



# Geospatial Dam Break, Rapid EAP, Consequences and Hazards GIS Toolkit

## User Manual

Version 2.0

*October 2013*



FEMA

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# **GeoDam-BREACH**

**GIS Tools for Support of Simplified Dam Break Modeling,  
Emergency Action Plans, and Consequence Assessment Using  
ArcGIS®**

## **User Manual**

**Version 2.0**

**October 2013**



**FEMA**

**Federal Emergency Management Agency  
National Dam Safety Program  
1800 South Bell Street  
Arlington, VA 20598-3935**

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## **GeoDam-BREACH**

The **Geospatial Dam Break, Rapid Emergency Action Plan, Consequences and Hazards** (GeoDam-BREACH) Geographic Information System (GIS) toolset for ArcGIS was developed for the Federal Emergency Management Agency (FEMA) by Risk Assessment, Mapping, and Planning Partners (RAMPP), a joint venture of Dewberry, URS Corporation and ESP Associates.

FEMA does not provide support for this software to non-FEMA users.

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## Acronyms and Abbreviations

1-D	1-Dimensional
2-D	2-Dimensional
BOR	U.S. Bureau of Reclamation
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DHS	Department of Homeland Security
DSO	Dam Safety Office
EAP	Emergency Action Plan
FEMA	Federal Emergency Management Agency
FGDB	File GeoDatabase
GeoDam-BREACH	Geospatial Dam Break, Rapid Emergency Action Plan, Consequences and Hazards
GIS	Geographic Information System
H&H	Hydrologic and Hydraulic
HAZUS-MH	Hazards U.S. – Multi-Hazard
HEC	U.S. Army Corps of Engineers Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center River Analysis System
LiDAR	Light Detection and Ranging
NDSP	National Dam Safety Program
NED	National Elevation Dataset
NFIP	National Flood Insurance Program
NRCS	Natural Resource Conservation Service
NWS	National Weather Service
PAR	Population at Risk
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
Risk MAP	Risk Mapping, Assessment and Planning
SMPDBK	NWS Simplified Dam-Break Model
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture

## Introduction

The **Geospatial Dam Break, Rapid Emergency Action Plan, Consequences and Hazards** (GeoDam-BREACH) is a suite of ArcGIS tools designed to support the development of simplified dam break studies, Risk Mapping, Assessment and Planning (Risk MAP) datasets, loss of life assessments, Emergency Action Plans (EAPs) and EAP map panel creation.

This version of GeoDam-BREACH can be used for various workflows including:

- **Simplified Dam Break Studies**  
Supports the use of the National Weather Service (NWS) Simplified Dam Break Model (SMPDBK) (Reference 1). SMPDBK is supported within an ArcGIS environment, enabling the automated creation of model geometry, model execution and inundation delineation.
- **Risk MAP Datasets**  
Supports the creation of non-regulatory Risk MAP datasets in accordance with draft Risk MAP guidance available at the time of development (Reference 2). Risk MAP datasets can be derived from studies created within GeoDam-BREACH using SMPDBK, or from other studies created outside of GeoDam-BREACH.
- **Loss of Life Assessment**  
Supports loss of life assessments for dam failure using either the Department of Homeland Security (DHS), 2011 document: *Dam Sector: Estimating Loss of Life for Dam Failure Scenarios* (Reference 3) Flood Severity method or the Brown and Graham method as referenced in the U.S. Bureau of Reclamation (BOR) Dam Safety Office (DSO) *Document 99-06* (Reference 4). Loss of life assessments can be performed with user provided population polygons and arrival time grids for the failure event.
- **EAP Map Panel Creation**  
Supports the creation of consistent EAP map products using the *Draft Federal Guidance for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures* (Reference 5). Panel scheme and individual map panels are created from either a default or user provided template.
- **EAP Development**  
Supports the creation of consistent EAP documents using the Natural Resources Conservation Service (NRCS) EAP Template (Reference 6) and FEMA publication P-64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*, July 2013 (Reference 7).

This version of GeoDam-BREACH includes several multi-media tutorials. These can be accessed by clicking on the multi-media icon:



This User Manual supports GeoDam-BREACH version 2.0 for ArcGIS version 10.0.

## Requirements

Users must have a thorough understanding of the NWS SMPDBK program, hydraulics and general dam safety knowledge, including the development of breach parameters, EAPs and consequence assessments including loss of life analysis. A working understanding of ArcGIS, 3D Analyst and Spatial Analyst is also required.

## Software Requirements

GeoDam-BREACH requires ArcGIS Editor or Info version 10.0 with the Spatial Analyst and 3D Analyst extensions. The inundation polygon smoothing option is available only at the ArcGIS Info level. Separate installation of NWS SMPDBK is not required because it is included in the GeoDam-BREACH installation package. It is recommended that all previous installations of SMPDBK be removed. In order to use the Loss of Life assessment tools, Microsoft® Word® 2003 or greater is required. To use the EAP Mapping tools, Adobe® Reader® is required. Adobe® Reader® can be downloaded from <http://www.adobe.com/products/reader.html>. To use the EAP document generator, both Microsoft® .NET Framework 4.0 and Word® 2003 or greater are required. Microsoft® .NET Framework 4.0 can be downloaded from <http://www.microsoft.com/download/en/details.aspx?id=17851>. To utilize the multi-media tutorial functions of GeoDam-BREACH, Microsoft Windows Media Player® is needed and can be downloaded from <http://windows.microsoft.com/en-us/windows/windows-media-player>

## Computer and Operating System Requirements

Computer requirements are consistent with those for ArcGIS version 10.0. GeoDam-BREACH is compatible with both Windows XP® and Windows 7® operating systems, although it is optimized for the Windows 7® operating system.

## Data Requirements

GeoDam-BREACH minimum data requirements vary by workflow as specified within this document.

### Digital Data Requirements

For development of a simplified inundation study and Risk MAP datasets, the minimum digital data requirement is a single Digital Elevation Model (DEM) in ESRI Grid format that covers the entire extent of the area to be studied, including the resultant inundation area. The user must carefully review and understand the accuracy of the input grid and evaluate its suitability for each study performed. Other datasets, including downstream river lines, reservoir polygons and cross sections can be imported using basic GIS functionality from other datasets, or may be developed by the user for use with GeoDam-BREACH. For EAP map panel creation and EAP development, the minimum data requirement is an inundation polygon.

### Non Digital Data Requirements

All workflows require basic information pertaining to the dam, including dam name, dam type, location etc.

## GeoDam-BREACH Installation – Version 2.0

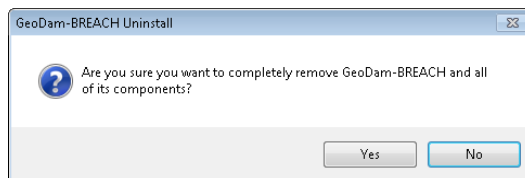
The GeoDam-BREACH installation includes a modified version of the NWS SMPDBK program, designed to run on both 32-bit and 64-bit computers and modified to support up to 500 cross sections.

**Users with existing installations of GeoDam-BREACH will need to remove the current Add-In (this includes beta testers).**


To remove existing GeoDam-BREACH Add-In:

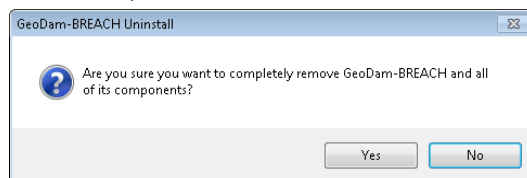
Windows XP:

1. Click Start, click **Control Panel**, and then double-click **Add or Remove Programs**.
2. In the Currently installed programs box, click the **GeoDam-BREACH Toolkit 1.0.0.0**, and then click Remove.
3. You're prompted to confirm the removal of the GeoDam-BREACH Toolkit, and click Yes.



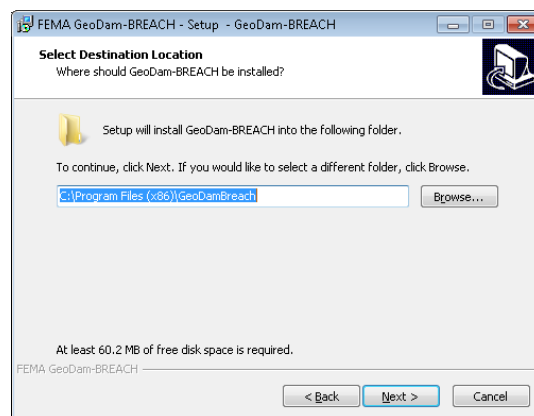
Windows 7:

1. Open Programs and Features by clicking the **Start** button , clicking **Control Panel**, and then clicking **Programs and Features**.
2. Select GeoDam-BREACH Toolkit 1.0.0.0, and then click **Uninstall**. If you're prompted for an administrator password or confirmation, type the password or provide confirmation. You're prompted to confirm the removal of the GeoDam-BREACH Toolkit, and click Yes.

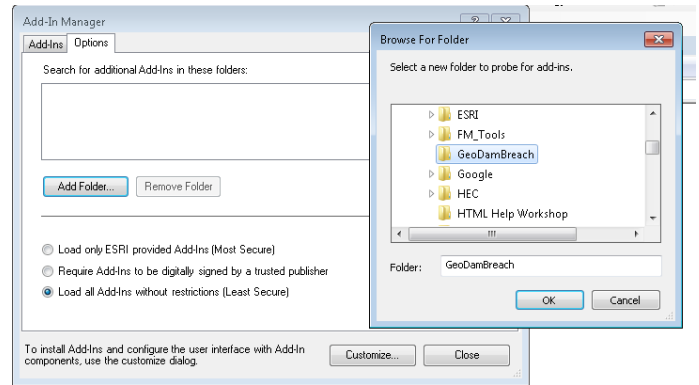


To install a new GeoDam-BREACH Add-In (after removing existing Add-Ins and for first time installs)

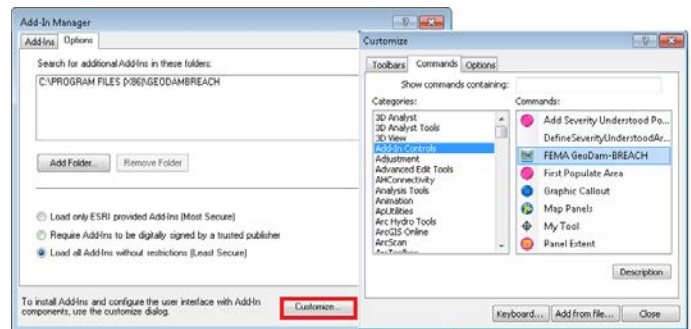
1. Download and save the executable **FEMA\_GeoDam-BREACH\_v2.exe** to your computer.
2. Double click on **FEMA\_GeoDam-BREACH\_v2.exe** and click on **Yes** to install GeoDam-BREACH. It is recommend to use default destination folder:  
Win 7 : C:\Program Files (x86)\GeoDamBreach  
Win XP: C:\Program Files\GeoDamBreach



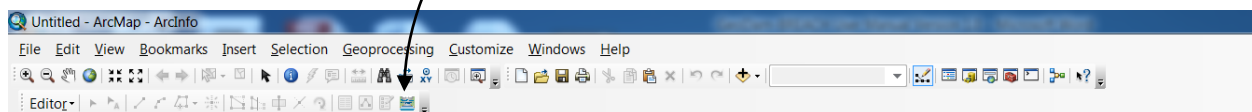
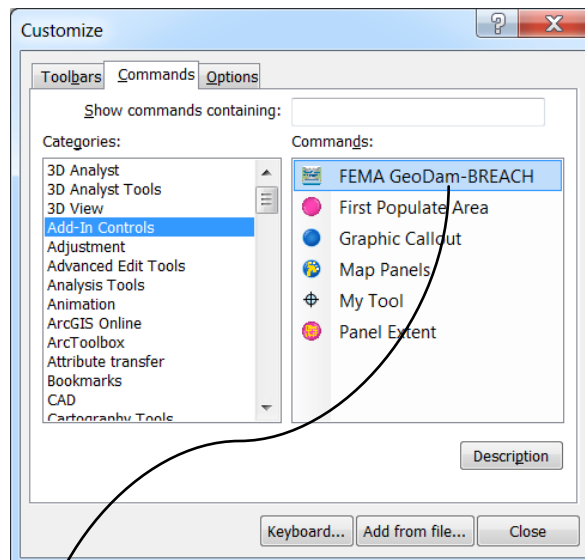
- Open a new ArcMap document and select Customize->Add-In Manager -> 'Options' tab and then select the GeoDamBreach folder (installation folder created during step 2)



- Click on Customize (in the bottom right corner of window) and then click the Commands tab and select Add-In Controls



- Click on FEMA GeoDam-BREACH – and drag the command icon onto a toolbar of your choice as illustrated below



6. Save the MXD – Any MXD you open should have the FEMA GeoDam-BREACH Tool Button at that location which can be used to launch the toolset.

## Working with GeoDam-BREACH

### GeoDam-BREACH Workflows

GeoDam-BREACH has five major workflows that can be performed in sequence or individually where appropriate:

#### 1. SMPDBK Pre and Post Processing Workflow

The SMPDBK Pre- and Post-Processing Workflow allows users to generate SMPDBK input data within GIS; execute SMPDBK on the fly; and then import the SMPDBK output back into GIS to automatically create inundation polygons.

#### 2. Risk MAP Datasets Workflow

The Risk MAP Datasets Workflow allows users to automate the generation of Risk MAP datasets for each dam. This can include dams that have been analyzed using the SMPDBK Pre- and Post-Processing Workflow, as well as dams that have been analyzed using other models, including the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) or various 2-D models. This data can then be used for non-regulatory datasets, as well as for supporting the Loss of Life Assessment, EAP Mapping and EAP Development Workflows.

#### 3. Loss of Life Assessment Workflow

The Loss of Life Assessment Workflow allows users to automate probable loss of life estimates using the Flood Severity Method (Reference 3) or the Brown and Graham Methodology (Reference 4). Users must supply polygons attributed with population counts and provide information pertaining to the dam and unique downstream conditions, including the flood severity, understanding of severity and determination of when a breach warning would be initiated.

#### 4. EAP Mapping Workflow

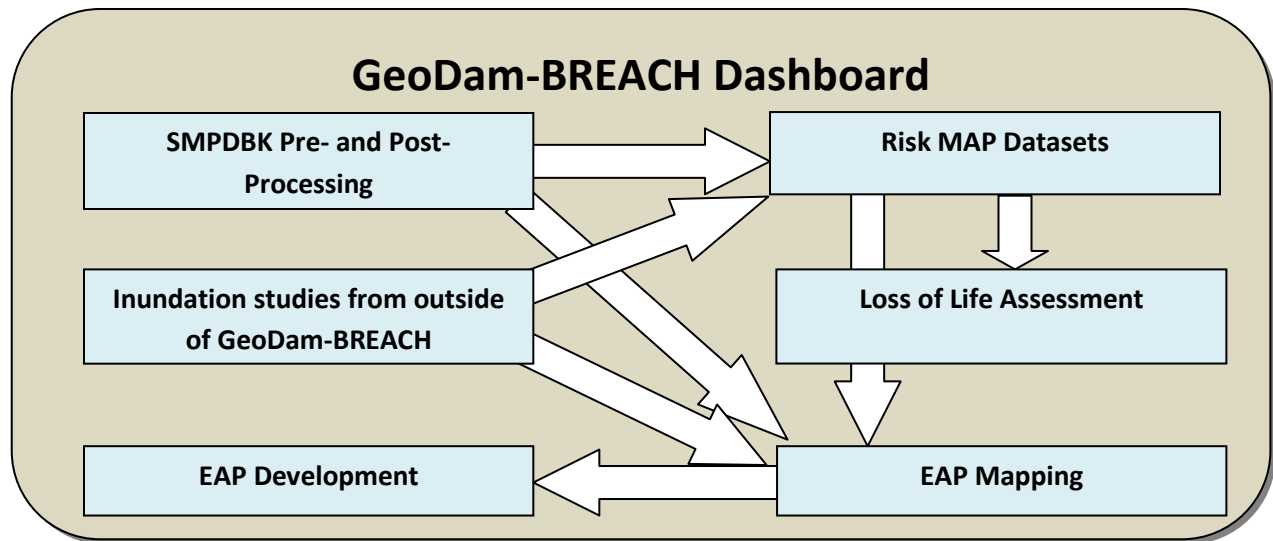
The EAP Mapping Workflow allows users to automate the development of a mapping panel scheme and the creation of individual mapping panels. The EAP Mapping Workflow requires an inundation polygon and optional base map data. Other data, including Risk MAP Datasets, can be leveraged to automate annotation and development of individual panels. For EAP map panel layout and formatting, GeoDam-BREACH uses the guidance provided in the *Draft Federal Guidance for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures* (Reference 4).

## 5. EAP Development Workflow

The EAP Development Workflow allows users to semi-automate the creation of an EAP by using a simplified version of the NRCS EAP template (Reference 5). GeoDam-BREACH provides users with a simplified environment for developing an EAP document efficiently and consistently.

### GeoDam-BREACH Workflow Relationships

The following diagram illustrates the relationships between the five workflows and how GeoDam-BREACH can utilize the simplified dam break studies developed during Workflow 1; or can leverage more detailed inundation data developed outside of GeoDam-BREACH for Workflows 2 and 3.



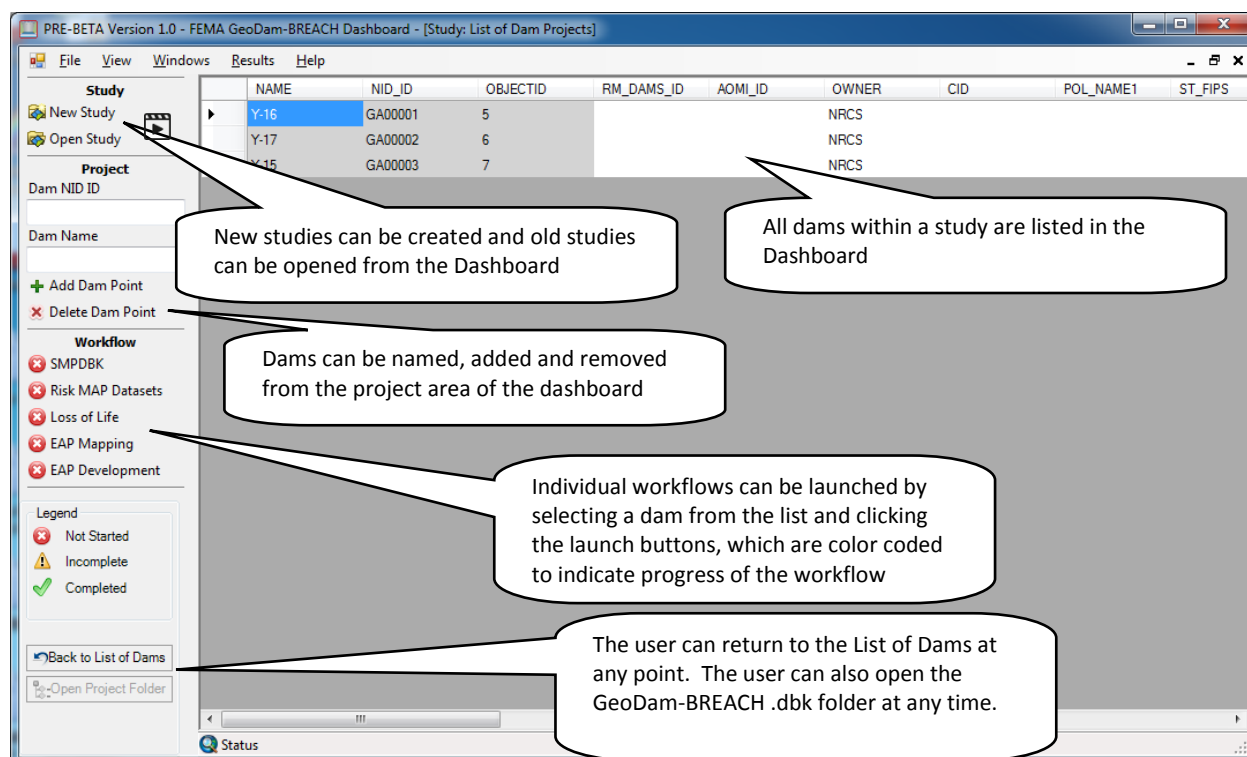
## Loading GeoDam-BREACH

GeoDam-BREACH is launched by clicking the GeoDam-BREACH icon on a toolbar. This location will vary depending on where users choose to add the tool during installation.



## GeoDam-BREACH Dashboard

The GeoDam-BREACH Dashboard is where studies are managed and set up. The Dashboard provides users with a simple window in which dams can be identified, individual workflows can be launched and the overall progress of an analysis can be tracked.




## ArcMap Extensions

3D and Spatial Analyst extensions for ArcMap are required for some GeoDam-BREACH workflows and functions. Ideally, both extensions should be enabled prior to starting a GeoDam-BREACH study. However, if these extensions are not readily available to users, GeoDam-BREACH can still be used with limited functionality. Table 1 summarizes where these extensions are required and the potential limitations if either extension is not available.

## ArcMap Editor Toolbar

The ArcMap Editor toolbar is required when developing SMPDBK models.

The Editor toolbar contains the various commands needed to edit data within ArcMap. Using the Editor toolbar, users can start and stop editing data and save those edits. To edit data, users need to add the Editor toolbar to ArcMap.

To display the Editor toolbar, click the Editor Toolbar button  on the Standard toolbar. Alternatively, right click in the top margin of ArcMap and check the Editor Toolbar.

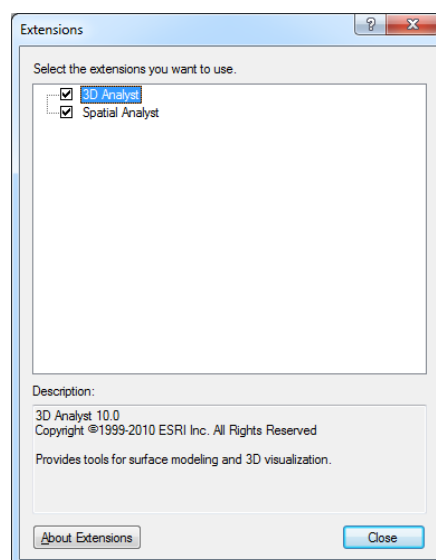
The toolbar should now appear.



**Table 1. ArcMap Extension Requirements for GeoDam-BREACH**

Workflow	3D Analyst	Spatial Analyst
Workflow 1 – SMPDBK	Required to smooth inundation delineation (SMPDBK models can be created without extension and unsmoothed inundation polygons can be created)	Required
Workflow 2 – Risk MAP	Required if new raster data sets are created from Workflow 1 or external 1D features	Required if raster datasets are to be created
Workflow 3 – Loss of Life	Not Required	Required
Workflow 4 – EAP Maps	Not Required	Not Required
Workflow 5 – EAP Development	Not Required	Not Required

To enable Spatial and 3D Analyst extensions, select **Customize** from the ArcMap main menu and then select **Extensions**. Enable Spatial and 3D Analyst extensions by checking the boxes to the left of their name in the Extensions window, as illustrated below:




### GeoDam-BREACH Study

GeoDam-BREACH is designed to support the analysis of either single or multiple dam assessments. It is specifically designed to efficiently manage data in a consistent, organized manner to preserve all supporting data, thus enabling it to be effectively stored, queried and retrieved, as needed.

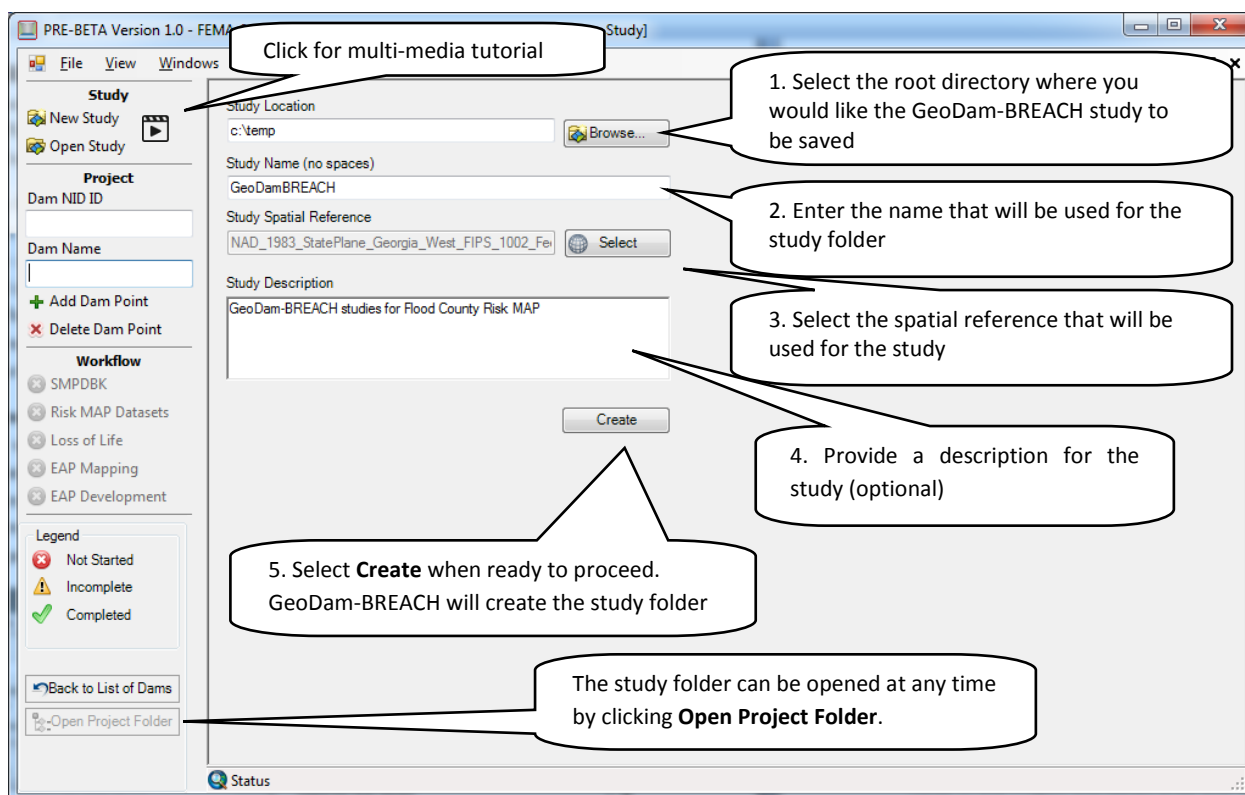
Within GeoDam-BREACH, a **Study** is defined as an assessment or collection of one or many dams. All related data are stored in a user-defined folder with the suffix **.dbk**, which enables users to recognize that folder as a collection of dams assessed using GeoDam-BREACH. Within this folder, GeoDam-BREACH creates a standard data structure to support assessments and encourage consistency between multiple dams for all workflows. Users can choose which dams to include within a study. A study may be limited to geographic areas, such as Hydrologic Unit Codes, counties, regions etc., or may be broken out based on the work of various individuals or groups.

### Creating a GeoDam-BREACH Study

GeoDam-BREACH features a multi-media tutorial for creating a new GeoDam-BREACH study.

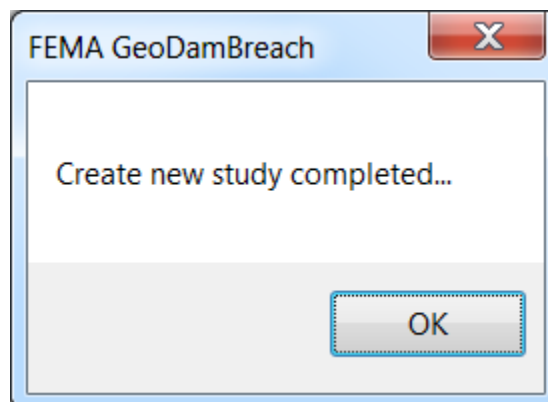
Just look for the  icon.

