PLANNING LARGE GI PROGRAMS USING AUTOMATED ARCGIS TOOL

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Ohio Water Environment Association

Design & Consultancy for natural and built assets

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Agenda

- ❑ Why Siting Tool for Green Infrastructure program?
- ❑ GI Siting Tool on City Level Planning
- ❑ GI Siting Tool in Design Stage
- ❑ Integrating Siting Tool with H/H Modeling

Benefits of Green Infrastructures

Runoff Reduction

- Mitigate CSO (EPA and CD driven)
- Mitigate street flooding
- Reduce velocities to protect stream banks
- Groundwater recharge

Social and Public Health

- Reduce pollution to streams, protect habitat life
- Increase green space, reduce air pollution and urban heat island
- Reduce stress and increase neighborhood interaction
- Increase property values
- New jobs (installation and maintenance)

GI Siting Consideration

- Disruption to public
  - Pedestrian walkways, bus stops, parking spots, mature tree, etc.
- Surface and subsurface infrastructure
  - Fire hydrants, electric poles, electric structures, etc.
  - Sewer lines, water pipes,, gas lines, etc.

Oversized GI Units Example

Larger footprint than needed.

Almost no flow is arriving at the site.

Undersized GI Unit Example

Placed within meadow area, no street flooding

Finding Good Sites

Comprehensive planning in advance of the design phase

Minimum disruption to public activities and utilities requires evaluation of several factors

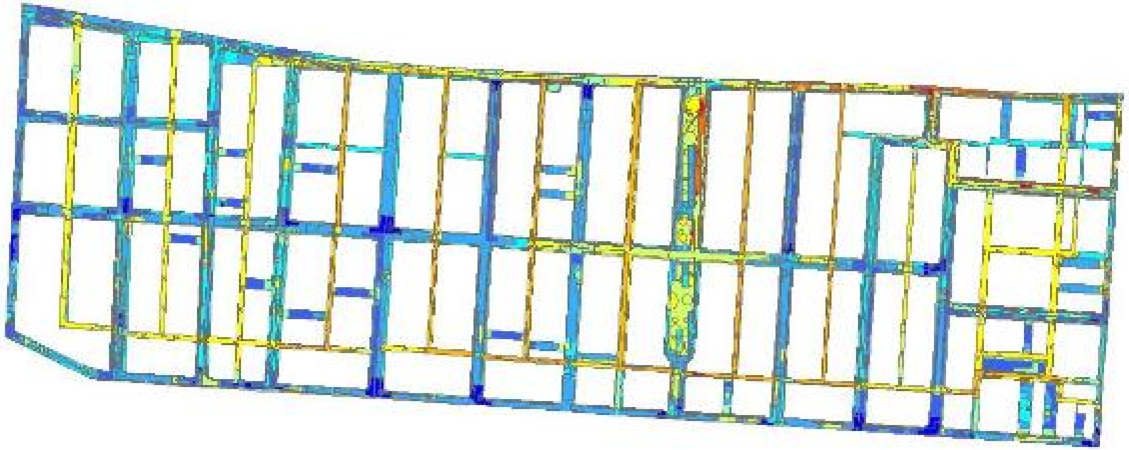
Impact of the factors could be simplified by using the available wealth of remote sensing and digital data at the planning level

The Approach

Narrow number of sites for the design team before performing field activities

Use digital data to develop a continuum map ranging from more-favorable to less-favorable sites

Use ArcGIS as a platform to cross the information and assign a score for each factor



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- ❑ Why GI Siting Tool?
- ❑ GI Siting Tool at City Level Planning
  - ❑ Case Study and Tool Approach
  - ❑ Analysis Results
- ❑ GI Siting Tool in Design Stage
- ❑ Integrating Siting Tool with H/H Modeling

Background

- Current study with The National Conservancy in Los Angeles County, California
- Need for efficient way to identify areas to prioritize nature-based solutions

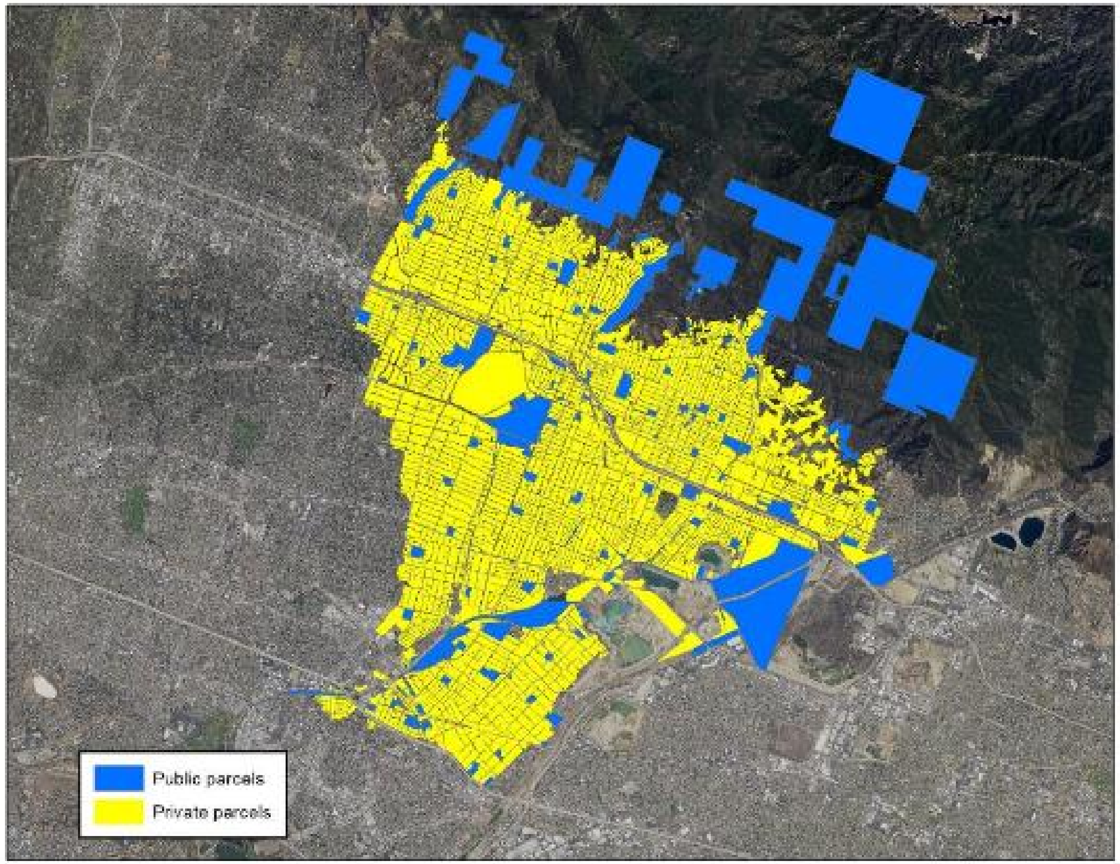
Tool Design Driving Factors

- Easy to use by diverse users
- Reduces processing and analysis time
- Easy to adjust input parameters
- Flexibility
- Produces output that is easy to translate to decision making

Tool Analysis

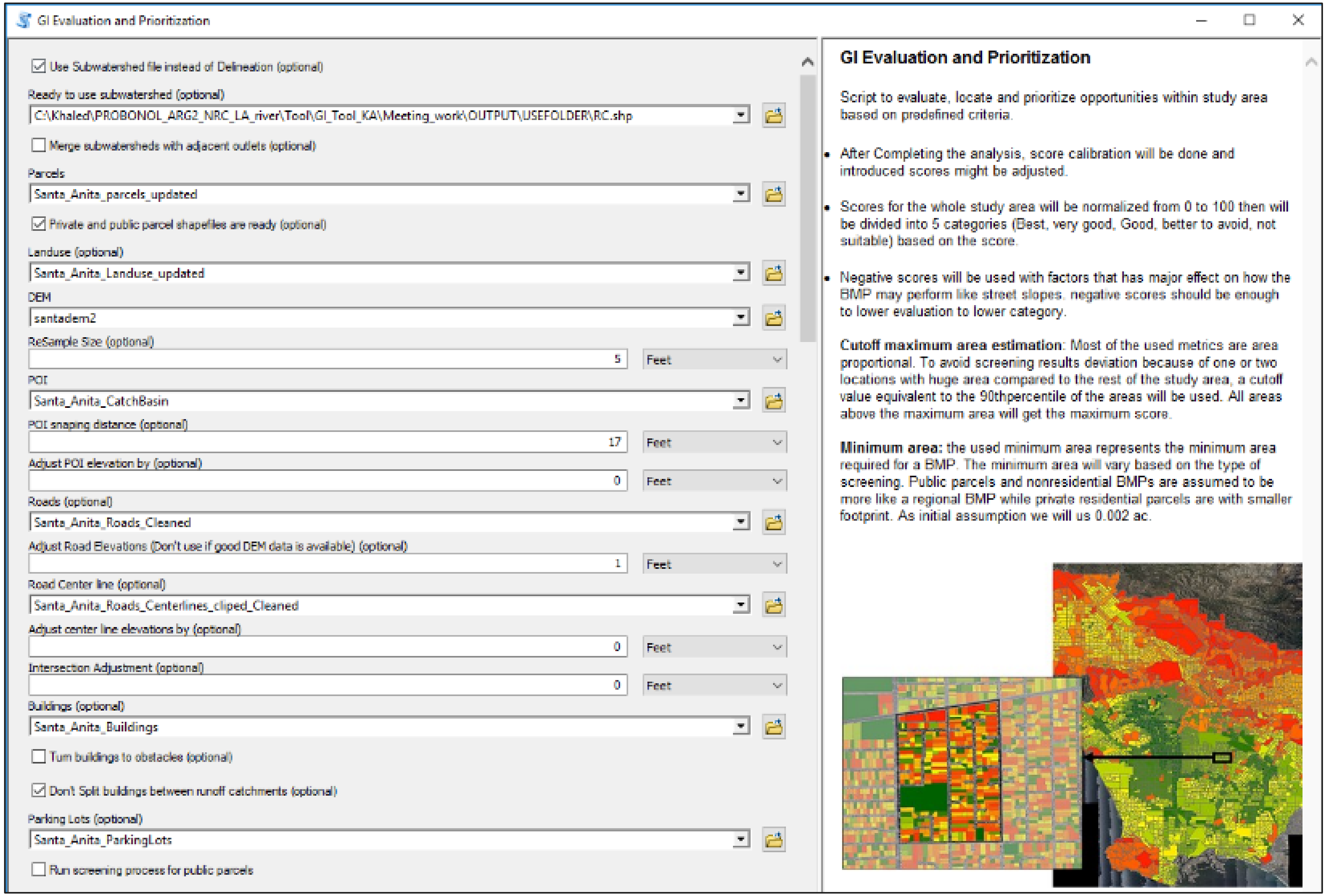
- Public parcels evaluation
- Private parcels evaluation
- Roads evaluation

Metric	Public Parcels	Private Parcels	Roads
Volume Capture	✓	✓	✓
Road Slope	✓		✓
Parcel elevation	✓		
Soil Contamination	✓	✓	✓
Soil Infiltration	✓	✓	✓



