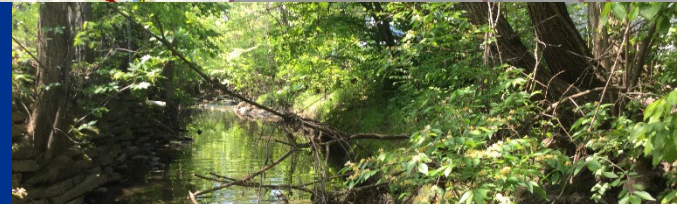


Automation in an Asset Management Approach to Stormwater Master Planning



5/09/2019

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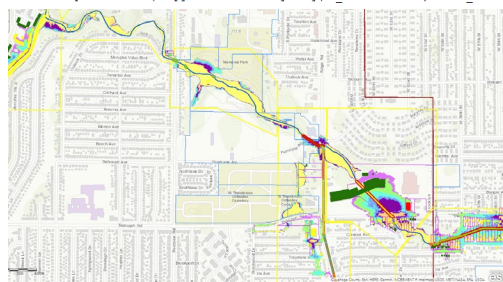
Agenda



```
def sendtable2GIS(pdtable,database, outTable):
    nptable = np.array(np.rec.fromrecords(pdtable.values))
    names = pdtable.dtypes.index.tolist()
    nptable.dtype.names = tuple(names)
    outTable_loc = os.path.join(database, outTable)
    if featurecheck(database, outTable)==1:
        arcpy.Delete_management(database+'/' +outTable)
    arcpy.da.NumPyArrayToTable(nptable, outTable_loc)
    return outTable_loc

def featuretopanda (feature,fields = [''], field_types= ['Double', 'String']):
    try:
        return pd.DataFrame(arcpy.da.FeatureClassToNumPyArray(in_table=feature,
    except:
        fields = []
        for field_t in field_types:
            fields.extend([f.name for f in arcpy.ListFields(feature, field_type
            print('default field types sent to pandas for feature '+feature)
            return pd.DataFrame(arcpy.da.FeatureClassToNumPyArray(in_table=feature,

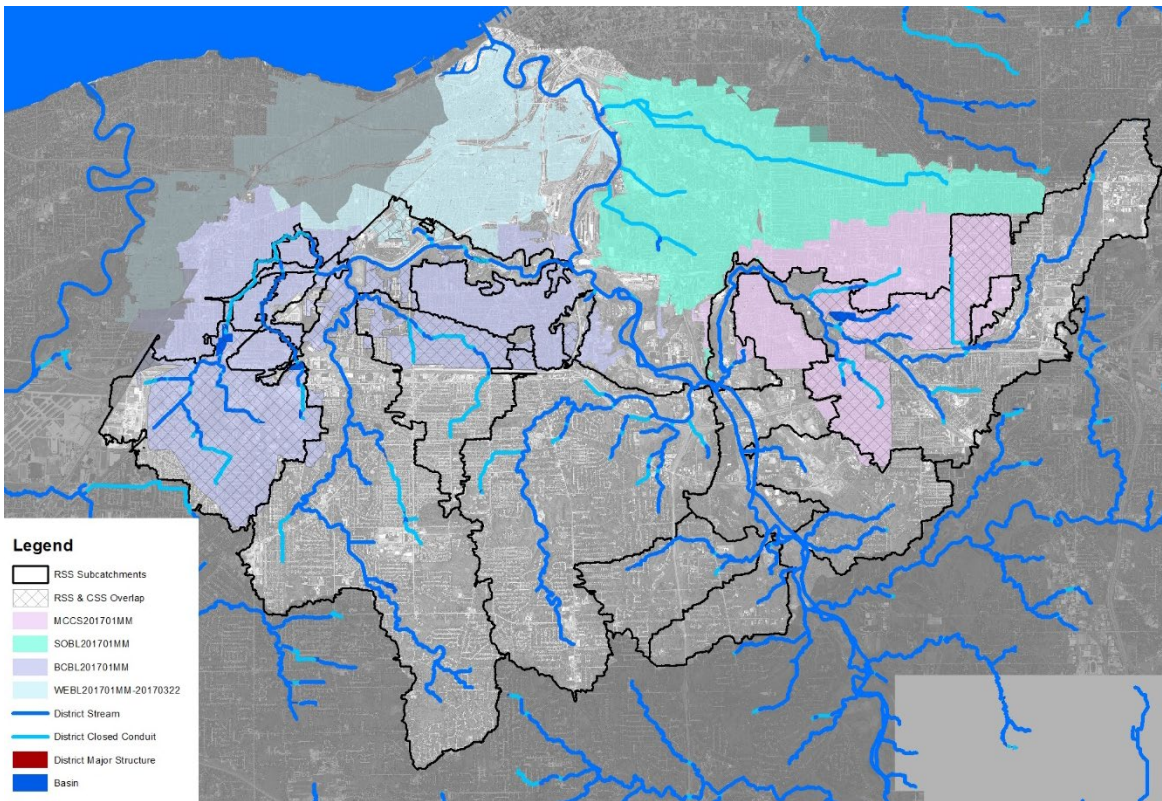
def tabletopanda (feature, fields = ['']):
    return pd.DataFrame(arcpy.da.TableToNumPyArray(in_table=feature, field_names =
```