1. To create a study, select New Study from the left side of the Dashboard. The new study entry form will appear in the Dashboard and users must enter the location and name as illustrated below.
2. The Study Spatial Reference refers to the coordinate system that GeoDam-BREACH will use for all dams studied. GeoDam-BREACH has been tested using both Geographic and projected coordinate systems in both feet and meters, although the user is strongly recommended to verify that any calculations performed by GeoDam-BREACH appropriately handle vertical and horizontal units. A coordinate system must be selected before proceeding.
3. The Study Description is an optional data entry whereby the user can describe the GeoDam-BREACH study.



4. By clicking **Create**, GeoDam-BREACH will now create a study folder which will be used to store all data. The folder takes the Study Name entered into the Dashboard upon creating a New Study. The Study Name folder will be given the suffix .dbk, which indicates that it is a GeoDam-BREACH study folder. In the above example, the Study Name FloodCountyRiskMAP was used. Therefore, the study folder will be named FloodCountyRiskMAP.dbk.

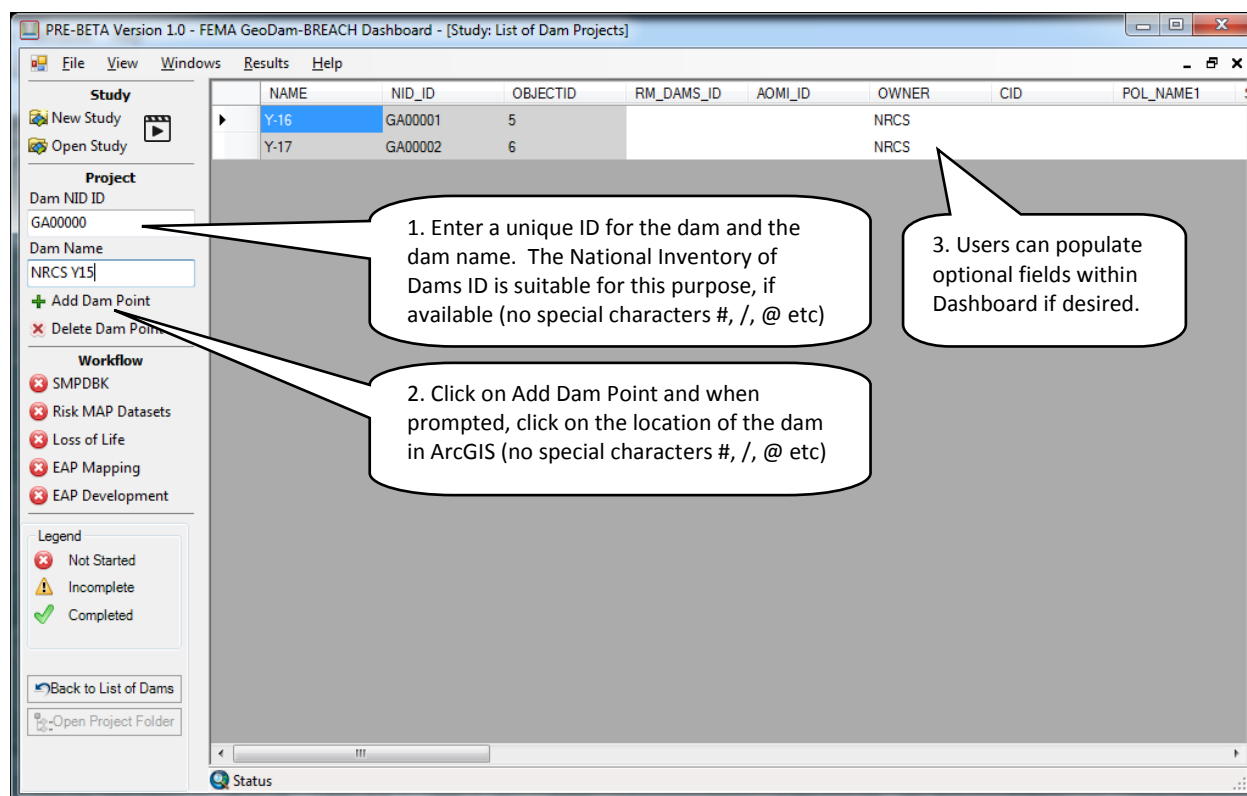
***After clicking Create, GeoDam-BREACH may take up to 2 minutes to create the database and folder structure. Please do not click or perform any ArcGIS functions until the following message appears:***



## Adding a Dam to GeoDam-BREACH

One or more dams can be added to a GeoDam-BREACH study by clicking on the location of the dam. At least one dam is required to perform any of Workflows 1 through 5.

1. To add a dam to the study, populate the NID\_ID and Name fields in the Project attributes area and select Add Dam Point from the Dashboard. GeoDam-BREACH will now prompt you to click on the location of the dam.



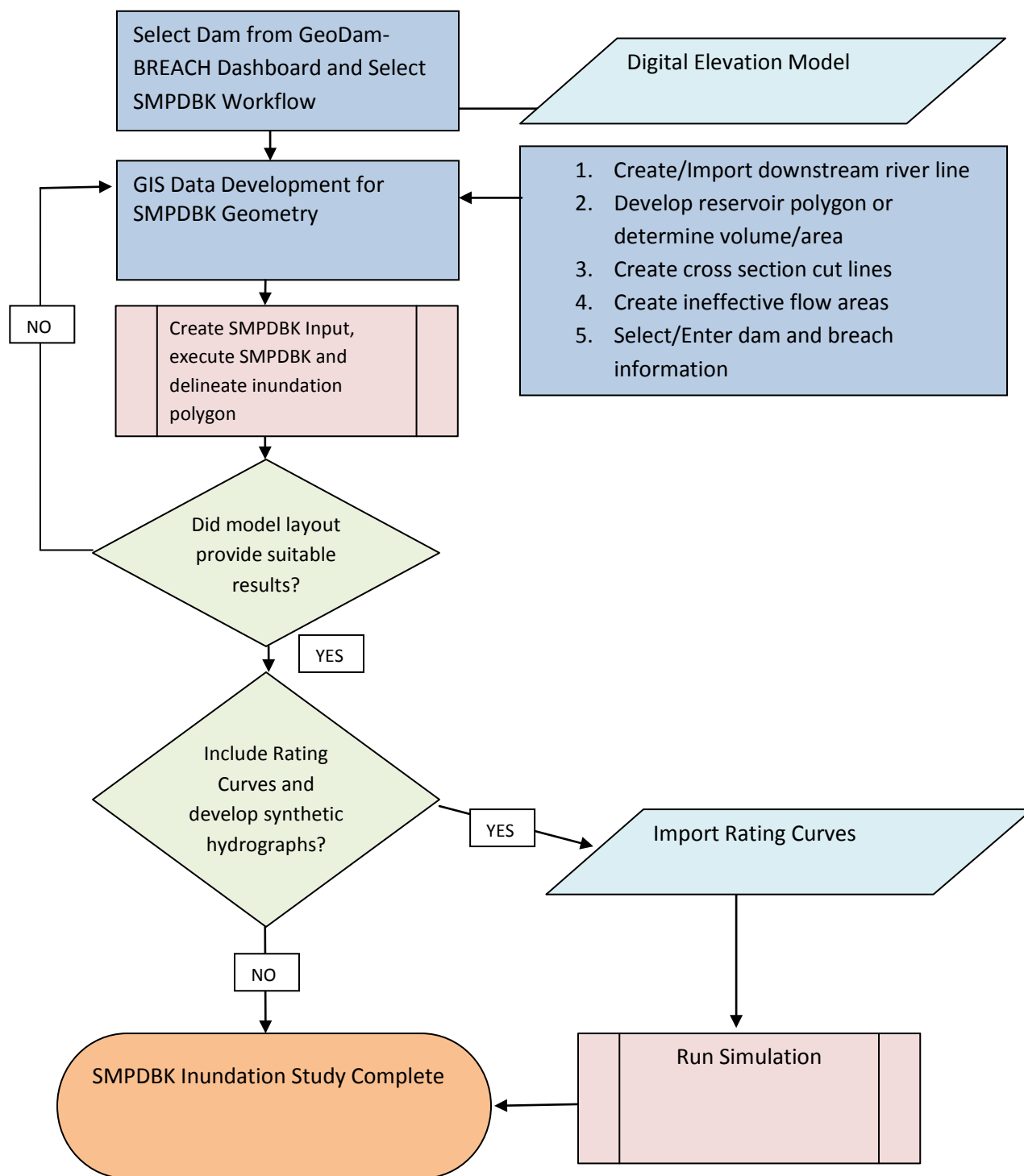
***Please note that neither the Dam NID ID or the Dam Name will accept special characters such as #, /, !, @ etc. This is because many ArcMap geoprocessing functions do not support special characters and will cause GeoDam-BREACH to fail.***

Once a dam has been added, it will be listed within the Dashboard and GeoDam-BREACH automatically creates a folder within the .dbk folder that adopts the NID\_ID previously entered for the dam. This folder will contain all GeoDam-BREACH data specific to that dam.

Selecting the dam in the Dashboard will cause the workflow launch buttons on the left to change color to indicate the workflow progress for that specific dam. Red generally indicates that a workflow has not been started or contains no data. Yellow generally indicates that a workflow has been started, but has errors or omissions. Green generally indicates that the workflow is complete. Each workflow can be launched by simply clicking the launch buttons when an individual dam is selected.

## Work Flow 1 – SMPDBK Pre- and Post-Processing

The SMPDBK Pre- and Post-Processing Workflow is illustrated in Figure 1



**Figure 1. SMPDBK Pre- and Post-Processing Workflow**

## Input Data Requirements

The minimum digital data requirement for the SMPDBK Pre-and Post-Processing Workflow is a DEM in an ESRI Grid or File Geodatabase (FGDB) formats. The DEM is required to extract cross-section geometry of the downstream valley.

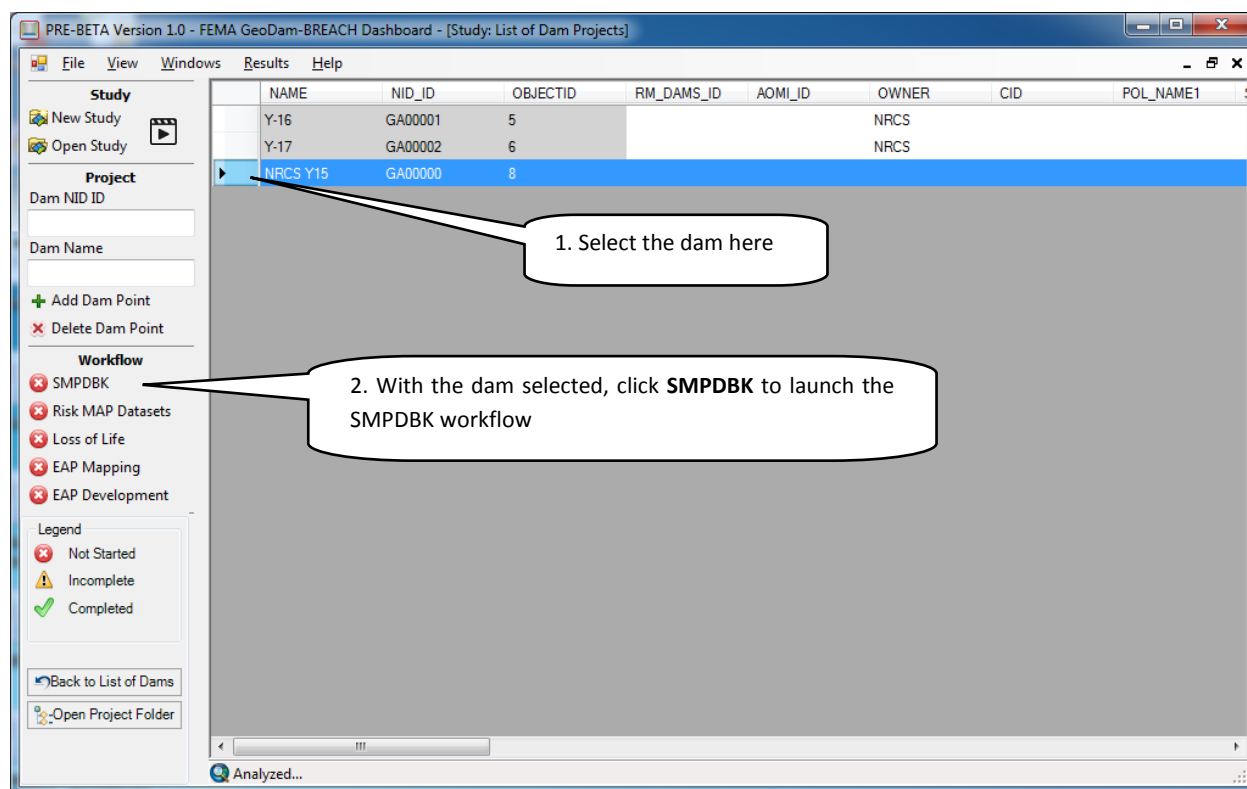
Additional digital datasets that are not used to perform SMPDBK calculations can assist the development of Workflow 1 data by providing visual references. This can include aerial imagery, planimetric data and land-use data, all of which can help users make better engineering decisions when setting up the model.

Where available, GIS datasets containing a continuous stream centerline, cross-section lines and/or a reservoir pool polygon can all be imported directly into GeoDam-BREACH during Workflow 1, effectively eliminating or minimizing the user's need to develop these datasets.

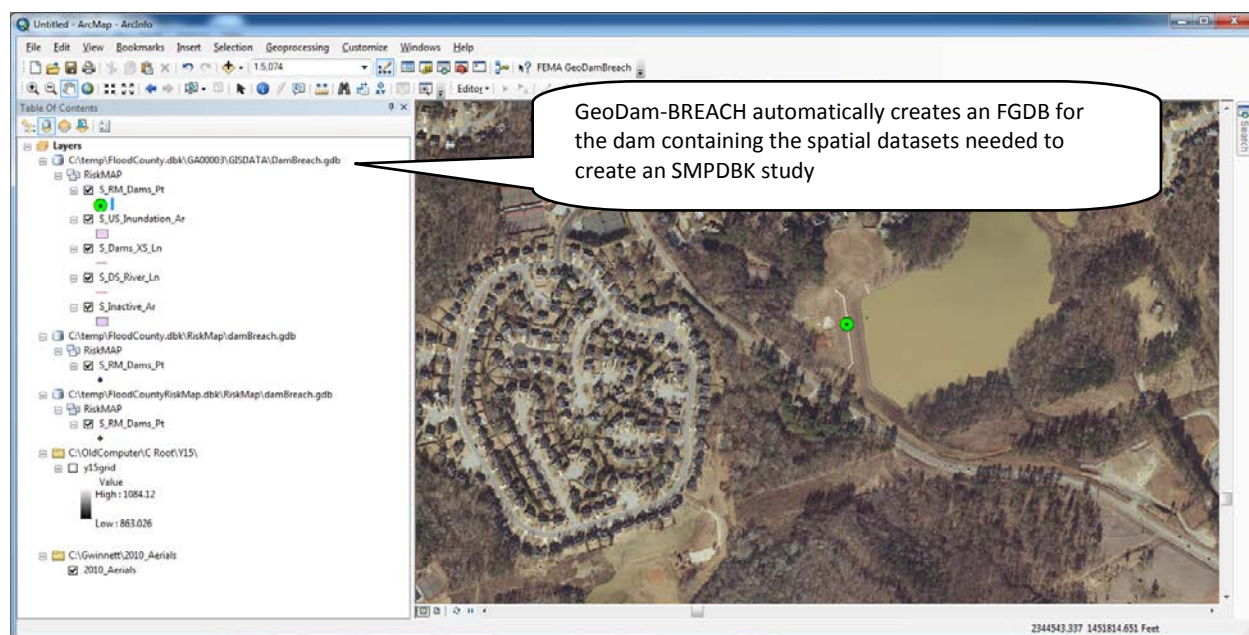
Information pertaining to the dam, breach event and reservoir conditions is required. This includes the dam type (Earthen, Concrete Gravity, Concrete Arch), Breach Parameters (Optional: Breach Width, Breach Development Time) and reservoir area or volume.

## Using SMPDBK Pre- and Post-Processing Tools

1. To launch the SMPDBK Pre- and Post-Processing Workflow, simply select the dam in the Dashboard and click the **SMPDBK** launch button, as illustrated below:



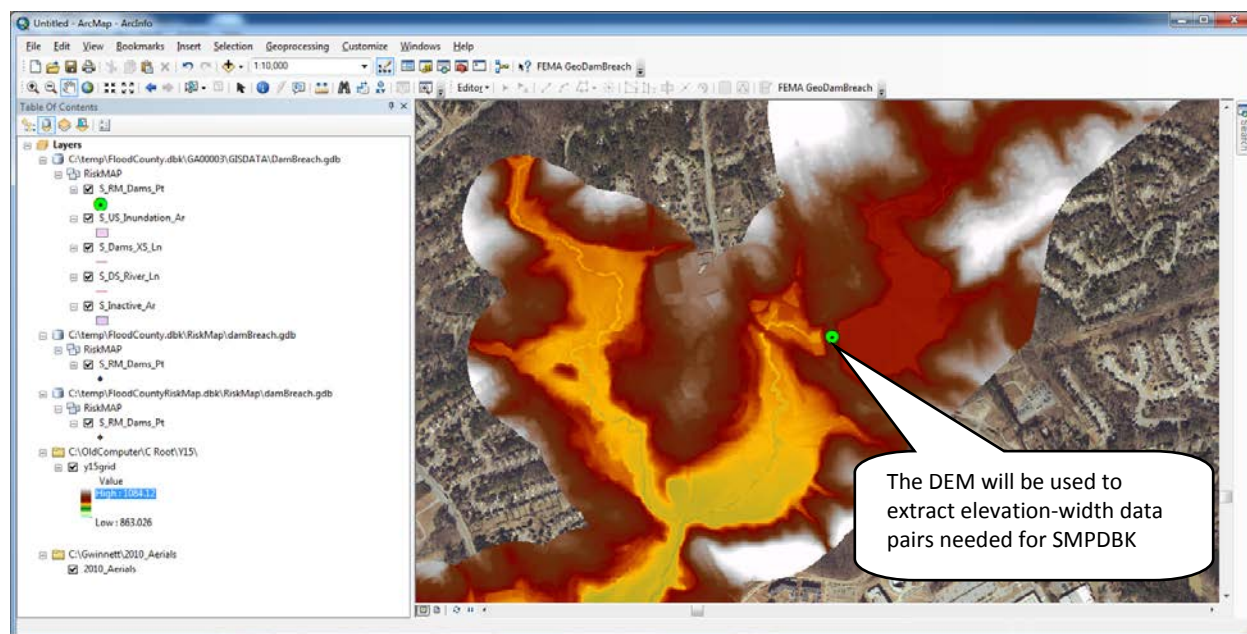
Upon launching the SMPDBK Workflow, GeoDam-BREACH automatically creates the empty data structure needed to develop the geometry for a SMPDBK model. This is stored in an FGDB within the individual dam folder.



## ***Digital Elevation Models***

DEMs can be obtained from many sources including the National Elevation Dataset or various State, regional and local agencies. Users must carefully evaluate the accuracy of the DEM to ensure that it is suitable for its intended purposes. The DEM accuracy will greatly affect the accuracy of any GeoDam-BREACH study.

1. The DEM should be added to the ArcMap document (MXD) before proceeding with the SMPDBK Pre- and Post-Processing Workflow by using the Add Data tool and selecting the DEM to be stored in either ESRI Grid or FGDB format.




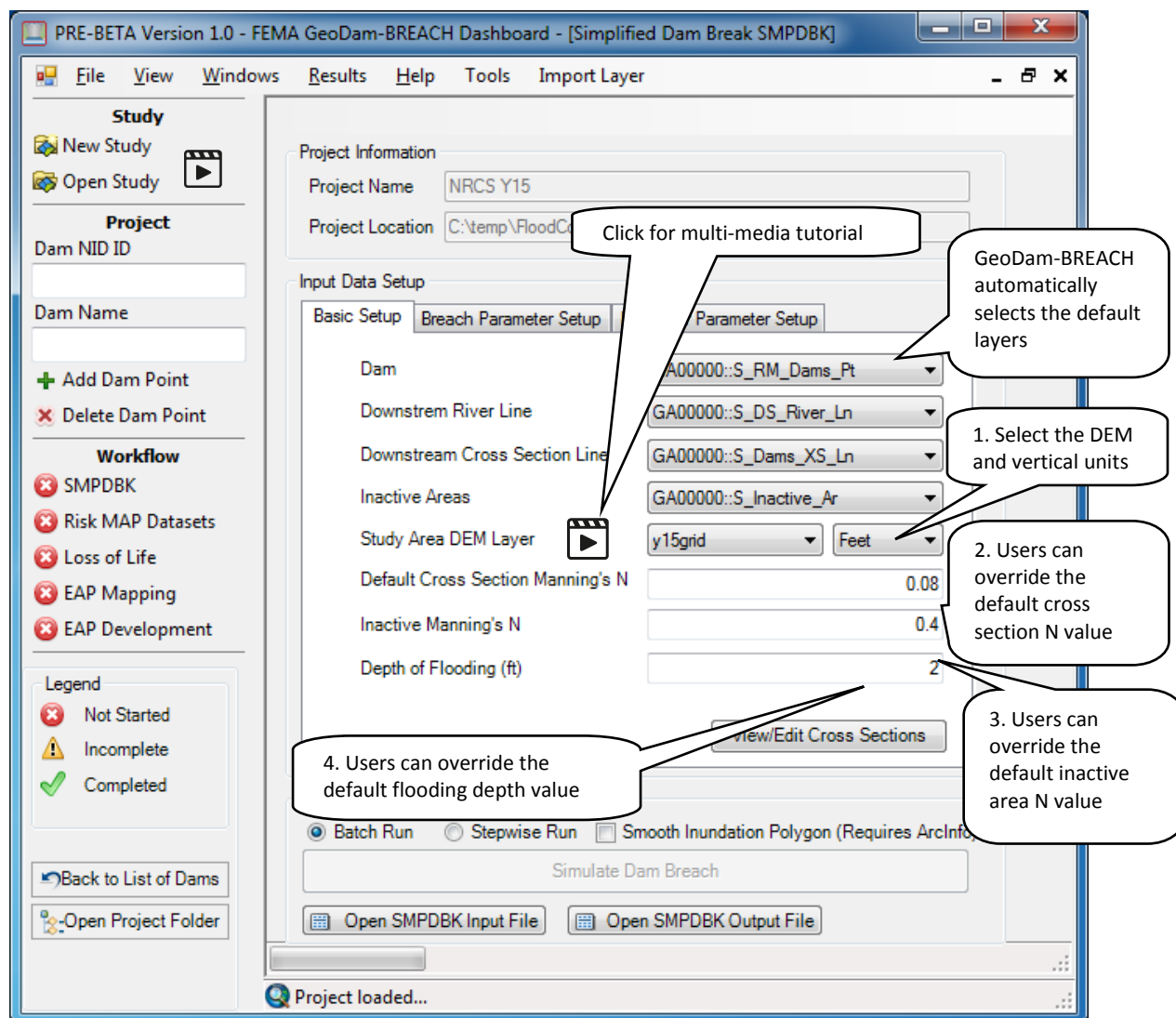
### ***Basic Setup***

The Basic Setup is used to define layers and model defaults. By default, the empty schema for Dam Points, Downstream River Line, Downstream Cross-Section Lines and Inactive Area layers are automatically created and selected to encourage the use of consistent file names and storage locations.

The user must first select the Study Area DEM layer and specify its vertical units before proceeding.

GeoDam-BREACH features a multi-media tutorial for selecting a DEM.

Just look for the  icon.



**Default Cross Section Manning's N** and **Inactive Manning's N** represent the global values that will be applied to all cross sections in the SMPDBK input.

**Inactive Manning's N** represents the Manning's N value that will be applied to the portion of a cross section considered as dead storage or ineffective area. The user defines these areas by using the **Inactive Areas** polygons.

The **Depth of Flooding (ft)** represents the definition of a flood. The depth of flooding is the depth at which the leading edge of the inundation is considered to have arrived.

### ***Breach Parameter Setup***

When setting up breach parameters, users have two ways to define the final breach width and breach development time. The **Predefined Parameter Setup** option enables users to simply specify the dam type from three options: Earthen, Concrete Gravity or Concrete Arch. Default values are then applied for breach width and development time, as described in the SMPDBK documentation (Reference 1). The **User Defined Breach Parameters** option enables users to specify the final breach width and breach development time manually, enabling the use of more detailed methods for determining these parameters.

#### **Breach Parameter Background Information**

**Pool Elevation at Breach** represents the elevation of the reservoir at the time that the dam begins to breach.

**Final Breach Bottom Elevation** represents the final elevation of the breach.

**Non Breach Flow** represents the flow going through the dam at time of failure not associated with the breach. This can include turbine, spillway or overtopping flows.


When using the **Predefined Breach Parameter** option, SMPDBK assumes the following default values for Final Breach Width, Time of Breach Formation (failure) and Final Elevation of Breach Bottom.

<u>Value</u>	<u>Units</u>	<u>Description</u>	<u>Default</u>
$B_r$	Feet	Final breach width	3H for earthen dams
			5H for concrete gravity dams
			$0.9 \times$ maximum width of tailwater section for concrete arch dams
$t_f$	Minutes	Time of breach formation (failure)	H/10 for earthen dams
			H/40 for concrete gravity dams
			H/50 for concrete arch dams
$h_r$	Feet	Final elevation of breach bottom	Elevation of bottom of tail water (first) cross section

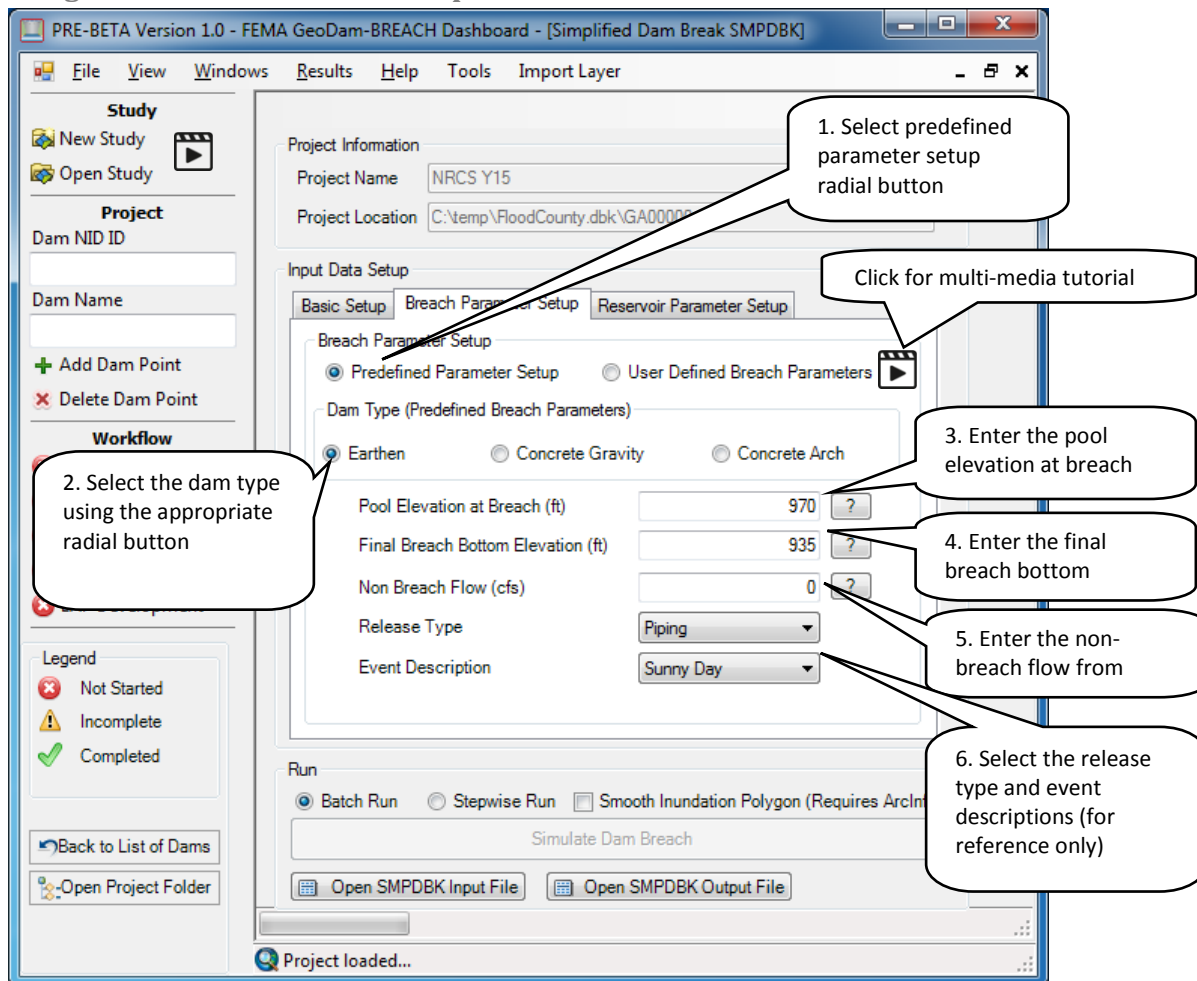
Note: H is the difference (in feet) between the reservoir water-surface elevation when the breach commences to form and the final bottom elevation of the breach ( $h_r$ )

Source: "The NWS Simplified Dam-Break Flood Forecasting Model" (Reference 1)

GeoDam-BREACH features a multi-media tutorial for selecting Breach Parameters.