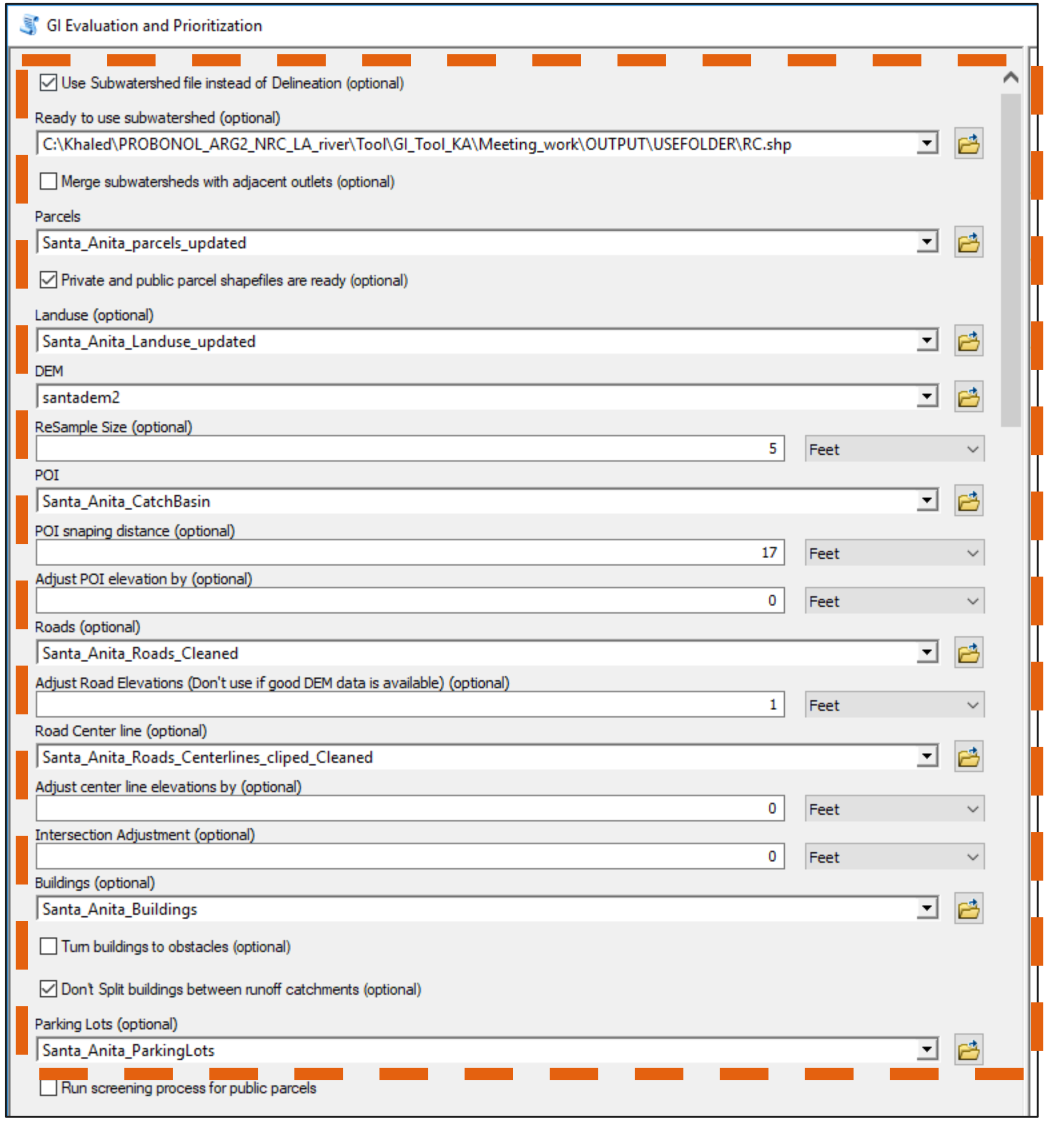
Tool Interface

- Preprocessing
- Public parcels evaluation
- Private parcels evaluation
- Roads evaluation



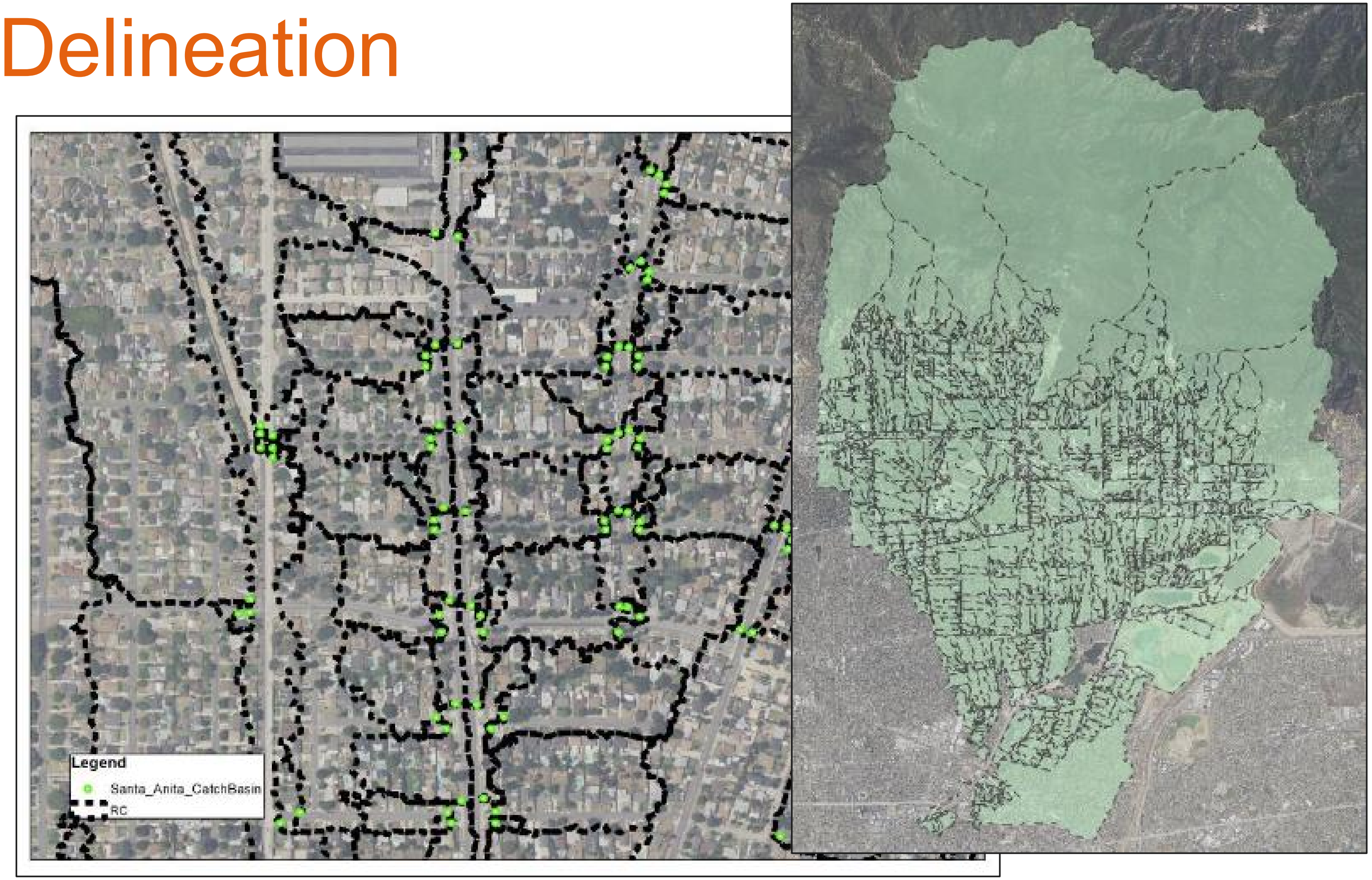
Preprocessing

- Parcels ownership (public and private parcels)
- Subwatershed delineation
- Flow accumulation raster
- Flow accumulation raster per subwatershed



Sub-Watershed Delineation

- Inputs
  - Topology (DEM)
  - Point of interest (Storm inlets)
  - Road shapefile
  - Street centerline
  - Building shapefile
  - Parking lots
  - Other user inputs

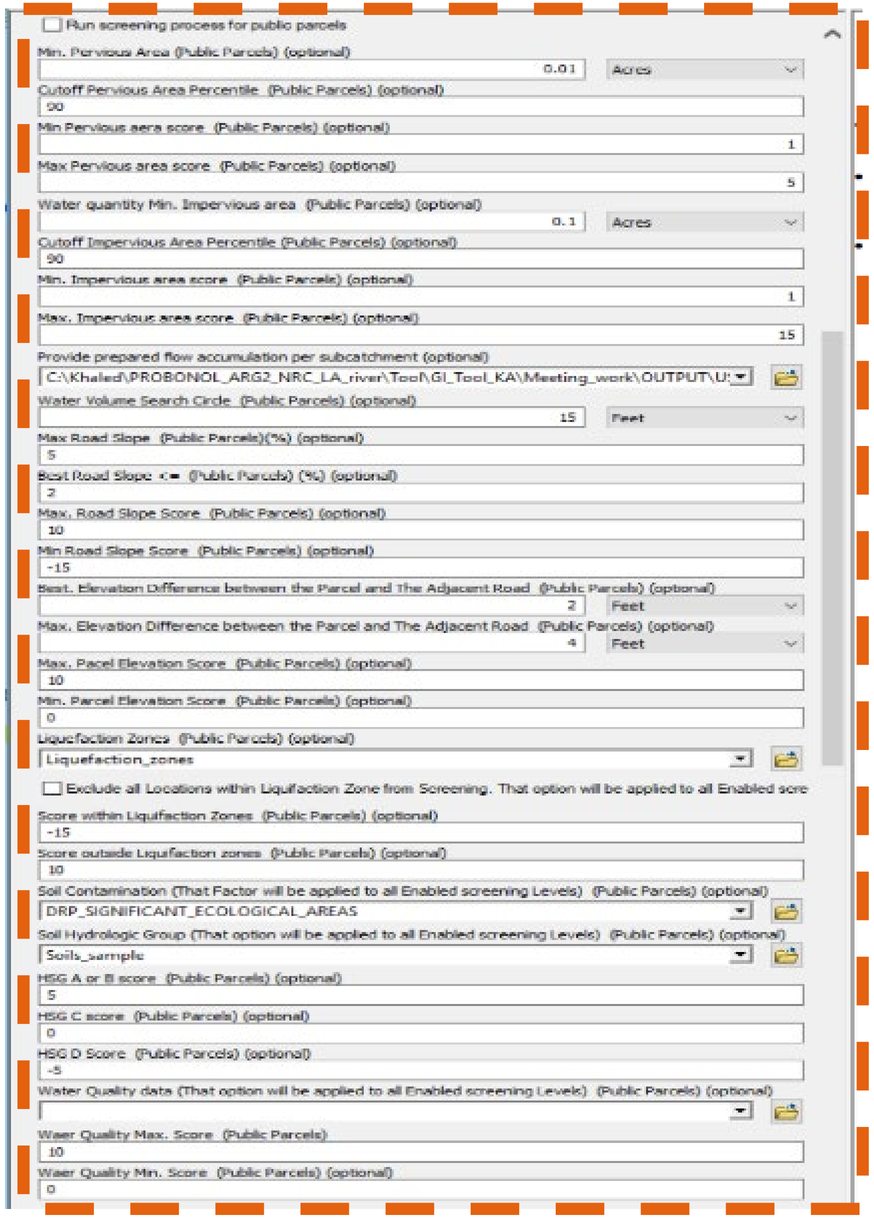


Sub-Watershed Delineation Results

- Most time consuming if done by hand
- The tool delineate to the storm inlet level, or any point of interest layer defined by the user
- Some cleaning at the boundary might be needed, but this step reduces engineering time by 80%