1. SWMP Overview
2. Why should you care
3. SWMP Approach to Automations
4. Key Takeaways

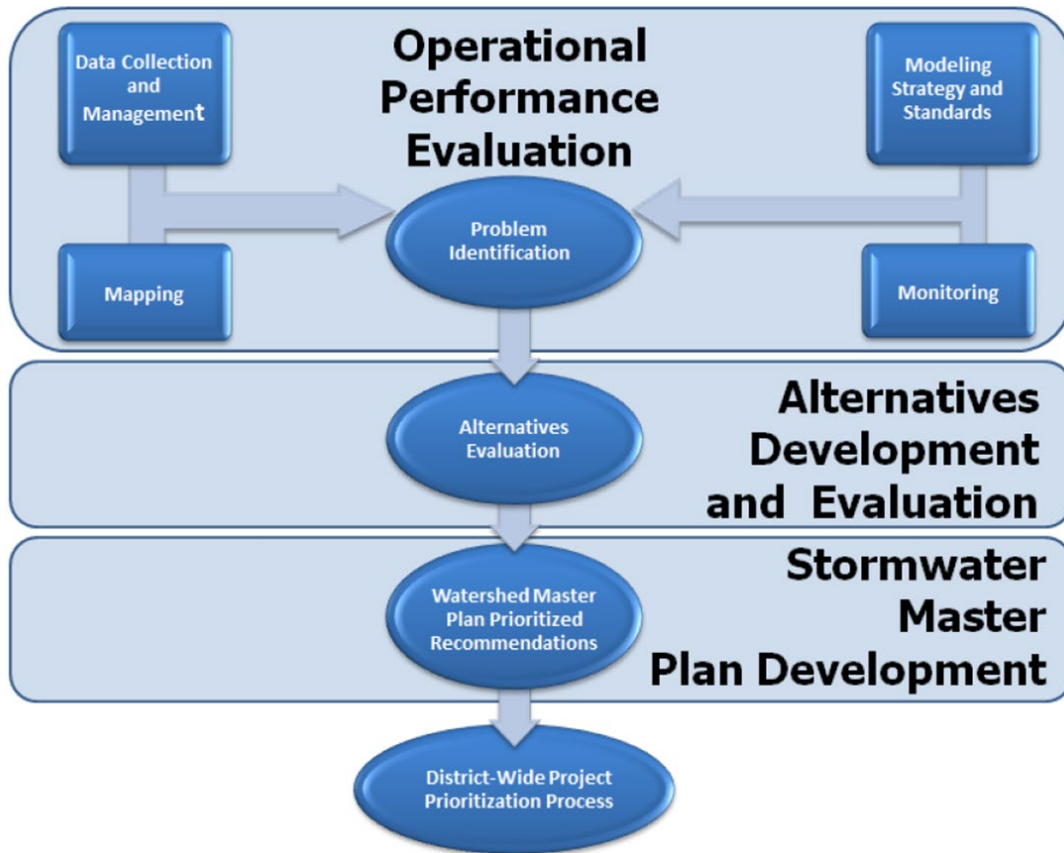
Project Area – Cuyahoga River North (CRN) Regional Stormwater System Assets

- 114 Square miles
- Over 20 Communities within watershed
- 65.7 miles of stream
- 35.7 miles of culverted stream
- Combined Sewer systems (modeled in Infoworks ICM)
- Regional Stormwater System (modeled in SWMM)



Project Scope

1. Operational Performance Evaluation
2. Alternative Development and Evaluation
 - Culverted Stream Inspection and Condition Assessment
 - Non-RSS Stormwater Master Planning Assets
3. Development of Recommendations including Phasing and Prioritization
4. Stakeholder Support



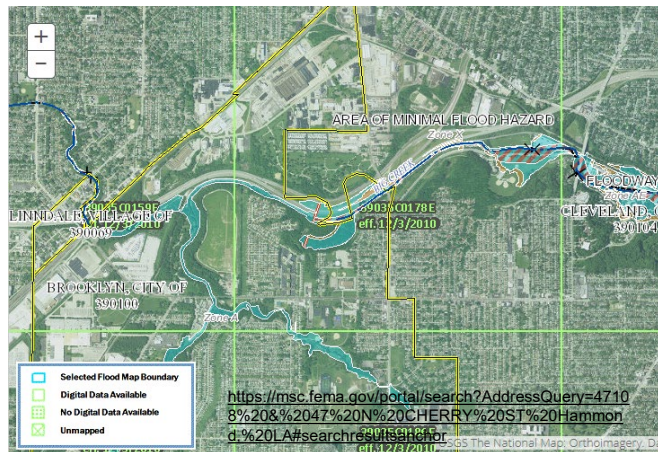
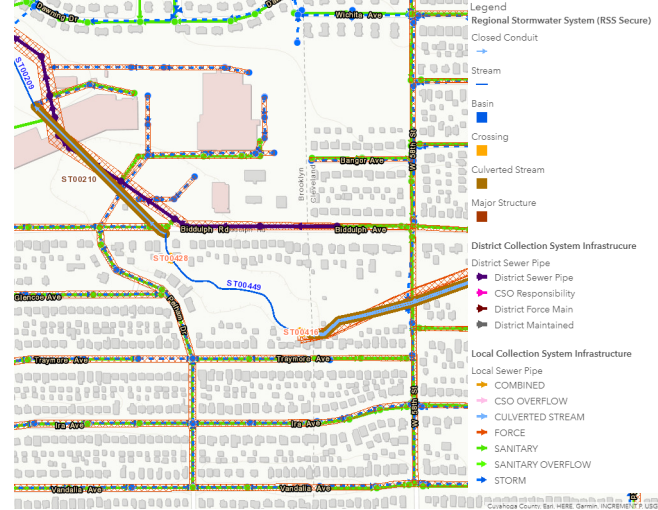
Why Should you Care ... or Not

