



REPORT

MAP TO MAP IMPLEMENTATION WORKFLOW

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Map To Map Implementation Workflow

Introduction

This document presents description of the Map To Map (M2M) implementation workflows developed for the Hydrologic Modelling Section, Water Resources Management Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, Canada, (WRMD) in the context of modeling of impacts of global climate change (GCC) on flooding.

Map To Map is a concept initially developed and implemented in 2003 as a demonstration project of Model Builder capabilities. It was developed at the University of Texas at Austin by Oscar Robayo under guidance of David Maidment and support from Esri Inc. and US Army Corps of Engineers, Hydrologic Engineering Center (HEC) (<http://www.crrw.utexas.edu/gis/gishydro05/Modeling/Map2Map.htm>). The basic concept is to take a “map of rainfall” and transform it to the “map of flooding”, thus Map To Map.

Original implementation of M2M used HEC-HMS hydrologic model to transform the NEXRAD rainfall precipitation into discharges and HEC-RAS hydraulic model to calculate water surface elevations along cross-sections. Floodplain delineation was performed using ArcGIS processing capabilities and Model Builder for process automation. As a demonstration project, original M2M implementation was successful as it proved that such a concept can be successfully implemented within GIS environment. The original M2M implementation though had many custom parts that were “hand-crafted” for each model run and made it difficult to implement in a generic way. Also, they were not maintained as the components used for their initial implementation evolved.

With transition to ArcGIS 10, Arc Hydro tools implemented several of M2M original components and simplified the overall process. Arc Hydro infrastructure now allows M2M implementation that is simpler and more sustainable. Proper M2M implementation though requires careful considerations when developing both HMS and RAS models. WRMD’s focus on impacts of GCC adds additional requirements on the M2M process. The original M2M process did not consider potential changes in the models (e.g. model parameters) and boundary conditions, just changes in precipitation over a fixed H&H environment and mapping of that change into floodplain. With GCC concerns, fixed H&H environments cannot be assumed.

The scope of this document is to present the M2M implementation workflows using existing ArcGIS and Arc Hydro infrastructure, focusing on specific WRMD requirements for GCC modeling. Tools that would make that process easier but do not currently exist are identified. The workflows are described by presenting a specific use case for a flood study performed for the Shearstown area, by Hatch in 2012. The intent is that this document can be used as a blueprint for future studies of similar type and facilitate efficient integrated H&H model development with respect to M2M implementation.

Documentation and evaluation of the results of hydrologic and hydraulic models run to support GCC impact assessment can be complex and is out of scope of this document. GIS technology can be used for such documentation and evaluation and further study can be undertaken to identify effective GIS role and products that could be produced to support GCC evaluation.

GIS data and H&H models

GIS data and hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models for the Shearstown area used in this document were provided by the WRMD. They were used as is without any changes, except in few places to facilitate M2M process. These changes will be highlighted in the latter text as they are critical for successful M2M implementation.

Software environment

All processing was performed using Arc Hydro version 2.1.0.42 (March 2012) operating on ArcGIS V10 sp3.

Organization of the document

Document has two main sections. The first section describes the organization of the key M2M components. The second section then presents explicit example using sample data and “design” M2M workflow scenario.

Map To Map Methodology for GCC

Introduction

The basic M2M concept is to take a “map of rainfall” and transform it to the “map of flooding”, by first applying a hydrologic model to transform rainfall into discharge and then use the discharge in the hydraulic model to get water surface elevations (WSE) at cross-sections. These WSE are then mapped into floodplain using GIS processing. The original M2M implementation had the following steps:

- 1) Transform spatially distributed rainfall (time series) obtained from NEXRAD polygons to HMS subbasin polygons (GIS operation).
- 2) Convert GIS time series into DSS (custom code).
- 3) Run HMS model using DSS input (generates DSS output).
- 4) Convert HMS DSS to RAS DSS (custom code).
- 5) Run RAS using DSS as input.
- 6) Post process RAS results to floodplain (GIS operation).

In this workflow, neither HMS and RAS models, nor RAS boundary conditions change. The only thing that changes is the rainfall input. This is the “operational” scenario.

In the context of global climate change analyses, M2M consists of running hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models in a sequence with different initial and boundary conditions. Normally these operations are performed for steady-state design conditions and not in real-time operational conditions as the original M2M. This is the “design” scenario. There are several conditions that can be investigated:

- Change in landscape affecting hydrologic model (e.g. land use change, impervious area change, etc.). These changes would generate changes to the hydrologic model (basin model in HMS).
- Changes in landscape affecting hydraulic model (e.g. change in hydraulic properties such as roughness coefficients, or changes in channel morphology that would affect channel geometry). These changes would generate changes to the hydraulic model (geometry model in RAS).
- Changes in (design) rainfall pattern. In HMS, these changes would generate a different time series for the design gage (a different gage) used in the model if uniform rainfall distribution is used (typical implementation), or change in the whole met model if change in spatial distribution of rainfall is investigated.
- Change in hydraulic boundary conditions to the hydraulic model (flow model in RAS).

For NL GCC implementation, focus was on changes to design rainfall and hydraulic boundary conditions. The organization of the data and models for M2M process presented in this document will support all four types of changes that can be investigated. The examples though will focus on design rainfall and boundary change implementation.

The intent of M2M process is to minimize necessary manual interaction between the end user and the process of model and initial/boundary condition selection, and the model execution. This requires very specific organization of the models and the data, sometimes against the standard industry practices. The following sections describe individual components of the M2M process and identify how each component needs to be configured to enable effective incorporation within the M2M infrastructure.

HMS model setup requirements

In order to run “Run HMS” AH function (that runs HMS in “silent mode” in the background) names of the hms project, basin, gage, and met files **MUST** have the same name. This requirement dictates the naming used for model components and significantly limits any naming flexibility.

One HMS model should have only one basin, one met, one gage, and one control component (while a single HMS model used in M2M can have multiple components, they cannot be used since only the component that has the same name as the model itself can be executed in automated way).

For design conditions modeling, the precipitation time series does not vary in space. Thus, a single “design” gage can be developed for each design condition (e.g. 100-year, 24-hour, current condition) and applied uniformly to each subbasin in HMS.

In HMS model setup, time series data associated with the input precipitation must be separate and completely independent from the spatial “paired data” (e.g. storage-discharge or cross-section data). The precipitation data will be stored in a dss file that is directly tied into the “design” gage data and does not depend on the geometry of the model but only on the precipitation event being used for the modeling. The name of the dss storing the temporal data will be the same as the name of the HMS model. Any “paired data” must be stored in a dss file that is directly associated with the geometry of the model and has a different name than the HMS model name.

GeoHMS model setup requirements

There are a few restrictions on GeoHMS model development. GeoHMS is not used dynamically in the M2M process, that is, it is not called directly to update any of the parameters. GeoHMS is used only in HMS model development. In design conditions discussed here, that is even more pronounced as the distribution of precipitation is applied uniformly and does not depend on the spatial characteristics of the HMS subbasins.

Once GeoHMS model is defined in spatial context, the only significant consideration is definition of “design gage”. In the GeoHMS subbasin file, there is “PrecipGage” field that needs to contain the name of the design gage to be used for precipitation model. That name must **exactly** match the name of the design gage that has the dss file with the precipitation time series to be used in the model and is referenced in the “.gage” HMS file. That name will then be exported into the “.met” file generated by GeoHMS that will link the subbasin name to that gage name.

If several precipitation models will be analyzed, a “.met” file needs to be generated for each precipitation model (design gage).

In order to be consistent and enable potential use for GeoHMS/HMS models in a broader M2M context (operational mode), the following best practices should be followed:

- 1) GeoHMS and HMS subbasins should match in spatial context. Basically the GeoHMS derived subbasins should not be manually modified within HMS (their spatial extent and shape). Instead, if any discrepancies are observed, GeoHMS model should be updated and new HMS basin file generated. This will ensure that GeoHMS subbasins can then be used for calculation of spatially varying rainfall in operational conditions.

RAS model setup requirements

In order to run “Run RAS” AH function (that runs RAS in “silent mode” in the background) definition of the RAS run MUST be specified by fully defined RAS “.prj” file. The geometry, flow, and plan file extensions should be named consistently (e.g. g01, f01, and p01 respectively) and referenced as such in the “.prj” file. RAS project should reference only one geometry, one flow, and one plan.

Flow exchange points where the flows will be passed on from HMS to RAS have to be explicitly defined in RAS. This is done by specifying the “Node Name” of the cross-section that will be receiving the flow from HMS to be the name of the HMS element (normally that will be a HMS junction element) that will be the source of the flow. Normally, that will be assigned to the cross-section in GeoRAS and brought into the RAS through GIS data import option.

GeoRAS model setup requirements

There are a few restrictions on GeoRAS model development. GeoRAS is not used dynamically in the M2M process, neither in pre- or post-processing. GeoRAS is used only in RAS model development. For post-processing of RAS results, only AH and standard ArcGIS geoprocessing functions are used.

When developing GeoRAS model, cross-sections that serve as flow exchange points need to be linked to the HMS elements that provide the flow to that cross-section. This is done by populating the “NodeName” attribute in the GeoRAS cross-section cut line feature class with the name of the HMS element providing the flow (e.g. “J28” if junction with name J28 is the one providing the flow). This is done by hand. Once the GeoRAS generates the RAS .sdf file, node name will be passed on to RAS and will not have to be populated in RAS explicitly.

M2M component automation

HMS and RAS input file structures and tool operations define the approach that has to be taken in defining the variation of the M2M runs. There are three key components in M2M process definition:

- 1) Organization of viable model alternatives (HMS/RAS).
- 2) Selection of model components to represent a single M2M run (which precipitation event is to be combined with what hydrologic and hydraulic environment and boundary conditions).
- 3) Running of the M2M model alternative.

In addition, the results need to be archived for later analysis and documentation. M2M component automation can take many forms depending on the organizational and project needs. In this document, individual M2M workflow steps are presented and then a specific set of automated processes are presented as an example of what can be accomplished.

M2M data organization

To enable effective management of M2M model components, a simple directory and model naming structure is recommended to keep models independent and easily accessible. The structure is based on keeping the model component names fixed (all models have the same component names) and utilizing names of folders to differentiate between the alternatives. This is driven by the complex structure of HMS and RAS control files. If model components are allowed to have flexible names, each time a M2M run was constructed, HMS and RAS control file would have to be created/modified on the fly. While possible, that is risky as these structures can change with new HMS/RAS releases making the maintenance of the system difficult and less sustainable.