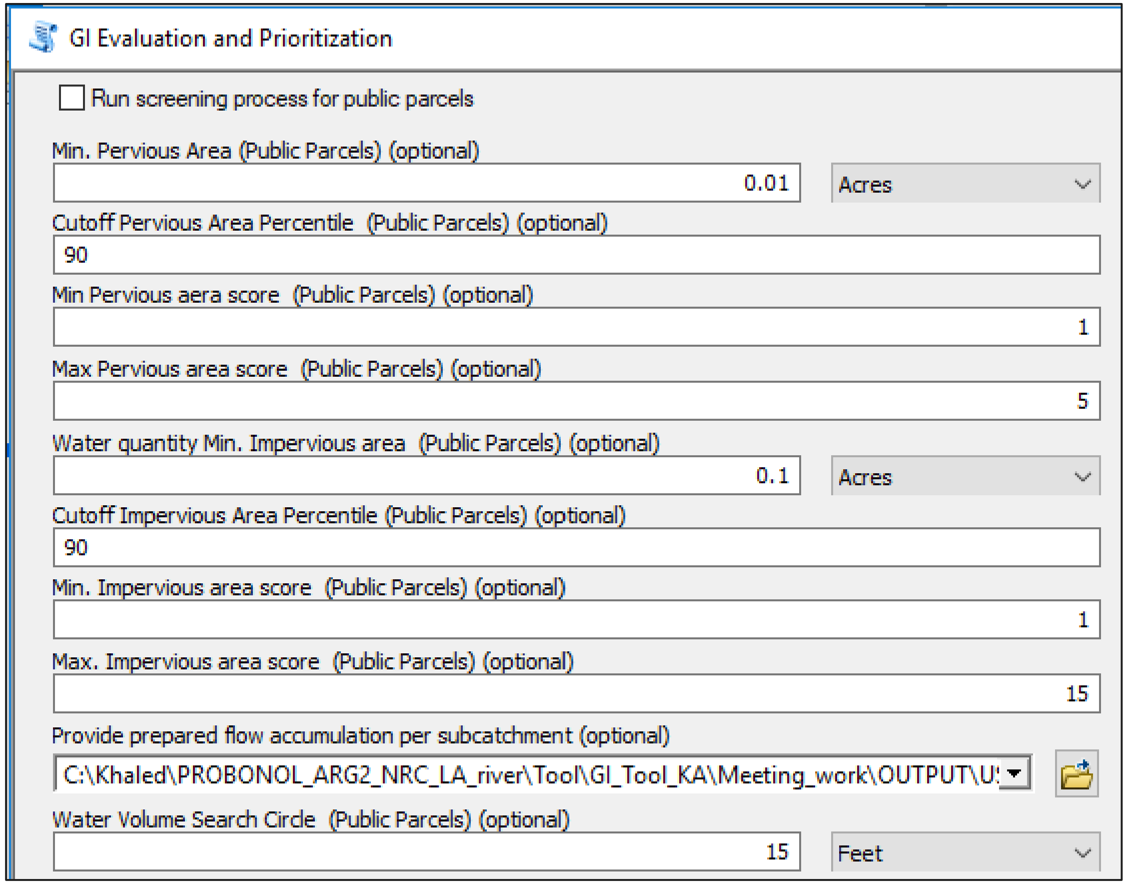
Public Parcel Screening Factors

- Volume capture
- Road slope
- Parcel elevation
- Soil contamination
- Soil infiltration



Volume Capture

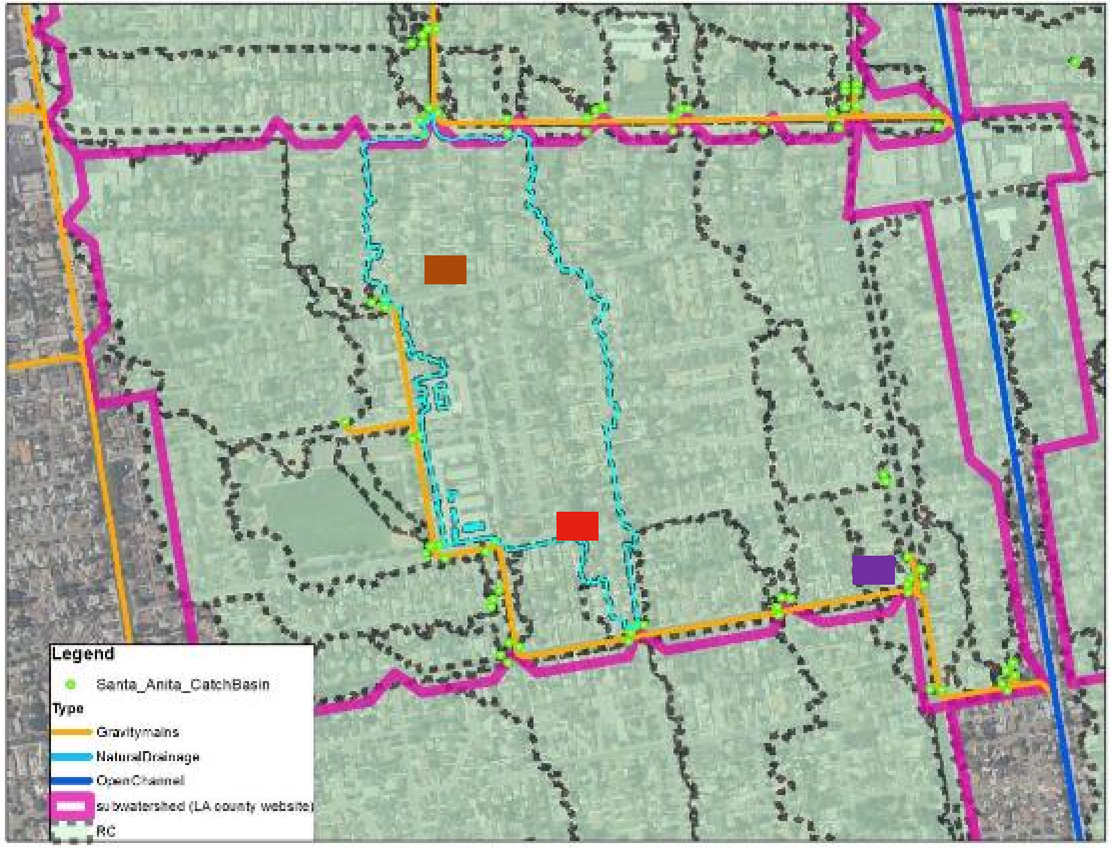
- Input Layers
  - Buildings
  - Parking lots
  - Roads
  - Sub-watersheds
  - Points of interest (storm inlets)
  - Sub-watershed flow accumulation raster
  - Public parcels



Volume Capture

- Available area
- Impervious area in the watershed.
- Parcel proximity to the watershed outlet

Parcel 1
Parcel 2
Parcel 3

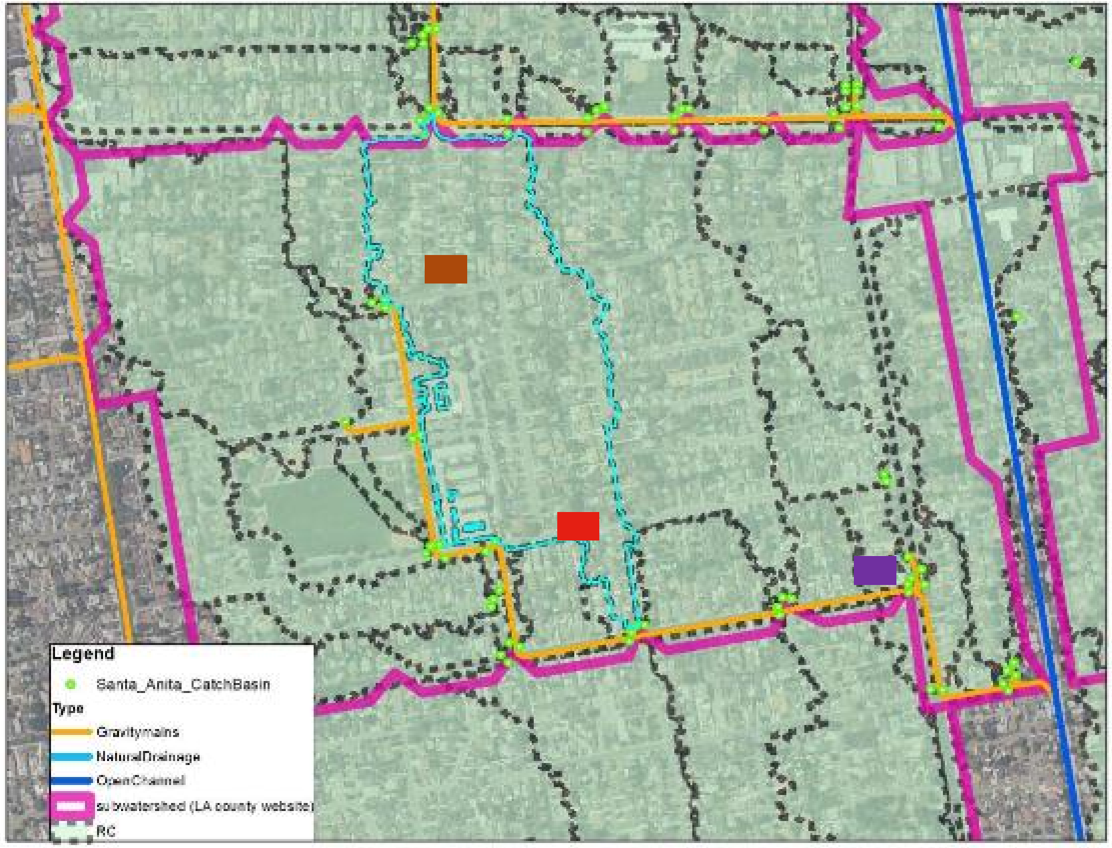


Volume Capture

Total score = a + b*c

a: Available Area Score
b: Sub-watershed Water Volume Score.
c: % of subwatershed runoff that can be captured by the parcel

Parcel	a	b	c	Total score
Parcel 1	4/5	15/15	85%	16.75
Parcel 2	4/5	4/15	100%	8
Parcel 3	4/5	15/15	35%	9.25



