

# Lakeshore example for ArcNLET-Py

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1. Introduction

2. Lakeshore example

3. New features





# I. Introduction

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# 1.1 Model History

Jun 2011

ArcNLET Version 1.0  
Developed for ArcMap 9.x

Mar 2012

VZMOD

Feb 2015

ArcNLET Version 3.0  
Can simulate reactive transport  
of both ammonium and nitrate

Aug 2011

ArcNLET Version 1.1  
Add ArcMap 10 compatibility

Jul 2013

ArcNLET Version 2.0  
Add a new function of  
Monte Carlo simulation

Dec 2023

ArcNLET-Py  
Python version for  
ArcGIS Pro



# 1.2 ArcNLET resources

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- Training videos on Youtube:

<https://www.youtube.com/@mingye9168/videos>

- Source code on GitHub and online User's manual:

<https://github.com/ArcNLET-Py/ArcNLET-Py>

- FSU Website:

<https://atmos.eoas.fsu.edu/~mye/ArcNLET/>



# 1.3 Purpose

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- Describe how to complete a simulation using ArcNLET-Py
- This is only a demo for the new version. For the principles and algorithm behind the software, please see Dr. Ye's video, or the technical manual
- If there are any questions, please submit a new issue on GitHub or contact us directly



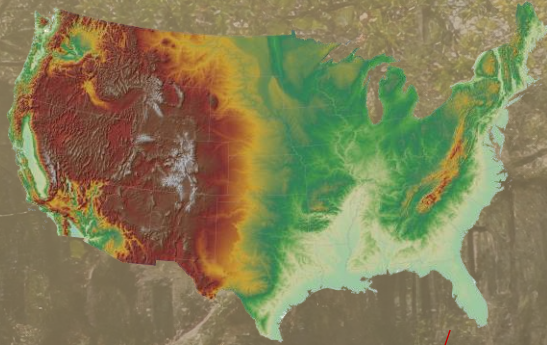


## 2. Lakeshore example

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# 2.1 Study area

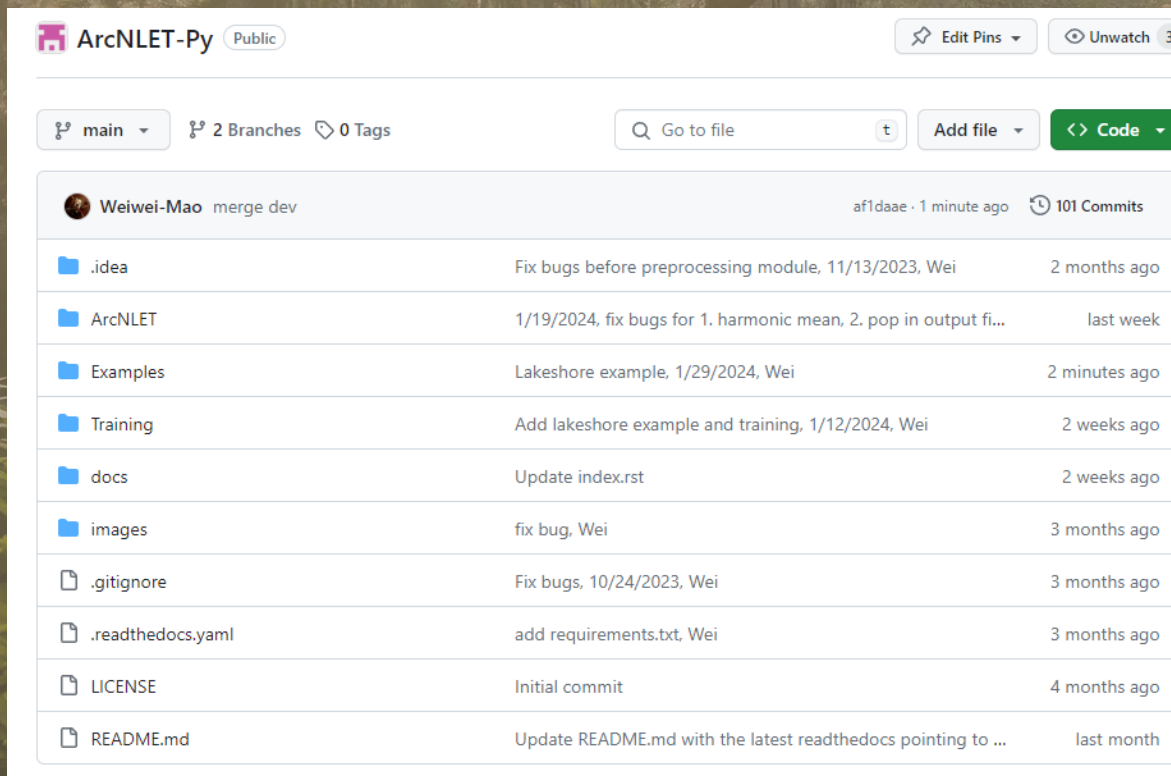


265 septic tanks



## 2.2 ArcNLET-Py preparation

- <https://github.com/ArcNLET-Py/ArcNLET-Py>
- Understanding repository structure is key



The screenshot shows the GitHub repository page for ArcNLET-Py. The repository is public and has 2 branches and 0 tags. The file structure is listed below:

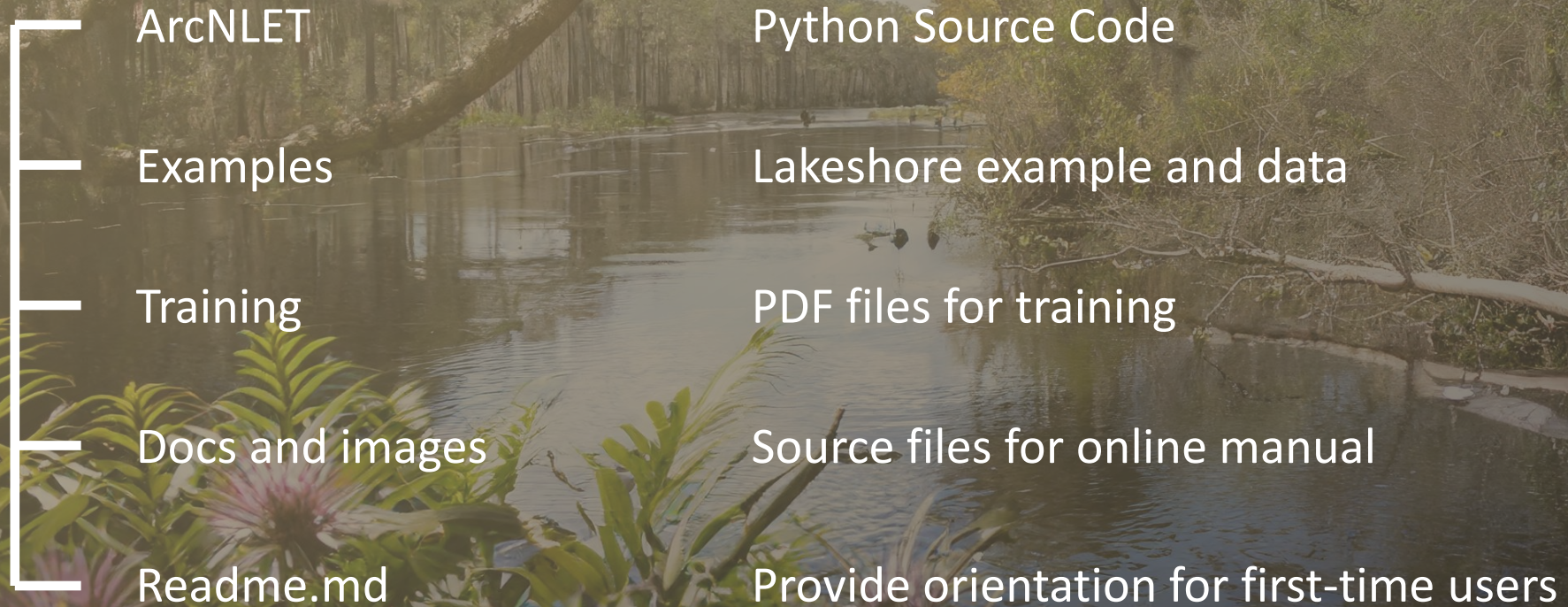
File/Folder	Commit Message	Commit Date
.idea	Fix bugs before preprocessing module, 11/13/2023, Wei	2 months ago
ArcNLET	1/19/2024, fix bugs for 1. harmonic mean, 2. pop in output fi...	last week
Examples	Lakeshore example, 1/29/2024, Wei	2 minutes ago
Training	Add lakeshore example and training, 1/12/2024, Wei	2 weeks ago
docs	Update index.rst	2 weeks ago
images	fix bug, Wei	3 months ago
.gitignore	Fix bugs, 10/24/2023, Wei	3 months ago
.readthedocs.yaml	add requirements.txt, Wei	3 months ago
LICENSE	Initial commit	4 months ago
README.md	Update README.md with the latest readthedocs pointing to ...	last month