The following general directory structure is recommended (only key files are highlighted in each directory). The actual names of directories and files are not important and can be changed as desired. It is suggested though, that once the names are fixed, they are not changed to facilitate documentation and implementation.

```

MapToMap\
  Maptomap.gdb          geodatabase with reference layers
  HMS\
    Dss\
      Rmodel1\HMSM2M.dss
      Rmodel2\HMSM2M.dss
      Rmodel3\HMSM2M.dss
    Basin\
      Smodel1\HMSM2M.basin, HMSM2M.met
      Smodel2\HMSM2M.basin, HMSM2M.met
      Smodel3\HMSM2M.basin, HMSM2M.met
    Fix\HMSM2M.gage, HMSM2M.hms
    CurrentRun\          (for selected Rmodel# and Smodel*)
      HMSM2M.dss          from "Rmodel#" directory
      HMSM2M.basin        from "Smodel*" directory
      HMSM2M.met          from "Smodel*" directory
      HMSM2M.gage         from "Fix" directory
      HMSM2M.hms          from "Fix" directory
  GeoHMS\
    Smodel1\ all GeoHMS data for support of HMS spatial model 1
    Smodel2\ all GeoHMS data for support of HMS spatial model 2
    Smodel3\ all GeoHMS data for support of HMS spatial model 3
  RAS\
    BoundaryConditions\
      BC1\RASM2M.f01, RASM2M.p01
      BC2\RASM2M.f01, RASM2M.p01
      BC3\RASM2M.f01, RASM2M.p01
    Geometry\
      Smodel1\RASM2M.prj, RASM2M.g01
      Smodel2\RASM2M.prj, RASM2M.g01
      Smodel3\RASM2M.prj, RASM2M.g01
    CurrentRun\          (for selected BC# and Smodel*)
      RASM2M.f01          from "BC#" directory
      RASM2M.g01          from "BC#" directory
      RASM2M.f01          from "Smodel*" directory
      RASM2M.prj          from "Smodel*" directory
  GeoRAS\
    Smodel1\ all GeoRAS data for support of RAS spatial model 1
      \Layers\demfp      DEM to be used for floodplain delineation
    Smodel2\ all GeoRAS data for support of RAS spatial model 2
      \Layers\demfp      DEM to be used for floodplain delineation
    Smodel3\ all GeoRAS data for support of RAS spatial model 3
      \Layers\demfp      DEM to be used for floodplain delineation
  ResultArchive\
    Run_ID%% (single combination of HMS (Rmodel# and Smodel*) and RAS (BC# and
              Smodel*). There needs to be a control table/file with the list of all the HMS
              and RAS components that went into that run and description of why that run
              was done. %%% is the unique identifier of the run.
    HMS\all HMS files for that run
    RAS\all RAS files for that run
    GeoRAS\ all postprocessed spatial data

```

Figure 1. M2M directory structure.

Directory structure explanation:

- 1) In order to automate component processing in the M2M, specific naming of M2M processing elements is recommended:
 - a. All HMS components should be named “HMSM2M”.
 - i. Exception is naming of design gaging stations that can have any name.
 - b. All RAS components should be named “RASM2M”.
- 2) All M2M related files are organized under single parent directory called “MapToMap”.
- 3) Maptomap.gdb contains all “global” spatial layers that are used to support the M2M implementation. At least this includes the M2MRUN table (described later in the text). It can also include any background spatial layers that can be used to support M2M implementation (e.g. RAS/HMS model footprints, political/natural reference layers to be used in M2M starting map, etc.).
- 4) “HMS” directory contains all files related to HMS models.
 - a. “Dss” directory contains design precipitation time series data. The name of the dss file is the same for all possible precipitation scenarios – “hmsm2m.dss”. Every precipitation scenario has its own unique directory name (denoted as “Rmodel1”, “Rmodel2”, etc.). This directory name can be user specified and can reflect specific scenario for easy identification (e.g. “D_100_24” for “design, 100-year, 24-hour storm”).
 - b. “Basin” directory contains specific basin and met models. These are specific combinations of HMS spatial elements (basin file) and precipitation scenarios applied to them (met file). Each subdirectory (denoted as “Smodel1”, “Smodel2”, etc.) presents one unique combination of basin and met models. This directory name can be user specified and can reflect specific scenario for easy identification (e.g. “Shearstown_D_100_24” for “Shearstown area, design storm, 100-year, 24-hour storm”).
 - i. Example 1. If the same basin model is modeled with two different precipitation scenarios, there will be two “S*” directories, in which the basin files will be the same and met models will be different (pointing to a different design gage).
 - ii. Example 2. If the same precipitation is used with two HMS models for the same area (e.g. change in subbasin layout or model parameter to accommodate fully developed conditions), there would be two “S*” directories, in which the basin files will be different and met models will be the same.
 - c. “Fix” directory contains two files that are the same for all combinations. This is the “HMSM2M.gage” file that has reference to all the design gages, and “HMSM2M.hms” that always references the same basin and met components.
 - d. “Currenttrun” directory contains the complete HMS model that is currently being analyzed.
- 5) “GeoHMS” directory contains all the spatial data used in GeoHMS for HMS model development. Each “S*” subdirectory matches the names in the “HMS\Basin\S*” directory and contains all the spatial data for development of HMS basin and met model contained in the “HMS\S*” directory.
- 6) “RAS” directory contains all files related to RAS models.

- a. “BoundaryConditions” directory contains specific flow (“RASM2M.f01”) and plan (“RASM2M.p01”) files that define the boundary conditions and flow exchange points for a particular scenario for a particular location. Each subdirectory (denoted as “BC1”, “BC2”, etc.) presents one unique combination of geometry and boundary conditions. This directory name can be user specified and can reflect specific scenario for easy identification (e.g. “Shearstown_Current_100” for “Shearstown area, current conditions, 100-year design storm”).
 - b. “Geometry” directory contains specific RAS geometry and project files. These are specific combinations of RAS spatial elements (geometry file) and project elements. Each subdirectory (denoted as “Smodel1”, “Smodel2”, etc.) presents one unique geometry model. This directory name can be user specified and can reflect specific scenario for easy identification (e.g. “Shearstown_D_100_24” for “Shearstown area, design storm, 100-year, 24-hour storm”). Although this name does not need to match the HMS “Basin\S*” name, it is good practice to do so for RAS model that matches the HMS model (points to the same flow exchange points).
 - c. “Currentrun” directory contains the complete RAS model that is currently being analyzed.
- 7) “GeoRAS” directory contains all the spatial data used in GeoRAS for RAS model development (preprocessing). Each “S*” subdirectory matches the names in the “RAS\Geometry\S*” directory and contains all the spatial data for development of RAS geometry and flow files.
 - a. The subdirectory \Layers contains Esri grid “demfp” that is the DEM to be used in post-processing. This grid needs to have the appropriate spatial extent and resolution (cell size).
- 8) “ResultArchive” directory contains archive of all the results of M2M runs. Each subdirectory contains one combined HMS-RAS run. Subdirectories are referenced by the run ID. The ID is maintained in the M2MRUN table and uniquely identifies the combination of HMS and RAS modeling alternatives used for that particular M2M run.
 - a. “HMS” directory contains all the HMS files for the run.
 - b. “RAS” directory contains all the RAS files for the run.
 - c. “GeoRAS” directory contains all the postprocessed spatial layers (floodplain polygon and depth grid) for the run.

It is not recommended that input spatial data be archived for each run. While it is anticipated that HMS and RAS models might be calibrated in RAS and HMS and thus a particular run might be slightly different from the “raw” input data and need to be explicitly archived to preserve those “tweaks”, for spatial data if changes are being made, they should be done on the core data level and that spatial model needs to be stored as an explicit new model. Thus archiving of spatial (GIS) component is not needed as they are available in their respective model folder as is. Postprocessed spatial data (at least flood depth and extent) are archived.

Selection of model components to represent a single M2M alternative run

A single M2M run consists of one chained execution of HMS and RAS models and RAS model result mapping (flood depth and extent definition). Definition of the HMS and RAS models has the following elements:

- 1) Selection of precipitation model (*.dss).
- 2) Selection of HMS spatial model (*.basin).
- 3) Selection of RAS spatial model (*.g01).
- 4) Selection of RAS boundary conditions (*.f01).

In addition, a name and some description of the model run should be provided. These data are stored in the M2MRUN table stored in the “Maptomap.gdb” geodatabase. The M2MRUN table has the following structure:

Field Name	Field Type	Description
ID	Long	Unique internal identifier for the run
M2MRUNNAME	Char 30	Short name of the run
PMODEL	Char 30	Name of the relative directory containing the precipitation model to use
HMSMODEL	Char 30	Name of the relative directory containing the HMS spatial model to use
RASMODEL	Char 30	Name of the relative directory containing the RAS spatial model to use
BCMODEL	Char 30	Name of the relative directory containing the RAS boundary conditions to use
DESCRIPTION	Char 100	Model run description
ISRUN	Long	Field indicating whether the model has been run or not. 0 – not run, 1 – already run and the result directory exists

Table 1. M2MRUN table structure.

NOTE: At this point, there is not an Arc Hydro tool to populate this table. It needs to be populated manually.

Once the M2M alternative is executed, the “ISRUN” field is set to 1. The results are stored in the ResultArchive\Run_ID%%%\ directory where %%% is the values of the ID field for that alternative.

Map2Map example run

Data organization

To demonstrate the basic principles of M2M implementation, Shearstown data that were provided were organized in the proposed structure and a sample M2M run was performed.

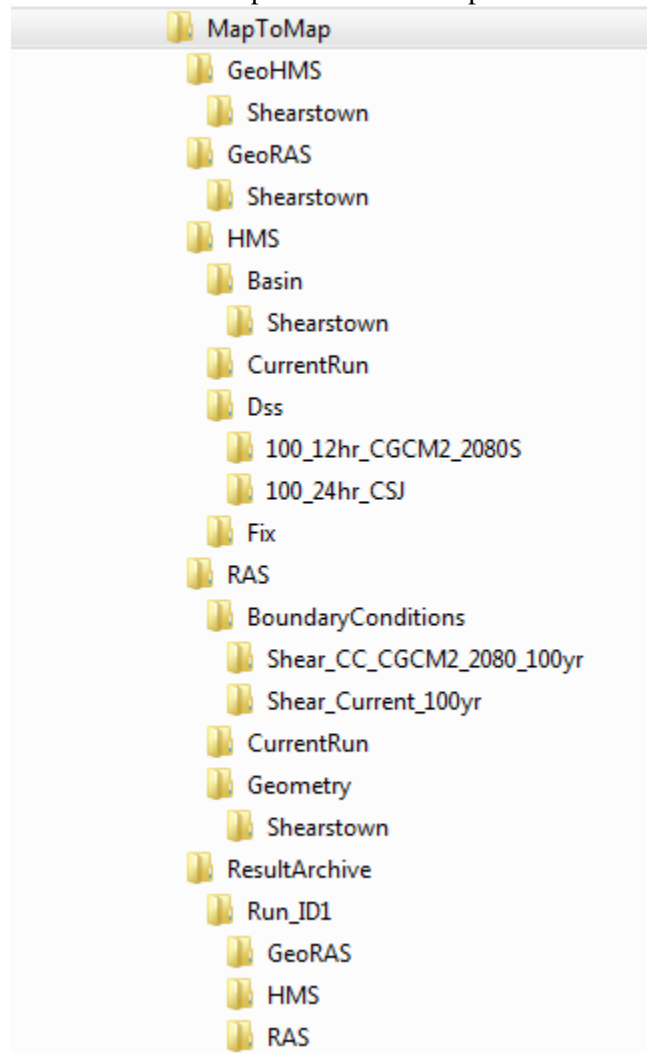


Figure 2. M2M directory structure for the example.