Parcel 1
Parcel 2
Parcel 3

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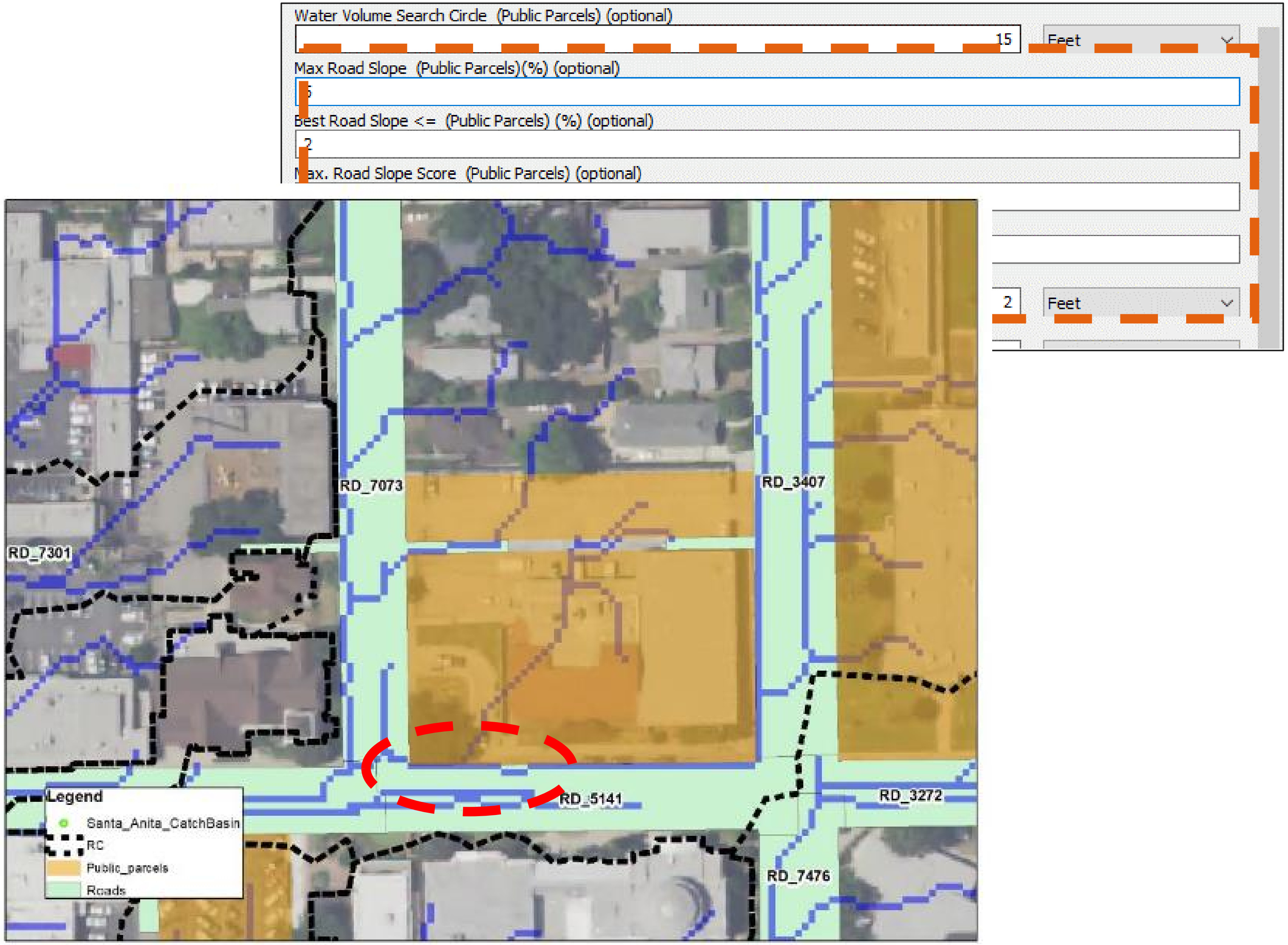
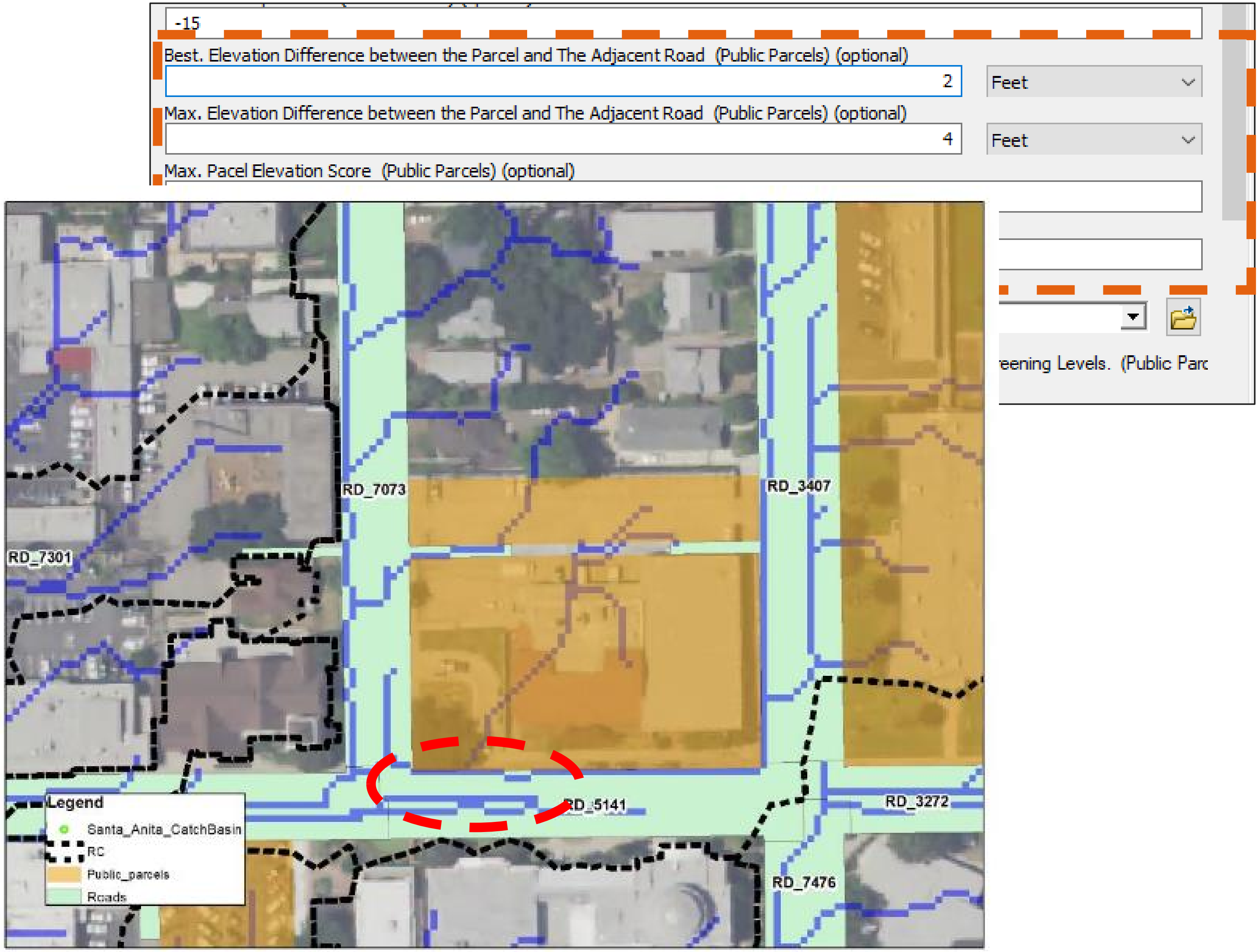
Road Slope

- Input Layers
  - Public parcels
  - Road shapefile
  - DEM



Parcel Elevation

- Input Layers
  - Public parcels
  - Road shapefile
  - Street Centerline
  - DEM



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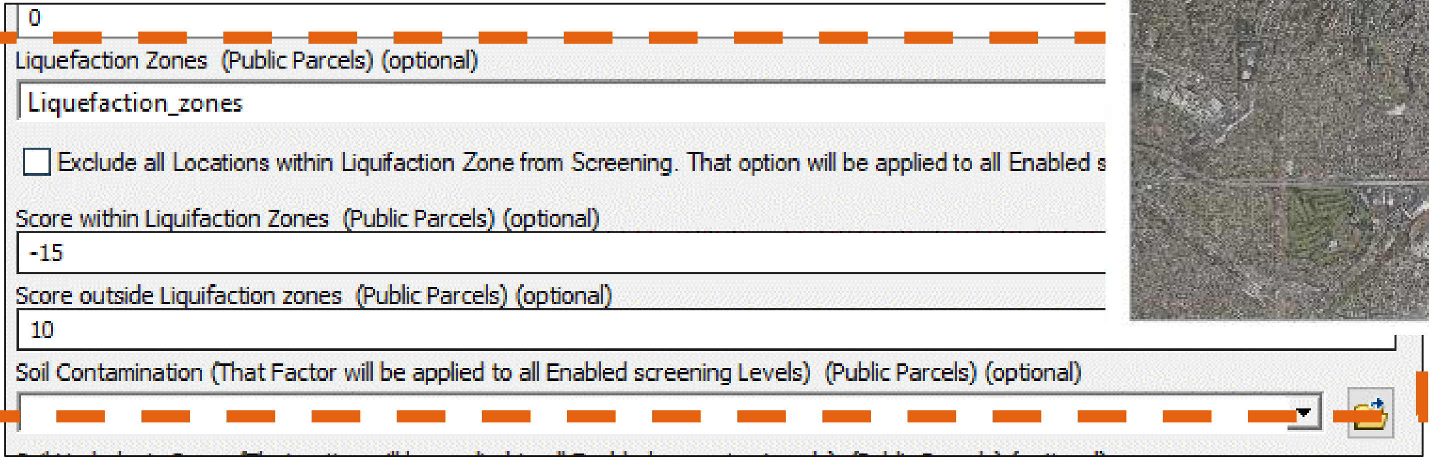
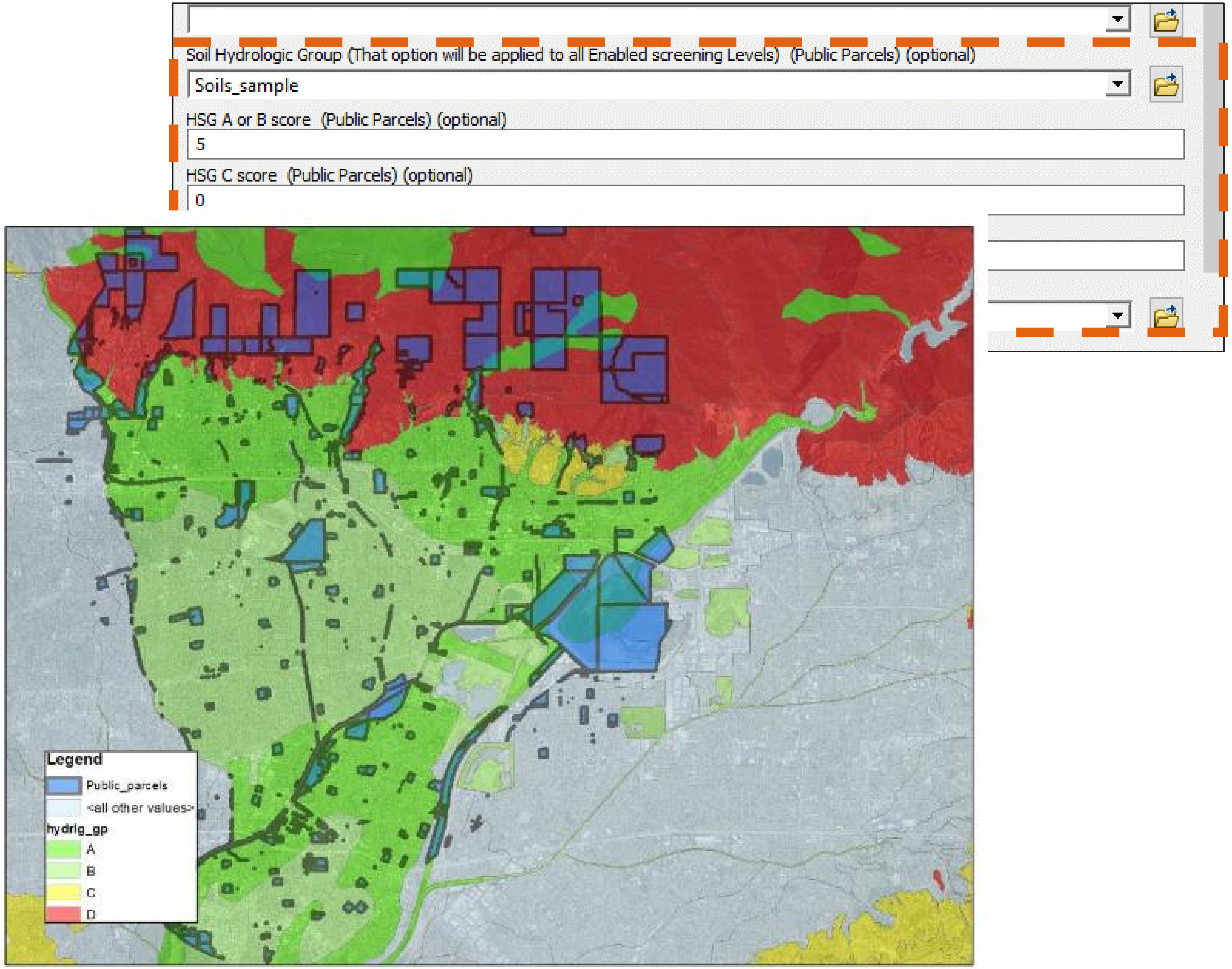
Contaminated Soils

- Input Layers
  - Public parcels
  - Contaminated Soils.



