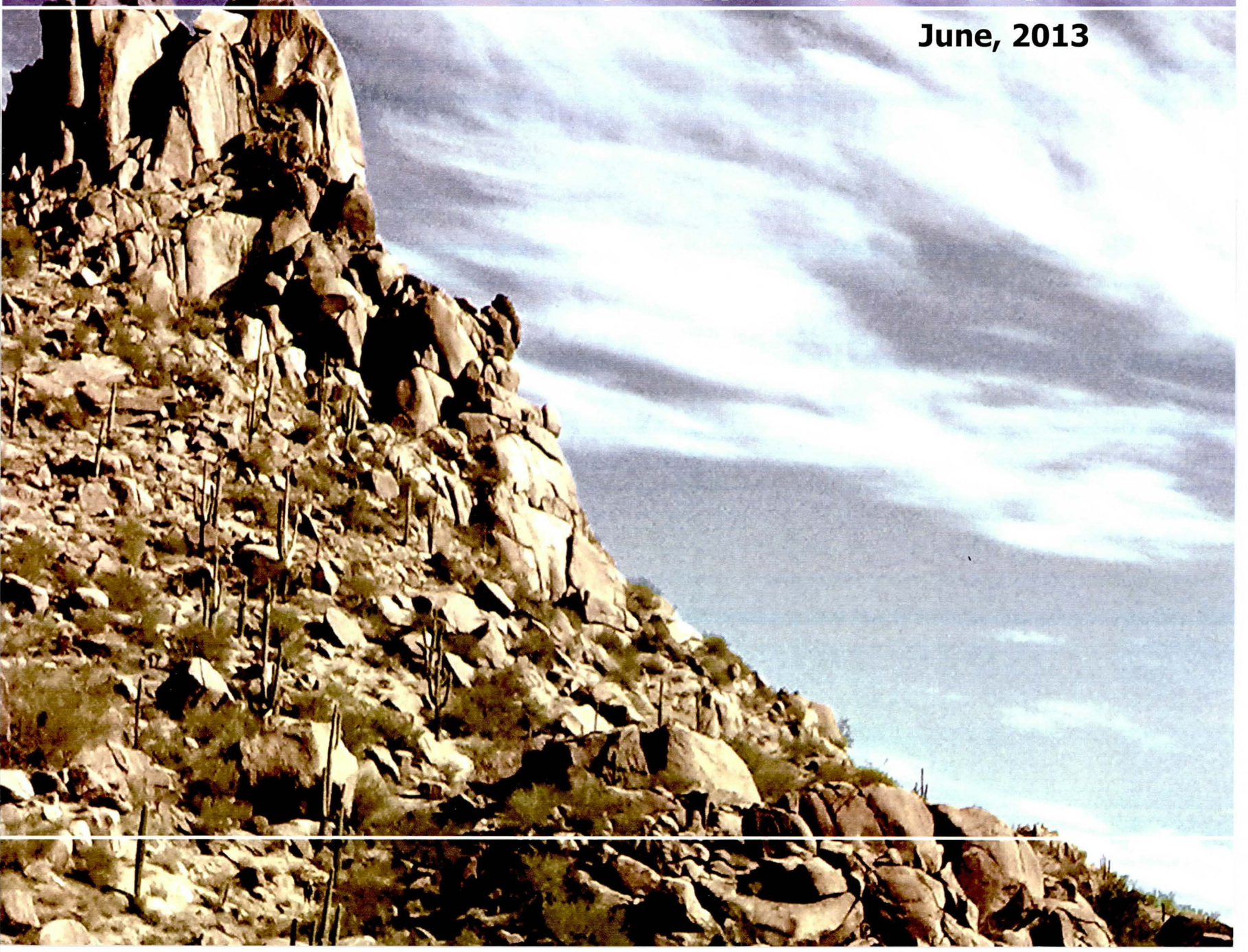
Flood Control District of Maricopa County

Pinnacle Peak West Area Drainage Master Study
Work Assignment 1
Task 5 - Hydrology and Hydraulics Report

June, 2013



JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

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Memorandum

DATE: December, 2012

TO: Theresa Pinto, FCDMC

FROM: Patricia K. Quinn, PE, RLS, AVS & Rob Lyons, PE, CFM

RE: Pinnacle Peak West ADMS Task 5 – Hydrology and Hydraulics Modeling Approach Decision Summary

Registered Professional Engineer (Civil) CERTIFICATE NO. 42752 ROBERT O. LYONS Date Signed 6-17-2013 ARIZONA, U.S.A.

Expires 6/30/2014

The purpose of this summary memorandum is to document the methodologies and approaches to be taken for the detailed hydrologic and hydraulic (H&H) modeling for the Pinnacle Peak West (PPW) Area Drainage Master Study (ADMS). Furthermore, the report summarizes the conclusions and findings of Work Assignment Number 1, Task 5.0 for contract FCD 2011C024. The consultant team responsible for Task 5.0 includes JEF and Stantec. The consultant team met with the District technical team on three separate occasions to discuss the findings of each sub-task and to arrive at a decision for the methodologies and approaches to use in the detailed H&H modeling to be performed in the next Work Assignment.

This report is organized in three levels: 1.) Executive Summary Table, 2.) Meeting Notes, and 3.) Appendices. The Executive Summary Table below includes the sub-task number and description, the Meeting and Appendix references, and a brief summary of the decision made. Meeting Notes are included following the Executive Summary Table and contain additional information related to the decisions made by the technical team. Finally, additional documentation is included in the Appendix for some of the tasks in the form of technical memoranda addressing in more detail particular work task items (parameters), associated analyses, and/or rationale for the recommended approach.

Executive Summary

Sub-Task	Sub-Task Description	Meeting Reference	Appendix Reference
5.1	HEC-1 Update vs. FLO-2D Model Approach	July 5, 2012	Appendix A
Decision - FLO-2D will be used to model the NE portion of the study area at a similar resolution as the remainder of the PPW ADMS study area. Using FLO-2D to model this portion of the study area will ensure consistency and facilitate model integration with the FLO-2D model to be developed for the remainder of the study area.			
5.2.1	Topography Data Collection	July 5, 2012	Appendix B
Decision – The group agreed on the mapping sources to be used for the PPW AMDS (i.e., Pinnacle Peak South, Pinnacle Peak North, Pinnacle Peak ADMS, Camp Creek Mapping, and Scottsdale Mapping).			
5.2.2	Topography Interpolation Methodology	July 5, 2012	Appendix C
Decision – The team decided to use the Terrain Data Set to Raster approach for elevation assignment to FLO-2D grid elements. Two primary options were originally considered: 1) direct interpolation of mass points using GDS (usually recommended for natural terrain); and/or 2) direct			

Sub-Task	Sub-Task Description	Meeting Reference	Appendix Reference
averaging of points obtained from a higher resolution raster obtained from a TIN surface (approach used for urban areas). However, the team identified a third option, Terrain Data Set to Raster that seems to yield the best results when comparing conveyance area, surface volume, and expediency in grid elevation assignment.			
5.2.3.1	Frequencies to Analyze	July 5, 2012	
Decision – The 10- and 100-year frequencies will be modeled. Two additional frequencies will be included as an OPTIONAL task in the next work assignment so they may be modeled if deemed necessary at a later time.			
5.2.3.2	Duration (6- and 24-hr)	July 5, 2012	Appendix D
Decision – The group agreed that the 24-hour duration will be used (no 6-hour). JEF presented preliminary results of 6- vs. 24-hr duration storm events using the District's 50-foot grid FLO-2D model. The comparison of peak discharges and maximum discharge grids indicated that the 24-hr event is controlling. A spot check of the 6-hr duration may be made after detailed model development to confirm this is still the case.			
5.2.3.3	Distribution		
Decision – No decision needed. A FCDMC Approved NOAA 14 rainfall statistics shapefile was created for the assignment of spatially varied rainfall within the FLO-2D model area.			
5.2.4.1	Infiltration Rates	July 5, 2012	
Decision – Infiltration rates will be set using values from the Districts' Drainage Design Manual and adjusted based on information from the soils characteristics descriptions.			
5.2.4.2	Impervious Areas	July 5, 2012	
Decision – Impervious areas will be determined from building, concrete, and asphalt polygons that originated from planimetrics prepared by the mapping contractor and subsequently cleaned up and closed by FCDMC (FCDMC Post-processed Mapping Planimetrics). Natural impervious areas (rock outcrop) will either be hand digitized from aerial photography or assumed based on NRCS soil descriptions.			
5.2.4.3	Initial Abstractions	July 5, 2012	
Decision – Initial abstraction will be assigned based on land cover type using the Districts' Drainage Design Manual. Land cover type will be determined from FCDMC Post-processed Mapping Planimetrics, aerial photography and/or land use layers.			
5.2.4.4	Initial Soil Moisture Condition	July 5, 2012	
Decision – Initial soil moisture condition will be assigned based on land cover type using the Districts' Drainage Design Manual.			
5.2.4.5	Infiltration Depths	July 5, 2012	Appendix E
Decision – The soils descriptions will be used to determine if a limiting infiltration depth is indicated (E.g. shallow clay or bedrock). This will result in a spatially varied limiting infiltration depth. GARR model results will be compared to gage data and other ground model verification data to determine if a spatially varied depth is appropriate or if uniform value produces better results.			
5.2.5	Area and Width Reduction Factors (ARF.DAT)	July 5, 2012	
Decision – ARF data will come from building polygons included in the FCDMC Post-processed Mapping Planimetrics. Width reduction factors will be used as needed in special circumstances such as hydraulic structures.			
5.2.6	Manning's n-values	July 5, 2012	
Decision – Initial Manning's n- values will be assigned based on FCDMC Post-processed Mapping Planimetrics (E.g. Asphalt, Concrete, Lawn). The use of Feature Analyst generated surface feature polygons is not warranted for this project.			

Sub-Task	Sub-Task Description	Meeting Reference	Appendix Reference
5.2.7	Model Numerical Stability Controls	July 18, 2012	
Decision – The District would prefer to use SHALLOWN, limit infiltration depth, and use a spatially varied limiting Froude number (FROUDL in FPLAIN.DAT). The District suggests that XKSAT values are not adjusted for vegetation (to stay conservative) however, initial abstraction and Manning's N should account for vegetation.			
5.2.8	Grid Size Selection	July 11, 2012	Appendix F
Decision – A 20-ft grid size will be used for the FLO-2D models. This will yield adequate hydraulic results for alluvial fan flood hazard assessment, sheet flow, shallow concentrated flow, and adequately depict larger riverine watercourses. There will likely be 7 sub-models within the study area with this grid size.			
5.2.9.1	External Boundary	June 12, 2012	Appendix G
Decision – The PPW ADMS study area boundary within the Pinnacle Peak South (PPS) study area will remain unchanged. The PPW model boundary will extend to the eastern watershed boundary north of and east into the PPS study area. The PPW ADMS FLO-2D model external boundary extends further to the east into the PPS study area to capture potential breakouts from Rawhide Wash at the apex and above the apex. In the event that future modeling depicts relatively little breakout, a portion of this overlap will be removed by blocking grid elements or masking results.			
5.2.9.2	Internal Boundaries	July 18, 2012	Appendix H
Decision – Given the selected 20'grid element size and an optimal sub-model size of approximately 1 million grid elements, at least 7 models will be needed for the PPW ADMS. A very preliminary internal sub FLO-2D model boundary was presented to the project team. The internal boundaries will be refined further keeping the Model Integration approach selected in mind.			
5.2.9.3	Model Integration	July 18, 2012	Appendix I
Decision – A one grid element overlap will be used for Model Integration using outflow nodes (OUTNQ.OUT). Revisions to internal sub FLO-2D model boundaries will be very likely and this approach will minimize the effort required for revision of model input and post-processing model output. Jim O'Brien has been authorized to make add a feature to the engine (FLO.EXE) to accommodate writing an inflow file (INFLOW.DAT) for downstream sub FLO-2D models. The results along the transfer boundary will not be 100-percent accurate (~ 3 grid elements wide). Therefore, internal boundaries will be selected in areas of less concern than others, e.g. areas with structures or walls will be avoided.			
5.2.10	Flood Pool Issues	July 18, 2012	
Decision – Flood pool areas behind the CAP Reach 11 Dikes and Cave Buttes Dam Dike #2 will be included in the FLO-2D model domain with the same level of input parameterization as the rest of the PPW ADMS area. The team may find that there is no significant need for modeling the pool areas and the final models may be permanently 'turned off'; however, it is too early in the project for this decision to be made.			
5.2.11.1	Roadway Drainage Inventory	July 11, 2012	Appendix J
Decision – No decision needed. Refer to referenced Appendix.			
5.2.11.2	Walls and Other Obstructions Inventory	July 11, 2012	Appendix J
Decision – No decision needed. Refer to referenced Appendix.			
5.2.11.3	Inventory of Existing Engineered Channels	July 11, 2012	Appendix J
Decision – No decision needed. Refer to referenced Appendix.			
5.2.11.4	OPTIONAL Storm Drain Structure Inventory		
Decision – This OPTIONAL was not exercised. However, an optional task will be included for the next work assignment to collect storm drain data, if needed.			

Sub-Task	Sub-Task Description	Meeting Reference	Appendix Reference
5.2.12	Floodplain Cross Sections (FPXSEC.DAT)		
Decision – No decision needed. Floodplain cross sections (FPXSEC.DAT) were added to the District's preliminary FLO-2D model of the PPW ADMS to make a recommendation on storm duration (Task 5.2.3.2).			
5.2.13.1-7	GARR, Gage Data, Streamflow	July 18, 2012	Appendix K
Decision – The team will conduct model verification using the best available information. There is relatively little stream gage data available for model calibration. Therefore, the team will likely be relying on anecdotal/photographic/post-flood evidence of high water marks and other indicators to compare to Gage Adjusted Radar Rainfall (GARR) FLO-2D model results.			

Meeting Notes

TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETINGS SUMMARY

LOCATION: Flood Control District of Maricopa County
Engineering ALERT Conference Room
2801 W. Durango St.
Phoenix, AZ 85009

DATE: Thursday, July 5, 2012

TIME: 9:00 – 10:30 am

INTRODUCTION – Pat Quinn

Meeting Purpose – The purpose of the meeting is to discuss with the H&H workgroup each of the scope items for modeling approach and FLO-2D parameterization for the H&H analyses for the Pinnacle Peak West (PPW) ADMS study area. The desired outcome is to arrive at consensus agreement on the Task 5.0 scope items so that we can begin the process of drafting the scope of work for the next Work Assignment 3 addressing the actual FLO-2D H&H modeling tasks based upon the agreed upon approach.

Future Meetings Schedule – It is anticipated that the H&H workgroup will meet twice to discuss the Task 5.0 work tasks. A second meeting is scheduled for Wednesday, July 11, 2012. If necessary, a third meeting will be scheduled.

Work Product Format – A tri-level work product will be provided. With this work product, the reader will have the flexibility to drill down to the desired level of detail for any particular element of the H&H modeling approach. A brief table will be provided as an executive summary listing each parameter and the resultant decision about how it will be addressed in the future FLO-2D modeling task. At the middle level of detail, the group discussion and consensus outcome will be captured in the meeting summary notes. Where necessary, appendix materials will be provided in the form of technical memoranda addressing in more detail a particular work task item (parameter), associated analyses, and/or rationale for the recommended approach.

5.1 HEC-1 Update vs. FLO-2D Model Approach – Ted Lehman

Decision – FLO-2D will be used to model the NE portion of the study area at similar resolution as the remainder of the PPW ADMS study area.

Discussion – JEF submitted a technical memorandum (see **Appendix**) for District review on Jun 12, 2012 with a recommendation that the NE portion of the study area formerly modeled using HEC-1 for the North Scottsdale and Upper Rawhide Wash FDSs be modeled using FLO-2D for the PPW ADMS. Using FLO-2D to model this portion of the study area will ensure consistency and facilitate model integration with the FLO-2D model to be developed for the remainder of the study area. A few related issues/actions items were discussed:

- Buildings – It appears that building polygons are available for this NE portion of the study area, but this needs to be verified. Alejandro Riano will confirm that these data are available. Alejandro reported that the topology issues in other portions of the study area

with open (not closed) building and driveway polygons were being fixed by Joe Wagner. These data will be provided to JEF when ready.

- Hydraulic Structure Inventory – JEF needs to check whether the PPW ADMS hydraulic structure inventory covers this NE portion of the study area.

- Model Usage – The model will be used currently for hydrologic purposes. The results of the FLO-2D model may be used for LOMR or floodplain redelineation in the future. If necessary, more detail can be added later.

Action Items

1. Alejandro will check into building polygon availability in the NE portion of the PPW ADMS study area *(completed 7/11/2012)*.
2. Alejandro will provide to JEF the fixed topology data (closed polygons) for the study area when completed by Joe Wagner.
3. JEF will follow up with Mike Gerlach to determine if the hydraulic structure inventory covers the NE portion of the study area *(completed 7/11/2012).*

5.2.2 Topography Interpolation Methodology – Rob Lyons

Decision – TBD

Discussion – Two options are considered for this task: 1) direct interpolation of masspoints using GDS (usually recommended for natural terrain); and/or 2) create small resolution grid by rasterizing the TIN surface (approach used for urban areas). JEF presented comparative profiles of sample thalwegs using the two approaches (see **Appendix)**. The group agreed that the goal is to use one approach for the entire study area recognizing the inherent limitations. Tom Loomis would rather not use the raster approach in the upper portion of the study area. The group agreed on the need to investigate more to determine for each mapping dataset if the masspoints GDS approach would work for the lower portion of the watershed.

Action Items

4. JEF will review mapping datasets to review breakline vs. masspoint distributions to determine applicability of the masspoint GDS approach study area-wide.
5. JEF will provide more examples of comparative profiles at subsequent H&H workgroup meetings.

5.2.1 Topographic Mapping Collection – Rob Lyons

Decision – The group agreed on the mapping sources to be used for the PPW AMDS (i.e., Pinnacle Peak South, Pinnacle Peak North, and Pinnacle Peak ADMS).

Discussion – JEF presented the limits, datum, and vintage of the three sources for the mapping data to be used for the PPW ADMS (see **Appendix**). The group agreed that this information will be used as a basis for the modeling. JEF compared older data sets (2008) against recent aerial photography (2011) to determine if further survey or updated mapping is needed (see **Appendix**). The finding was that the differences were very minor and consisted of homes in large residential areas and homes built in previously mass graded subdivisions. These changes are not significant enough to make a large impact on the modeling results.

Action Items

6. JEF will send the 2008 vs. 2011 aerial photography comparison memorandum to the District (*completed 7/10/12*).

5.2.3.2 Duration (6- and 24-hr) – Rob Lyons

Decision – The 24-hr duration will be used.

Discussion – JEF presented the results of preliminary results of 6- vs. 24-hr duration storm events using the District's 50-foot grid FLO-2D model (see **Appendix**). The comparison of peak discharges and total infiltration grids indicated that the 24-hr event is controlling. The group agreed that both the 6- and 24-hr durations will **not** be run for all scenarios. We will determine later if a spot check is needed for the 6-hr duration and we can always run the 6-hr duration later if needed for developing mitigation options.

Action Items – None

5.2.3.1 Frequencies to Analyze – Ted Lehman

Decision – The 10- and 100-year frequencies will be modeled. Two additional frequencies will be included as an OPTIONAL task so they may be modeled if determined to be needed.

Discussion – The group agreed that the 10- and 100-yr frequencies should be modeled. Additional frequencies may be added as necessary depending on the need for those results. Stakeholder and team input will be sought in regard to the need for other frequencies. Specific examples discussed of potential need for additional frequencies included the following:

- COP – 2-yr event for storm drain analysis purposes;
- Alluvial fans – 500-yr event for flow uncertainty analysis (active vs. inactive);
- Transportation – 50-yr event for design purposes; and/or
- Public outreach – 25- or 50-yr event to help clarify the message about the relative severity of the 100-yr event

Action Items – None

5.2.4.2/3/4 Impervious Areas/IA/Initial Soil Moisture – Rob Lyons

Decision – TBD

Discussion – JEF previously provided a map to the District showing areas recommended for Feature Analyst based land characterization (see **Appendix**). Alejandro responded that it was a large area and perhaps the detailed Feature Analyst approach could be focused somewhat. Instead the surface characteristics polygon data (Action Item 2 above) could be used once it is cleaned up supplemented by hand digitized rock outcrop features. The District currently working on this item under the supervision of Joe Wagner.

Action Items

7. The District is to finalize surface character polygon data clean up. JEF will then intersect those data with soils data to make assignments for IA, rock outcrop, vegetation cover, etc. based on NRCS soil survey data and other descriptions/guidance as needed.

5.2.5/6 ARF.DAT/Manning's n-values – Rob Lyons

Decision – Use the surface characteristics data and large polygon generalized data from soils or other source(s) to assign Manning's n-values. ARF data will come from building polygons from surface character polygons.

Discussion – Related discussion to 5.2.4.2/3/4. General agreement that the Feature Analyst process is not really needed and that the surface characteristics data can be used for developed areas supplementing the remaining areas from other land cover data sources including the NRCS soil survey data.

Action Items – Same as 5.2.4.2/3/4.

5.2.4.1 Infiltration Rates – Ted Lehman

Decision – Start with values from the Districts' Drainage Design Manual and adjust based on information from the soils characteristics descriptions.

Discussion –JEF provided a table and map of the existing NRCS soils data (see **Appendix**). There are not many units within the study area. Some cover large portions of the model area (up to 25%). Ted suggested that review of the NRCS horizon descriptions indicate some limiting infiltration depths could be assigned based on info from those descriptions such as shallow bedrock, hard pan, or clay layers. See also 5.2.4.5 below.

Action Items – None

5.2.4.5 Infiltration Depths – Ted Lehman

Decision – Use the soils descriptions to determine if a limiting factor to infiltration depth is indicated. Compare results to the previous storm data and determine whether or not to stick with the spatially varied values or to go to a uniform value.

Discussion – The goal is to mimic the losses in HEC-1 unless better data is available. Ted Lehman suggested that the soils horizon descriptions may contain information that would inform the decision about the limiting infiltration depth. If the soils description indicates the presence of anything in the first 5 feet that limits infiltration (e.g., clay, shallow bedrock, etc.), then we use it as a starting point for a spatially varied infiltration depth instead of a constant value (used 4" in the PPS ADMS model). Use the data from previous storm events for calibration. Ted will look at the gage data for the July 31, 2007 storm to determine if enough data for that hydrograph is available for calibration purposes. After comparing the model results with the calibration storm, make a decision to whether or not to stick with the spatially varied values or to go to a uniform value.

Action Items

8. Ted will look at the gage data for the July 31, 2007 storm to determine if enough data for that hydrograph is available for calibration purposes *(completed). Follow-up at 7-11 meeting* – No good hydrograph data are available for Stagecoach Pass Wash. The maximum reading was less than 2 feet, whereas the high water mark was over 5 feet.

DEFERRED TO NEXT H&H COORDINATION MEETING

5.2.8 **Grid Size Selection** – Ted Lehman

5.2.9.3 **Model Integration** – Rob Lyons

5.2.10 **Flood Pool Issues** – Rob Lyons

5.2.13 **Model Verification** – Ted Lehman

5.2.11 **Hydraulic Structure Inventory** – Mike Gerlach

5.2.7 **Numerical Stability Controls** – Rob Lyons

ACTION ITEM SUMMARY – Rob Lyons/Pat Quinn

1. Alejandro will check into building polygon availability in the NE portion of the PPW ADMS study area *(completed 7/11/2012)*.
2. Alejandro will provide to JEF the fixed topology data (closed polygons) for the study area when completed by Joe Wagner.
3. JEF will check with Mike Gerlach to determine if the hydraulic structure inventory covers the NE portion of the study area *(completed 7/11/2012)*.
4. JEF will review mapping datasets to review breakline vs. masspoint distributions to determine applicability of the masspoint GDS approach study area-wide.
5. JEF will provide more examples of comparative profiles at subsequent H&H workgroup meetings.
6. JEF will send the 2008 vs. 2011 aerial photography comparison memorandum to the District (*completed 7/10/12*).
7. The District is to finalize surface character polygon data clean up. JEF will then intersect those data with soils data to make assignments for IA, rock outcrop, vegetation cover, etc. based on NRCS soil survey data and other descriptions/guidance as needed.
8. Ted will look at the gage data for the July 31, 2007 storm to determine if enough data for that hydrograph is available for calibration purposes *(completed). Follow-up at 7-11 meeting* – No good hydrograph data are available for Stagecoach Pass Wash. The maximum reading was less than 2 feet, whereas the high water mark was over 5 feet.

NEXT H&H WORK GROUP MEETING

LOCATION: Flood Control District of Maricopa County
Engineering ALERT Conference Room
2801 W. Durango St.
Phoenix, AZ 85009

DATE: Wednesday, July 11, 2012

TIME: 8:30 – 10:00 am

PINNACLE PEAK WEST AREA DRAINAGE MASTER STUDY

TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETING
July 5, 2012

NAME	ORGANIZATION	PHONE		E-Mail
		Office	Mobile	
Pat Quinn	JE Fuller	480-222-5708		pat@jefuller.com
Ted Lehman	JE Fuller	480-222-5709		tel@jefuller.com
Tom Loomis	FCD	602-506-4767		trl@mail.maricopa.gov
Rob Lyons				
Alejandro Riano	FCD	602 372 1227		alejandroRiano@mail.
Theresa Pinto	FCD	602 506 8127		tmpo maricopa.gov mail.maricopa.gov

TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETINGS SUMMARY

LOCATION: Flood Control District of Maricopa County
Engineering ALERT Conference Room
2801 W. Durango St.
Phoenix, AZ 85009

DATE: Wednesday, July 11, 2012

TIME: 8:30 – 10:00 am

INTRODUCTION – Pat Quinn
Pat reviewed the purpose of the H&H workgroup meetings. She indicated that the summary for the first meeting held on 7/5/2012 was drafted and would be distributed to the workgroup in a day or two *(completed 7/12/2012)*.

7/5/2012 ACTION ITEM CHECKLIST REVIEW – Pat Quinn

1. Alejandro will check into building polygon availability in the NE portion of the PPW ADMS study area. Alejandro indicated that these were available add provided a geodatabase to JEF *(completed 7/11/2012)*.
2. Alejandro will provide to JEF the fixed topology data (closed polygons) for the study area when completed by Joe Wagner. Alejandro reported that these currently being worked on and should be ready in August.
3. JEF will check with Mike Gerlach to determine if the hydraulic structure inventory covers the NE portion of the study area *(completed 7/11/2012)*.
4. JEF will review mapping datasets to review breakline vs. masspoint distributions to determine applicability of the masspoint GDS approach study area-wide *(completed 7/11/2012)*.
5. JEF will provide more examples of comparative profiles at subsequent H&H workgroup meetings. *(partially completed 7/11/2012; additional examples requested at 7/11 meeting – see also item 5.2.2 below)*
6. JEF will send the 2008 vs. 2011 aerial photography comparison memorandum to the District (*completed 7/10/12*).
7. The District is to finalize surface character polygon data clean up. JEF will then intersect those data with soils data to make assignments for IA, rock outcrop, vegetation cover, etc. based on NRCS soil survey data and other descriptions/guidance as needed.
8. Ted will look at the gage data for the July 31, 2007 storm to determine if enough data for that hydrograph is available for calibration purposes *(completed). Follow-up at 7-11 meeting* – No good hydrograph data are available for Stagecoach Pass Wash. The maximum reading was less than 2 feet, whereas the high water mark was over 5 feet.

5.2.11 Hydraulic Structure Inventory – Mike Gerlach

Mike provided an overview of the hydraulic structure inventory database and an update as to status.

- Culverts –Mike reported that the culvert field survey was 100% complete. About 50% of the culvert data was post-processed and incorporated in the geodatabase. The field crew had a

few inquiries from residents. They handed out a few fact sheets to the public and to gain entry to gated communities.

- Walls – Mike reported that the inventory of walls will be finished next week. About 15% of wall opening info into database at this time. The wall opening data is collected at a particular location if the opening has conveyance equivalent to or greater than a 24" diameter culvert. The field crew found less wall openings than originally scoped. It was recommended that a task be included in the next Work Assignment to allow for future field survey to capture additional wall openings after the base FLO-2D model is run.

- Channels – Mike indicated that the criterion used to determine which engineered channels were to be measured and included in the database was if the bottom width was ≤ 20'. Once preliminary model results are available, the decision can be made whether or not the channel conveyance is accurately captured with the FLO-2D grids or if a 1-D channel is needed in the model. Similar to the walls, it was recommended that a task be included in the next Work Assignment to allow for future field survey to capture additional channels after the base FLO-2D model is run.

Action Items

9. JEF will follow up with Rob Lyons regarding what hydraulic structure information has been already collected from the Pinnacle Peak South (PPS) ADMS team.
10. Alejandro will provide the input files used for the base FLO-2D model for the PPS ADMS so that the hydraulic structure data from that area can be extracted and used. *(completed 7/11/2012)*

5.2.8 Grid Size Selection – Ted Lehman

Decision – 20-ft grid size will be used for the FLO-2D model.

Discussion – The rationale for the selection of the 20' grid size includes the following:

- With a 20' grid size, there will be approximately 6.8M grids required to model the study area. Ted reported that there will likely be 7 submodels. One criterion in establishing the submodel size is to allow the use of MS Excel for data processing and manipulation if possible.
- The 20' grid size will match every third grid cell with the 30' grid size used for the adjacent PPS ADMS FLO-2D model since they share a common divisor (see **Figure 1**). This will aid model inputs/outputs between the PPW and PPS ADMS FLO-2D models.
- The 20' grid size fits well with the field data collected for engineered channels with bottom widths less than 20'.
- The 20' grid size is adequate for alluvial fan flood hazard assessment.
- The 20' grid size provides good resolution for the types of elements for which we are assessing flood hazard (e.g., 4 grids per house, 2 grids per street).
- The opportunity still exists to go to smaller grid size/higher resolution at specific sites for future analyses for flood hazard mitigation purposes.