## 2.2 ArcNLET-Py preparation

- Organizations of files on GitHub





## 2.3 Procedures 1 – Installation Prerequisites

- Is ArcGIS Pro installed and up-to-date?
- Spatial Analyst license active
- Create an ArcGIS Pro Project File for ArcNLET-Py
- Project files help organize workflows

### ArcGIS Pro 3.2 system requirements

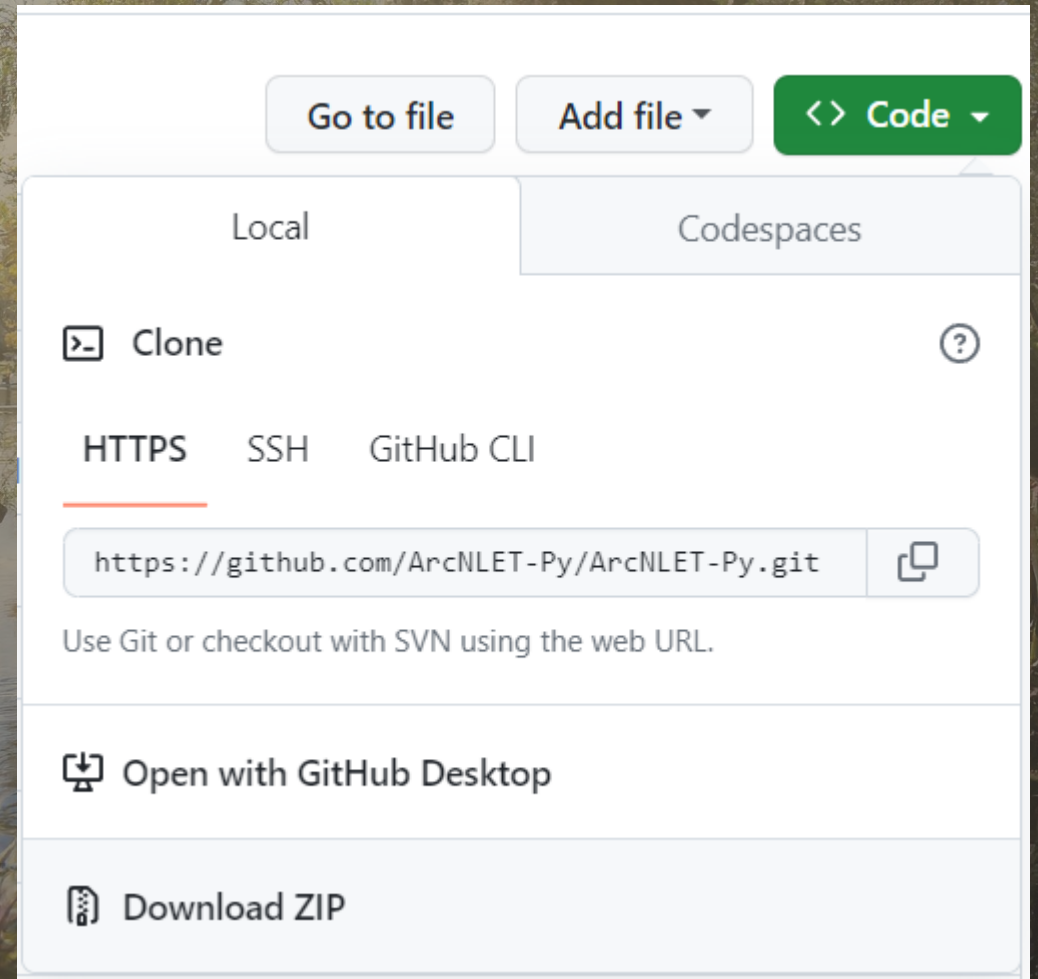
ArcGIS Pro 3.2 | [Other versions](#) ▾ | [Help archive](#)

Before installing or upgrading ArcGIS Pro on a virtual or physical machine, ensure that your system meets the minimum requirements to run it. Also, learn what resources are recommended to get the best performance.



## 2.4 Procedures 2 – ArcNLET-Py Download

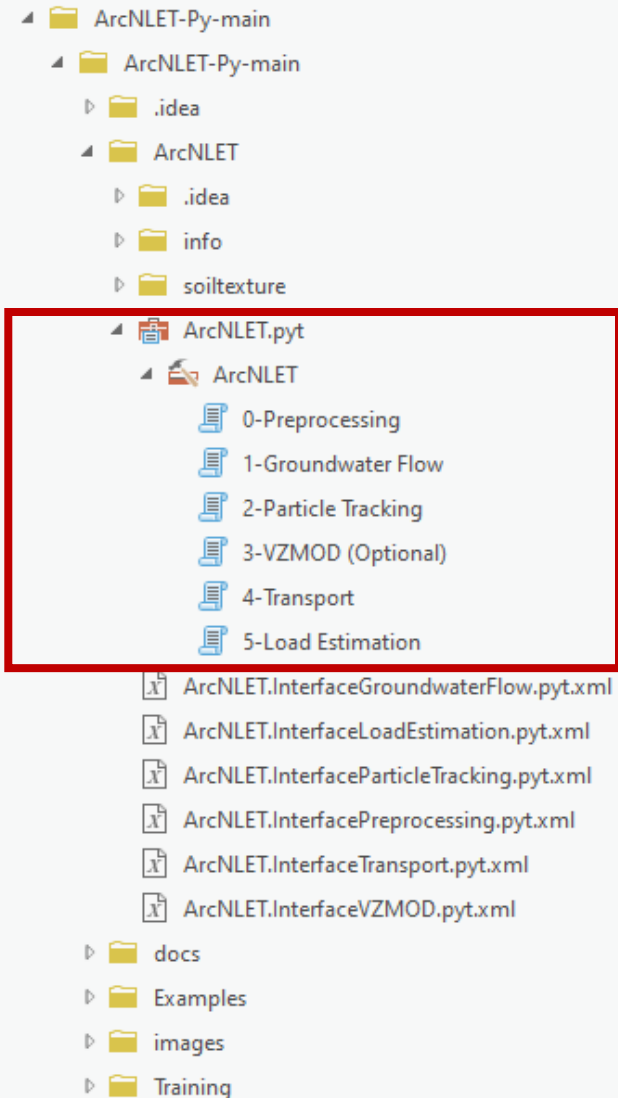
- Access the latest version (dev branch)
- ‘Download ZIP’ for the ArcNLET-Py repository
- Unzip the ‘Download ZIP’