- Save Time in long run
- Repeatability
- Customizable
- Documentation
- Can be used and understood without knowing how to code
- Time intensive early on front end
- If you're only doing something once do you need automation??
- There are better ways to document that everyone can understand

*“Don’t Reinvent the Wheel, Just Use it”
(unknown)*

Data Sources - External Sources

- Enterprise data – Data provided and managed by the Client
 - District Stormwater Distribution Infrastructure (DSDI) (Stream, Crossings, culverted streams, Basins, Major Structures)
 - Past inspection, maintenance, reported Problems, Design Drawings, etc.
- External Data – Data from third party
 - USGS, County data, FEMA, etc.



Project Data – Field Collection

- Data Collected
 - Geomorphic inspection
 - Building, Transportation & Utility (BTU) inspections
 - Crossing and Culvert Stream Inspection
 - High Water Marks
- Collection Method
 - Survey123
 - Pen and paper
 - CCTV

The image displays two screenshots of a mobile application interface for "CRN SWMP Culverted Stream Survey".

The left screenshot shows the "Summary Data" section, which includes the following fields:

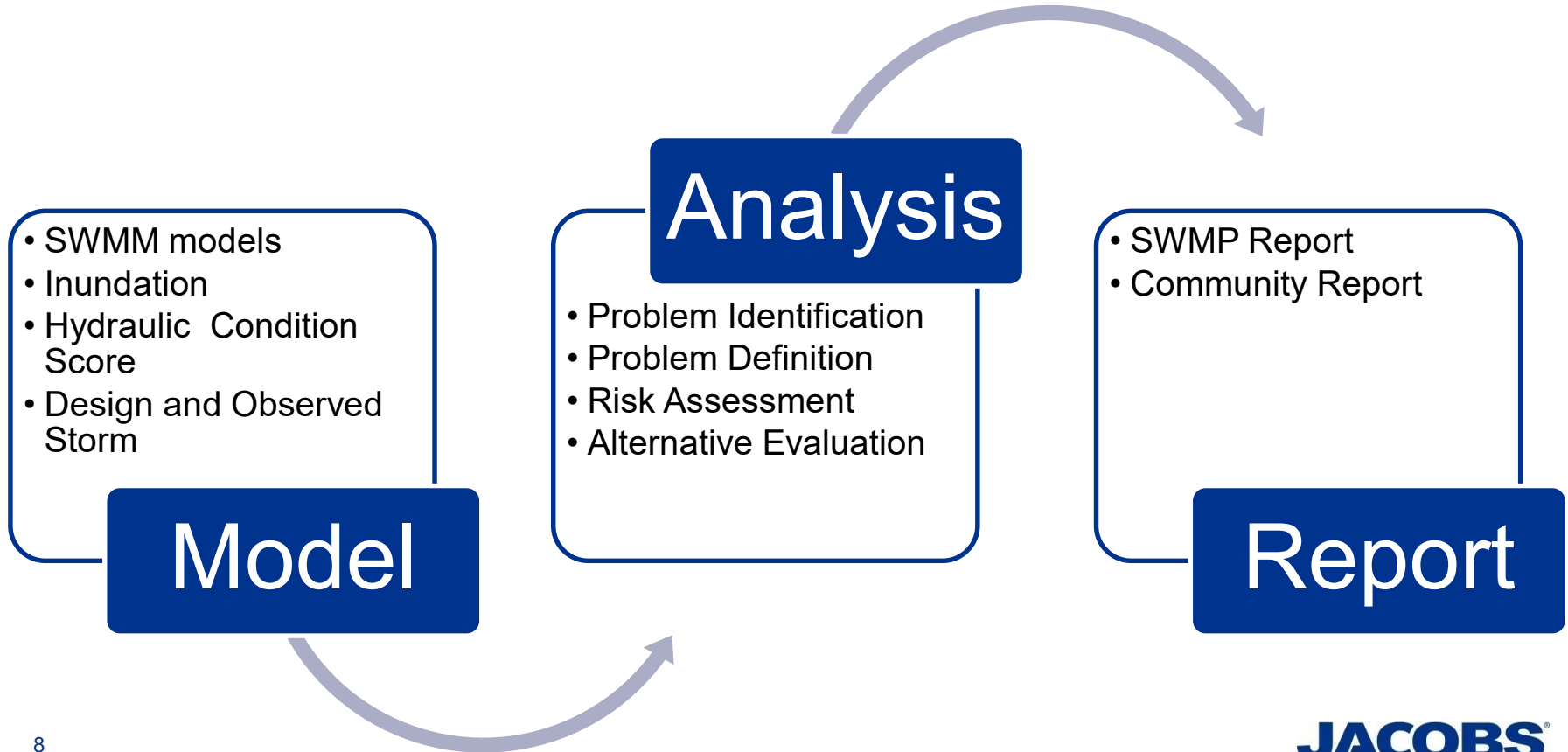
- Asset ID: Auto-populated - DO NOT EDIT - if you believe the value to be incorrect, add a note in general notes section below:
- Asset Type: ☐ Bridge ☐ Culvert
- Number of Barrels/Cells:
- Shape: Auto-populated from conduit data if available - check d
- Material: Auto-populated from conduit data if available - check d
- Width (in): Auto-populated from culvert data if available - check d
- Height (in): Auto-populated from culvert data if available - check d
- Length (ft): Auto-populated from culvert data if available - check d
- Inspectors:
- Weather:

The right screenshot shows the "Additional Photos" section, which includes the following fields:

- Right Wingwall Scour Condition:
- Channel Protection Condition:
- Channel Protection Scour Condition:
- Embankment Protection Condition:
- Embankment Protection Scour Condition:
- Debris/Sediment: Channel debris/sediment at upstream end
- Additional Photos: Additional Photos Needed? ☐ Yes ☐ No
- Point Location: A map showing the location of the survey point, with coordinates 41°29'N 81°45'W ± 1414 m.

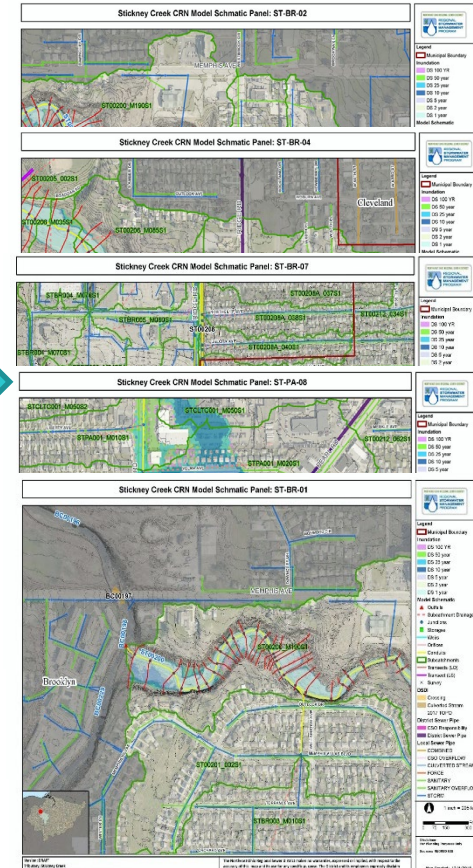
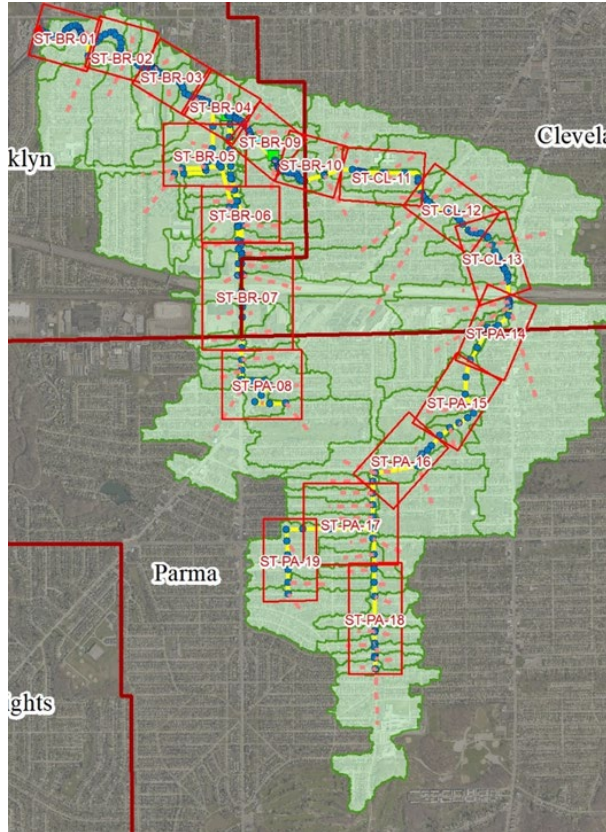
A green checkmark is visible in the bottom right corner of the right screenshot.

Project Data – Desktop & Model Based



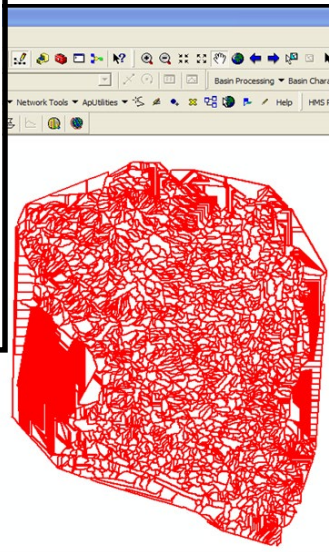
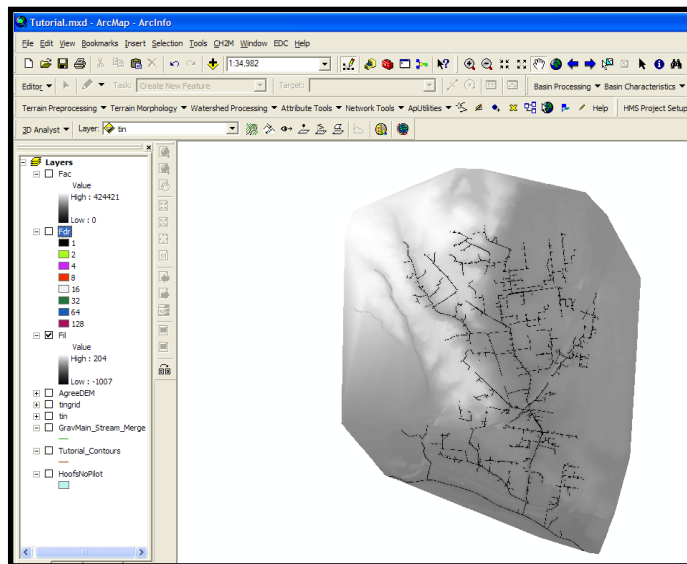
Project Challenges – Data Management