Action Items – None

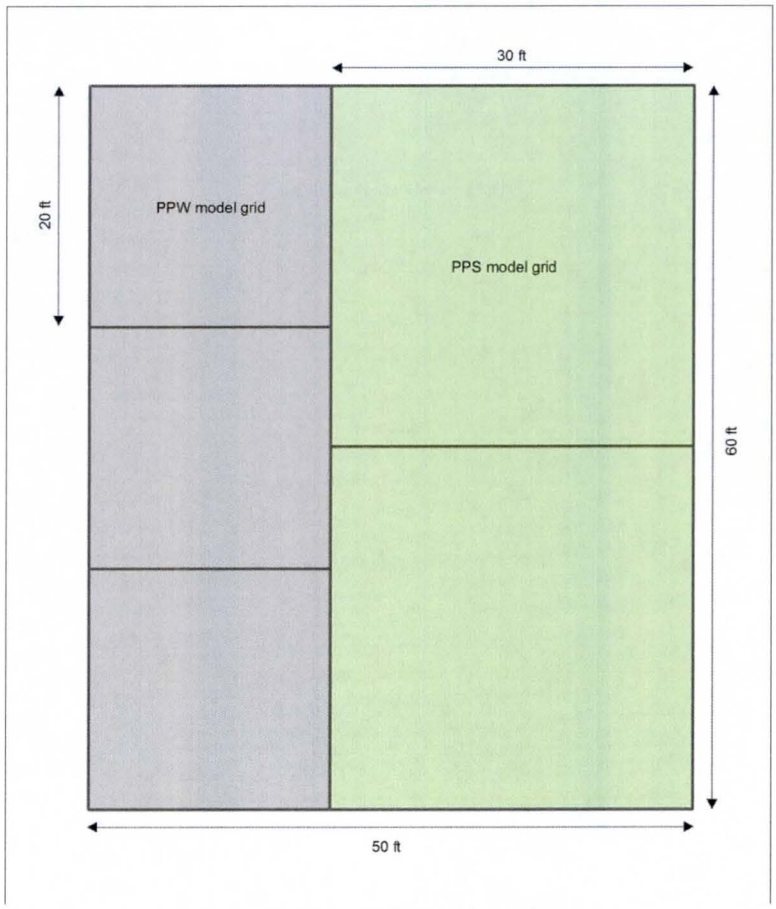

Figure 1. 30- to 20-foot grid match-up

5.2.2 Topography Interpolation Methodology – Follow up to 7/5/2012 H&H meeting

Decision – TBD

Discussion – Ted reviewed a sample of breakline vs. masspoint distributions at select locations to determine applicability of the masspoint GDS approach study area-wide. The mapping data is breakline-dominated and a TIN rasterization approach seems preferential.

Action Items

11. JEF will provide more examples of comparative profiles and cross sections in the piedmont portion of the study area in both developed and undeveloped areas. This is being done to provide additional needed information to help with the selection of a grid elevation computation method.

DEFERRED TO NEXT H&H COORDINATION MEETING

5.2.10 **Flood Pool Issues** – Rob Lyons

5.2.7 **Numerical Stability Controls** – Rob Lyons

5.2.13 **Model Verification** – Ted Lehman

5.2.9.3 **Model Integration** – Rob Lyons

UPDATED 7/13/2012 ACTION ITEM SUMMARY

1. The District will provide to JEF the fixed topology data (closed polygons) for the study area when completed by Joe Wagner.
2. The District is to finalize surface character polygon data clean up. JEF will then intersect those data with soils data to make assignments for IA, rock outcrop, vegetation cover, etc. based on NRCS soil survey data and other descriptions/guidance as needed.
3. JEF will follow up with Rob Lyons regarding what hydraulic structure information has been already collected from the Pinnacle Peak South (PPS) ADMS team.
4. Alejandro will provide the input files used for the base FLO-2D model for the PPS ADMS so that the hydraulic structure data from that area can be extracted and used *(completed 7/11/2012)*.
5. JEF will provide more examples of comparative profiles and cross sections in the piedmont portion of the study area in both developed and undeveloped areas. This is being done to provide additional needed information to help with the selection of a grid elevation computation method.

NEXT H&H WORK GROUP MEETING

LOCATION: Flood Control District of Maricopa County
Engineering ALERT Conference Room
2801 W. Durango St.
Phoenix, AZ 85009

DATE: Wednesday, July 18, 2012

TIME: 2:00 – 4:00 pm

PINNACLE PEAK WEST AREA DRAINAGE MASTER STUDY

TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETING
July 11, 2012

NAME	ORGANIZATION	PHONE		E-Mail
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Pat Quinn	JE Fuller	480-222-5708		pat@jefuller.com
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TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETINGS SUMMARY

LOCATION: Flood Control District of Maricopa County
Engineering ALERT Conference Room
2801 W. Durango St.
Phoenix, AZ 85009

DATE: Wednesday, July 18, 2012

TIME: 2:00 – 4:00 PM

INTRODUCTION – Pat Quinn
Pat reviewed the purpose of the H&H workgroup meetings. Pat mentioned the FCDMC/JEF project team is mostly through the critical decisions that need to be made on FLO-2D modeling and that the objective is to begin scoping of the FLO-2D work assignment as soon as practical. The FLO-2D work assignment will be a standalone work assignment to keep scoping simple, and detach the detailed H&H work from other tasks that may have other time and schedule constraints.

7/13/2012 ACTION ITEM CHECKLIST REVIEW – Pat Quinn

1. The District will provide to JEF the fixed topology data (closed polygons) for the study area when completed by Joe Wagner. – ***Yvonne of Joe Wagner's group is working on fixing the mapping topology. Tom plans to Quality Control Yvonne's work and provide to JEF by late July and at the very latest, Mid-August.***

2. The District is to finalize surface character polygon data clean up. JEF will then intersect those data with soils data to make assignments for IA, rock outcrop, vegetation cover, etc. based on NRCS soil survey data and other descriptions/guidance as needed. ***Tom plans to Quality Control Yvonne's work and provide to JEF by late July and at the very latest, Mid-August. Julie Cox brought up the option to adjust XKSAT for vegetation. The team agreed that no adjustment would be used for this project. However, vegetated areas will likely have a different Initial Abstraction (IA) and Manning's N than other surface types.***

3. JEF will follow up with Rob Lyons regarding what hydraulic structure information has been already collected from the Pinnacle Peak South (PPS) ADMS team (*completed 7/18/2012*). ***Rob reviewed the data provided by Scottsdale. JEF has received a tabular inventory of structures within PPS, however, no spatial indexing data. Furthermore, JEF did not receive hydraulic ratings for each structure. JEF has received the PPS FLO-2D culvert file (HYSTRUC.DAT) that will be of some assistance. JEF will identify a comprehensive PPS data request list and coordinate with Theresa Pinto when she's back to make the formal request.***

4. Alejandro will provide the input files used for the base FLO-2D model for the PPS ADMS so that the hydraulic structure data from that area can be extracted and used *(completed 7/11/2012)*. ***Alejandro has provided the PPS FLO-2D input files. However, this data alone will not be sufficient.***

5. JEF will provide more examples of comparative profiles and cross sections in the piedmont portion of the study area in both developed and undeveloped areas. This is being done to provide additional needed information to help with the selection of a grid elevation computation method. ***JEF is still working on this action item. JEF will provide to FCDMC when the Action Item is complete.***

5.2.9.3 Model Integration – Alejandro Riano/ Rob Lyons

Decision – The team decided that a one grid element overlap will be used for Model Integration using outflow nodes (OUTNQ.OUT). This approach was named Approach C in the handout JEF distributed at the meeting, also shown in the Figure 1 below.

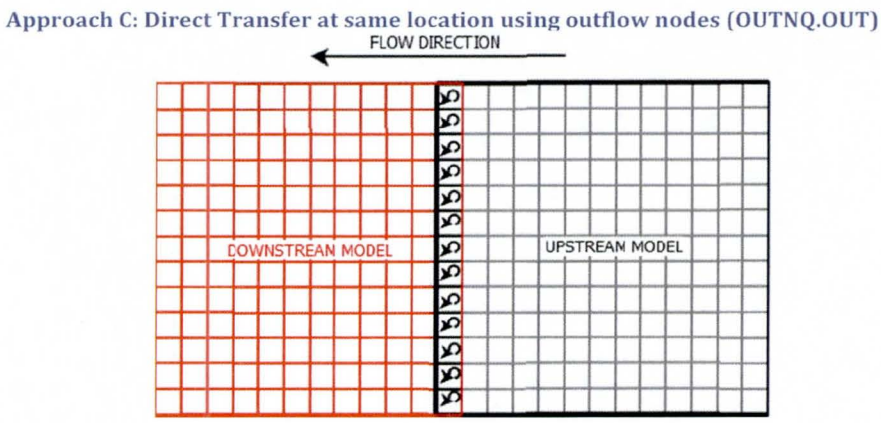

Figure 1. Approach C

Discussion – Alejandro started the discussion by provided a demonstration of issues the District has run into regarding flow transfer from one FLO-2D model to another. The District has been using the floodplain cross section input file (FPXSEC.DAT) on individual grid elements to extract flow hydrographs in upstream models (HYCROSS.OUT) and then transfer to the downstream model. The District has discovered that caution should be used in selecting the flow direction as significant errors (double counting) can occur. The District also pointed out that the current FLO-2D executable conducts a direct sum of the hydrograph in the direction of the flow selected, and the two adjacent vector direction instead of the previous 'Vector Component' method. This will result in conservative results for the purposes of extracting design peak discharges. However, if FPXSEC.DAT output is used for flow transfer, this will bias the results in the downstream model.

Rob distributed a hand-out to meeting attendees demonstrating the various methods of model integration that the JEF team has considered and the pros and cons of each approach. Unfortunately, no single approach was identified that would have no hydraulic bias and straight-forward pre-and post-processing. Most of the approaches were immediately deemed unsatisfactory by the team leaving only two choices, Approach F (the same approach the District has been using with FPXSEC.DAT) and Approach C, as shown in Figure 1. Although Approach F may be the most hydraulically accurate, the team agreed that the extra work required to execute this approach for PPW would be significant. Furthermore, the team recognizes that revisions of internal sub FLO-2D model boundaries will be very likely and an approach needs to be selected that will minimize the effort required for revision of model input and post-processing model output. Given the number of

expected sub FLO-2D models and the number of interior flow transfer grid elements, it was decided that Approach C was the best choice for the project.

The team recognizes that the results along the transfer boundary, perhaps 3 grid elements wide, will not be 100-percent accurate. Therefore, the team will attempt to select an internal boundary location in areas of less concern than others, e.g. avoid areas with structures or walls.

The District would like clarification from Jim O'Brien regarding the computations of outflow for grid elements assigned with OUTFLOW.DAT. Specifically, which adjacent, upstream grid elements contribute to outflow elements. JEF mentioned that Jim could revise the FLO.EXE to write an INFLOW.DAT file directly for the downstream model for Approach C with relatively little effort. The District agreed that this seems like a worthwhile investment for this project and others.

Rob passed out a map with very preliminary internal sub FLO-2D models shown. Given the grid element size selected of 20' and an ideal sub-model size of approximately 1 million grid elements, at least 7 models will be needed for the PPW ADMS. The internal boundaries will be refined further with the Model Integration Approach C in mind.

Action Items

1. JEF will follow up with Jim O'Brien to verify the outflow computations. JEF will forward Jim's response to the District.
2. JEF will follow up with Jim O'Brien to see if he can get started on revising FLO.EXE to directly write the INFLOW.DAT file for downstream models from the upstream model output.

5.2.10 Flood Pool Issues – Rob Lyons

Decision – Flood pool areas behind the CAP Reach 11 Dikes and Cave Buttes Dam Dike #2 will be included in the FLO-2D model domain with the same level of input parameterization as the rest of the PPW ADMS area. The team may find that there is no significant need for modeling the pool areas and the final models may be permanently 'turned off', however, it is too early in the project for this decision to be made.

Discussion – The pool areas are expected to significantly increase the model run time (estimated at 40%). Therefore, the pool areas will be effectively 'turned off' for interim models by assigning outflow nodes upstream of the pools to speed up the time for completion. The areas will be 'turned on' for the final model runs. Additional n-value modifications may be needed for the pool areas once they are 'turned on'.

Action Items – None

5.2.7 Numerical Stability Controls – Rob Lyons

Decision – At this time, the District would prefer to use SHALLOWN, limit infiltration depth, and use a spatially varied limiting Froude number (FROUDL in FPLAIN.DAT).

Action Items

1. The District will provide the FLO.EXE that the District is using (an advanced version of FLO-2D version 2009) and a document Jim O'Brien provided the District explaining the changes to the model.

5.2.13 Model Verification – Ted Lehman

Decision – The team will conduct model verification using the best available information.

Discussion – Ted reiterated that there is relatively little stream gage data available for model calibration. Therefore, the team will likely be relying on anecdotal/photographic/post-flood evidence of high water marks and other indicators to compare to Gage Adjusted Rainfall Radar (GARR) FLO-2D model results. Rob has initiated O&M/EMS interviews with Phoenix, Scottsdale, and Maricopa County to identify areas of frequent flooding and any other evidence of flooding depths/extents from historic storms. The team intends to collect flood evidence from the public in the near future. Tom provided the dates of the GARR he has requested. Tom reminded the team we have at least one flood photo from a recent storm that was provided by a resident in North Scottsdale that may be of some value for model verification.

Action Items – None

NEXT H&H WORK GROUP MEETING – ***The need for another meeting was not anticipated at the conclusion of the meeting.***

PINNACLE PEAK WEST AREA DRAINAGE MASTER STUDY

TASK 5.0 HYDROLOGY & HYDRAULICS COORDINATION MEETING

July 18, 2012

NAME	ORGANIZATION	PHONE		E-Mail
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Alejandro Riano	FCDMC	602 372 1227		
Pat Quinn	JE Fuller	480-222-5708		

Rob Lyons

From: Rob Lyons
Sent: Thursday, June 14, 2012 11:28 AM
To: 'Theresa Pinto - FCDX'
Cc: Felicia Terry - FCDX; Pat Quinn
Subject: RE: PPW Revised Study Boundary and FLO-2D External Boundary for Review

Sure thing, I don't know how I missed that, I remember discussing at the end of the meeting Tuesday.

Rob Lyons, PE, CFM
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From: Theresa Pinto - FCDX [mailto:tmp@mail.maricopa.gov]
Sent: Thursday, June 14, 2012 10:56 AM
To: Rob Lyons
Cc: Felicia Terry - FCDX; Pat Quinn
Subject: RE: PPW Revised Study Boundary and FLO-2D External Boundary for Review

Hi Rob – I agree with the model boundary and your summary below except the study boundary needs to be expanded slightly. The study boundary should be revised to match the modeling boundary in the area I highlighted in yellow (i.e., include the Troon area) and tiny area immediately southwest I circled in green. Feel free to call me if you need clarification. If not, can you revise the study boundary accordingly and send the shape file back to me? As soon as I get it from you, I'll send it to Elaine and Jason so we can get the hydraulic structure survey and inventory data from them.
Thanks!
Theresa

From: Rob Lyons [mailto:rob@jefuller.com]
Sent: Wednesday, June 13, 2012 5:11 PM
To: Theresa Pinto - FCDX
Cc: Felicia Terry - FCDX; Pat Quinn
Subject: PPW Revised Study Boundary and FLO-2D External Boundary for Review

Hi Theresa,

I've attached the PPW Revised Study Boundary and the proposed FLO-2D External Boundary for your review. Both these boundaries are based on the conclusions we arrived at during yesterday's meeting (6-12-12). Our understanding is that the Pinnacle Peak West ADMS boundary within the Pinnacle Peak South study area will remain unchanged at this time. The attached study boundary shapefile reflects this. However, the FLO-2D external boundary extends further to the east as we discussed yesterday to capture potential breakouts from Rawhide Wash at the apex and above the apex. The attached FLO-2D External Boundary shapefile depicts the alignment we reviewed yesterday. We understand that in the event that future modeling depicts relatively little breakout, a portion of this overlap will be removed by blocking grid elements or masking results. Please let us know if you concur with our understanding and the shapefile boundary alignments attached.

Thank you,

Rob Lyons, PE, CFM
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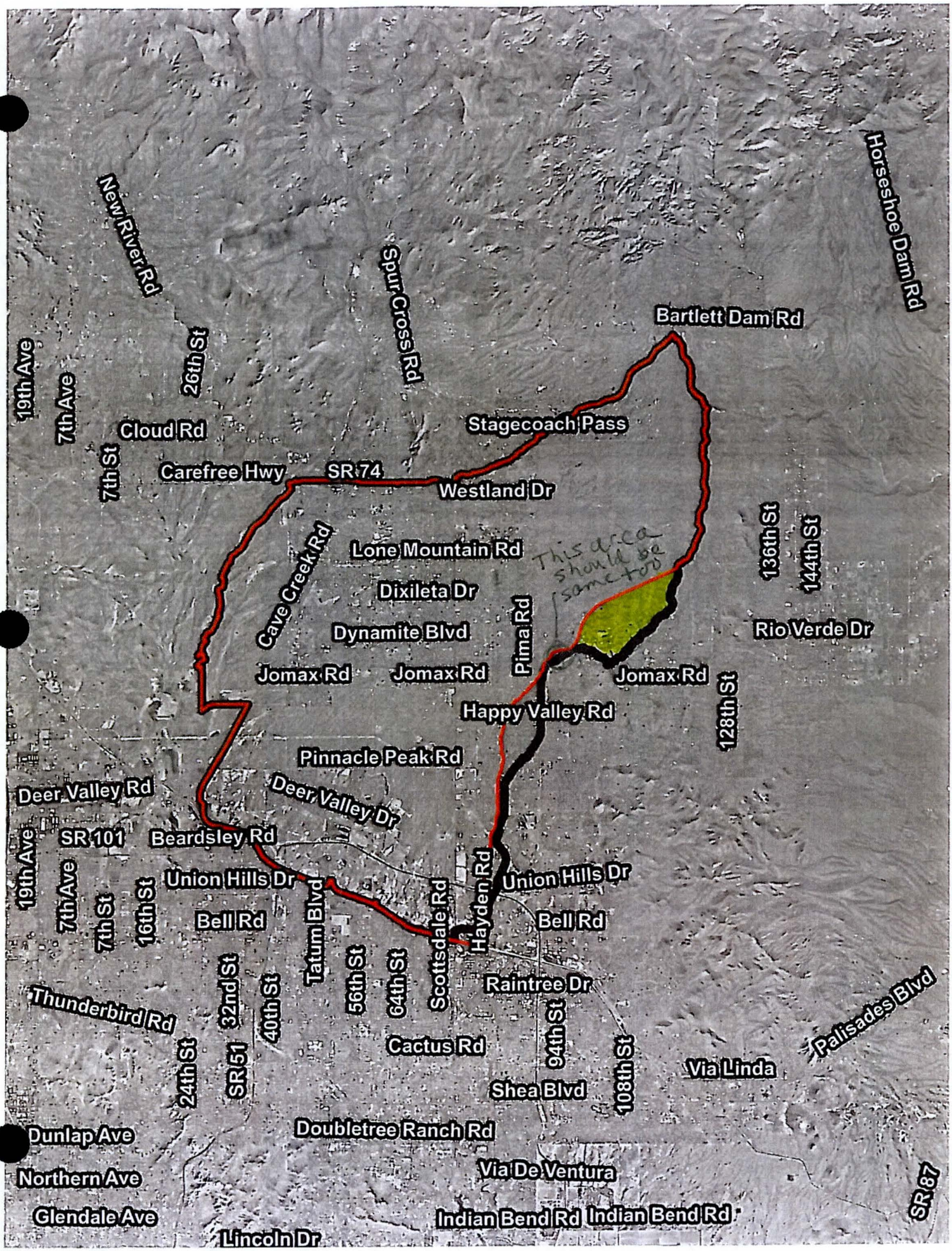
New River Rd
Spur Cross Rd
Horseshoe Dam Rd
Bartlett Dam Rd
19th Ave
7th Ave
26th St
Cloud Rd
Stagecoach Pass
7th St
Carefree Hwy
SR 74
Westland Dr
Cave Creek Rd
Lone Mountain Rd
This area should be same too
136th St
144th St
Dixileta Dr
Dynamite Blvd
Pima Rd
Rio Verde Dr
Jomax Rd
Jomax Rd
Jomax Rd
Happy Valley Rd
128th St
Pinnacle Peak Rd
Deer Valley Rd
Deer Valley Dr
SR 101
Beardsley Rd
19th Ave
7th Ave
7th St
16th St
Union Hills Dr
Union Hills Dr
Hayden Rd
Bell Rd
Bell Rd
Tatum Blvd
Scottsdale Rd
Raintree Dr
Thunderbird Rd
32nd St
40th St
56th St
64th St
94th St
Palisades Blvd
Cactus Rd
24th St
SR 51
108th St
Via Linda
Shea Blvd
Dunlap Ave
Doubletree Ranch Rd
Northern Ave
Via De Ventura
Glendale Ave
Indian Bend Rd
Indian Bend Rd
SR 87
Lincoln Dr

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Appendices

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JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

DEFINE | COMMUNICATE | SOLVE

Memorandum

DATE: June 12, 2012; rev. July 5, 2012

TO: Theresa Pinto, FCDMC

FROM: Ted Lehman, PE; Pat Quinn, PE, RLS, AVS

RE: APPENDIX A: Task 5.1 - Pinnacle Peak West ADMS HEC-1 Update vs. FLO-2D Model for NE Portion of Study Area Recommendations

Introduction

JE Fuller/Hydrology & Geomorphology, Inc. (JEF) has reviewed the North Scottsdale Floodplain Delineation Study (FDS) (DEI, 2005) and Upper Rawhide Wash FDS (KHA, 2002). Figure 1 shows the location of the areas modeled in these projects within the Pinnacle Peak West (PPW) ADMS study area. The objective of this task is to evaluate the advantages and disadvantages of updating the HEC-1 models developed for those two studies in comparison to development of new FLO-2D models for the area as part of the Pinnacle Peak West ADMS. This memorandum first provides a summary of the hydrologic modeling elements of these two studies and identifies the elements that would need to be modified/updated to work with the PPW ADMS followed by a recommendation on the preferred modeling approach for the ADMS.

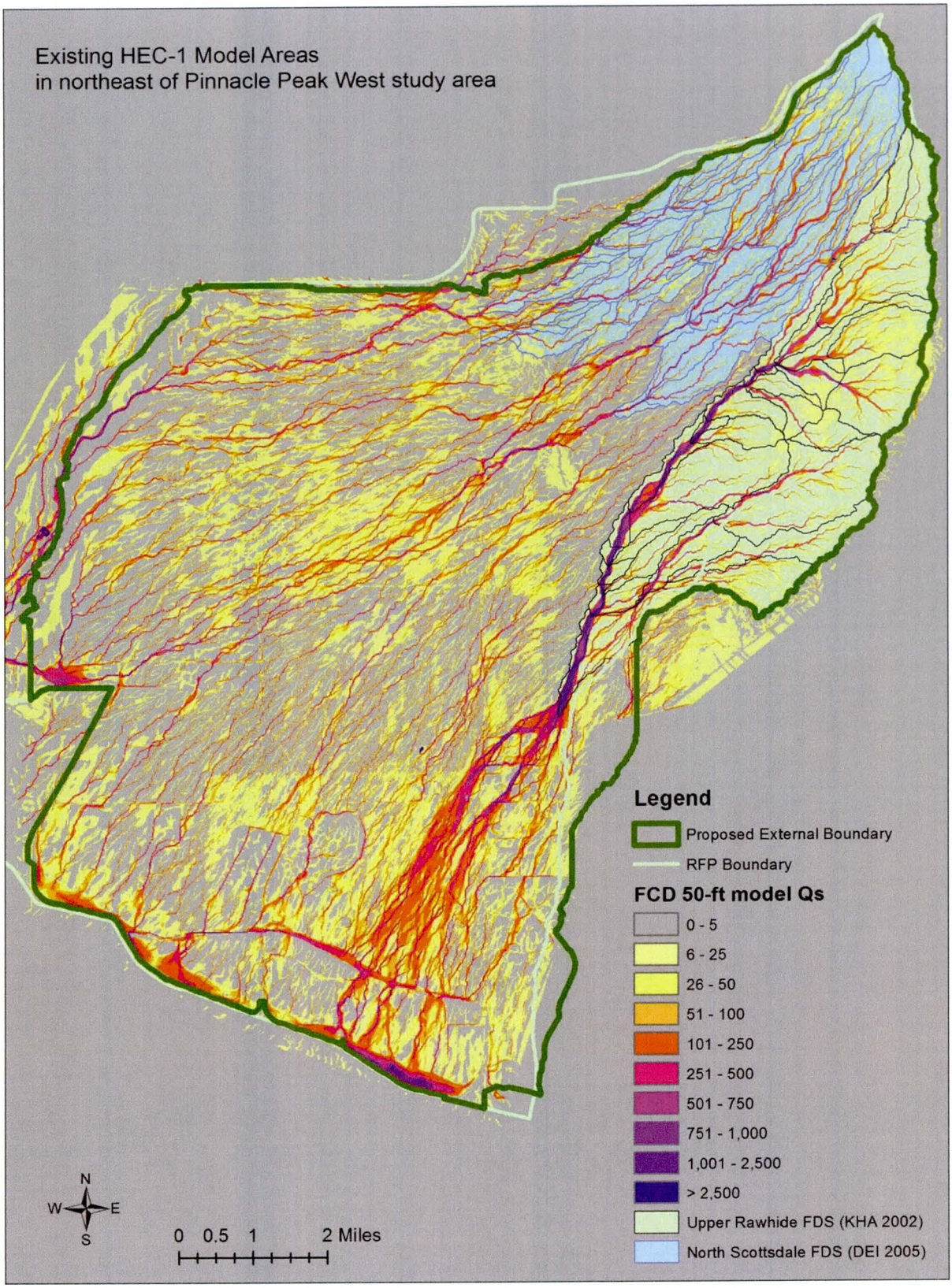


Figure 1. HEC-1 Model Areas from North Scottsdale & Upper Rawhide FDS

North Scottsdale FDS

The North Scottsdale FDS (NSFDS) was performed by DEI Professional Services under contract FCD2003C008. The hydrology was originally completed in May 2002. A final FDS report was issued in 2003. Subsequent errors were discovered in the hydrology in Sept. 2004 which were corrected and a new FDS report issued in April 2005. As a result, the discharges for Fan 6A washes decreased about 10 percent due to changes resulting from the revised hydrology. In the areas not redelineated, the reduced revised discharges were considered insignificant compared to the 2002 report values.

The following is a summary of the bases for the hydrology developed for the North Scottsdale FDS:

Topography

The NSFDS used topography with an 'origination date' of 9/1/1993. The vertical datum was NAVD88. Review of the subbasin delineations show that they are mostly satisfactory, however, some minor subbasin delineation issues were found based on comparison with the newer mapping. The NSFDS report also notes that several areas including the Sand Flower, Boulders, Winfield, Mirabel, and Legend Trail developments had changed the topography between the time of mapping and their study.

Rainfall

The NSFDS used NOAA Atlas 2 and modeled 6-hour duration storms for the 100-, 50-, 25-, 10-, 5-, and 2-year return periods. JD records were applied using the District 6-hour patterns and areal reduction methods. The total upstream drainage area was used on the HC records downstream of splits with JD.

NOAA Atlas 14 gives an average 6-hour value of 3.223 inches for the NSFDS study area as compared to the NOAA 2 value of 3.50 used in the NSFDS. The 24-hour from NOAA Atlas 14 is 5.085 inches while the PREFRE output in the NSFDS showed a point rainfall depth of 4.80 inches.

Rainfall Losses

The Green and Ampt loss method was used. Rock outcrop was assumed 100% effective imperviousness. Future land use was used including what has become the City of Scottsdale Preserve area around Legend Trails. This area was assumed to be developed in the NSFDS. This area represents about 2.6 square miles of total 15.2 square mile area modeled in the NSFDS.

Unit Hydrographs

The Clark unit hydrograph method in HEC-1 was used using the District's Tc and R equations as implemented in DDMSW Version 1.8. A relatively small average subbasin size (< 0.2 sq.mi.) was used in the model.

Routing

Hydrologic routing was performed using the normal depth method with 8-point cross sections.

Model

HEC-1 version 4.1 was used in conjunction with DDMSW Version 1.8 to help develop the model input.

Split Flows

Four major flow splits were modeled:

1. *Rawhide upper flow split* – The NSFDS shows 815 cfs staying in their study area with 1006 cfs leaving to the south into the Rawhide Wash watershed (total Q = 1822). (pg. 124 in Vol. 3 pdf – RHW-1 – see output on p. 233 of Vol. 3 pdf) (The KHA study reports the rating curve at this location (CP012) (Table 4-2, p. 12 of Hydrology volume the pdf) at 1904 cfs that 776 cfs goes to the NSFDS area while 1128 cfs stays in the Upper Rawhide watershed. However the KHA model results show only 697 cfs peak discharge in the 6-hour event and 1111 cfs for the 24-hour. Of those, 448 cfs remains in Rawhide in the 6-hour event and 688 cfs remains in the watershed for the 24-hour event (see also p. 16 in the KHA pdf – Table 4-4).
2. *Pima Road flow split* – Flow passes along Pima Road between two washes from Fan 6C wash to the north. However, the model shows only 24 cfs (out of 1363 cfs) being diverted.
3. *Stage Coach Pass Sandflower Levee* - The report notes that Legend Trail Levee 'does not meet FEMA criteria'.
4. *Westland Road and Fan 6C* – Several houses are shown in the resulting floodplain north of Westland Road. This is also downstream of the Pima Road flow split (item 2 above).

Another location is noted as a potential breakout that was not modeled. This was located near river mile 2.23 on Stage Coach Pass Wash.

