Double |

## 3. Maintenance Sections

The Maintenance Section Boundaries are obtained from the TxDOT Open Data Portal at: https://gis-txdot.opendata.arcgis.com/datasets/3209155fa26b470db63f56733dd17d36_0/ Download these and load them into the project. Export this feature class to the **BridgeQualityAssessment** geodatabase with the same name



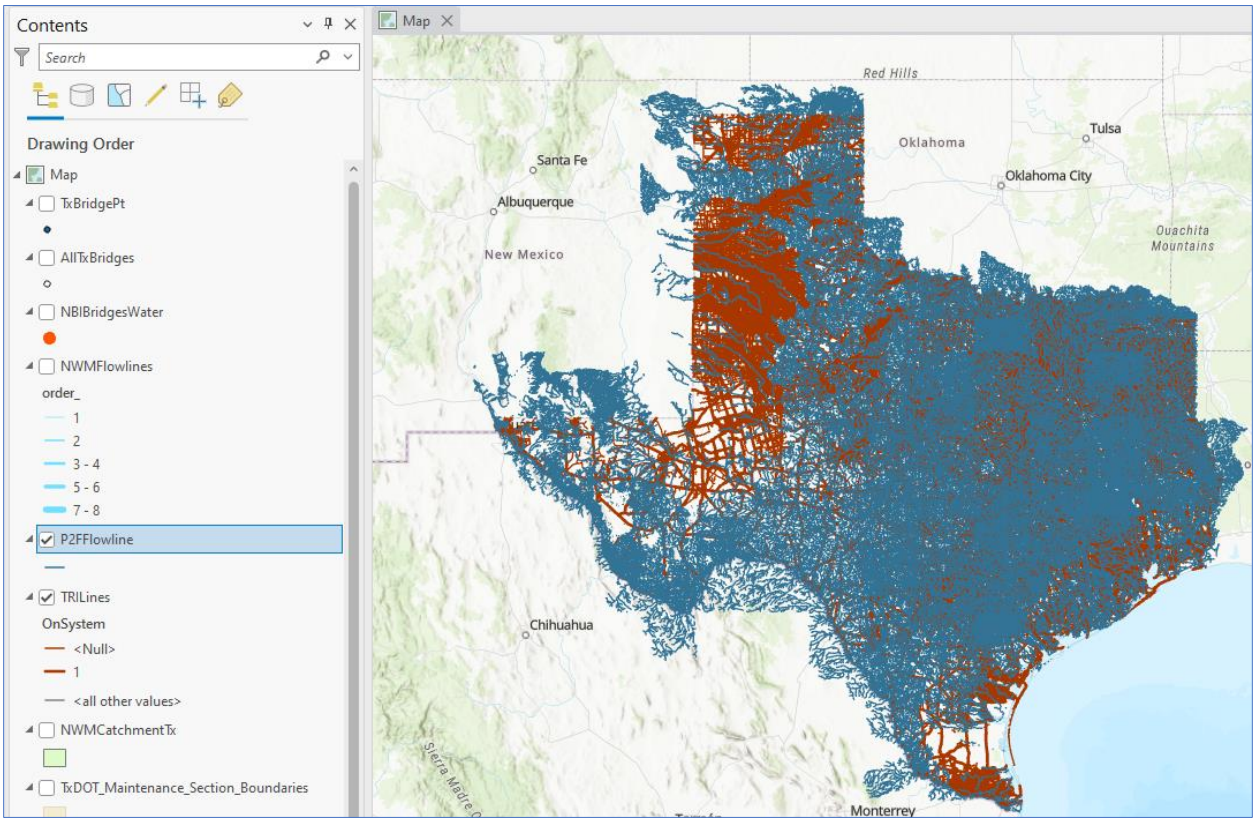

## 4. Pin2Flood Hydrofabric

The National Water Model Hydrofabric was created with a 10m DEM, and for Texas a more refined Pin2Flood Hydrofabric was created in a previous project done for the Texas Division of Emergency Management (TDEM) by the project team.