The following scenarios are presented:

- 1) Rainfall model. There are two models:
 - a. Current conditions – 100 year, 24-hour.
 - b. CC precipitation distribution – 100 year, 12-hour, CGCM2 model for 2080.
- 2) Spatial HMS model. There is one HMS basin model.
 - a. Shearstown.
- 3) Spatial RAS model. There is one RAS geometry model.
 - a. Shearstown.

- 4) RAS Boundary conditions. There are two boundary conditions:
 - a. Current conditions – 100 year event.
 - b. CC conditions – CGCM2, 2080 – 100 year event.
- 5) GeoHMS. There is one GeoHMS model.
- 6) GeoRAS. There is one GeoRAS model.

M2M model component modification

Minor changes to the original models and GIS data were necessary to enable their inclusion in the M2M workflow.

- 1) HMS model was simplified to contain only one basin, one met, one gage, and one control component.
- 2) All components of the HMS model were renamed according to proposed structure and placed in proper directory structure.
- 3) Temporal and spatial paired data were placed in separate dss files (HMSM2M.dss for temporal data and HMSM2M_PairedData.dss for spatial data).
- 4) RAS model was simplified to contain only one geometry, one flow profile, one flow file, and one steady plan file.
- 5) All components of the RAS model were renamed according to proposed structure and placed in proper directory structure.
- 6) In RAS, for all RAS cross-sections receiving flows from HMS, their NodeName was populated with appropriate junction label matching HMS junction providing the flows.
- 7) In the GeoRAS cross-section (cut line) feature class, for all cross-sections receiving flows from HMS, their NodeName was populated with appropriate junction label matching HMS junction providing the flows.

M2M workflow execution

M2M HMS model component run

This section presents individual tool runs for the part of M2M workflow that runs HMS and generates flows that need to be “moved” to RAS. It is envisioned that this will be one of the M2M sub-models. The starting point for the analysis is an ArcMap project with the DEM and GeoRAS cross-sections loaded. The project needs to be saved before running any of the tools.

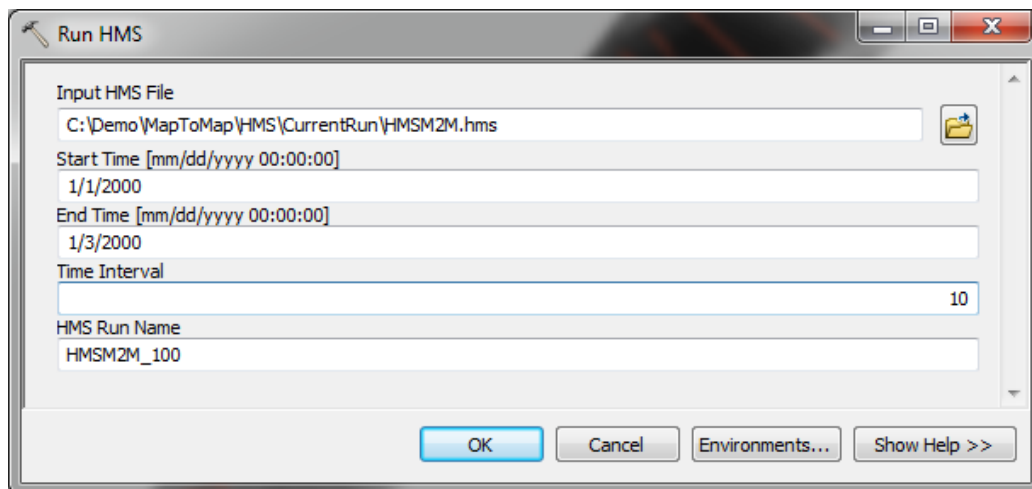
RAS *.f01 file (this is a flow file that has boundary conditions for the RAS run) before running the HMS M2M operations has the following content (“RASM2M.f01”):

```

1 Flow Title=FloodM2MP_100
2 Program Version=4.10
3 Number of Profiles= 1
4 Profile Names=1:100
5 River Rch & RM=Shearstown_Brook,Main , 6544.472
6     38
7 River Rch & RM=Shearstown_Brook,Main , 4527.462
8     42
9 River Rch & RM=Shearstown_Brook,Main , 2846.736
10    53
11 River Rch & RM=Shearstown_Brook,Main , 1960.358
12    57
13 Boundary for River Rch & Prof#=Shearstown_Brook,Main , 1
14 Up Type= 3
15 Up Slope=0.0001
16 Dn Type= 1
17 Dn Known WS=1.7
18 DSS Import StartDate=
19 DSS Import StartTime=
20 DSS Import EndDate=
21 DSS Import EndTime=
22 DSS Import GetInterval= 0
23 DSS Import Interval=
24 DSS Import GetPeak= 0
25 DSS Import FillOption= 0
26

```

- 1) Run "Run HMS" from "Arc Hydro -> H & H Modeling -> Map to Map" toolbox. Input elements match manually run HMS model. A new ".control" and ".script" files are created based on provided "HMS Run Name". ".run" file is updated. The result of the tool is a HMS run whose results are stored in the model ".dss" file. All files will be in the same directory as specified ".hms" file.

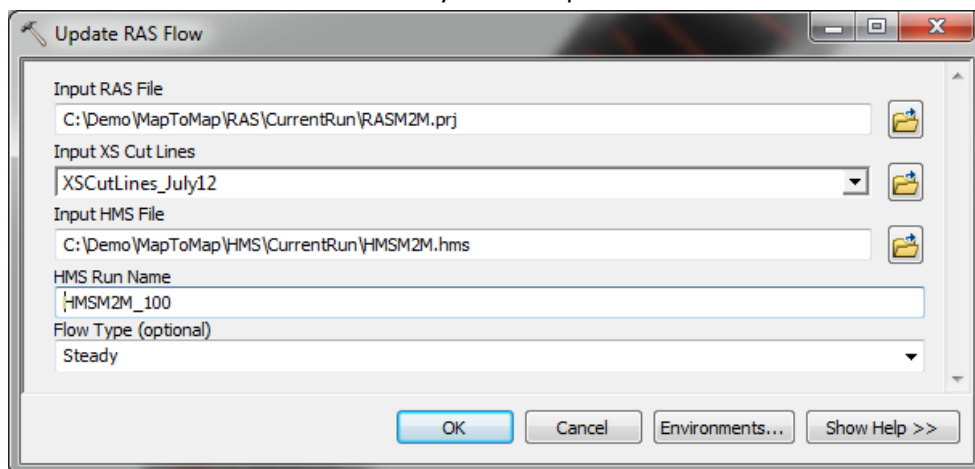


```

Executing: RunHMS C:\Demo\MapToMap\HMS\CurrentRun\HMSM2M.hms 1/1/2000
1/3/2000 10 HMSM2M_100
Start Time: Wed Mar 28 03:14:36 2012
Succeeded at Wed Mar 28 03:14:46 2012 (Elapsed Time: 10.00 seconds)

```

- 2) Run “Update RAS Flow” from “Arc Hydro -> H & H Modeling -> Map to Map” toolbox. The result of the tool is modified “*.prj” file for the specified RAS model .xml file version of the input .sdf file. File will be in the same directory as RAS input files.



```

Executing: UpdateRASFlow C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.prj
XSCutLines_July12 C:\Demo\MapToMap\HMS\CurrentRun\HMSM2M.hms HMSM2M_100
Steady
Start Time: Wed Mar 28 03:18:56 2012
Reading DSS path and updating RAS flow..
Flow values updated for 4 features from DSS File
C:\Demo\MapToMap\HMS\CurrentRun\HMSM2M.dss!
Succeeded at Wed Mar 28 03:18:58 2012 (Elapsed Time: 2.00 seconds)

```

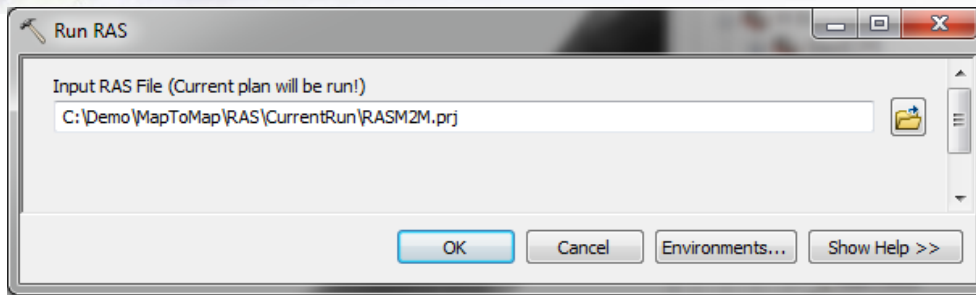
M2M RAS model component run

This section presents individual tool runs for the part of M2M workflow that runs RAS and generates output geodatabase with results. It is envisioned that this will be one of the M2M sub-models. Generated geodatabase will contain at least:

- Stream centerline (2D)
- Cross-sections (2D) with water surface elevation field populated
- Bounding polygon

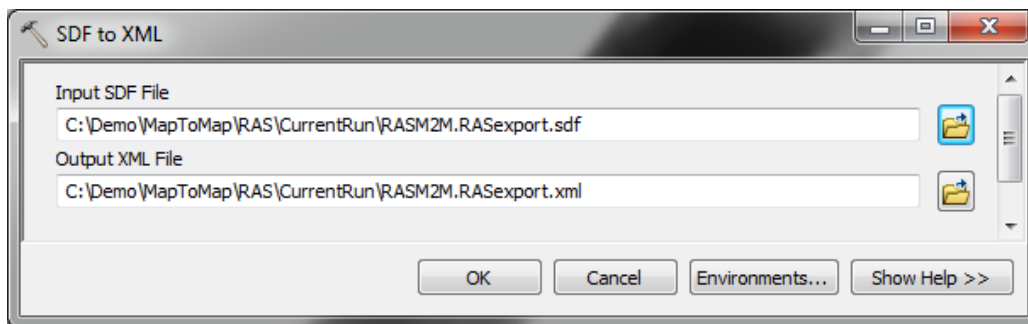
The starting point for the analysis is an ArcMap project with the DEM loaded. The project needs to be saved before running any of the tools.

