# Storm AI

## INTRODUCTION TO POTENTIAL APPLICATIONS OF AI FOR STORMWATER AND FLOOD MITIGATION

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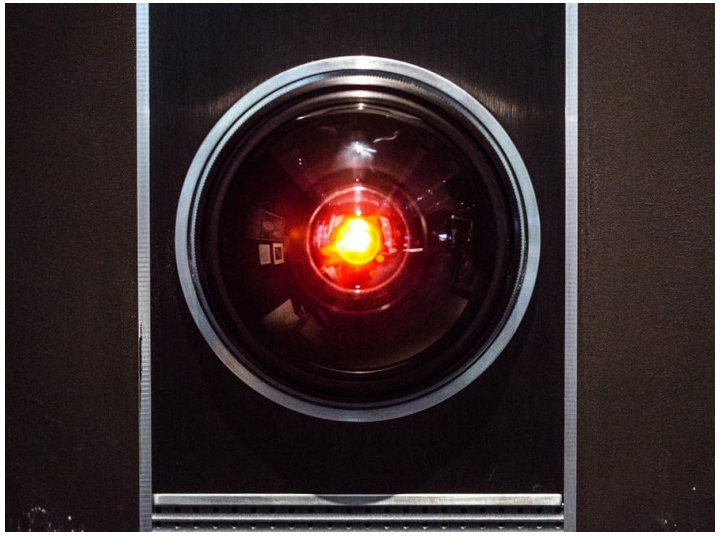
# Outline

- Introduction & Background
- AI Tools
- Potential Applications for Flood Hazard Management
- Practical “Now” Examples
- Closing Thoughts

# Introduction & Background

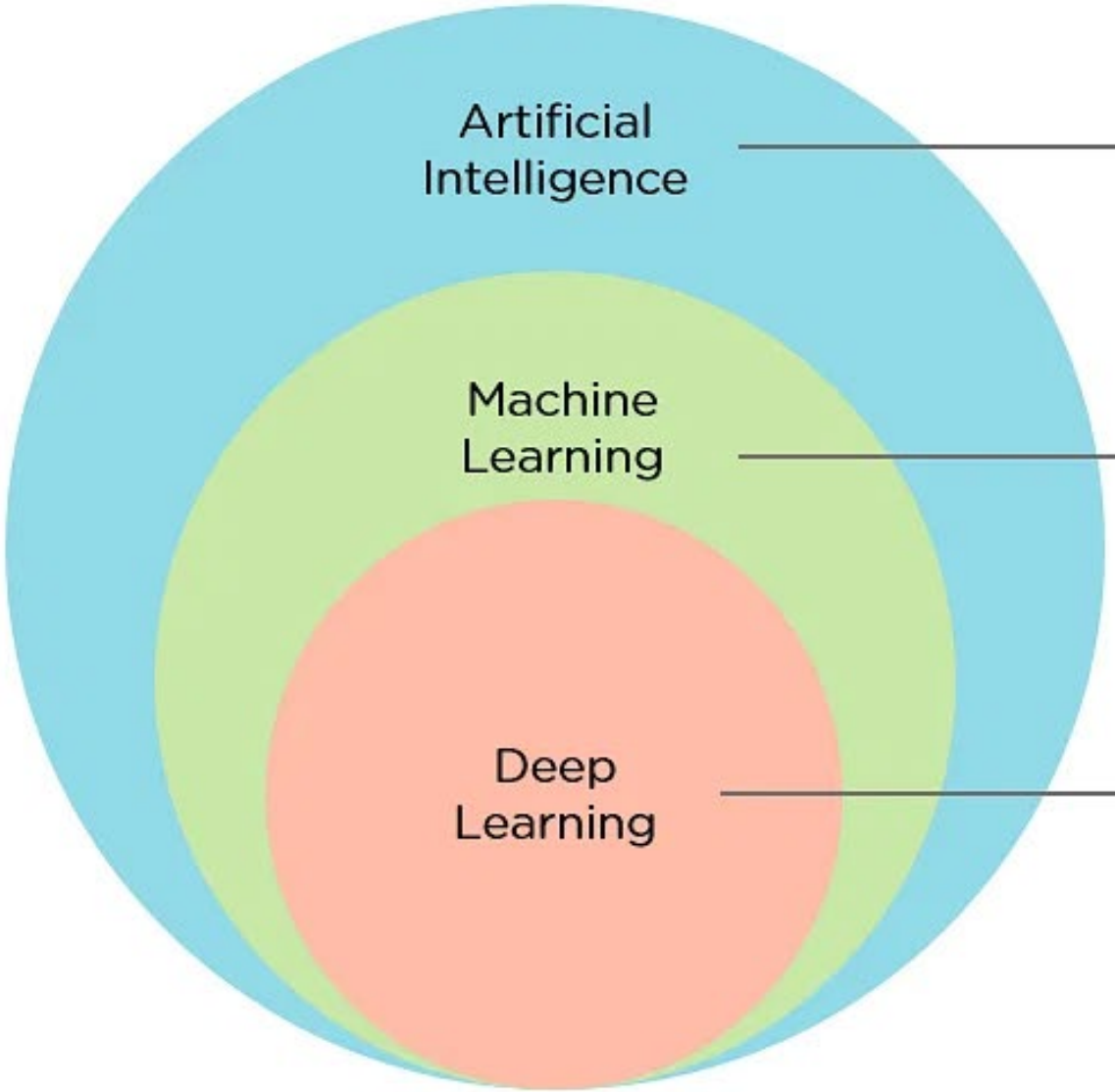
- "Modern" Artificial Intelligence (AI) has beginnings in 1950's
  - Term coined in 1956 (John McCarthy MIT)
  - Like other technology development has progressed exponentially in recent years