The flowlines created in this Pin2Flood processing are accessible at:

https://web.corral.tacc.utexas.edu/nfiedata/pin2flood/texas/streams_texas.gdb.zip

Export this dataset to the **BridgeQualityAssessment** geodatabase as **P2FFlowline**

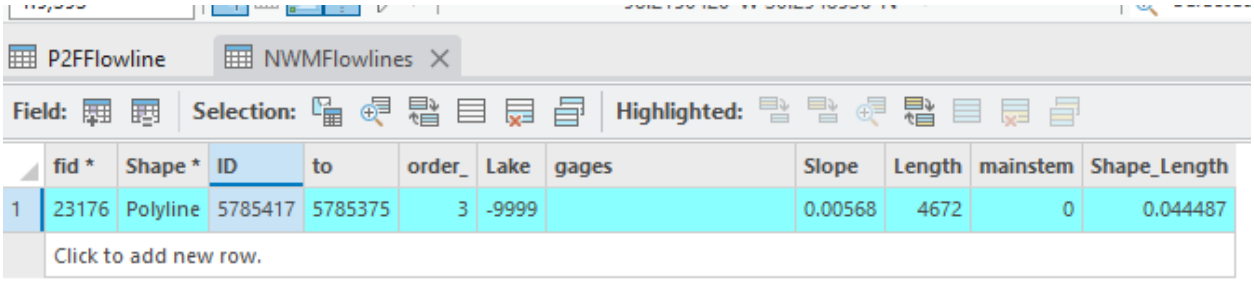


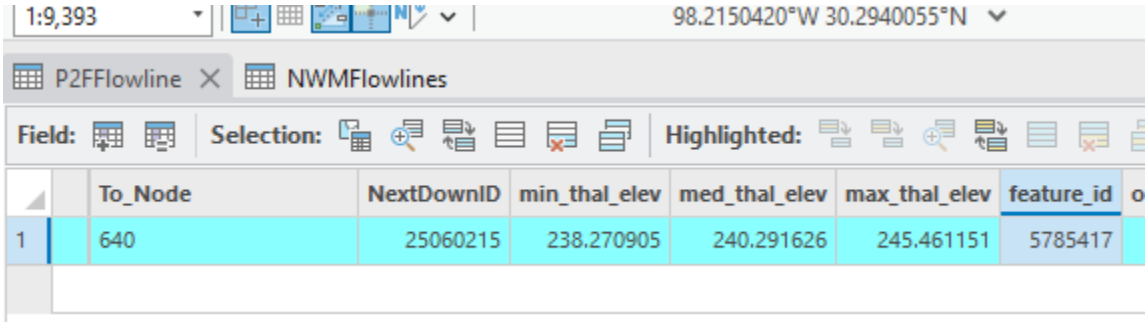

## 5. National Water Model Hydrofabric

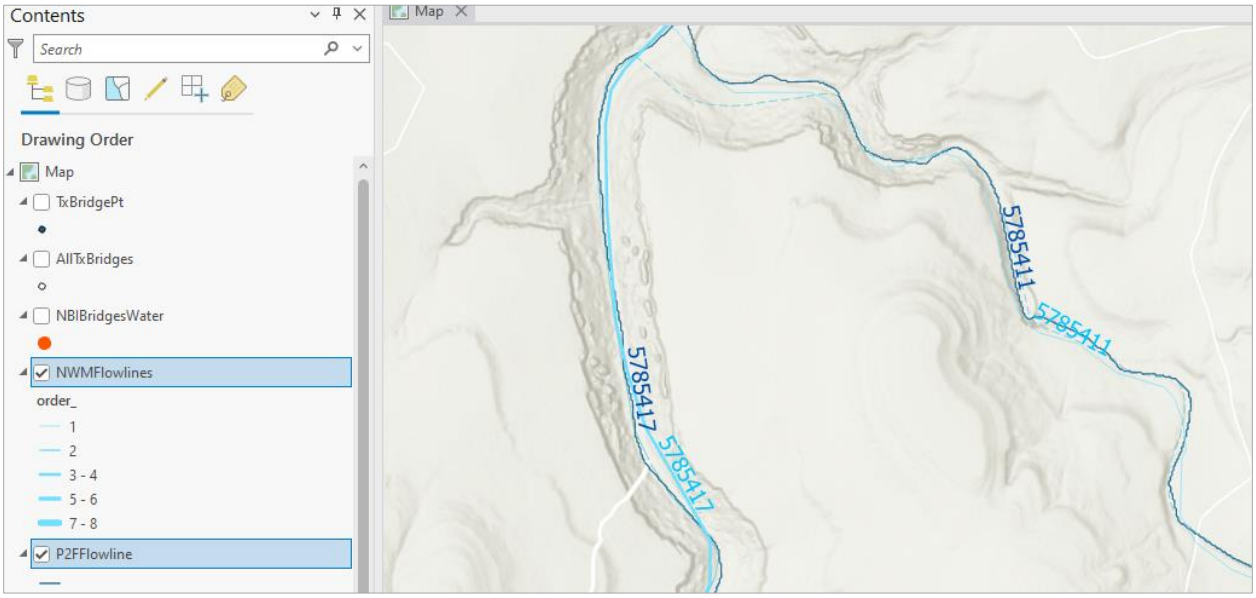
The National Water Model Hydrofabric is accessible in Geopackage format. I have a copy of the FIM3 version of the NWM Flowlines, which I have incorporated into this geodatabase. There is a newer