- 1) Run “Run RAS” from “Arc Hydro -> H & H Modeling -> Map to Map” toolbox. The result of the tool is a RAS run with export of results into .sdf file. File will be in the same directory as RAS input files.



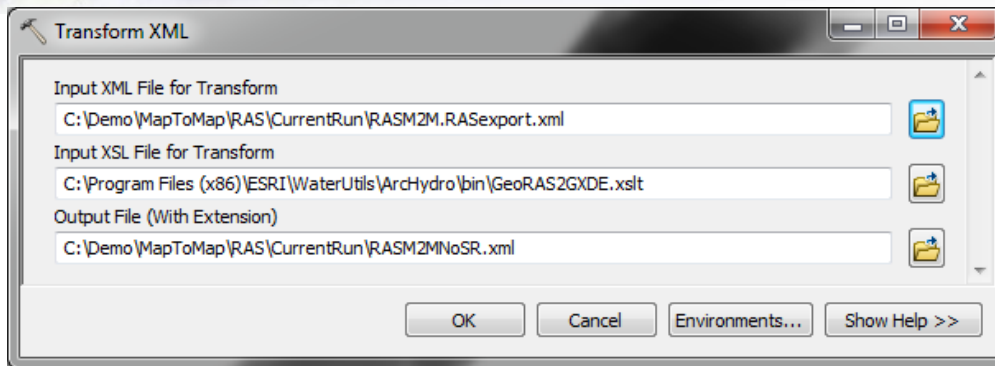
```
Executing: RunRAS C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.prj
Start Time: Wed Mar 28 03:23:57 2012
RAS run results exported to
C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.RASexport.sdf.
Succeeded at Wed Mar 28 03:24:00 2012 (Elapsed Time: 3.00 seconds)
```

- 2) Run "SDF to XML" from "Arc Hydro -> H & H Modeling -> Map to Map" toolbox. The result of the tool is .xml file version of the input .sdf file. File will be in the same directory as RAS input files.




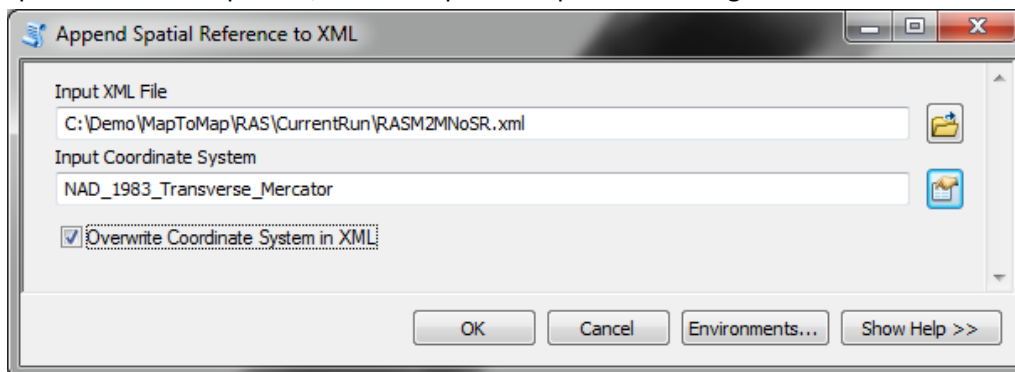
```
Executing: SDFToXML C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.RASexport.sdf
C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.RASexport.xml
Start Time: Wed Mar 28 03:26:18 2012
Converting SDF to XML...
SDF successfully converted
C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.RASexport.xml
Succeeded at Wed Mar 28 03:26:18 2012 (Elapsed Time: 0.00 seconds)
```

- 3) Run "Transform XML" from "Arc Hydro -> GIS Data Exchange -> XML Exchange" toolbox. The result of the tool is transformed .xml file version (AH generic) of the input .xml file (model specific). File will be in the same directory as RAS input files. Proper XSLT needs to be specified for RAS->AH xml format conversion ("GeoRAS2GXDE.xslt" from Arc Hydro bin directory – usually C:\Program Files (x86)\ESRI\WaterUtils\ArcHydro\bin).



```
Executing: TransformXML C:\Demo\MapToMap\RAS\CurrentRun\RASM2M.RASexport.xml
"C:\Program Files (x86)\ESRI\WaterUtils\ArcHydro\bin\GeoRAS2GXDE.xslt"
C:\Demo\MapToMap\RAS\CurrentRun\RASM2MNoSR.xml
Start Time: Wed Mar 28 03:30:10 2012
Succeeded at Wed Mar 28 03:30:11 2012 (Elapsed Time: 1.00 seconds)
```

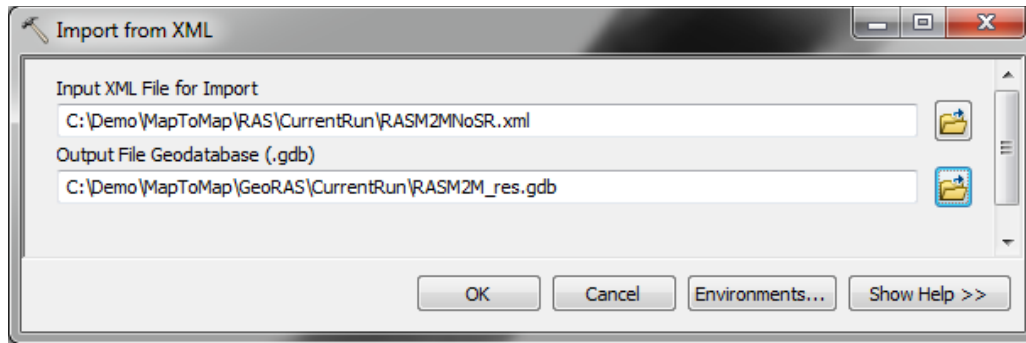
- 4) Since the original sdf file generated by RAS does not contain information about spatial reference that is needed to construct the result's geodatabase, the XML generated in the previous step needs to be updated with the spatial reference information. Run "Append Spatial Reference to XML" from "Arc Hydro -> GIS Data Exchange -> XML Exchange" toolbox. The result of the tool is updated .xml file with <WKT> element properly populated (no new file is created – the input file is updated). When asked for "Input Coordinate System", click on  next to it to open the spatial reference "picker", select "Import ..." option and navigate to the DEM.



```
Executing: AppendSpatialReferencetoXML
C:\Demo\MapToMap\RAS\CurrentRun\RASM2MNoSR.xml
PROJCS['NAD_1983_Transverse_Mercator',GEOGCS['GCS_North_American_1983',DATUM
['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIME
M['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transverse
_Mercator'],PARAMETER['False_Easting',304800.0],PARAMETER['False_Northing',0
.0],PARAMETER['Central_Meridian',-
53.0],PARAMETER['Scale_Factor',0.9999],PARAMETER['Latitude_Of_Origin',0.0],U
NIT['Meter',1.0]] true
Start Time: Wed Mar 28 03:32:23 2012
Running script AppendSpatialReferencetoXML...
Replacing coordinate system...
```


Completed script AppendSpatialReferencetoXML...
 Succeeded at Wed Mar 28 03:32:25 2012 (Elapsed Time: 2.00 seconds)

- 5) Now the generic import XML is ready and can be used to generate the results geodatabase. Run “Import from XML” from “Arc Hydro -> GIS Data Exchange -> XML Exchange” toolbox. The result of the tool is geodatabase according to GeoRAS import specifications.



Executing: ImportFromXML C:\Demo\MapToMap\RAS\CurrentRun\RASM2MNoSR.xml
 C:\Demo\MapToMap\GeoRAS\CurrentRun\RASM2M_res.gdb
 Start Time: Wed Mar 28 03:37:59 2012
 Succeeded at Wed Mar 28 03:38:06 2012 (Elapsed Time: 7.00 seconds)

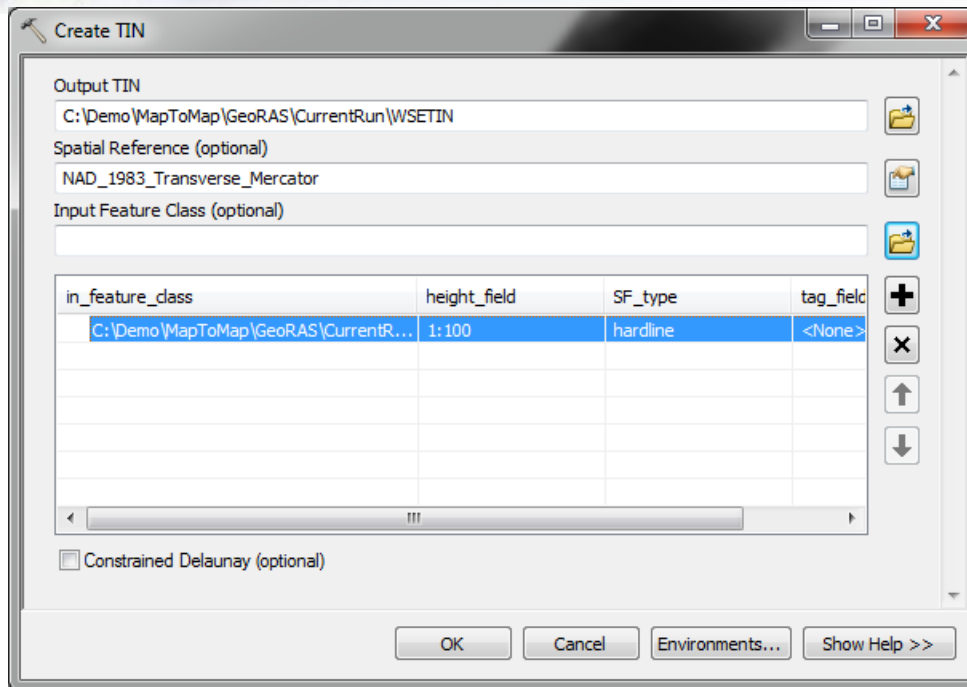
The features in the resulting geodatabase are not added to the map.

M2M RAS results mapping component run

This section presents individual tool runs for the part of M2M workflow that generates floodplain extent polygon and flood depth based on RAS result geodatabase created in the previous sub-model. It is envisioned that this will be one of the M2M sub-models.

The starting point for the sub-model is an ArcMap project with the DEM loaded and RAS results geodatabase generated by the previous sub-model. The project needs to be saved before running any of the tools. This can be the same project from the previous step.