# 2.5 Procedures 3 – Accessing Python Toolsets

- Access the ArcNLET-Py Python toolbox
  - Catalog Pane/View





## 2.5 Procedures 3 – Structure of ArcNLET-Py

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- Tools are organized into modules
  - 0-Preprocessing
    - Extracts data (hydraulic conductivity, porosity, and soil types) from SSURGO database
  - 1-Groundwater Flow
    - Analyzes groundwater velocity based on DEM and soil data
  - 2-Particle Tracking
    - Simulates water particle movement from sources (septic tanks) to waterbodies
  - 3-VZMOD (Optional)
    - Models nitrate and ammonium concentrations in the Vadose Zone
  - 4-Transport
    - Models nitrate and ammonium plume transport in the groundwater
  - 5-Load Estimation
    - Estimates mass loading to surface waterbodies



# 2.5 Procedures 3 – Metadata


- Metadata within each toolset highlights the purpose and functionality
- Blue ‘i’ icon help messages help users
- Custom warnings and error indicators guides workflows

Metadata Geography Table		
<b>1-Groundwater Flow</b>		
<b>Title</b> 1-Groundwater Flow		
<b>Description</b> There is no description for this item.		
<b>Usage</b> There is no usage for this tool.		
<b>Syntax</b> InterfaceGroundwaterFlow (DEM, Water bodies, Hydraulic Conductivity, Porosity, Smoothing Factor, Smoothing Cell, Fill Sinks, Merge Waterbodies, {Smoothing Factor after Merging}, Z-Factor, Velocity Magnitude, Velocity Direction, {Hydraulic Gradient}, {Smoothed DEM})		
Parameter	Explanation	Data Type
DEM	Dialog Reference Used to generate an approximation to the water table. This input must be a raster layer. Note that a higher resolution DEM does not necessarily give better results, since a coarser DEM may better approximate the water table.  Python Reference Test Scripting	Raster Layer
Water bodies	Dialog Reference Must be a polygon type layer. This dataset is used to determine the locations of water bodies to which groundwater will flow. There is no python reference for this parameter.	Feature Layer
Hydraulic Conductivity	Dialog Reference Must be a raster layer. This input represents a map of hydraulic conductivity for the domain. The linear units of the hydraulic conductivity must be the same as the units of the DEM. For example, if the DEM has linear (ground distance) units of meters, the hydraulic conductivity must have units of meters per unit time. The output seepage velocity magnitude will have the same units as this input. There is no python reference for this parameter.	Raster Layer
Porosity	Dialog Reference Must be a raster layer. This input represents a map of soil porosity for the domain. There is no python reference for this parameter.	Raster Layer
Smoothing Factor	Dialog Reference This controls the number of smoothing iterations that are performed on the DEM to generate a subdued replica of the topography. Higher numbers mean more smoothing and a flatter replica. As	Long



## 2.5 Procedures 3 – Structure of Data

- Data needed      [GitHub/Examples/lakeshore\\_example.zip](#)      Remember unzip



Lakeshore_example.aprx	ArcGIS Pro project file
Example_Inputs	Demo input data
Example_Outputs	Demo output data
Preprocessing_module	Data for preprocessing module
Original_Data	Downloaded original data for the study site



# 2.6 Procedures 4

## Groundwater Flow Module

- Inputs
  - DEM,
  - Waterbodies
  - Hydraulic Conductivity
  - Porosity
- Parameters
  - Smoothing Factor
  - Z-Factor
- Outputs
  - Velocity Magnitude and Direction
  - Hydraulic Gradient
  - Smoothed DEM

Geoprocessing ▼ 🔍 ✕

← 1-Groundwater Flow → ⊕

Parameters Environments ?

