PMP Evaluation Tool Description and Usage

The PET is a Python scripting language-based tool designed to be run within the ArcGIS environment. The tool provides gridded PMP values at a spatial resolution of 90 arc-seconds for a user-designated drainage basin or area. PMP values are calculated for general frontal and local storm types at user-supplied durations. The gridded PMP is calculated and stored as GIS files stored within file geodatabases.

As an ArcGIS based tool – much of terminology used to describe and discuss the PET is unique to the ArcGIS environment. The following definitions are applicable in reference to the PET:

1. **Folder** – A container element designed to group files or other folders (also called a directory).
2. **Datasets**– A collection of data often stored as a raster (GRID), vector (Shapefile or Feature Class), or Table.   May or may not have a spatial component.
3. **Geodatabase** – An ArcGIS specific spatial database. The geodatabase is a container used to hold a collection of datasets. Similar to a folder, but ArcGIS specific. The PET uses File Geodatabases.
4. **GRID** – a raster dataset format (can be either integer or floating point)
5. **Shapefile** – a commonly vector geospatial dataset format. Contains a collection of shapes, or features.   Can be stored within a folder.
6. **Feature Class** - A single collection of geographic features. Similar to a shapefile but specific to the ArcGIS environment. Feature classes must be stored within a Geodatabase or Feature Dataset.
7. **Feature Dataset** – An ArcGIS specific folder used to store a collection of feature classes with the same spatial reference and extent. Must be stored within a geodatabase.
8. **Metadata** – Information describing a dataset. The PET uses the FGDC metadata format. Stored in an .xml file sharing the name of the target dataset.
9. **ArcMap** – A visual GIS mapping application included within the ArcGIS environment.
10. **ArcCatalog** – A GIS file browser included within the ArcGIS environment.
11. **ArcToolbox** – A user interface in ArcGIS used for accessing, organizing, and managing a collection of georpocessing tools, models, and scripts.
12. **Python** – A high-level scripting language commonly used for scripting within the ArcGIS environment.

A fundamental level of experience with the ArcGIS Desktop software suite is recommended for the implementation and use of the PET.

1.1 File Structure

The tool, source script, all input data, and output data locations are all stored within the 'PMP_Evaluation_Tool' project folder. The file and directory structure within the 'PMP_Evaluation_Tool' folder should be maintained as it is provided – as the script will locate various data based on its relative location within the project folder. If the subfolders or

geodatabases within are relocated or renamed then the script must be updated to account for these changes.

The file structure consists of only three subfolders: Input, Output, and Script.

The 'Input' folder contains all input GIS files. There are three ArcGIS file geodatabase containers within the 'Input' folder: DAD_Tables.gdb, Storm_Adj_Factors.gdb, and Non_Storm_Data.gdb. The DAD_Tables.gdb contains the DAD tables (in file geodatabase table format) for each of the 79 SPAS analyzed storm DAD zones. The Storm_Adj_Factors.gdb contains a feature class for each analyzed event and stores the adjustment factors for each grid point as a separate feature. These feature classes are organized into feature datasets, according to storm type (General, Local, and Tropical). The storm adjustment factor feature classes share their name with their DAD Table counterpart. The naming convention is SPAS_XXXX_Y, where XXXX is the SPAS storm ID number and Y is the DAD zone number. Finally, the Non_Storm_Data.gdb contains spatial data not directly relating to the input storms. Grid_Points is a point feature class for each of the 24,372 grid points. Vector_Grid is a polygon feature class representing the grid cells for each of 24,372 grid points, AND Vector_Grid_Outline is the boundary for the entire analysis domain.

The 'Output' folder is designed to store the model output after it is created and contains a subfolder for each storm type (General, Local, and Tropical). There are also two sub-folders; Metadata_Templates and Text_Output. The 'Metadata_Templates' folder contains the .xml metadata templates that are applied to the output GIS files when they are created
The 'Script' folder contains an ArcToolbox called PMP_Tools.tbx and the Python script PMP_Calc.py. The toolbox contains a tool called 'PMP Tools" that is used by ArcGIS to call the script. The ArcToolbox was created with ArcGIS v. 10.2 but has been exported to a version 10.0 toolbox for version compatibility.