version, FIM4, which is available at: https://web.corral.tacc.utexas.edu/nfiedata/fim4/inputs.zip We need to check that these two sets of flowlines are consistent.

The **ID** field from the **NWM Flowlines**, should be the same as the **feature_id** field of the **P2FFlowlines**, as illustrated in the images below.



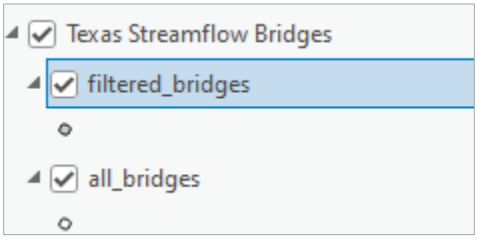



## 6. Tx-Bridge Profiles

Tx-bridge is a project created by Andy Carter for extracting bridge geometry and hydraulic properties from lidar data (https://github.com/andycarter-pe/tx-bridge ). We need to associate the Tx-Bridge bridge deck, low chord and bed cross-section profiles with the NBI bridge points. The bridge points are available via an ArcGIS Online feature service: In Pro, click the dropdown for **Add Data**, and click **Data From Path**.

https://ut-austin.maps.arcgis.com/home/item.html?id=c36ee7a51fa34c649f7b6b6d1f44a0cf

In Contents pane, click the triangle to expand Texas Streamflow Bridges.




The filtered bridges (18, 722) were selected using the following criteria:

* Must be associated with NWM flowline (feature_id is not null; and, the feature_id must be present in an example NWM streamflow file)

* Must have a HAND rating curve computed (hand_r is not null or empty string)

* Must be less than 200 feet from stream (dist_river < 200)

* Must have a minimum streamflow conveyance area greater than 1 sq ft (convey_ar > 1)

* Minimum low chord elevation must be present (min_low_ch <> -99)

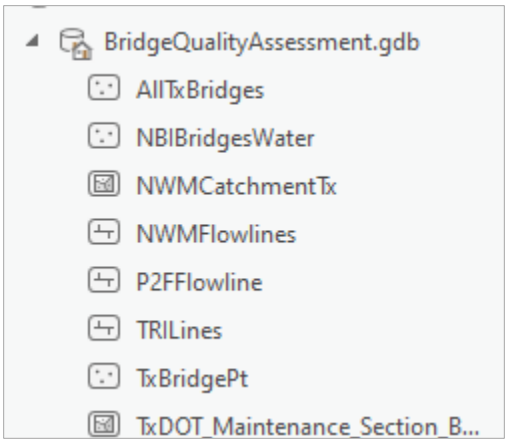
* Sometimes there are duplicate uuids with different hydroids (HAND catchments). Manually inspect and keep the best match. Result is to remove the following:

uuid == 'ac8e03ad-0636-4669-af7d-0dad8c8168d8' and hydroid == '24421109'