Input DEM [L] (raster)  
lakeshore.img 📁

Input Water bodies (polygon)  
waterbodies 📁

i Input Hydraulic conductivity [L/T] (raster)  
hydr\_cond.img 📁

Input Soil porosity (raster)  
porosity.img 📁

Output Velocity Magnitude [L/T]  
demo\_vel\_mag 📁

Output Velocity Direction [°wrt N]  
demo\_vel\_dir 📁

(Optional) Output Smoothed DEM (VZMOD required)  
demo\_smthdem 📁

(Optional) Output Hydraulic Gradient  
demo\_grad 📁

▼ Parameters

Smoothing Factor

Smoothing Cell

☐ Fill Sinks

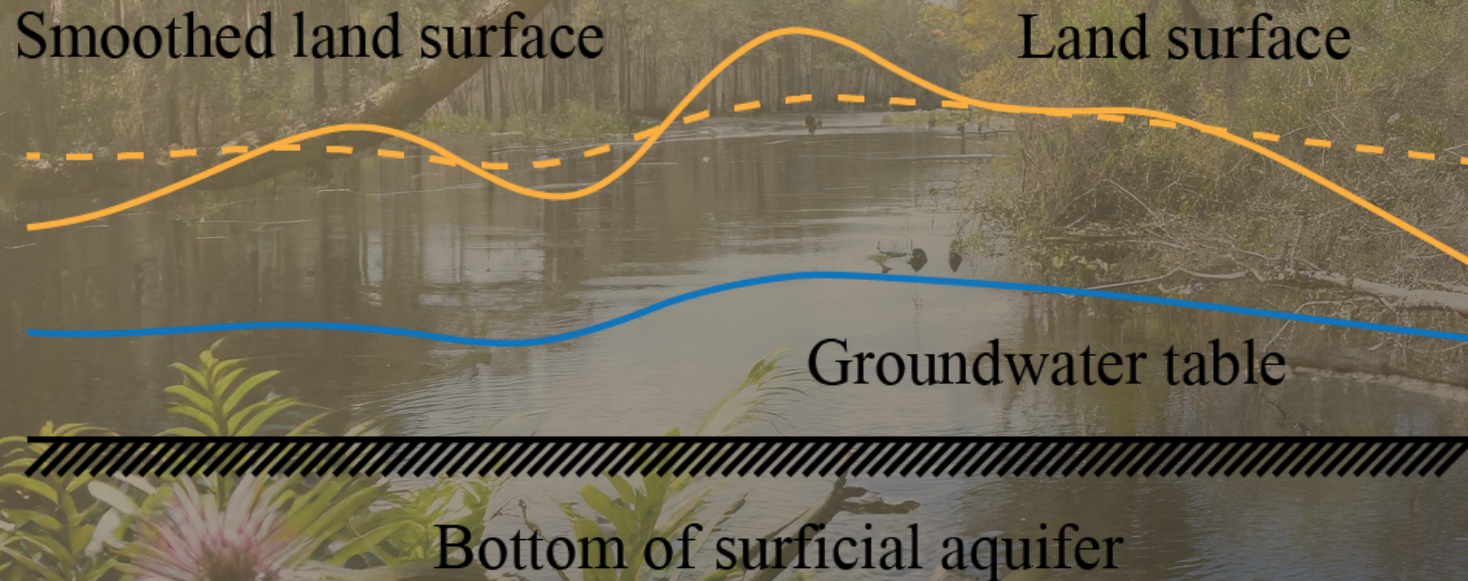
☐ Merge Waterbodies

Z-Factor



## 2.6 Procedures 4

### How the Groundwater Flow Module Work?



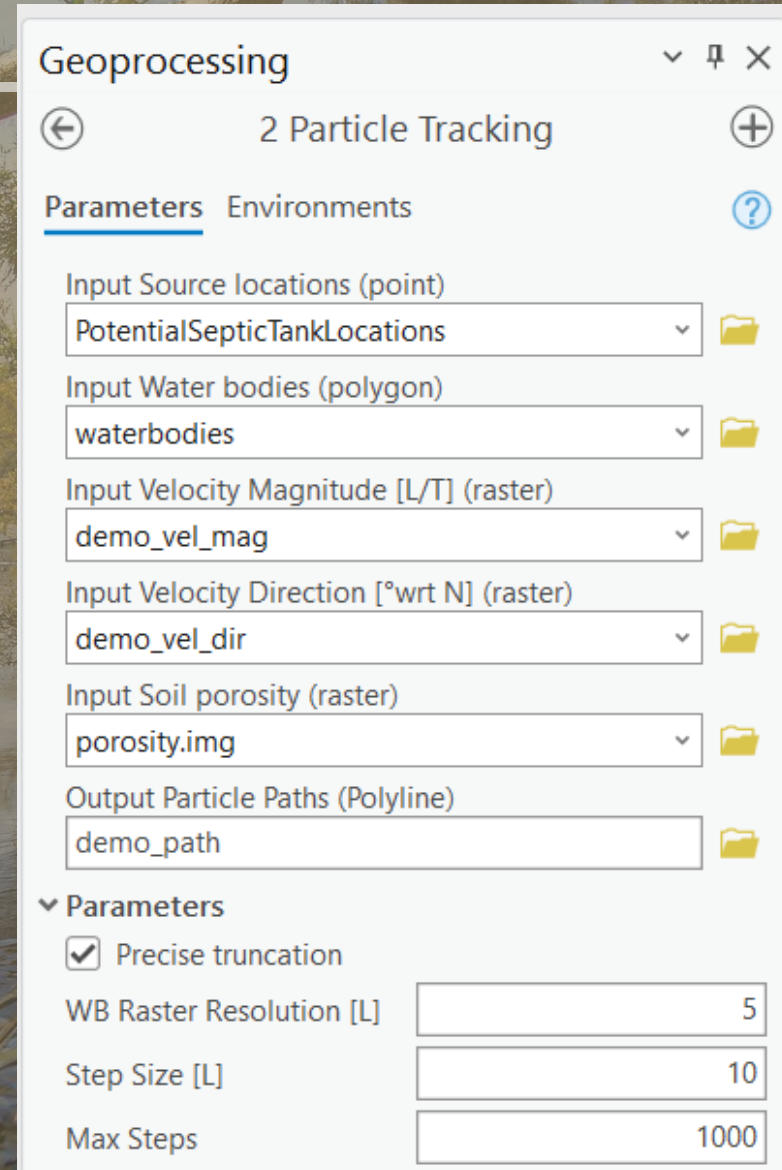
See Youtube video or technical manual for details



# 2.7 Procedures 5

## Particle Tracking Module

- Inputs
  - Velocity Magnitude and Direction
  - Source locations
  - Waterbodies
  - Porosity
- Outputs
  - Particle paths of potential contaminant travel routes



Geoprocessing

2 Particle Tracking

Parameters Environments

Input Source locations (point)  
PotentialSepticTankLocations

Input Water bodies (polygon)  
waterbodies

Input Velocity Magnitude [L/T] (raster)  
demo\_vel\_mag

Input Velocity Direction [°wrt N] (raster)  
demo\_vel\_dir

Input Soil porosity (raster)  
porosity.img

Output Particle Paths (Polyline)  
demo\_path

Parameters

☒ Precise truncation

WB Raster Resolution [L] 5

Step Size [L] 10

Max Steps 1000



# 2.7 Procedures 5

## Particle Tracking Module





# 2.8 Procedures 6

## VZMOD Module

- Ammonium and nitrate transport with sorption, nitrification, and denitrification in vadose zone

### Geoprocessing



3-VZMOD (Optional)



Parameters Environments



Single or multiple OSTDS

Single OSTDS

Soil types

Clay

Concentration of  $\text{NH}_4$  (mg/L)

60

Concentration of  $\text{NO}_3$  (mg/L)

1

Depth to water table (cm)

150

\* Output folder



> Hydraulic Params

> Nitrification Params

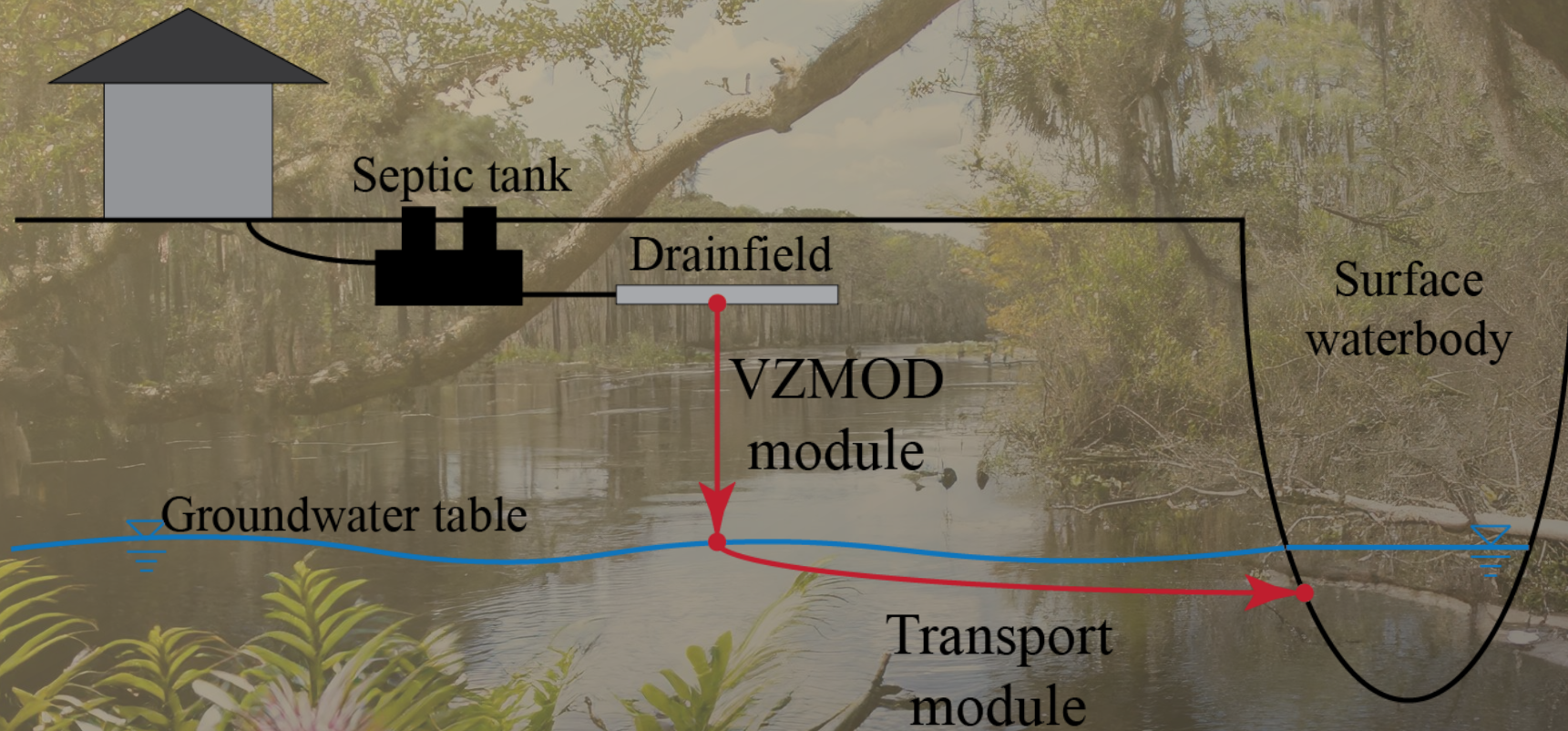
> Denitrification Params

> Adsorption Params

> Temperature and Transport Params



## 2.8 Procedures 6





# 2.9 Procedures 7

## Transport Module

- Predicting nitrate and ammonium plumes in groundwater
- Inputs
  - Source locations
  - Waterbodies
  - Particle paths
- Outputs
  - Plume raster of concentration distribution
  - Plume info shapefile