The locations of the modeled and unmodeled split flows are shown in Figure 2. Figure 2 also includes a few additional locations identified as potential flow splits identified by review of the District's preliminary 50-foot grid FLO-2D model. In addition to the five split flow locations discussed in the NSFDS, two others are indicated by the District's preliminary model. One occurs internal to a subbasin, the second occurs in an area where the 1993 topography has possibly been affected by development within Legend Trail. Two other unmodeled split flow locations are indicated within the Upper Rawhide Wash HEC-1 model area.

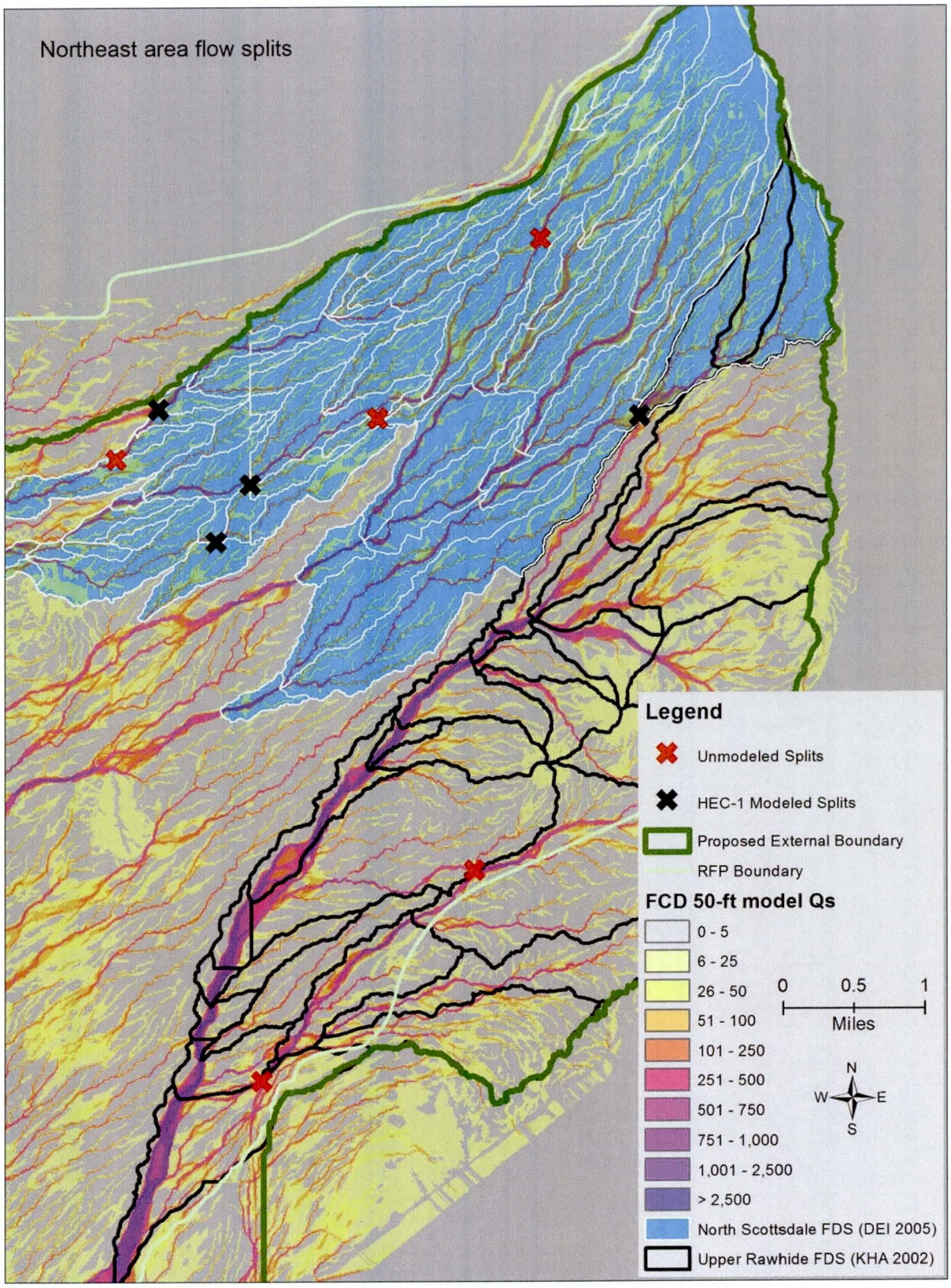


Figure 2. North Scottsdale & Upper Rawhide FDS area split flows

Upper Rawhide Wash FDS

The Upper Rawhide Wash (URW) FDS was performed by Kimley-Horn & Associates (KHA) under contract FCD 98-12 and was completed in March 2002. A total drainage area of 14 square miles was modeled. Of that, 1.05 square miles overlaps with the NSFDS study above the 'Upper Rawhide split'.

Topography

The same 1993 topography used in the NSFDS was also used in the URW FDS. Again, some minor areas of differences in subwatershed boundaries can be detected compared to the new ADMS mapping. In addition, portions of the watershed experienced development between the time of the mapping and the study. However, these areas are limited to the southern portions of the URW study area in and around the Troon North development.

Rainfall

NOAA Atlas 2 was used to develop average watershed rainfall depth. The 100-year 6- and 24-hour durations were modeled. The watershed average point rainfall were 3.45 inches for the 100-year 6-hour event and 4.60 inches for the 100-year 24-hour. The areally reduced depths were 3.201 and 4.269 inches, respectively. JD records were not used.

By comparison, NOAA 14 yields a 100-year 6-hour average watershed point rainfall depth of 3.162 inches and 5.011 inches for the 24-hour duration.

Rainfall Losses

The Green and Ampt loss method was used per the District guidance in the 1995 Drainage Design Manual. Existing condition land use (ca 1999) was used to depict land cover. Almost all of the area was undeveloped except for portions of Troon North & corner of Vistana at that time.

Unit Hydrographs

The District's Clark unit hydrograph approach was used. This means time of concentration was a function of rainfall excess and would require updating for new rainfall depths and any additional frequencies.

Routing

The normal depth 8-point cross section routing approach was used to perform hydrologic routings.

Model

The old MS-DOS version DDMS software was used. Models were run in HEC-1 v. 4.1.

Split Flows

Two split flow locations are discussed in the URW hydrology.

1. Split at CP012 - This is the 'Rawhide upper flow split' also modeled in the NSFDS. The KHA report notes that the split 'could change in future as flows and/or sedimentation change the cross section characteristics'. The rating curves were independently developed in each study. While the curves are similar, the results are quite different as the computed peak discharges are very different (see number 1 in split flow list for NSFDS above).
2. Split at CP066 – This split location was not modeled. It is located downstream of Dynamite Boulevard near Pima Road. However, the KHA report notes that 'currently flow splits at this location. With the Rawhide Wash Dam project these flows will be cut off and route to the dam site. The routing in this model indicates this.' Because the dam project was not realized, this split would need to be added into an updated model.

One additional potential split flow location not modeled is indicated by examination of the District's 50-foot FLO-2D model. The new topography shows a series of small hills dividing two drainages, but the computed flows in the District model show several hundred cfs passing above the ridge between them.

All three locations are shown in Figure 2.

Summary of Needed Updates to HEC-1 Models for Application to PPW ADMS

The following is a summary of the updates that would be needed to the FDS HEC-1 models in order to use them as part of the PPW ADMS:

- Update rainfall to NOAA Atlas 14 rainfall depths
- Add additional frequencies and durations depending on storms selected for ADMS
- New rainfall will require updating Clark Tc & R for all storm durations and frequencies to be modeled
- Update to current version of DDMSW
- Update subbasin boundaries to reflect new topography
- Resolve overlapping model areas (see Figure 3)
- Redelineate Tc flow paths as needed based on revised subwatershed boundaries
- Update flow splits based on the new topography
- Update rainfall loss parameters to reflect current land use
- Redelineate subbasin watersheds as needed to reflect preferred inflow locations to the downstream FLO-2D model area. The existing downstream concentration points may be acceptable in some locations, but will lead to a sawtoothed boundary. Moreover, the downstream limit of the Rawhide Wash model should be moved upstream to allow FLO-2D to compute the unmodeled split flow at Pima Road just south of Dynamite Boulevard.

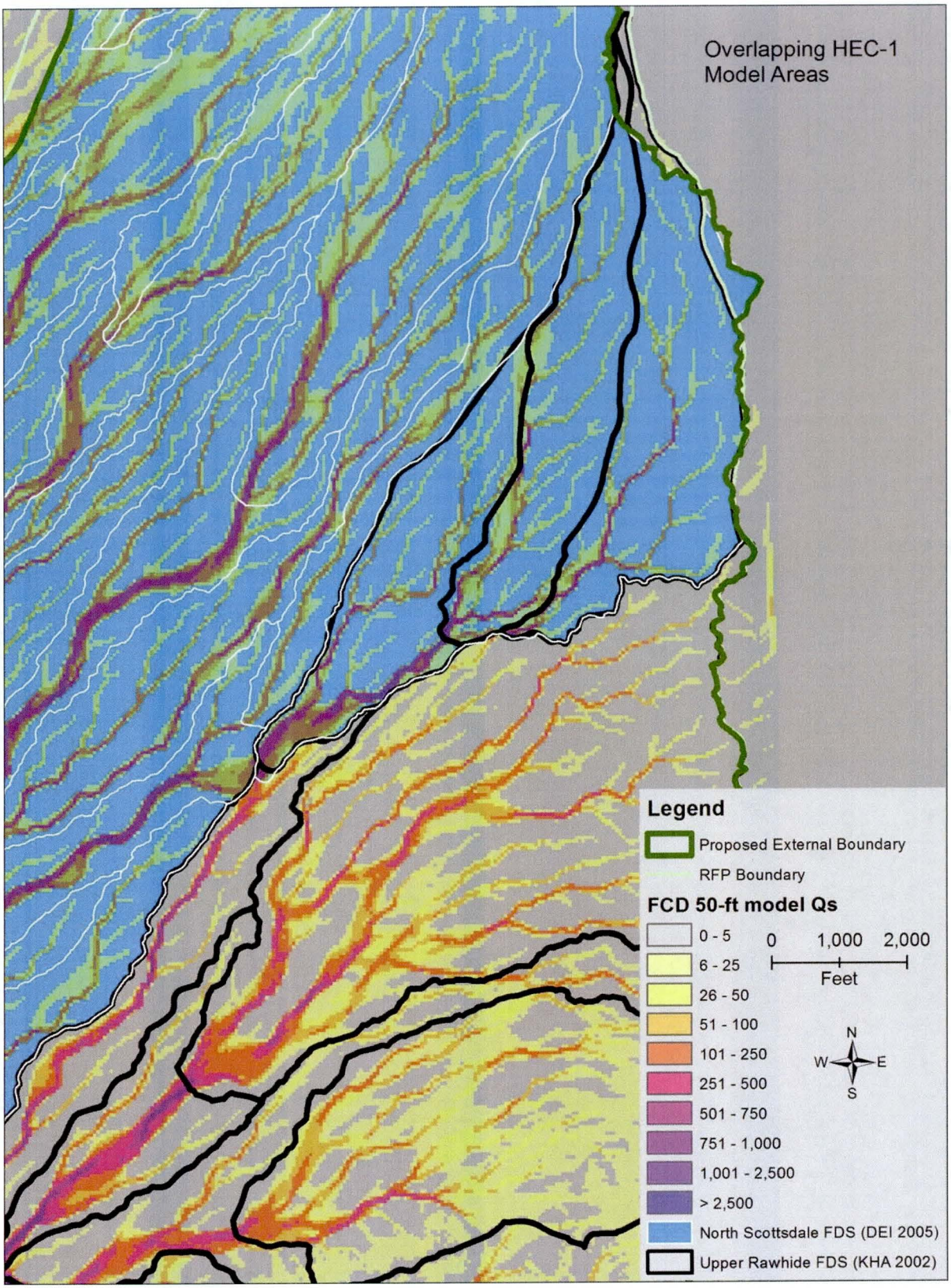


Figure 3. Overlapping HEC-1 Model Areas from North Scottsdale & Upper Rawhide FDS

Based on the elements listed above, the northeast study area HEC-1 models need to be updated in order to make the inflow hydrology for this area compatible with the requirements and assumptions associated with the PPW ADMS. While in some ways, the existing studies could assist in the development of model updates for the PPW ADMS, the HEC-1 models would need to be essentially completely redone. However, the current tools (DDMSW) and datasets (rainfall, soils, land cover) available from the District make this a relatively efficient process.

FLO-2D vs. HEC-1

Rather than update the existing HEC-1 models to make them compatible with the objectives and assumptions of the PPW ADMS, the area could also be updated by remodeling the area with FLO-2D. The following sections address the advantages and disadvantages of updating the hydrology for the ADMS using FLO-2D as compared to HEC-1.

Advantages

The District has developed pre- and post-processing tools, datasets, and procedures to assist in efficient, cost-effective FLO-2D modeling. The aspects of model development that require the most attention and effort relate to collection and coding of hydraulic structures and other man-made features affecting rainfall-runoff. A large portion of the northeast portion of the PPW ADMS study area is undeveloped desert. Therefore, the additional effort associated with hydraulic structures and other man-made features is modest. Moreover, the District has already made the investments in the new (2007) topographic mapping which includes the other man-made features influencing flood runoff in the area (i.e. buildings, roads, etc.) Hence, the overall level of effort compared to updating the HEC-1 models is considered similar.

FLO-2D requires calibration to provide realistic model results. The only available stream gages in the study area are located in the northeast portion of the ADMS study area. Therefore, any model calibration of the FLO-2D model parameters would need to cover this part of the study area. The single largest historic storm event recorded was at the Stagecoach Pass Wash gage located within the NSFDS HEC-1 modeled area. In order to leverage the real-storm rainfall-runoff data to calibrate the ADMS FLO-2D models, modeling of the northeast portion of the ADMS study area is required.

HEC-1 provides a hydrograph at a distinct location (concentration point). FLO-2D provides information on flow depth and velocity at every grid cell within the model. As a result an animation, or movie, of the flood development and movement across the landscape can be generated. These visualizations are helpful for both the modeler and stakeholders resulting in better communication and understanding of the model results for everyone. Moreover, the FLO-2D model results are inherently geographic. That is, we know where they are on the earth's surface. Consequently, flow depth and velocity can be compared to other geographic features such as houses, roads, etc. to explicitly evaluate flood risk at every location within the study area.

Additionally, since it is two-dimensional in construction, FLO-2D inherently incorporates the 'flow split' concept. Flow splits must not be identified in advance and modeled hydraulically outside the

hydrologic model. FLO-2D 'finds' these locations and computes the hydraulic quantities and performs the hydrologic accounting all at once.

Finally, by modeling the northeast portion of the study area in FLO-2D a comprehensive picture of flooding in the entire area can be realized. That picture will be at the same resolution and built upon the same bases as everywhere else within the study area. Moreover, flood hazards exist within the northeast area as well, not all within the existing delineated floodplains. Use of FLO-2D in this area will allow for accurate comprehensive identification of flood hazards throughout the ADMS study area.

Disadvantages

New FLO-2D model results will provide a different depiction of the flood inundation areas as compared to the NSFDS and URW FDS floodplain delineations. However, given the other model changes needed to update the HEC-1 models for the ADMS (rainfall, split flows, topography, etc.), changes in peak discharges would also be anticipated. Hence, the floodplain delineations might still be 'different' with HEC-1 model updates too.

Recommendations

Based on this evaluation, we recommend that the northeast portion of the study area be modeled with FLO-2D in a manner and level of detail similar to that planned for the remainder of the study area downstream. The project will benefit from a comprehensive set of analyses and results with the same resolution (grid size) and methodologies. Importantly, FLO-2D model calibration will require development of a FLO-2D model for the area so that the entire study area model(s) can be calibrated to historic storms. The area-wide grid-based results will also facilitate presentation, communication, and understanding of those results to the District, stakeholders, and the public.

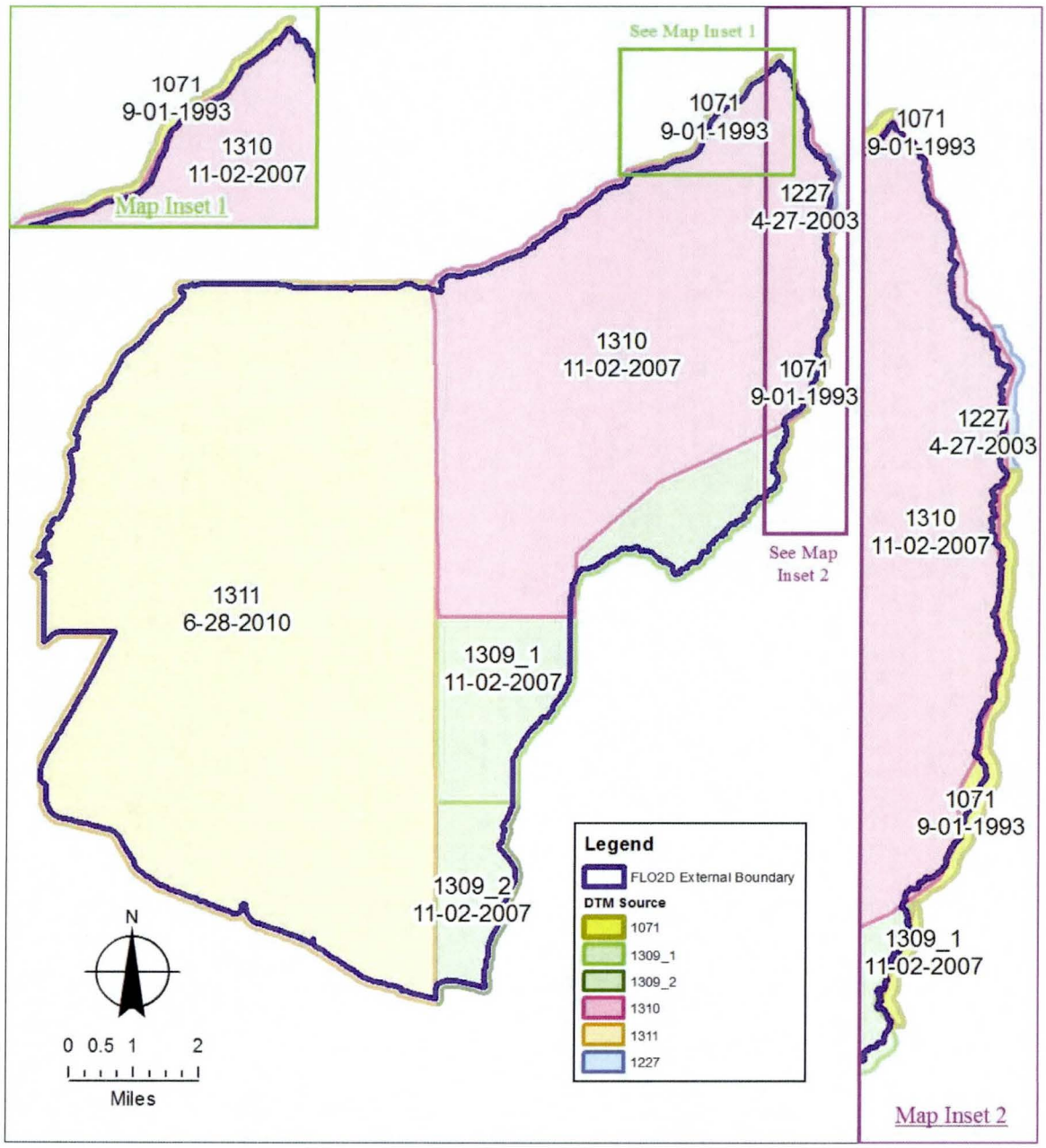
References

DEI Professional Services, 2005, North Scottsdale Floodplain Delineation Study, report prepared for Flood Control District of Maricopa County under contract FCD 2003C008, original hydrology submitted May 2002, Final Report Sept. 2003, revised April 2005.

Kimley-Horn & Associates, 2002, Upper Rawhide Wash Floodplain Delineation Study, report prepared for Flood Control District of Maricopa County under contract FCD 98-12, March 2002.

APPENDIX B: Task 5.2.1 - Topographic Mapping Sources

Project	FCDMC Contract #	Project ID	Flight Date	Contractor	Mapping Scale / Contour Interval (ft)	Vertical Datum
Pinnacle Peak ADMS	09-44	1311	6/28/2010		200 / 2	NAVD88
Pinnacle Peak North	10-26	1310	11-02-2007		200 / 2	NAVD88
Pinnacle Peak South	10-26	1309	11-02 & 11-03-2007		200 / 2	NAVD88
Camp Creek Mapping	01-52	1227	4/27/2003	Wilson & Company	200 / 2	NAVD88
Scottsdale Mapping	IGA 93-07	1071	9-01-1993 & 12/27/2000	Michael Baker Jr., Inc	200 / 2	NAVD88



Master Terrain Data Mapping Sources

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

DEFINE | COMMUNICATE | SOLVE

Memorandum

DATE: August 1, 2012

TO: Theresa Pinto, FCDMC

FROM: Rob Lyons, PE, CFM; Pat Quinn, PE, RLS, AVS

RE: APPENDIX C: Task 5.2.2 – Pinnacle Peak West ADMS Topographic Interpolation Methodology

JE Fuller/Hydrology & Geomorphology, Inc. (JEF) has investigated the pros and cons of using one topographic interpolation approach versus another in the piedmont portion of the PPW ADMS study area. This investigation was conducted at the request of the FCDMC at the H&H Coordination meeting held on July 11, 2012. Ten additional profile locations were selected as shown in Figures 1 and 2. Six of the profiles were selected along a wash bottom thalweg and 4 were selected perpendicular to the prevailing slope of the terrain (these 4 profiles would be commonly known as cross sections). All 10 profiles were placed within the Pinnacle Peak ADMS Topographic mapping contract area (Project ID 1311, Flight Date: 6-28-2010).

JEF developed 20' pixel rasters using several topographic interpolation methodologies for an area covering the 10 profile alignments. Station and elevation data were then extracted for each methodology and compared to the actual surface (Triangular Irregular Network or TIN), referred to herein as the 'True Profile'. Although several methodologies are presented in the following profiles and/or the enclosed Excel spreadsheet, this memorandum will focus on three primary methodologies briefly described below:

1. GDS Masspoints: Direct Interpolation of mass points using the GDS – The topographic mass points, breakline vertices, and spot elevations were imported into the GDS as DTM elevation points. The GDS software was then used to assign the grid element elevations. The GDS software uses a direct average of points falling within a grid element if there are a sufficient number of points. Otherwise, the GDS uses an Inverse Distance Weighting (IDW) algorithm based on points outside the grid element.
2. TIN to Raster: Rasterized TIN approach – This approach uses a three-step approach by first generating a higher resolution raster (4' Pixel) from the ArcGIS TIN or a Terrain Data Set, converting the raster to points, then using the GDS to assign grid element elevations based on the points.

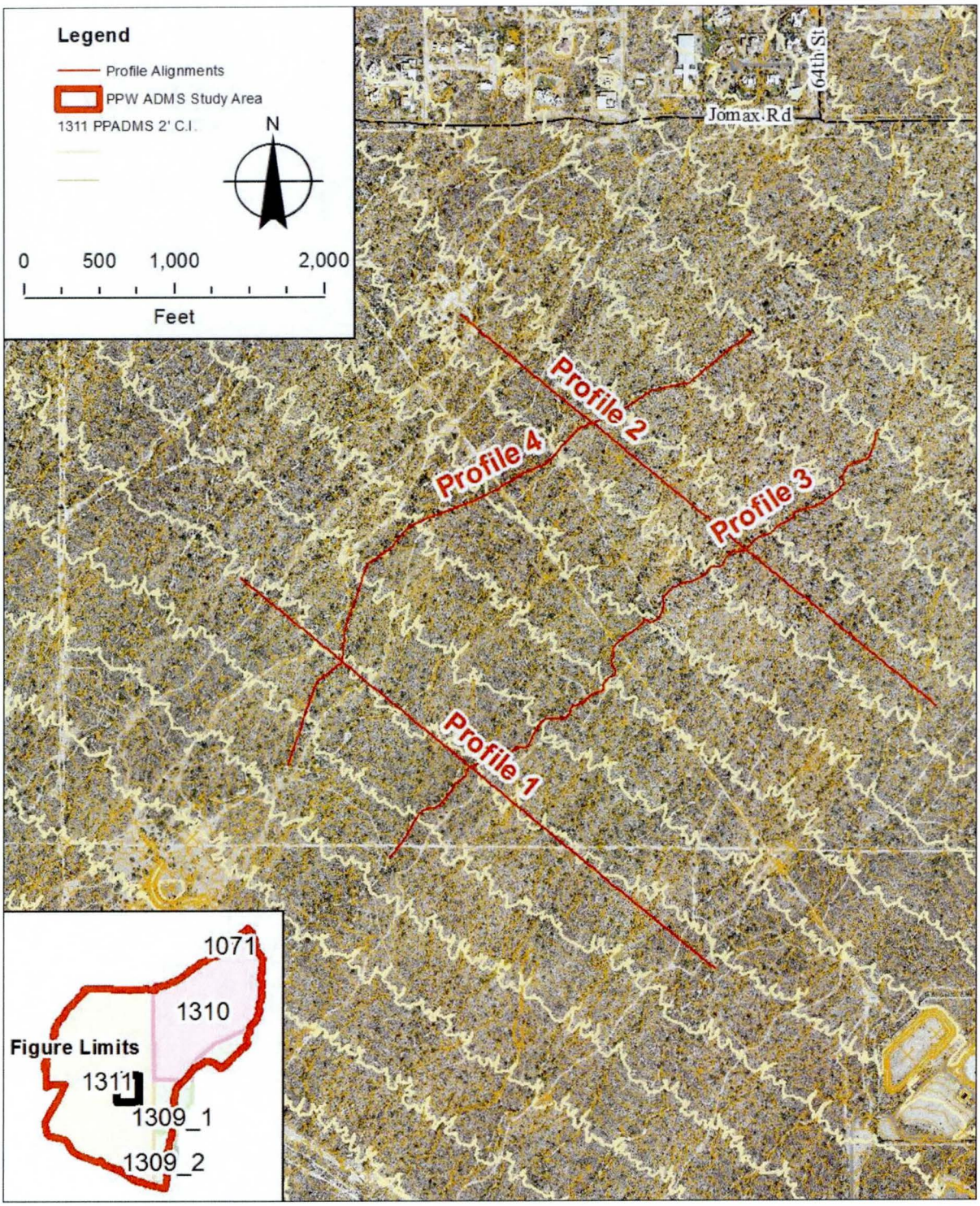


Figure 1. Profile 1 through 4 alignments in Piedmont Area

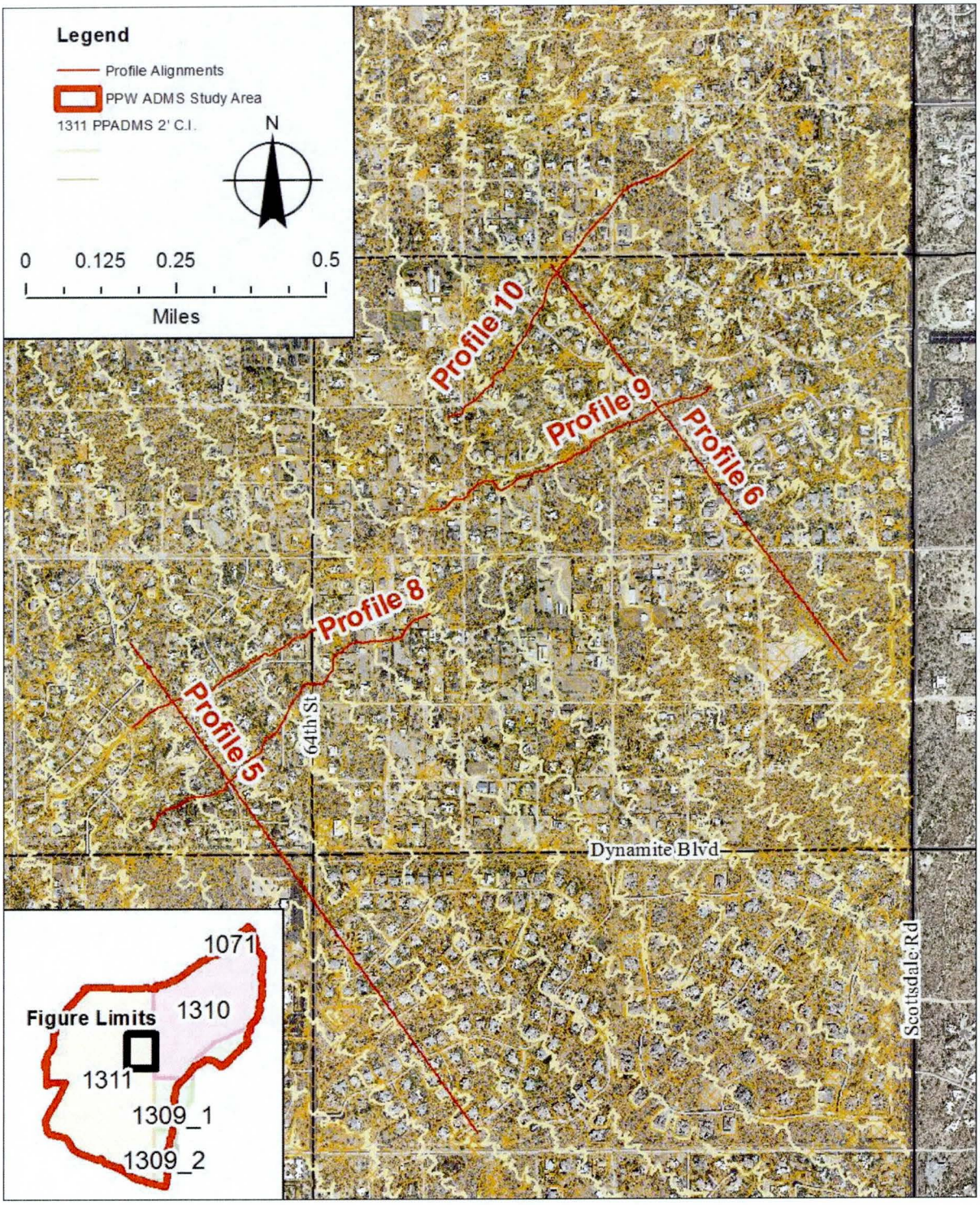
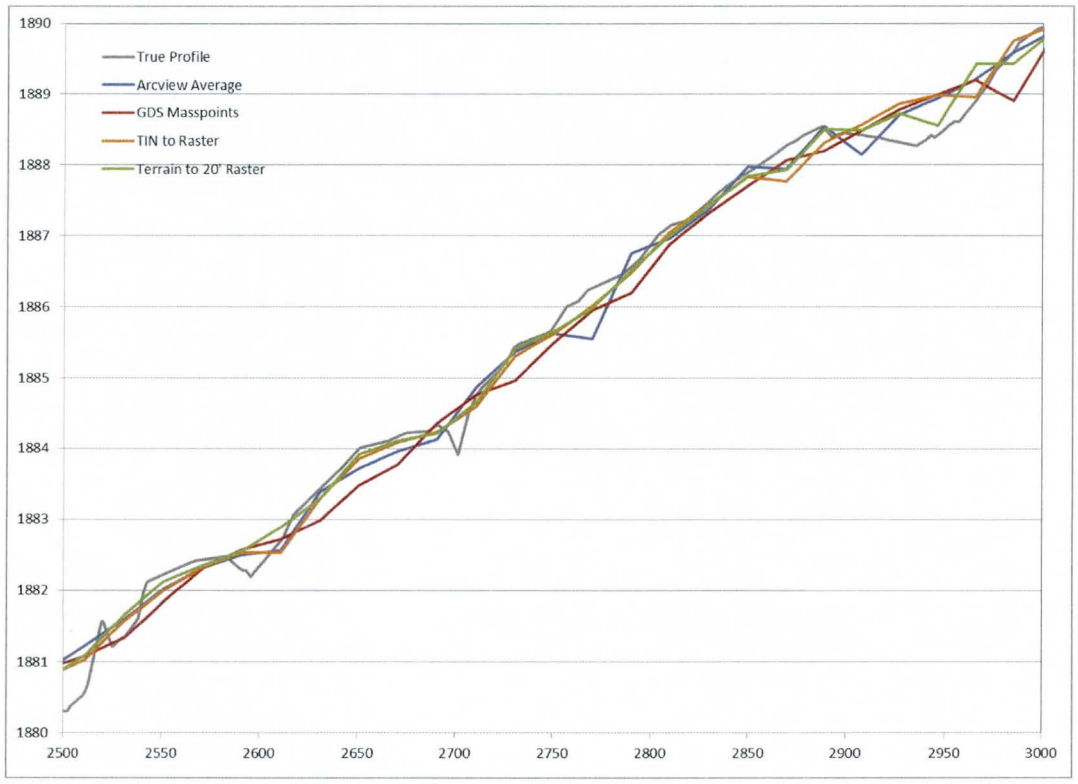