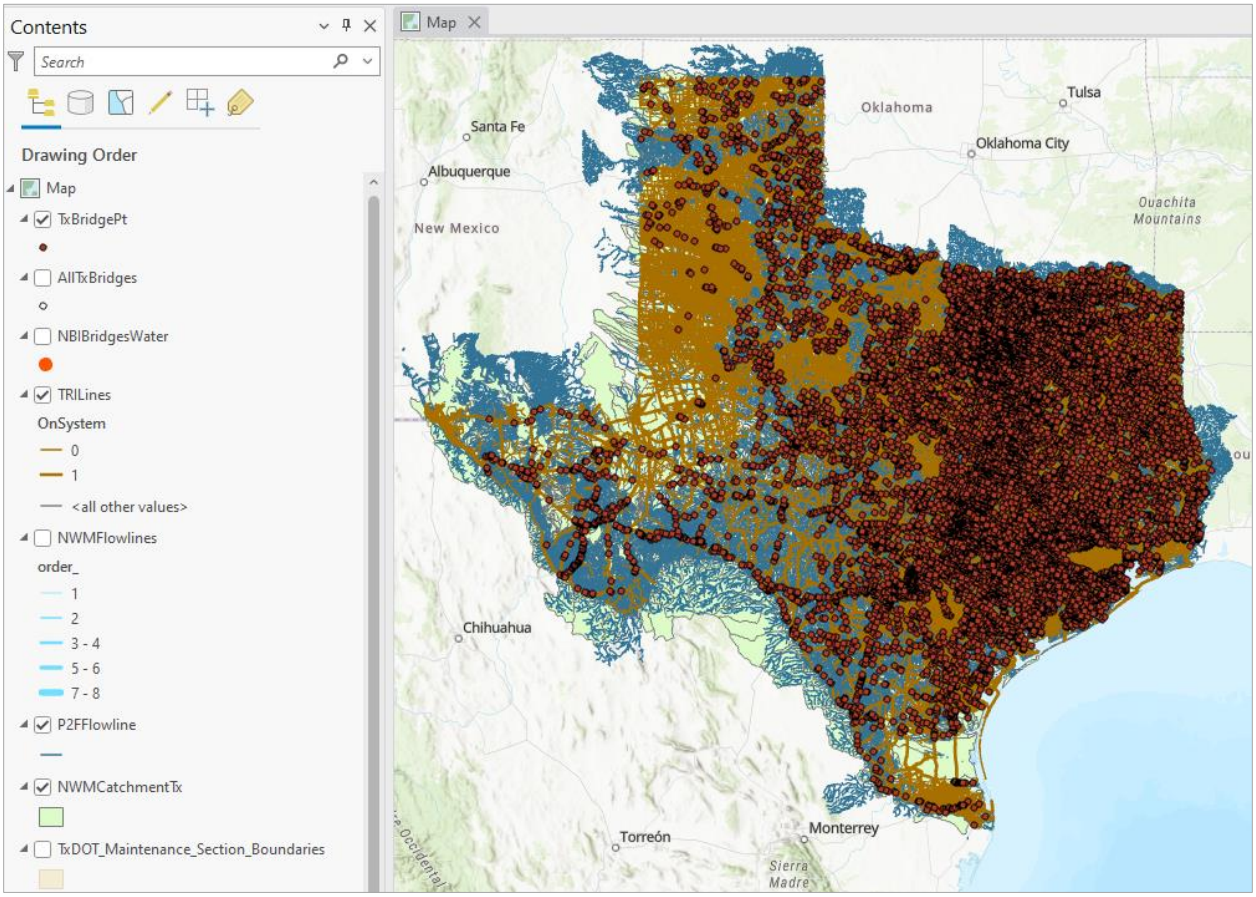
uuid == 'ca985d1d-5bec-4f98-9804-2264fed52003' and hydroid == '24781489'

In Geoprocessing use Copy Features to copy the **filtered_bridges** to the **BridgeQualityAssessment** geodatabase as **TxBridgePt.**

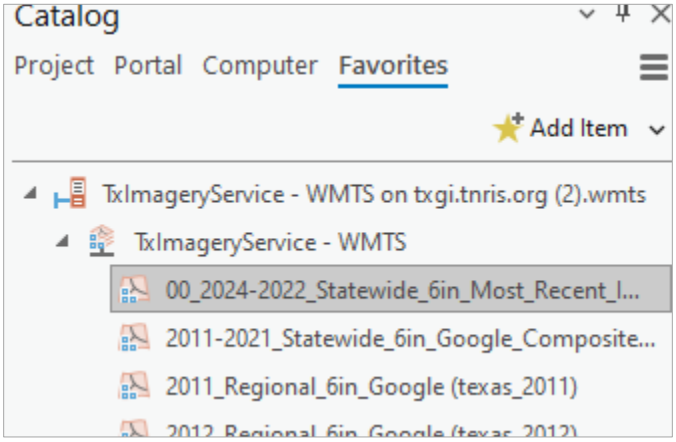
As a backup, all bridges (37,488) created by Tx-Bridge are copied into the Bridge Quality Assurance geodatabase as feature class **AllTxBridges**.