- 1) Run “Create TIN” from “3D Analyst -> TIN Management” toolbox. Define the spatial reference to be the same as for the DEM. Select as “in_feature_class” XSCutLine feature class from the RAS results geodatabase created in the previous step. Specify “1:100” as the height_field from which to extract water surface elevations. The result of the tool is water surface elevation TIN surface whose extent is defined by the extent of cross-sections.

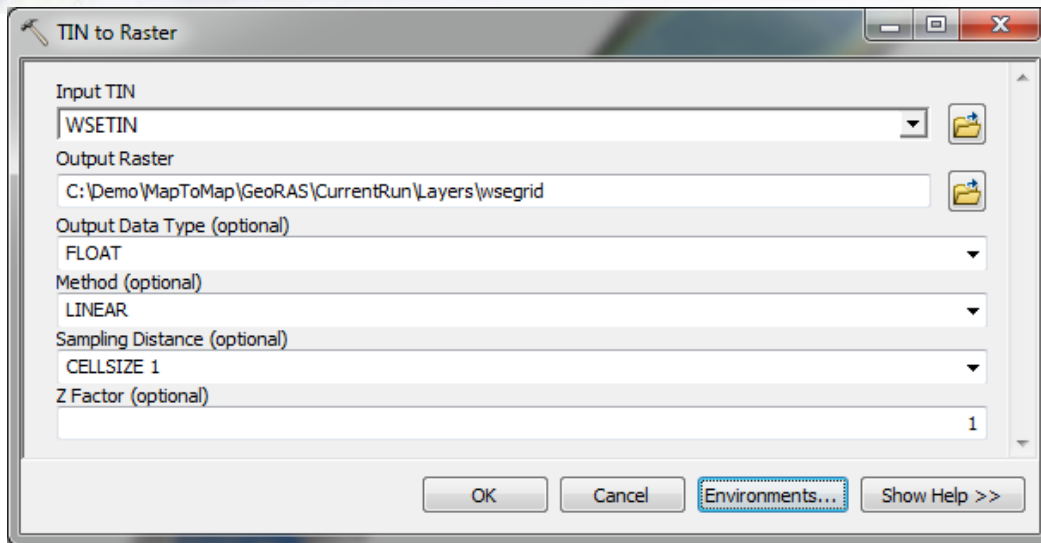


```

Executing: CreateTin C:\Demo\MapToMap\GeoRAS\CurrentRun\WSETIN
PROJCS['NAD_1983_Transverse_Mercator',GEOGCS['GCS_North_American_1983',DATUM
['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],PRIME
M['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transverse
_Mercator'],PARAMETER['False_Easting',304800.0],PARAMETER['False_Northing',0
.0],PARAMETER['Central_Meridian',-
53.0],PARAMETER['Scale_Factor',0.9999],PARAMETER['Latitude_Of_Origin',0.0],U
NIT['Meter',1.0]]
"C:\Demo\MapToMap\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\XSCutlines
1:100 hardline <None>" DELAUNAY
Start Time: Wed Mar 28 03:48:34 2012
Succeeded at Wed Mar 28 03:48:34 2012 (Elapsed Time: 0.00 seconds)

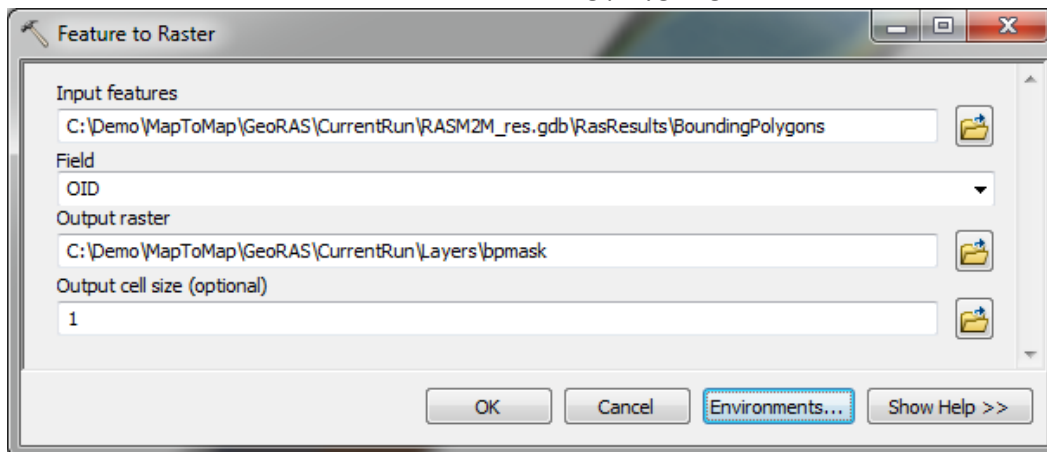
```

- 2) Convert WSE TIN to a WSE grid. Run "TIN to Raster" from "3D Analyst -> Conversion -> From TIN" toolbox. Define environments: snap raster = DEM. Set the Sampling Distance as "CELLSIZE 1" for example, where 1 is the cell size of the DEM. The result of the tool is water surface elevation grid.



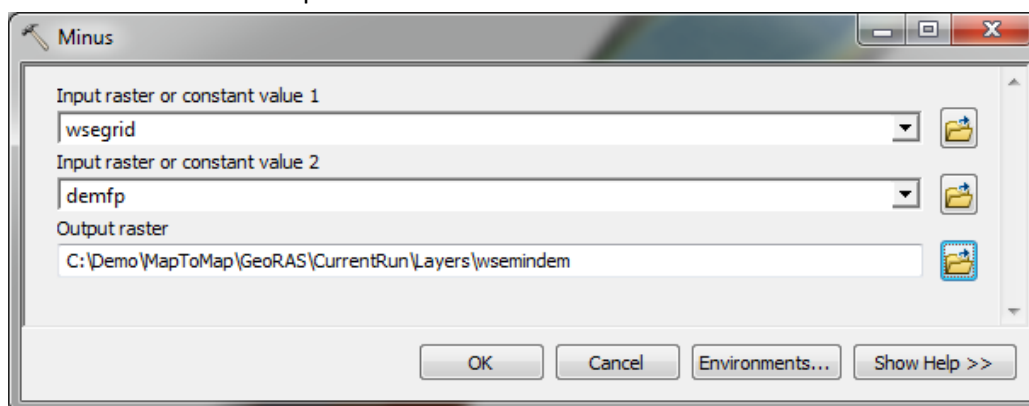
```
Executing: TinRaster WSETIN
C:\Demo\MapToMap\GeoRAS\CurrentRun\Layers\wsegrid FLOAT LINEAR "CELLSIZE 1"
1
Start Time: Wed Mar 28 03:52:10 2012
Succeeded at Wed Mar 28 03:52:17 2012 (Elapsed Time: 7.00 seconds)
```

- 3) Generate bounding polygon raster mask. It will be used to mask out the results of the depth calculations since flooding must be confined within the model bounding polygon. Run “Feature to Raster” from “Conversion -> To Raster” toolbox. Define environments: snap raster = DEM, cell size = DEM. The result of the tool is bounding polygon grid.



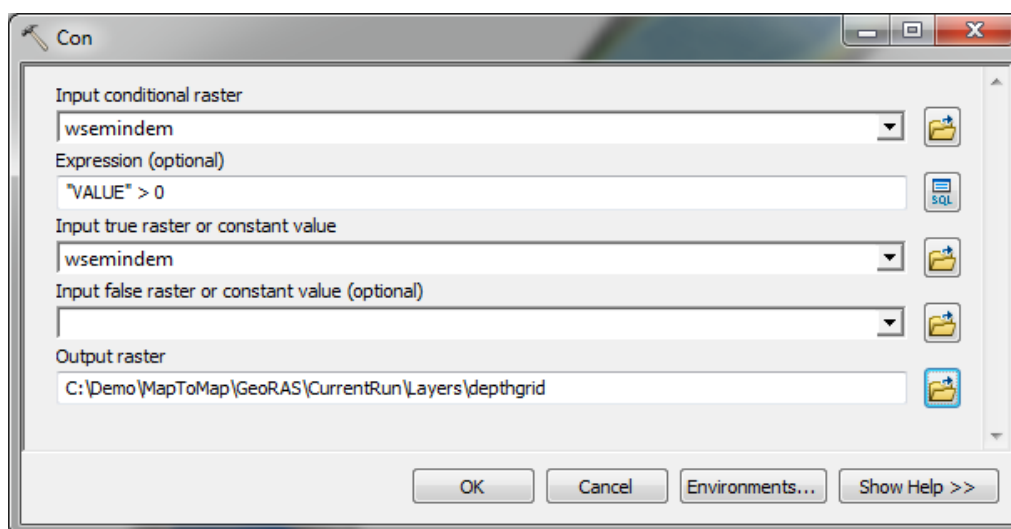
```
Executing: FeatureToRaster
C:\Demo\MapToMap\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\BoundingPolygon
s OID C:\Demo\MapToMap\GeoRAS\CurrentRun\Layers\bpmask 1
Start Time: Wed Mar 28 03:55:37 2012
Succeeded at Wed Mar 28 03:55:39 2012 (Elapsed Time: 2.00 seconds)
```

- 4) Calculate difference between WSE and DEM (positive values are inundated areas). Run “Minus” from “Spatial Analyst -> Math” toolbox. Define environments: snap raster = DEM, cell size = DEM, mask = bpmask. Negative values need to be removed as they do not make sense in the context of inundation depth.



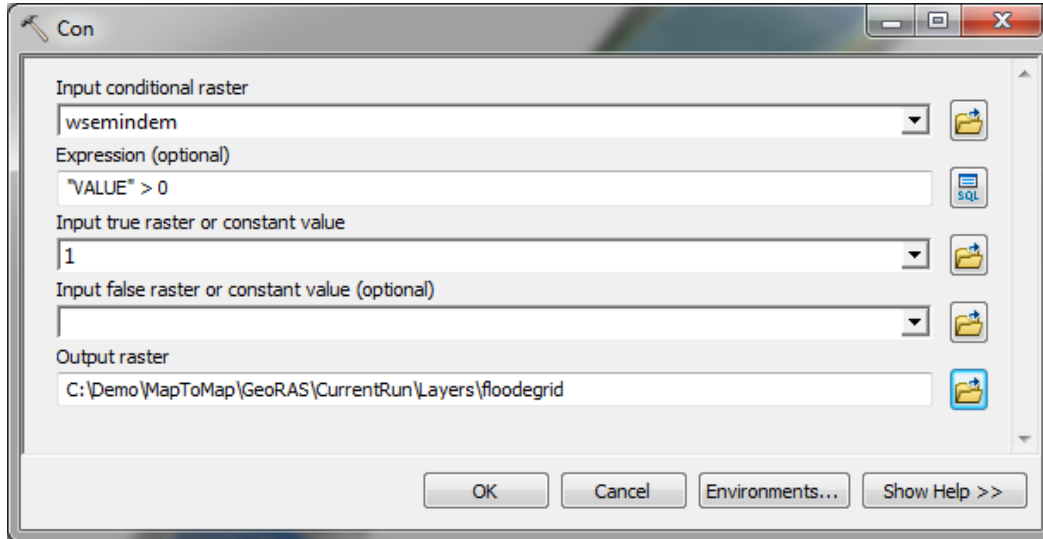
```
Executing: Minus wsegrid demfp
C:\Demo\MapToMap\GeoRAS\CurrentRun\Layers\wsemindem
Start Time: Wed Mar 28 03:59:47 2012
Succeeded at Wed Mar 28 03:59:51 2012 (Elapsed Time: 4.00 seconds)
```

- 5) Limit the depth grid only to positive values. Run “Con” from “Spatial Analyst -> Conditional” toolbox. Define environments: snap raster = DEM, cell size = DEM, mask = bpmask. The result of the tool is inundation depth grid contained within the bounding polygon.