- AI broadly refers to machines that can perform human-like decision making with algorithms
  - Programmed to learn the task rather than just perform it
  - Different levels of sophistication and terminology



*I'm sorry, Dave, I'm afraid I can't do that….*

HAL 9000 – 2001: A Space Odyssey (1968)




Ability of a machine to imitate intelligent human behavior

Application of AI that allows a system to automatically learn and improve from experience

Application of Machine Learning that uses complex algorithms and deep neural nets to train a model

# Modern AI Timeline


## 1956
*Dartmouth Conference – Term AI "Introduced*

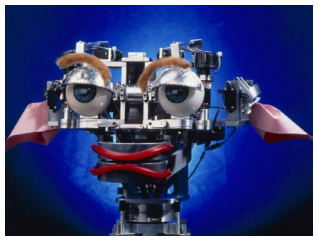

## 1980's
*Deep Learning Algorithm Advancements*

Hey Siri

## 2010's
*Voice & Face Recognition (Siri 2008, Alexa & FB DeepFace 2014)*

## 1964
*ELIZA – first chatbot*


## 1990's
*Robots (DeepBlue, Kismet)*



## 2020's
*Public AI (ChatGPT 2022, Copilot, Gemeni*

ChatGPT

Gemini

# General Benefits of AI

- Automation of Repetitive Tasks
- Faster and More Informed Decision Making
- Reduce Human Error
- Full-Time Availability
- Complex Problem Solving
- Rapid Prediction
- Performs Risky Operations

# AI Tools

- AI may be a little difficult to wrap arms around – best way to get a sense for it is to give it a try

- There are a number of web-based AI platforms/tools that are available that can be broadly grouped:
  - ***Chatbots*** – enter text question and receive AI generated text responses
  - ***Multi-Media*** – automatically edit and/or generate images, videos, music
  - ***Content Creation*** – focused content creators (coding, blogs, etc.)
  - ***Productivity/Assistants*** – provide strategies/work-flows to perform tasks

- AI continues to evolve quickly so leverage web resources (Google, YouTube, etc.) to keep up

# Example “Out of the Box” AI Tools

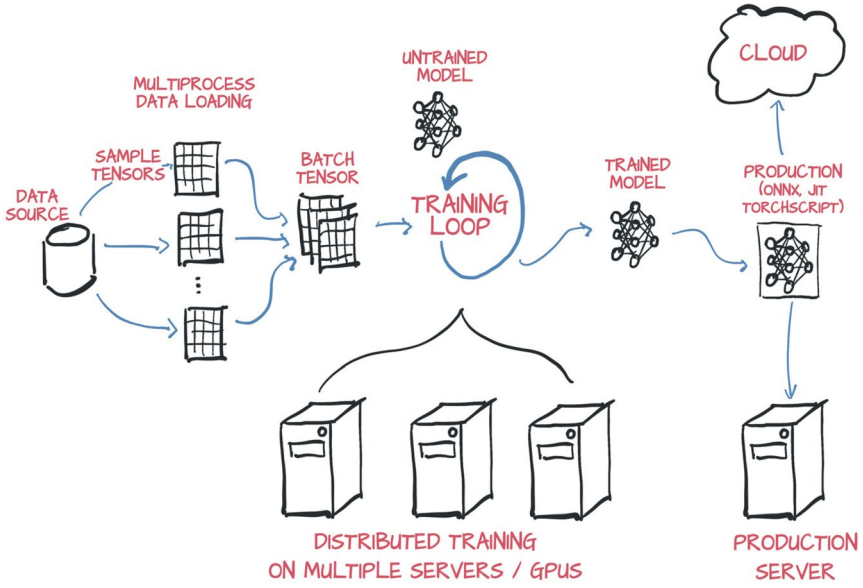
| | |
|---|---|
| Chatbots | • ChatGPT, MS Copilot, Google Gemeni |
| Multi-Media | • DALL-E, Midjourney, Fotor |
| Content Creation | • Grammarly, Jasper, GitHub copilot |
| Productivity/Assistants | • AI Agent, Fireflies, Krisp |