***This geodatabase contains all the information needed to do the quality assessment.***



## 7. Background Imagery




TxDOT licenses a high resolution imagery file from TxGIO and this can be added with a login and password as shown above.

The ArcGIS Project and geodatabase from this exercise can be found at:
https://utexas.box.com/s/frn7a8ut8yxgsp2j91gqktzsbgee4cyp

## Appendix

**Andy Carter, PE**
**Senior Engineering Scientist**
The University of Texas at Austin
Center for Water and the Environment
Reference data used in computing the tx-bridge data are available at

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-global-input-20231027/

including:

a) Nbi_bridges_texas_4326.shp --- TxDOT provided nbi points
b) texas_osm_transport_dissolve_ln_4326.gpkg --- Open street map road lines as Geopackage
c) nwm_flows.gpkg --- National Water Model flow lines
d) nhd_h_texas_state_flowline_4269.gpkg --- NHD Flowlines (used for getting the stream name)
e) demDerived_reaches_split_filtered_addedAttributes_crosswalked.gpkg --- Yans 3m hydrofabric
f) hydroTable_rp_bf_lmtdischarge_cda.parquet --- Yans rating curves

Looking at an example bridge '0178de33-3f8e-458a-b9ed-9b1ad890eb8a' from geojson located at …

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-db-20240430/

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-db-20240430/tx_bridge_3857_20240430.geojson

| | Property | Value |
|---|---|---|
| 0 | adj_hull | 0.0 |
| 1 | bad_hull | 0.0 |
| 2 | hull_len | 99.97 |
| 3 | avg_width | 17.8 |
| 4 | nhd_name | Smith Creek |
| 5 | reachcode | 12030105000267 |
| 6 | name | Cut-Off Road |
| 7 | ref | None |
| 8 | file_path | /work2/08140/acarter/stampede2/tx_bridge_20230... |
| 9 | mjr_ax_idx | 196 |
| 10 | hull_idx | 299 |
| 11 | sta | 0.0, 1.01, 2.02, 3.03, 4.04, 5.05, 6.06, 7.07,... |
| 12 | ground_elv | 329.13, 329.13, 329.29, 329.29, 329.29, 329.22... |
| 13 | deck_elev | 329.13, 329.13, 329.29, 329.29, 329.29, 329.22... |
| 14 | hull_wkt | POLYGON ((2595398.9277714803 6830143.431016326... |
| 15 | latitude | 32.3879 |
| 16 | longitude | -96.4692 |
| 17 | aoi_name | run_437_HUC_12030105_collection_001 |
| 18 | copc_name | ellis_hill_johnson_navarro |
| 19 | copc_date | 20220113 |
| 20 | copc_name_s | 001 |
| 21 | uuid | 0178de33-3f8e-458a-b9ed-9b1ad890eb8a |
| 22 | feature_id | 1262529 |
| 23 | order_ | 3 |
| 24 | dist_river | 0.0 |
| 25 | nbi_asset | 180710AA0475002 |
| 26 | nbi_thick | 1.24 |
| 27 | nbi_dist | 10.37 |
| 28 | score | 0.985 |
| 29 | score_dist | 0.948 |
| 30 | score_span | 1.0 |

**Example:**

(1) **Bridge cross sections --- static plots**
https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-xs-plots/

**Example:**

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-xs-plots/0178de33-3f8e-458a-b9ed-9b1ad890eb8a.png

All cross section images as a compressed (tar.gz)… 4.9 Gb
…. https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-xs-plots/000000_archive_xs_gzip.tar.gz

**(2) Bridge DEM --- Geotiff**
https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-dem/

**Example:**

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-dem/0178de33-3f8e-458a-b9ed-9b1ad890eb8a.tif

All bridge deck dems as a compressed (tar.gz)… 723 Mb
…. https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-dem/000000_archive_gzip.tar.gz

**(3) Collection bridge deck point clouds**
https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-copc-20231027/

This bridge is on copc collection 001

**Example:**

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-copc-20231027/001_bridge_merge.copc.laz

COPC point clouds are best viewed in QGIS or at https://viewer.copc.io/

**(4) View run KMZ**
https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-kml/

This bridge was part of run #437, HUC-8: 12030105, LiDAR collection #001

A 'run' is a combination of Lidar collection in a given HUC-8 watershed.