- Over 20 communities within watershed
 - Community reports
 - Data driven maps to automate reporting
- Requires extensive organizational skills
- Key computer automation tools
 - ArcGIS models
 - Python coding
 - Microsoft access



Model Development – Subcatchment Delineation

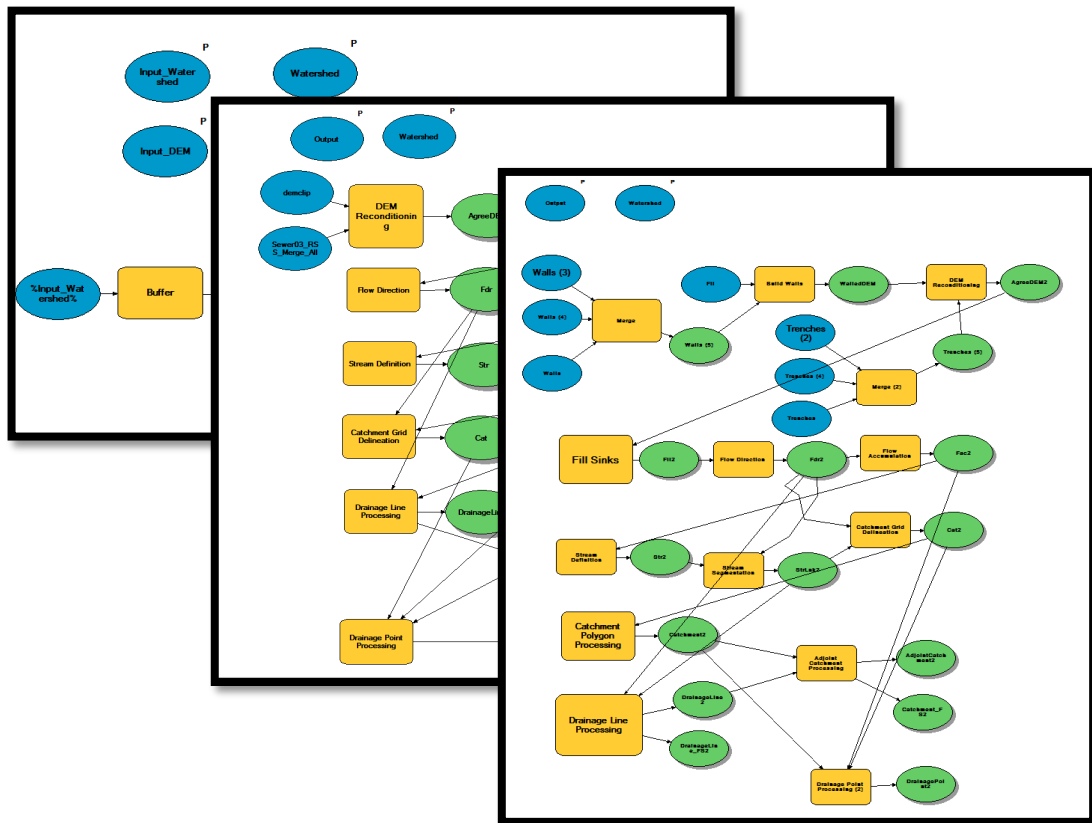
- Data Source
 - Enterprise data set
 - Local and regional sewer network (streams, culverts, storm sewers, sanitary/combined sewers)
 - External Data set
 - DEM
- ESRI Arc Hydro
 - Burn in sewer and streams
 - Automates the delineation
 - Customizable Catchment size



Model Development – Delineation

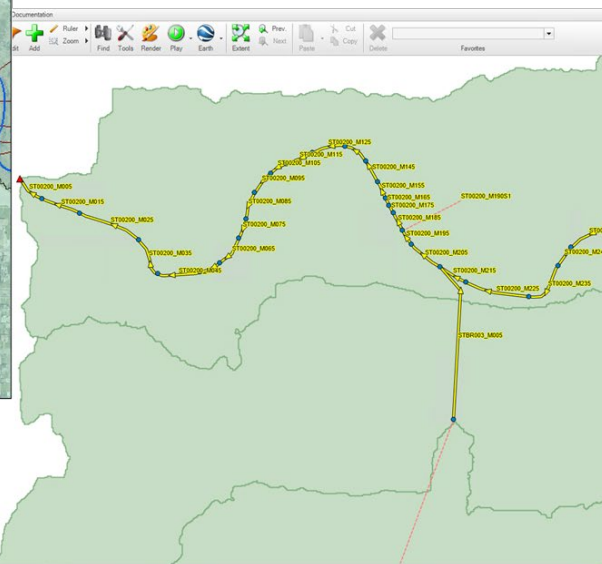
- GIS Modules

- Group multiple processes together
- Streamline & Documents process
- Drag and drop functionality
- No coding experience required to use