Figure 2. Profile 5 through 10 alignments in Piedmont Area

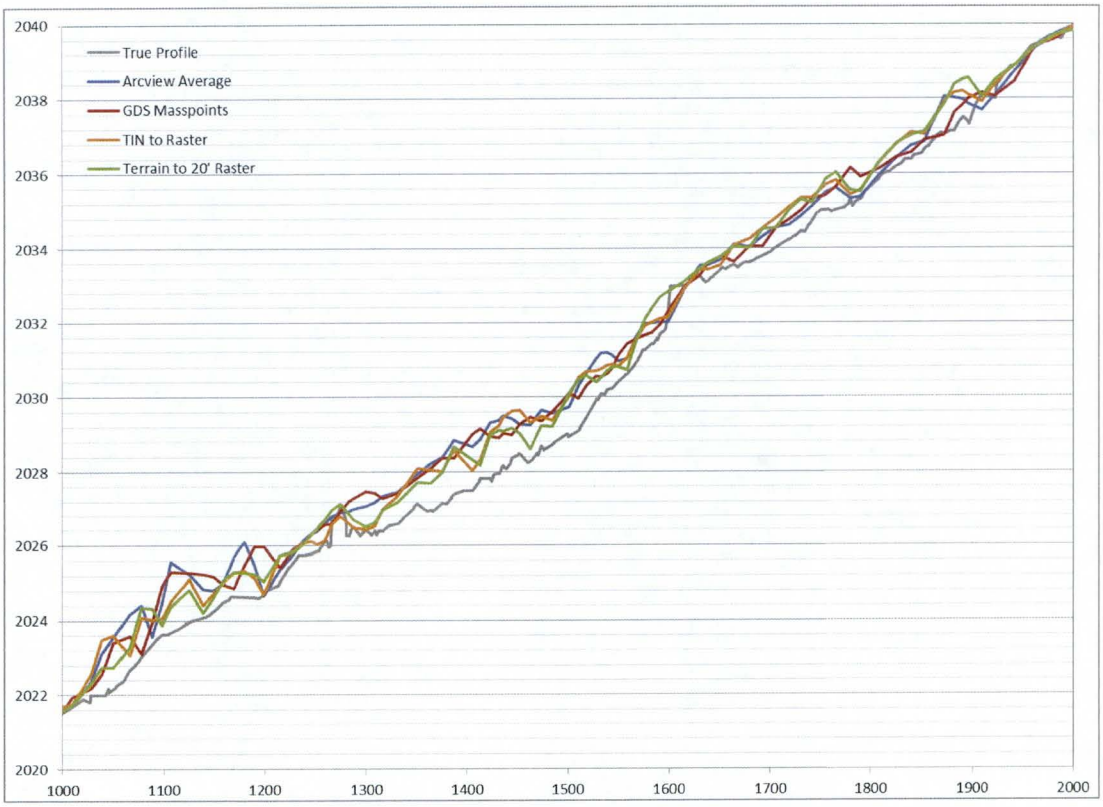
3. Terrain to 20' Raster: Direct conversion to 20' Raster from a Terrain Data Set – The masspoints and breaklines provided by FCDMC were used to build a Terrain Data Set (TDS) for the entire PPW ADMS FLO-2D model area. The TDS was then converted to a raster using the 'Terrain to Raster' conversion tool within the 3D Analyst ArcToolbox. *This approach was not presented at the July 11th meeting, but has since been investigated and found to have promising results. Furthermore, the conversion tool finished execution in less than 5 minutes for an approximate area of 150 square miles.*

Each profile alignment was plotted within Excel to graphically review the results as compared to other methodologies and the True Profile. Then, a second set of 'Blowup' profile graphs were developed within each profile to zoom in and compare one profile against another. Only a select sample of these profiles is shown below since this resulted in 20 graphs. Refer to the enclosed Excel file to review each profile. Profiles 4, 7, and 9 below are a sample of blowup profile comparisons on alignments along a wash bottom (thalweg).

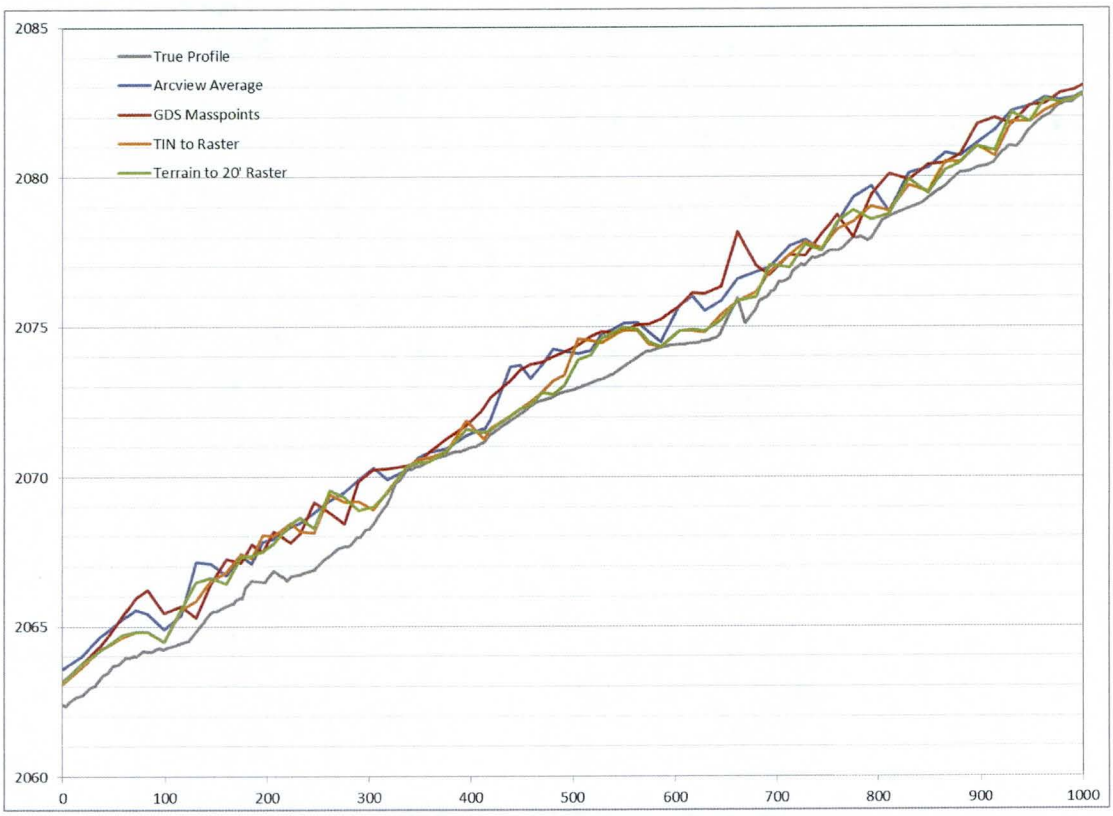
Of the four approaches shown in each of the 6 profiles along wash thalwegs, no approach stands out as the 'best' approach. In some cases, the TIN to Raster & Terrain to 20' Raster profiles appears generally lower in elevation and closer to the True Profile than others. In other cases, the GDS Masspoints approach seems lower. It is difficult to quantify why each approach varies by location.



Profile 4. Blowup Comparison



Profile 7. Blowup Comparison



Profile 9. Blowup Comparison

It can also be seen that each approach has a somewhat erratic profile from one data point to the next. This is mostly due to the profile alignment catching a raster pixel that was sampled from both the channel bottom and along the channel side slope. Figure 3 below depicts some example locations of this phenomenon along Profile 9. Flood routing within FLO-2D will not take the same path as the profile alignment but rather, the path of least resistance. That is, flow exchange between one grid element and the next will occur most favorably with adjacent grid elements with the lowest relative elevation. Furthermore, it is also interesting to note that the 'True' profile itself has 'Pits' or depressions along the thalweg in some locations. It is recommended that the project team consider testing and potentially using adjustments made by the GDS using the new Pit Removal Tool to remove or dampen any of these issues that are solely a result of discretization.

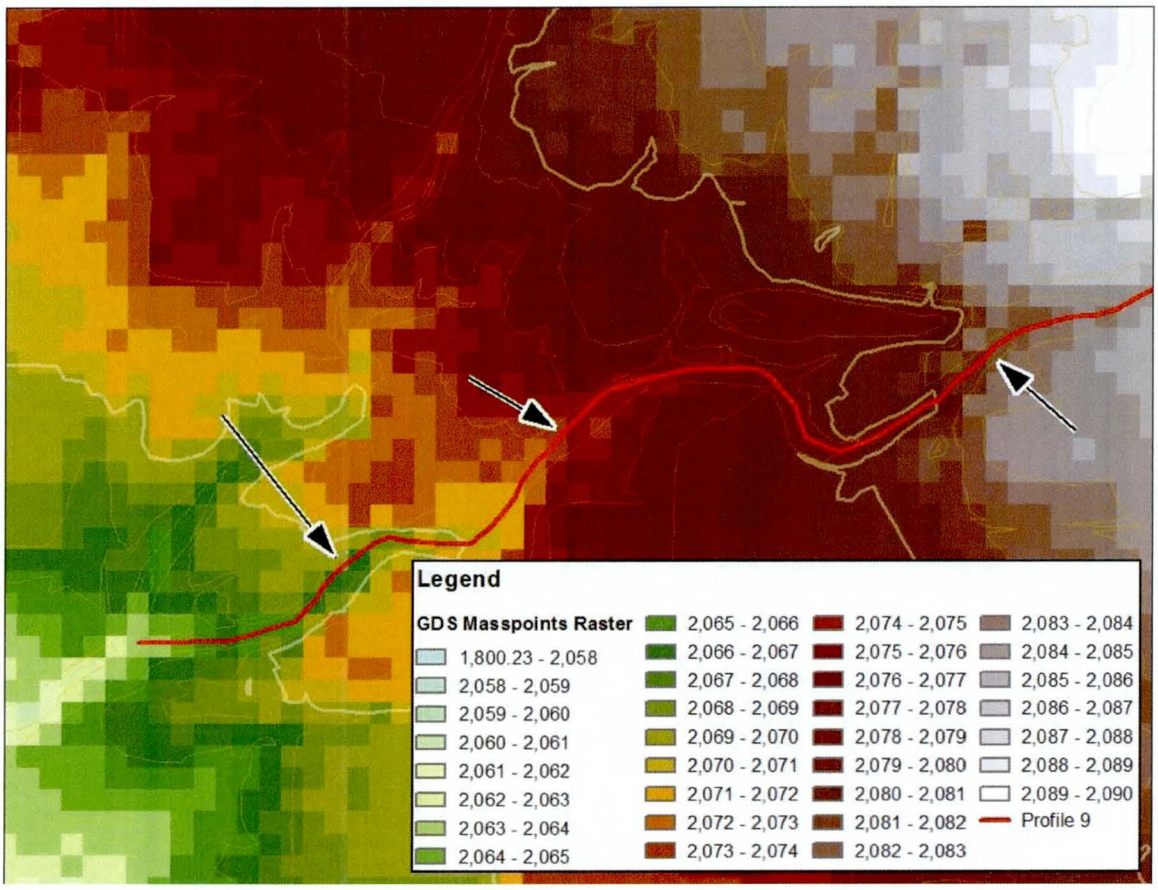
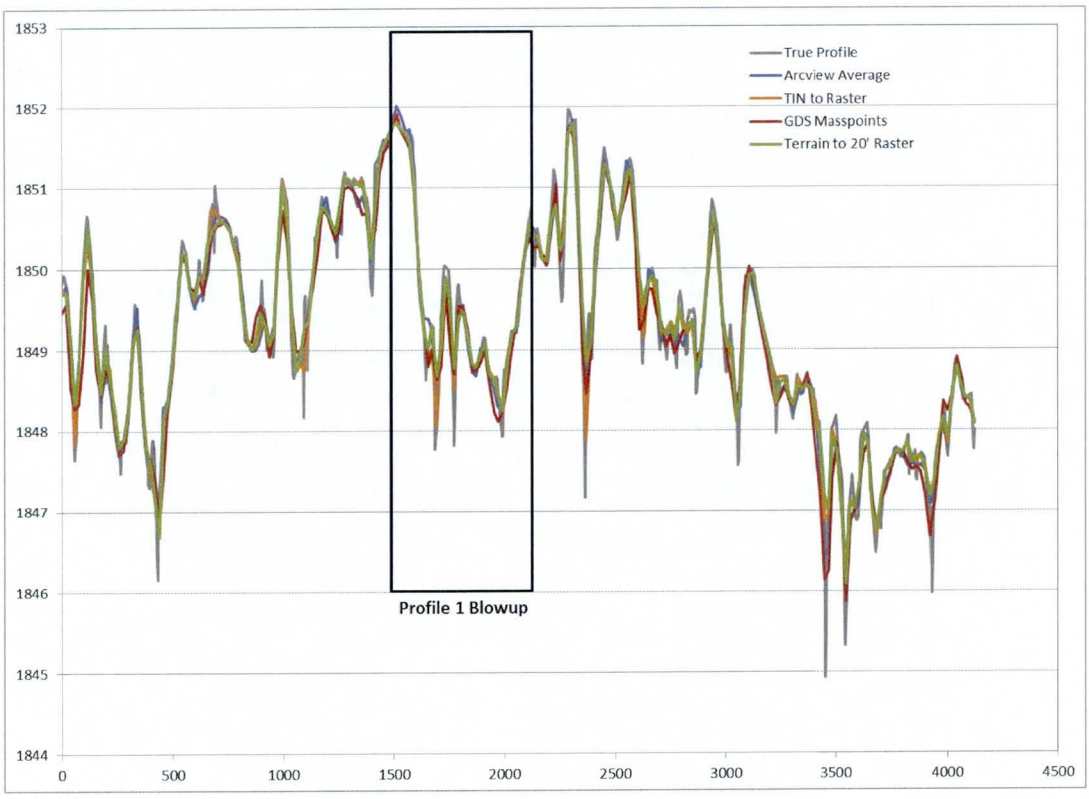
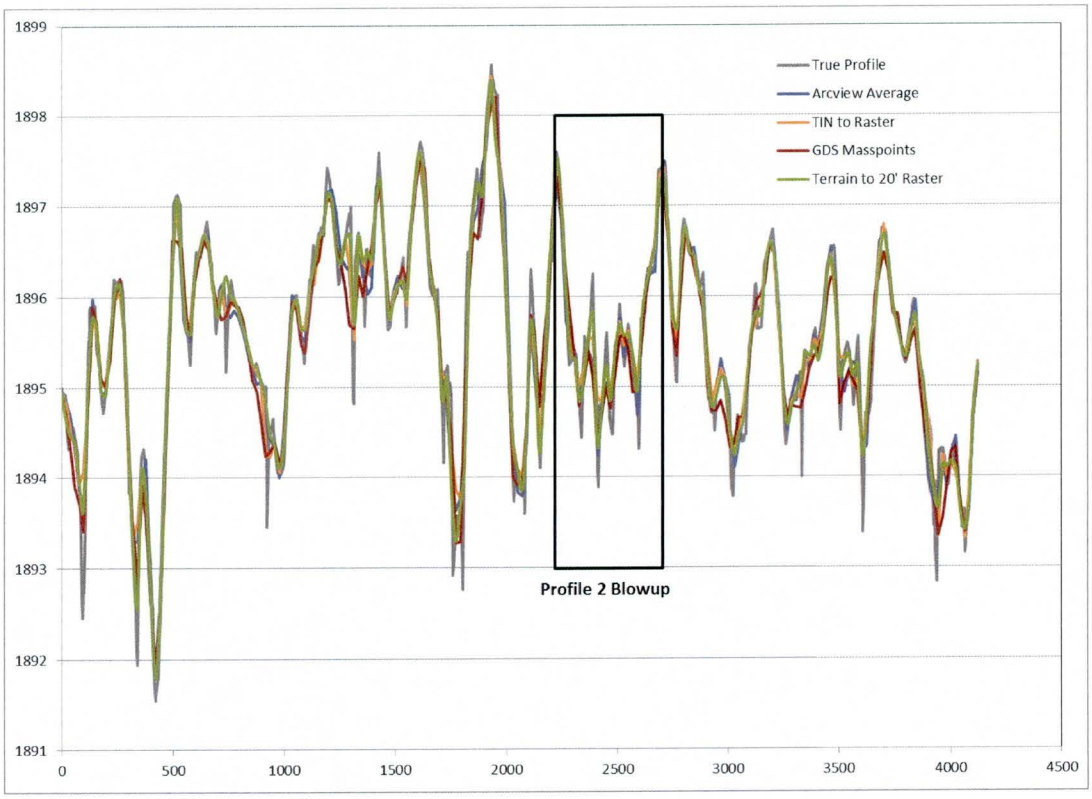


Figure 3. Profile 9 along the GDS Masspoints Raster

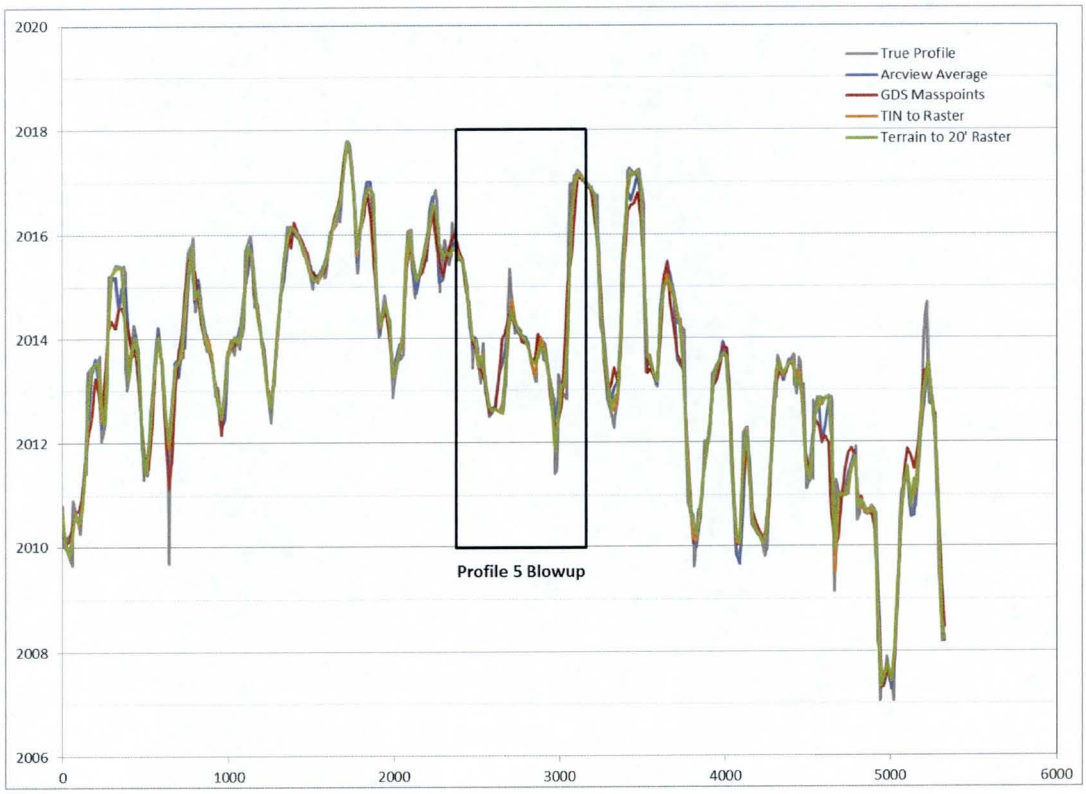
Profiles 1, 2, 5, and 6 shown below, are the profile comparisons on alignments taken perpendicular to the general prevailing terrain (cross sections).



Profile 1. Cross Section Comparison



Profile 2. Cross Section Comparison

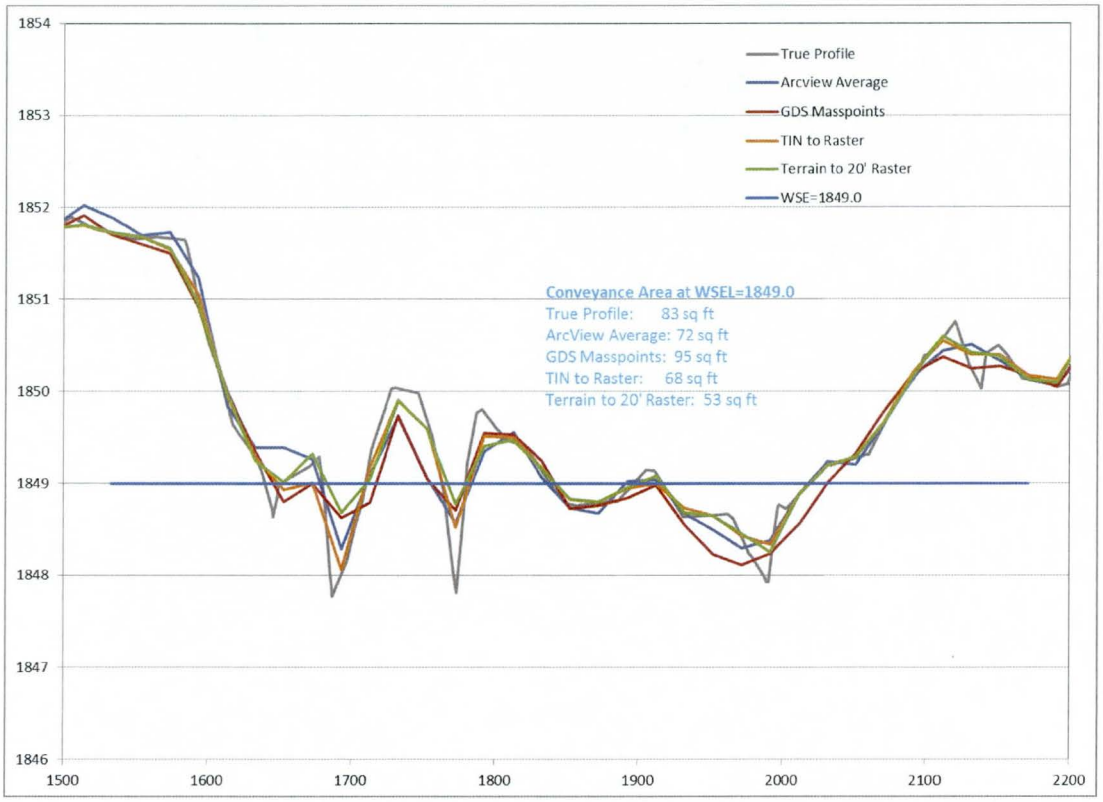


Profile 5. Cross Section Comparison

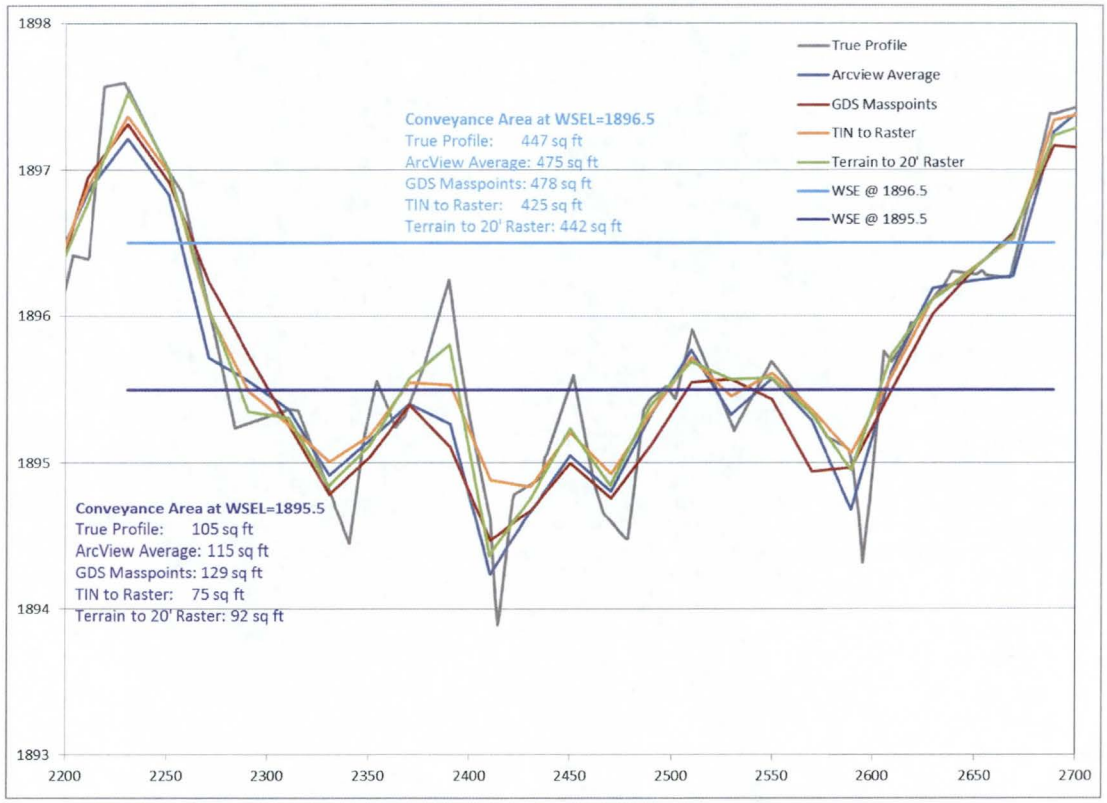
Profile 6. Cross Section Comparison

These 4 profiles (cross sections) also do not show an obvious ideal approach. The TIN to Raster & Terrain to 20' Raster profiles appear generally lower in elevation in the wash bottoms, and higher in elevation along the ridges than the GDS Masspoints approach in some locations, and in other locations, the reverse is true.