Just look for the  icon.

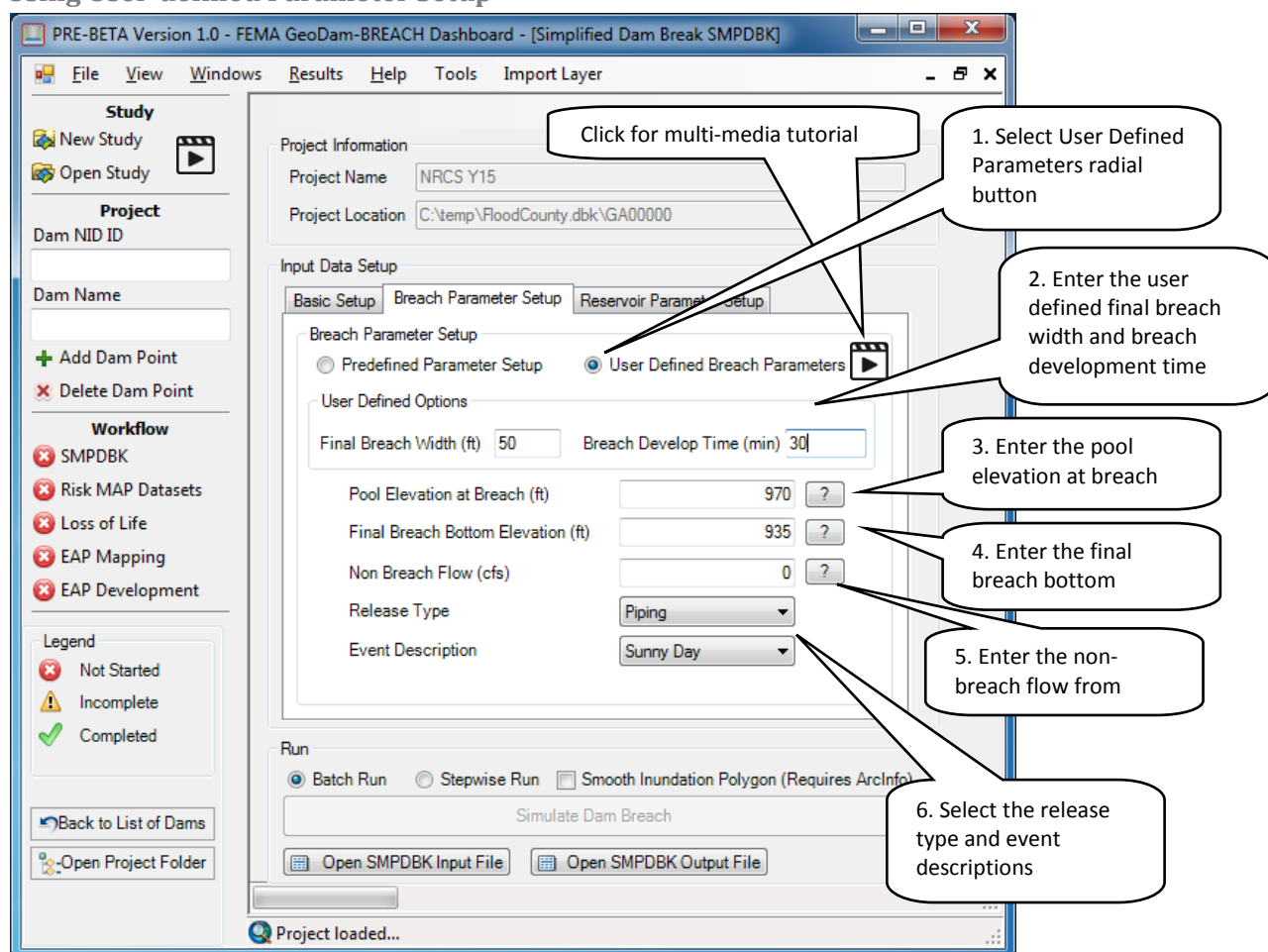
## Using Predefined Parameter Setup



The screenshot shows the 'PRE-BETA Version 1.0 - FEMA GeoDam-BREACH Dashboard - [Simplified Dam Break SMPDBK]' window. The interface includes a menu bar (File, View, Windows, Results, Help, Tools, Import Layer), a left sidebar with 'Study' (New Study, Open Study), 'Project' (Dam NID ID, Dam Name, Add Dam Point, Delete Dam Point), and 'Workflow' (Legend: Not Started, Incomplete, Completed; Back to List of Dams; Open Project Folder). The main area is divided into 'Project Information' (Project Name: NRCS Y15, Project Location: C:\temp\FloodCounty.dbk\GA000000), 'Input Data Setup' (Basic Setup, Breach Parameter Setup, Reservoir Parameter Setup), and 'Run' (Batch Run, Stepwise Run, Smooth Inundation Polygon). The 'Breach Parameter Setup' tab is active, showing 'Predefined Parameter Setup' selected. Below this, 'Dam Type (Predefined Breach Parameters)' has 'Earthen' selected. The 'Pool Elevation at Breach (ft)' is 970, 'Final Breach Bottom Elevation (ft)' is 935, and 'Non Breach Flow (cfs)' is 0. 'Release Type' is set to 'Piping' and 'Event Description' is 'Sunny Day'. The 'Run' section has 'Batch Run' selected. Callouts indicate: 1. Select predefined parameter setup radial button; 2. Select the dam type using the appropriate radial button; 3. Enter the pool elevation at breach; 4. Enter the final breach bottom; 5. Enter the non-breach flow from; 6. Select the release type and event descriptions (for reference only). A 'Click for multi-media tutorial' button is also present.

The **Release Type** and **Event Description** drop down menus allow users to enter the failure mode and failure event description. Although not used in the calculations, this is used in the naming convention of digital datasets and features, and provides a permanent record of what the simulation represents.

## Using User-defined Parameter Setup

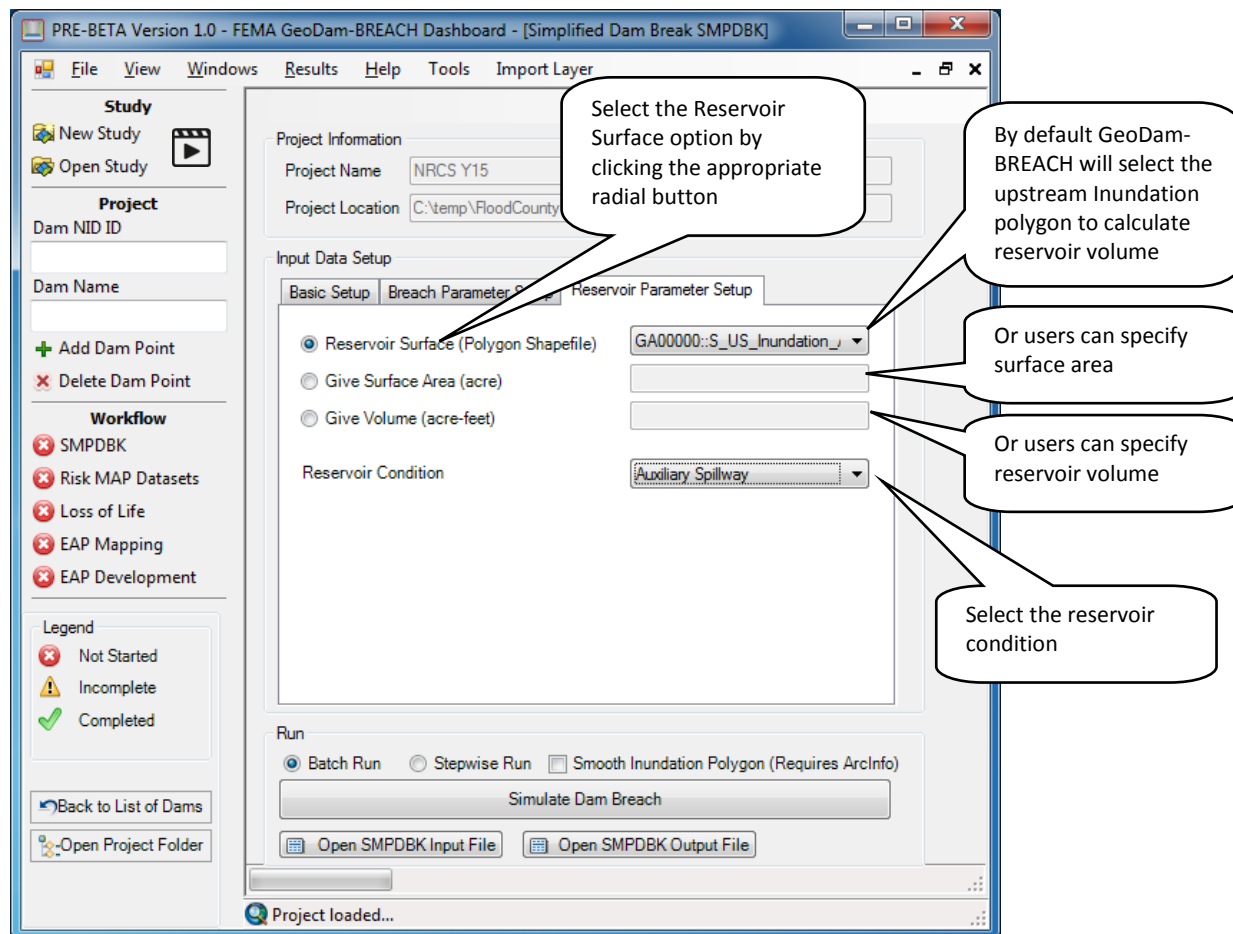


Note that **Final Breach Width** represents a rectangular breach. Users may choose to apply engineering judgment and enter Final Breach Width as an average breach width if the breach is assumed to be trapezoidal.

As previously mentioned, the **Release Type** and **Event Description** drop down menus allow users to describe the failure mode and failure event description. Although not used in the calculations, this is used in the naming convention of digital datasets and features, and provides a permanent record of what the simulation represents.

## Reservoir Parameter Setup

There are three options for the **Reservoir Parameter Setup**, which is used by SMPDBK to estimate the volume of water released during a breach. Users can select which method to use from the three radial buttons. The **Reservoir Surface** option enables users to provide or digitize a polygon representing the upstream pool of the reservoir at the time of breach. GeoDam-BREACH stores this in the S\_US\_Inundation\_AR feature class. Alternatively, users can specify either the surface area or volume of the reservoir at the time of breach, thus eliminating the need to digitize polygons. The SMPDBK user manual (Reference 1) provides details on how Reservoir Surface Area ( $A_s$ ) and Volume are calculated.



The **Reservoir Condition** drop down menu allows users to select the reservoir condition. Although not used in the calculations, this is used in the naming convention of digital datasets and features and provides a permanent record of what the simulation represents.

## ***Preprocessing of GIS Data***

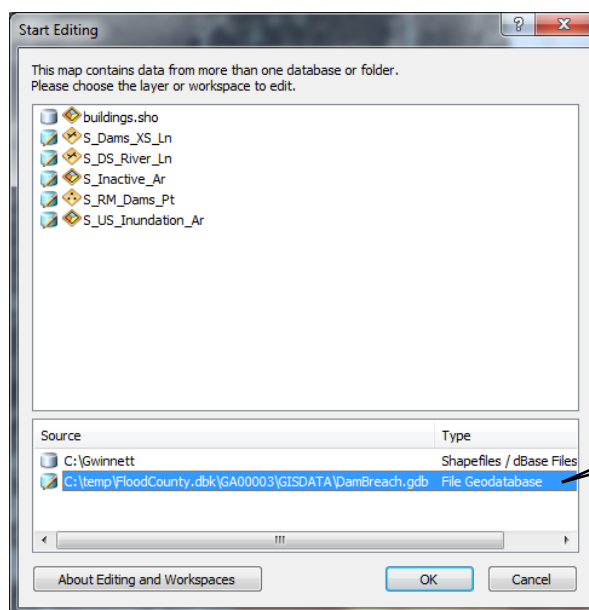
To Preprocess GIS data, users must use basic ArcGIS editing functions to create, at a minimum, River Centerlines and Cross Sections

### **River Centerline (Required)**

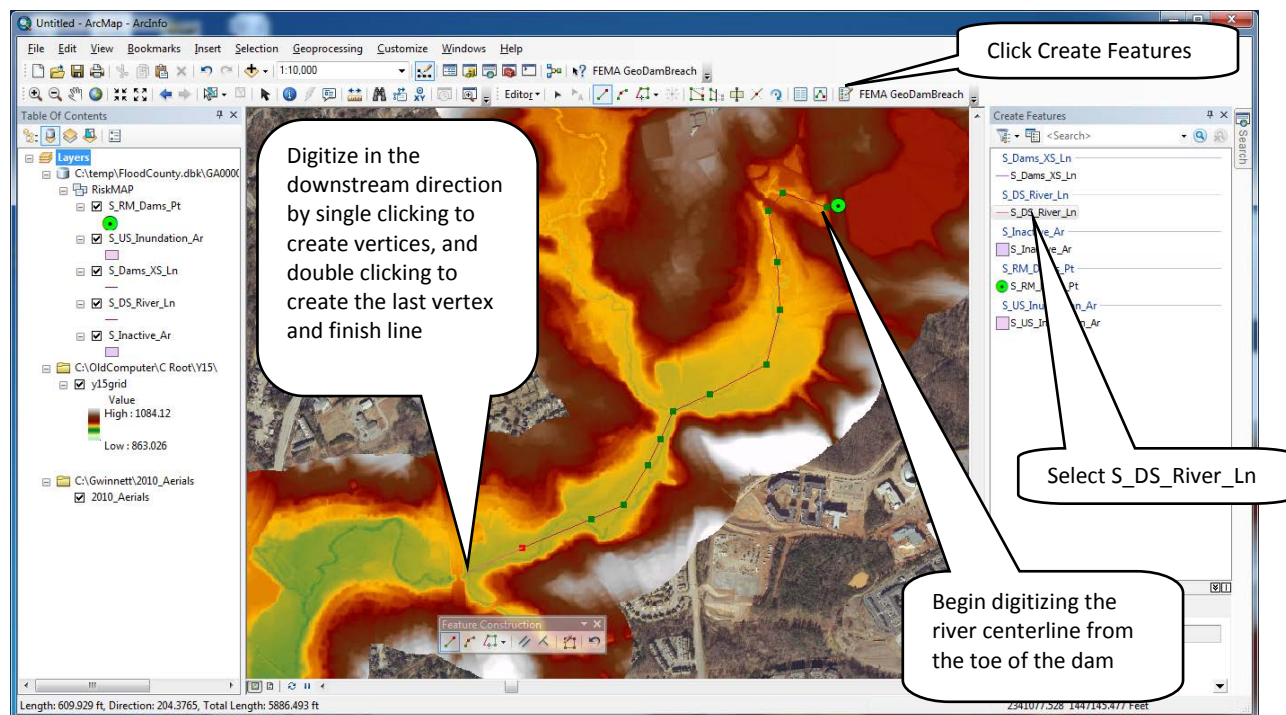
The river centerline is the backbone behind the model cross sections and serves as the baseline to determine the distance from the dam and the distance between individual cross sections. GeoDam-BREACH requires a single-part river centerline to be digitized from the upstream toe of the dam to the downstream limit of study, which is stored in the **S\_DS\_River\_Ln** feature class.

If users have an existing streamline, it can be imported by selecting **Import Layer -> River Line** from the main Dashboard menu.

1. To begin drawing or editing the river, select **Start Editing** from the Editor Toolbar. If an ArcMap document contains multiple editable databases, the user will need to select the DamBreach.gdb FGDB under the **Source** section of the **Start Editing** window and click OK. If there is only one FGDB within the ArcMap document, then this step will be automatically skipped.



- To begin digitizing, select **S\_DS\_River\_Ln** in the **Create Features** window that appears on the right side of the ArcMap document. With **S\_DS\_River\_Ln** selected, begin to digitize the stream centerline from upstream to downstream starting at the base of the dam and moving in the downstream direction.



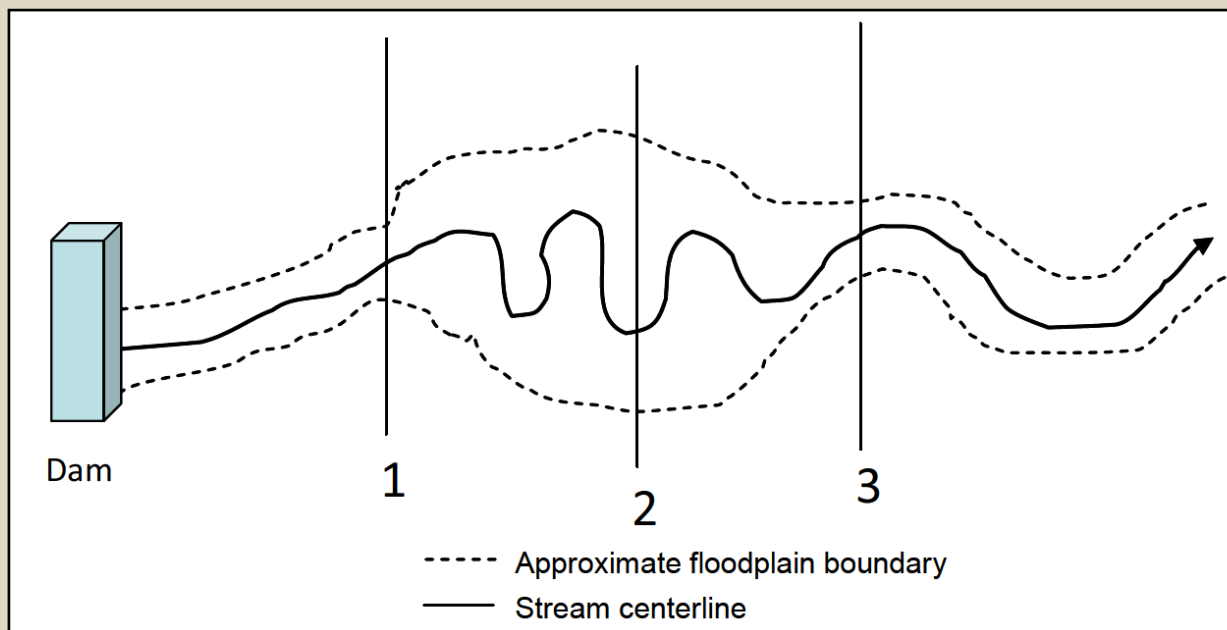
Note that it is not necessary, nor does it increase the accuracy of the SMPDBK study, for the **S\_DS\_River\_Ln** to accurately follow the river centerline. The **S\_DS\_River\_Ln** should capture the centroid of the inundation flood wave that takes the path of least resistance, often ignoring minor changes in riverline direction such as meanders. Additionally, excessive detail, such as digitizing meanders, can lead to overestimation of the flow path length and, consequently, floodplain storage, resulting in over attenuation of dam break discharges.

### Cross Sections (Required)

The cross section features are the key to producing a SMPDBK file and are stored in the **S\_Dams\_XS\_Ln** feature class. Placing the cross sections appropriately is important. GeoDam-BREACH uses the cross sections in combination with the elevation information to produce the elevation-topwidth tables in the SMPDBK input file. The cross section table defines the left- and right-bank inactive area limits and also allows for entry of a Manning's roughness coefficient.

## Background Information for Creating SMPDBK Cross Sections

The first cross section should be placed just below the dam and subsequent sections should be placed at points of interest where depth-of-flow information is desired. SMPDBK will run with a minimum of two cross sections in the input file, but additional cross sections should be placed to capture variability in the floodplain width. For example, at least one cross section should be placed before, in the middle of, and after any dramatic changes in floodplain width. Look for floodplain changes below major junctions to see if a cross section is needed. See below for an example of appropriate section placement.

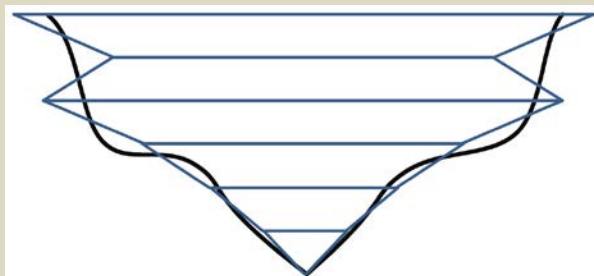


**SMPDBK uses distance weighting for average section properties. Users should place cross sections where major changes in valley width begin and end.**

In order to produce the topwidth vs. depth series for each cross section in the SMPDBK input file, GeoDam-BREACH subdivides each section area into SMPDBK slices and computes the area within each slice using the basic algorithm developed by the NWS and documented in “GeoSMPDBK: Instructions” (Reference 8). The application then creates a series of stacked trapezoids, each with the same area as the corresponding slice. These stacked trapezoids define the topwidths, which are printed to the SMPDBK input file and used to compute the hydraulic properties of the reach.

The translation to topwidth vs. depth pairs from area vs. depth pairs via this method of trapezoids introduces a small complication. The complication arises because there are infinite combinations of trapezoids that produce the correct area calculation for a given set of slices. The GeoSMPDBK algorithm chooses the set of trapezoid topwidths that produce the smoothest side slope from top to bottom, constrained so that the areas of the trapezoids match the corresponding slices through the real cross section.

Sometimes the area constraint on the trapezoids has the effect of causing a see-saw alternation of widths giving the appearance of an upside-down “Christmas tree;” as one width is increased, the adjacent widths decrease, with the area acting as the see-saw point. It is possible for this see-saw pattern to appear as the optimal case when the bottom trapezoid is constrained to a zero bottom width (See below).



**Symmetric trapezoid representation of cross sectional area with no slicing optimization.**

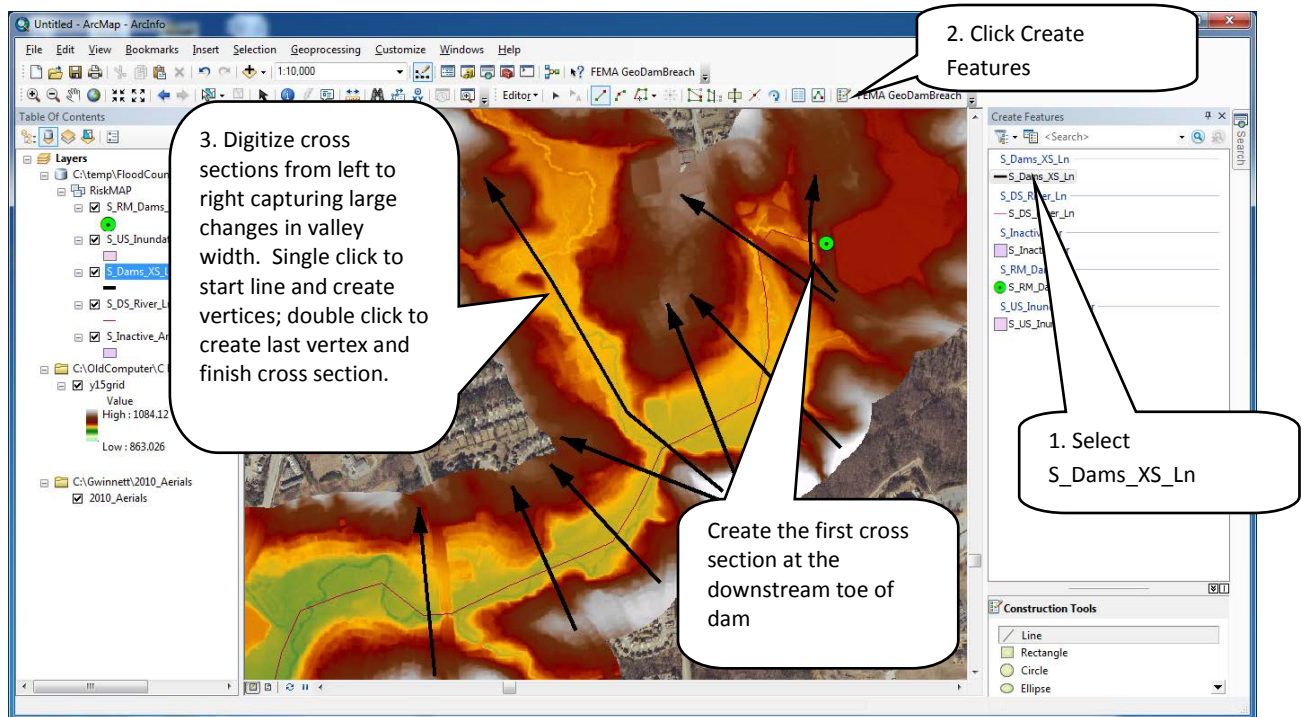
\*Note that the zero width of the bottom trapezoid is constraining the geometry of the rest of the trapezoids and creating the see-saw effect in the three uppermost widths. For the topwidth to decrease, the bottom would have to also decrease, which is not possible.

This tends to happen when there are large changes in channel area with small increases in depth, such as with the abrupt transition from a channel to a broad floodplain. This can also occur if a section is drawn crossing multiple channels, as may happen near a confluence. Although “Christmas tree” or see-saw cross sections created in these cases are not aesthetically pleasing, they do maintain the correct area-elevation curves from the DEM, and the resulting flow and depth calculations at these cross sections are physically realistic model estimates.

If a user has existing cross sections, then these can be imported by selecting **Import Layer -> Cross Section** from the main Dashboard menu.