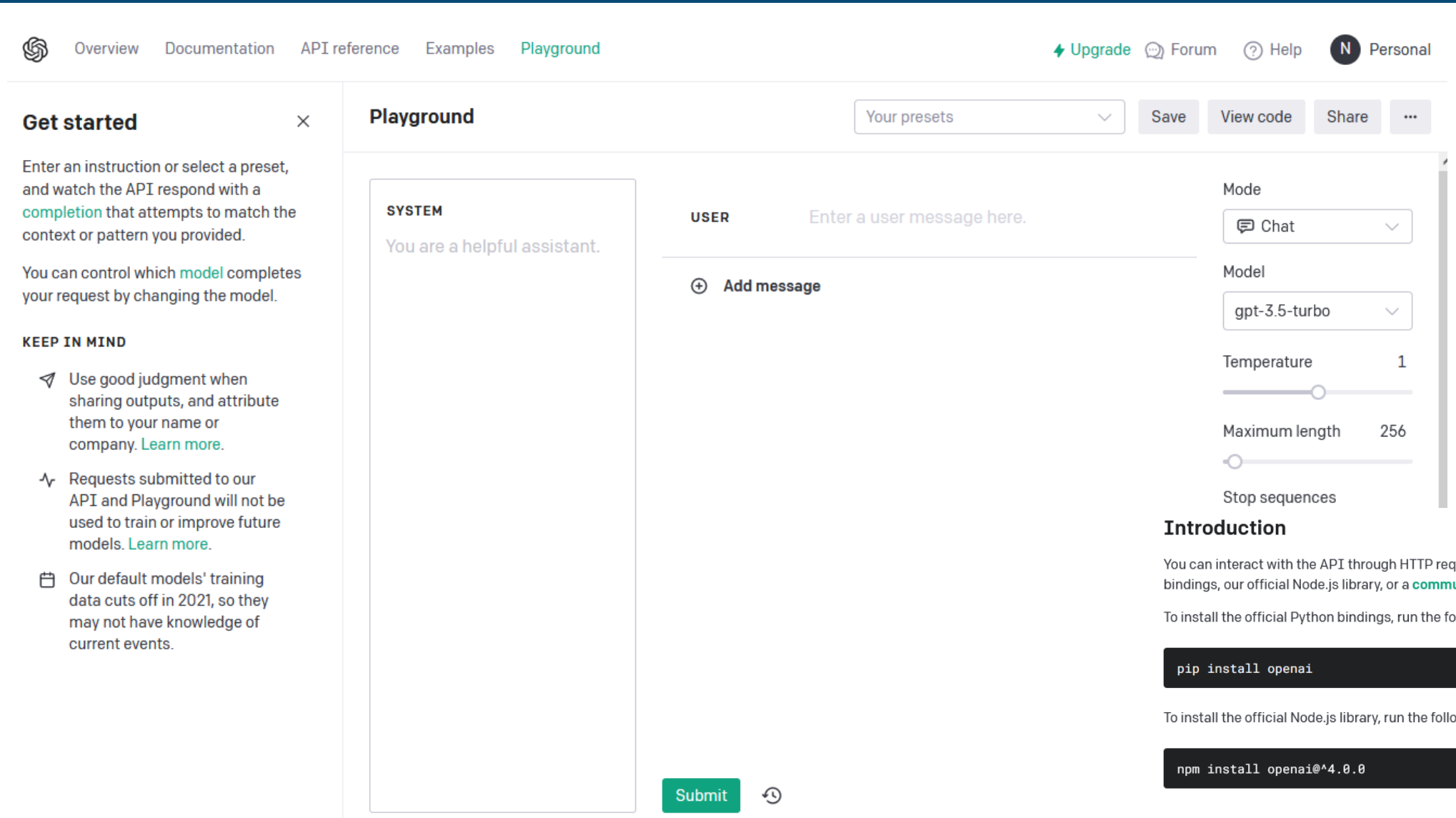
# Extending and Customizing AI

- Out-of-the-Box platforms and tools are very powerful and reasonably user friendly as-is