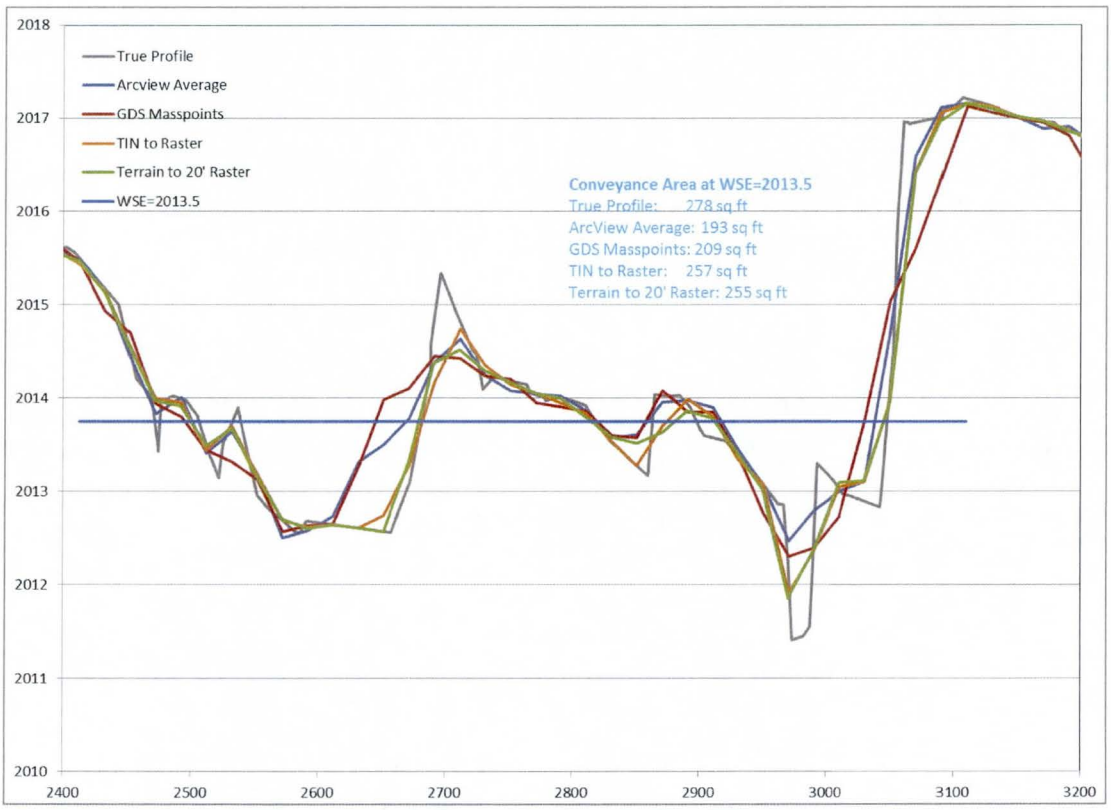
A sample of each profile was blown up to compare each profile more closely. Blowups graphs of each cross section are shown below. In addition, JEF computed the conveyance area within the irregular cross section within each blow up area based on an assumed water surface elevation (WSE). This comparison is certainly not conclusive based on the relatively small sample, but it appears that the GDS Masspoints approach results in the highest conveyance area in most cases. Compared to the GDS Masspoints approach, the resulting conveyance area for the Terrain to 20' Raster approach tends to yield a closer correlation to the True Profile. Again, this comparison is not conclusive given the small sample size.



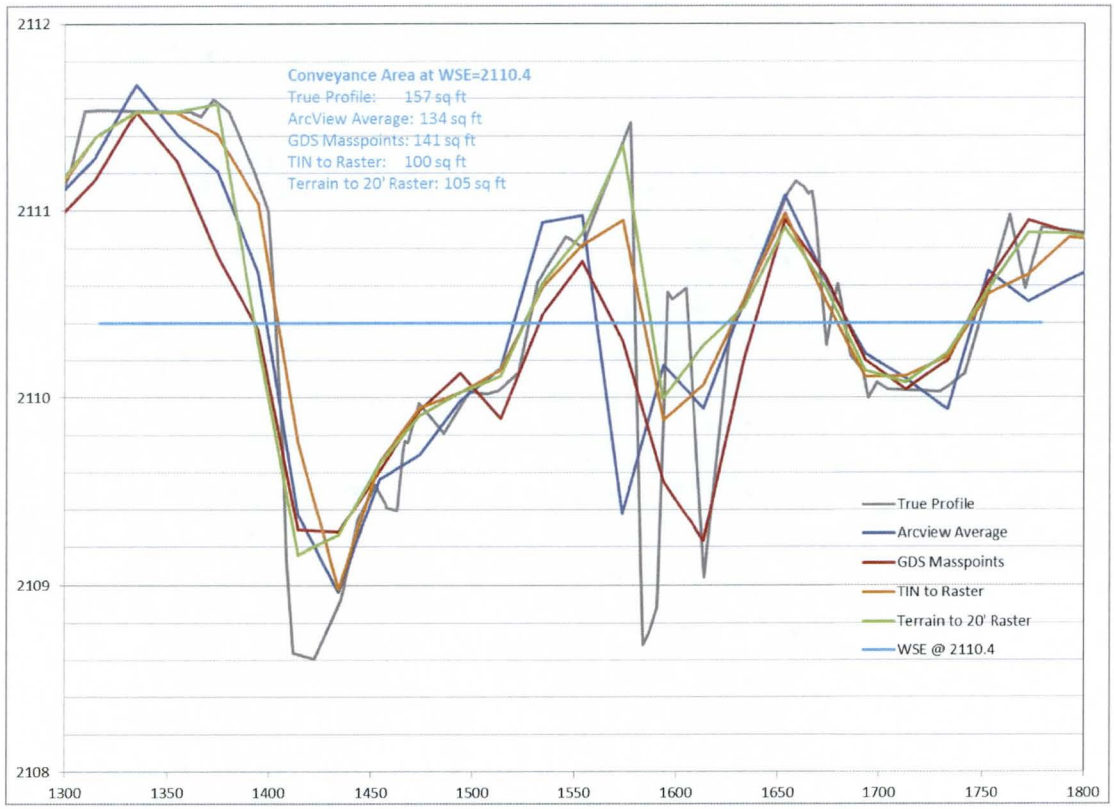
Profile 1. Blowup Profile and Conveyance Area Comparison



Profile 2. Blowup Profile and Conveyance Area Comparison



Profile 5. Blowup Profile and Conveyance Area Comparison



Profile 6. Blowup Profile and Conveyance Area Comparison

The final terrain discretization comparison involves the actual raster surface. A volumetric comparison of the three approaches to the True Terrain was made using the Raster Surface tool, 'Cut Fill' within the 3D Analyst ArcToolbox. This tool is a comparison of Raster surface types only (no TIN or Terrain Data Set option is available). Therefore, a portion of the TIN within the 1311 mapping area was rasterized at a 1' Pixel to approximate the True Surface for this comparison. Each of the three topographic interpolation methodologies was compared to the rasterized True Surface. Table 1 below depicts the volumetric difference. When you spread the difference out over the entire sample surface area, the difference is relatively small and can be converted to inches.

Table 1. Volumetric Difference in Raster Surfaces from the True Terrain

Topo Interp Method	Cut-Fill Difference (cf)	Coverage Area (sq ft)	Difference (in)
GDS Masspoints	27,380,022	81,733,600	4.02 (fill)
TIN to Raster	-36,302,682	1,222,640,000	-0.36 (cut)
Terrain to 20' Grid	26,503,373	1,222,640,000	0.26 (fill)

It can be seen that the Terrain to 20' Grid approach yields the lowest difference. It is not readily apparent why the GDS Masspoints approach yields the highest difference. It could be that the majority of this difference occurs in areas with relatively little conveyance, but this was not confirmed or tested.

The final comparison of the various methods has to do with the level of effort required to develop a comprehensive Raster for use in assigning grid element elevations as follows:

- TIN to Raster: This process is expected to take the longest amount of time of all approaches. A 4-foot pixel Raster covering the entire FLO-2D model area has already been developed and takes relatively little time to build from the Terrain Data Set. However, 25 points will exist within each 20' FLO-2D grid. Given the approximate 100 square mile model domain, approximately 7 million grid elements are required. That results in 175,000,000 elevation points. This will require the elevations to be processed in several pieces within the GDS. Each grid piece will then need to be rasterized, and ultimately mosaicked to develop a master file. This process is expected to take approximately **two to three weeks**. It is possible that the exact same sampling scheme within GDS could be mimicked in ArcMap with custom programming, or in another GIS platform that may result in some time savings.
- GDS Masspoints: Based on the two sample areas analyzed, there will be as many as 30,000,000 elevation points within the project area. This will require the elevations to be processed in 2 to 3 pieces within the GDS, similar to the TIN to Raster approach. This process is expected to take approximately **one week**.
- Terrain to 20' Raster: As stated previously, a 20' pixel Raster was developed in 5 minutes using the Terrain to 20' Raster approach based on a previously built Terrain Data Set. The only additional effort required for this approach is to line the raster up with the exact position of the anticipated FLO-2D grid elements. **The level of effort for this is expected to be trivial**.

Summary and Recommendations

A graphical review of the profile comparisons based on the three dominant approaches did not yield a 'best' approach. Based on the comparison of some assumed conveyance areas within a few sample washes, the Terrain to 20' Raster seemed to yield the closest conveyance area to the actual conveyance based on the True Profile. A comparison of volumetric differences from the various rasterization approaches indicated the Terrain to 20' Raster approach resulted in the smallest difference in volume. Finally, the Terrain to 20' Raster will require the least amount of effort to develop the master elevation file (Raster). Based on this evaluation, we recommend that the Terrain to 20' Raster approach be used. Furthermore, it is recommended that the new Pit Removal Tool within the GDS be tested to identify artificial ponding areas along washes and potentially dampen or remove these areas if they are solely a result of discretization.

Memorandum

DATE: July 5, 2012

TO: Theresa Pinto, FCDMC

FROM: Nathan Logan, PE, CFM

RE: APPENDIX D: Task 5.2.3.2 - Pinnacle Peak West ADMS Preliminary FLO2D storm event duration comparison (100-Year and 10-Year)

Preliminary Model

JE Fuller/Hydrology & Geomorphology, Inc (JEF) received a preliminary FLO2D model of the Pinnacle Peak West (PPW) ADMS study area from the Flood Control District of Maricopa County (FCDMC). This preliminary model served as a base model for the investigation performed by JEF to determine the effects of the 24-hour versus 6-hour duration on the watershed for the 100-year and 10-year events. The purpose of this investigation is to determine which duration will control the watershed and will be used for future more detailed modeling. The basics of the preliminary model as received by FCDMC are outlined below:

- Grid Size: 50-foot
- Storm Event and Duration: 100-Year, 6-hour (Pattern 1) event (simulation time = 8-hours)
- Single Point Rainfall: 3.2 inches; No spatial variation
- Depth Roughness Function (AMANN) turned off and Shallow-n set to 0.0
- Courant Number = 0.6
- Single Roughness value of 0.04 set for all 1,249,142 grids in the model
- Grid Elevations are not based off current detailed topographic data but on 10-foot contour interval data.

The preliminary model was run by JEF using the 2009.06 64-bit version of FLO2D and the depth and discharge results are shown in **Figure-1** and **Figure-2** respectively. The output shown in these two figures represents the output of the model as received by FCMDC without any modifications by JEF.

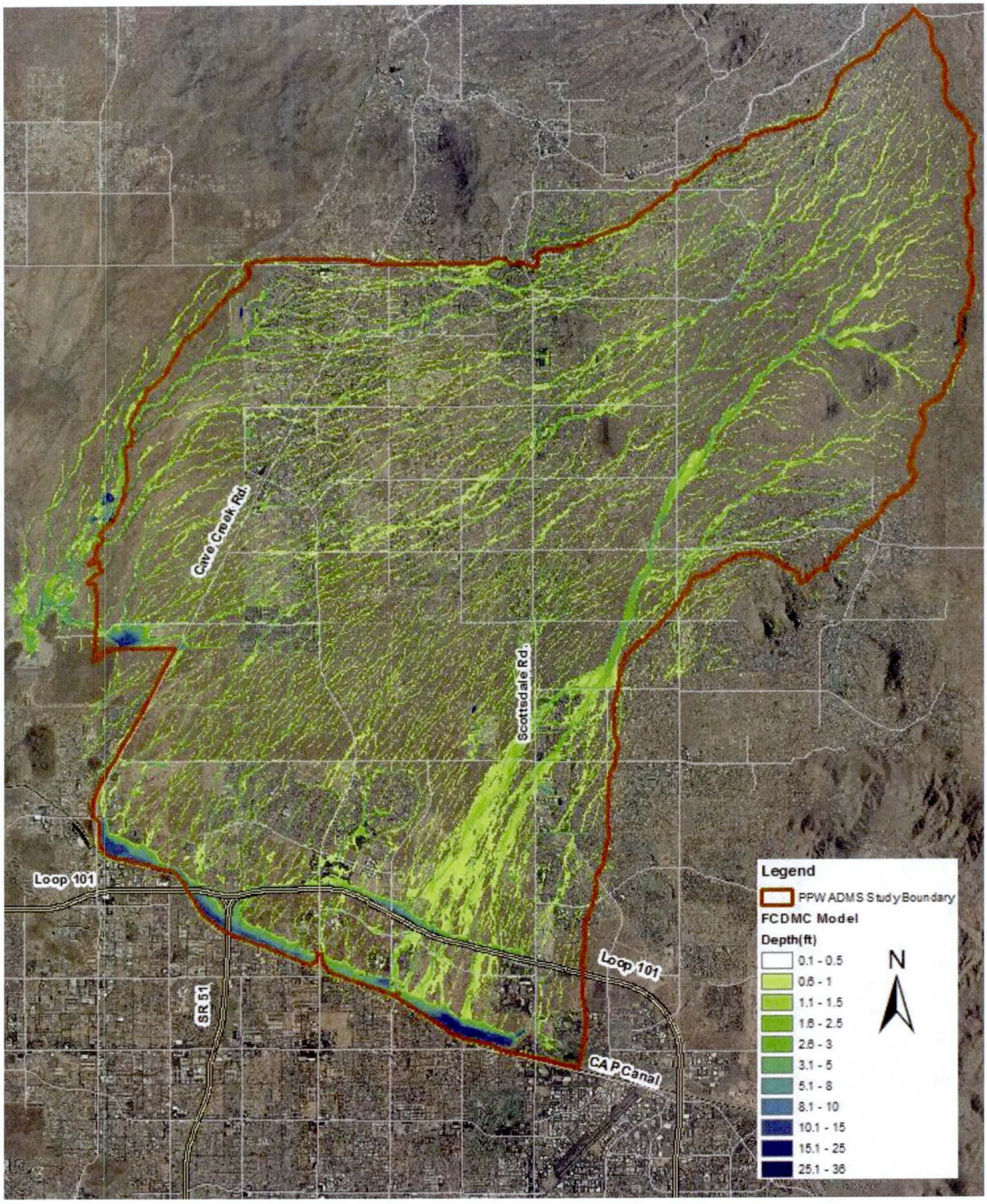


Figure-1 – FCDMC FLO2D Model Flow Depths

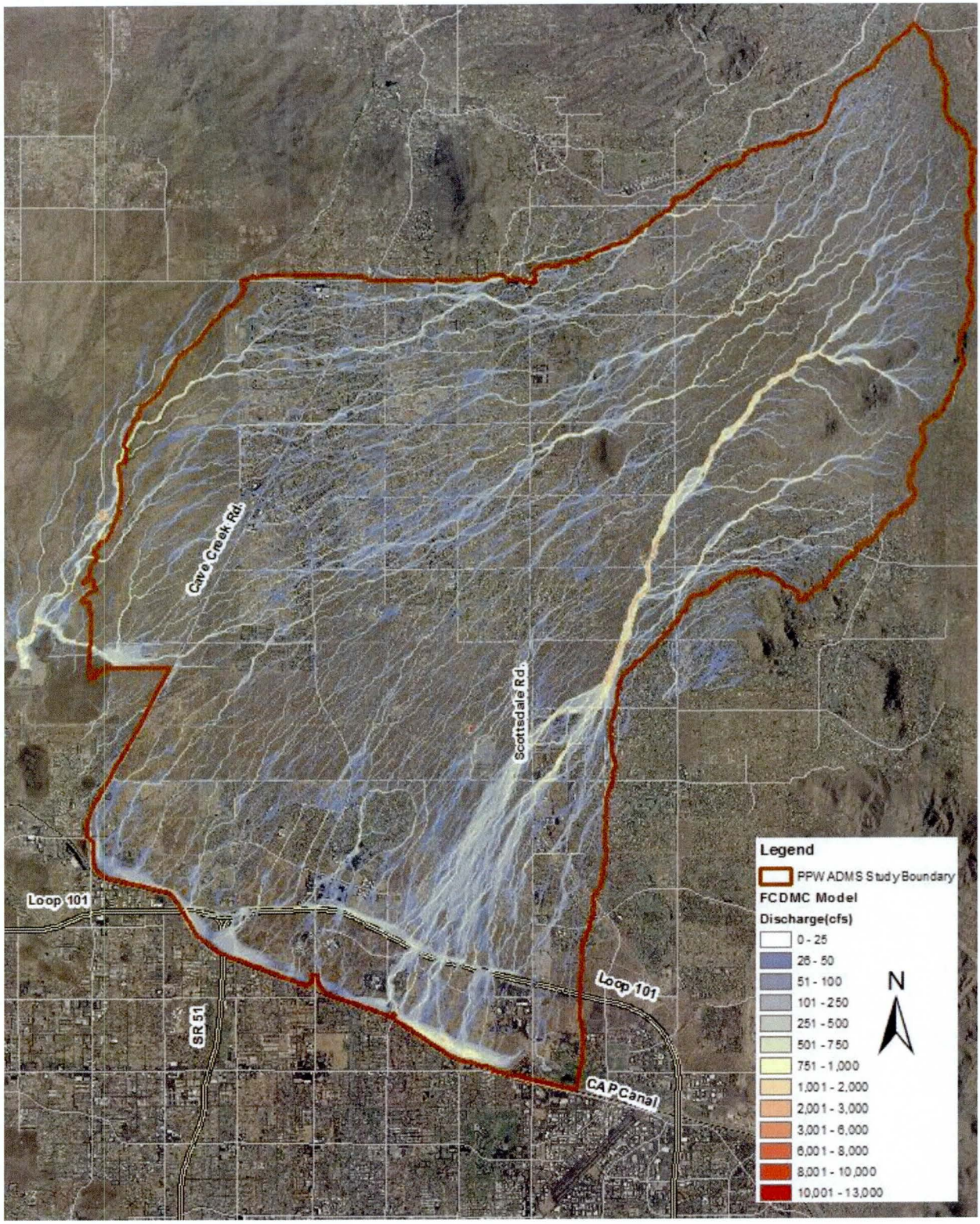


Figure-2 – FCDMC FLO2D Model Flow Discharges

Model Modifications by JEF

Upon reviewing the results of the preliminary model JEF added a total of thirty floodplain cross-sections to the input files, the location of the sections are shown in Figure-3.

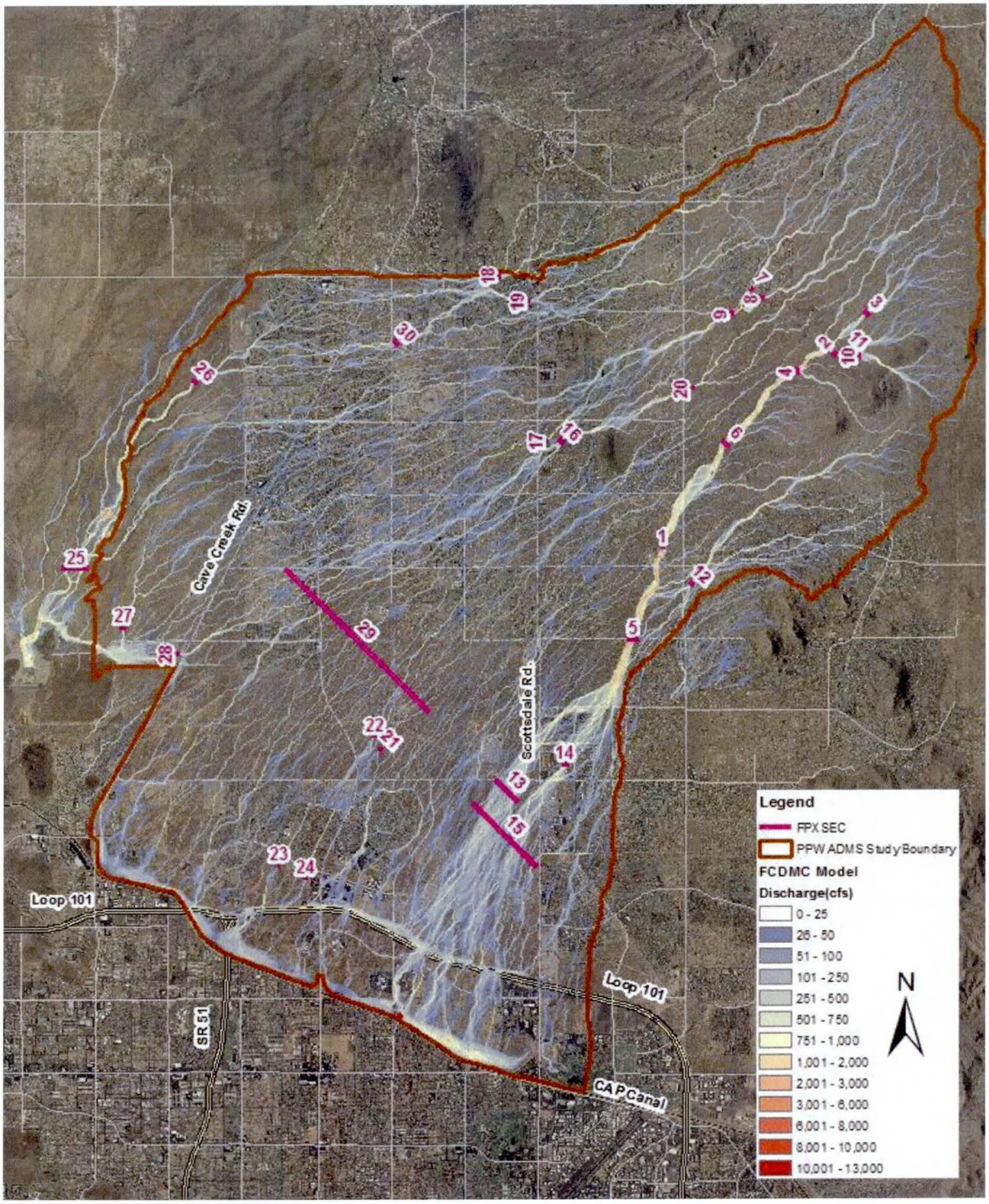


Figure-3 – FCDMC FLO2D Model Flow Discharges with Floodplain Cross-Section Locations

JEF also changed the rainfall input file (RAIN.DAT) for the modified FLO2D model to account for spatial rainfall variations over the watershed. The FCDMC model used only a single rainfall depth over the watershed; however, the rainfall varies across the watershed as can be seen in **Figure-4** and **Figure-5** which show the NOAA Atlas 14 24-hour rainfall depths for the 10-, and 100-year events respectively. The 24-hour depths are shown in the exhibits since the 24-hour duration has the larger spread of values when compared to the 6-hour duration.

The rainfall data shown in the figures are from the NOAA Atlas 14 rainfall shapefile supplied by the FCDMC; the variations in rainfall depths over the watershed are listed in **Table-1**. The rainfall depths were extracted from the NOAA Atlas 14 data by intersecting a shapefile created from the FLO2D CADPTS.DAT file with the FCDMC supplied NOAA Atlas 14 shapefile; the maximum and minimum values were extracted from the intersect file.

Table-1 – FCDMC NOAA Atlas 14 Maximum and Minimum Rainfall Depths

	10-Yr, 6-Hr	10-Yr, 24-Hr	100-Yr, 6-Hr	100-Yr, 24-Hr
Maximum Rainfall Depth (in)	2.220	3.451	3.369	5.608
Minimum Rainfall Depth (in)	1.783	2.369	2.709	3.682

Due to the spread in rainfall values, especially with the 24-hour, JEF decided to spatially vary the rainfall data over the grid. The rainfall distribution for the 6-hour is Pattern 1 and the SCS type II distribution was used for the 24-hour duration. The 6-hour model was simulated for 8 hours and the 24-hour model was simulated for 32 hours.

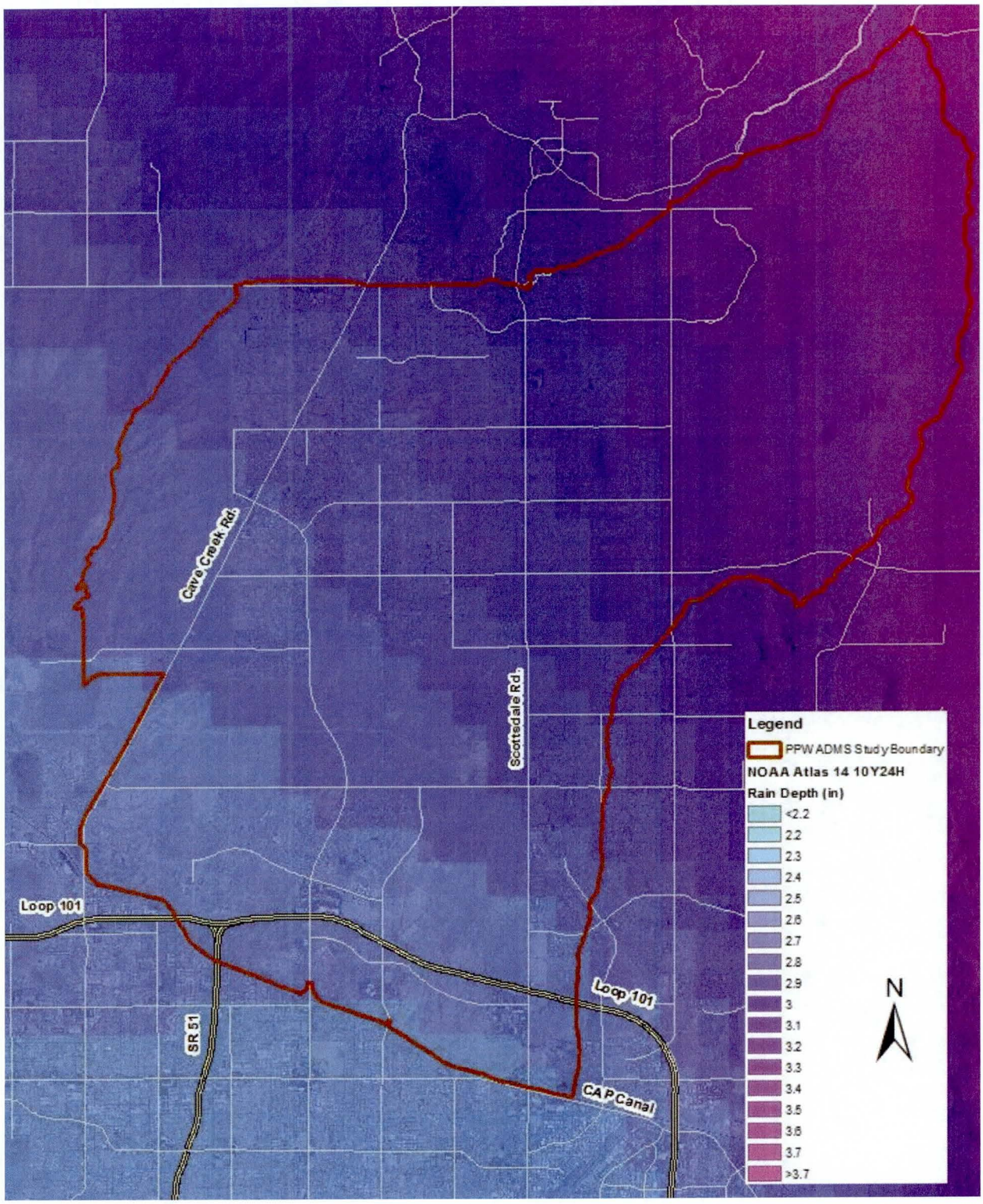


Figure-4 – FCDMC NOAA Atlas 14 10-Year, 24-Hour Rainfall Depth

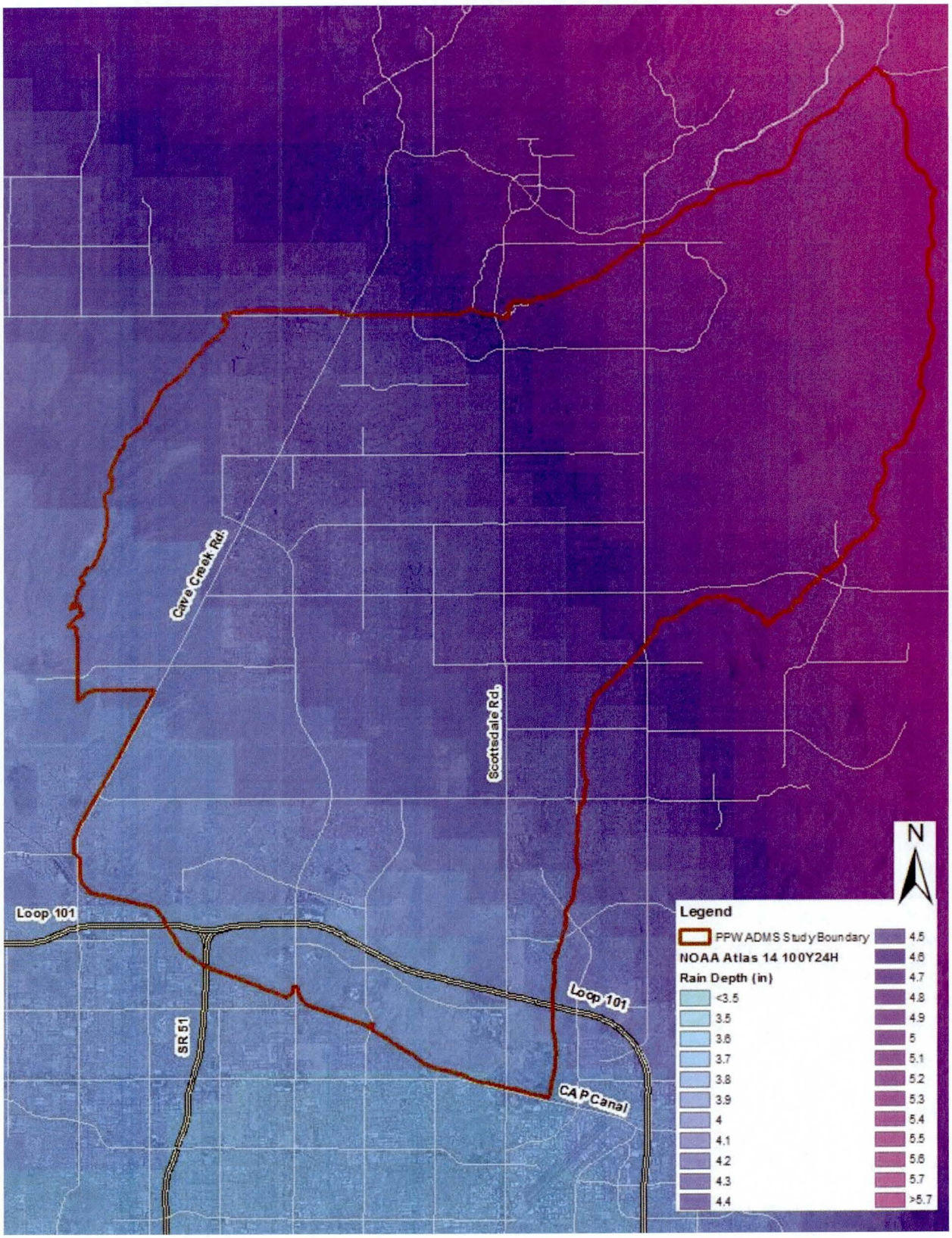


Figure-5 – FCDMC NOAA Atlas 14 100-Year, 24-Hour Rainfall Depth

The initial runs of the 24-hour JEF modified model (spatially varied RAIN.DAT file) ran for a lengthy time due to the water ponding that occurs against the Loop 101, CAP Canal, and various levee features within the model computational domain. The 10-Year, 24-hour, and 100-Year, 24-Hour runtimes are 138.6 hours and 155.04 hours respectively. The 10-year, 6-hour and 100-year 6-hour model runtimes are 9.37 hours and 20.79 hours respectively. To see the effects on model runtime when the ponding areas are removed, additional outflow nodes were added to the model at the ponding locations. The FCDMC model had outflow nodes along the computational domain which extended past the limits of ponding (CAP Canal, Loop 101, SR51 etc.). JEF placed additional outflow nodes at the deepest parts of the ponds; the additional outflow nodes are shown in **Figure-6**.