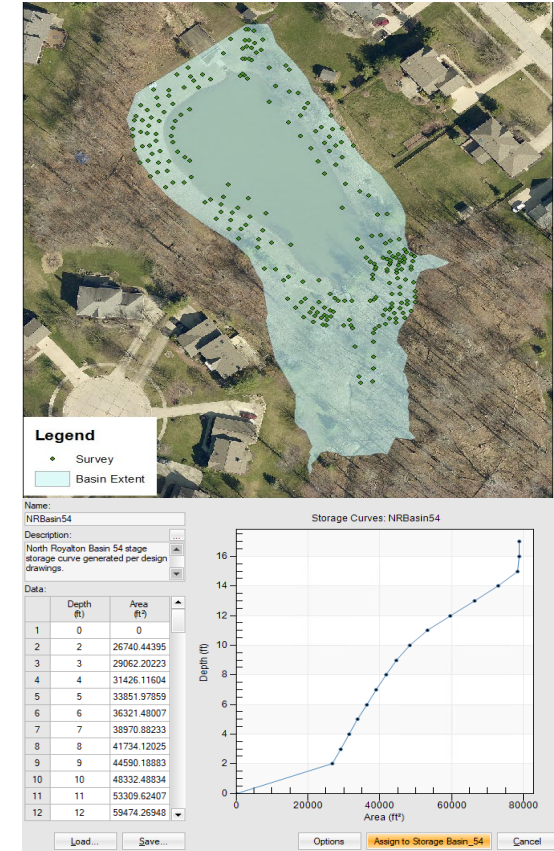
Model Development Approach – Model generation

- Raw Data
 - Enterprise Data (DSDI layers)
 - Project Data
- Python and GIS Models
 - Generate naming scheme
 - Assigns inlet and outlets
 - Parameterize and Imports Transect
- Result
 - Few hours to generate working model from pre-generated data sources



Model Development Approach – Basin Stage Storage Curves

- Raw Data
 - One Polygon
 - or
 - Polygon & Survey Data
- Python
 - Clips DEM based on Polygon
 - Creates surface from Survey data (if provided)
 - Combines DEM surface and Survey
 - Creates Stages storage based on user defined interval
- Result
 - Little GIS tool knowledge to quickly generate stage storage profiles



Model Management Approach – ICM & SWMM

Innovyze ICM

- NEORSD standardized flagging and documentation
- Robust internal documentation schema
 - Tag for each parameter
 - Multiple description fields

SWMM5/PCWMM

- Model management approach not standardized at time of project
- PCSWMM – Tag and descriptions easily customizable
 - Customization does not carry to EPA-SWMM
- EPA-SWMM – One tag and one description

Model Management Approach

- Consolidate data to single database:
 - Original Model Data
 - Current Model Data
 - Model updates: including deletions and transect parameterization
- Allows:
 - Quick and automated QC
 - Maintains documentation
- Alternative Approach
 - Make changes in Model and automate generation of database

The screenshot displays the Microsoft Access interface. On the left, the 'All Access Objects' pane shows a list of objects including 'frmModelLinkUpdates', which is currently selected. The main window shows the 'frmModelLinkUpdates' form, which includes fields for 'Model Version ID' (set to 11), 'DateTime_Modified', and 'FileLocation'. Below these fields is a 'Notes' section with the text: 'Inundation and 2D model runs based on v10 NOT v11 this is because changes are in the downstream reach and away from'. A yellow warning box on the right says 'Are you on the right Model?'. Below the form is a table view showing a list of records with columns: NAME, INLETNODE, OUTLETNODE, INOFFSET, OUTOFFSET, LENGTH, XSECTION, and GEOM. The table contains 11 records, all with 'IRREGULAR' in the GEOM column. Below the table is a 'Conduit Updates - Individual' form with a dropdown menu for 'FieldName' showing a list of fields including 'InletNode', 'OutletNode', 'XSection', 'Geom1', 'Geom2', 'Transect', 'Roughness', 'Length', 'EntryLossCoeff', 'ExitLossCoeff', 'AvgLossCoeff', 'Seepage', 'FlapGate', 'Barrels', 'InletElev', and 'OutletElev'.

NAME	INLETNODE	OUTLETNODE	INOFFSET	OUTOFFSET	LENGTH	XSECTION	GEOM
ST00200_M005	ST00200_M010	BC00199	0	0	81.221	IRREGULAR	
ST00200_M015	ST00200_M020	ST00200_M010	0	0	109.62	IRREGULAR	
ST00200_M025	ST00200_M030	ST00200_M020	0	0	176.547	IRREGULAR	
ST00200_M035	ST00200_M040	ST00200_M030	0	0	108.88	IRREGULAR	
ST00200_M045	ST00200_M050	ST00200_M040	0	0	116.315	IRREGULAR	
ST00200_M055	ST00200_M060	ST00200_M050	0	0	59.6	IRREGULAR	
ST00200_M065	ST00200_M070	ST00200_M060	0	0	86.67	IRREGULAR	
ST00200_M075	ST00200_M080	ST00200_M070	0	0	53.927	IRREGULAR	
ST00200_M085	ST00200_M090	ST00200_M080	0	0	75.753	IRREGULAR	
ST00200_M095	ST00200_M100	ST00200_M090	0	0	68.297	IRREGULAR	
ST00200_M105	ST00200_M110	ST00200_M100	0	0	51.374	IRREGULAR	