- However, one has more options to extend/customize and create own tools

- Popular resources:
  - OpenAI Playground
  - Scikit-Learn
  - PyTorch

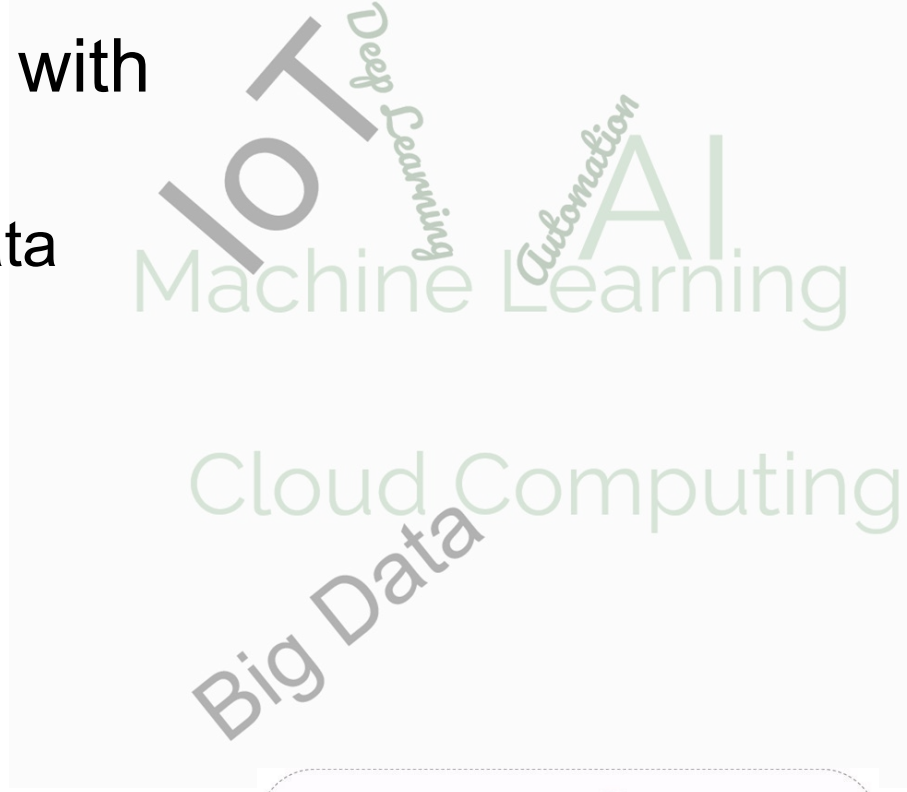





*OpenAI Playground*

# Potential Applications for Flood Mitigation

- Number of data/technology advancements with significant impact on SWM:
  - Exponentially more consumable large-area data
    - Hi-res topographic (lidar)
    - Precipitation and other climate data (e.g. MRMS, HRRR)
  - Low-cost sensors for localized
  - 2-D modeling for masses
  - Computing power (e.g. parallel, cloud)
- IoT (Internet-of-Things) has been trending
  - Uses data rules based on data fed from connected technologies to create alerts or take actions
  - SC/NC examples (e.g. Impact, RARR, FIMAN, BridgeWatch)



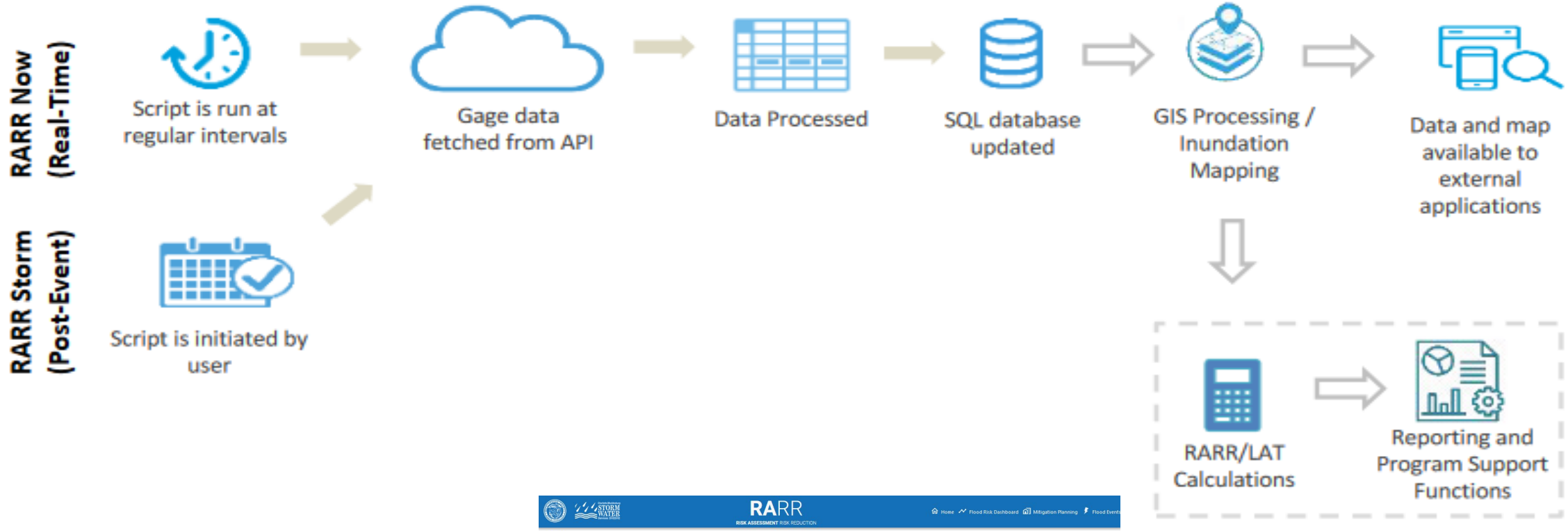

# Potential Applications for Stormwater Management

- AI has ability to take IoT to next level, as well as play a role in many other aspects