Soil Infiltration

- Input Layers
  - Public parcels
  - Soil layer (HSG)



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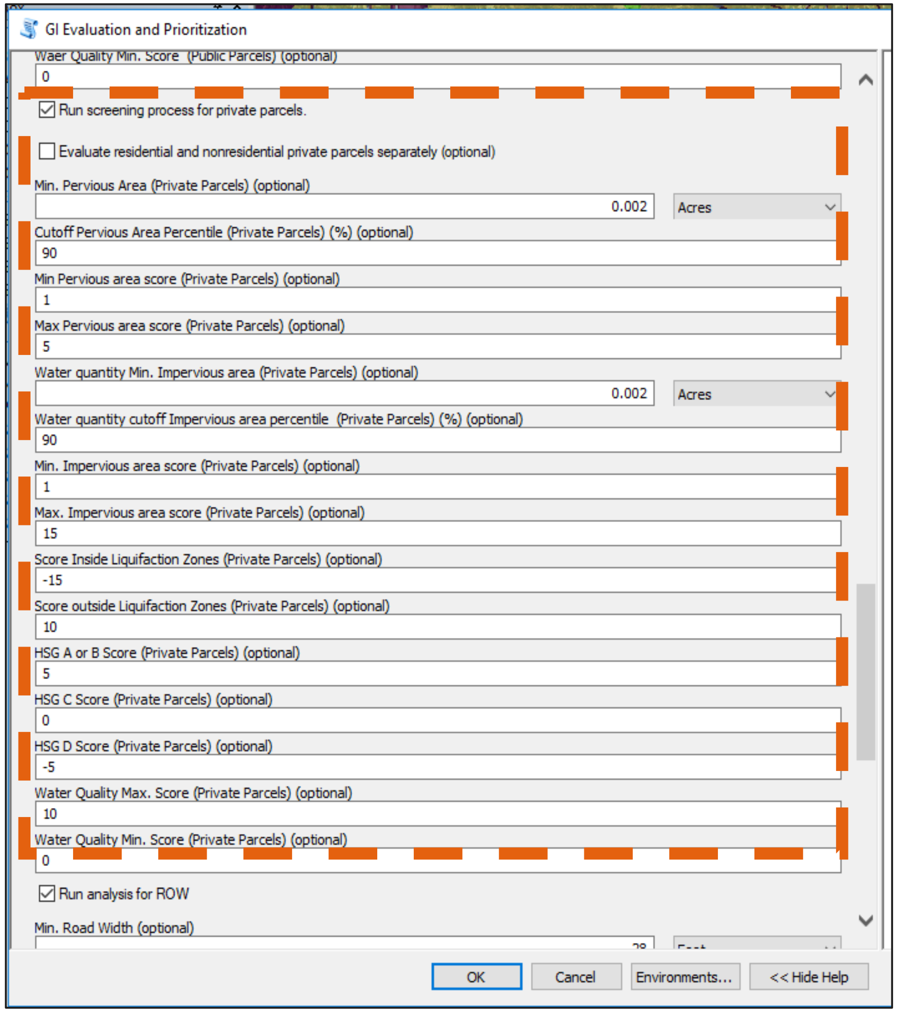
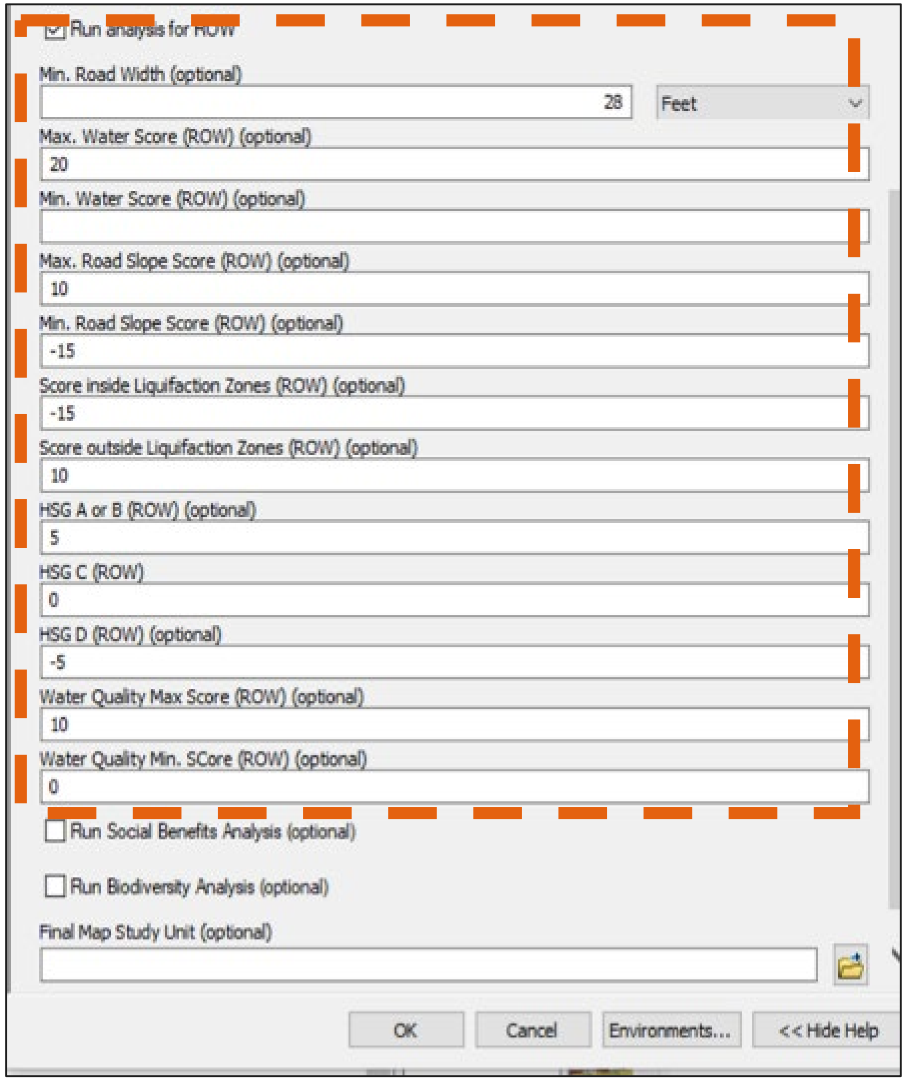
Private Parcel Screening

- Screening Factors
  - volume capture
  - Soil Contamination.
  - Soil Infiltration.



Road Screening

- Screening Factors
  - Volume capture
  - Road slope
  - Soil contamination
  - Soil infiltration



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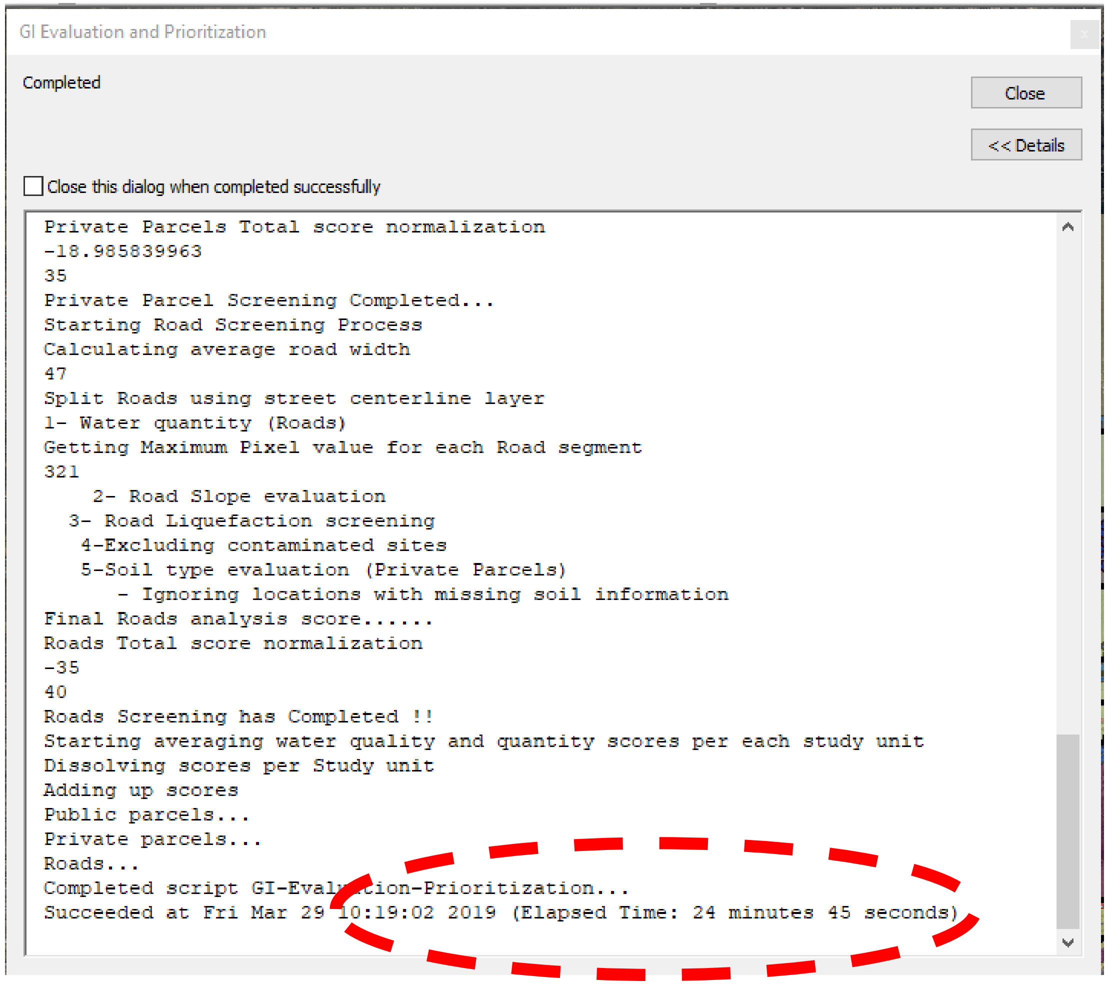
Processing Time



- Analysis for more than 64,000 ac was done in 24 minutes

Public Parcels Screening Results

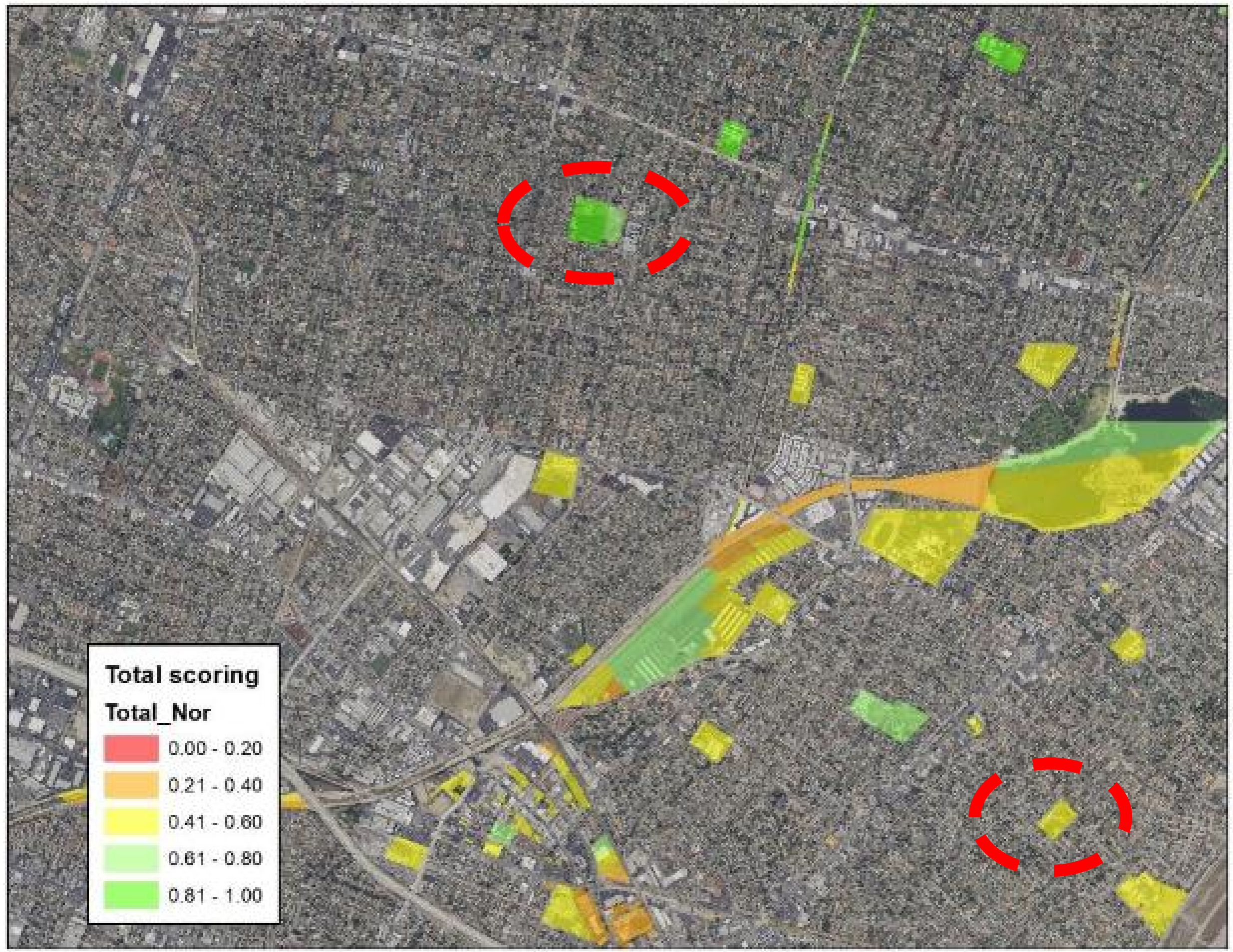
Identify

Identify from: <Top-most layer>

Total scoring

Location: -8,560,018.490 678,096.944 Feet

Field	Value
FID	244
Shape	Polygon
Pub_ID	Par_322
WQperv_scr	4.94514
MAX_WQV_sc	15
PP_WQScr	19.94514
Pub_slpScr	10
PubElv_Scr	10
Lqu_Scr	10
Conmnt_Scr	0
soil_scr	5
Pub_total	54.94514
Total_Nor	0.999364