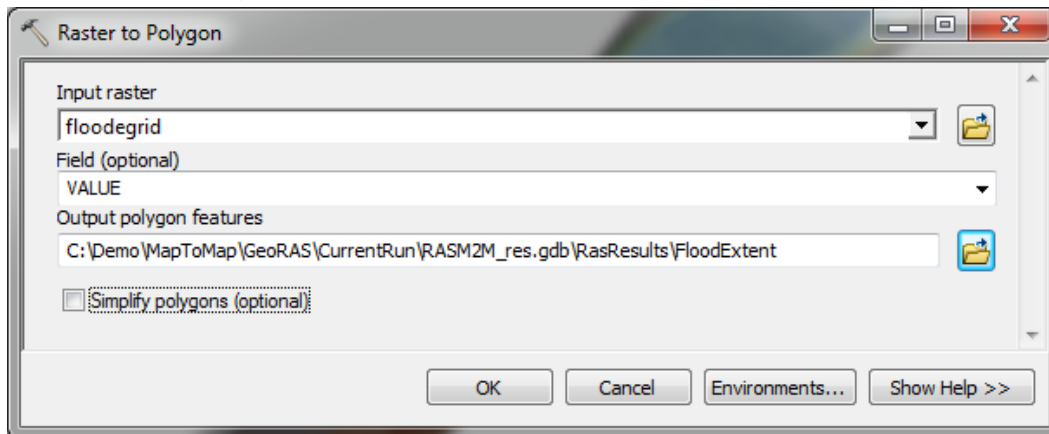
```
Executing: Con wsemindem wsemindem
C:\Demo\MapToMap\GeoRAS\CurrentRun\Layers\depthgrid # ""VALUE" > 0"
Start Time: Wed Mar 28 04:02:54 2012
Succeeded at Wed Mar 28 04:02:58 2012 (Elapsed Time: 4.00 seconds)
```

- 6) Create a flood extent grid of 1 where there is inundation and no data elsewhere. Run “Con” from “Spatial Analyst -> Conditional” toolbox. Define environments: snap raster = DEM, cell size = DEM, mask = bpmask.



```
Executing: Con wsemindem 1
C:\Demo\MapToMap\GeoRAS\CurrentRun\Layers\floodegrid # ""VALUE" > 0"
Start Time: Wed Mar 28 04:05:24 2012
Succeeded at Wed Mar 28 04:05:28 2012 (Elapsed Time: 4.00 seconds)
```

- 7) Generate floodplain polygon by converting the floodplain extent grid to a polygon. Run “Raster to Polygon” from “Conversion -> From Raster” toolbox. Save the result in the geodatabase (but not feature dataset).



```
Executing: RasterToPolygon floodegrid
C:\Demo\MapToMap\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\FloodExtent
NO_SIMPLIFY VALUE
Start Time: Wed Mar 28 04:07:54 2012
Succeeded at Wed Mar 28 04:07:58 2012 (Elapsed Time: 4.00 seconds)
```

Perform optional floodplain “cleaning” (e.g. remove disconnected flood polygons). This is not recommended before thorough quality control of the results is performed and is not presented here. Also, there are no “standards” for doing this. It is recommended that NL develops their “standard” and encapsulates it into a sub-model that would be run after the basic floodplain information is derived in previous steps.

M2M process automation

Two model builder models have been developed to demonstrate how the individual steps presented above can be automated. The first model builder is called “HMS to GeoRAS” and it takes process from running HMS to running RAS to generating results GeoRAS geodatabase. The user interface is presented in the following figure.

The screenshot shows the 'HMS to GeoRAS' model builder interface. The fields are as follows:

- Input HMS Project File (.hms):** C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.hms
- Start Time [mm/dd/yyyy 00:00:00]:** 1/1/2000
- End Time [mm/dd/yyyy 00:00:00]:** 1/3/2000
- Time Interval:** 10
- Input RAS Project File (.prj):** C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.prj
- Input Cross Section Features:** C:\Demo\Map2Map\GeoRAS\Shearstown\shearstown_georas.gdb\Layers\XSCutLines_July12
- Input Coordinate System:** NAD_1983_Lambert_Conformal_Conic
- Input GeoRAS2GXDE XSLT File:** C:\Program Files (x86)\ESRI\WaterUtils\ArcHydro\bin\GeoRAS2GXDE.xslt
- Processing Directory:** C:\Demo\Map2Map\GeoRAS\CurrentRun
- Output GeoRAS GDB:** %Processing Directory%\RASM2M_res.gdb

Buttons at the bottom: OK, Cancel, Environments..., Show Help >>

Figure 3. Run time interface for “HMS to GeoRAS” model.

```
Executing: HMStoGeoRAS C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.hms 1/1/2000
1/3/2000 10 C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.prj
C:\Demo\Map2Map\GeoRAS\Shearstown\shearstown_georas.gdb\Layers\XSCutLines_Ju
ly12
PROJCS['NAD_1983_Lambert_Conformal_Conic',GEOGCS['GCS_North_American_1983',D
```



```

ATUM['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lamber
t_Conformal_Conic'],PARAMETER['False_Easting',1968500.0],PARAMETER['False_No
rthing',13123333.3333333],PARAMETER['Central_Meridian',-
99.0],PARAMETER['Standard_Parallel_1',28.3833333333333],PARAMETER['Standard
_Parallel_2',30.2833333333333],PARAMETER['Latitude_Of_Origin',27.8333333333
333],UNIT['Foot_US',0.3048006096012192]] "C:\Program Files
(x86)\ESRI\WaterUtils\ArcHydro\bin\GeoRAS2GXDE.xslt"
C:\Demo\Map2Map\GeoRAS\CurrentRun "%Processing Directory%\RASM2M_res.gdb"
Start Time: Thu Mar 29 15:02:54 2012
Executing (Run HMS): RunHMS C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.hms
1/1/2000 1/3/2000 10 "Run 1"
Start Time: Thu Mar 29 15:02:57 2012
Succeeded at Thu Mar 29 15:03:14 2012 (Elapsed Time: 17.00 seconds)
Executing (Update RAS Flow): UpdateRASFlow
C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.prj
C:\Demo\Map2Map\GeoRAS\Shearstown\shearstown_georas.gdb\Layers\XSCutLines_J
uly12 C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.hms "Run 1" Steady
Start Time: Thu Mar 29 15:03:14 2012
Reading DSS path and updating RAS flow..
Flow values updated for 4 features from DSS File
C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.dss!
Succeeded at Thu Mar 29 15:03:57 2012 (Elapsed Time: 43.00 seconds)
Executing (Run RAS): RunRAS C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.prj
Start Time: Thu Mar 29 15:03:57 2012
RAS run results exported to
C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.RASexport.sdf.
Succeeded at Thu Mar 29 15:04:00 2012 (Elapsed Time: 3.00 seconds)
Executing (Parse Path): ParsePath C:\Demo\Map2Map\HMS\CurrentRun\HMSM2M.hms
NAME
Start Time: Thu Mar 29 15:04:00 2012
Succeeded at Thu Mar 29 15:04:00 2012 (Elapsed Time: 0.00 seconds)
Executing (SDF to XML): SDFToXML
C:\Demo\Map2Map\RAS\CurrentRun\RASM2M.RASexport.sdf
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M.RASexport.xml
Start Time: Thu Mar 29 15:04:00 2012
Converting SDF to XML...
SDF successfully converted
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M.RASexport.xml
Succeeded at Thu Mar 29 15:04:00 2012 (Elapsed Time: 0.00 seconds)
Executing (Transform XML): TransformXML
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M.RASexport.xml "C:\Program Files
(x86)\ESRI\WaterUtils\ArcHydro\bin\GeoRAS2GXDE.xslt"
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M_GenericXML.xml
Start Time: Thu Mar 29 15:04:00 2012
Succeeded at Thu Mar 29 15:04:01 2012 (Elapsed Time: 1.00 seconds)
Executing (Append Spatial Reference to XML): AppendSpatialReferencetoXML
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M_GenericXML.xml
PROJCS['NAD_1983_Lambert_Conformal_Conic',GEOGCS['GCS_North_American_1983',
DATUM['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]]
,PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Lam
bert_Conformal_Conic'],PARAMETER['False_Easting',1968500.0],PARAMETER['Fals
e_Northing',13123333.3333333],PARAMETER['Central_Meridian',-
99.0],PARAMETER['Standard_Parallel_1',28.3833333333333],PARAMETER['Standar

```

```

d Parallel 2',30.283333333333334],PARAMETER['Latitude_Of_Origin',27.833333333
333333],UNIT['Foot US',0.3048006096012192]] true
Start Time: Thu Mar 29 15:04:01 2012
Running script AppendSpatialReferencetoXML...
Replacing coordinate system...
Completed script AppendSpatialReferencetoXML...
Succeeded at Thu Mar 29 15:04:03 2012 (Elapsed Time: 2.00 seconds)
Executing (Import from XML): ImportFromXML
C:\Demo\Map2Map\GeoRAS\CurrentRun\HMSM2M_GenericXML.xml
C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb
Start Time: Thu Mar 29 15:04:03 2012
Succeeded at Thu Mar 29 15:04:07 2012 (Elapsed Time: 4.00 seconds)
Succeeded at Thu Mar 29 15:04:08 2012 (Elapsed Time: 1 minutes 14 seconds)

```

The following figure presents the “HMS to GeoRAS” model overview and zoomed-in details.