The effective "removal" of the ponding areas decreased the overall runtime on the 24-hour model by about 60% with runtimes of the 10-Year, 24-hour and 100-Year, 24-hour simulations at 47.84 hours and 54.06 hours respectively. It should be noted that the actual decrease in runtimes will vary depending on the computer processing speed. JEF used multiple computers to run the models with some processors faster than others. However, regardless of computer processing speed, the overall effect on the runtime due to the ponds is quite significant.

Furthermore, the overall effect of removing the ponds from the model is minimal over the watershed. There are obvious changes in depth and discharge around the ponded areas but away from these areas the effects are considered to be negligible with the difference in depths less than 0.1 foot upstream of the ponded areas. The most noticeable change outside of the ponds is the overflow that occurs in between the Loop 101 and the CAP Canal. The revised outflow model reduces the depth of flow in between these features, the depths in the ponded areas is shown in **Figure-7** and **Figure-8** for the 100-Year, 24-hour JEF Modified Model (spatially varied RAIN.DAT) with the FCDMC outflows and JEF Modified Model with the additional outflows respectively.

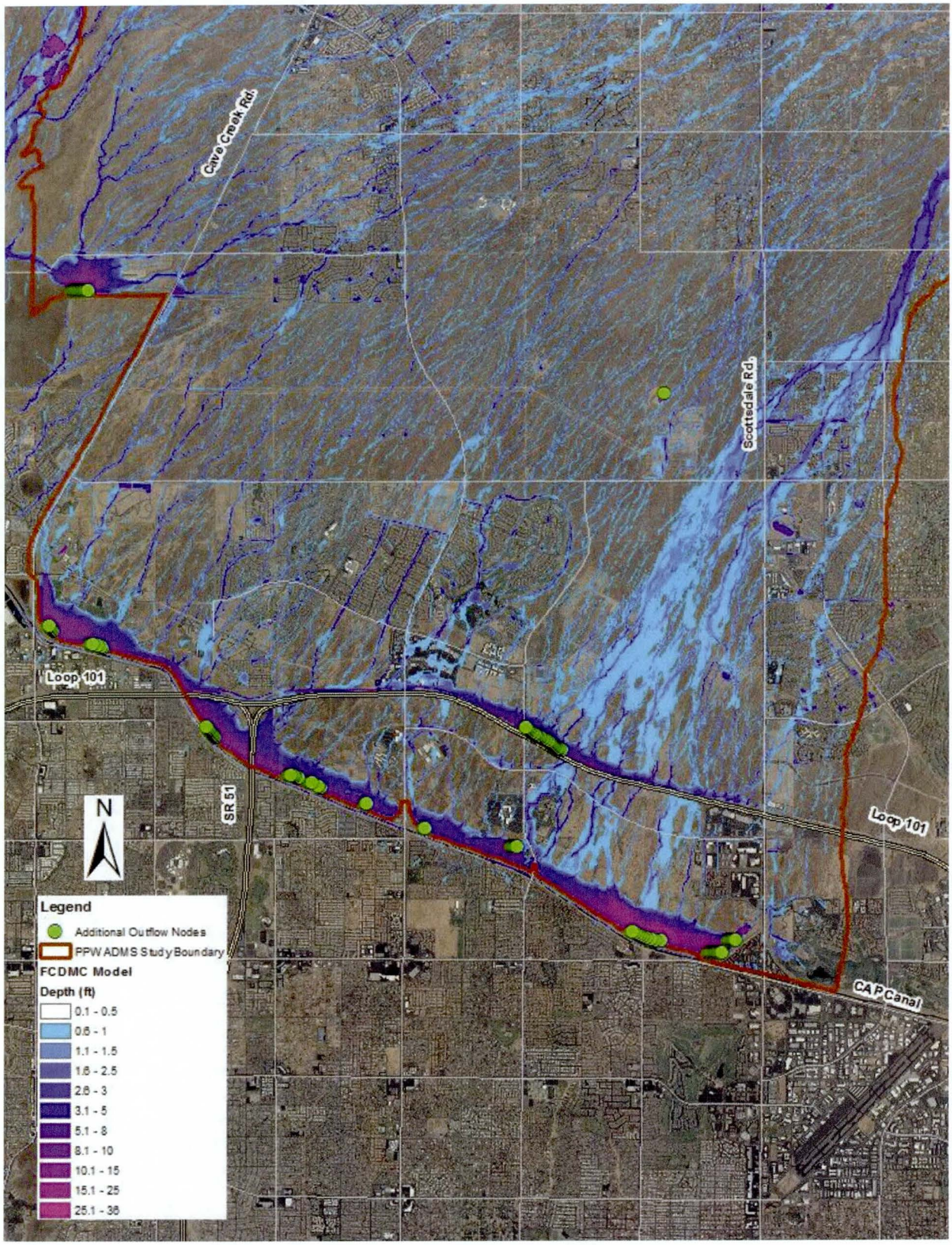


Figure-6 – FCDMC Model Flow Depths with Additional Outflow Node Locations added by JEF

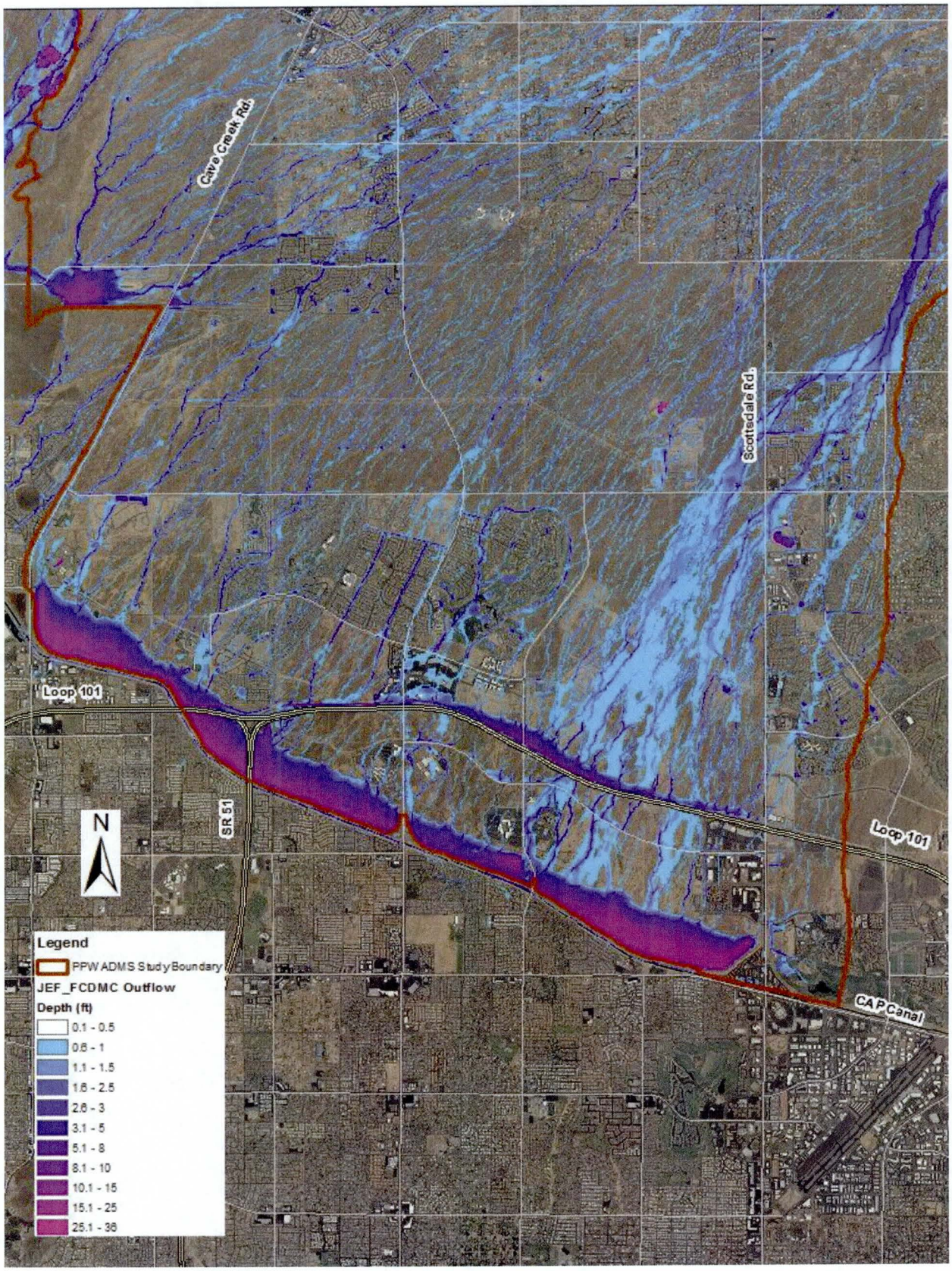


Figure-7 – JEF Modified Model Flow Depths with FCDMC Outflows

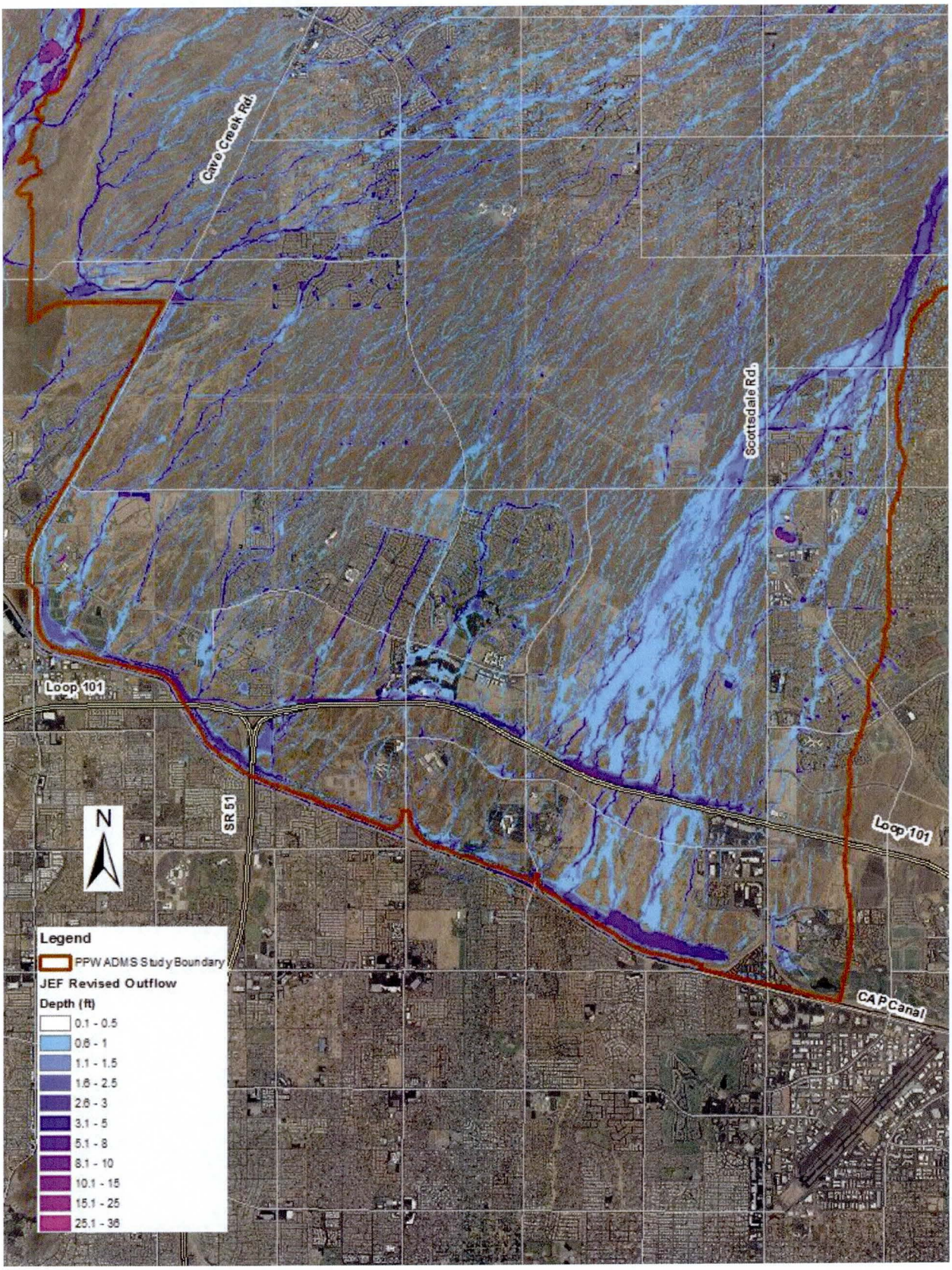


Figure-7 – JEF Modified Model Flow Depths with Additional Outflows

Model Results

The comparison of the 24-hour versus 6-hour model is made with the results of the JEF Modified model (spatially varied RAIN.DAT file) with the revised outflow nodes. The depth and discharge results comparison between the 6-, and 24-hour duration for the 100-Year event are shown in **Figure-8** and **Figure-9** respectively. The depth and discharge depiction in the figures are the difference between the two durations where the 6-hour values are subtracted from the 24-hour values. Therefore, where negative values occur, the 6-hour duration is the controlling event (blue coloring) and where the values are positive the 24-hour duration is controlling (red coloring).

The images shown in **Figure-10** and **Figure-11** represent the percent change in depth and discharge respectively from the 24-hour duration for the 100-Year event. These figures were developed by taking the difference of the depths and discharges between the 6-, and 24-hour durations and dividing by the 24-hour depths and discharges respectively. Discharge differences less than 1.0 cfs and depth differences less than 0.05-foot were not used in the percent change computations. The negative percentages (blue coloring) indicate that the 6-hour duration controls and the positive percentages (red coloring) indicate that the 24-hour duration controls. Each figure only shows changes greater than 5%.

The differences between the 10-year durations is shown in **Figure-12**, and **Figure-13** for the depth and discharge respectively. The format for each of these figures is the same as the 100-Year where negative values indicate that the 6-hour duration controls and positive values indicate where the 24-hour controls.

The images shown in **Figure-14** and **Figure-15** represent the percent change in depth from the 24-hour duration for the 10-Year event. These figures were developed by using the methodology as described above for the 100-year event figures. Each figure only shows changes greater than 5%.

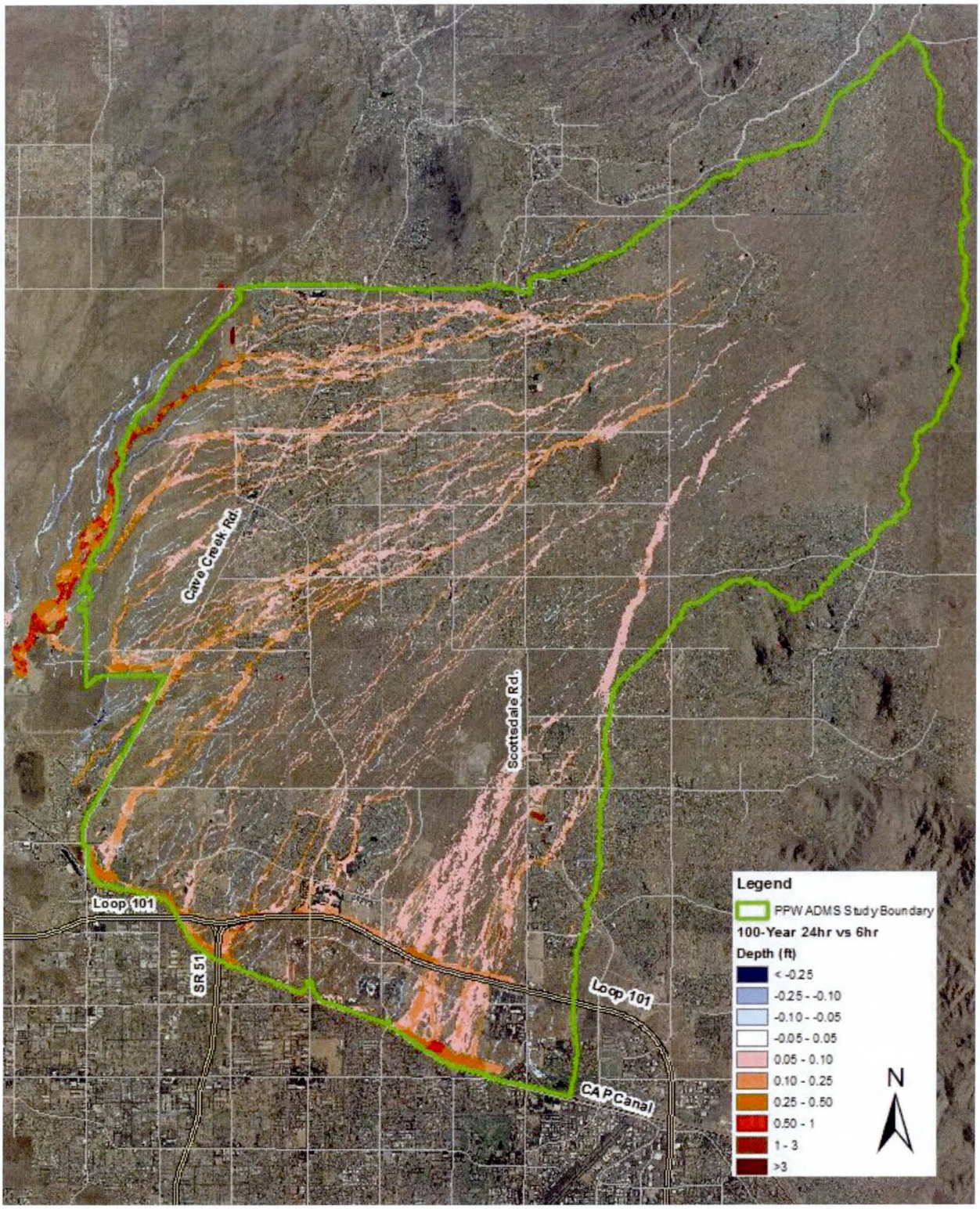


Figure-8 – 100-Year Depth Difference Between the 24-hour and 6-hour Durations

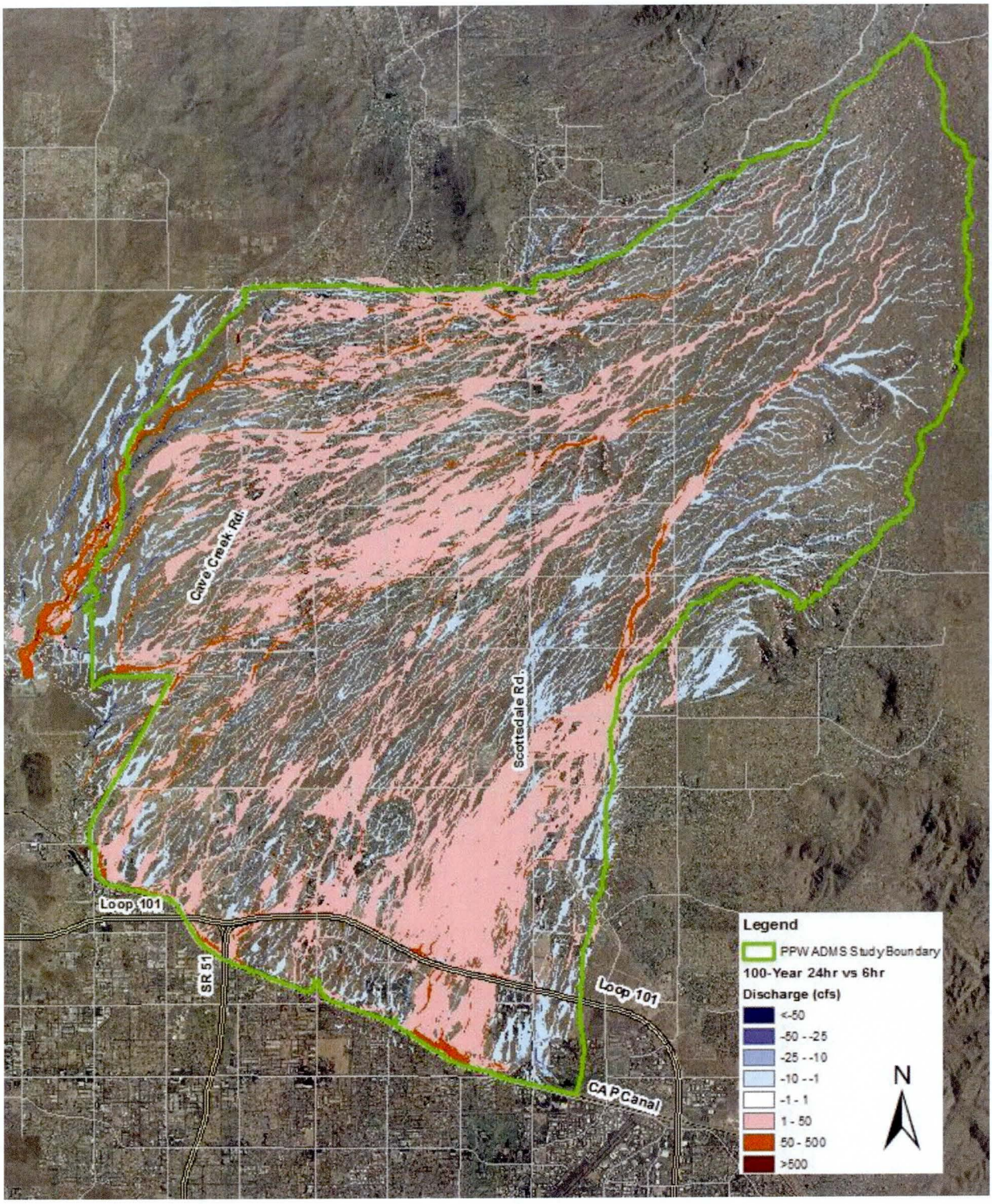


Figure-9 – 100-Year Discharge Difference Between the 24-hour and 6-hour Durations

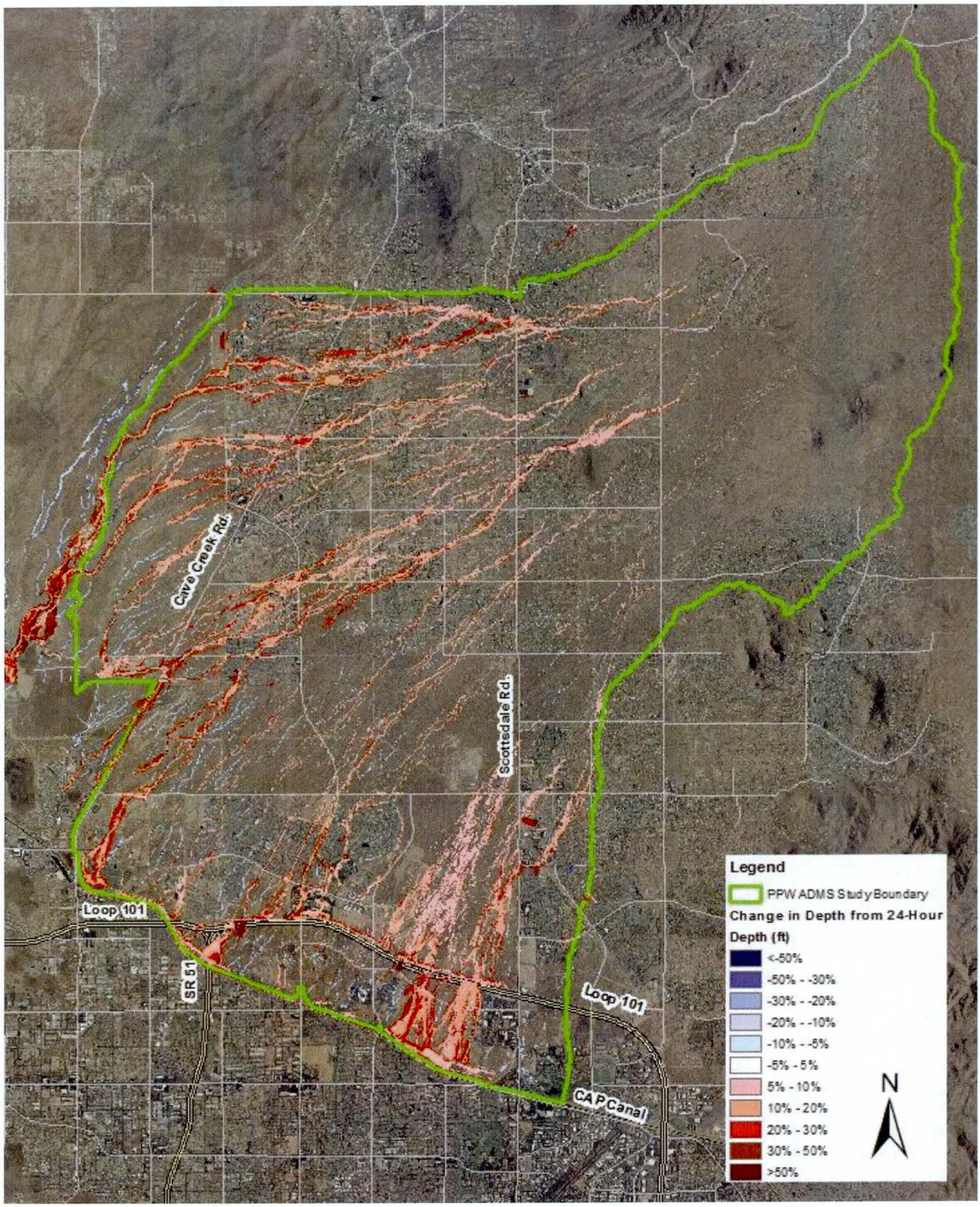


Figure-10 – Percent Change in Depth from the 24-Hour Duration for the 100-year Event (Depth differences less than 0.05-foot were removed)

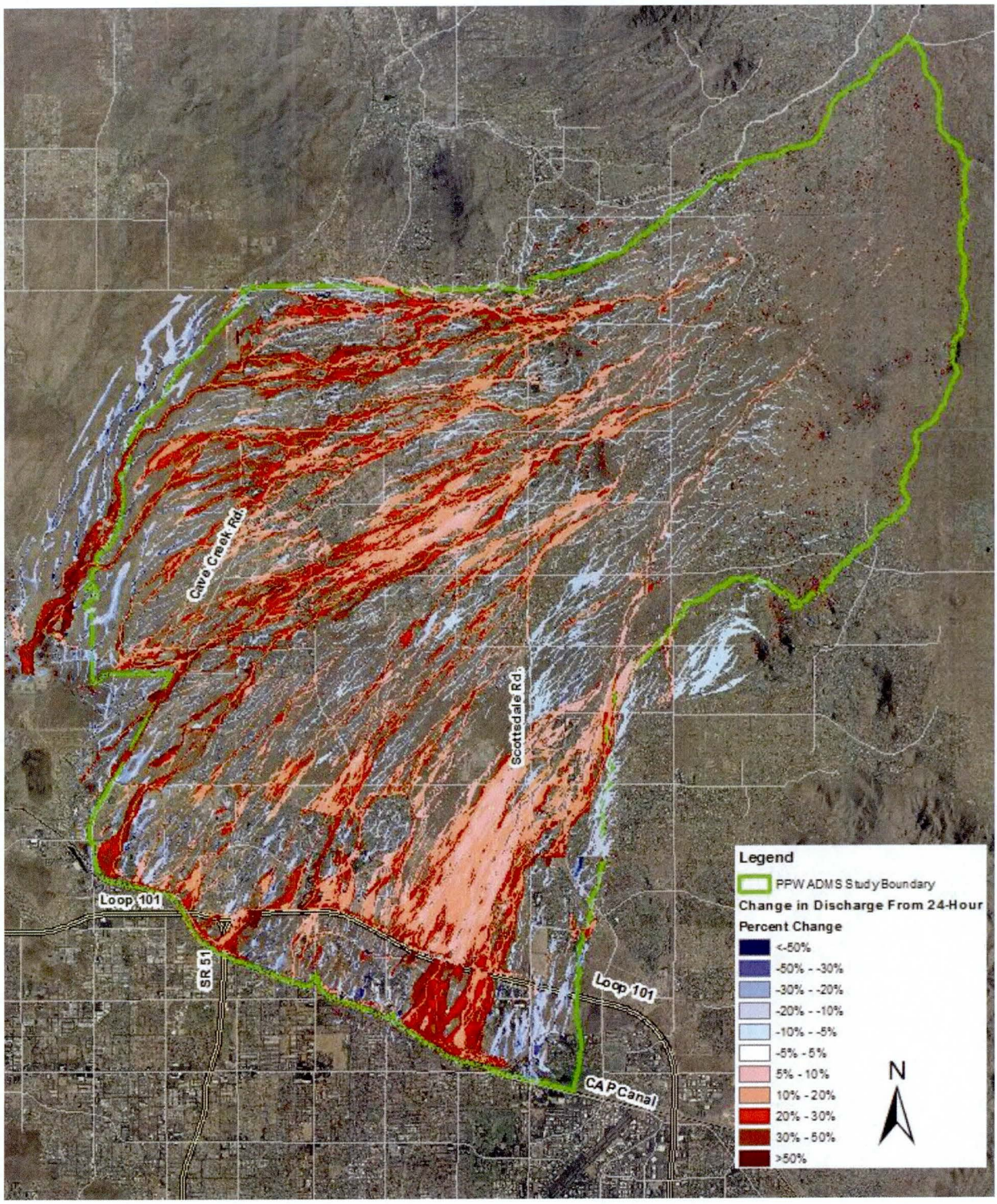


Figure-11 – Percent Change in Discharge From the 24-Hour Duration for the 100-year Event (Discharge differences less than 1.0 cfs were removed)