ArcCatalog should be used for viewing the PET file structure and interacting with the input and output geospatial data and metadata. A typical operating system's file browser does not allow access to the geodatabase containers and cannot be used to run the PET.
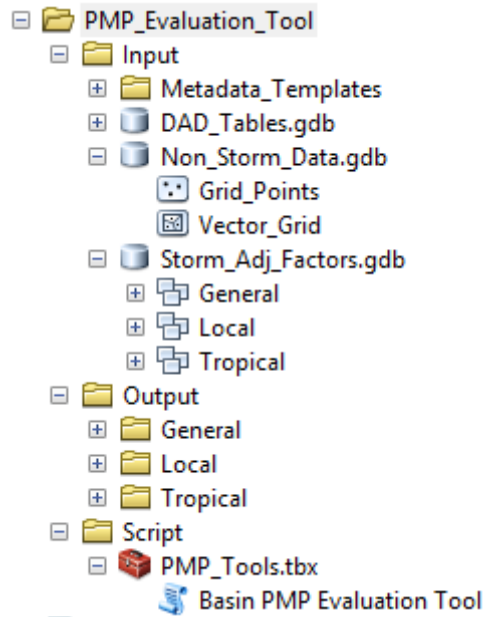
Figure 1.1 GIS file structure for the PMP Evaluation Tool as viewed from ArcCatalog

1.2 Python Script

Due to the large number of storm datasets and grid points within the project domain, a scripted process is necessary to process and compare each value efficiently and accurately for a given area of interest. ArcGIS has adopted the Python scripting language as the viable option for compiling powerful geoprocessing operations as clearly and concise as possible.

The script is stored within the PET project folder at \Script\PMP_Calc.py. The PMP_Calc.py code can be opened and edited within any text editor. The python script uses the arcpy, arcpy.management, and arcpy.conversion modules. After the input parameters are provided, the script runs the pmpAnalysis() three times, once for each storm type. To shorten and simplify the code, repeatable functions are designed and called within the code when needed. Within the broader pmpAnalysis() function, several smaller functions are called to perform various tasks:

createPMPfc()   Creates the PMP_Points feature class to store vector (point) results

getAOIarea()   Calculates the area of the input basin

dadLookup()   Gets the DAD value for the current storm based on basin area

updatePMP()   Writes the largest adjusted rainfall value (PMP) to the PMP_Points feature class

outputPMP()   Creates raster PMP output, basin-average table output, text file output, and applies metadata to output GIS files

There is extensive documentation with the code in the form of '#comments'. These comments provide guidance toward its functionality and describe the code.

While the script performs many actions, its primary purpose is to iterate through both the storm list and the grid points within the AOI, comparing each, and creating output based on the maximum values. To accomplish this, several layers of nested iterative "for" loops are used. The following high-level algorithm broadly describes the script process:

- Calculate Basin Area (in sqmi)
- For each Storm Type (general, tropical, and local)
    - For each duration
        - Set all PMP values to 0
        - For each storm in database
            - Lookup storm's depth-area-duration (DAD) value for basin size
            - For each grid point in basin
                - Calculate total adjusted rainfall (TAR) by multiplying DAD value by total adjustment factor for the grid point
                - If TAR > PMP, the TAR becomes the new PMP value for that grid point
    - Create PMP_Point feature class for the storm type
    - Create raster GRID files for each duration
    - Attach metadata to each output file

The 'PMP_Evaluation_Tool' script tool within the PMP_Tools.tbx ArcToolbox opens and runs the script within the ArcGIS environment. In addition to running as a standalone tool, the script tool can be incorporated into Model Builder or be called as a sub-function of another script.

1.3 Usage

The 'PMP_Evaluation_Tool' project folder should be stored locally at a location that can be accessed (both read/write) by ArcGIS desktop. The 'PMP Evaluation Tool' is located in the PMP_Tools.tbx toolbox, within the 'Script' folder. The 'PMP Evaluation Tool' ArcToolbox is an ArcGIS Desktop version 10.0 toolbox and can be open and ran from either ArcCatalog or ArcMap. The tool is forward compatible with ArcGIS desktop versions.