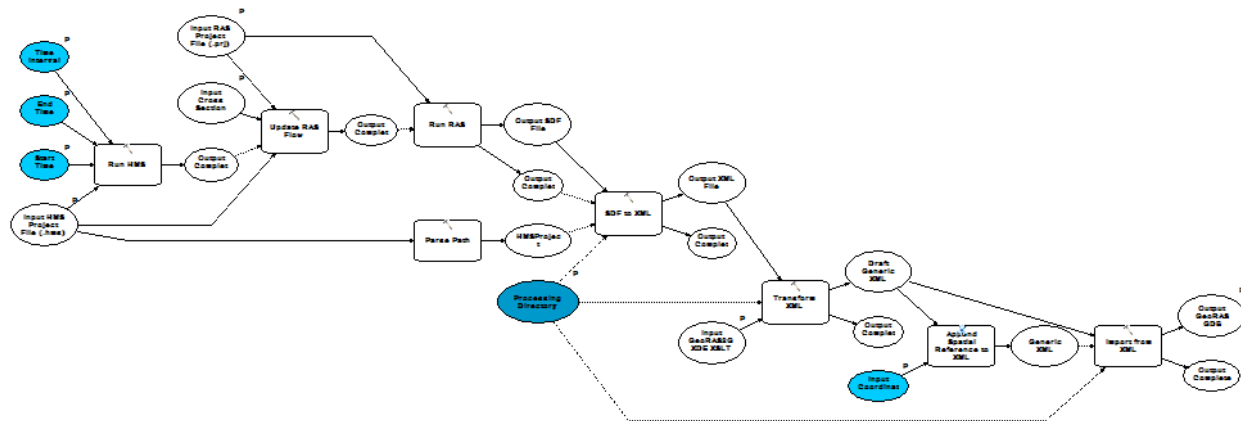


Figure 4. “HMS to GeoRAS” model.

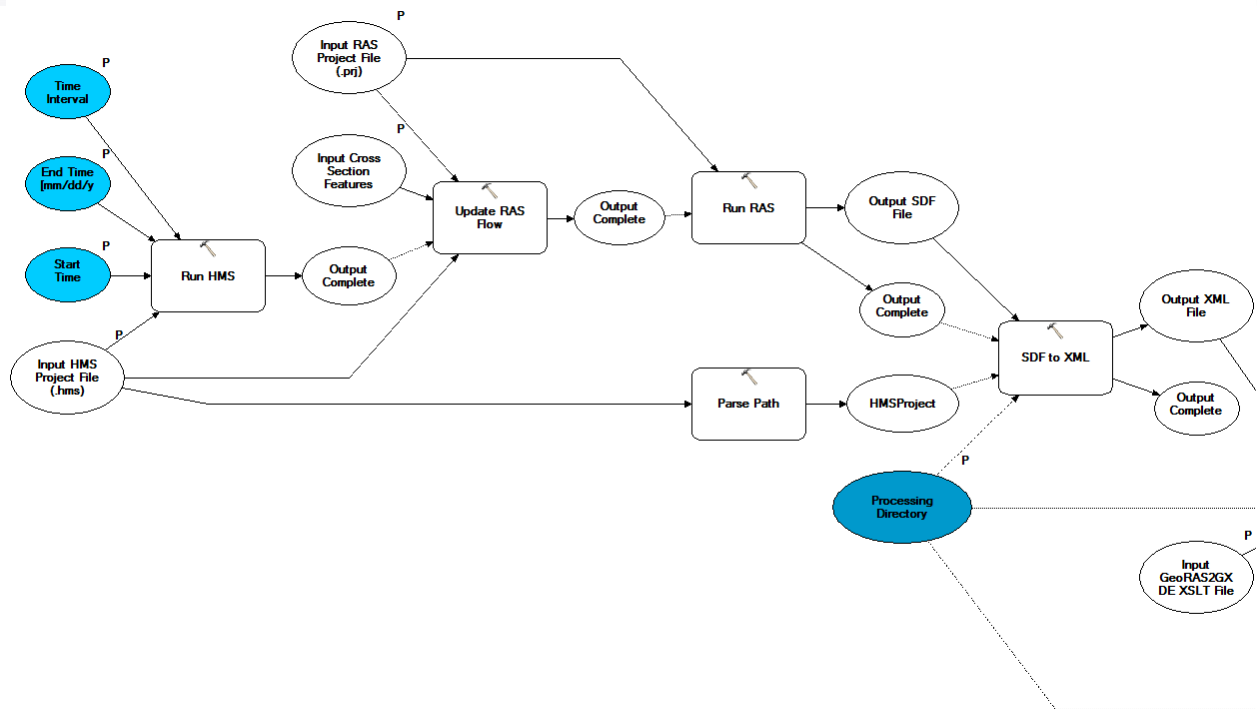


Figure 5. "HMS to GeoRAS" model details (1/2).

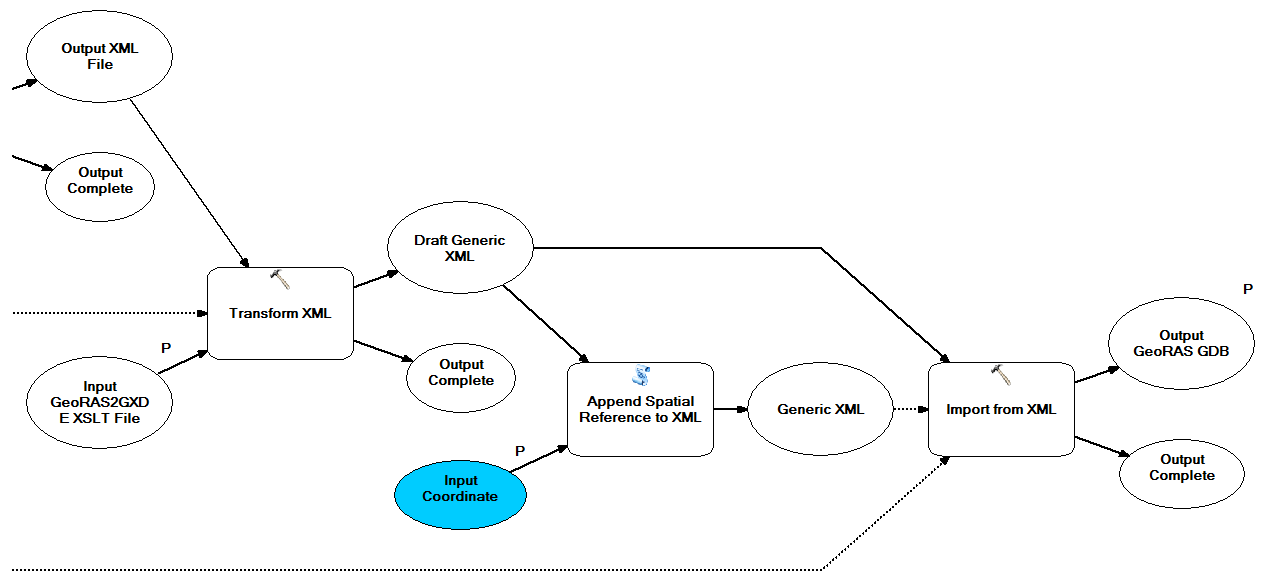


Figure 6. "HMS to GeoRAS" model details (2/2).

The second model builder is called “GeoRAS to Flood” and it takes results GeoRAS geodatabase and DEM and generates flood depth and flood extent polygon. The user interface is presented in the following figure.

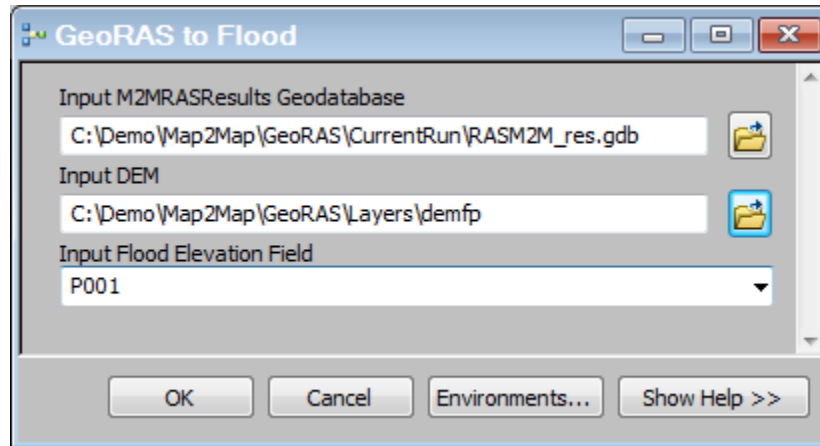


Figure 7. Run time interface for "GeoRAS to Flood" model.

```

Executing: GeoRASToFlood C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb
C:\Demo\Map2Map\GeoRAS\Layers\demfp P001
Start Time: Thu Mar 29 14:37:38 2012
  Executing (Spatial Reference From Raster): SpatialReferenceFromRaster
    C:\Demo\Map2Map\GeoRAS\Layers\demfp
    Start Time: Thu Mar 29 14:37:40 2012
    Running script SpatialReferenceFromRaster...
      Projection type = Projected
      Projection name = NAD_1983_Transverse_Mercator
    Completed script SpatialReferenceFromRaster...
    Succeeded at Thu Mar 29 14:37:40 2012 (Elapsed Time: 0.00 seconds)
  Executing (Select Data): SelectData
    C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb RasResults
    Start Time: Thu Mar 29 14:37:40 2012
    Succeeded at Thu Mar 29 14:37:40 2012 (Elapsed Time: 0.00 seconds)
  Executing (Select Data (2)): SelectData
    C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults XSCutlines
    Start Time: Thu Mar 29 14:37:40 2012
    Succeeded at Thu Mar 29 14:37:40 2012 (Elapsed Time: 0.00 seconds)
  Executing (Get Field Alias): GetFieldAlias
    C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\XSCutlines P001
    Start Time: Thu Mar 29 14:37:40 2012
    Running script GetFieldAlias...
    Alias: 1:100
    Completed script GetFieldAlias...
    Succeeded at Thu Mar 29 14:37:40 2012 (Elapsed Time: 0.00 seconds)
  Executing (Parse Path): ParsePath
    C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb PATH
    Start Time: Thu Mar 29 14:37:40 2012
    Succeeded at Thu Mar 29 14:37:40 2012 (Elapsed Time: 0.00 seconds)
  