Identify

Identify from: <Top-most layer>

Total scoring

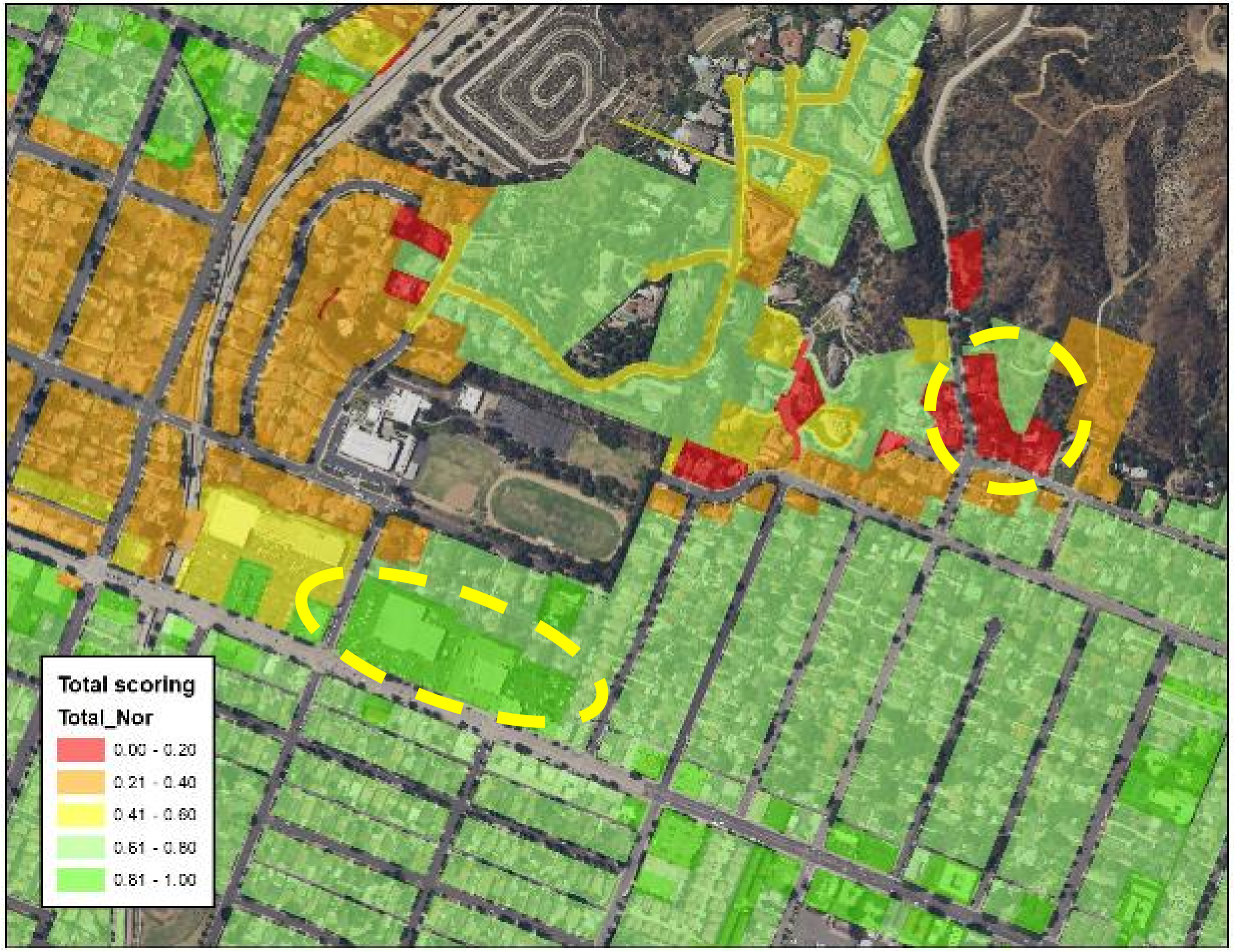
Location: -8,551,680.923 667,572.215 Feet

Field	Value
FID	87
Shape	Polygon
Pub_ID	Par_1145
WQperv_scr	3.15395
MAX_WQV_sc	0.968662
PP_WQScr	4.122612
Pub_slpScr	10
PubElv_Scr	0
Lqu_Scr	-15
Conmnt_Scr	0
soil_scr	5
Pub_total	4.122612
Total_Nor	0.410161

Private Parcels Screening Results

Location: -8,546,545.782 691,960.474 Feet

Field	Value
FID	10674
Shape	Polygon
Priv_ID	Priv_40719
WQperv_scr	1.20411
WQ_scr	15
Lqu_Scr	10
Conmnt_Scr	0
soil_scr	5
Priv_total	31.204109
Total_Nor	0.929687
Prv_tempID	Priv_10674



Location: -8,544,245.771 692,850.645 Feet

Field	Value
FID	1508
Shape	Polygon
Priv_ID	Priv_14351
WQperv_scr	2.18454
WQ_scr	2.94824
Lqu_Scr	-15
Conmnt_Scr	0
soil_scr	0.976161
Priv_total	-8.891058
Total_Nor	0.186989
Prv_tempID	Priv_1508

Roads Screening

Location: 6,556,048.385 1,876,900.804 Feet

Field	Value
FID	12735
Shape	Polygon
CL_ID	RD_4201
Area_ac	2.6987
Width	59.4287
GRIDCODE	1310
WQ_scr	15
RCQ_pixl	26331
RD_RC_ID	RD_4201_1310_15725
MAX	26331
RD_WQ_scr	14.99943
Avg_Slope	1.068479
RD_slpScr	10
In_Liqu	
RD_Lqu_Scr	10
Contamnt	
RDCont_Scr	0
RDSoil_scr	5
RD_total	39.99943
Total_Nor	0.999992
RD_tempID	RD_12735

dentify

Identify from: <Top-most layer>

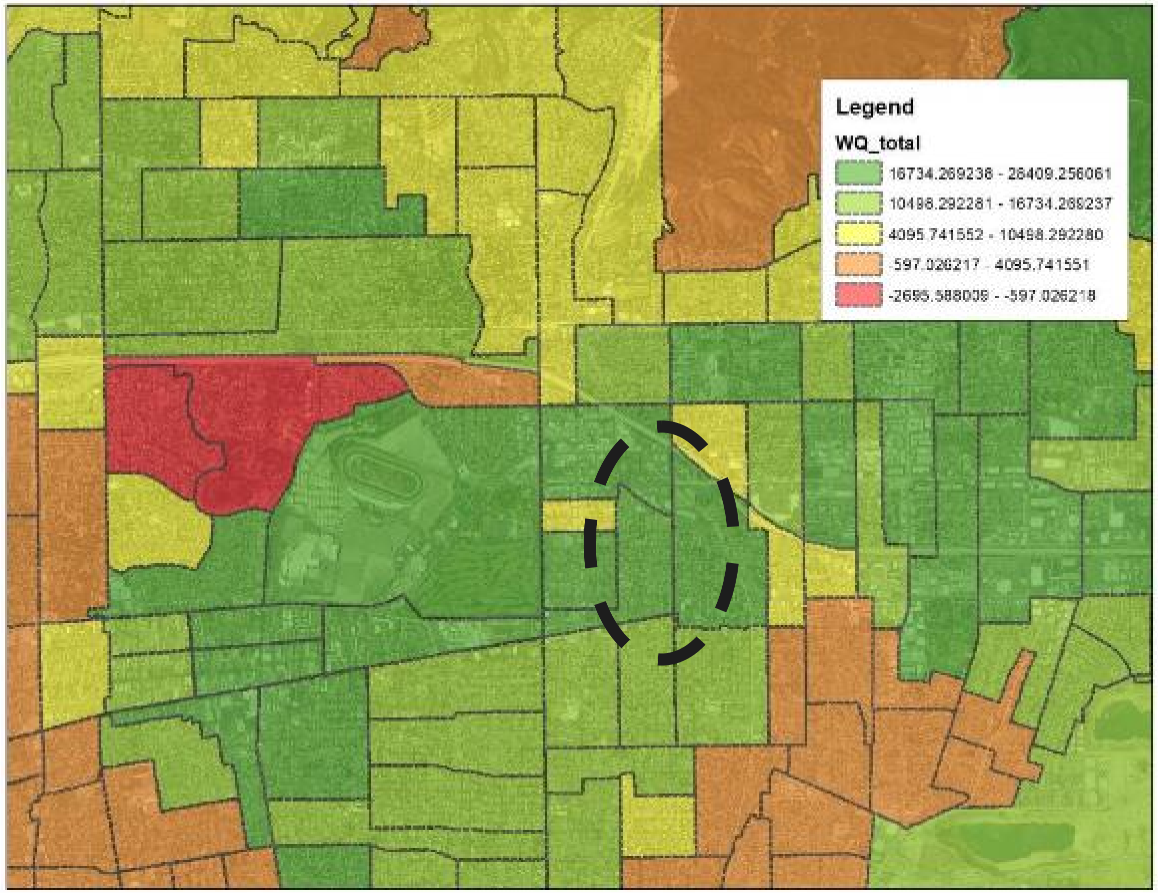
Final_Road_scores_cleaned
RD_7168

Location: 6,556,248.760 1,879,065.375 Feet

Field	Value
FID	21702
Shape	Polygon
CL_ID	RD_7168
Area_ac	0.467648
Width	51.2528
GRIDCODE	1711
WQ_scr	14.0151
RCQ_pixl	24582
RD_RC_ID	RD_7168_1711_26936
MAX	6411
RD_WQ_scr	3.654997
Avg_Slope	4.430019
RD_slpScr	-10.25016
In_Liqu	In
RD_Lqu_Scr	-15
Contamnt	
RDCont_Scr	0
RDSoil_scr	5
RD_total	-16.595162
Total_Nor	0.245398
RD_tempID	RD_21702

Averaging the Scores

- Tool can be used to average the analysis results city wide using
  - Watersheds
  - Flowmeter basins
  - School districts
  - census blocks
  - Any other user preferred boundary



Identify

Identify from: <Top-most layer>

60374309021

Location: 6,557,095.515 1,871,544.179

Field	Value
FID	95
Shape	Polygon
bg_id	60374309021
bg_id_1	60374309021
SUM_WQperv	19.3095
SUM_MAX_WQ	45.092586
SUM_Pub_sl	148.80074
SUM_PubElv	70
SUM_Lqu_Sc	180
SUM_Commnt	0
SUM_soil_s	90
SUM_Pub_to	553.202826
SUM_WQpe_1	1507.677638
SUM_WQ_scr	3175.695346
SUM_Lqu__1	6750
SUM_Conm_1	0
SUM_soil_1	3375
SUM_Priv_t	14808.372998
SUM_RD_WQ_	615.313327
SUM_RD_slp	2042.565129
SUM_RD_Lqu	2700
SUM_RDCont	0
SUM_RDSoil	1350
SUM_RD_tot	6707.878456
WQ_total	22069.45428

Identified 1 feature

Social/Public Health Indicators

- Air Quality Pollution Burden
- Water Quality Pollution Burden
- Economic Hardship Index
- Connect Green Spaces
- Reduce Effect of Urban Heat Island
- Provide Equitable Access to Greenspace
- Race/Ethnicity
- Population Density

Summary

- User-friendly Tool developed to identify potential locations for nature-based solutions
- Screen potential public, private and road ROW parcels
- Tool is based in ArcGIS and scalable across block, subwatershed, watershed and county level

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Newton/Bedford, City of Columbus

- Different Version of the tool was used in one of the areas in the City of Columbus Blueprint program
- Tool output was used as a support for the design and modeling teams
- The tool focuses on utility conflicts