1.3.1 Model Input Paramaters

The tool requires several parameters as input. The first parameter is feature layer, such as a basin shapefile or feature class, designed to outline the area of interest for the PMP analysis. The basin shapefile must have a map surface projection spatial reference, with units of either feet

or meters (e.g. Universal Transverse Mercator or State Plane). If the feature layer has multiple features (or polygons) the tool will use the combine area as the analysis region. Only the selected polygons will be used if the tool is run from the ArcMap environment with selected features highlighted. If the basin shapefile extends beyond the project analysis domain, only the grid cells within the domain will be analyzed, although the PMP depths will be calculated for the area of the entire basin. If none of the basin lies within the project analysis domain, an error will occur.

The second input parameter is the file path location of the 'PMP_Evaluation_Tool' project folder. This parameter points the script to the location if the input datasets and tells the script where to place the output. The tool then requires the user to specify the durations to be run for the general and local storm types. Finally, the user can override the basin size to be used as the PMP area and provide an alternate area size.
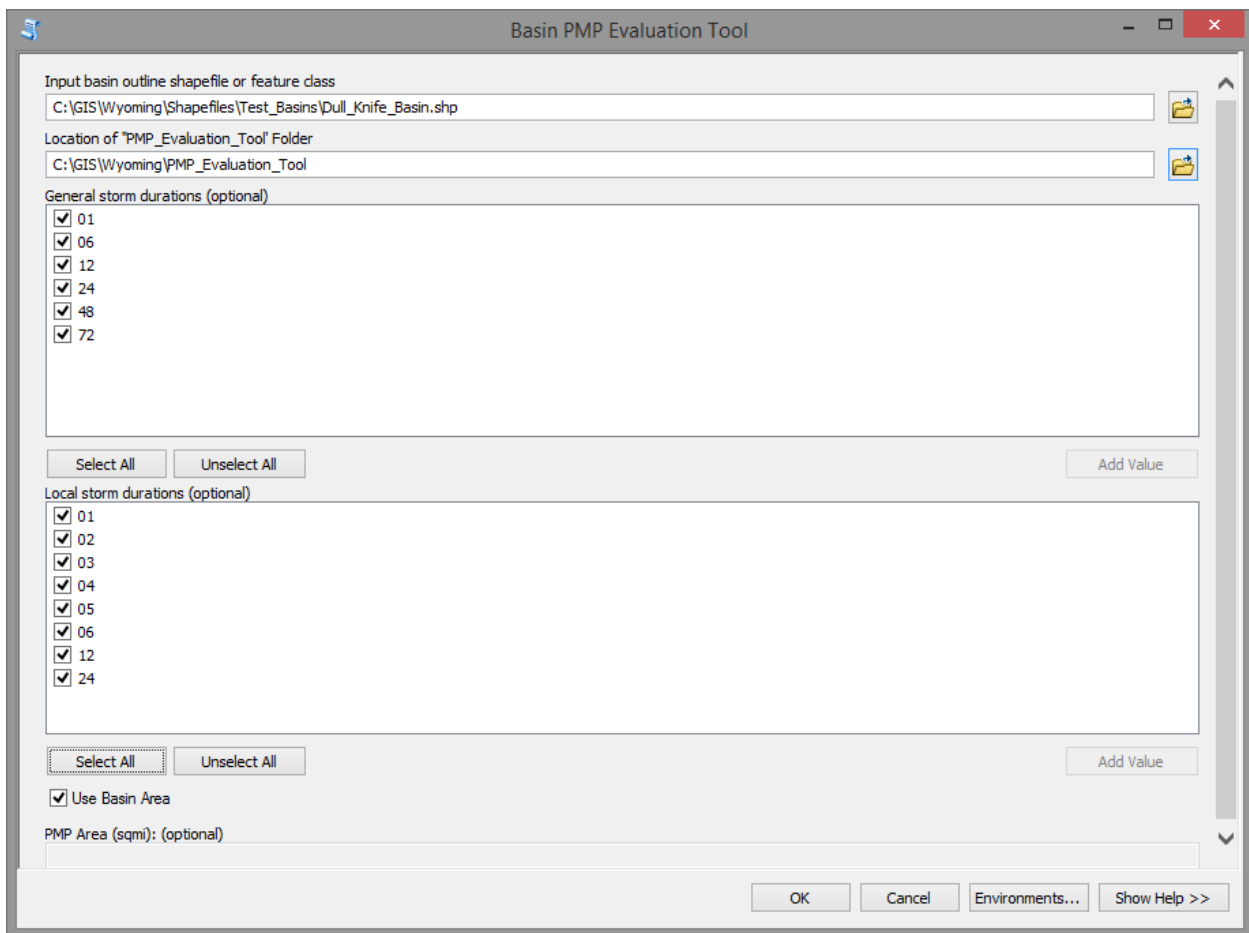
Figure 1.2 Example of PET parameter input dialogue window as run from ArcGIS Desktop

1.3.2 Model Runtime

On a typical workstation the tool will take 5-15 minutes to run for most drainage basins. Several hours may be needed to complete an analysis of the entire project domain.