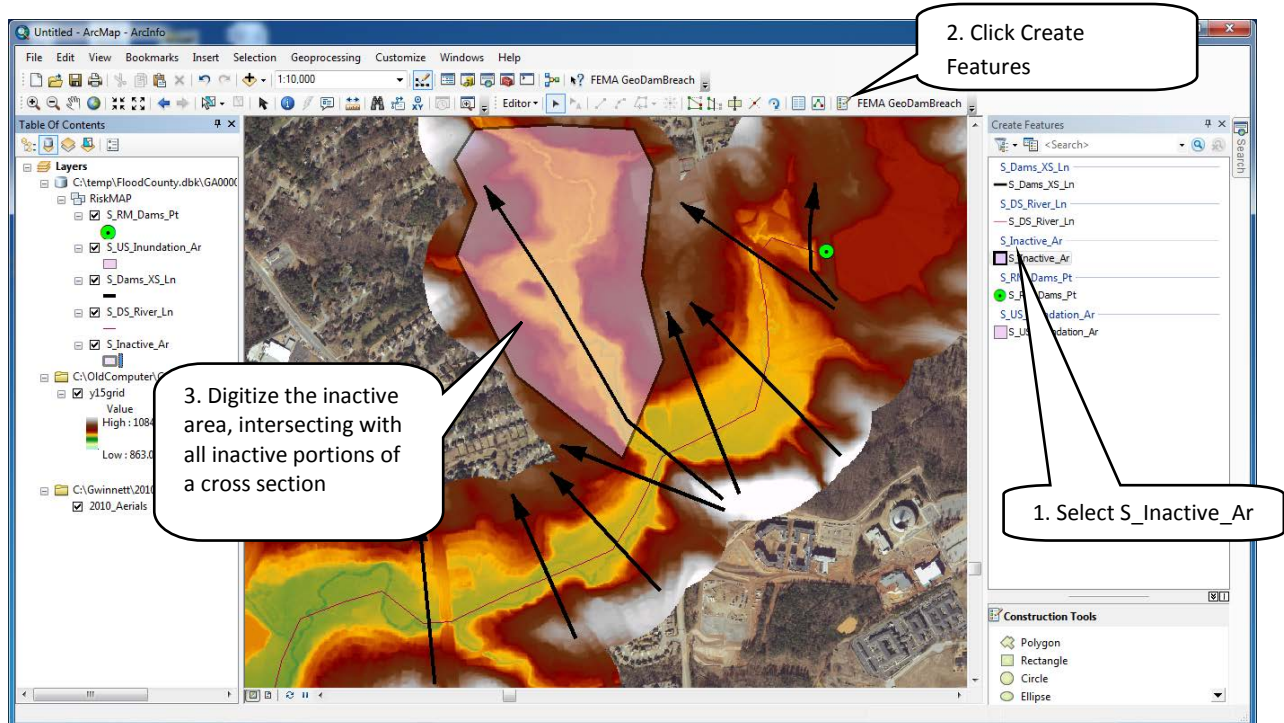
1. To create cross sections, open up an editing session (or keep open) and follow the same procedure used for creating the river centerline; however, in the Create Features window on the right of the ArcMap document, select S\_Dams\_XS\_Ln, which changes the target for creating features to the cross section line layer. Cross sections should be digitized from left to right looking in the downstream direction.

***The upstream most cross section must be located at the downstream toe of the dam because the lowest elevation of this cross section will be used by SMPDBK to determine the invert elevation of the reservoir.***



### Inactive Areas (Optional)

Inactive areas represent portions of a cross section that provide minimal conveyance (dead storage). This can include the outer parts of a wide floodplain or backwater areas. Inactive Areas are stored in the S\_Inactive\_Ar layer. Users can identify inactive areas within GeoDam-BREACH by digitizing polygons using the S\_Inactive\_Ar layer.



### Upstream Inundation Areas (Optional)

Upstream inundation areas represent the pool of the reservoir at time of breach and are only needed if using the **Reservoir Surface** option in **Reservoir Parameter Setup**. Upstream inundation areas are stored in the S\_US\_Inundation\_Ar layer.

If users have existing reservoir polygons that represent the reservoir area at time of breach, then these can be imported by selecting **Import Layer** -> **Upstream Reservoir** from the main Dashboard menu.

Users can identify upstream inundation areas within GeoDam-BREACH by digitizing polygons using the S\_US\_Inundation\_Ar layer and creating a polygon in the same way that the Inactive Areas layer was illustrated above.

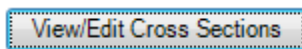
### Cross Section View and Advanced Functions (Optional Functions)

GeoDam-BREACH provides tools for viewing and reviewing individual cross sections, as well as performing advanced functions like individually setting cross section Manning's N values, adding rating curves and developing synthetic hydrographs.

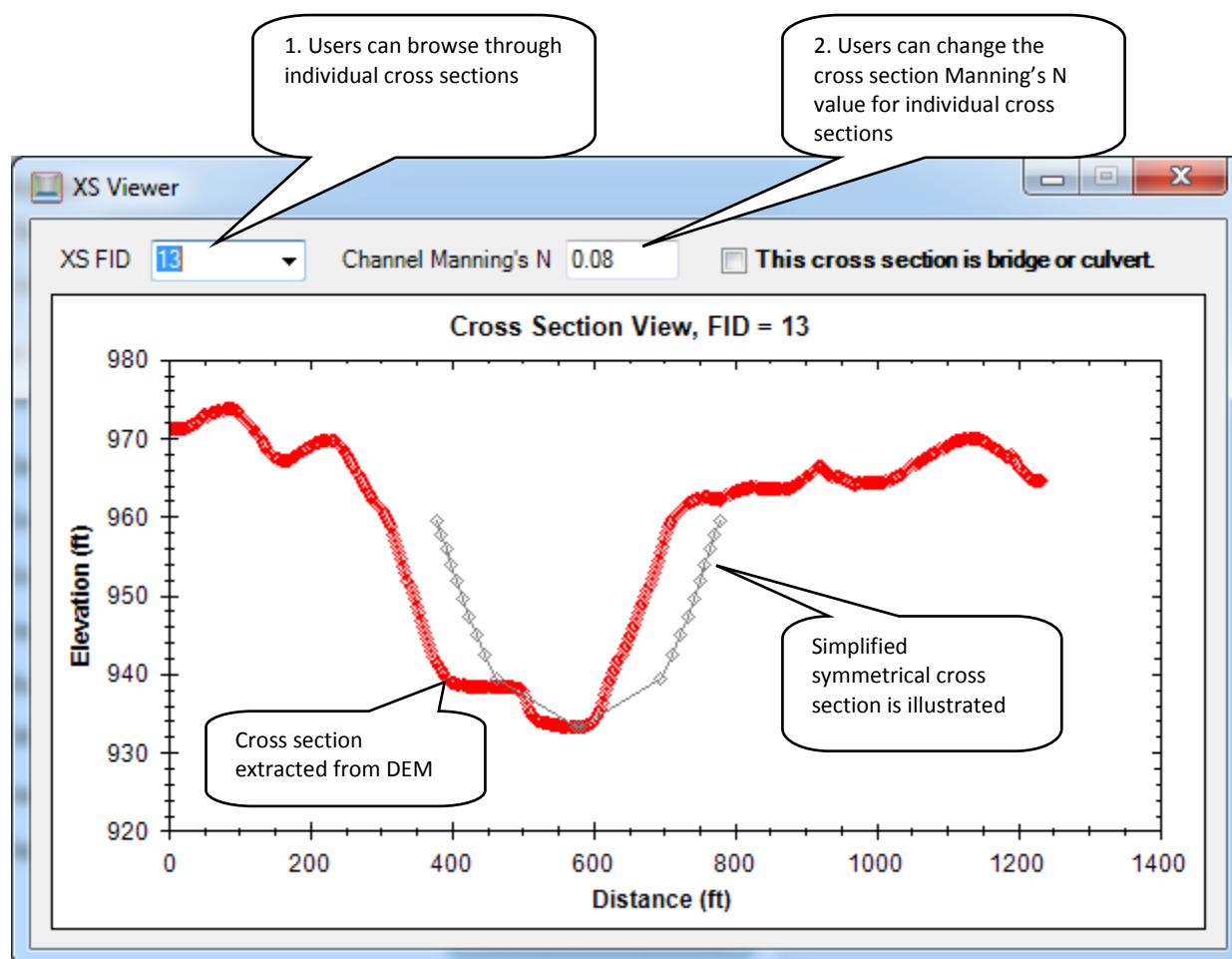
#### View/Edit Cross Sections

The **View/Edit Cross Sections** button is found at the bottom of the **Basic Setup** tab and provides tools for viewing and editing individual cross sections.

1. Click on View/Edit Cross Section to access these tools.



Users can select individual cross sections to view from the drop down menu at the top left. GeoDam-BREACH provides a view of the actual cross section, cut directly from the DEM, and overlaid with an image of the simplified symmetrical cross section used to extract elevation-width data pairs for the SMPDBK input file. Users can individually change the cross section Manning's value for each cross section.



### Adding Rating Curves (optional)

This optional function allows the users to improve the accuracy of GeoDam-BREACH studies that utilize SMPDBK by allowing the SMPDBK results to be overwritten by a more detailed rating curve at hydraulic structures, and then automatically mapping this elevation upstream until SMPDBK elevations exceed the backwater elevations.

To utilize this function, users must place a cross section at the downstream toe of a hydraulic structure and assign a rating curve. The cross section ObjectID can be labeled to enable quick cross referencing with the Cross Section Viewer.

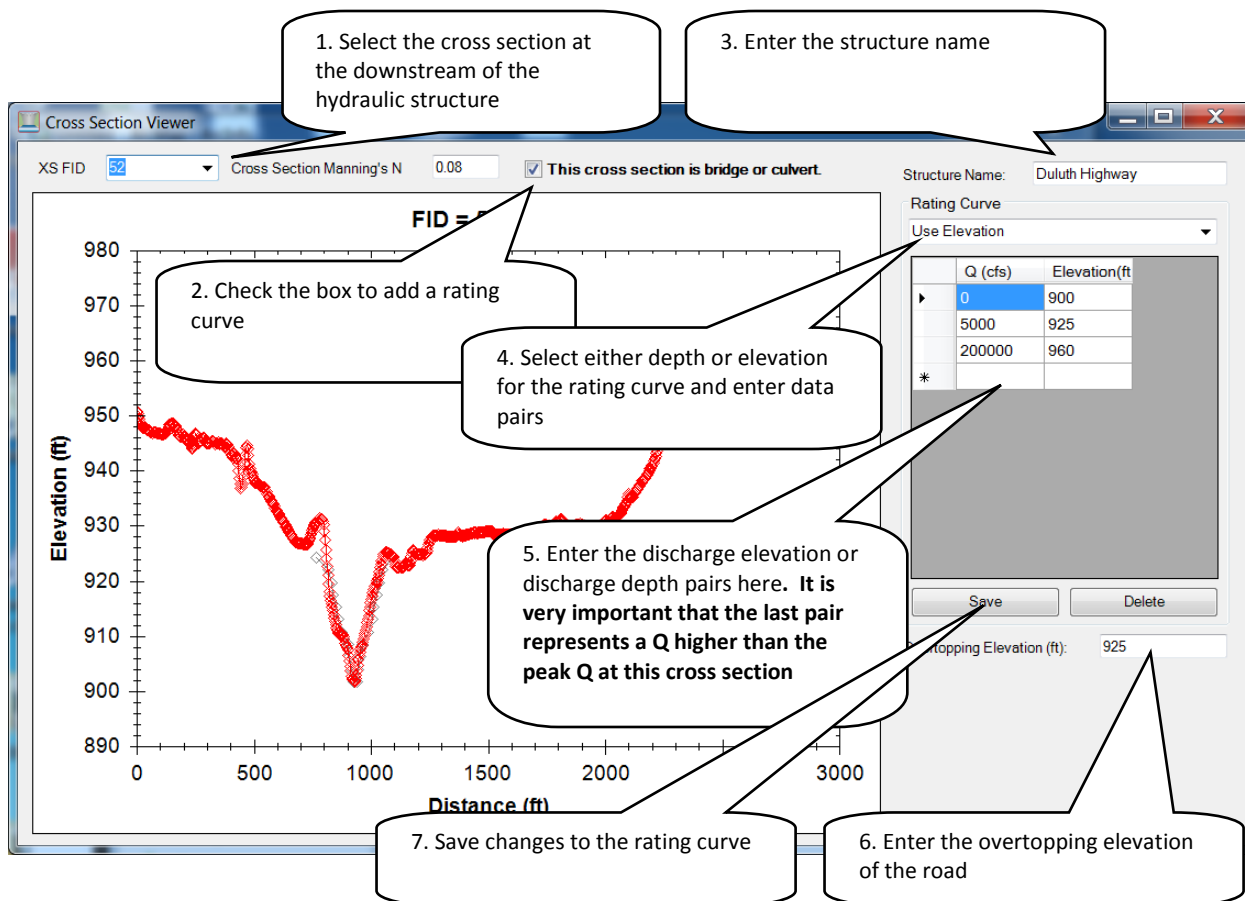


### Rating Curves in GeoDam-BREACH

Rating curves can be determined using other hydraulic models, such as HEC-RAS or monographs. GeoDam-BREACH will initially run SMPDBK and then utilize the peak discharge calculated by SMPDBK at the cross section just downstream of the structure. GeoDam-BREACH will then interpolate the flood elevation from the rating curve. The interpolated elevation will then be applied just upstream of the cross section and inundations and results will be updated to reflect the more detailed flood elevation. GeoDam-BREACH does not consider the additional attenuations created by the rating curve.

Users are recommended to carefully review any rating curves and determine whether they appropriately represent typical conditions experienced during a dam breach, such as blockage and the possibility of structural failure and breaching.

1. To add a rating curve, check the **“This cross section is bridge or culvert”** box in the **Cross Section Viewer**. A new form will appear to the right enabling the rating curve to be entered.



The screenshot shows the 'Cross Section Viewer' window. The main plot area displays a cross-section profile with 'Elevation (ft)' on the y-axis (ranging from 890 to 980) and 'Distance (ft)' on the x-axis (ranging from 0 to 3000). A red line represents the cross-section profile. The 'XS FID' is set to 52, and 'Cross Section Manning's N' is 0.08. The checkbox 'This cross section is bridge or culvert.' is checked. To the right, a 'Structure Name' field contains 'Duluth Highway'. Below this, a 'Rating Curve' section is visible, showing a table with columns 'Q (cfs)' and 'Elevation(ft)'. The table contains three rows: (0, 900), (5000, 925), and (200000, 960). Below the table are 'Save' and 'Delete' buttons. A 'Stopping Elevation (ft):' field is set to 925. Numbered callouts provide the following instructions:

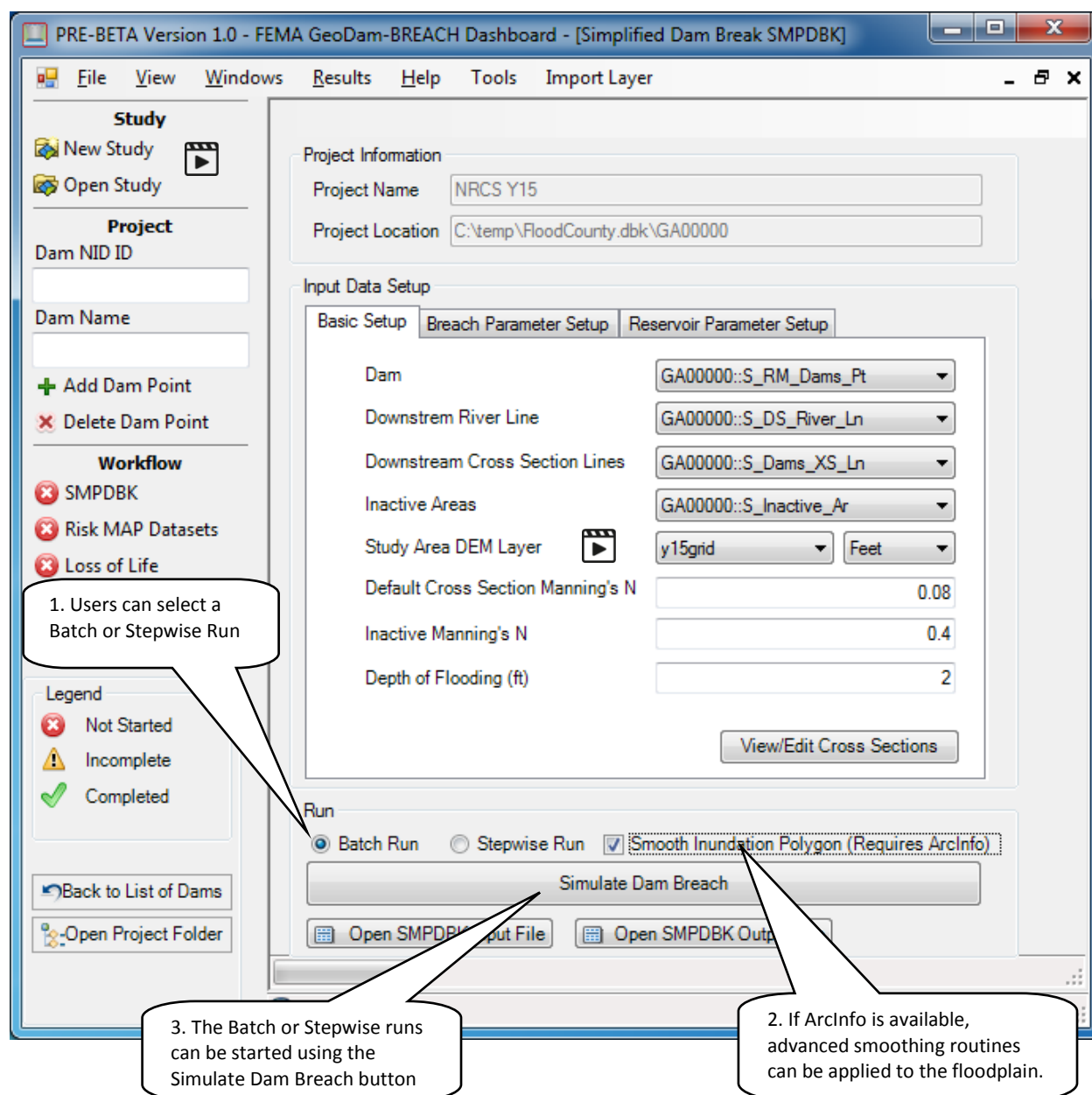
1. Select the cross section at the downstream of the hydraulic structure
2. Check the box to add a rating curve
3. Enter the structure name
4. Select either depth or elevation for the rating curve and enter data pairs
5. Enter the discharge elevation or discharge depth pairs here. It is very important that the last pair represents a Q higher than the peak Q at this cross section
6. Enter the overtopping elevation of the road
7. Save changes to the rating curve

The overtopping elevation represents the elevation at which the road crossing starts to flood. Using this elevation, GeoDam-BREACH internally creates a synthetic hydrograph ordinate that represents the time that the structure begins to overtop. Additionally, it determines at what time the flood recedes to a discharge that does not inundate the road using the rating curve. This allows the time to flood and duration of flooding to be determined for structures modeled using this option.

### ***Running Simulations and Post Processing***

GeoDam-BREACH provides users with two ways to run a SMPDBK simulation and delineate the inundation polygon. The Batch Process allows users to perform one-click simulations and inundation delineation. The Stepwise Process provides users with a less automated, three-click simulation. On first click, users are able to create the SMPDBK input files, review and perform limited editing. On second click, GeoDam-BREACH will execute SMPDBK and allow users to review the output file. The third and final click allows users to perform the inundation delineation.

The Batch and Stepwise Processes are located at the bottom of the SMPDBK User Interface. Once the minimal data requirements have been met, the **Simulate Dam Breach** button will be enabled and can be clicked as illustrated below:

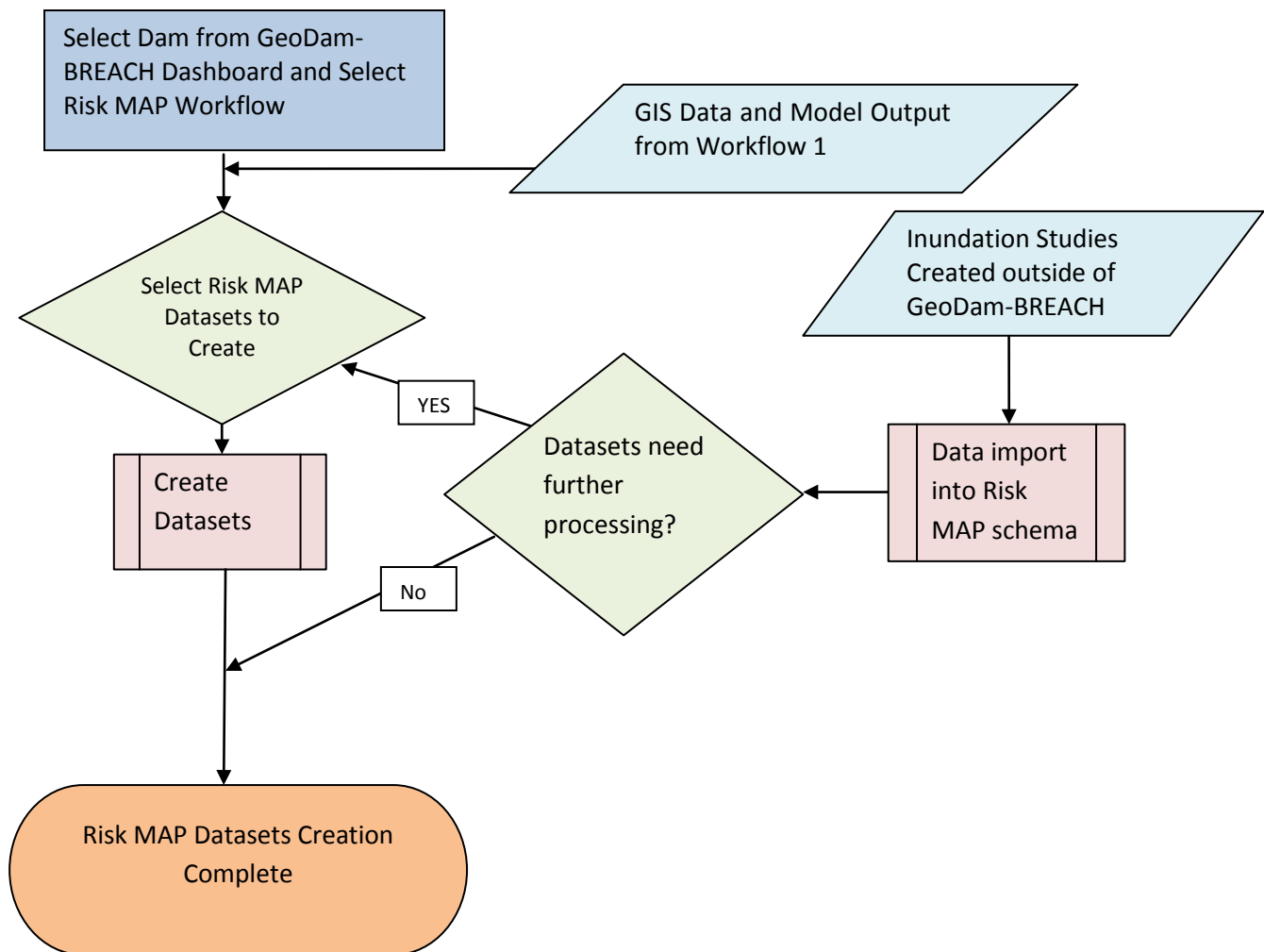


## Viewing SMPDBK Results

The inundation polygon will automatically appear in the ArcMap table of contents as S\_DS\_Inundation\_Ar once the simulation has completed. Along with being stored in the SMPDBK output file located within the SMPDBK folder for that specific dam, model outputs are also stored within a linked database table located within the FGDB and called L\_Dams\_XS\_MDL\_Results. Within this table, the results are linked to the S\_Dams\_XS\_Ln feature class by the DAMS\_XS\_ID field, which is found in both datasets.

## Work Flow 2 – Risk MAP Datasets

The Risk MAP Datasets Workflow is illustrated below in Figure 2.



**Figure 2. Risk MAP Datasets Workflow**

### **Background Information for Risk MAP Datasets.**

Risk MAP Datasets are a compilation of data gathered during a Flood Risk Project. This can include floodplain studies, as well as dam inundation studies. Risk MAP datasets can be used to assess, visualize and communicate flood risk. Risk MAP datasets for dams include a series of vector and raster GIS datasets comprised of inundation depth and analysis grids which communicate various inundation model results such as inundation depth, elevation, arrival time, time to peak, inundation duration and velocity. Full descriptions of these datasets can be found in the draft FEMA document entitled “Proposed Non-Regulatory Flood Risk Datasets – Dams” (Reference 2).

GeoDam-BREACH supports the creation of numerous Risk MAP datasets including:

- Risk MAP Dam Locations (S\_RM\_Dams\_Pt)
- Dams Cross Sections (S\_Dams\_XS\_Ln)
- Dams Cross Section Model Results Lookup Table (L\_Dams\_XS\_MDL\_Results)
- Scenario Lookup Table (L\_Scenario)
- Upstream Inundation (S\_US\_Inundation\_AR)
- Downstream Inundation (S\_DS\_Inundation\_Ar )
- Depth Grid (Dam\_Depth\_[SCENARIO])
- Velocity Grid (Dam\_VEL\_[SCENARIO])
- Flood Wave Arrival Time Grid (Dam\_Arrival\_[SCENARIO])
- Time to Peak Grid (Dam\_Peak\_[SCENARIO])
- Flood Inundation Duration (Dam\_FID\_[SCENARIO])
- Water-Surface Elevation Grid (Dam\_WSE\_[SCENARIO])

Where [SCENARIO] represents the dam breach inundation scenario presented in the dataset, as illustrated in Table 2, Scenario Lookup Table.

Additional Risk MAP-style datasets are created by GeoDam-BREACH including:

- Downstream River Line S\_DS\_River\_Ln
  - Single river baseline starting at the toe of the dam
- Residual Risk Polygons (S\_Res\_Risk\_AR)
  - Polygons that show the additional risk of flooding associated with a dam inundation that is greater than the FEMA Special Flood Hazard Area at a county level
- Distance from Dam Grid (DAM\_DIST\_[SCENARIO])
  - Raster dataset that depicts the distance from the dam for the inundation extents
- Celerity Grid (Dam\_CEL\_[SCENARIO])
  - Raster dataset that depicts the inundation wave celerity for peak discharge

**Table 2. Scenario Lookup Table**

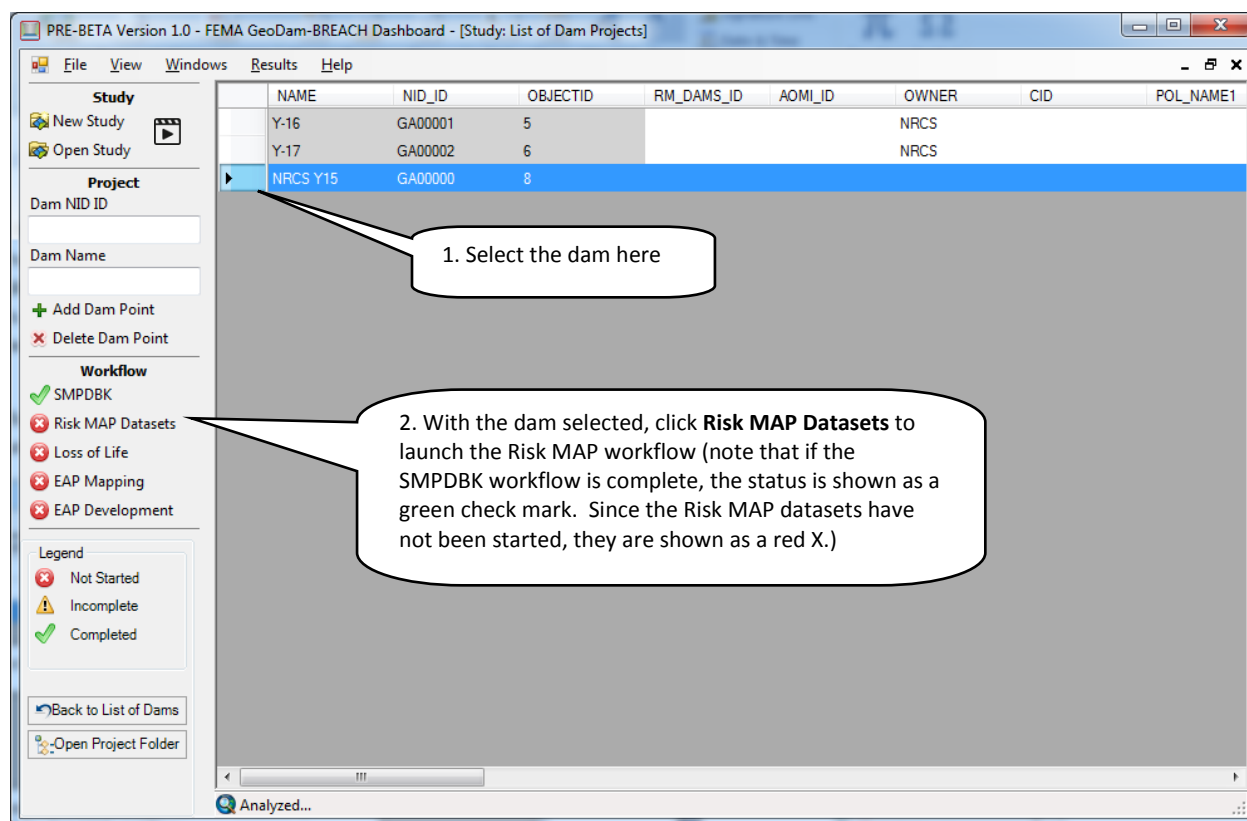
Event (See D_Event)	Release Type (See D_Release_Typ)	Reservoir Condition (See D_Reservoir_Cond)
<b>0_2</b> – 0.2% annual chance event <b>01</b> – 1% annual chance event <b>02</b> – 2% annual chance event <b>04</b> – 4% annual chance event <b>10</b> – 10% annual chance event <b>PMF</b> – Probable Maximum Flood <b>PMF14</b> – ¼ of PMF <b>PMF13</b> – ⅓ of PMF <b>PMF12</b> – ½ of PMF <b>PMF34</b> – ¾ of PMF <b>PMP</b> – Probable Maximum Precipitation <b>PMP14</b> – ¼ of PMP <b>PMP13</b> – ⅓ of PMP <b>PMP12</b> – ½ of PMP <b>PMP34</b> – ¾ of PMP <b>SUN</b> – Sunny Day <b>FOR</b> – Flood of Record (to be described in L_Scenario and metadata)	<u>P</u> iping  <u>O</u> vertop  <u>G</u> ate Failure	<u>F</u> ull  <u>N</u> ormal Pool  <u>A</u> uxiliary Spillway  <u>P</u> rimary Spillway

### Input Data Requirements

The minimum digital data requirement for the Risk MAP Datasets Workflow is either a complete dam break study created from the SMPDBK Pre- and Post-Processing Workflow, or a dam break study created externally with results stored in an ESRI format with appropriate database attributes populated as needed by individual Risk MAP datasets. The comprehensiveness of the externally derived data may influence which Risk MAP datasets can be created.