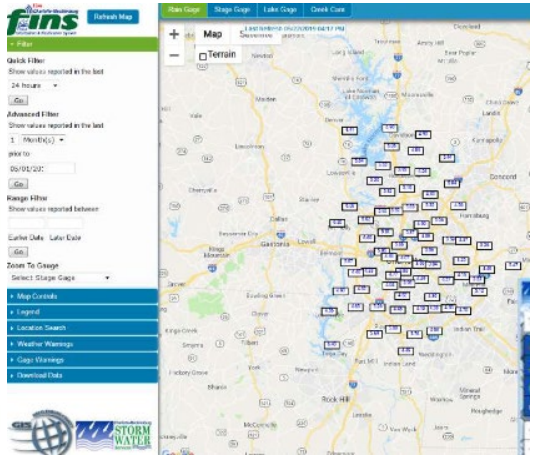
<u>SWM/Flood Mitigation Opportunities</u>

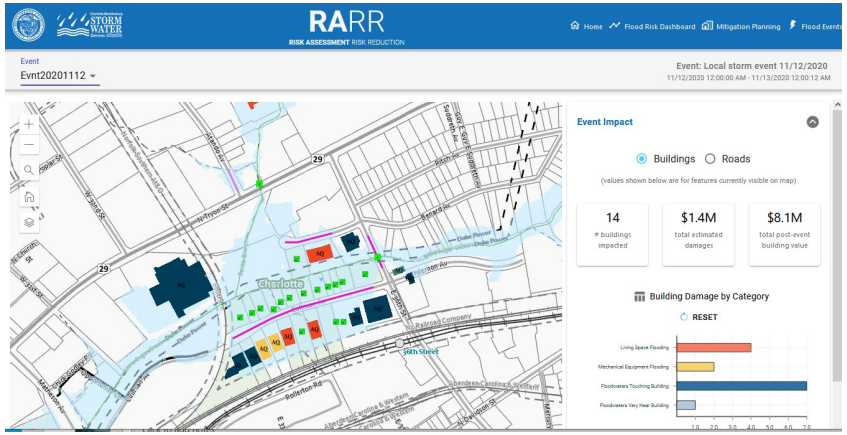
- Weather/Flood forecasting
- Improved modeling – consideration of more factors and fewer iterations
- Enhanced stakeholder engagement and decision making
- Leverage tools now to enhance current capabilities and expedite existing workflows

# *Mecklenburg County RARR*








# Practical “Now” Examples

- So much talk and info out there on AI – it all sounds great, but how do start?

- Jump right in with free/easier tools:
  - Bing Chat and Image Creator
  - ChatGPT / OpenAI Playground (free sign-up)

- One BIG note – since these tools are ‘generative’ you usually get different response even if input is identical
  - Use regenerate to get options!
  - Also, typically your previous creations/searches are saved

# Example #1: Create EPA-SWMM Model Input File

## Try 1

TE

create epa swmm 5 model with one catchment

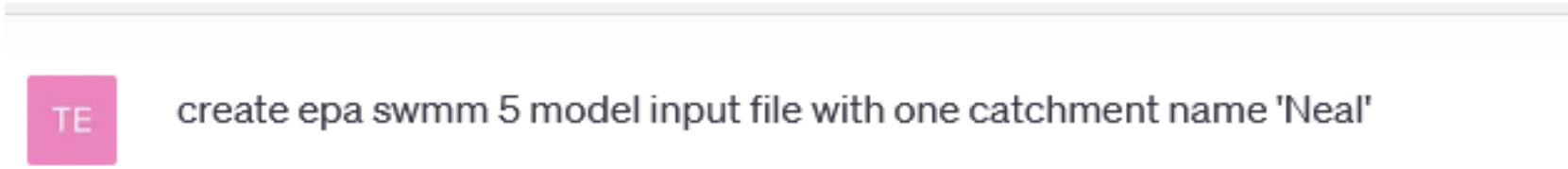
Sure, here's an example of how to create an EPA SWMM 5 model with one catchment:

1. Open EPA SWMM 5 software and create a new project.
2. In the "Project" tab, click "Add Subcatchment" to add a new catchment.
3. Enter a name for the catchment and specify the catchment parameters, such as the area, slope, and imperviousness.
4. In the "Climate" tab, specify the rainfall data for the catchment. You can either use the default rainfall data provided by the software or import your own data.
5. In the "Hydrology" tab, select a hydrologic method to model the runoff from the catchment. You can choose from various methods such as SCS, Green-Ampt, and Horton.
6. In the "Quality" tab, specify any pollutant parameters for the catchment, such as the buildup and washoff coefficients.
7. In the "Outfall" tab, specify the outfall node for the catchment. This is where the runoff from the catchment will be discharged.
8. In the "Simulation" tab, specify the simulation duration and time step, as well as any other simulation parameters.
9. Save the model and run the simulation to generate the results.