The PET outputs continuously outputs text to the ArcGIS geoprocessing message dialogue window while the tool is running. This text is useful for understanding where the tool is in its current iteration while the PET is running, identifying errors, and recording run times and dates. After the tool has completed, the geoprocessing dialogue can be referenced and viewed with ArcGIS under the geoprocessing results window.

1.3.3 Model Output

Once the tool has been run, the output folders and geodatabases will be populated with the model results (Figure 1.3). The GIS files can then be brought into an ArcMap, or other compatible GIS environment, for mapping and analysis. The tool is set to have overwrite capabilities. If output data exists, it will be overwritten the next time the tool is run. Output data should be moved to an alternate permanent storage location before the tool is run again, if it is desired that the output data be preserved.

```
PMP_Evaluation_Tool
  Input
  Output
    General
      PMP.gdb
      PMP_1.gdb
      PMP_10.gdb
      PMP_100.gdb
        G_01_00100
        G_06_00100
        G_12_00100
        G_24_00100
        G_48_00100
        G_72_00100
        General_PMP_Points_100
      PMP_1000.gdb
      PMP_10000.gdb
      PMP_200.gdb
      PMP_50.gdb
      PMP_500.gdb
      PMP_5000.gdb
    Local
  Script
```
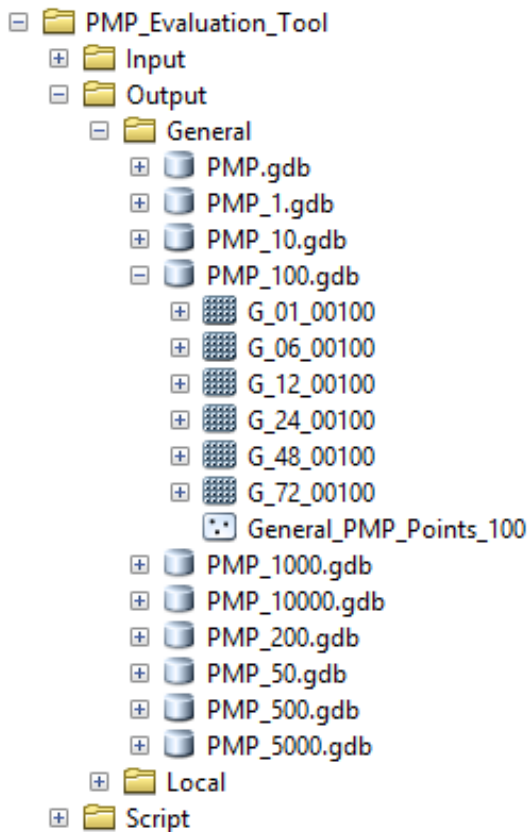
Figure 1.3 Example of the PET Output folder populated after a run

The output data is organized into a file geodatabase containers with the naming convention PMP_XXXXX, where XXXXX is the PMP area size. The geodatabase contains a single GRID file for each analyzed duration and a feature class which has stores each grid point centroid as a separate feature. Each feature has a field for the grid ID, latitude, longitude, analysis zone, elevation, and PMP for each duration.

1.3.4   GIS Dataset Metadata

Comprehensive metadata have been included for every GRID output file. The metadata were compiled using the Federal Geographic Data Committee (FGDC) .xml format standard and are attached to each file. The metadata can be viewed in ArcCatalog under the description tab (the FGDC metadata style may need to be enabled under ArcCatalog 'options' for proper viewing).

Metadata added primarily consist of a description of the element and a description of each attribute field (when fields are present). Metadata for all existing input data and file structure elements are present with the deliverable project folder. Metadata for each output element is applied with a function within the PET script during runtime. The output metadata originates from templates stored within the 'Metadata_Templates' sub-folder within the 'Input' folder.