**Example:**

https://web.corral.tacc.utexas.edu/nfiedata/acarter/tx-bridge-kml/run_437_HUC_12030105_collection_001_001_20230914.kmz

View KMZ in Google Earth

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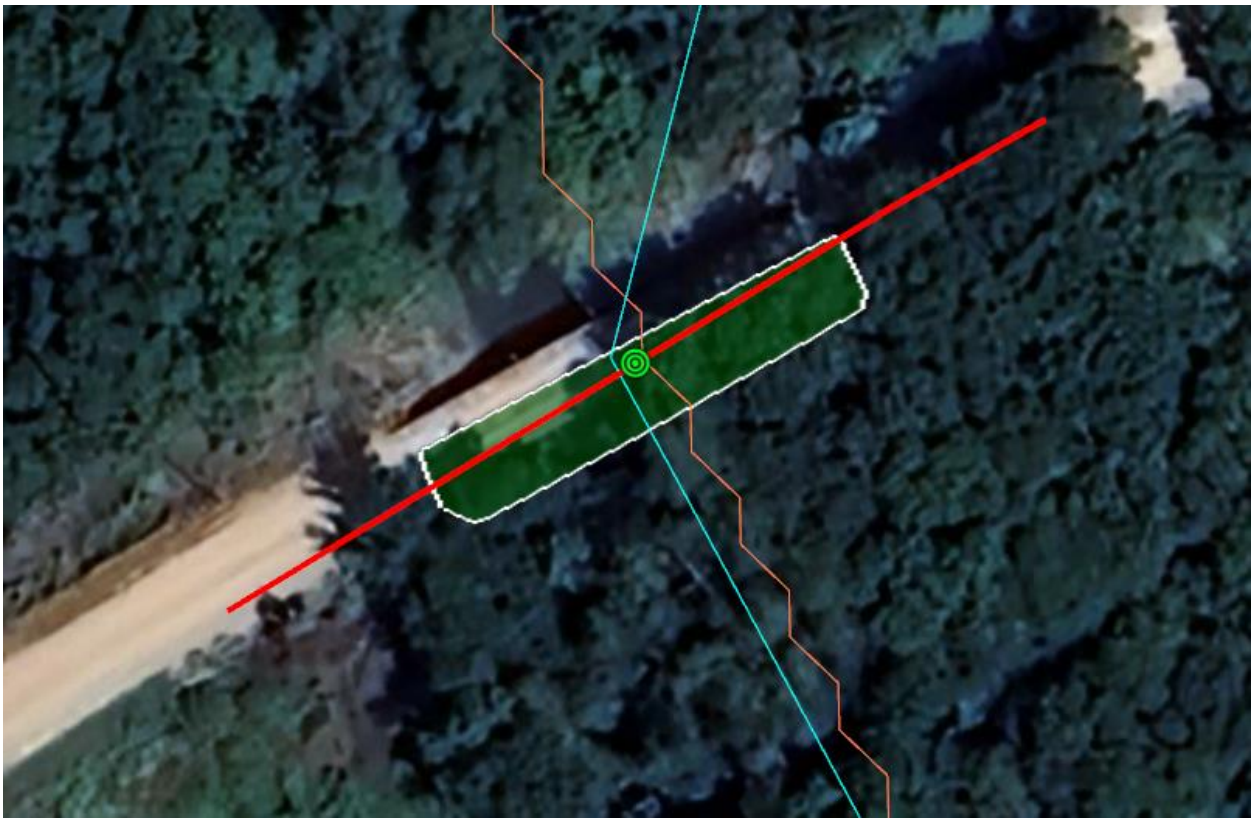
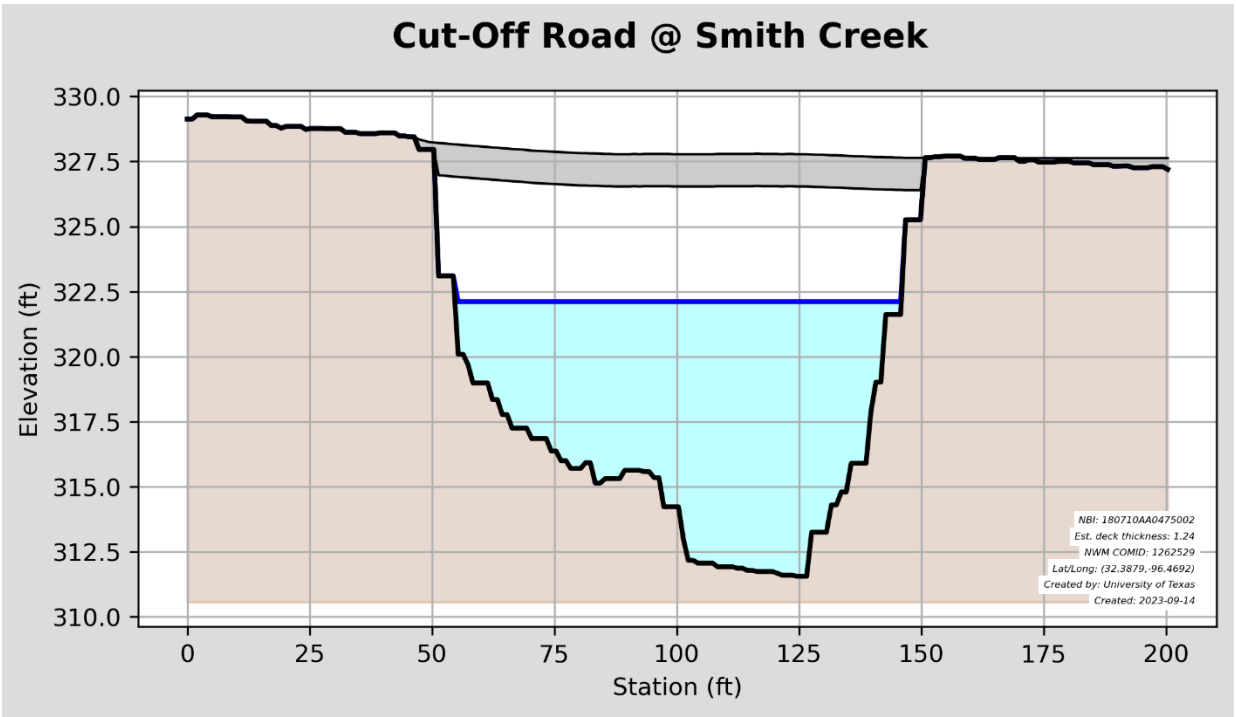
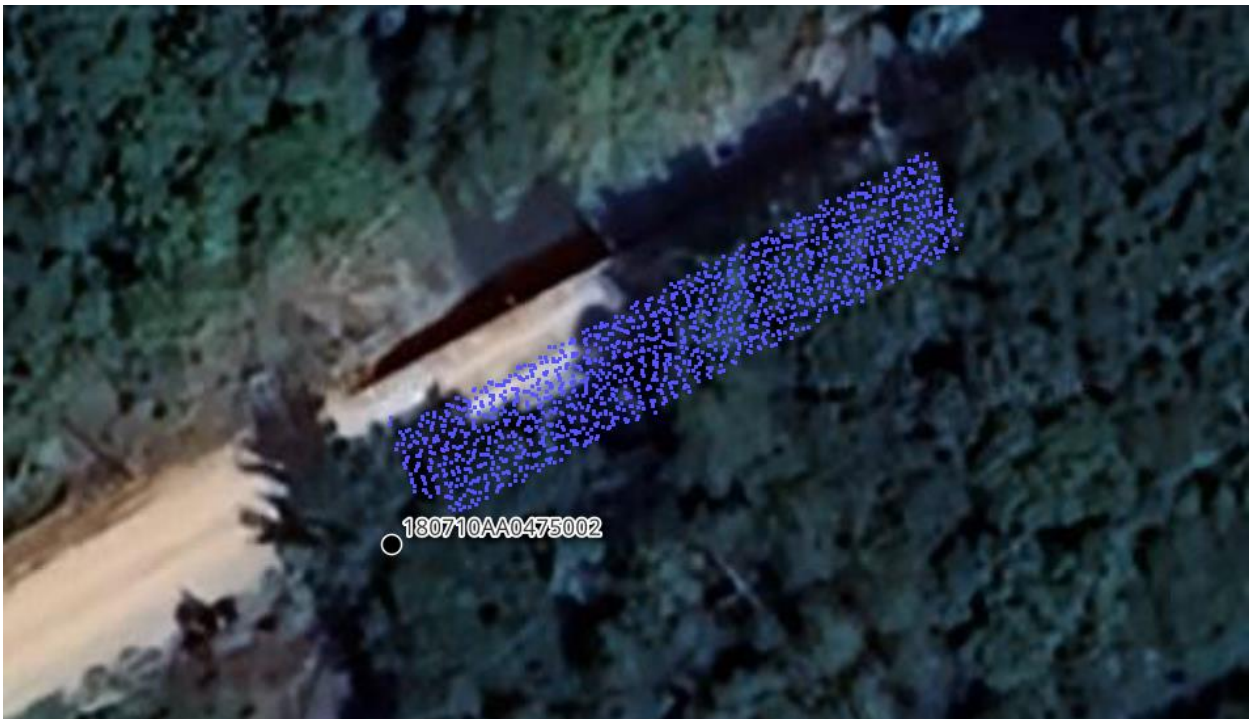
Sample Images of this bridge's data…