Note that this is just a basic example of how to create an EPA SWMM 5 model with one catchment. Depending on your specific project requirements, you may need to adjust the parameters and settings accordingly.

# Example #1:  Create EPA-SWMM Model Input File

- Helpful process list, but not all that much different from Google search
- Second try, with slightly different language



Certainly! Here's an example input file for an EPA SWMM 5 model with one catchment named "Neal":

```
[OPTIONS]
FLOW_UNITS           CFS
INFILTRATION         HORTON
FLOW_ROUTING         DYNWAVE
START_DATE           01/01/2000
START_TIME           00:00:00
REPORT_START_DATE    01/01/2000
REPORT_START_TIME    00:00:00
END_DATE             01/01/2000
END_TIME             01:00:00
REPORT_END_DATE      01/01/2000
REPORT_END_TIME      01:00:00
SWEEP_START          01/01/2000
SWEEP_END            01/01/2000
DRY_DAYS             0
REPORT_STEP          00:15:00
WET_STEP             00:05:00
DRY_STEP             01:00:00
ROUTING_STEP         00:01:00
LENGTHENING_STEP     00:05:00
MIN_SURFAREA         12.566
NORMAL_FLOW_LIMITED  BOTH
SKIP_STEADY_STATE    NO
FORCE_MAIN_EQUATION  H-W
LINK_OFFSETS         DEPTH

[EVAPORATION]
;type    parameters
CONSTANT 0.0

[RAINGAGES]
;              format     interval   SCF    source
;              --------   ---------  ----   ------
Rain_Gage_1    INTENSITY  0:15       1.0    TIMESERIES Rain_Data

[SUBCATCHMENTS]
;                                                    Total    Pcnt.
;Name           Raingage         Outlet           Area     Imperv   Width
;-----------------------------------------------------------------------
Neal            Rain_Gage_1      Outfall          10       50       100

[SUBAREAS]
;                                                     Total    Pcnt.    Pcnt.
;Name           Raingage         Outlet           Area     Imperv   Width
;-----------------------------------------------------------------------
Neal            Rain_Gage_1      Neal             10       50       100

[INFILTRATION]
;Subcatchment     Curve Number     Hydraulic Conductivity     Initial Moistu
;-----------------------------------------------------------------------
Neal             70               0.5                        0.1

[OUTFALLS]
;Name           Elevation  Type       Stage Data       Gated    Route To
;-----------------------------------------------------------------------
Outfall         0.0        FREE       0:00       0.0   NO       Lagoon

[TIMESERIES]
;              Name     Date       Time       Value
;              ----     ----       ----       -----
Rain_Data      Jan-01   00:00:00   0.00
               Jan-01   00:15:00   0.00
               Jan-01   00:30:00   0.00
               Jan-01   00:45:00   0.00
               Jan-01   01:00:00   0.00

[REPORT]
;Reporting Options
INPUT      NO
CONTROLS   NO
SUBCATCHMENTS ALL
NODES      NONE
LINKS      NONE

[MAP]
DIMENSIONS  5000.0 5000.0
Units       FEET
```

*ChatGPT Generated SWMM Input File*

# What Just Happened?

- Created a formatted text object that can be simply copy/pasted into texted editor and saved as .inp file that can be opened in EPA-SWMM

- I only gave it a catchment name – it figured out all the other essential parameters and actually made “reasonable” assumptions

# Example #2: Develop O&M Plan for Asset Management

TE

develop operations and maintenance plan for asset management

Developing an operations and maintenance plan for asset management involves creating a comprehensive strategy to effectively manage and maintain assets throughout their lifecycle. Here's a step-by-step guide to help you develop an operations and maintenance plan for asset management:

1. Define Objectives and Scope: Clearly define the objectives and scope of your asset management plan. Identify the types of assets you will be managing and the goals you want to achieve. Consider factors such as asset performance, reliability, cost optimization, and compliance.
2. Asset Inventory and Classification: Create an inventory of all the assets you will be managing. Classify assets based on their criticality, lifespan, maintenance requirements, and other relevant factors. This classification will help prioritize maintenance activities.
3. Asset Lifecycle Analysis: Understand the lifecycle of each asset, including acquisition, installation, operation, maintenance, and disposal. Identify the key milestones, activities, and responsibilities associated with each stage.
4. Maintenance Strategies: Determine the appropriate maintenance strategies for each asset based on its criticality and lifecycle stage. Common strategies include reactive maintenance (fixing assets after a failure), preventive maintenance (scheduled inspections and maintenance), predictive maintenance (using data and analytics to predict failures), and condition-based maintenance (monitoring asset condition and performing maintenance as needed).
5. Maintenance Plans: Develop detailed maintenance plans for each asset category and maintenance strategy. Specify the frequency, tasks, resources, and procedures required for maintenance activities. Consider factors such as maintenance schedules, spare parts management, contractor management, and documentation requirements.
6. Maintenance Procedures and Work Instructions: Document step-by-step procedures and work instructions for each maintenance task. Include safety precautions, tools and equipment needed, troubleshooting guides, and any specific requirements or best practices.
7. Performance Metrics and KPIs: Define key performance indicators (KPIs) to measure the