Tool Methodology

Buffer width

- Scoring based on the impact area

- Runoff catchments
- Sewer lines
- HSTS
- Area lighting
- Miscellaneous electrical equipment
- Electrical surface structure
- Electrical Pole
- Fire hydrant
- Parcels

- Bus stops
- Tree
- Water network
- Gas lines
- Impervious area
- Vacant parcels
- Roads
- Street centerline
- Intersections
- Contours

Tool Methodology

- Scoring based on the feature properties

- Runoff catchments
- Sewer lines
- HSTS
- Area lighting
- Miscellaneous electrical equipment
- Electrical surface structure
- Electrical Pole
- Fire hydrant
- Parcels

- Bus stops
- Tree
- Water network
- Gas lines
- Impervious area
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Tool Methodology

- Removing undesired locations

- Runoff catchments
- Sewer lines
- HSTS
- Area lighting
- Miscellaneous electrical equipment
- Electrical surface structure
- Electrical Pole
- Fire hydrant
- Parcels

- Bus stops
- Tree
- Water network
- Gas lines
- Impervious area
- Vacant parcels
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- Street centerline
- Intersections
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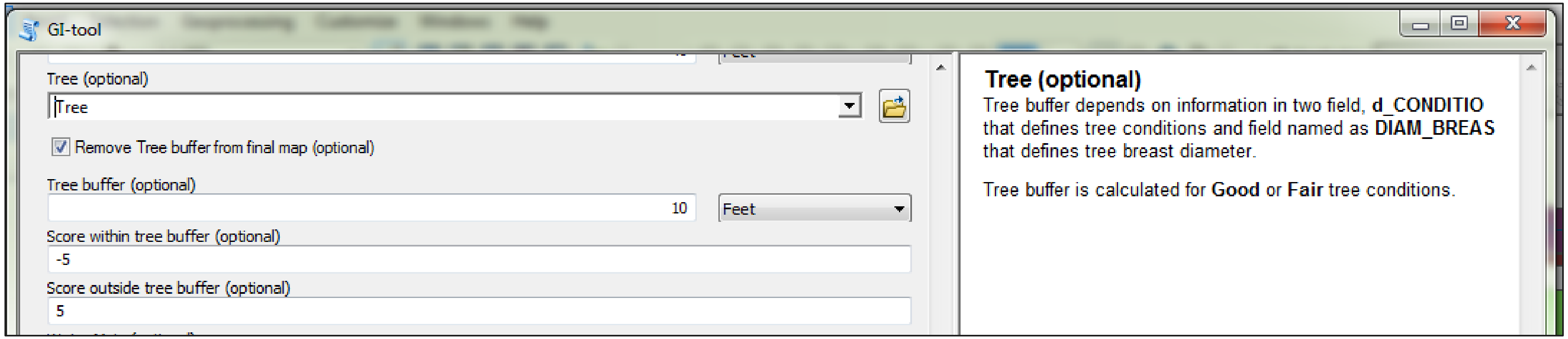
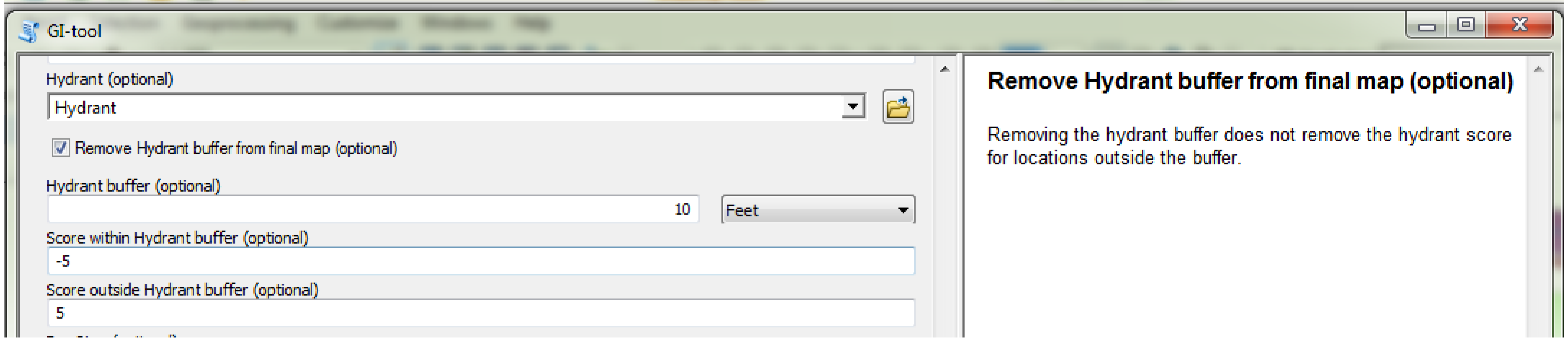
GI Siting Tool Interface

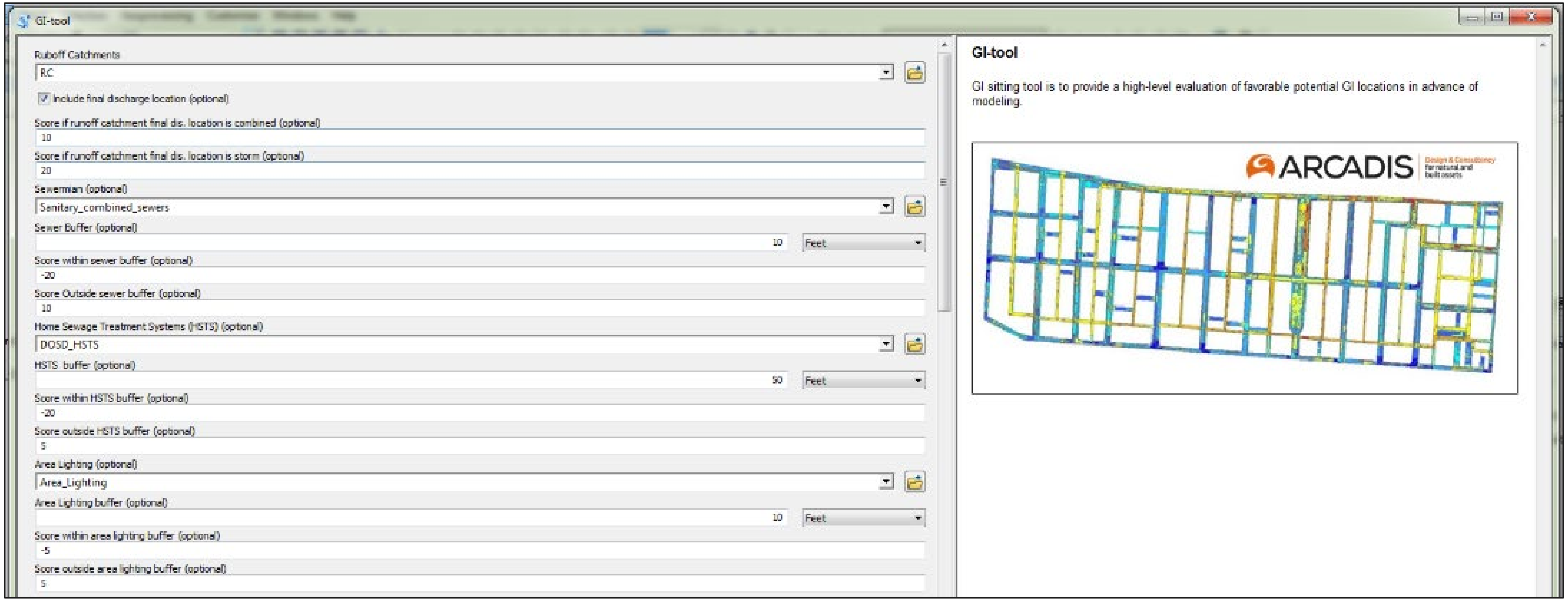
- Layer requirements or clarifications on how the selected option will impact the calculation are shown in the side description panel.





GI Siting Tool Interface

- User can define buffer size and scores within and outside the buffer.
- User can ignore any layer by not providing any input



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Tool Output

Score	
Total_Nor	
	0.00 - 0.20
	0.21 - 0.40
	0.41 - 0.60
	0.61 - 0.80
	0.81 - 1.00

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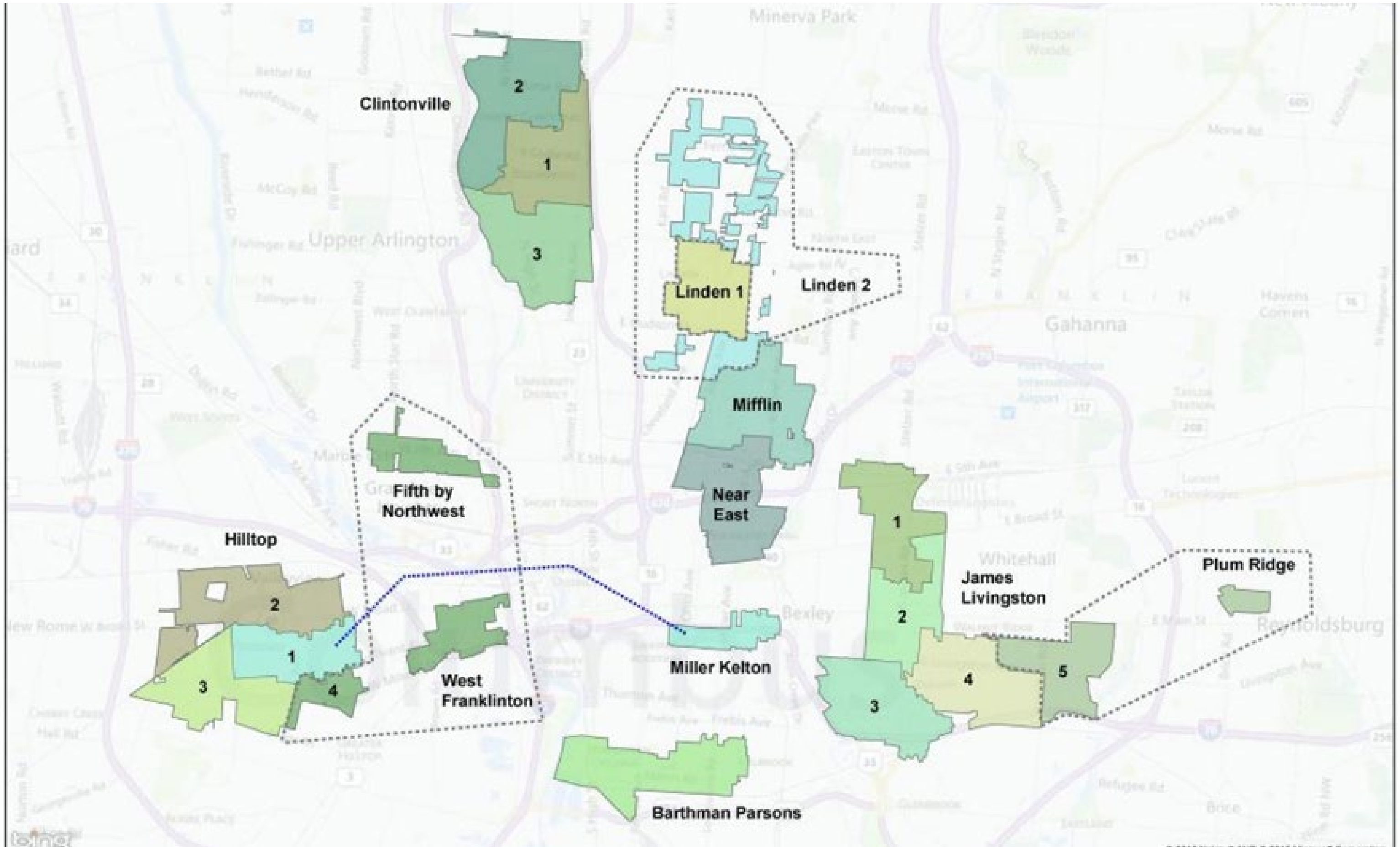
Tool Output

Field	Value
FID	19
Shape	Polygon
San_Score	-20
Light_Scor	5
mELEC_Scor	5
eSurf_Scor	5
Pole_Scor	5
Hyd_Scor	5
WM_Scor	-5
ImpA_scr	0
Tree_scr	5
LBP_scr	0
Slope_scr	0
HSTS_Score	5
Total	25
Gas_Scr	5
Q_scr	10
Id	0
Total_Nor	0.294118