Data Visualization – Stream inundation and Problem Definition

- Inundation Python script (Arcpy)
- Data sources
 - Raw data from model build
 - SWMM model
 - DEM
- Result
 - Saves ~20 minutes manual effort per inundation
 - Problem definition tool
 - Alternative performance screening tool

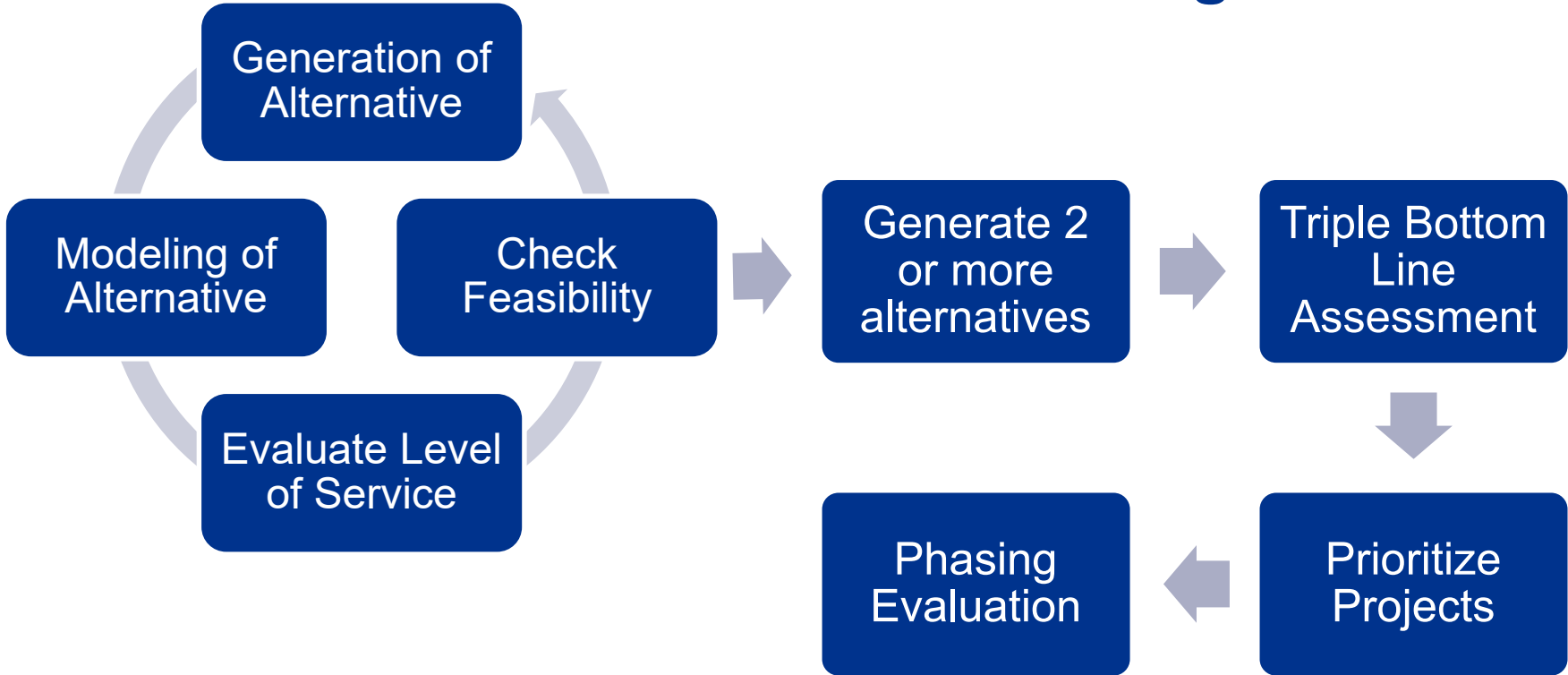


Problem Definition – Buildings and Transportation

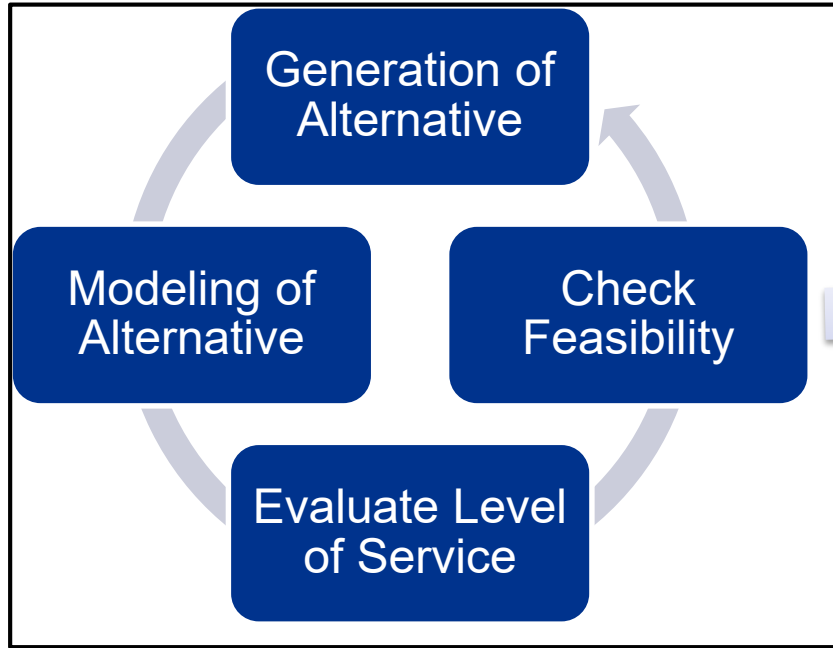
- Business Risk Exposure (BRE) Factors
 - Inundation depth
 - Community report and Model
 - Stream Condition Scores
 - Geomorphic inspection & Model Data
 - Culvert Stream condition Scores
 - Field inspection & model