Regenerate

# Example #3: Write a Script to Extract WSEs from HEC-RAS Model to Excel

TE

write python script to extract water surface elevations from hec-ras model to excel

To extract water surface elevations from an HEC-RAS model and save them to an Excel file, you can use Python with the `pywin32` library to automate HEC-RAS, and the `openpyxl` library to work with Excel files. Before running the script, make sure you have HEC-RAS installed and a HEC-RAS project ready.

Here's a Python script to get you started:

Make sure to replace the `hec_ras_project_file` and `excel_output_file` paths with your actual file paths. Also, specify the desired river reach and river station you want to extract water surface elevations for.

You'll need to install the `pywin32` and `openpyxl` libraries if you haven't already:

bash Copy code

```
pip install pywin32 openpyxl
```

Please note that this script assumes that HEC-RAS is installed on your system and configured properly. Also, it's important to use the correct reach and station names as they appear in your HEC-RAS project.

```
import win32com.client
import openpyxl

# Replace these paths with your HEC-RAS project file and Excel output file paths
hec_ras_project_file = "C:\\Path\\To\\Your\\HEC-RAS\\Project.ras"
excel_output_file = "C:\\Path\\To\\Your\\Output\\WaterSurfaceElevations.xlsx"

# Create a connection to HEC-RAS
ras = win32com.client.Dispatch("RAS511.HECRASController")

# Load the HEC-RAS project file
ras.Project_Open(hec_ras_project_file)

# Define the river reach and river station where you want to extract water surface elevations
river_reach = "YourRiverReach"
river_station = "YourRiverStation"

# Get the water surface elevations for the specified river reach and station
water_surface_elevations = ras.Output_GetWaterSurfaceElevations(river_reach, river_station)

# Create a new Excel workbook and worksheet
wb = openpyxl.Workbook()
ws = wb.active

# Write the headers to the Excel worksheet
ws['A1'] = 'River Station'
ws['B1'] = 'Water Surface Elevation (meters)'

# Write the water surface elevations to the Excel worksheet
for i, (station, elevation) in enumerate(water_surface_elevations):
    ws.cell(row=i + 2, column=1, value=station)
    ws.cell(row=i + 2, column=2, value=elevation)

# Save the Excel workbook to the specified file
wb.save(excel_output_file)

# Close the HEC-RAS project
ras.Project_Close()
```