Geoprocessing

4 Transport

Parameters Environments

☐ Consideration of NH<sub>4</sub>

Input Source locations (point)  
PotentialSepticTankLocations.shp

Input Water bodies (polygon)  
waterbodies.shp

Input Particle Paths (polyline)  
demoPath.shp

Output Plumes of NO<sub>3</sub> (raster)  
demoNO3Plumes

Options

Solution type  
DomenicoRobbinsSSDecay2D

Plume warping control point spacing [Cells]  
48

Plume warping method  
Polyorder2

Threshold Concentration [M/L<sup>3</sup>]  
0.000001

Post processing  
Medium

Domenico Bdy.  
Specified Z

Parameters

Source Dimension Y [L]	12
Source Dimension Z [L]	1.5
Plume cell size [L]	0.8
NO <sub>3</sub> Concentration [M/L <sup>3</sup> ]	40
NO <sub>3</sub> Dispersivity α <sub>L</sub> [L]	2.113
NO <sub>3</sub> Dispersivity α <sub>TH</sub> [L]	0.234
Denitrification Decay Rate [1/T]	0.008
Volume Conversion Factor	1000

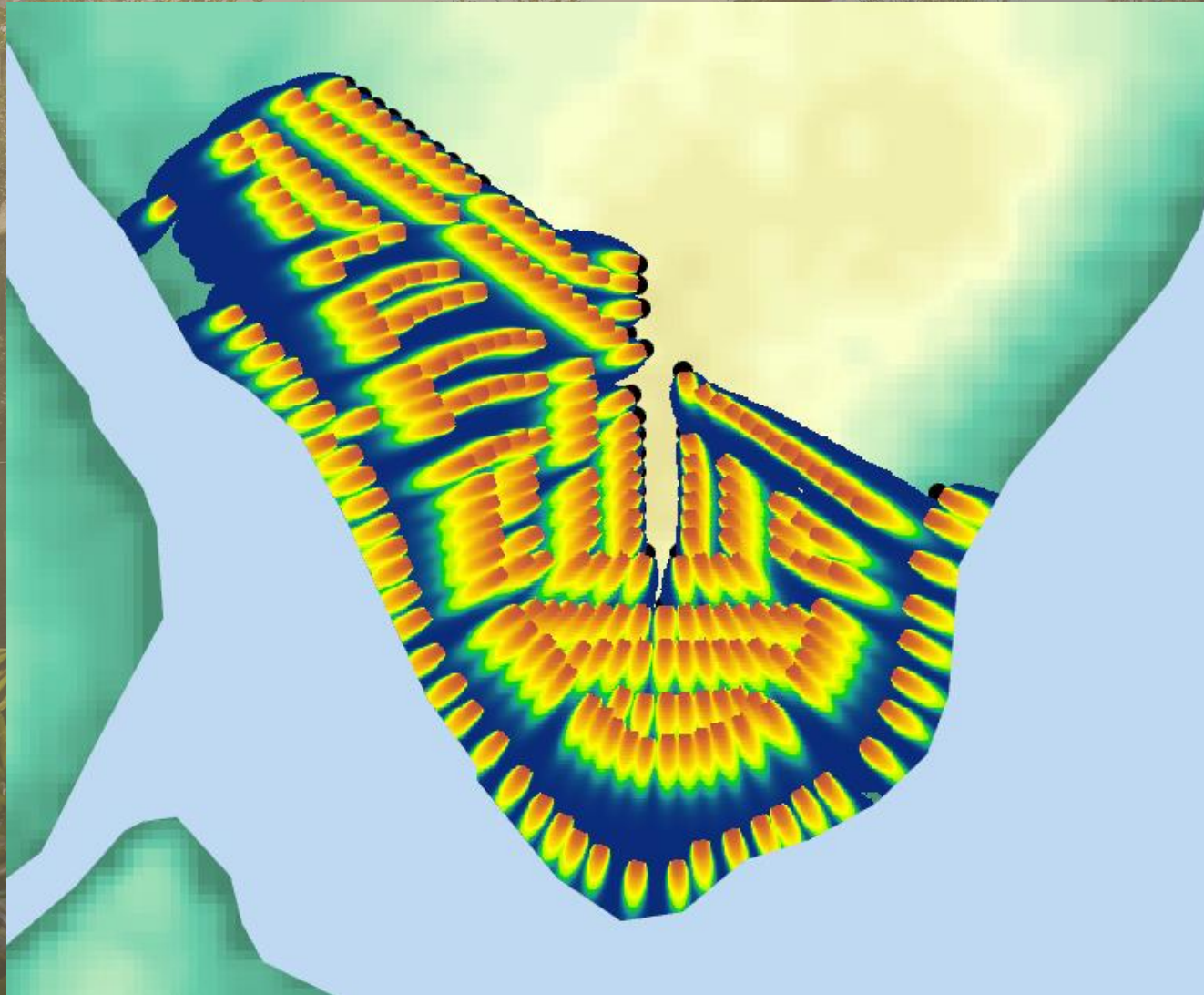
Run

Geoprocessing Catalog History



## 2.9 Procedures 7

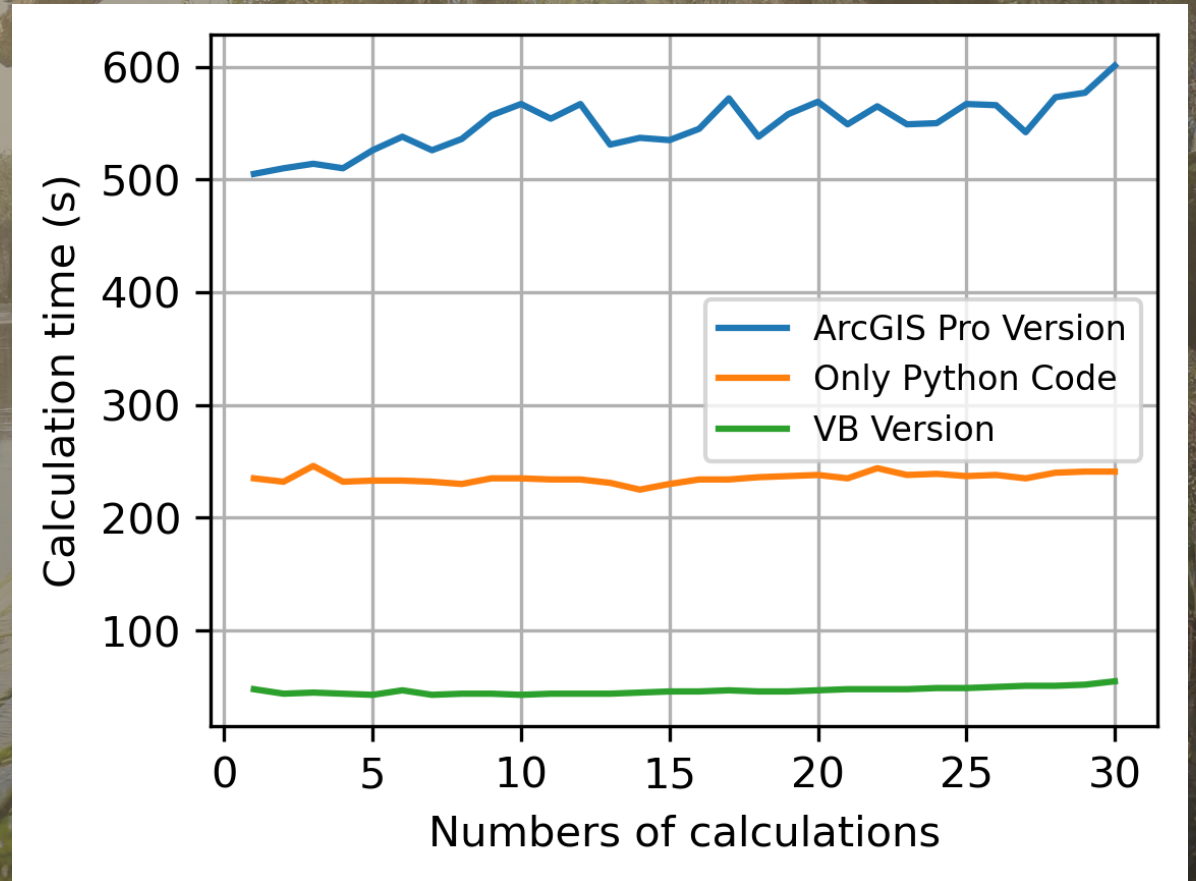
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## 2.9 Procedures 7