Consistency for All Blueprint Projects

City of Columbus distributed the tool to all Blueprint consultants to reduce siting effort and to ensure consistency of product



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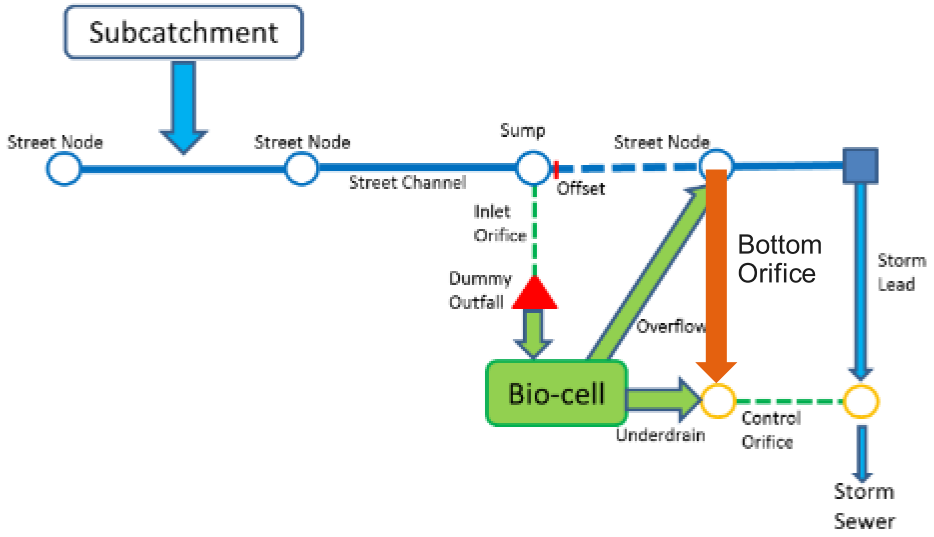
GI Units Representation in H/H Model

- GI unit in a catchment receives flow from the directly connected impervious area (not the catchment generated flow!)
- Inlet configuration requires its own evaluation to understand its effectiveness
- Engineered soil permeability has an important role, including potential degradation due to maintenance

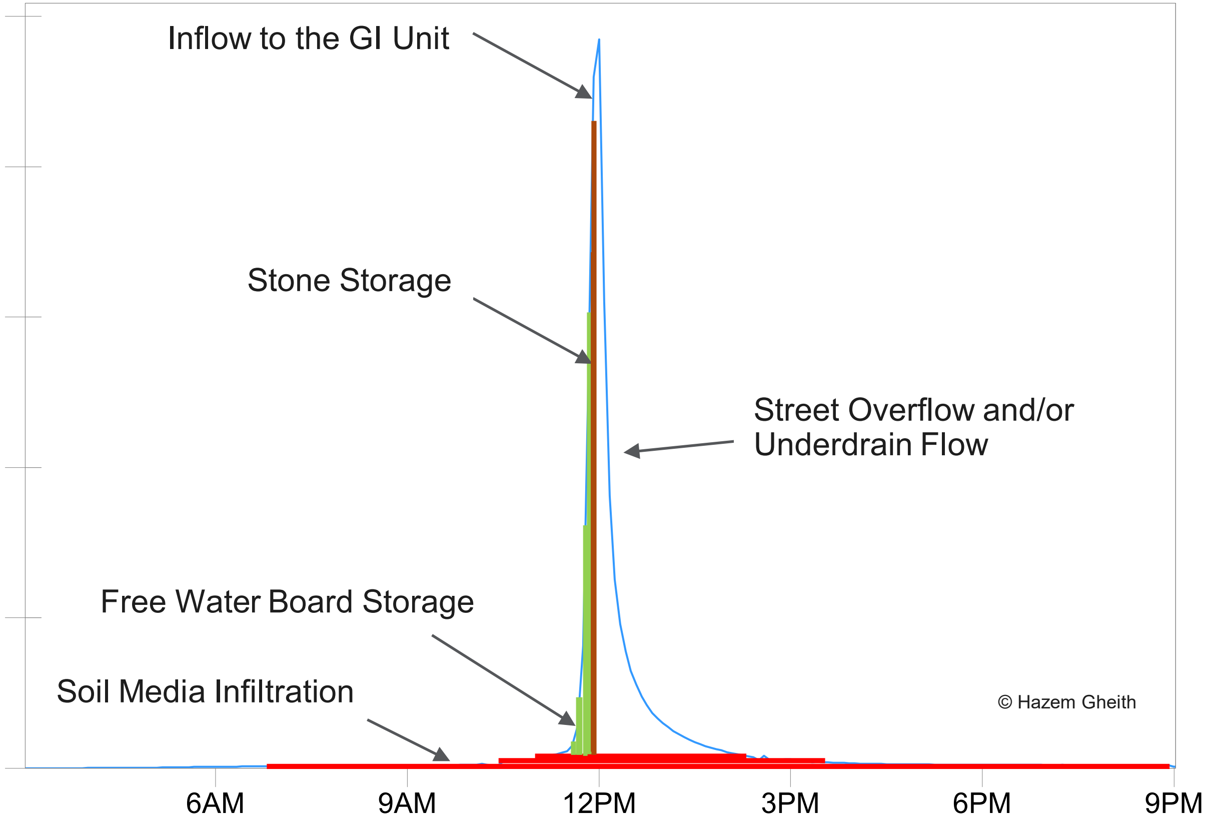


Surface Layer		Soil Layer		Storage Layer		Underdrain	
Berm Height (in)	6 - 12	Thickness (in)	18 - 24	Thickness (in)	12 - 18	Drain Coef. (in/hr)	1.5
Vegetation Vol.(fraction)	0.05	Porosity (Vol. Fraction)	0.26	Void Ratio	0.7	Drain Exponent	0.5
Surface Roughness	0.25	Field Capacity (Vol. Fraction)	0.09	Seepage Rate (in/hr)	0.01	Drain Offset (in)	3 - 6
Surface Slope (%)	1.0	Wilting Point (Vol. Fraction)	0.035	Clogging factor	0		
		Conductivity (in/hr)	2.1				
		Conductivity Slope	8				
		Suction Head	3.5				

How GI Units Capture Flow

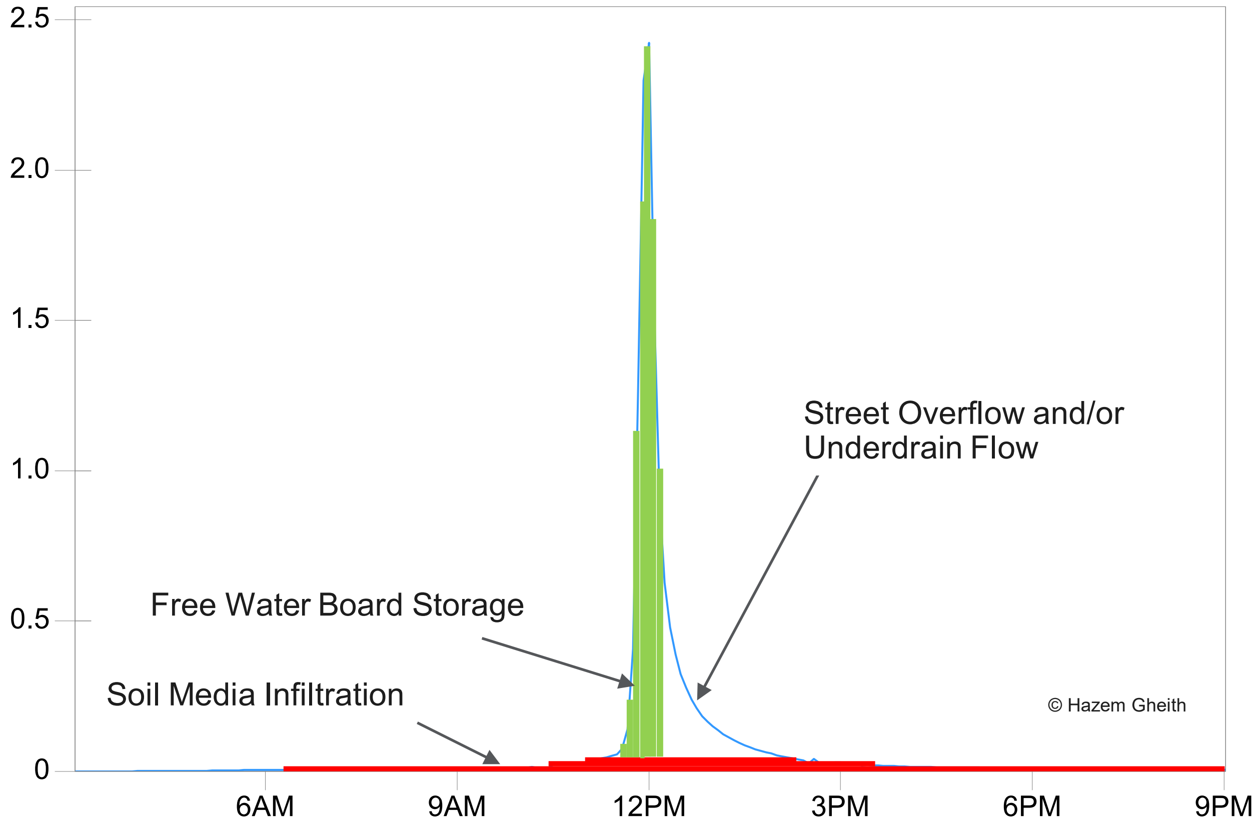
- Footprint infiltration
  (engineered soil conductivity)
- Free waterboard storage
  (flow > infiltration capacity)
- Stone layer storage
  (vertical pipe/stone column)

- This GI unit does not control the target storm peak flow
- It has about 50% impact on volume control



Capture Flow Hydrographs – Deeper Pond

- Increase storage on the surface or stone layer
- This GI unit shaves the target storm peak flow by 75%
- It has about 75% impact on volume control



Combining Sites Score and Flow Levels

- Sort sites by area-weighted score
- Add information on predicted flow peak and volume
  - Water quality: Locate high score sites with high water volume
  - Flood control: Locate high score sites with high peak flow

Inlet Catchment	Site Score (area weighted)	Total volume (mg) TY	Peak flow (mgd) 5yr DS
0035T0806-A	0.933	0.316	2.746
0035T1125-A	0.926	0.127	2.403
0035T0943-A	0.900	0.226	1.686
0016T0840-A	0.894	0.281	3.060
0035T1123-A	0.869	0.895	6.847
0016T0822-A	0.833	0.152	3.768
0016T0837-A	0.833	0.601	1.663
0015T1044-A	0.826	0.337	1.015
0015T0872-A	0.819	0.000	0.005
0015T0886-A	0.801	0.189	1.380
0015T0866-A	0.800	0.322	2.392
0016T1167-A	0.796	0.038	1.001
0015T0446-A	0.792	0.003	0.126
0015T0865-A	0.790	0.147	1.971
0015T0447-A	0.790	0.002	0.514
0034T1415-A	0.786	0.189	0.815
0034T0015-A	0.786	0.122	1.961
0015T0445-A	0.785	0.125	0.995
0015T0870-A	0.778	0.212	1.619
0015T0867-A	0.774	0.177	0.756
0015T1047-A	0.773	0.260	2.833
0015T1043-A	0.772	0.393	1.689
0015T0117-A	0.771	0.118	1.133

Volume

Peak

Good sites but no flow arriving at the site

Conclusions

- The user-friendly GI Siting Tool is easy to use serves different stakeholders
- It identifies sites that provide the highest benefit based on available space, enough flow, good soil properties, etc.
- Enhanced modeling platform provides accurate flow prediction at the GI unit

Conclusions

- User friendly tool that can support decision making by different stakeholders during planning, outreach and design stage
- Defensible approach vs “Best Engineering Judgment”
- The tool saves time during both planning and design stages
- It identifies sites that provide the highest benefit based on available space, enough flow, good soil properties, etc.
- Modeling step provides accurate flow prediction at the GI unit

Thank You

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Imagine the result