## Using Risk MAP Datasets Tools

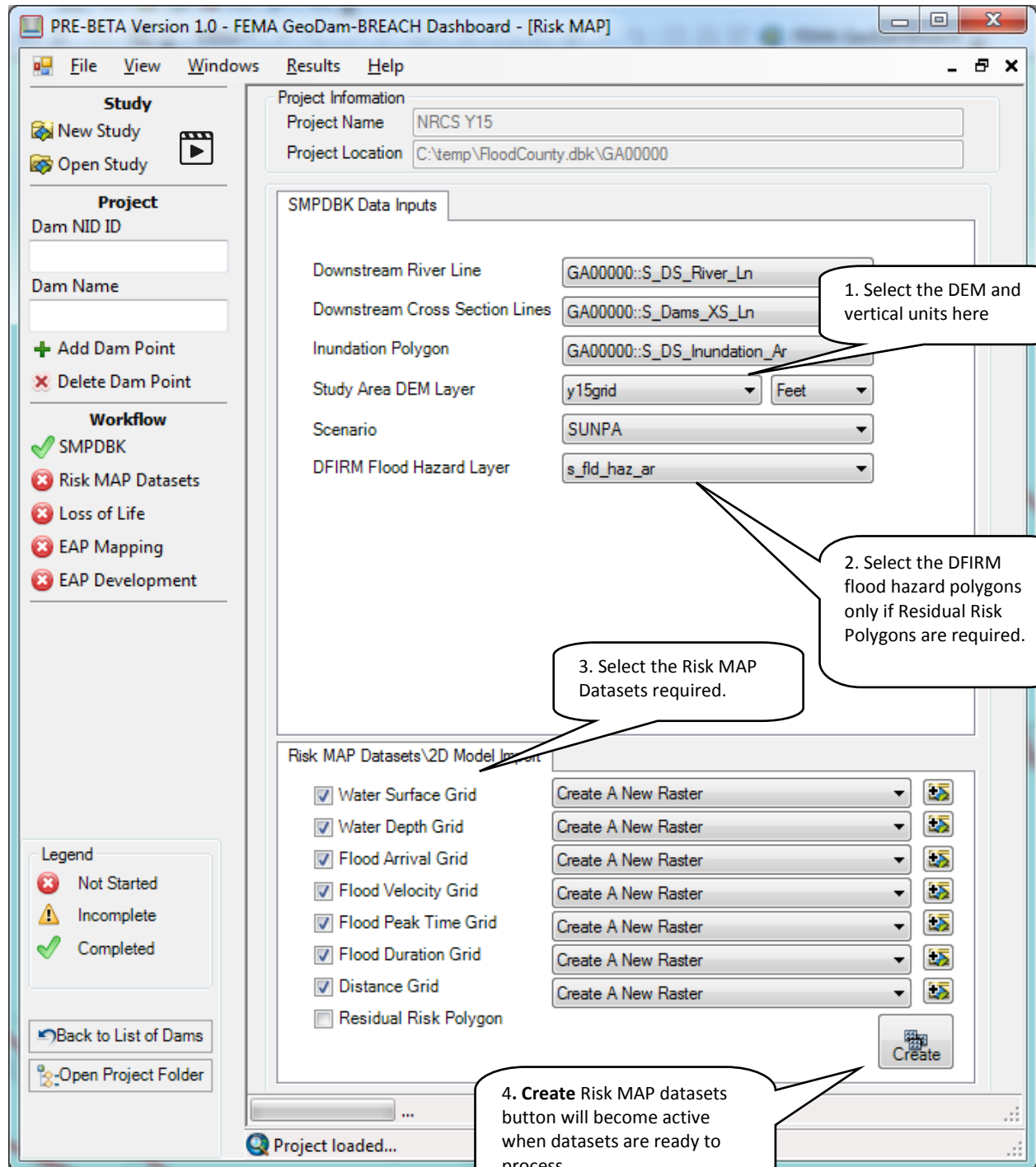
1. To launch the Risk MAP Datasets Workflow, simply highlight the dam in the Dashboard and select the **Risk MAP Datasets** launch button, as illustrated below:



The **Risk MAP Datasets** Workflow provides the user with two approaches for creating Risk MAP datasets. The first approach allows the direct use of inundation studies previously created through the SMPDBK Workflow of GeoDam-BREACH. The second approach allows users to import both vector and raster datasets from inundation studies performed outside of GeoDam-BREACH. This can include 1-D HEC-RAS studies and 2-D models. To be compatible with GeoDam-BREACH, these datasets must be in ESRI compatible formats. If the SMPDBK Workflow is complete, GeoDam-BREACH will automatically launch the Risk MAP toolsets for SMPDBK Data Inputs. If the SMPDBK Workflow has not been performed, then GeoDam-BREACH will automatically open the Import External Datasets toolsets.

## ***Risk MAP Datasets for Inundation Studies Created Using the SMPDBK Pre- and Post-Processing Workflow***

Within the **Risk MAP Datasets** Workflow window, GeoDam-BREACH automatically recognizes river centerlines, cross-section lines, inundation polygons and model results generated from the SMPDBK Workflow. The user must identify the DEM layer to be used for generating Risk MAP datasets. Users can then check the required boxes for individual Risk MAP Datasets.



### ***Risk MAP Datasets for Inundation Studies Created Outside of GeoDam-BREACH***

GeoDam-BREACH allows users to import both vector and raster datasets into the GeoDam-BREACH study using Risk MAP Dataset formats. To import external datasets, users must first initiate a GeoDam-BREACH study and create a dam using the **Add Dam Point** function. This creates the empty schema for Risk MAP products. To create Risk MAP products, the user should select the dam and then select the Risk MAP Datasets Workflow. To import an external dataset, select the **Import External Layers** tab in the Risk MAP Datasets Workflow. The user must then select the Scenario by identifying Release Type, Event Description and Reservoir Condition.

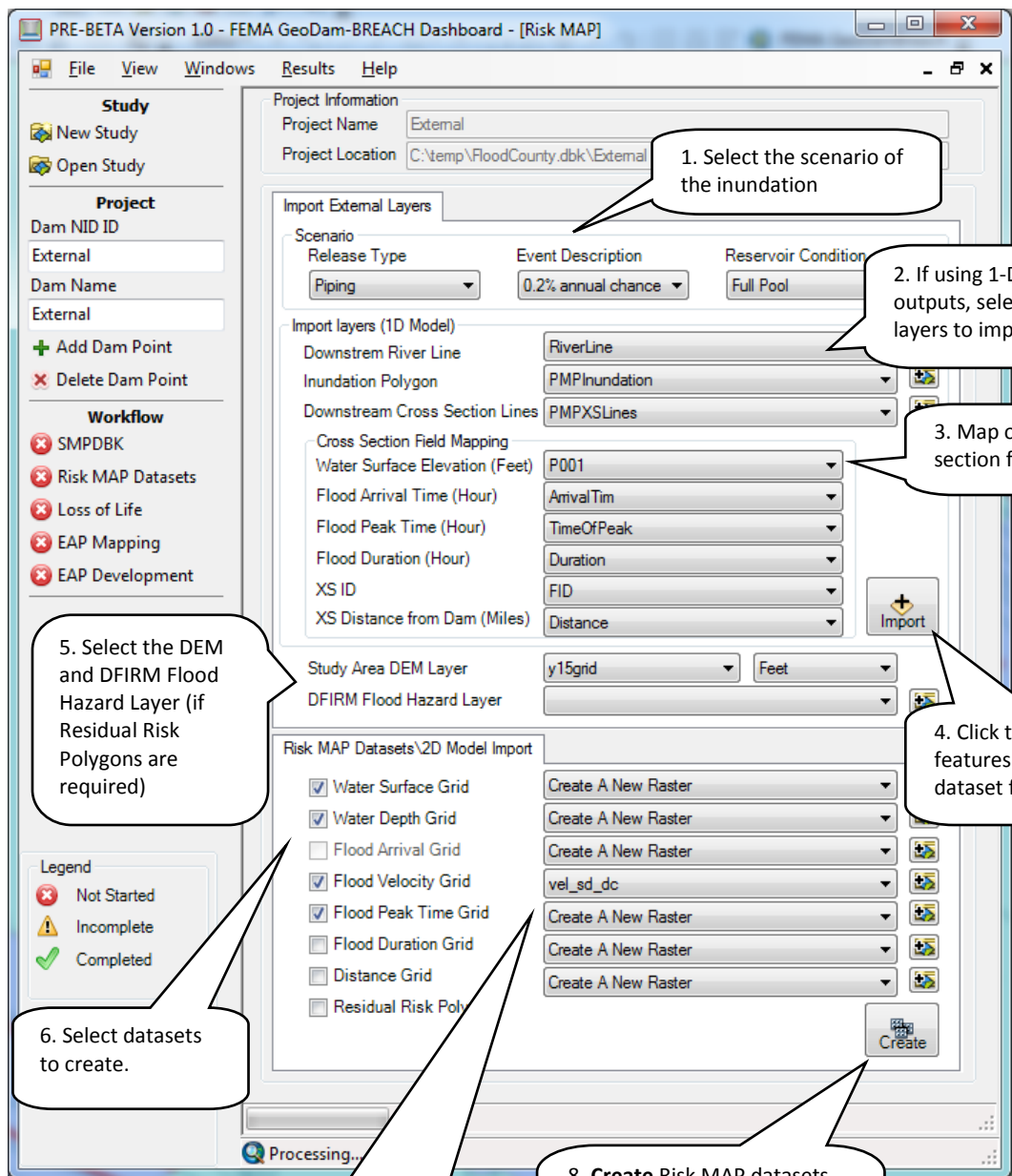
### **Importing Vector 1-D Model Data**

The external datasets must contain the following features and attributes:

- Downstream River Line
  - Single river line digitized from the downstream toe of the dam to the downstream limit of study
- Inundation Polygon
  - Polygons of the resulting inundation
- Cross-section Lines
  - Cross sections indicating alignment attributed with:
    - Water-surface elevation in feet (Double)
    - Flood arrival time in hours (Double)
    - Flood time of peak in hours (Double)
    - Flood Duration in hours (Double)
    - Cross-section ID (Long)
    - Cross-section stationing (Double)

To import the layers into a Risk MAP format, the downstream river line, inundation polygon and downstream cross-section layers must be identified or added through the **Import Layers (1-D Model)** section of the Import External Layers tab. The cross-section attributes must then be mapped as illustrated in the next image.

Once these layers are selected and the cross-section fields are mapped, the data is ready to import using the **Import** button.



**PRE-BETA Version 1.0 - FEMA GeoDam-BREACH Dashboard - [Risk MAP]**

**Study**

- New Study
- Open Study

**Project**

Dam NID ID: External

Dam Name: External

+ Add Dam Point

- Delete Dam Point

**Workflow**

- ☒ SMPDBK
- ☒ Risk MAP Datasets
- ☒ Loss of Life
- ☒ EAP Mapping
- ☒ EAP Development

**Legend**

- ☒ Not Started
- ☒ Incomplete
- ☒ Completed

**Project Information**

Project Name: External

Project Location: C:\temp\FloodCounty.dbk\External

**Import External Layers**

Scenario: **1. Select the scenario of the inundation**

Release Type: Piping

Event Description: 0.2% annual chance

Reservoir Condition: Full Pool

**Import layers (1D Model)**

Downstream River Line: RiverLine

Inundation Polygon: PMPInundation

Downstream Cross Section Lines: PMPXSLines

**Cross Section Field Mapping**

Water Surface Elevation (Feet): P001

Flood Arrival Time (Hour): ArrivalTim

Flood Peak Time (Hour): TimeOfPeak

Flood Duration (Hour): Duration

XS ID: FID

XS Distance from Dam (Miles): Distance

**3. Map out the cross section fields**

**Study Area DEM Layer**: y15grid

**DFIRM Flood Hazard Layer**

**4. Click to Import 1-D features into Risk MAP dataset formats**

**Risk MAP Datasets\2D Model Import**

- ☒ Water Surface Grid: Create A New Raster
- ☒ Water Depth Grid: Create A New Raster
- ☐ Flood Arrival Grid: Create A New Raster
- ☒ Flood Velocity Grid: vel\_sd\_dc
- ☒ Flood Peak Time Grid: Create A New Raster
- ☐ Flood Duration Grid: Create A New Raster
- ☐ Distance Grid: Create A New Raster
- ☐ Residual Risk Poly: Create A New Raster

**5. Select the DEM and DFIRM Flood Hazard Layer (if Residual Risk Polygons are required)**

**6. Select datasets to create.**

**7. If new features are to be developed from 1-D data, then select **Create a New Raster**. If 2-D model grids or 1-D model grids developed outside of GeoDam-BREACH are to be imported into the Risk MAP format, then select or browse to these files.**

**8. Create Risk MAP datasets button will become active when datasets are ready to process.**

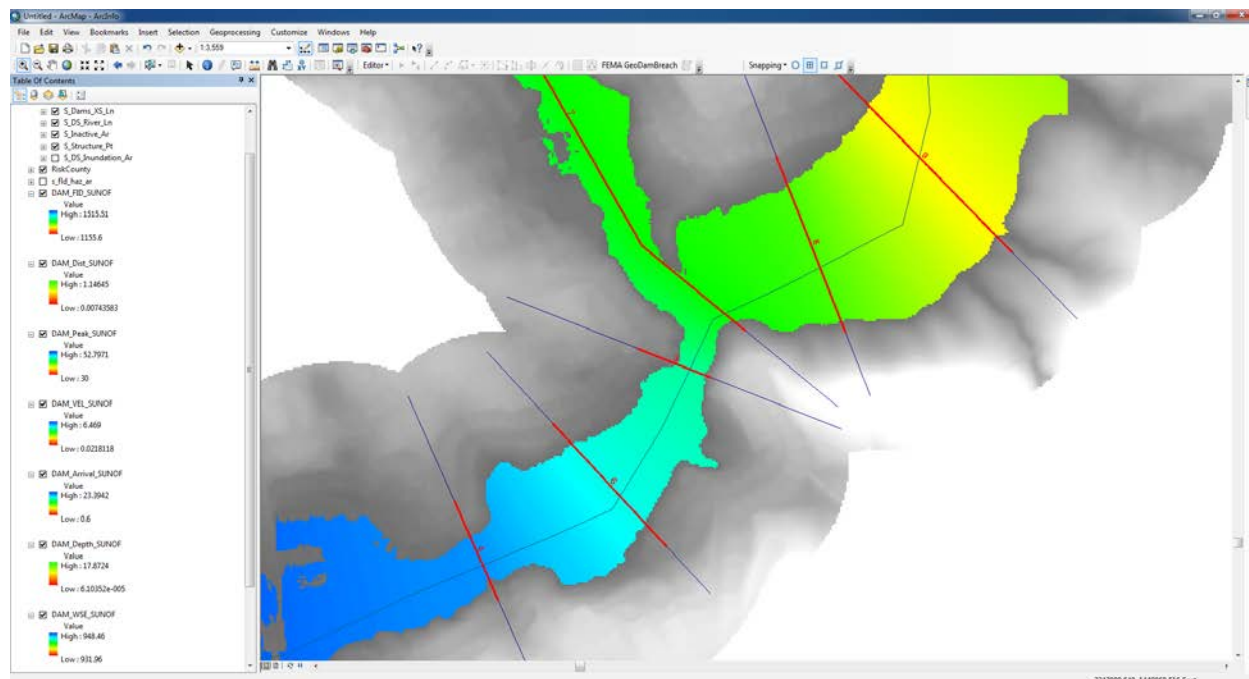
**Import**


**Create**

Processing...

## Viewing Results

Once GeoDam-BREACH has finished creating Risk MAP Datasets, these datasets will automatically appear in the ArcMap Table of Contents and can be turned on and off as desired. The raster values can be queried using the standard ArcMap Identify function, which allows users to click on any feature and query the raster or vector values and attributes.



If datasets do not appear after the “Risk MAP Datasets Complete” message appears, they can be manually added by opening up the project folder using the  **Open Project Folder** in the bottom left of the Dashboard and browsing to the GISData folder and adding the datasets from the root of the DamBreach.gdb FGDB.

All data is stored within the study folder (.dbk). Tabular and raster data is stored at the root level of the database:

`\\[NID ID]\\GISDATA\\damBreach.gdb\\RiskMAP`

Vector data is stored in the RiskMAP feature dataset:

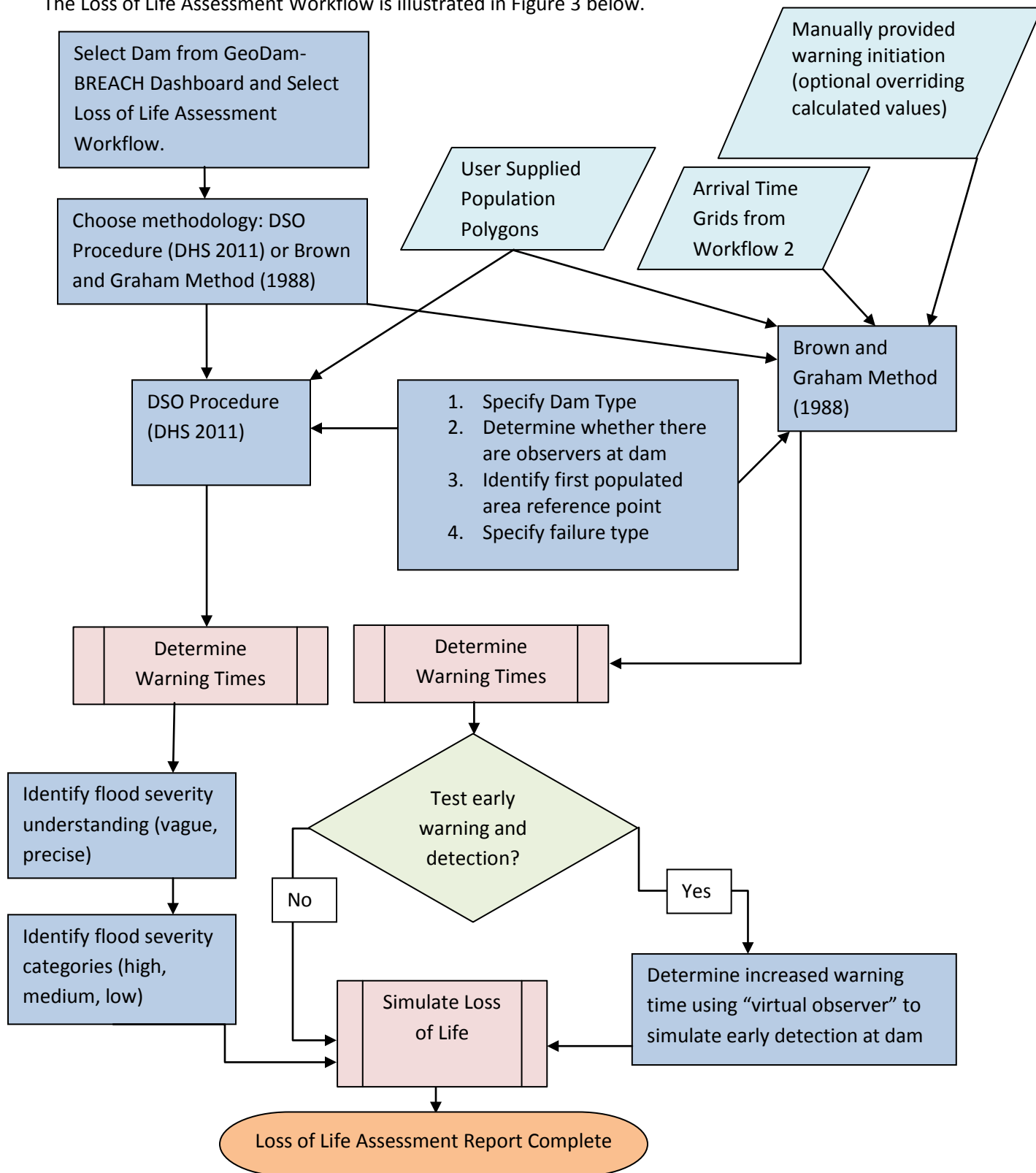
`\\[NID ID]\\GISDATA\\damBreach.gdb\\RiskMAP`

The vector cross sections are stored in a linked database table located within the FGDB and called L\_Dams\_XS\_MDL\_Results. Within this table, the results are linked to the S\_Dams\_XS\_Ln feature class by the DAMS\_XS\_ID field found in both datasets:

`[Study Folder .dbk] \\[NID ID]\\GISDATA\\damBreach.gdb\\RiskMAP`

### Work Flow 3 – Loss of Life Assessment

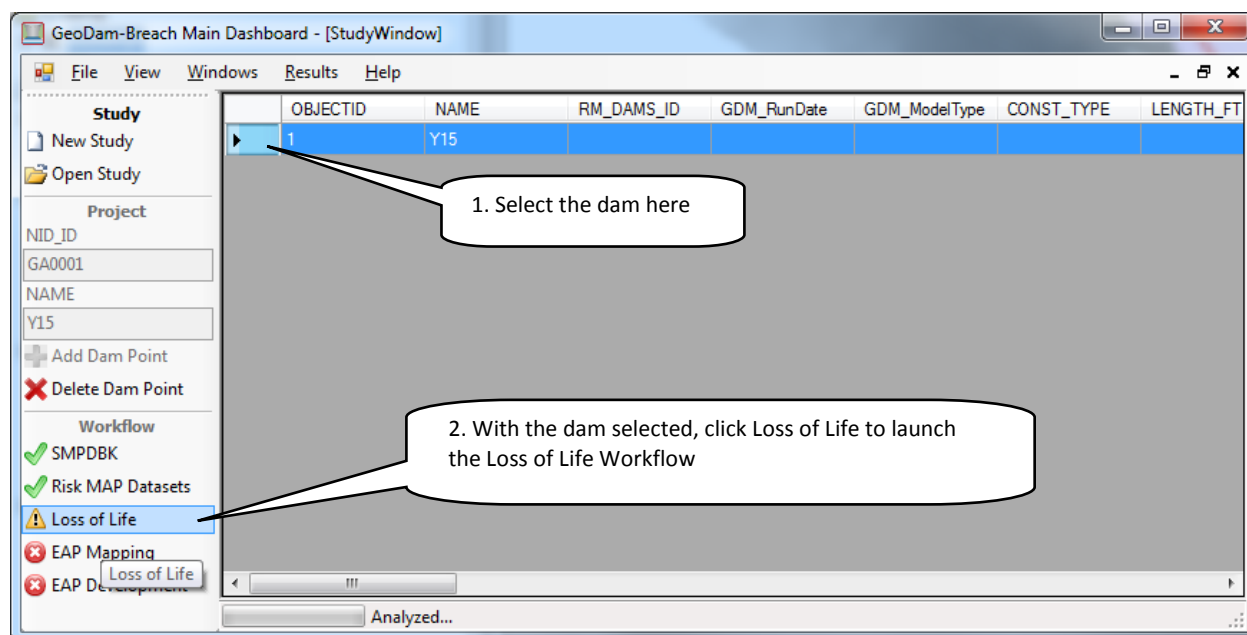
The Loss of Life Assessment Workflow is illustrated in Figure 3 below.



**Figure 3. Loss of Life Assessment Workflow**

## Using Loss of Life Tools

1. To launch the Loss of Life Workflow, simply highlight the dam in the Dashboard and select the **Loss of Life** button as illustrated below:



The Loss of Life user interface will now appear.

Two methods for calculating the probable Loss of Life are presented in the GeoDam-BREACH program. These two methods are presented in the DHS (2011) document *Dam Sector: Estimating Loss of Life for Dam Failure Scenarios* (Reference 3):

- Bureau of Reclamation DSO-99-06 Flood Severity Method
- Brown and Graham Method

Users are expected to have a thorough understanding of the inputs, methods and limitations of both methods.

## DSO Procedure

The DSO Procedure is the recommended method for estimating loss of life resulting from dam failure. This procedure is based on an analysis of dam failures, flash floods and floods located in the U.S. The procedure can be used to estimate when a dam failure warning would be initiated. It provides estimated fatality rates based on flood severity, warning time and warning quality that can be used to estimate the probable loss of life from a dam failure (Reference 3). Advantages and limitations to this procedure are provided in the DHS document. The DHS procedure provided within GeoDam-BREACH is based on the DSO document *A Procedure for Estimating Loss of Life Caused by Dam Failure*, DSO-99-06, September 1999 (Reference 4).

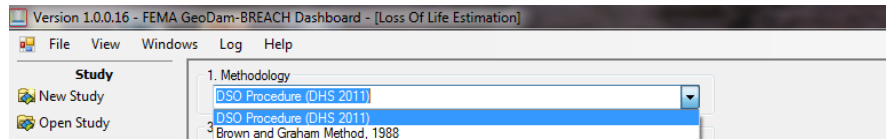
## Input Data Requirements

To perform a probable loss of life assessment using the DSO Procedure, GeoDam-BREACH requires a digital dataset containing the structures/buildings downstream of the dam and attribute fields with the daytime and nighttime population of each structure. Additionally, GeoDam-BREACH requires user input to determine the warning initiation and flood severity including:

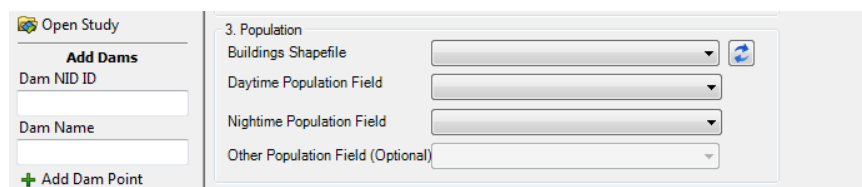
- Dam type (earthen, concrete)
- Failure type
  - Failure caused by piping during normal weather conditions,
  - Failure caused by an earthquake during normal weather conditions,
  - Failure caused by a flood which results in high reservoir levels or dam overtopping, and
  - Failure caused by intentional human actions under highest reasonable reservoir levels (worst reasonable conditions)
- Are there observers at the dam? (yes, no)
- Failure period (immediate, delayed)
- Drainage area of the dam (less than or greater than 100 sq. mi.)
- Flood severity understating (vague, precise)
- Flood severity categories (high, medium, low)

## Steps for Using the DSO Procedure to Estimate the Probable Loss of Life

1. Methodology - Select the “DSO Procedure (DHS 2011)” from the methodology drop-down box.



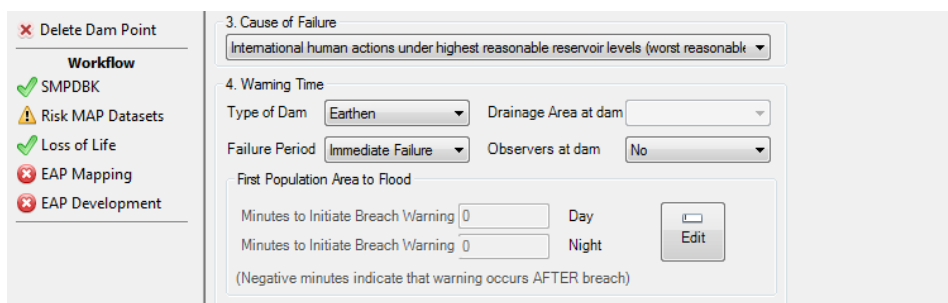
2. Population - Select the GIS shapefile that contains the buildings/structures downstream of the dam, as part of this study. Next, select the attribute fields containing the daytime and nighttime population data.