- The transport module has a long computation time. On the one hand, Python inherently runs slower than VB.NET. On the other hand, Python environment in ArcGIS Pro may be affected by the software, such as GUI interface and diagnostic monitoring in the software

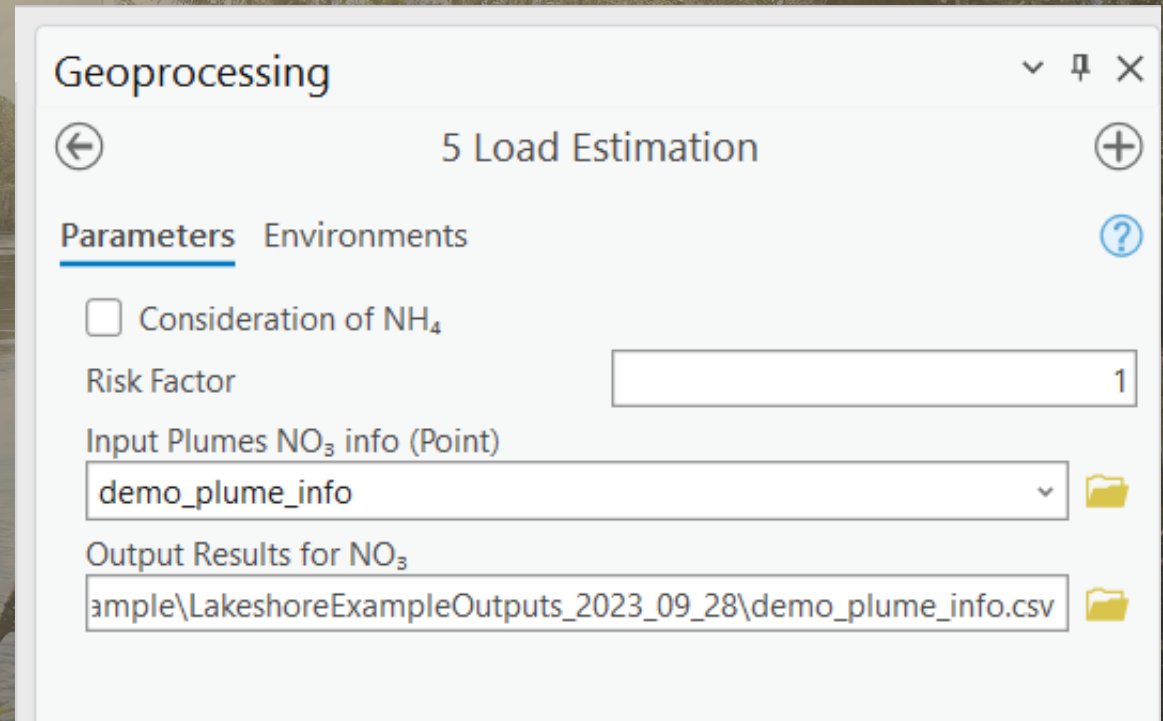




# 2.10 Procedures 8

## Load Estimation Module

- Calculates the removal rate of nitrate and ammonium via denitrification
- Inputs
  - Plume info shapefile from the 4-Transport module
- Outputs
  - CSV
  - Mass output load
  - Mass removal rate
  - Mass input load



The screenshot shows the 'Geoprocessing' window with the tool '5 Load Estimation' selected. The 'Parameters' tab is active, showing the following settings:

- ☐ Consideration of NH<sub>4</sub>
- Risk Factor: 1
- Input Plumes NO<sub>3</sub> info (Point): demo\_plume\_info
- Output Results for NO<sub>3</sub>: sample\LakeshoreExampleOutputs\_2023\_09\_28\demo\_plume\_info.csv