*ChatGPT Generated Python Script*

TE

Extract water surface elevation from HEC-RAS model to exce
RASController VBA

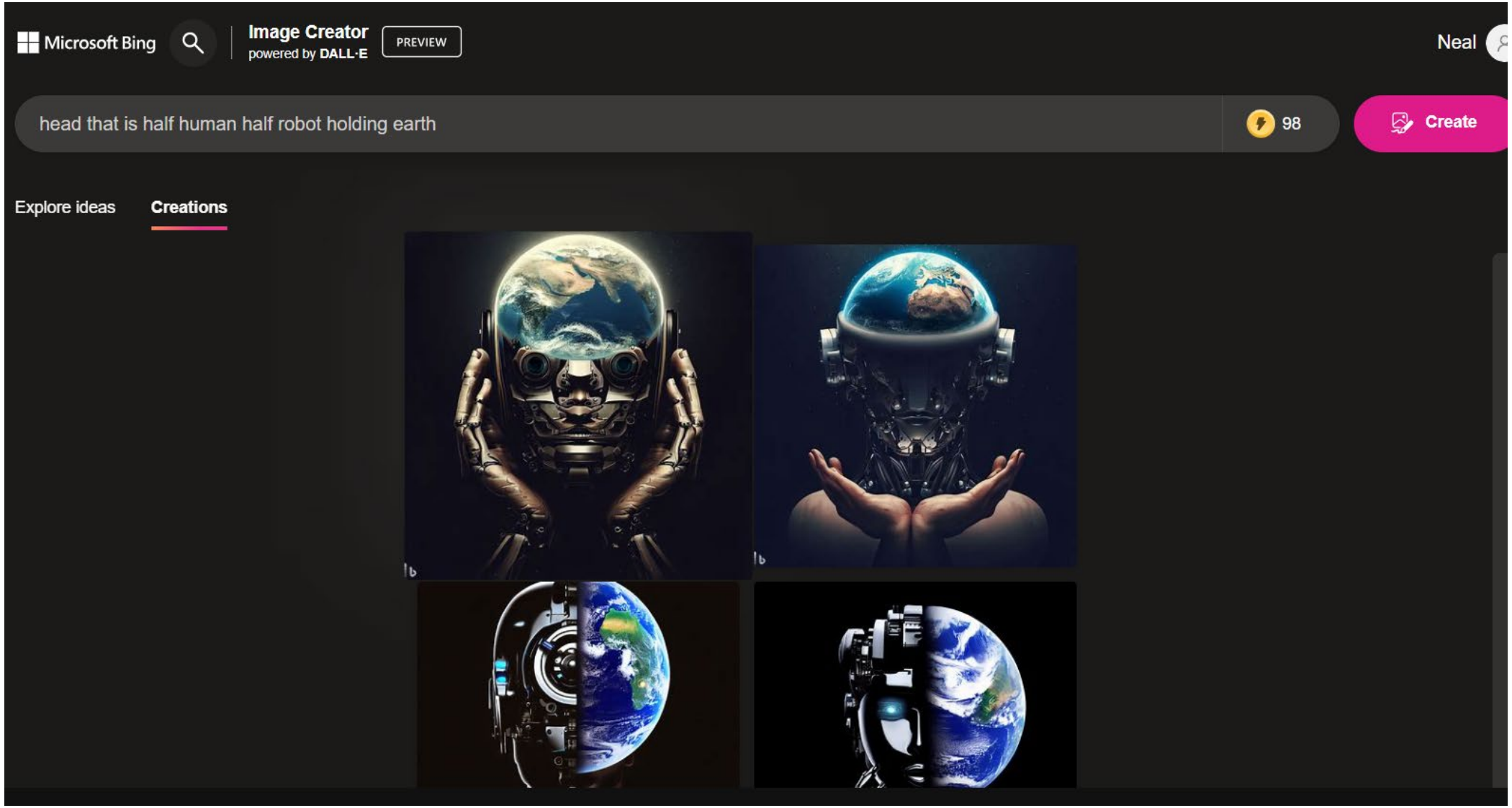
‹ 2 / 2 ›

To extract water surface elevation data from an HEC-RAS mo
spreadsheet using RASController and VBA, you can follow th

```
Sub ExportWSEtoExcel()
    ' Create a new instance of RASController
    Dim ras As New RASController

    ' Load the HEC-RAS model
    ras.Project_Open ("C:\Path\to\your\model.prj")

    ' Get the number of river reaches in the model
    Dim numReaches As Integer
    numReaches = ras.Geometry_GetRiverReachCount

    ' Create a new Excel workbook and worksheet
    Dim wb As Workbook
    Set wb = Workbooks.Add
    Dim ws As Worksheet
    Set ws = wb.Sheets(1)

    ' Set the headers in the worksheet
    ws.Cells(1, 1).Value = "River Reach"
    ws.Cells(1, 2).Value = "Station"
    ws.Cells(1, 3).Value = "Water Surface Elevation"

    ' Loop through each river reach
    Dim reachIndex As Integer
    For reachIndex = 1 To numReaches
        ' Get the river reach name
        Dim reachName As String
        reachName = ras.Geometry_GetRiverReachName(reachIndex)

        ' Get the number of cross sections in the river reach
        Dim numXS As Integer
        numXS = ras.Geometry_GetCrossSectionCount(reachIndex)

        ' Loop through each cross section
        Dim xsIndex As Integer
        For xsIndex = 1 To numXS
            ' Get the station and water surface elevation for the cross section
            Dim station As Double
            Dim wse As Double
            station = ras.Geometry_GetCrossSectionStation(reachIndex, xsIndex)
            wse = ras.Results_GetStage(reachIndex, xsIndex)

            ' Write the data to the worksheet
            Dim row As Integer
            row = row + 1
            ws.Cells(row, 1).Value = reachName
            ws.Cells(row, 2).Value = station
```

*ChatGPT Generated VBA Script*

# Example #4:  Create a Graphic for Presentation



# Closing Thoughts

- AI is here - In just the last year AI has moved from more of an abstract concept to something much more accessible and tangible

- AI offers incredible possibilities and will undoubtably continue to become integrated more into our daily lives

- Give it a try, see how it can help you!

# Closing Thoughts

- However, this does not mean we need to try to AI everything. Don't AI just for the sake of AI

Concerns with AI

- Dependency – loss of the ability to think effectively for ourselves
- Loss of original creativity
- Legal concerns (ownership, liability, etc.)
- Skill loss
- Ethical concern
- Loss of humanity – emotion, empathy, etc.

“ We need to focus on getting the ‘I’ right, before worrying too much about the ‘A’ ”

*David Key, PE, CFM*

# Questions

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