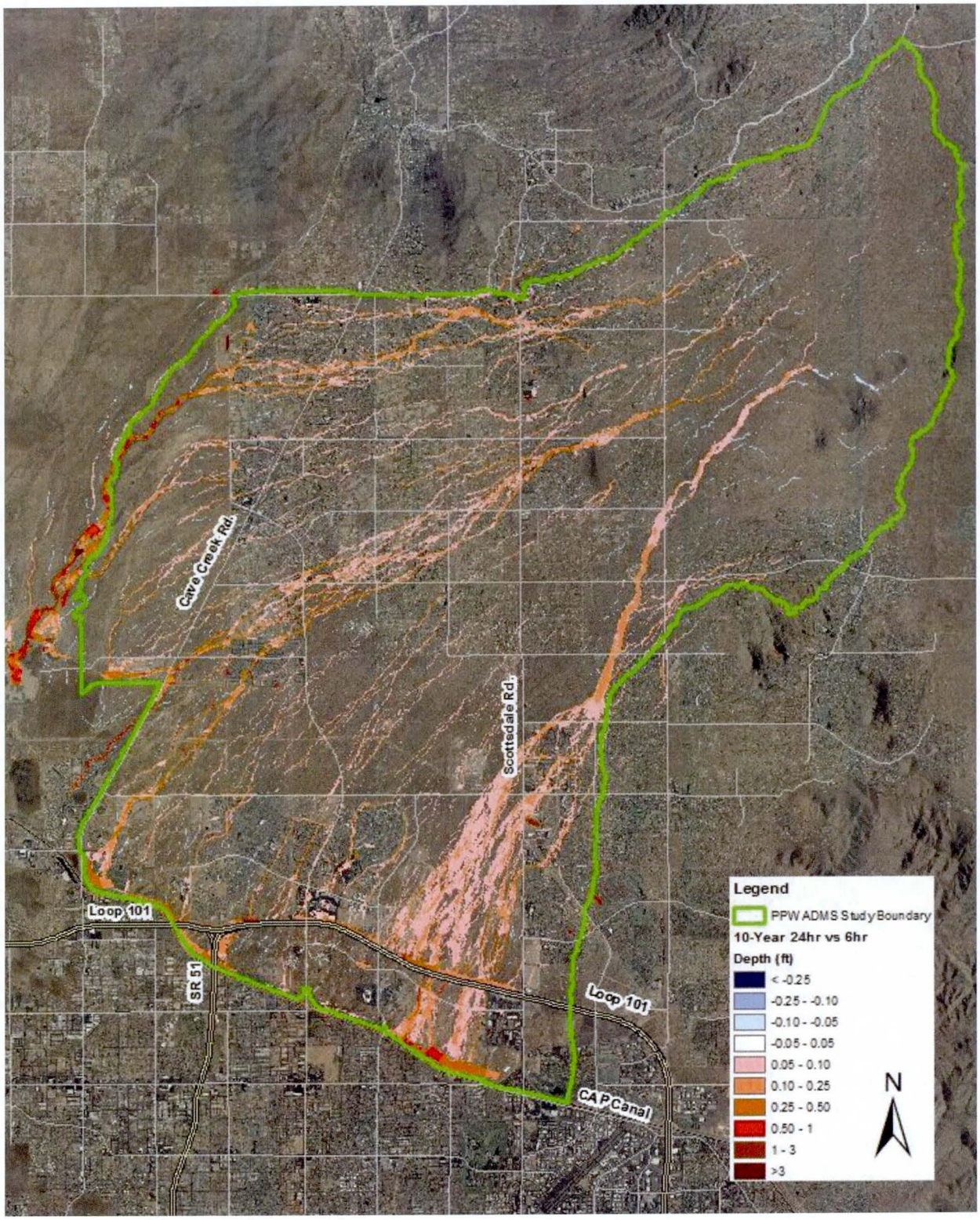


Figure-12 – 10-Year Depth Difference Between the 24-hour and 6-hour Durations

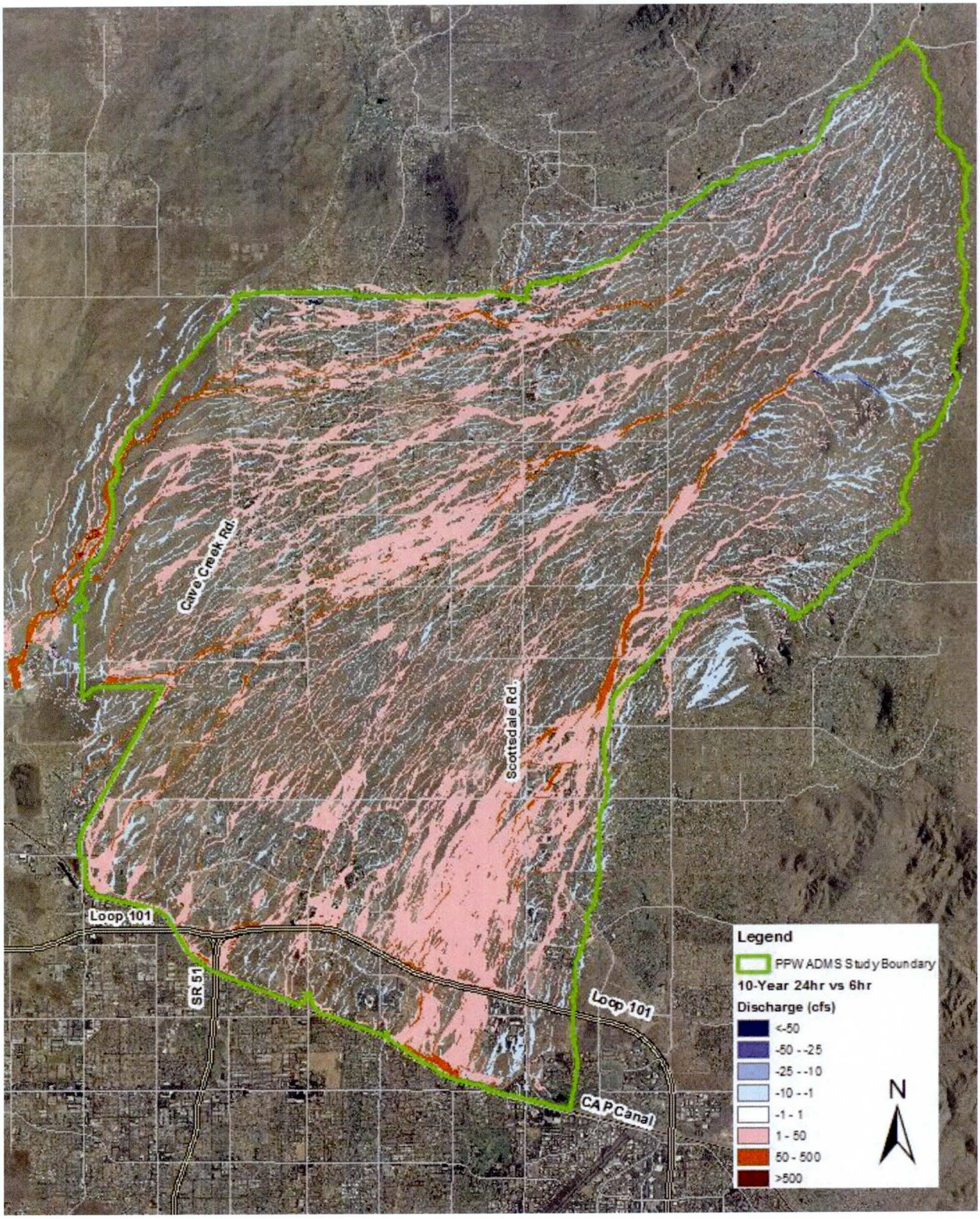


Figure-13 – 10-Year Discharge Difference Between the 24-hour and 6-hour Durations

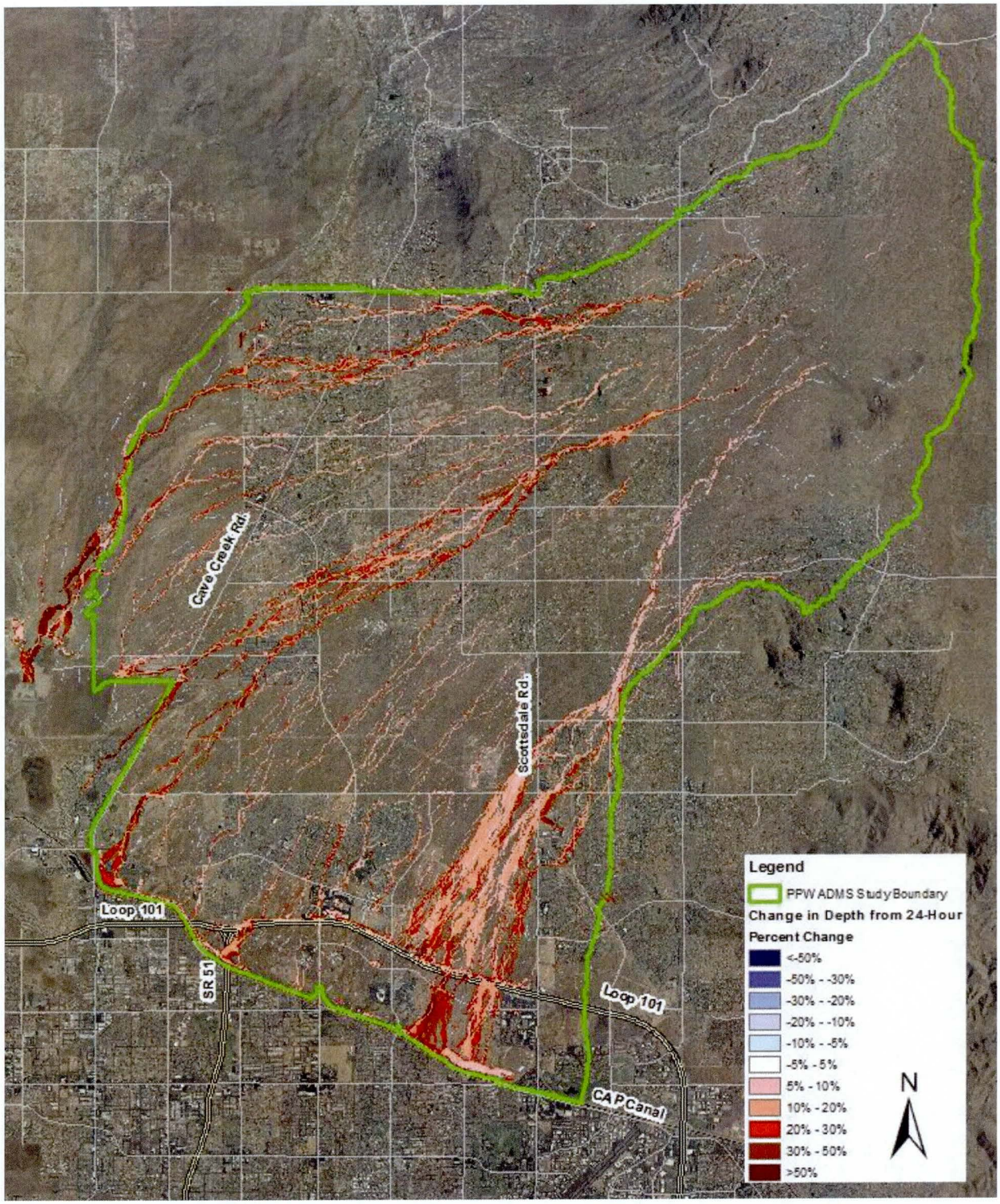


Figure-14 – Percent Change in Depth from the 24-Hour Duration for the 10-year Event (Depth differences less than 0.05-foot were removed)

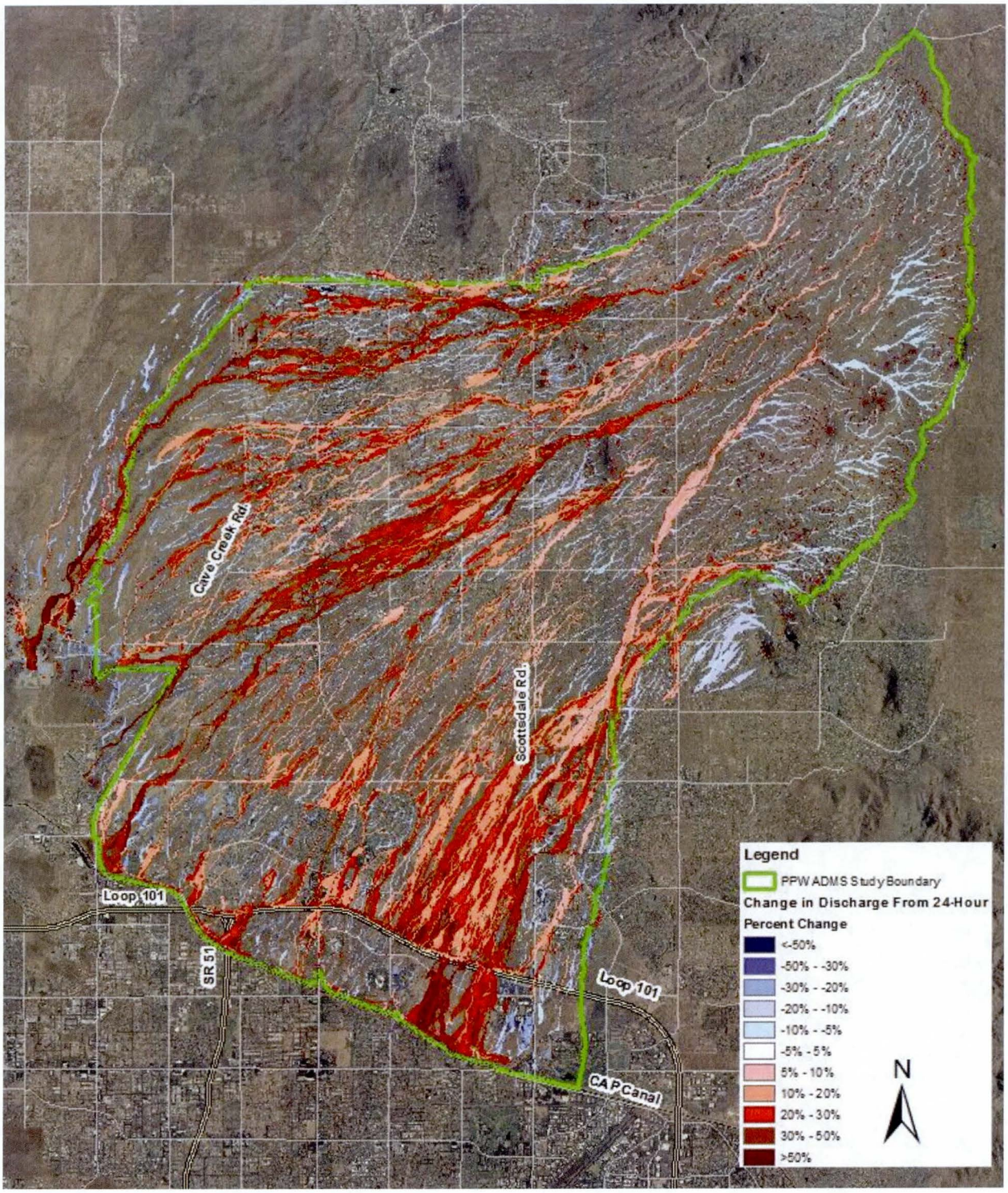


Figure-15 – Percent Change in Depth from the 24-Hour Duration for the 10-year Event (Discharge differences less than 1.0 cfs were removed)

The figures showing the differences between the 6-hour and 24-hour durations indicate that the primary wash corridors through the study area are controlled by the 24-hour duration. The wash corridors that are fed by smaller contributing areas are controlled by the 6-hour duration. However, the areas where the 6-hour controls, the differences between the two durations are relatively small with differences in depths generally less than 0.05-foot and differences in discharge less than 25 cfs.

Table-2 and **Table -3** below summarizes the output of the floodplain cross-section data between the models for the 100-Year and 10-year events respectively.

Table-2 100-Year event Summary

Section ID	100-Year, 6-Hour Results			100-Year, 24-Hour Results				
	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Percent Change in Discharge From the 24-Hour	Percent Change in Volume From the 24-Hour
1	13,175	4.6	1,164	13,760	12.57	2,075	4.3%	43.9%
2	5,697	4.16	323	5,609	12.17	567	-1.6%	43.0%
3	3,225	4.24	208	3,238	12.23	367	0.4%	43.3%
4	10,379	4.29	787	10,705	12.27	1,389	3.0%	43.3%
5	17,148	4.7	1,554	17,868	12.68	2,826	4.0%	45.0%
6	11,238	4.42	927	11,651	12.4	1,643	3.5%	43.6%
7	2,333	4.4	199	2,348	12.39	350	0.6%	43.1%
8	2,348	4.48	219	2,378	12.48	397	1.3%	44.8%
9	4,584	4.54	427	4,688	12.5	773	2.2%	44.8%
10	3,596	4.12	180	3,535	12.12	313	-1.7%	42.5%
11	2,059	4.11	126	2,036	12.1	225	-1.1%	44.0%
12	3,997	4.4	262	3,972	12.38	415	-0.6%	36.9%
13	8,851	5.21	918	9,835	13.12	1,693	10.0%	45.8%
14	5,826	5.02	726	6,081	12.96	1,454	4.2%	50.1%
15	15,889	5.32	2,065	17,944	13.23	3,928	11.5%	47.4%
16	3,618	5.18	505	4,076	13.09	886	11.2%	43.0%
17	2,274	5.22	303	2,495	13.14	606	8.9%	50.0%
18	2,514	4.25	230	2,601	12.21	394	3.3%	41.6%
19	2,231	4.81	286	2,536	12.71	521	12.0%	45.1%
20	2,689	4.36	329	3,067	12.3	584	12.3%	43.7%
21	523	4.75	128	639	12.69	242	18.2%	47.1%

Section ID	100-Year, 6-Hour Results				100-Year, 24-Hour Results				
	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)		Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Percent Change in Discharge From the 24-Hour	Percent Change in Volume From the 24-Hour
22	971	4.66	197		1,044	12.59	380	7.0%	48.2%
23	704	4.3	178		823	13.11	351	14.5%	49.3%
24	756	5.39	174		875	13.16	398	13.6%	56.3%
25	5,920	6.81	1,278		8,495	14.42	3,384	30.3%	62.2%
26	3,814	6.16	811		4,990	13.96	1,680	23.6%	51.7%
27	2,049	4.68	492		2,348	12.73	1,125	12.7%	56.3%
28	1,858	7.04	434		2,321	14.79	1,035	19.9%	58.1%
29	6,627	6.41	1,777		8,985	13.6	3,450	26.2%	48.5%
30	2,289	5.32	377		2,628	13.2	708	12.9%	46.8%

Table-3 10-Year event Summary

Section ID	10-Year, 6-Hour Results				10-Year, 24-Hour Results				
	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)		Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Percent Change in Discharge From the 24-Hour	Percent Change in Volume From the 24-Hour
1	6,952	4.8	667		7,566	12.73	1,184	8.1%	43.7%
2	3,309	4.25	190		3,154	12.23	324	-4.9%	41.4%
3	1,748	4.35	122		1,774	12.33	210	1.5%	41.9%
4	5,479	4.37	459		5,826	12.35	793	6.0%	42.1%
5	9,047	4.96	884		9,986	12.86	1,617	9.4%	45.3%
6	5,962	4.55	539		6,405	12.51	939	6.9%	42.6%
7	1,179	4.61	116		1,265	12.5	198	6.8%	41.4%
8	1,330	4.73	131		1,382	12.67	230	3.8%	43.0%
9	2,428	4.8	249		2,575	12.69	441	5.7%	43.5%
10	2,079	4.18	105		1,956	12.17	178	-6.3%	41.0%
11	1,193	4.18	75		1,173	12.15	130	-1.7%	42.3%
12	2,098	4.59	144		2,336	12.5	227	10.2%	36.6%
13	4,145	5.55	476		5,095	13.41	960	18.6%	50.4%

Section ID	10-Year, 6-Hour Results			10-Year, 24-Hour Results				
	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Discharge (cfs)	Time to Peak (hrs)	Volume (Ac-ft)	Percent Change in Discharge From the 24-Hour	Percent Change in Volume From the 24-Hour
14	3,833	5.28	473	4,235	13.18	891	9.5%	46.9%
15	8,215	5.71	1,135	10,067	13.55	2,264	18.4%	49.9%
16	1,572	4.76	260	2,067	12.73	479	23.9%	45.7%
17	1,173	5.63	167	1,366	13.49	347	14.1%	51.9%
18	1,188	4.3	123	1,343	12.3	212	11.5%	42.0%
19	1,077	4.98	162	1,404	12.99	291	23.3%	44.3%
20	1,222	4.6	184	1,589	12.44	327	23.1%	43.7%
21	275	6.12	71	338	14.01	146	18.6%	51.4%
22	571	4.88	116	655	12.76	236	12.8%	50.8%
23	363	5.78	88	448	13.58	200	19.0%	56.0%
24	447	5.83	99	521	13.74	256	14.2%	61.3%
25	1,868	7.11	423	3,449	15.85	1,744	45.8%	75.7%
26	1,744	6.75	381	2,428	14.5	924	28.2%	58.8%
27	929	4.91	227	1,051	12.81	632	11.6%	64.1%
28	1,028	7.97	197	1,412	15.49	616	27.2%	68.0%
29	3,140	4.73	894	4,298	14.76	1,949	26.9%	54.1%
30	1,228	5.77	209	1,600	13.52	408	23.3%	48.8%

Conclusions

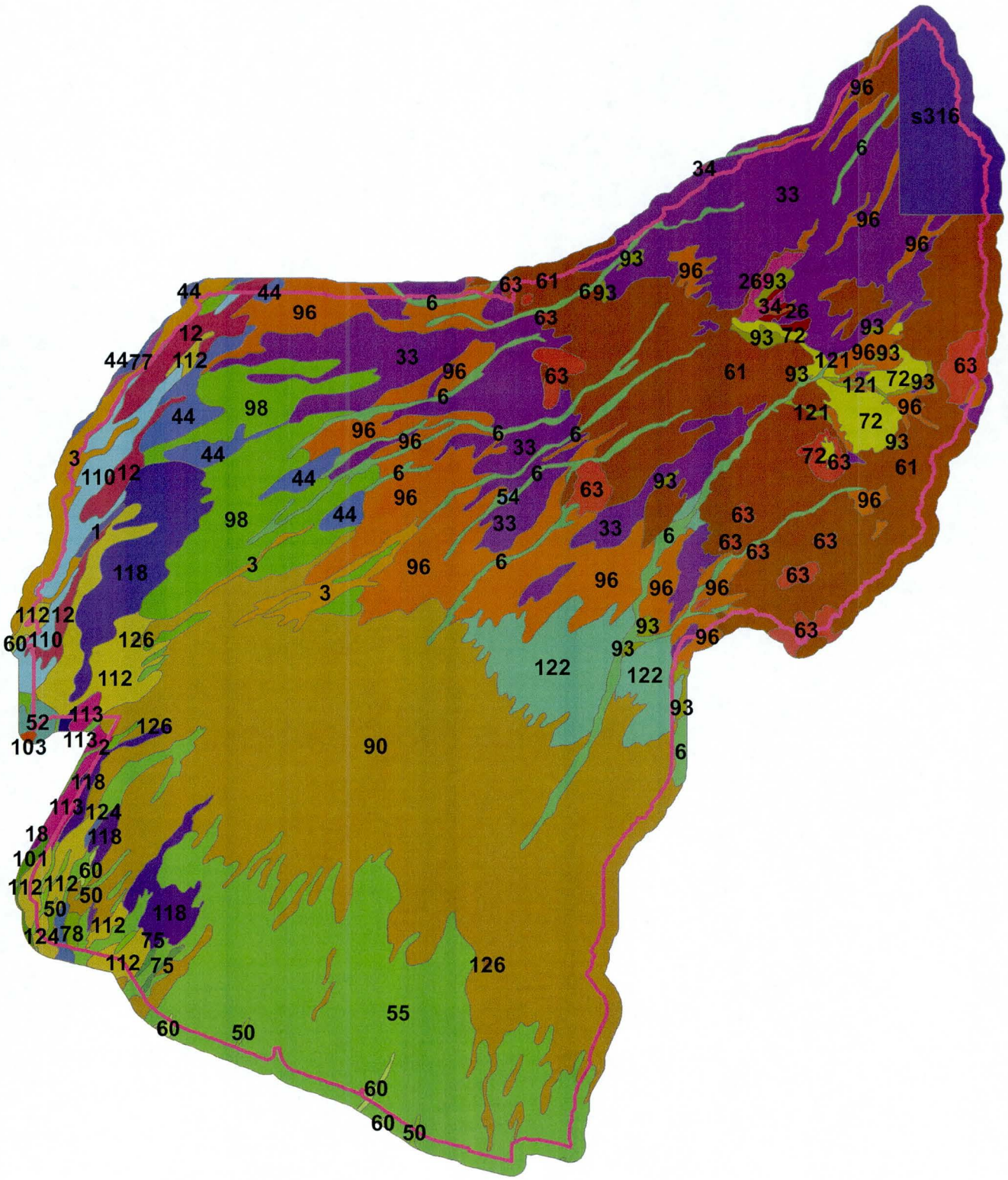
Based upon the results of the model runs, JEF makes the following recommendations.

- The models should be constructed in a way that accurately models the ponded areas; however, outflow nodes should be placed in the ponds to reduce the model runtime. In the event that the ponded areas become of interest and modeling is desired, removing the outflow nodes will be all that is required.

- Since the main wash corridors are clearly controlled by the 24-hour duration and the differences are considered minor where the 6-hour controls, it is not considered necessary to model both durations. Furthermore, the very upstream headwater regions of the model area where the 6-hour controls, are likely not areas of interest in terms of mapping or flood mitigation.

- However, given that the comparison of the 24-, and 6-hour duration was done with a preliminary rough 50-foot grid model, it may be warranted to run a 6-hour duration model again using the higher resolution models for comparison purposes. It is difficult to make a final decision at this point in time. The issue should be reviewed again before final models are developed and submitted.

APPENDIX E: Task 5.2.4.5 - Pinnacle Peak West ADMS Soil Map Units



BK_NMBR	MUSYM	SQ_MI	% area	Potential limiting horizon based on MU description	FCDMC XKSAT
645	1	0.073	0.1%		0.41
645	2	0.068	0.1%		0.41
645	3	1.780	1.7%		0.58
645	6	3.049	2.9%		0.62
645	12	1.284	1.2%	clay at 1"	0.01
645	18	0.013	0.0%	cemented material at 10", bedrock at 18"	0.33
645	21	0.038	0.0%	cemented material at 6"	0.38
645	26	0.110	0.1%	clay at 2"	0.01
645	33	13.524	12.7%	very gravelly clay at 3"	0.23
645	34	0.235	0.2%	very gravelly clay at 3"	0.23
645	44	1.472	1.4%	very gravelly clay at 3"	0.03
645	50	0.192	0.2%		0.26
645	52	0.184	0.2%	bedrock at 7"	0.16
645	54	0.017	0.0%		0.29
645	55	12.927	12.1%		0.27
645	60	0.131	0.1%		0.26
645	61	14.261	13.4%	bedrock at 12"	0.15
645	63	1.735	1.6%	bedrock at 12"	0.14
645	72	1.074	1.0%	bedrock at 20"; clay at 2"	0.09
645	75	0.077	0.1%	clay loam at 7"	0.23
645	76	0.023	0.0%	clay loam at 7"	0.23
645	77	0.061	0.1%	clay loam at 2"	0.05
645	78	0.110	0.1%	clay loam at 6"	0.05
645	90	25.135	23.6%		0.39
645	93	0.557	0.5%		0.33
645	96	10.061	9.5%		0.07
645	98	4.783	4.5%	Tremant component clay loam at 5"	0.37
645	101	0.109	0.1%		0.28
645	103	0.024	0.0%	bedrock at 7"	0.1
645	110	1.232	1.2%	cemented material at 6" (Cipriano) and 9" (Suncity)	0.13
645	112	2.668	2.5%	clay loam at 9"	0.39
645	113	0.421	0.4%	gravelly clay loam at 9"	0.39
645	118	3.025	2.8%	Tremant component clay loam at 9"	0.42
645	121	0.095	0.1%	clay loam at 2"	0.12
645	122	3.015	2.8%		0.33
645	124	0.130	0.1%		0.39
645	126	0.016	0.0%	water	0
GSM	s316	2.699	2.5%	Gran soils weathered bedrock at 12", Lehmans soils unwatered bedrock at 14"	

Memorandum

DATE: June 25, 2012

TO: Theresa Pinto, FCDMC

FROM: Ted Lehman, PE

RE: APPENDIX F: Task 5.2.8 - Pinnacle Peak West ADMS FLO-2D Grid Size Recommendation

The scope of work for Work Assignment 1 asks the Consultant to evaluate and recommend a grid size for the FLO-2D modeling for Pinnacle Peak West ADMS. The grid sizes to be considered should be in multiples of 4 for anticipated potential subdivision of the grid at a later time.