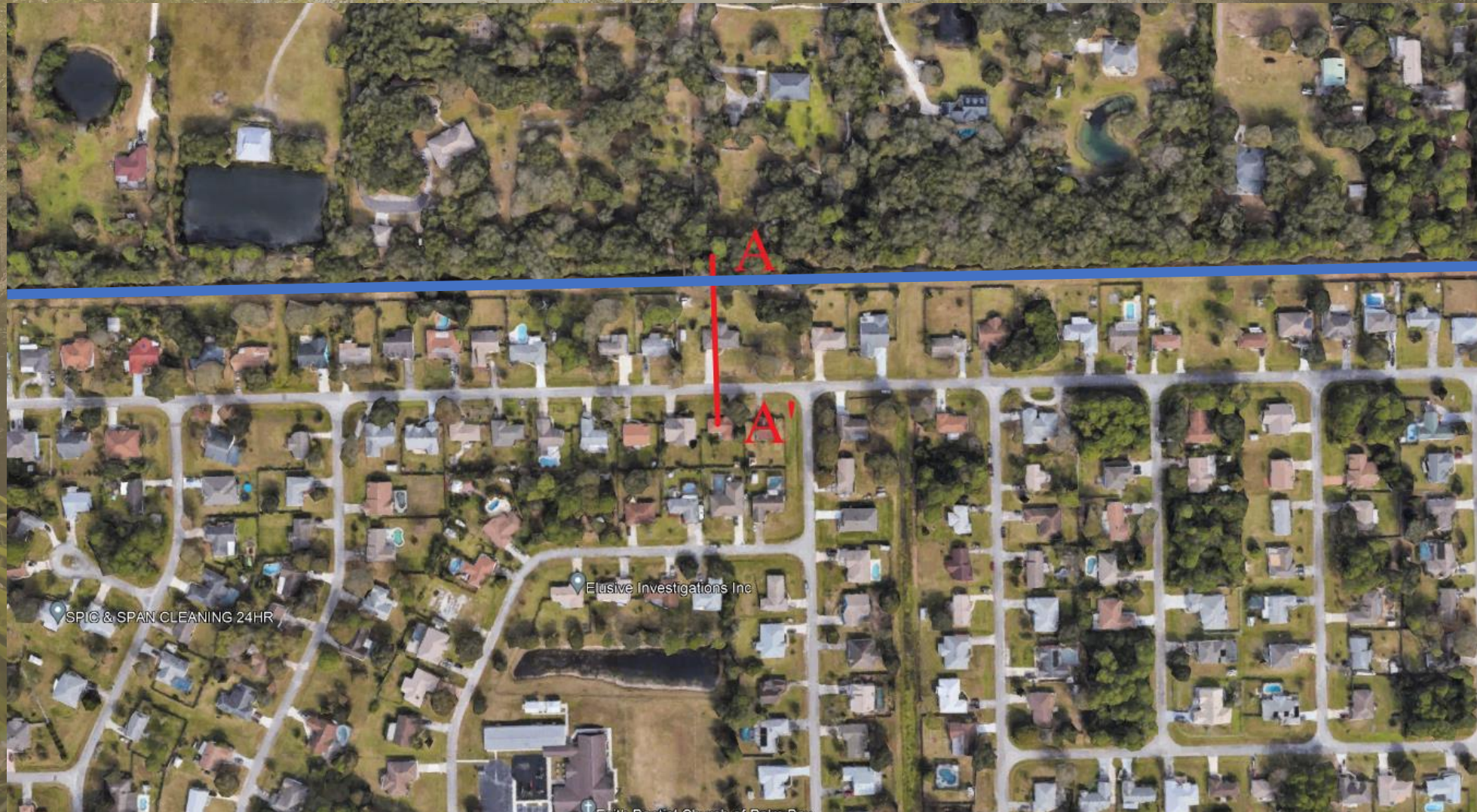


# 3. New Features

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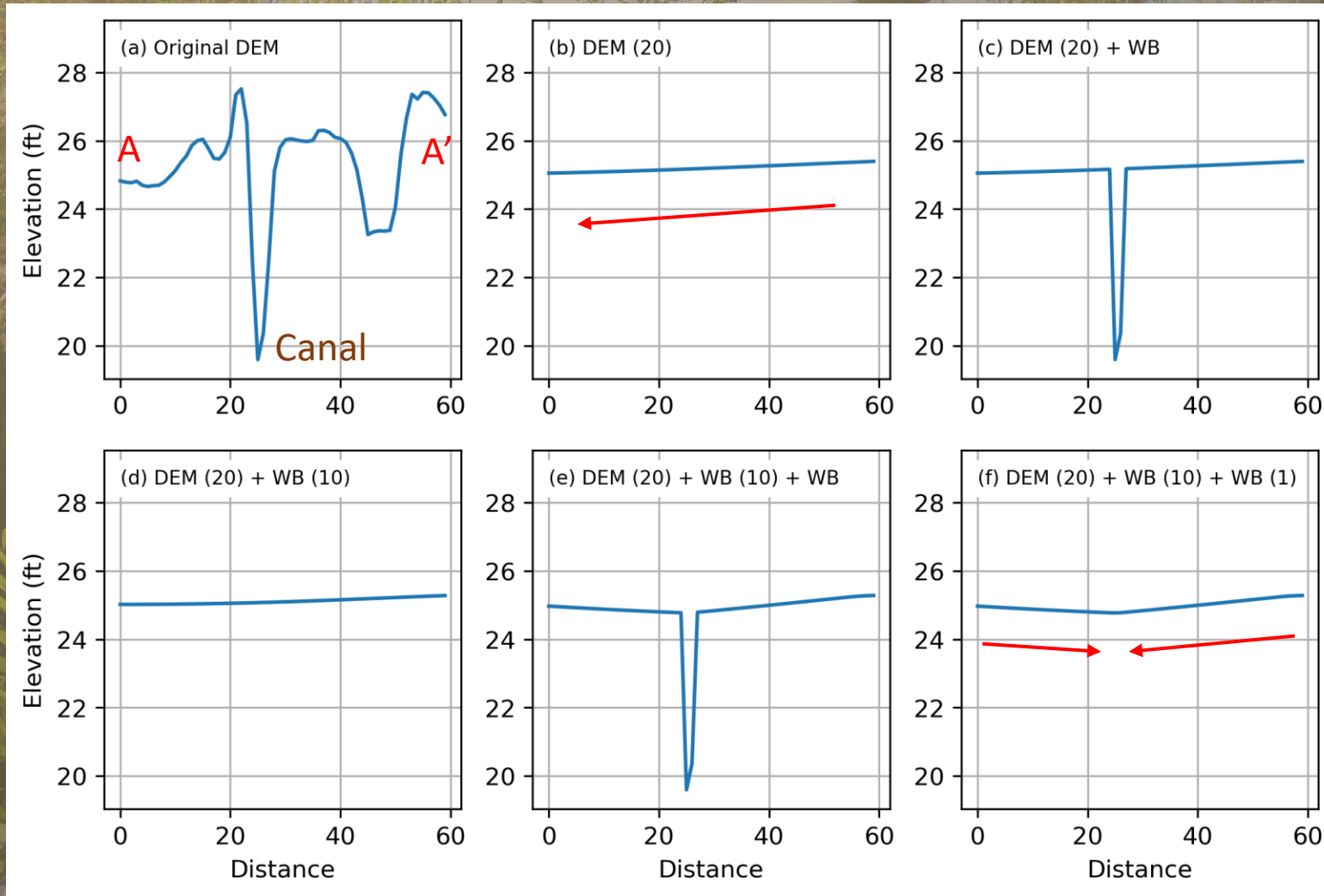