Cut-Off Road @ Smith Creek
Elevation (ft)
330.0
327.5
325.0
322.5
320.0
317.5
315.0
312.5
310.0
0
25
50
75
100
125
150
175
200
Station (ft)
NBI: 180710AA0475002
Est. deck thickness: 1.24
NWM COMID: 1262529
Lat/Long: (32.3879,-96.4692)
Created by: University of Texas
Created: 2023-09-14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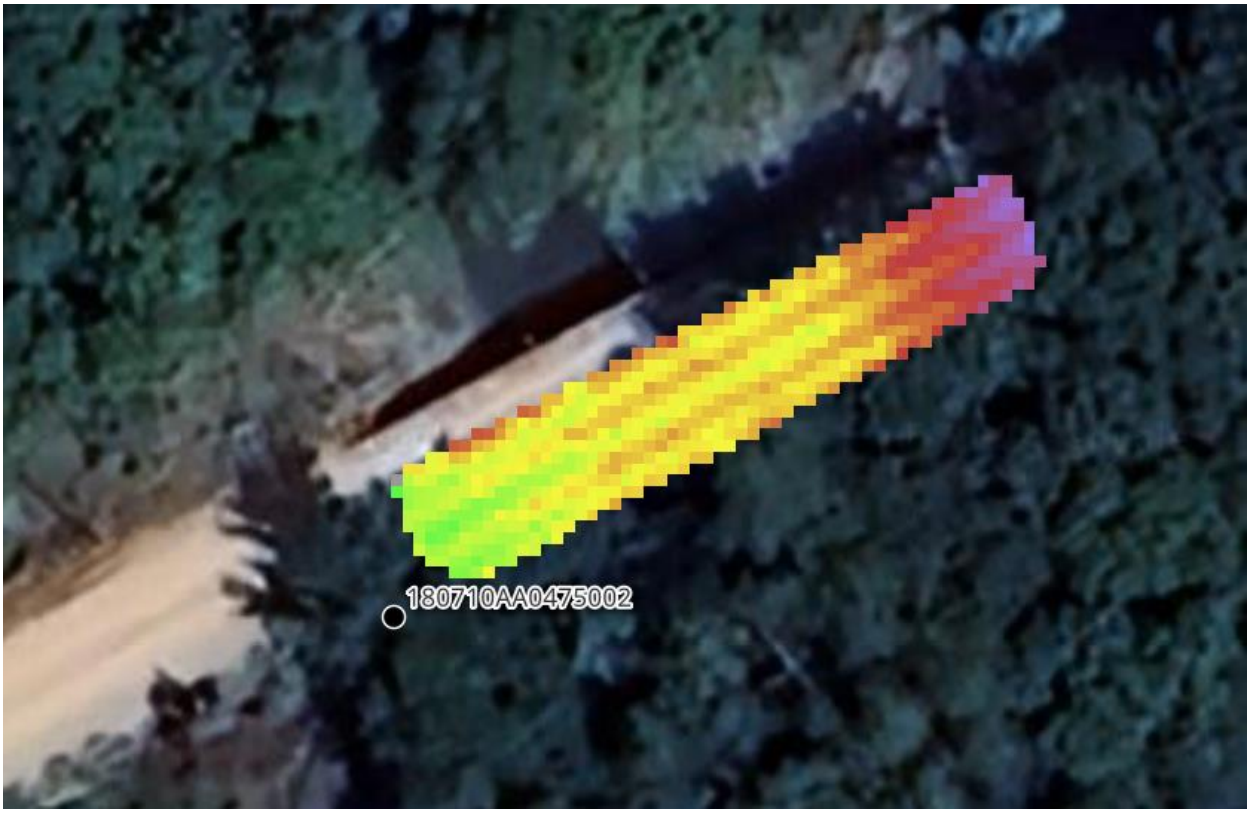
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