3. Cause of Failure - Select the cause of failure associated with this study. Depending on the dam type and reservoir condition selected in Work Flow 1 SMDBK, only applicable failure scenarios will appear for selection.
4. Warning Time - This step is used to estimate when a dam failure warning would be initiated. To estimate the breach warning time at the first area downstream of the dam that may be flooded, the following information is needed:
  - Type of dam: This field will automatically be populated from the selection of dam type made in Work Flow 1.

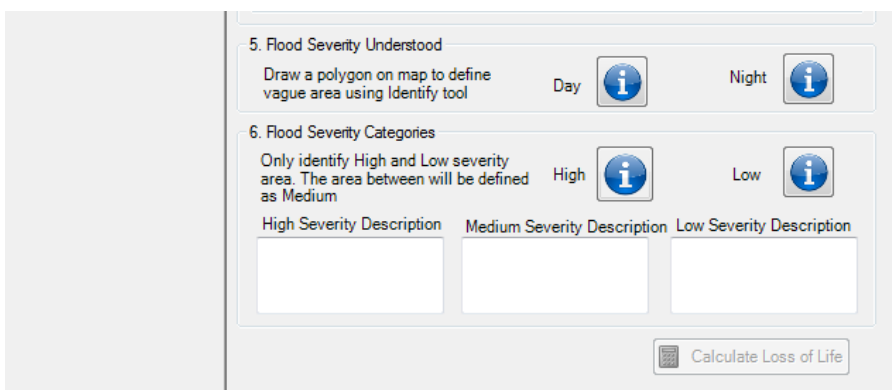
- Failure Period: Immediate or delayed. (this field is only applicable to seismic dam failures)
- Drainage Area at dam: Less than or greater than 100 sq. miles.
- Observers at dam: Yes or No. A “yes” means that a dam tender lives on high ground and within sight of the dam, the dam is visible from the homes of many people, or the dam crest serves as a heavily used roadway. These dams are typically in urban areas. A “no” means that there is no dam tender at the dam, the dam is out of sight of nearly all homes, and there is not a roadway on the dam rest. These types of dams are typically in remote areas.

For earthen dams, the GeoDam-BREACH program will calculate the breach warning initiation time based on the criteria entered above. The calculated times may be edited by selecting the **Edit** button to the left of the calculated time results. For concrete dams, the user is responsible for manually entering an appropriate breach warning initiation time for both day and night conditions.



The screenshot shows the 'Cause of Failure' and 'Warning Time' sections of the GeoDam-BREACH software. On the left is a 'Workflow' sidebar with options: 'Delete Dam Point' (with a red X icon), 'SMPDBK' (with a green checkmark), 'Risk MAP Datasets' (with a yellow warning triangle), 'Loss of Life' (with a green checkmark), 'EAP Mapping' (with a red X icon), and 'EAP Development' (with a red X icon). The main panel has a dropdown for 'Cause of Failure' set to 'International human actions under highest reasonable reservoir levels (worst reasonable)'. Below this is the 'Warning Time' section with 'Type of Dam' set to 'Earthen', 'Drainage Area at dam' as an empty field, 'Failure Period' set to 'Immediate Failure', and 'Observers at dam' set to 'No'. Under 'First Population Area to Flood', there are input fields for 'Minutes to Initiate Breach Warning' for 'Day' and 'Night', both set to '0'. An 'Edit' button is next to the 'Night' field. A note at the bottom states: '(Negative minutes indicate that warning occurs AFTER breach)'.

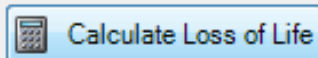
5. Flood Severity Understanding - Select the flood severity understanding of the downstream conditions from a dam failure for both day and night. Draw a polygon around the vague understanding area downstream of the dam. All other areas within the inundation boundary not contained within the vague understating area will be associated with a precise flood severity understanding.




The screenshot shows the 'Flood Severity Understanding' and 'Flood Severity Categories' sections of the GeoDam-BREACH software. The 'Flood Severity Understanding' section has a text box 'Draw a polygon on map to define vague area using Identify tool' and buttons for 'Day' and 'Night', each with an information icon (i). The 'Flood Severity Categories' section has a text box 'Only identify High and Low severity area. The area between will be defined as Medium' and buttons for 'High' and 'Low', each with an information icon (i). Below these are three text input fields: 'High Severity Description', 'Medium Severity Description', and 'Low Severity Description'. At the bottom right is a button labeled 'Calculate Loss of Life'.

The DSO Procedure (Reference 3) uses the term “Flood Severity Understanding” to describe the degree to which the events about to unfold are understood. These are classified into two categories:

- Vague Understanding: Warning issuers have not yet seen the dam fail or do not comprehend the true magnitude of the flood that is about to ensue. Dam failure is a possibility, but not certain to occur. Less forceful warnings are anticipated.
  - Precise Understanding: Warning issuers have an excellent understanding of the flooding due to observations of the flooding. Dam failure is in progress or has occurred. Strong and forceful warnings are anticipated with this type of warning.
6. Flood Severity Categories - Identify and select the flood severity categories of high, medium and low associated with the downstream flood severity conditions. Draw a polygon around the high flood severity category area by selecting the **high** button. If a high flood severity area does not exist, omit this step. Next, define the low flood severity area by drawing a polygon around that area using the **low** button. An area within the inundation boundary that is not contained within a high or low flood severity category polygon is automatically considered a medium flood severity area. Guidance is provided in the DHS publication for selecting the flood severity categories.
  7. Provide a description of each flood severity category including upstream and downstream limits, a description of the land use or habitants, number of buildings, etc., as appropriate. This description is not used in the procedure for calculations, but is included in the output results along with the calculated population at risk in each flood severity category.
  8. Calculating Loss of Life - Once all of the data is entered into the GeoDam-BREACH program for this methodology, select the **Calculate Loss of Life** button to determine the probable loss of life using the DSO Procedure.



9. Viewing Results - GeoDam-BREACH automatically saves the results of the loss of life assessment inside the GeoDam-BREACH study folder (.dbk). In the folder of the individual dam, the loss of life report is stored within the LossOfLifeDSO folder in Microsoft Word format.



**GeoDam-BREACH**  
Geospatial Dam Break, Rapid EAP,  
Consequences, and Hazards

**Report: Probable Loss of Life Assessment for Name**

Dam Name:	Name
NID ID:	ID
Dam Type:	Earthen
Loss of Life Assessment Method:	DSO Procedure (DHS 2011)

**Dam Break Scenario Information**

Event:	Sunny Day
Cause of Failure:	Failure caused by flood which results in high reservoir levels or dam overtopping
Observers at Dam:	No
Daytime Dam Failure Warning Initiation:	60 minutes
Nighttime Dam Failure Warning Initiation:	30 minutes

**Inundation Description**

The inundation study for Name was created using FEMA's GeoDam-BREACH GIS toolset which uses the National Weather Service's Simplified Dam Break model (SMPDBK) to estimate breach flows and elevations. The model was run on Wednesday, October 09, 2013.

**Population Source**

UNKNOWN - Please provide here.

## Brown and Graham Procedure

The Brown and Graham procedure is an older approach than the DSO procedure flood Severity method. Although it is recommended that the DSO procedure flood severity method be used, the Brown and Graham procedure provides a simplified approach that requires less input data. Advantages and limitations to this procedure are provided in the DHS document. The Brown and Graham procedure provided within GeoDam-BREACH is based on the DSO document *A Procedure for Estimating Loss of Life Caused by Dam Failure*, DSO-99-06, September 1999 (Reference 4).

### Background Information for Loss of Life Estimation Using the Brown and Graham Method

Warning time used in the equations is defined as the elapsed time between the initiation of an official evacuation warning to the public and the arrival of dangerous flooding to the population at risk (PAR). Warning time must therefore consider the time it takes for flood water to reach the community or group of people at risk.

When warning time is less than 15 minutes:

$$\text{Loss of Life} = 0.5 \times (\text{PAR})$$

When warning time is between 15 and 90 minutes:

$$\text{Loss of Life} = \text{PAR}^{0.6}$$

When warning time is more than 90 minutes:

$$\text{Loss of Life} = 0.0002 \times (\text{PAR})$$

It is easy to see that the loss of life estimate based on these relationships will vary widely depending on the warning time. With 5,000 people at risk, loss of life from dam failure could be as much as 2,500 people if these people are located in an area that receives less than 15 minutes of warning. In comparison, the estimated loss of life would be 1 if the PAR is located in an area that receives more than 90 minutes of warning.

### **Input Data Requirements**

To perform a probable loss of life assessment, GeoDam-BREACH requires the following digital datasets:

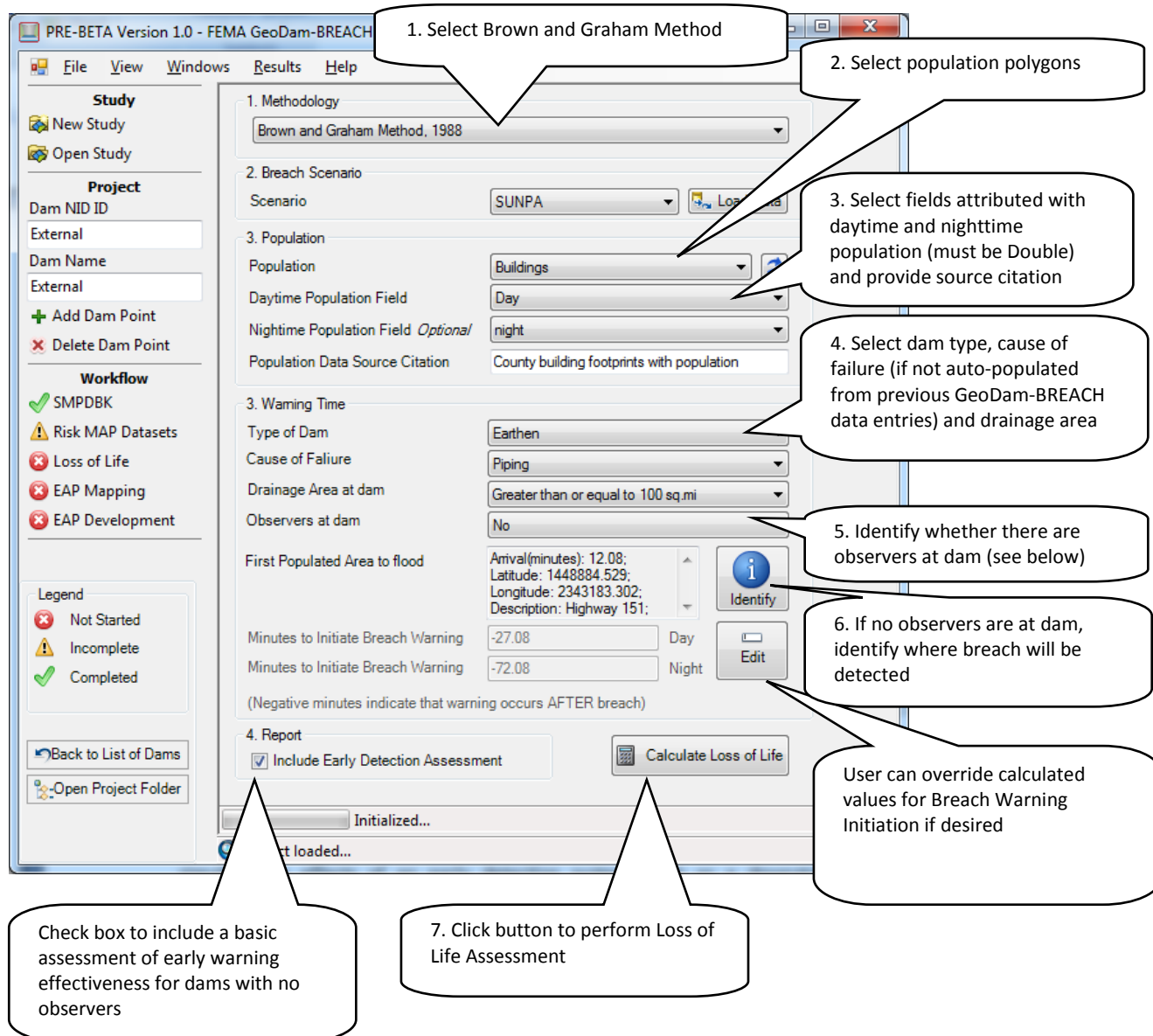
- Arrival time grid (created during Workflow 2 or referenced outside of GeoDam-BREACH)
- Population polygons (polygons populated with population data)

Additionally, GeoDAM-BREACH requires user input to determine the warning initiation. If fully attributed in the S\_Dam\_Pts Risk MAP dataset, much of this data will be automatically populated:

- Dam type (Earthen, Concrete)
- Failure type (seismic, overtopping, etc.)
- Are there observers at the dam?
- How long until the inundation reaches the first downstream populated area (for dams with no observers or automatic breach detection to detect failure)?

### ***Calculating Warning Time***

GeoDam-BREACH uses the recommendations of DSO 99-06, specifically Table 2 on Page 15 of Reference 4, to estimate when dam failure warnings would be initiated. For concrete dams, GeoDam-BREACH utilizes the procedures for earthen dams with the assumption that the breach warning is initiated no earlier than breach initiation.



## 1. Methodology

**Methodology** allows users to select the method for assessing Loss of Life.

## 2. Breach Scenario

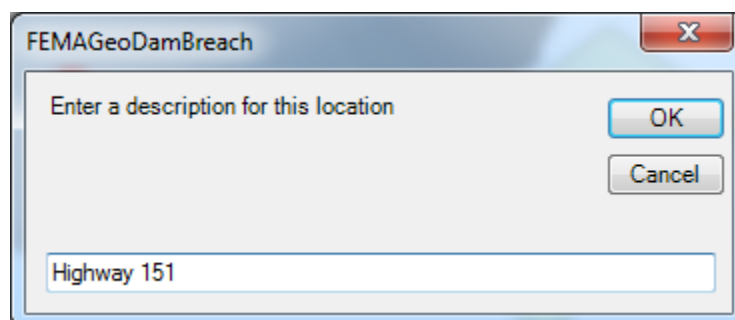
This allows the user to select which scenario to assess. Currently GeoDam-BREACH only supports running one scenario.

## 3. Warning Time

If the type of dam and cause of failure have already been identified previously within GeoDam-BREACH, these fields will be automatically populated. The **Drainage Area at Dam** is required for earthen dams.

If there are no observers at the dam, then the inundation is unlikely to be detected until it reaches the first populated area downstream. This can cause a significant delay in detecting the breach. A

populated area can be a busy road or a subdivision. Users must use their judgment when selecting where the breach will first be detected. To identify this area, click on the **Identify** button within the Loss of Life interface. GeoDam-BREACH will then prompt the user to identify the location by clicking within the inundation and providing a description of the area where the inundation will first be detected.



GeoDam-BREACH will use this area to determine from the arrival time grid how long after the breach initiation the flood wave arrived, and will then calculate the appropriate warning initiation delay.

The override defaults allow users to provide their own values for a daytime and nighttime breach warning initiation. If the warning occurs after the breach, then values should be entered as negative values in minutes.

#### 4. Report

For dams that do not have an observer, GeoDam-BREACH provides an option that automatically performs an additional calculation that assumes there is an observer at the dam. An observer can also simulate the effects of an early detection system, such as a downstream gage that is remotely monitored, thereby creating a virtual observer. When using this option, GeoDam-BREACH automatically provides a summary of the potential reduction in Loss of Life.

To utilize this option, simply check the box titled **Include Early Detection Assessment**.

#### *Calculating Loss of Life*

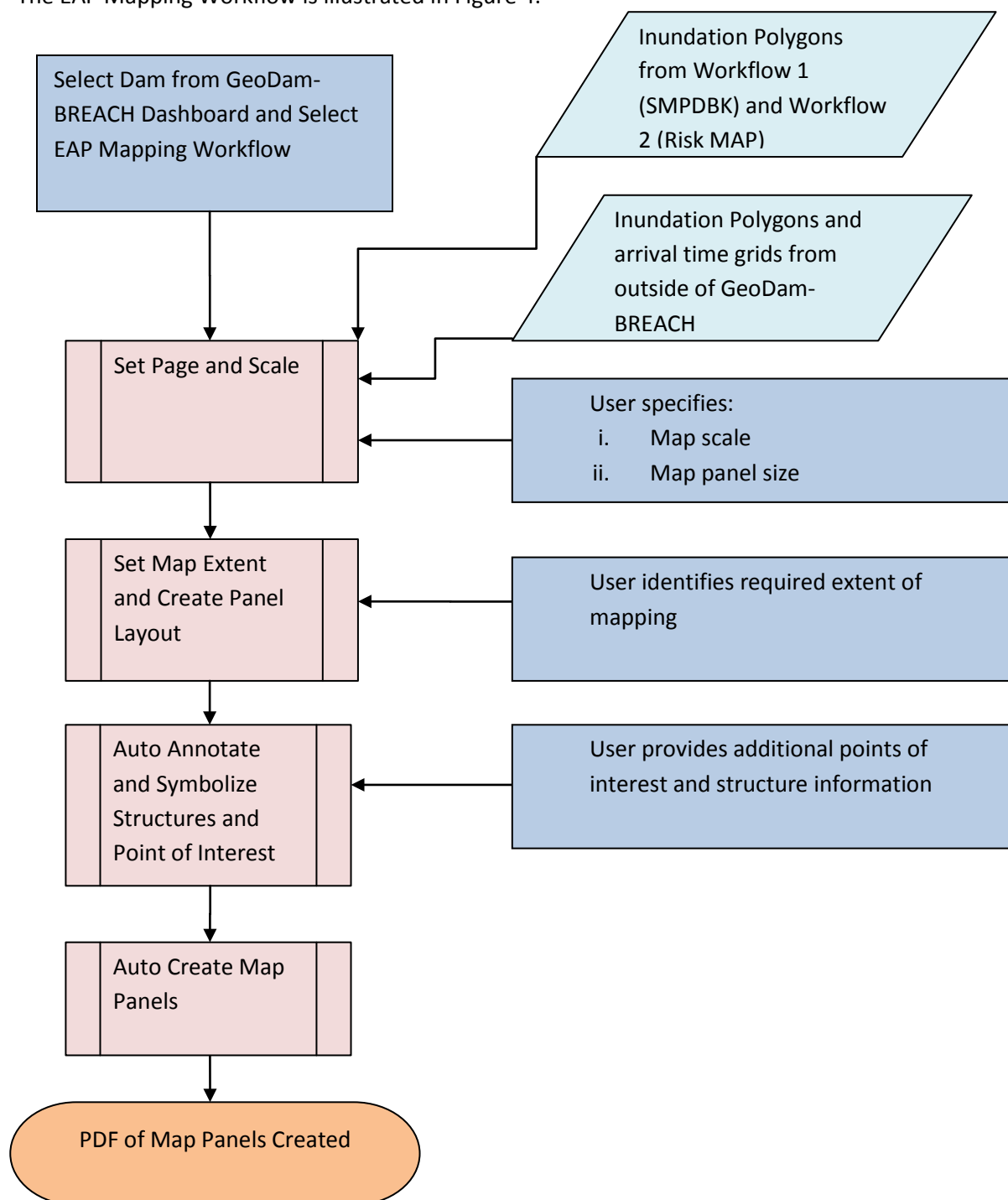
Once all data is entered for the Loss of Life calculation, the user can select **Calculate Loss of Life**. GeoDam-BREACH will determine the warning provided to each individual population polygon based on the breach warning initiation and arrival time. GeoDam-BREACH will then calculate the PAR for various time intervals and apply empirical equations for loss of life.

#### **Viewing Results**

GeoDam-BREACH automatically saves the results of the Loss of Life assessment inside the GeoDam-BREACH study folder (.dbk). Within the folder for the individual dam, the Loss of Life Report is stored within the LossOfLife folder in Microsoft Word format. Users will be prompted to open the report once it is complete.

## Work Flow 4 – EAP Mapping

The EAP Mapping Workflow is illustrated in Figure 4.



**Figure 4. EAP Mapping Workflow**

This workflow was designed to produce an EAP map that is editable in GIS. The user should expect to edit the maps for text overlaps, style and sizing exterior of the toolset.

### Input Data Requirements

To create EAP maps, users are **recommended** to provide the following GIS base map elements not provided by GeoDam-BREACH so that map users will have visual points of reference:

- Aerial imagery (highly recommended)
- Vector road feature for labeling of road names (highly recommended)
- Corporate limits for labeling of county and city boundaries (highly recommended)
- Parcels
- Building footprints
- Other features as required by user

The following datasets, which must be created or imported during the SMPDBK and/or Risk MAP Workflows, are **required** for the EAP map creation:

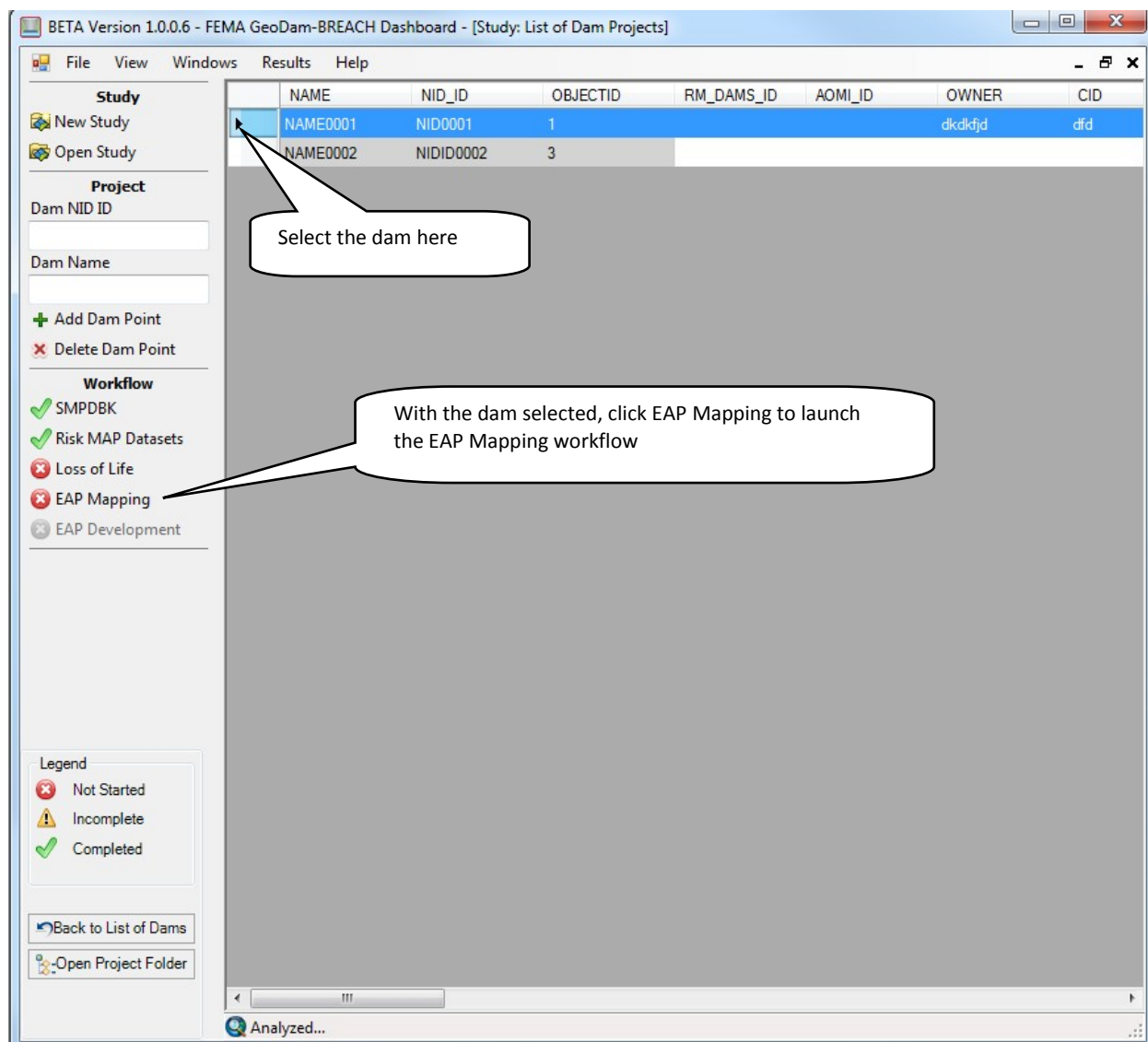
- Dam points (from S\_RM\_Dams\_Pt created from Dashboard)
- Stream Centerline (S\_DS\_River\_Ln created during SMPDBK or Risk MAP Workflows)
- Inundation Polygon (S\_DS\_Inundation\_Ar created during SMPDBK or Risk MAP Workflows)

Additional datasets created during the SMPDBK and/or Risk MAP Workflows are **recommended** and will facilitate auto annotation for road crossings and points of interest:

- Structure Points for automatic labeling of time to overtop, depth of over topping and duration of overtopping for road crossings (S\_Structure\_Pt created during SMPDBK from rating curves)
- Upstream Reservoir for automatic display of upstream reservoir (S\_US\_Inundation\_Ar created or imported during SMPDBK and/or Risk MAP Workflows)
- Arrival Time Grid for automated labeling of arrival time for points of interest (DAM\_Arrival\_[event scenario] created or imported during Risk MAP Workflow)
- Depth Grid for automated labeling of depth for points of interest (DAM\_Depth\_[event scenario] created or imported during Risk MAP Workflow)
- Inundation Duration Grid for automated labeling of inundation duration for points of interest (DAM\_FID\_[event scenario] created or imported during Risk MAP Workflow)

### Using the EAP Mapping Tools

To launch the EAP Mapping Workflow, highlight the dam in the Dashboard and click the **EAP Mapping** button (see illustration below).



Note: Clicking the **EAP Mapping** button will launch the Map Panel Generation Dashboard and create a new map document (8x11M.mxd). The current map must be saved before clicking **EAP Mapping**.