# 3.1 Merge Waterbodies



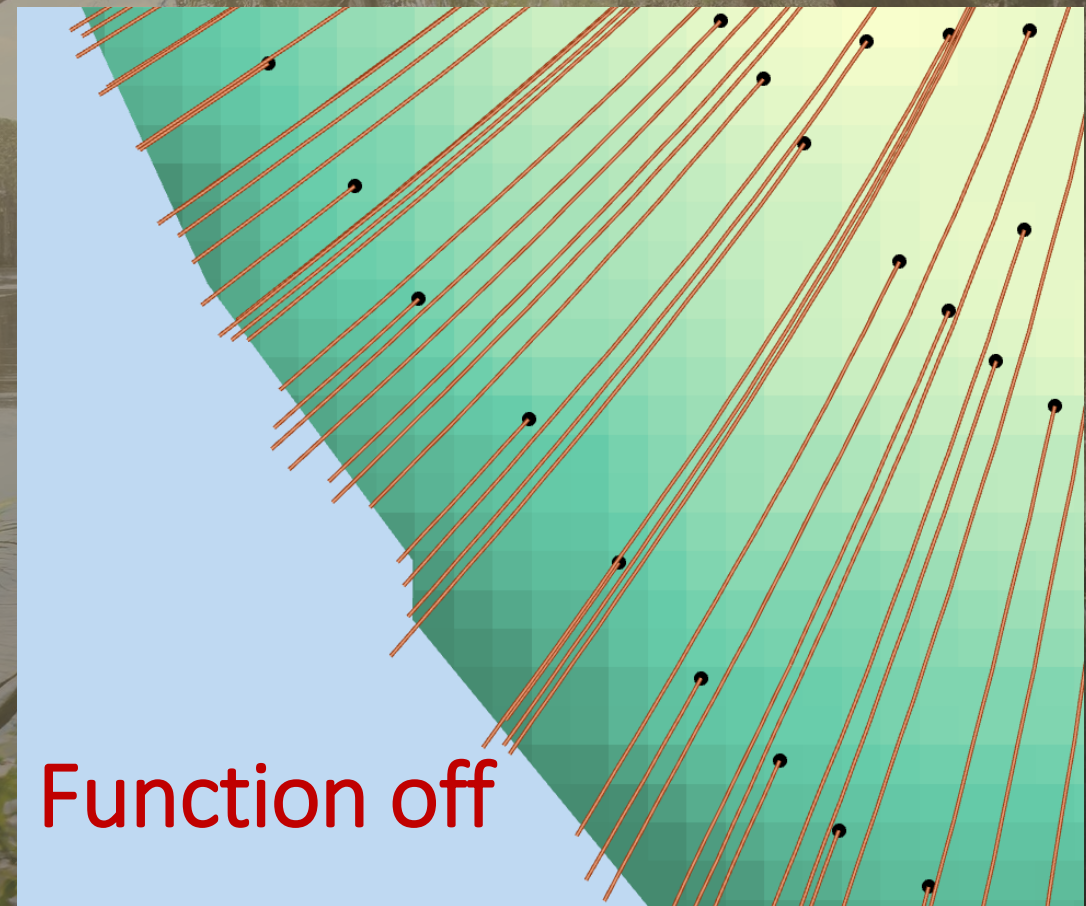
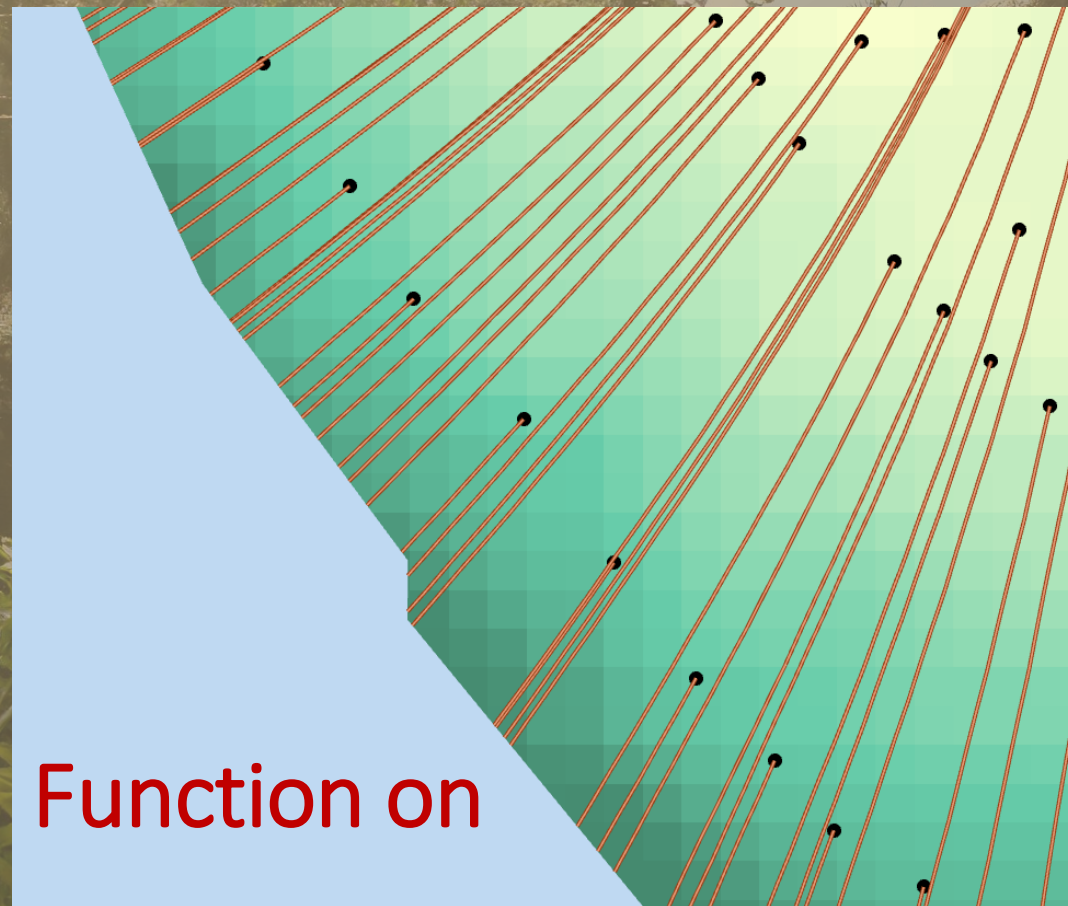


# 3.1 Merge Waterbodies



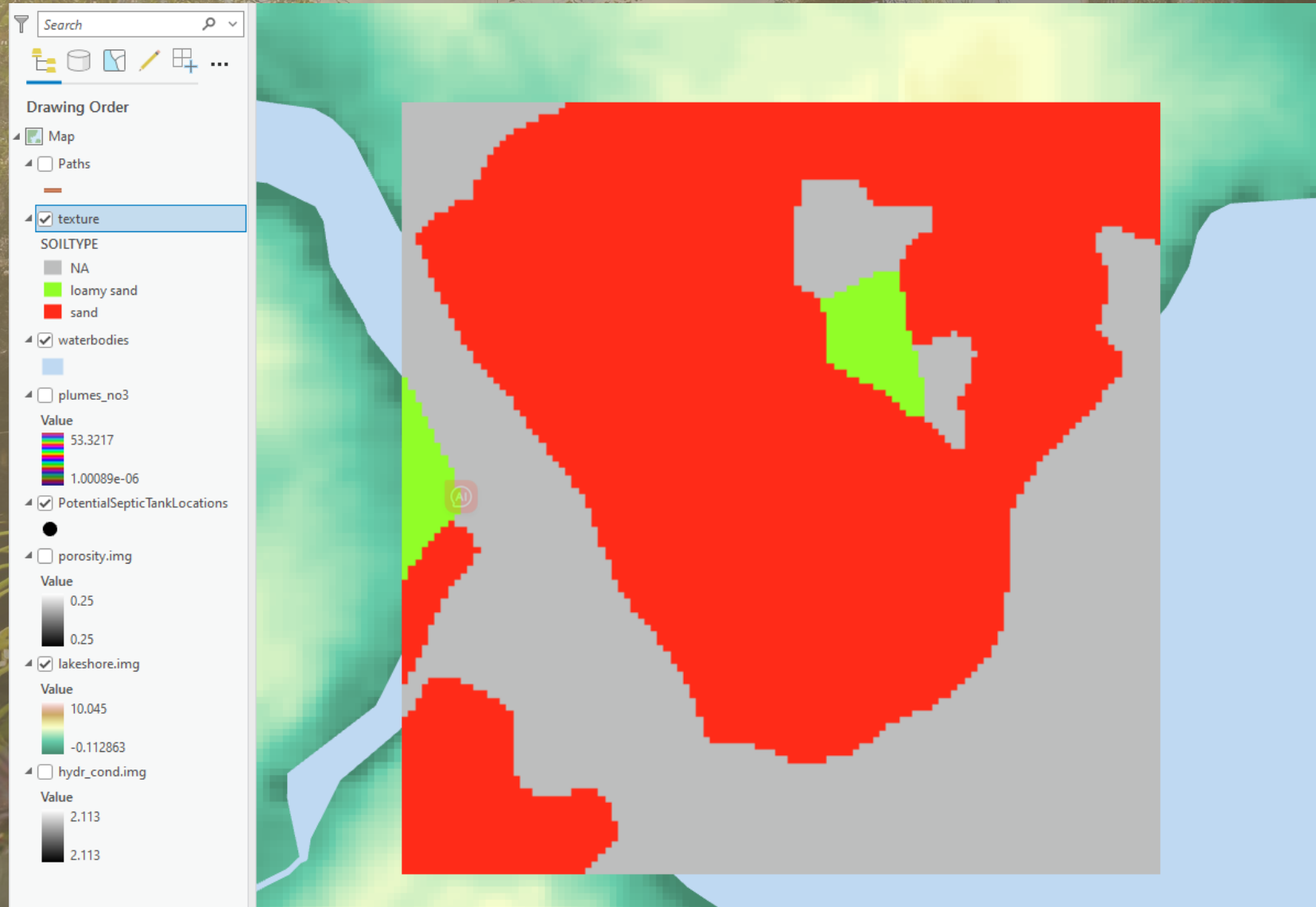


## 3.2 Flow Path Truncation





# 3.3 Preprocessing Module





A serene swampy landscape with a large tree branch arching over a body of water, surrounded by lush vegetation and Spanish moss. The scene is captured in a warm, slightly desaturated tone, giving it a vintage or artistic feel. The water is calm, reflecting the surrounding greenery and the sky. In the foreground, there are several large, green, spiky plants with purple flowers. The background shows a dense forest of trees, some with Spanish moss hanging from their branches. The overall atmosphere is peaceful and natural.

THANK YOU!