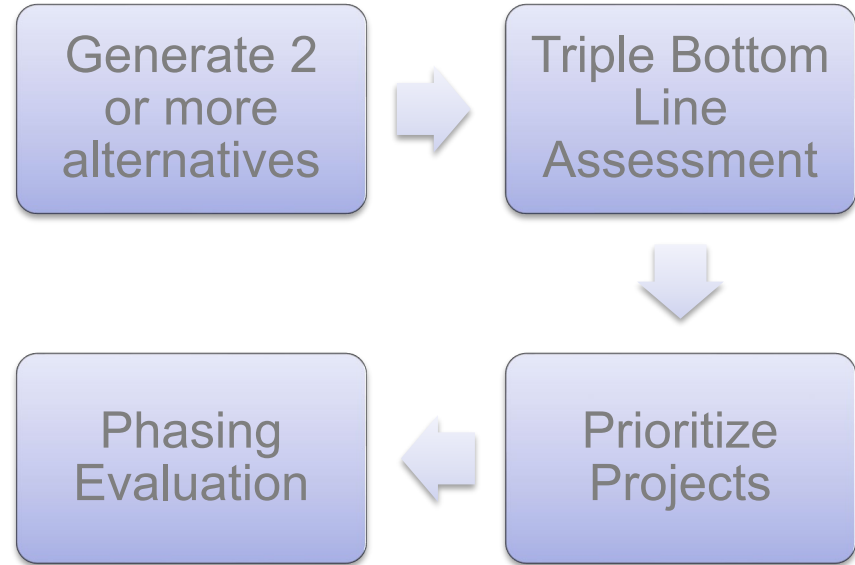
Alternative Recommendation Management



Alternative Recommendation Management

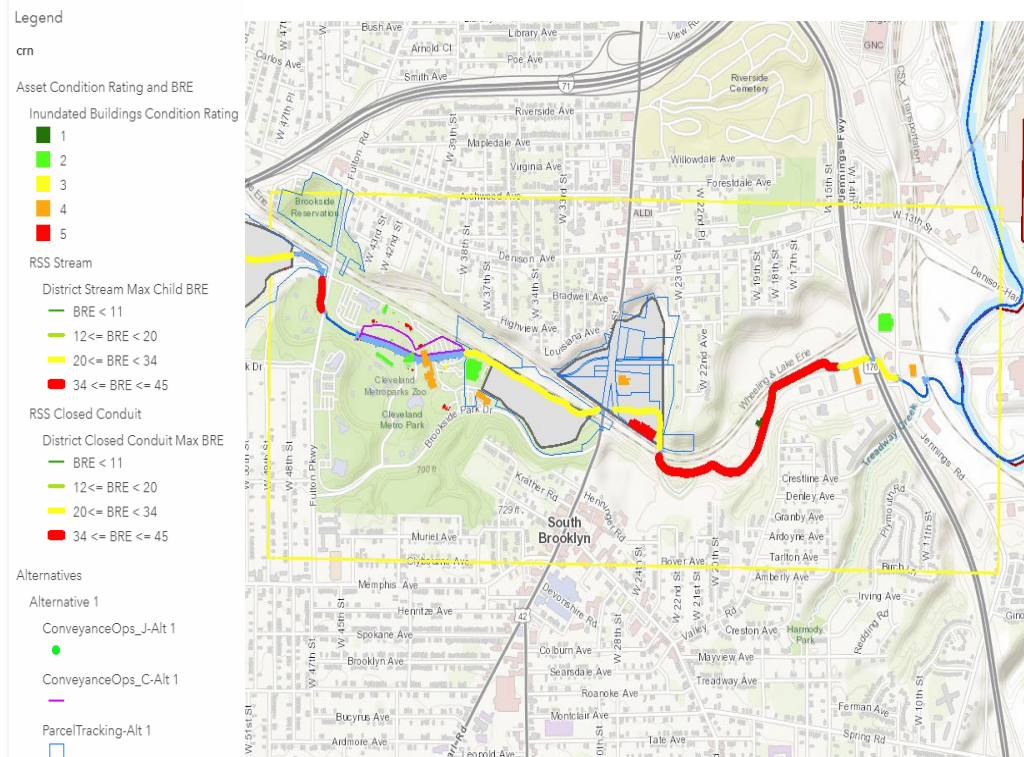


How to document in a time effective manner?



Alternative Recommendation Management

- Storing problems and solutions in one location
 - Geolocated Inspection data
 - Community reported problems
 - Condition scores and BRE of CRN RSS Assets
 - Model based alternatives



Key Takeaways – Data Management using Python\R and Databases

- Databases
 - Forces consistent structure
- Using Programming (python/R):
 - Require consistent structure
 - Versatile data manipulation and analysis
 - Can easily be adapted and modified for various purposes
 - Can be used to automate repetitive task
 - Documents work process
- Databases + Programming = Automated Tasks
 - Reduces errors from repetitive tasks
 - Creates a workflow for tracking down errors
 - Allows for focus on work that matters