### ***Creating Individual Map Panels***

1. Open ArcMap. Make sure the current map document is saved (clicking the **EAP Mapping** button will create a new map document 8x11M.mxd). Clicking the **EAP Mapping** button also launches the Map Panel Generation Dashboard (see illustration below). The following sections will help to complete the Map Panel output:
  - a. Output Location, Page Size, Map Scale
  - b. Map Title
  - c. Set Extent and Create Panels
  - d. Customizing Map Panels Annotation & Structures and Points of Interest Labels
  - e. Output

BETA Version 1.0.0.12 - FEMA GeoDam-BREACH Dashboard - [Map Panel Generation]

File View Windows Log Help

**Study**

New Study

Open Study

**Add Dams**

Dam NID ID

Dam Name

+ Add Dam Point

- Delete Dam Point

**Workflow**

✓ SMPDBK

⚠ Risk MAP Datasets

✓ Loss of Life

✓ EAP Mapping

✓ EAP Development

**Legend**

✗ Not Started

⚠ Incomplete

✓ Completed

↩ Back to List of Dams

📂 Open Project Folder

**Output Location, Page Size, Map Scale:**

Current Output Location:

C:\temp\DamStudies.dbk\GA0001\EAPMapping

Current Page Size: 8x11

Current Map Scale: 12000

Click Set Page and Scale to select map book page size and map scale:

Set Page and Scale

**1. Map Title:**

Y14 EAP

**2. Map Extent and Panels:**

Click Set Extent and draw a rectangle on the map to specify extent of map panels:

Set Extent and Create Map Panels

**3. Structures and Points of Interest Labels:**

Click Label Existing Structures to label existing structures from database. Click Create New Structure and click on the map to create new structure with label. Click Create Point of Interest and click on the map to create a point of interest with label. Click Clear all labels to clear all labels from the map:

Label Existing Structures

Create New Structure

Create Point of Interest

Delete All Labels

**4. Output:**

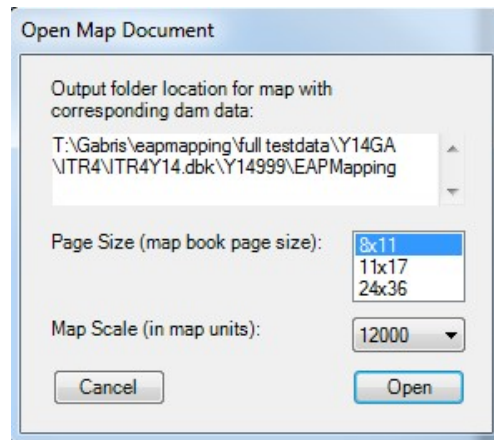
Click Create Output to create PDF and image based Map Books:

Create Output

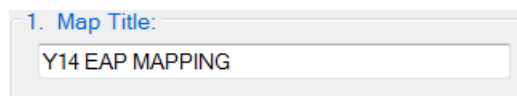
Status:

Project loaded...

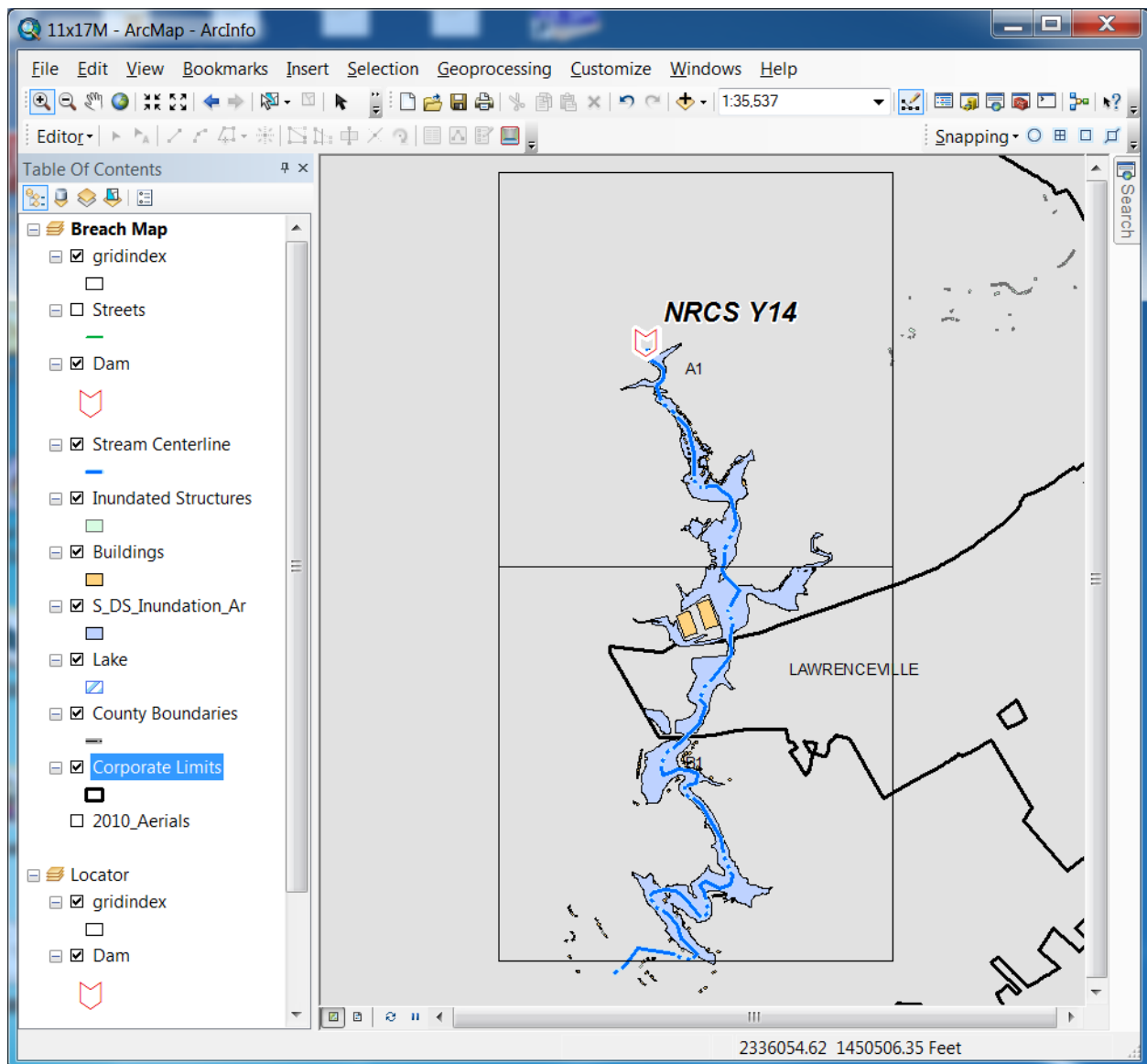
- With the Map Panel Generation Dashboard open, the first step is to set the Page Size and Map Scale (like the map document automatically created *8x11M.mxd*, the default page size is 8x11). To change the Page Size and Map Scale, click the **Set Page and Scale** button as illustrated above. Note the Output Folder Location; this cannot be changed. Choose a Page Size from the three options (8x11, 11x17 and 24x36) and choose a Map Scale from the pull down list.



3. Add any basemap feature layers as desired and label where necessary. This step can be performed at any stage prior to creating output and can include:
  - a. Aerial imagery. It is recommended that aerial imagery be set to 50% transparency so that it does not overpower the more critical information, such as the inundation polygon. The transparency level may vary depending on the brightness and general shades of imagery.
  - b. Vector road features. It is recommended that vector road features be added and used to label roads. It is also recommended that each label contain a halo in order to be readable against aerial basemaps. The font size of labels should be chosen commensurate with the map panel scale.
  - c. Corporate boundary features. It is recommended that corporate boundaries be added and used to label city and county names. It is recommended that either line features or hollow polygons be used and labeled with a halo so that they are readable against aerial basemaps. The font size of labels should be chosen commensurate with the map panel scale.
4. By default, the map panels are titled with the dam name. However, the user may provide a different name if desired in Section 1. Map Title.



5. In the section **Map Extent and Panels**, click the **Set Extent and Create Map Panels** button. Once in the map document, use the cursor to draw the desired area of extent. A "Start Map Panel Creation" popup will appear. Click "OK" and allow a few moments for the panels to be created. A "Map Panels Created!" popup will appear indicating that GeoDam-BREACH has created the panel schema. Click "OK" to continue.
6. With the panels now drawn (see illustration below), users can add graphics and annotation as needed.

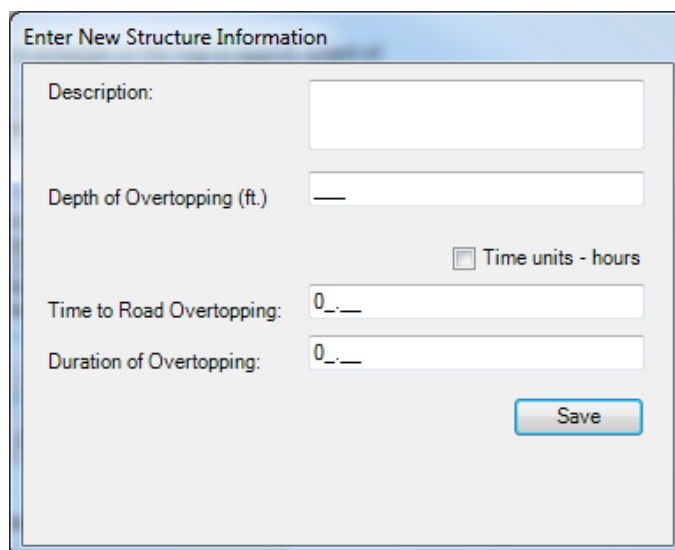


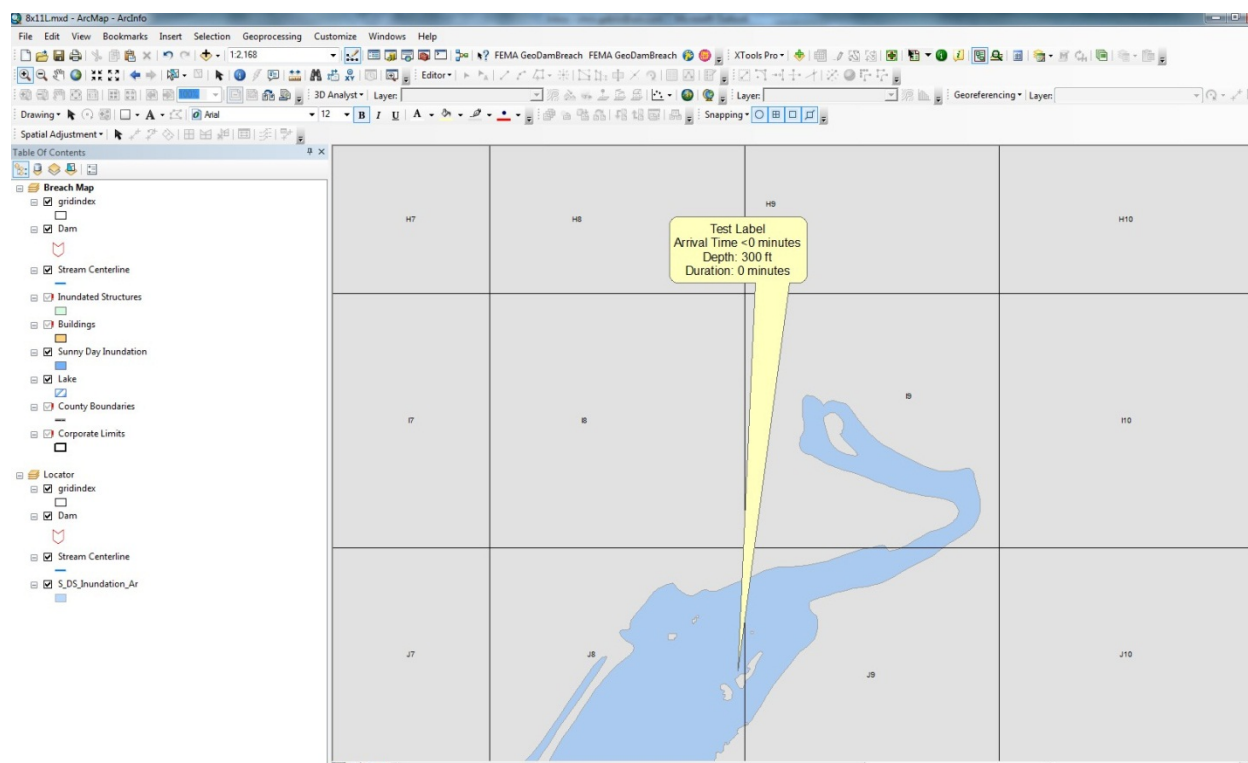
### ***Customizing Map Panel Annotations***

1. The map will load data and map symbology will be based on one of three predetermined templates (8x11, 11x17 and 24x36 page sizes). Once the tool has loaded the appropriate map template and data, users can modify and save the document before using the tool to produce the map book (i.e., map panels). These modifications can include adding more data layers, modifying current layers and adding custom graphics and annotations. However, the location of the map document, its name and its basic structure (especially the layout page) should not be modified, as this can cause problems during map panel generation. The tool will not overwrite these changes the next time the document is opened. To start from scratch without the customizations, simply delete all the files in the output folder.
2. Additionally, three options are available for adding labels to structures and points of interest (see illustration below).



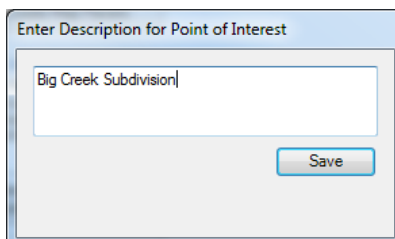
3. The **Label Existing Structures** function will automatically label inundated road crossings with the time to, duration of and depth of road overtopping. This function is only available for inundation studies performed using the SMPDBK Workflow, and more specifically, the Add Rating Curve function. The S\_Structure\_Pt feature class is used to automatically drive this labeling.
4. The **Create New Structure** function will allow the user to add a label to the map for road crossings. This is intended for studies performed outside of GeoDam-BREACH and imported during the Risk MAP Workflow. Click the **Create New Structure** button and using the cursor in the map document, click on the location of the inundated road crossing. Fill out the dialog box and click "Save" (see illustrations below).





5. The **Create Point of Interest** function can be used to annotate points of interest within or adjacent to the inundation zone with information pertaining to depth of flooding, arrival time and inundation duration. The points of interest may include:
- Critical facilities such as hospitals, fire stations, police facilities, etc.
  - Areas at high risk/concern such as subdivisions, schools, churches, senior living facilities, hazardous materials, etc.
  - Critical infrastructure such as pump stations, water treatment facilities, power distribution facilities, etc.

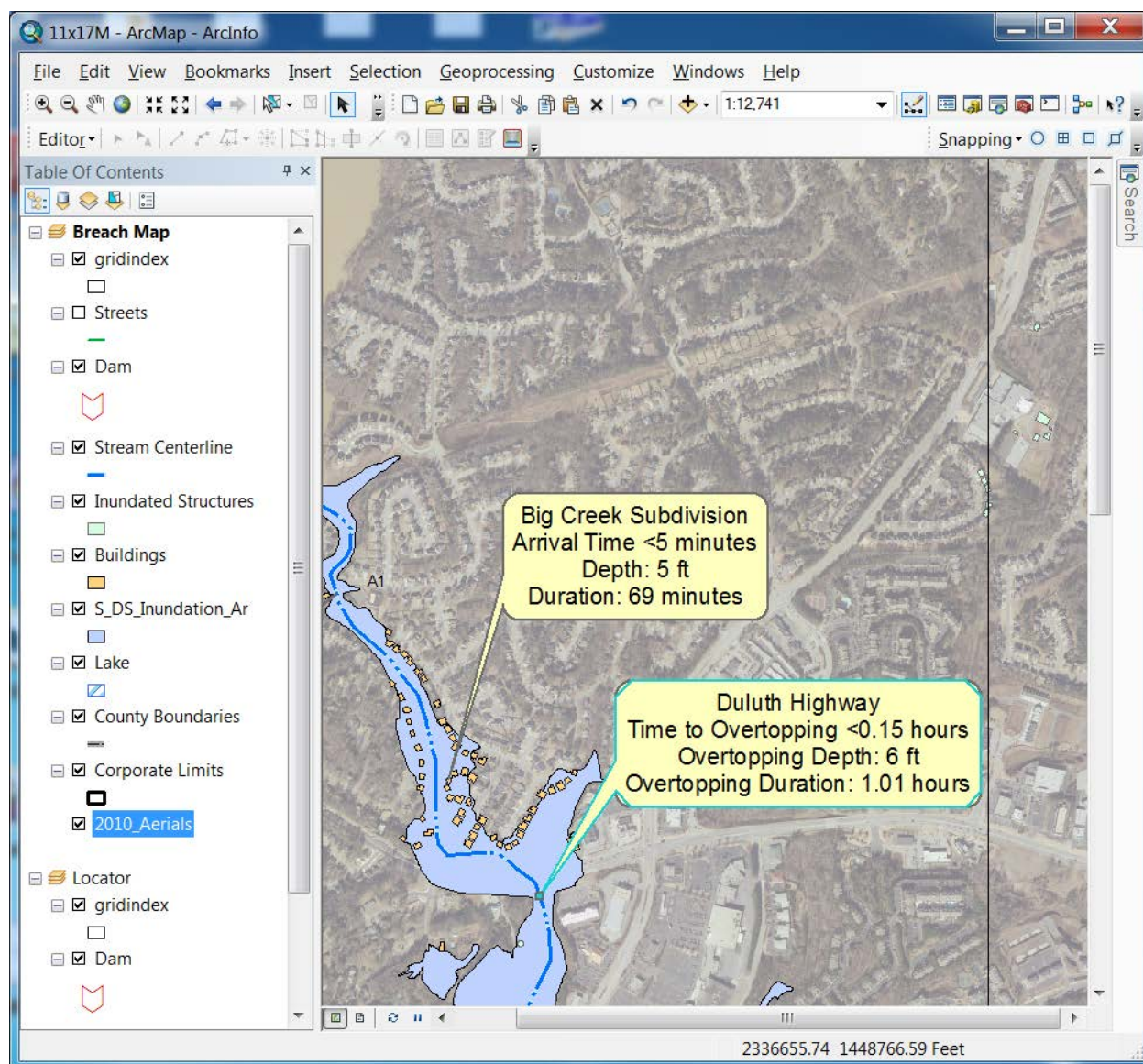
The **Create Point of Interest** function requires the user to enter only a description (see illustrations below) and arrival time; depth and duration information will be automatically populated based on raster datasets created during the Risk MAP Workflow. If these datasets are not available, depth, duration and time of arrival will be labeled as 0 by default. The user must then manually edit the labels within the map.



### Tips for Labeling Panels

When placing, viewing and editing all labels and annotations, it is recommended the viewing scale of the Map document be set to the same scale as the desired panel output in the ArcMap Tools Toolbar.

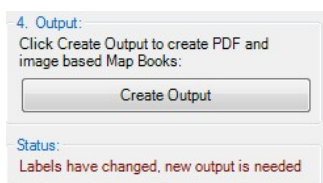
For example:  when using 1:6,000 scale panel outputs.



- The **Delete All Labels** button will delete any existing labels on the map that were created using any of the three previously discussed buttons (**Load Existing Structures**, **Create New Structures** or **Create Point of Interest**). Labels can also be deleted manually by selecting individual map elements and deleting them.

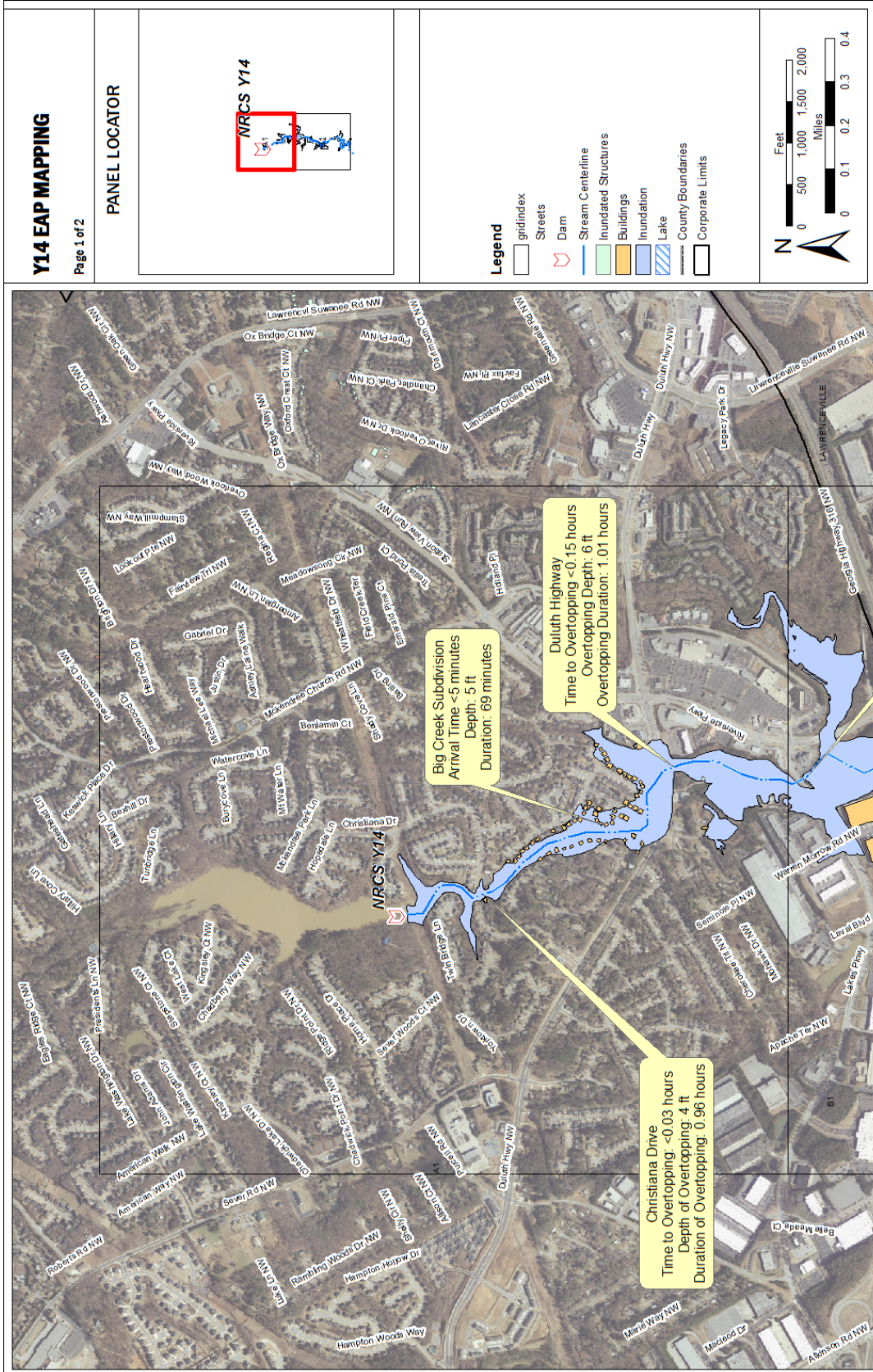
### ***Creating the PDF Output***

1. The final step in the EAP Mapping Workflow is to create a Portable Document File (PDF) output Map Book. Under the **Output** section, click the **Create Output** button. A “Start Map Book creation” popup will appear. Click “OK” to continue. The tool may run for several minutes to over an hour depending on the number and size of panels and the resolution of base map features. Once finished, GeoDam-BREACH will automatically open the map book PDF document.
2. You have the ability to go back and add/remove labels and annotation if desired. If new labels have been added since the last Output was generated, the **Status** box will be populated with the message “Labels have changed, new output is needed” (see illustration below). Follow the same **Create Output** procedure to create an updated Map Book.



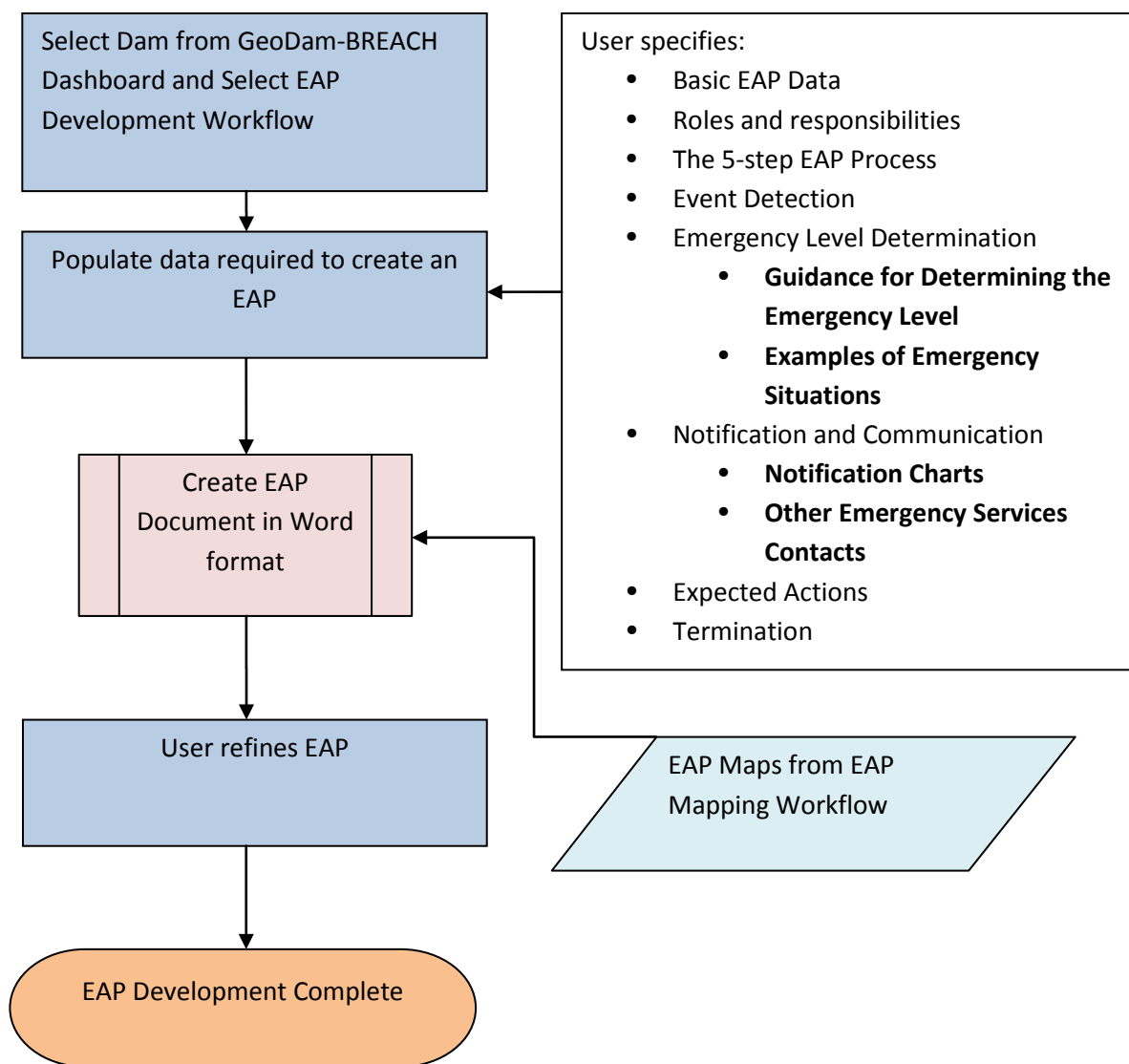
### ***Viewing Map Panel Outputs***

The Map Book Output is always saved in the .dbk study folder in the corresponding [Dam Name] -> EAPMapping folder. The first output is a PDF called “EAPMap.pdf” and it contains all map panels in a single file. The second output is called “EAPMapImage.zip” and is a compressed file containing separate images for each individual map panel in a Portable Network Graphics (.PNG) file format. Additionally, there are three map documents (.mxd files). These correspond to the three page sizes described above. Finally, a number of layer files (.lyr extension) are also in this folder. These include symbology and relative paths to the data used in the map.



## Work Flow 5 – EAP Development

The EAP Development Workflow is illustrated below in Figure 5.



**Figure 5. EAP Development Workflow**

## Background Information for EAP Development

An EAP is a plan of action to reduce the potential for property damage and loss of life in the event of a disaster. EAPs are commonly developed for failures and incidents related to high hazard potential dams and some lower hazard potential dams. EAPs can contain, but do not always require inundation mapping; however, an inundation map makes an EAP a much more effective product. EAPs can be used by a variety of stakeholders including dam safety officials, mitigation planners and emergency responders. Since EAP maps are intended to be used in an emergency, it is critical that the maps can be easily reproduced without losing critical information caused by duplication using equipment such as black and white copy machines.