```

```

Executing (Create Directory): CreateDirectory
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers
Start Time: Thu Mar 29 14:37:40 2012
Running script CreateDirectory...
Completed script CreateDirectory...
Succeeded at Thu Mar 29 14:37:41 2012 (Elapsed Time: 1.00 seconds)
Executing (Create TIN): CreateTIN
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsetin
"PROJCS['NAD_1983_Transverse_Mercator',GEOGCS['GCS_North_American_1983',DAT
UM['D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],PR
IMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Transv
erse_Mercator'],PARAMETER['False_Easting',304800.0],PARAMETER['False_Northi
ng',0.0],PARAMETER['Central_Meridian',-
53.0],PARAMETER['Scale_Factor',0.9999],PARAMETER['Latitude_Of_Origin',0.0],
UNIT['Meter',1.0]];-5317800 -10001100 450310428.589905;-100000 10000;-
100000 10000;0.001;0.001;0.001;IsHighPrecision"
"C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\XSCutlines
1:100 hardline <None>" #
Start Time: Thu Mar 29 14:37:41 2012
Running script CreateTIN...
Completed script CreateTIN...
Succeeded at Thu Mar 29 14:37:42 2012 (Elapsed Time: 1.00 seconds)
Executing (Get Raster Properties): GetRasterProperties
C:\Demo\Map2Map\GeoRAS\Layers\demfp CELLSIZE
Start Time: Thu Mar 29 14:37:42 2012
Cellsize in x direction = 1.000000
Succeeded at Thu Mar 29 14:37:42 2012 (Elapsed Time: 0.00 seconds)
Executing (TIN to Raster): TINtoRaster
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsetin
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsegrid # # "CELLSIZE 1" #
Start Time: Thu Mar 29 14:37:42 2012
Running script TINtoRaster...
Completed script TINtoRaster...
Succeeded at Thu Mar 29 14:37:48 2012 (Elapsed Time: 6.00 seconds)
Executing (Select Data (3)): SelectData
C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults
BoundingPolygons
Start Time: Thu Mar 29 14:37:48 2012
Succeeded at Thu Mar 29 14:37:48 2012 (Elapsed Time: 0.00 seconds)
Executing (Feature to Raster): FeatureToRaster
C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\RasResults\BoundingPolygon
s OID C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\bpmask 1
Start Time: Thu Mar 29 14:37:48 2012
Succeeded at Thu Mar 29 14:37:49 2012 (Elapsed Time: 1.00 seconds)
Executing (Minus): Minus C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsegrid
C:\Demo\Map2Map\GeoRAS\Layers\demfp
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsemindem
Start Time: Thu Mar 29 14:37:49 2012
Succeeded at Thu Mar 29 14:37:52 2012 (Elapsed Time: 3.00 seconds)
Executing (Con): Con C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsemindem
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsemindem
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\depthgrid # ""VALUE" > 0"
Start Time: Thu Mar 29 14:37:52 2012
Succeeded at Thu Mar 29 14:37:56 2012 (Elapsed Time: 4.00 seconds)

```

```

Executing (Con (2)): Con C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\wsemindem
1 C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\floodgrid # ""VALUE" > 0"
Start Time: Thu Mar 29 14:37:56 2012
Succeeded at Thu Mar 29 14:38:00 2012 (Elapsed Time: 4.00 seconds)
Executing (Raster to Polygon): RasterToPolygon
C:\Demo\Map2Map\GeoRAS\CurrentRun\Layers\floodgrid
C:\Demo\Map2Map\GeoRAS\CurrentRun\RASM2M_res.gdb\FloodExtent NO_SIMPLIFY
VALUE
Start Time: Thu Mar 29 14:38:00 2012
Succeeded at Thu Mar 29 14:38:04 2012 (Elapsed Time: 4.00 seconds)
Succeeded at Thu Mar 29 14:38:04 2012 (Elapsed Time: 26.00 seconds)

```

The following figure presents the “GeoRAS to Flood” model overview and zoomed-in details.

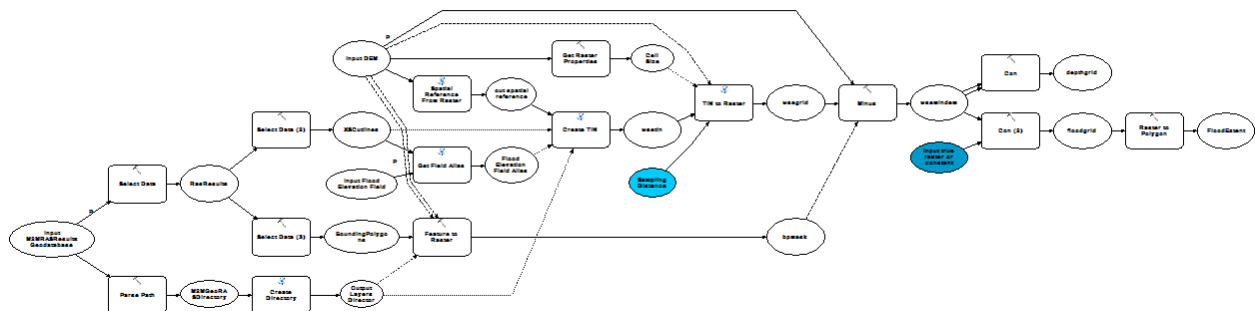


Figure 8. “GeoRAS to Flood” model.

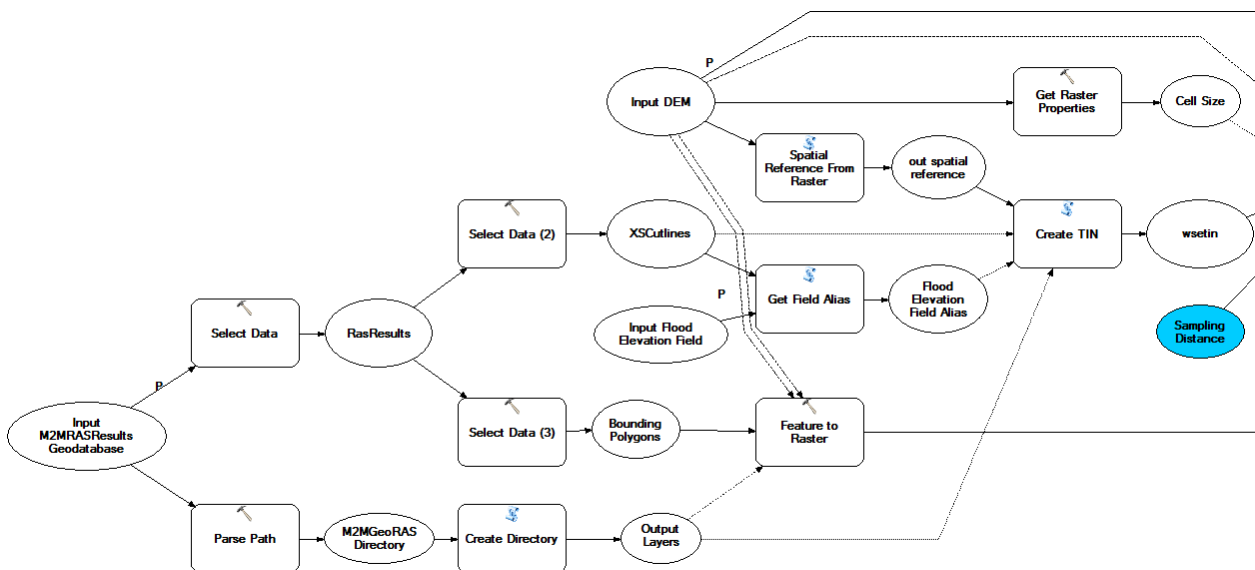


Figure 9. “GeoRAS to Flood” model details (1/2).

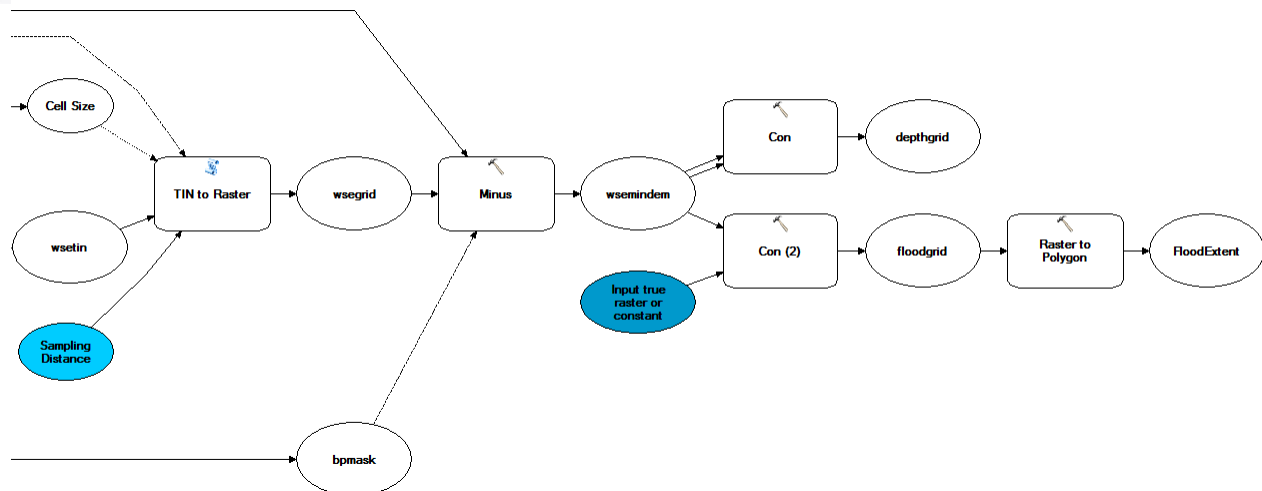


Figure 10. “GeoRAS to Flood” model details (2/2).

Variations to these two models can be made based on specific processing requirements.

Summary

This document describes the Map To Map (M2M) implementation workflows developed for the Hydrologic Modelling Section, Water Resources Management Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, Canada, (WRMD) in the context of modeling of impacts of global climate change (GCC) on flooding. The presented workflows are based on ArcGIS and Arc Hydro existing capabilities. Special considerations needed for GCC M2M implementation are explicitly addressed and an example is presented using the existing Shearstown HMS and RAS models.

Existing Arc Hydro tools for M2M implementation are identified and incorporated into two example Model Builder models that can be used to automate the M2M workflow. Two additional tools are identified that could further simplify/streamline M2M implementation in GCC context and could be developed in next step of M2M implementation at WRMD (currently their functionality is implemented using out of the box ArcGIS capabilities):

- 1) “Populate M2MRUN Table”. This tool would enable the analyst to organize M2M run scenarios (selection of HMS and RAS models, and their initial and boundary conditions) using a simple user interface and store those definitions in the M2MRUN table.
- 2) “Execute M2M Run”. This tool would loop through the selected records in the M2MRUN table and execute the M2M workflow for those selected records for which “IsRun” field = 0.

Current ArcGIS and Arc Hydro capabilities, together with systematic organization and development of HMS and RAS models to be used in GCC impact evaluation provide viable infrastructure for automation of GCC modeling.