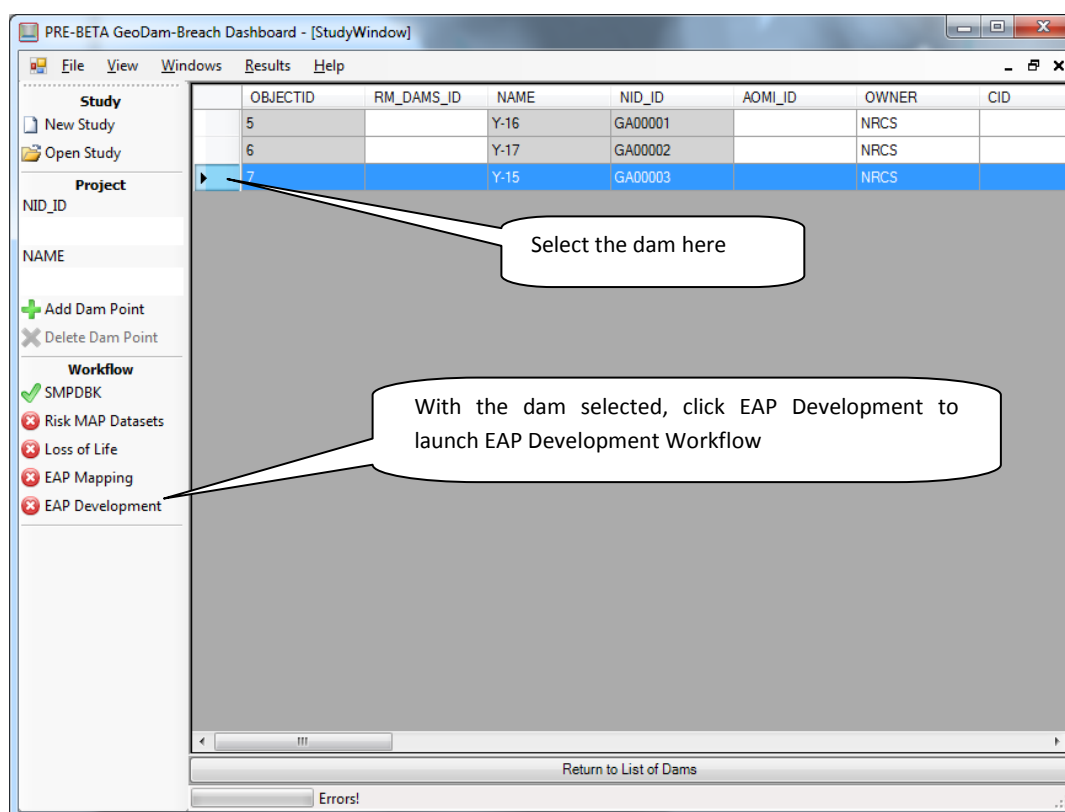
## Input Data Requirements

While there are no required fields, the generated EAP will display ***“This question has not been answered”*** for every field where no entry is made, signaling the user to manually enter this data within Microsoft Word. GeoDam-BREACH will also leverage any available data previously populated during the GeoDam-BREACH Workflows.

Images or photos to be uploaded must be less than 500kb.

## Using the EAP Development Tools

To launch the EAP Development Workflow, simply highlight the dam in the Dashboard and select the **EAP Development** launch button as illustrated below:



***Please note that if the EAP Development Workflow does not launch, the user should check that the necessary Microsoft .NET Framework, as described in the section entitled Software Requirements, has been installed.***

### **Overview**

Two EAP templates are available within GeoDam-BREACH; one is based on the 2007 NRCS Sample EAP “Fillable Form” (Reference 6) and the other is based on guidance provided in the FEMA publication FEMA P-64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*, July 2013 (Reference 7).

The NRCS Sample EAP “Fillable Form” can be found at  
[http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb1042130.doc](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042130.doc)

FEMA P-64 (Reference 7) can be found at:  
<http://www.fema.gov/media-library/assets/documents/3357?id=1672>

While both templates are similar, they contain slightly different information and are arranged in a different order. When determining which EAP template to select, users should keep in mind the intended use of the EAP and what data is available to populate the EAP. Consideration should also be made to follow any State and/or Federal reviewing regulatory agency standards and preferences.

Once the appropriate content is entered into the EAP Report Development interface, a Microsoft Word document of the EAP can be generated. This Word document is editable and additional information and revisions can be made directly within the document.

### **Developing an EAP**

Entries made in the GIS interface for the fields below are automatically transferred and displayed in the EAP application if previously populated or developed in other GeoDam-BREACH workflows.

Basic EAP Data, Dam Characteristics:

- Dam Name
- NID #
- Latitude
- Longitude

Model Output Data, Appendix B-5 (footer): Modeling Assumptions:

- What hydraulic model was used?
- What are the model assumptions for: Water-surface elevation in reservoir prior to breach at top of dam?
- What are the model assumptions for: Height of water at time of breach (ft)?
- What are the model assumptions for: Peak breach discharge (ft<sup>3</sup>/s)?

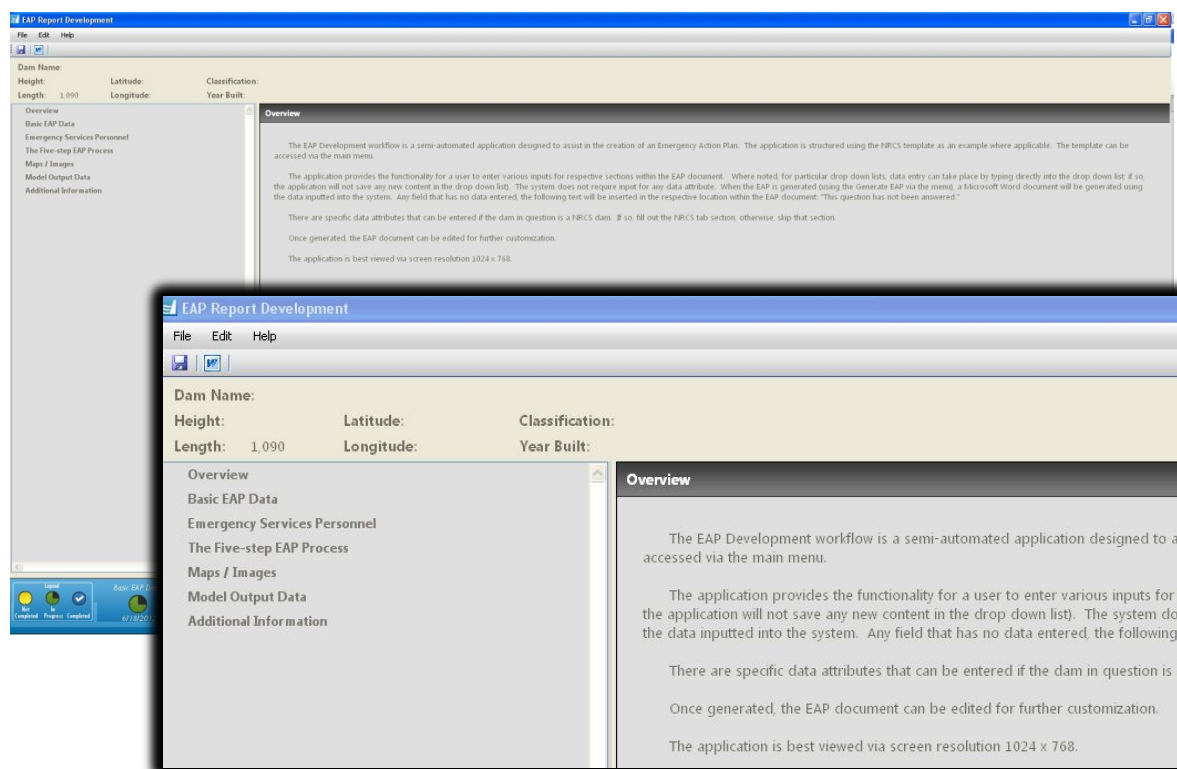
- What are the model assumptions for: # of cross sections?

While it is true that these data can be edited on the EAP form for the document, this should be the exception, as the change will not be reflected within the application data if changed within the GIS interface.

Disclaimer: Data appearing in the application screenshots is intended to serve as an example only. These data should not be relied upon as true and correct. Likewise, contact names and phone numbers are fictitious.

### Navigation:

The following image displays an example of the application when opened. The application is structured into two panes: the left tree view pane and the right detailed view displaying contents of a selected item from the left pane. In the default view shown in the inset image, the system displays the contents of the tree view in a collapsed view. Each item expands when clicked. The full tree view is displayed on the following page.



Click the triangle symbol (visible when the cursor hovers over a topic) next to any Menu Item within the tree view to expand the topic. The hollow triangle indicates the menu item is minimized. The solid triangle indicates that the menu item is maximized. The left menu items use the tree view and the default is a minimized view of the following:

Overview
<ul style="list-style-type: none"> <li>Basic EAP Data <ul style="list-style-type: none"> <li>Potential Area Impacted</li> <li>Directions to Dam</li> <li>Dam Characteristics</li> </ul> </li> <li>Emergency Services Personnel <ul style="list-style-type: none"> <li>Emergency Services Roster</li> <li>Roles and Responsibilities</li> <li>Appendix B-1: Resources Available</li> <li>Appendix B-1: Local Resource Sources</li> </ul> </li> <li>The Five-step EAP Process <ul style="list-style-type: none"> <li>Step 1 - Event Detection</li> <li>Step 2 - Emergency Level Determination</li> <li>Step 2 - Pre-existing conditions to dam</li> <li>Step 3 - Notification and Communication: Emergency Le</li> <li>Step 3 - Notification Flowcharts: Emergency Level 1</li> <li>Step 3 - Notification and Communication: Emergency Le</li> <li>Step 3 - Notification Flowcharts: Emergency Level 2</li> <li>Step 3 - Notification and Communication: Emergency Le</li> <li>Step 3 - Notification Flowcharts: Emergency Level 3</li> <li>Step 4 - Expected Actions</li> <li>Step 5 - Termination</li> </ul> </li> <li>Maps / Images <ul style="list-style-type: none"> <li>Cover map: Location of dam</li> <li>Appendix B-2: Location and Vicinity</li> <li>Appendix B-3: Watershed</li> <li>Appendix B-4: Evacuation</li> <li>Appendix B-6: Plan view</li> <li>Appendix B-7: Profile of Principal Spillway</li> </ul> </li> <li>Model Output Data <ul style="list-style-type: none"> <li>Appendix B-5 (footer): Modeling Assumptions</li> <li>Appendix B-8: Reservoir Data - Base</li> <li>Appendix B-8: Reservoir Data - Principal</li> <li>Appendix B-8: Reservoir Data - Auxiliary</li> </ul> </li> <li>Additional Information <ul style="list-style-type: none"> <li>EAP Review and Revisions</li> <li>Appendix B-5: Residents/Businesses/Highways at Risk</li> <li>Appendix B-9: NID Data</li> <li>NRCS Data</li> </ul> </li> </ul>

### Application functionality:

The following guidance is intended for application areas that require user attention. Not every data entry control will be discussed in the following documentation. The application used the NRCS template (accessible within the Help menu along with a Glossary of Terms) as a general guideline when

developing the application. It is recommended that users refer to that document for additional clarification on example content.

Some fields throughout the application hinge upon entries in other menu areas. For example:

Within Basic EAP Data - Dam Characteristics, the Conservation District Name will be populated when the Emergency Services Personnel - Emergency Services Roster is completed.

For the Emergency Services Personnel menu item, within Roles and Responsibilities, the following fields can be populated only when the Emergency Services Roster is completed:

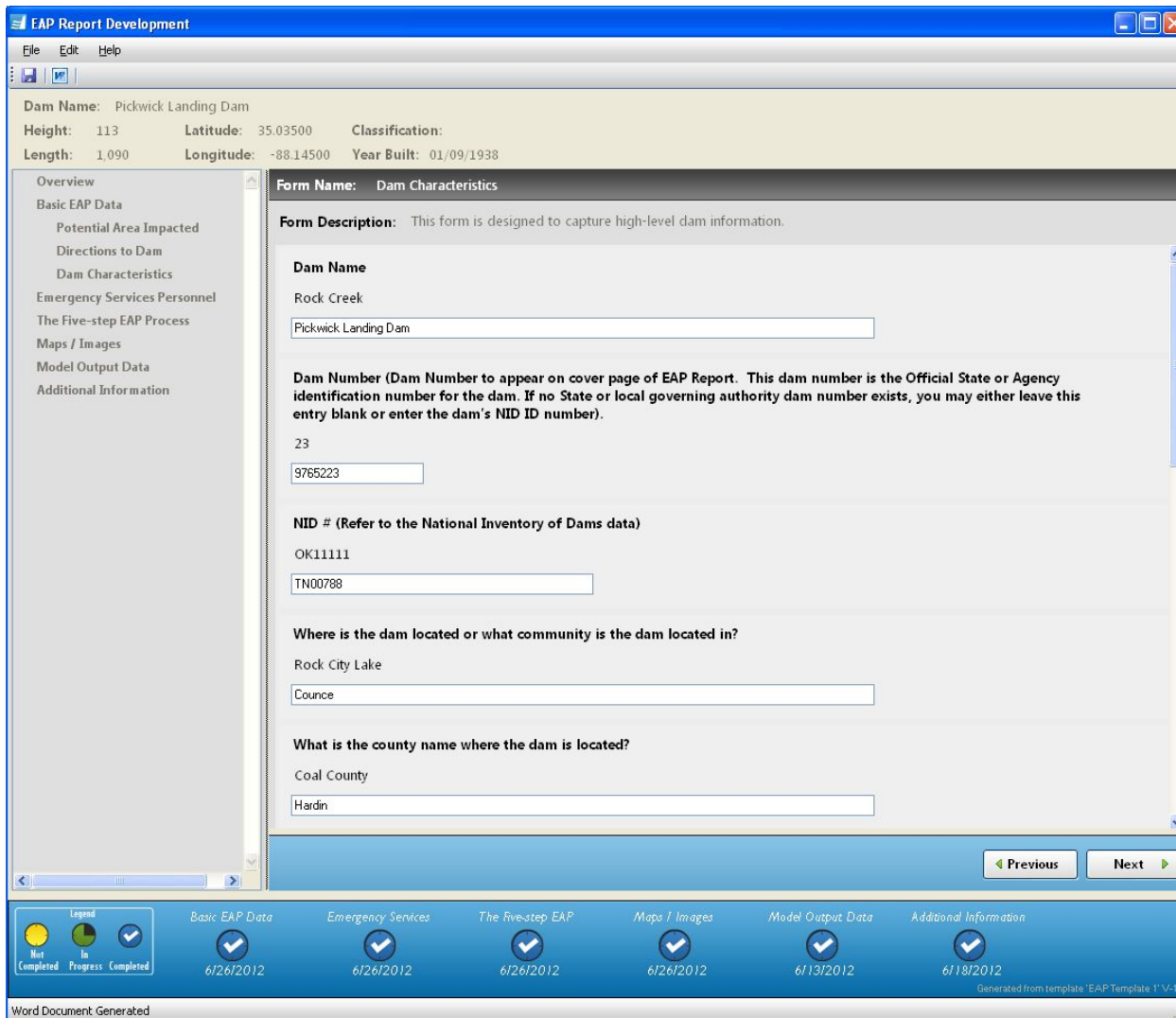
- Dam Operator's Representative
- Incident Commander
- Emergency Services Agency
- Dam Operator's Technical Representative
- State Dam Safety Agency

For the Additional Information menu item, under EAP Review and Revisions:

“What is the title of the individual responsible for EAP Annual Review” and “What organization is responsible for EAP revisions” can be populated only when the Emergency Services Roster is completed.

Screen-specific guidance is displayed to provide further clarification on the functionality of particular data attributes.

## General data entry instructions:



The screenshot displays the 'EAP Report Development' application window. The top menu bar includes 'File', 'Edit', and 'Help'. Below the menu, a summary bar shows 'Dam Name: Pickwick Landing Dam', 'Height: 113', 'Latitude: 35.03500', 'Classification:', 'Length: 1,090', 'Longitude: -88.14500', and 'Year Built: 01/09/1938'. A left-hand navigation tree lists various sections: Overview, Basic EAP Data (selected), Potential Area Impacted, Directions to Dam, Dam Characteristics, Emergency Services Personnel, The Five-step EAP Process, Maps / Images, Model Output Data, and Additional Information. The main content area displays the 'Form Name: Dam Characteristics' and a 'Form Description: This form is designed to capture high-level dam information.' The form fields include: 'Dam Name' (Rock Creek), 'Dam Number' (Pickwick Landing Dam), 'NID #' (OK11111), 'Where is the dam located or what community is the dam located in?' (Rock City Lake), and 'What is the county name where the dam is located?' (Coal County). At the bottom, a progress bar shows the completion status of various sections: Basic EAP Data (Completed, 6/26/2012), Emergency Services (Completed, 6/26/2012), The Five-step EAP (Completed, 6/26/2012), Maps / Images (Completed, 6/26/2012), Model Output Data (Completed, 6/13/2012), and Additional Information (Completed, 6/18/2012). The status bar at the bottom indicates 'Word Document Generated' and 'Generated from template: EAP Template 11 V-1'.

- Select a topic within the tree view and click to display the form (e.g., Dam Characteristics under Basic EAP Data).
- Fill in all fields manually or by making a selection from a drop down list. Above each input box is an example of the type of data to be entered, along with applicable guidance.
- Use the vertical and horizontal scroll bars, as available, to access the entire form.
- The icons at the bottom of the page track the completion progress of each form: Not Completed, In Progress and Completed. Additionally, the date when each form was last updated will be reflected.
- Clicking the Previous or Next buttons within the application will navigate the user through the pages. Additionally, a user can click an item on the left-hand menu bar to navigate to an individual area out of sequence. Users are prompted to save the data on each form before continuing.

## Areas of Interest:

### The Five-step EAP Process: Step 2 – Emergency Level Determination:

**Form Name:** Step 2 - Emergency Level Determination

**Form Description:** This step describes the following: after an unusual or emergency event is detected or reported, there is the responsibility for classifying the event into one of the following three emergency levels (see page 6 of the EAP example template via the menu):

Emergency Level 1—Nonemergency, unusual event, slowly developing;  
 Emergency Level 2—Potential dam failure situation, rapidly developing;  
 Emergency Level 3—Urgent; dam failure appears imminent or it is in progress.

See the following pages for guidance in determining the proper emergency level for various situations. See pages 7-9 of the EAP example template via the menu.

Event	Situation	Emergency Level	Applicable
Earth spillway flow	Reservoir water surface elevation at auxiliary spillway crest or spillway is flowing with no active erosion	1	Yes
Earth spillway flow	Spillway flowing with active gully erosion	2	No
Earth spillway flow	Spillway flow that could result in flooding of people downstream if the reservoir level continues to rise	2	No
Earth spillway flow	Spillway flowing with an advancing headcut that is threatening the control section	3	Yes
Earth spillway flow	Spillway flow that is flooding people downstream	3	No
Embankment overlapping	Reservoir level is 1 foot below the top of the dam	2	No
Embankment overlapping	Water from the reservoir is flowing over the top of the dam	3	No
Seepage	New seepage areas in or near the dam	1	No
Seepage	New seepage areas with cloudy discharge or increasing flow rate	2	No
Seepage	Seepage with discharge greater than 10 gallons per minute	3	No
Sinkholes	Observation of new sinkhole in reservoir area or on embankment	2	No
Sinkholes	Rapidly enlarging sinkhole	3	No

« Previous    Next »

The content for Event, Situation and associated Emergency Level from the NRCS template is pre-populated. The user can select from the **Applicable** drop down list if an Event, Situation and Emergency Level are applicable to this EAP.

The user also has the ability to add a new row(s) in the table and can change the width of the columns within the grid.

### Step 3 – Notification Flowcharts: Emergency Level 3:

**EAP Report Development**

File Edit Help

Dam Name: Picknick Landing Dam  
 Height: 113    Latitude: 35.03500    Classification:  
 Length: 1.090    Longitude: -88.14500    Year Built: 01/09/1938

**Dam Characteristics**

- Emergency Services Personnel
  - Emergency Services Roster
  - Roles and Responsibilities
  - Appendix B-1: Resources Available
  - Appendix B-1: Local Resource Sources
- The Five-step EAP Process
  - Step 1 - Event Detection
  - Step 2 - Emergency Level Determination
  - Step 2 - Pre-existing conditions to dam
  - Step 3 - Notification and Communication: Emergency Level 1
  - Step 3 - Notification Flowcharts: Emergency Level 1
  - Step 3 - Notification and Communication: Emergency Level 2
  - Step 3 - Notification Flowcharts: Emergency Level 2
  - Step 3 - Notification and Communication: Emergency Level 3
  - Step 3 - Notification Flowcharts: Emergency Level 3
  - Step 4 - Expected Actions
  - Step 5 - Termination
- Maps / Images
  - Cover map: Location of dam
  - Appendix B-2: Location and Vicinity
  - Appendix B-3: Watershed
  - Appendix B-4: Evacuation
  - Appendix B-6: Plan view
  - Appendix B-7: Profile of Principal Spillway
- Model Output Data
  - Appendix B-5 (Footer): Modeling Assumptions
  - Appendix B-8: Reservoir Data - Base
  - Appendix B-8: Reservoir Data - Principal
  - Appendix B-8: Reservoir Data - Auxiliary

**Form Name:** Step 3 - Notification Flowcharts: Emergency Level 3

**Form Description:** This form is designed to allow for the following images to be uploaded: Notification Flowcharts by Emergency Level, Cover Maps as well as location and vicinity of the dam, watershed, evacuation, dam plan view, and profile of principal spillway maps and images. See page 14 of the EAP example template.

**Dam Operator's Rep**  
 Emergency Ops Dir.  
 Janinos Rumpo  
 (423) 555-2145 Ext. \_\_\_\_  
 (423) 555-6467 Ext. \_\_\_\_  
 (423) 555-9551 Ext. \_\_\_\_

**(1) Incident Commander**  
 Sheriff  
 Marvin Daines  
 (731) 555-1212 Ext. \_\_\_\_  
 (731) 555-0526 Ext. \_\_\_\_  
 (731) 555-8897 Ext. \_\_\_\_

**(2) State Dam Safety Official**  
 Emergency Ops Mgr.  
 Kevin Markham  
 (423) 555-1445 Ext. \_\_\_\_  
 (423) 555-9841 Ext. \_\_\_\_  
 (423) 555-6447 Ext. \_\_\_\_

**(3) Dam Operator's Technical Rep**  
 Historian  
 Dennis Mauk RH  
 (888) 989-7777 Ext. \_\_\_\_  
 (111) 111-1111 Ext. 11111  
 (777) 777-7770 Ext. 00000

**Captain**  
 Jarvis Sneed  
 (731) 555-4990 Ext. \_\_\_\_  
 (731) 555-8778 Ext. \_\_\_\_  
 (731) 555-4785 Ext. \_\_\_\_

**Title**  
 Make Selection...  
 XXXXXXXXXXXX (Office)  
 XXXXXXXXXXXX (Home)  
 XXXXXXXXXXXX (Cell)

**Title**  
 Make Selection...  
 XXXXXXXXXXXX (Office)  
 XXXXXXXXXXXX (Home)  
 XXXXXXXXXXXX (Cell)

« Previous    Next »

Legend    Basic EAP Data    Emergency Services    The Five-step EAP    Maps / Images    Model Output Data    Additional Information

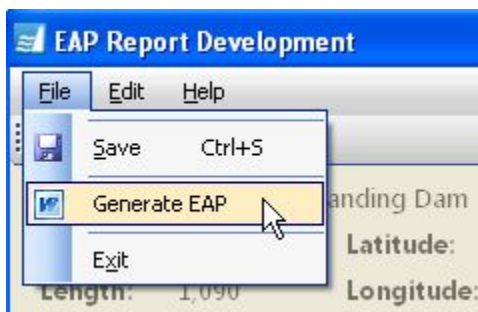
Max Completed    Progress Completed    6/27/2012    6/28/2012    6/28/2012    6/28/2012    6/13/2012    6/27/2012

Changes Made

Generated from template: EAP Template V 1.0

The flowchart is based on the NRCS template and is populated in the same manner as all flowcharts from the Emergency Services roster—providing drop down lists of identified personnel and their respective contact information. There are also Notification Flowcharts for Emergency Levels 1 and 2. These flowcharts are based exclusively on the examples within the NRCS template.

### Generating an EAP:



After completing the desired fields for each form, click **File** and **Generate EAP**.

Whenever information has not been entered for a field, the generated EAP will display, “This question has not been answered” in red within the document.

# Emergency Action Plan (EAP)

## Pickwick Landing Dam Watershed, Dam No. **9765223**

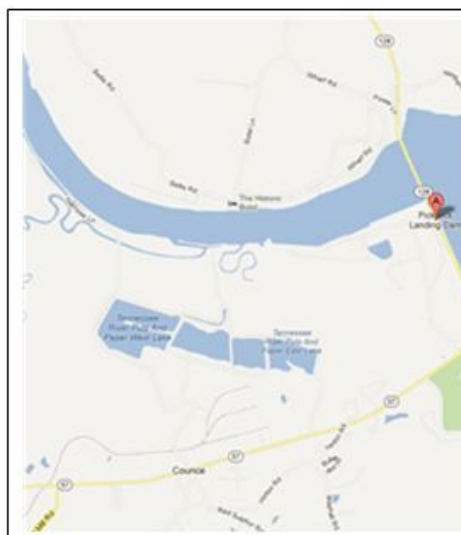
### (Counce)|

National Inventory of Dams (NID) No. **TN00788**

**Hardin County, Tennessee**

**Water Safety Board**

With assistance from the  
U.S. Department of Agriculture  
Natural Resources Conservation Service



Reviewed and Updated:

\_\_\_\_\_  
*Chief of Police, ~~NID~~ Dam Panel of Engineers*

\_\_\_\_\_  
*Date*

\_\_\_\_\_  
*Hardin Co. Fire Dept., Hardin County, Tennessee*

\_\_\_\_\_  
*Date*

Copy \_\_\_\_ of \_\_\_\_

Pickwick Landing Dam Watershed, Dam No. 9765223, Hardin County, Tennessee - NID TN00788

Once the document is generated in Microsoft Word, it will automatically open and be saved in the .dbk study folder in the corresponding [Dam Name] -> EAPDevelopment -> Reports folder.

## References

- 1) Wetmore, J.N., Fread, D.L., Lewis, J.M., and Wiele, S.M., "The NWS Simplified Dam-Break Flood Forecasting Model." pp 1-46 (1991), National Weather Service Office of Hydrology, Hydrologic Research Laboratory.  
[http://www.nws.noaa.gov/oh/hrl/hymb/docs/hydraulics/papers\\_before\\_2009/hl\\_286.pdf](http://www.nws.noaa.gov/oh/hrl/hymb/docs/hydraulics/papers_before_2009/hl_286.pdf)
- 2) FEMA, "Proposed Non-Regulatory Flood Risk Datasets – Dams," draft document, dated 2011.
- 3) Department of Homeland Security document, Dams Sector "*Estimating Loss of Life for Dam Failure Scenarios*", 2011
- 4) U.S. Department of the Interior, Bureau of Reclamation, Dam Safety Office, "A Procedure for Estimating Loss of Life Caused by Dam Failure," DSO-99-06, 1999. <http://www.usbr.gov/ssle/damsafety/TechDev/DSOTechDev/DSO-99-06.pdf>
- 5) Federal Emergency Management Agency (FEMA). "Draft Federal Guidance for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures," 2012.
- 6) NRCS EAP  
Template [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb1042130.doc](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042130.doc), 2007.
- 7) FEMA, "Federal Guidelines for Emergency Action Planning for Dams", FEMA Publication Number 64, June 30, 2013 <http://www.fema.gov/media-library/assets/documents/3357>
- 8) Halgren, J., and Reed, S., "GeoSMPDBK Instructions," NWS, 2012.