Selection of a grid size should consider several factors including model resolution and model performance. The model resolution needs to be sufficient to capture features in the watershed that significantly affect runoff generation, flow hydraulics, and flow distribution. Model resolution is also key to evaluate flood hazards at specific locations. The resolution of the model should be fine enough to allow key features to be adequately represented within the model input and output.

It is anticipated that to achieve the desired model resolution, the study area will need to be divided into multiple sub-models. For practical reasons, limiting the number of grid cells per sub-model to less than 1,048,576 which is the limit to the number of rows available in Excel 2010. Limiting the number of cells to less than Excel's capacity allows for easier manipulation of FLO-2D input files during model development and troubleshooting. Use of Excel allows for easier grid-wide calculations (say increasing n-values by 10% in the FPLAIN.DAT file) or search and replace functions.

The external model boundary encompasses a total area of about 97.1 square miles. With a 20-ft grid size, this would yield 6,767,482 grid cells. 6,767,482 divided by 1,048,576 equals 6.45 or 7 individual FLO-2D models. A 16-ft grid size, this would give 10,574,190 grid cells or a minimum of 11 FLO-2D models. A 24-ft grid size, results in 4,699,640 grid cells or 5 FLO-2D models. In each case the number of models is a minimum number as the study area may not be easily divided in X equally-sized areas.

A further consideration when selecting the grid size for the Pinnacle Peak West ADMS is the integration with the neighboring Pinnacle Peak South ADMS model. That model uses a 30-foot grid size. In order to facilitate easier, more seamless integration of the two models, it would be helpful if the 30-foot grid could be matched up directly with the Pinnacle Peak

West ADMS grid. Working with numbers divisible by 4 and 30, a 20-foot grid size appears to be the best match. This would allow for a direct mapping of two PPS grids to three PPW grids. Output from the two matching PPS grids could be added and then divided by three and mapped to the three corresponding PPW grids. Other alternatives might be to consider a 15-foot grid size so that each PPS grid could be mapped to two PPW grids. A 15-foot grid size would yield 12,031,078 grids. A 15-ft grid could be broken down evenly into 5-foot cells. However, 5-foot cells would not meet the 4-foot grid size objective noted in the scope of work.

Recommendation

Given the practicalities of model size, resolution, and performance discussed above, we recommend the selection of a 20-foot grid size for the Pinnacle Peak West ADMS FLO-2D models. We believe this offers a balance of number of sub-models, model performance, and model resolution. A 20-foot grid size will accommodate streets and other important hydraulic features in the watershed while yielding excellent resolution output to depict and evaluate flood hazards within the study area.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

DEFINE | COMMUNICATE | SOLVE

Memorandum

DATE: May 24, 2012

TO: Theresa Pinto, FCDMC

FROM: Rob Lyons, PE, CFM; Pat Quinn, PE, RLS, AVS

RE: APPENDIX G: Task 5.2.9.1 - Pinnacle Peak West ADMS FLO-2D External Boundary Recommendations

Introduction

JE Fuller/Hydrology & Geomorphology, Inc (JEF) has reviewed the current Pinnacle Peak West (PPW) ADMS study boundary in conjunction with topography, aerial photographs, and other hydrologic information to determine the extents of FLO-2D model boundaries for the project. This memorandum summarizes our findings and makes recommendations for the final FLO-2D modeling external boundary to be used for the project. The following sections are organized in a counter clockwise direction around the perimeter of the PPW study area starting in the northwest corner of the study area along Cave Creek.

Western Boundary along Cave Creek

The current PPW western boundary coincides generally with the eastern boundary of the Cave Creek effective floodplain, see Figure 1. This seems like an adequate boundary as is.

Western Boundary near Cave Buttes Dam and Flood Pool

The western boundary will then cut through the Cave Buttes Dam along the east side of the flood pool at a north-south alignment. Again, the PPW western boundary seems adequate as is. JEF recently evaluated the flood pool water surface elevations for various frequencies under a previous On-Call Contract with FCDMC. These water surface elevations can be used for boundary conditions. Refer to Figure 2. It is suggested that external boundary then follow the drainage divide along the ridge of the hill between Cave Buttes Dam and Dike #2, then tie into the actual dam crest to the west.

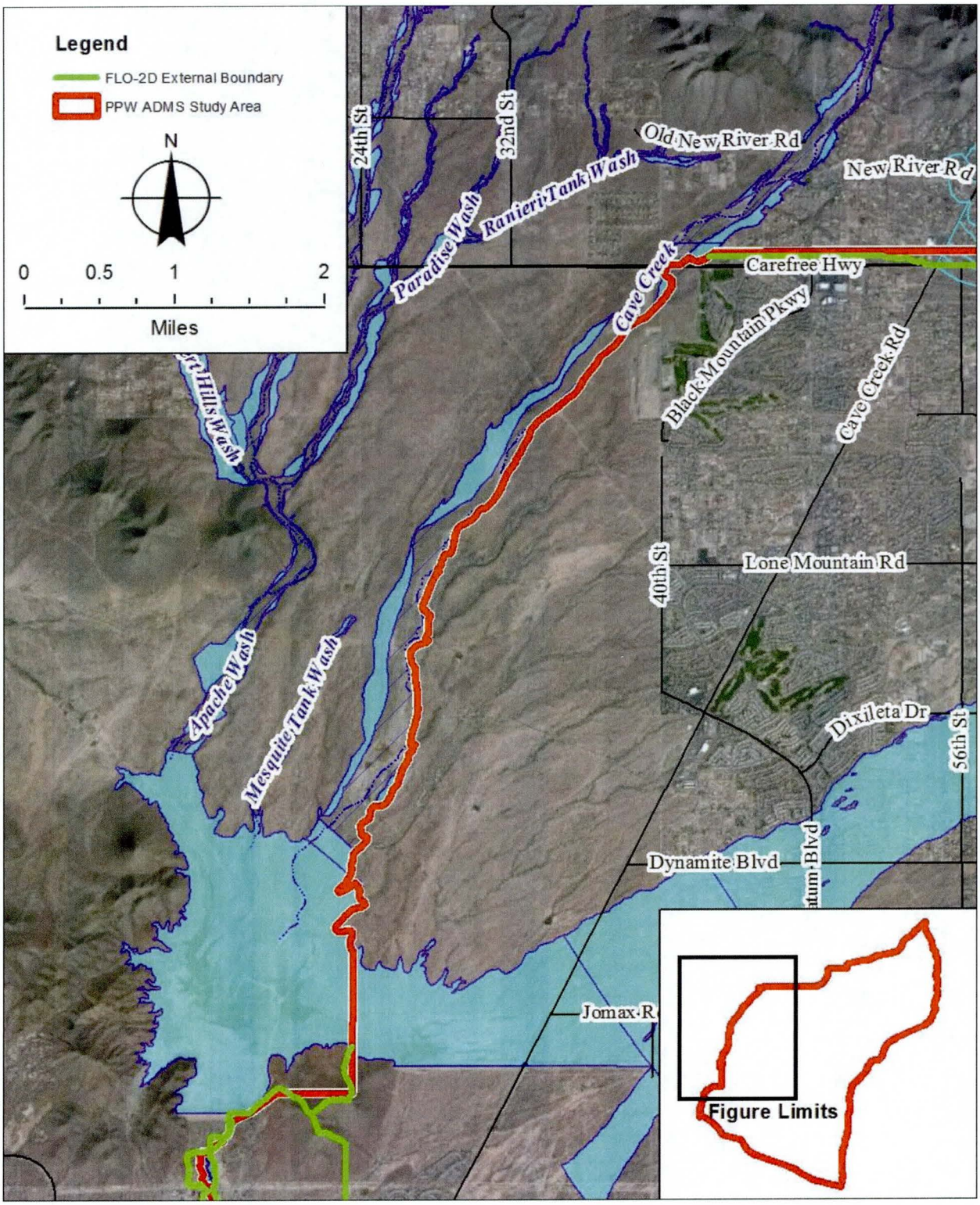


Figure 1. Western Boundary

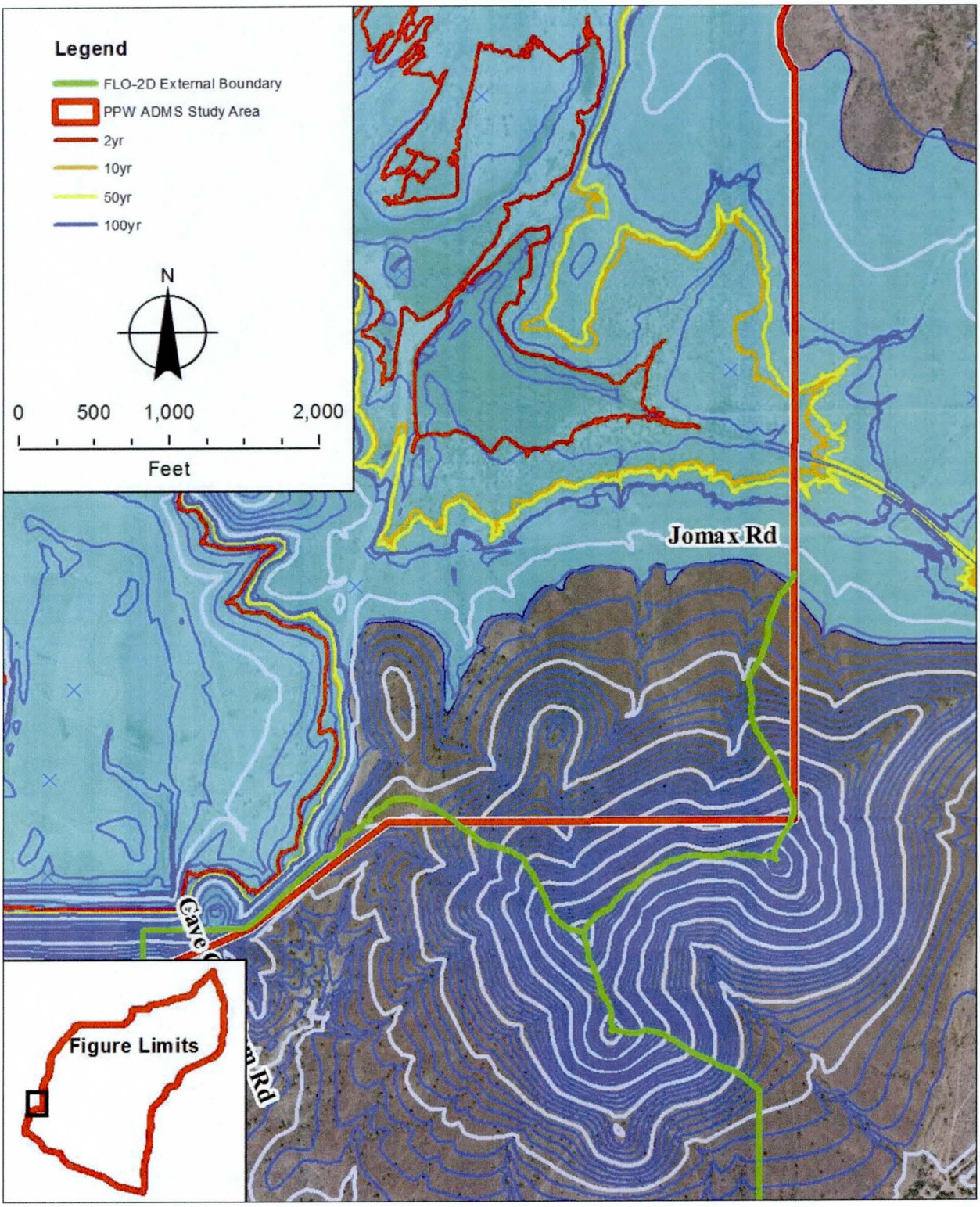


Figure 2. Cave Buttes Dam Flood Pool

Cave Buttes Dam Outfall Floodplain

The western boundary is currently shown along the west floodplain edge of Cave Creek from the Cave Buttes Dam outlet to the CAP. There are two issues with modeling Cave Creek downstream of the Dam.

1. The best topography is from a flight date in 1990. It appears some grading has occurred in overbanks and possibly within the Cave Creek channel in comparing the 1990 topography with the current aerial photography.

2. Accurately developing the Cave Creek hydraulics in the FLO-2D model will take a non-trivial amount of effort. The relatively one-dimensional nature of this reach of Cave Creek may be better suited for an independent HEC-RAS model. An alternative external model boundary is shown in Figure 3.

The southwestern corner of the PPW study area covers a few subdivisions north of the CAP that have been developed after at least 1992/1993 (see aerial photo comparison in Figure 4). Therefore, the 1990 topography is out of date and would not be applicable to this area. The orange topography shown along the eastern edge of the subdivision in Figure 3 is the 2010 PPW ADMS mapping (1311). Note the western limits of this mapping. The third green line represents another possible external boundary at the new mapping edge. Other boundaries could also be considered such as the Cave Creek Road alignment north to Cave Buttes Dam Dike #2 (not shown).

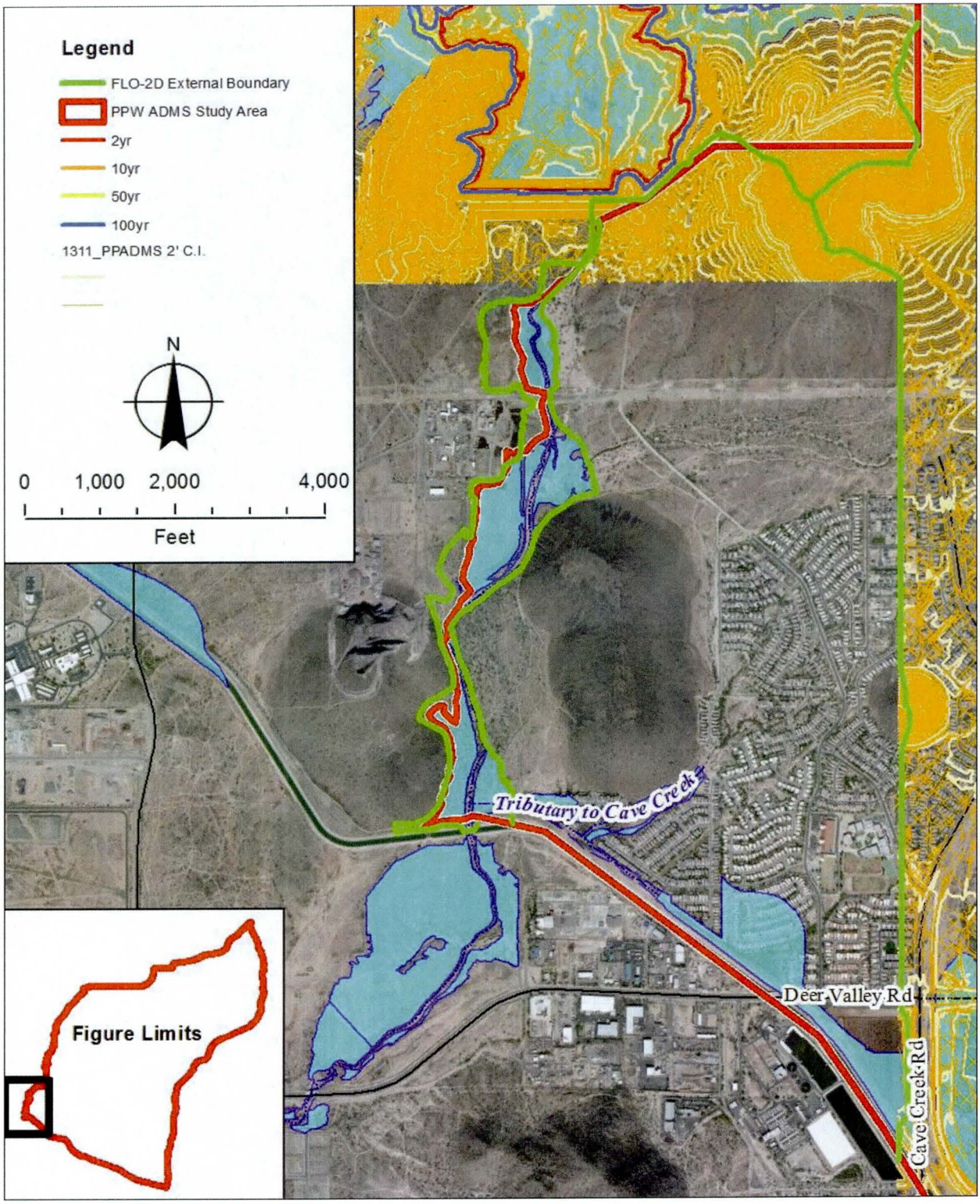


Figure 3. Cave Buttes Dam Outfall Floodplain

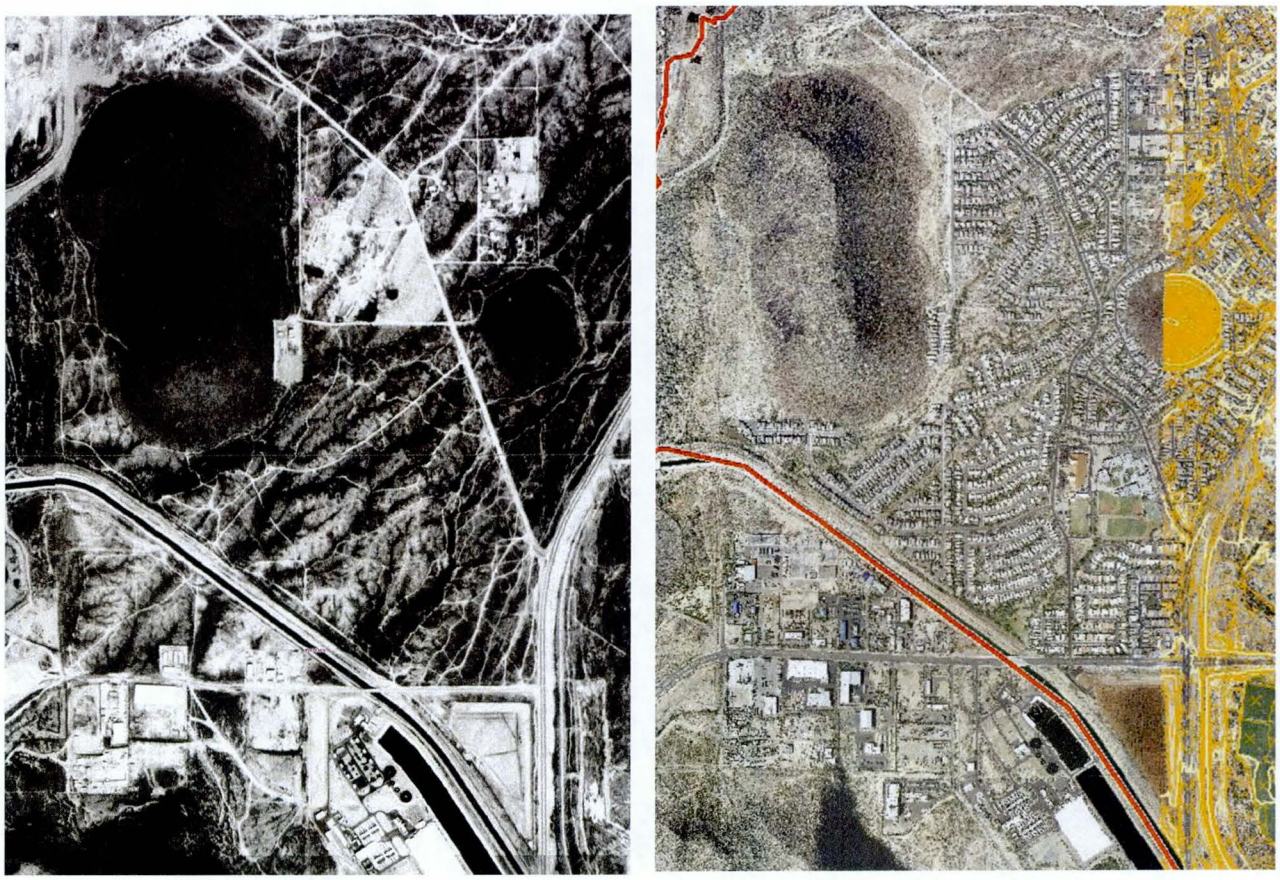


Figure 4. 1992/1993 to 2011 Aerial Photo Comparison

Reach 11 Dikes (CAP)

The southern boundary is currently shown predominantly along south embankment of the CAP Canal. We recommend placing the FLO-2D boundary along the crest of the Reach 11 dikes along the north side of the CAP as shown in Figure 5 and 6. Recent studies conducted by the USBR have found that the Reach 11 dikes contain flood events in excess of the 1000-year storm. However, there are four outlets along the dikes that directly discharge into the canal. These boundary conditions should be considered for modeling within the flood pool. Another alternative (not shown) is to remove the impoundment areas (flood pools) all together from the FLO-2D models, however, this will require further discussion with the project team.

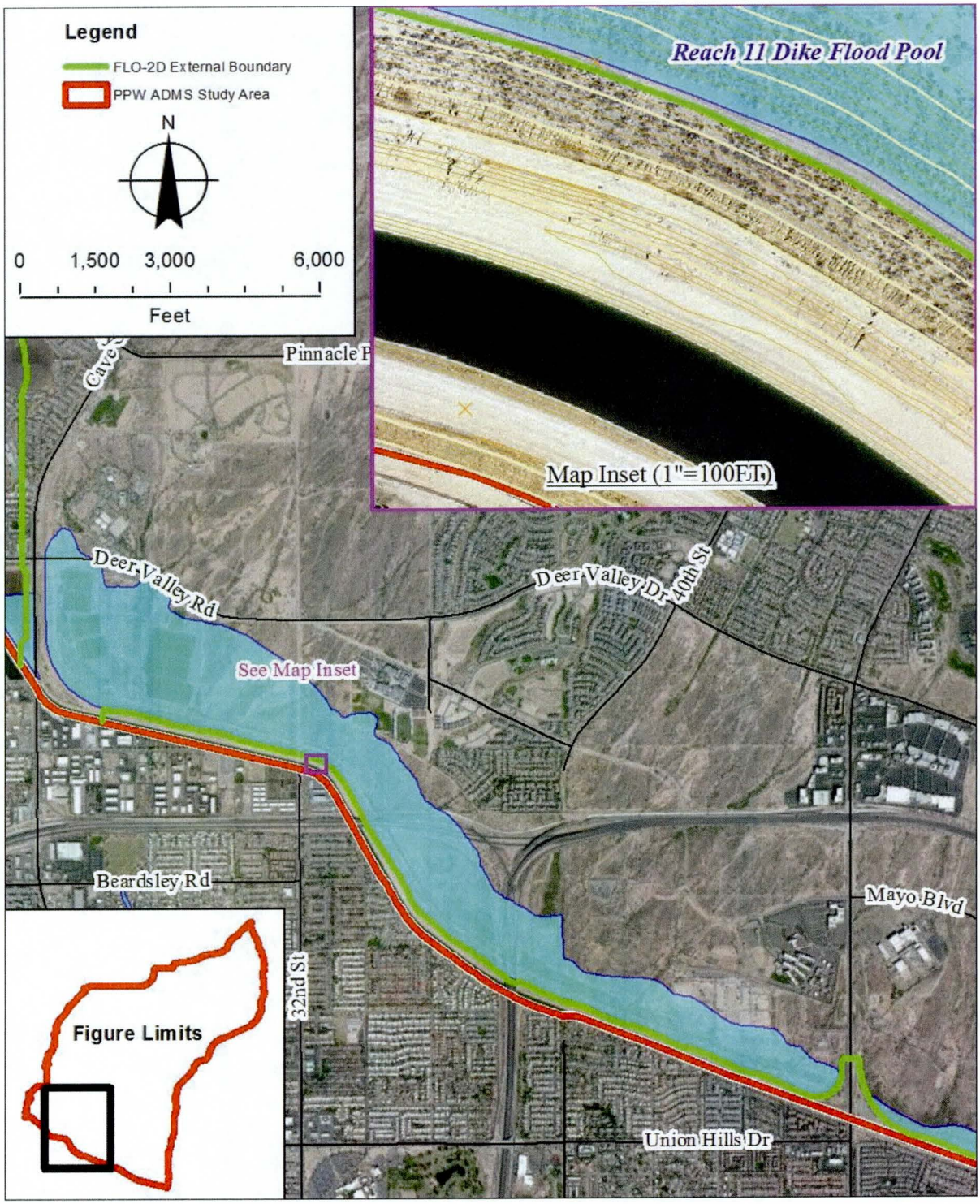


Figure 5. Reach 11 Dike-West Section

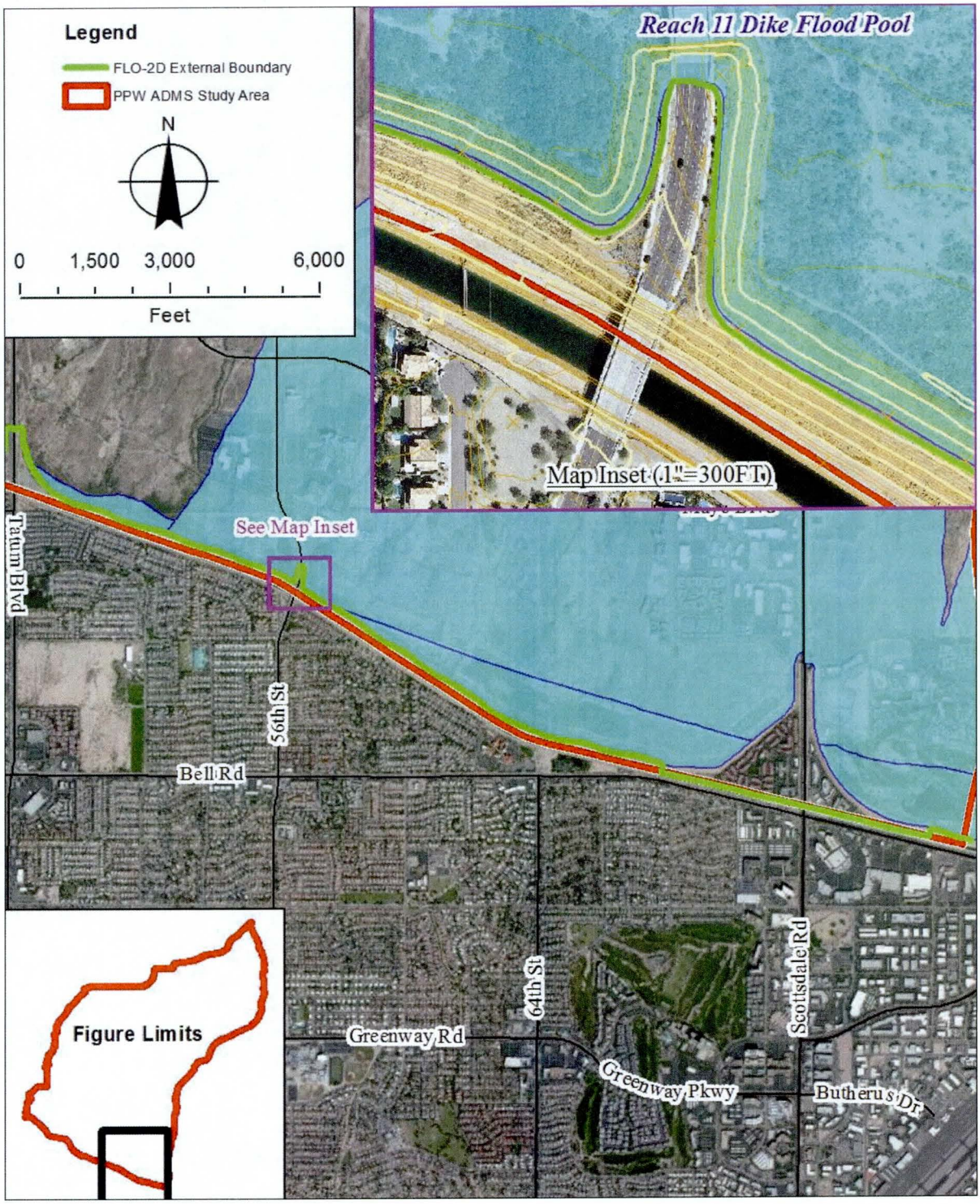


Figure 6. Reach 11 Dike-East Section

Southeast Section along Pinnacle Peak South ADMS

The southeastern boundary overlaps the Pinnacle Peak South (PPS) ADMS boundary, see Figure 7. The interface between these two model boundaries was discussed in great detail during the June 12, 2012 meeting with the District including the PPS project manager. The outcome of the meeting was a PPW FLO-2D external boundary that met the objectives of both studies. The external boundary in this location is illustrated in Appendix H.

East Section along Troon North and Northern limits of Pinnacle Peak South ADMS

Approximate two square miles of additional watershed drain to the PPW study area north of the PPS study area boundary, see Figure 8. This watershed encompasses Troon North (Golf Course Subdivision north of Dynamite Blvd). Furthermore, a portion of the PPS ADMS area drains through this area. Further discussion and consideration is warranted for the interface of these two models. There are 'sliver' gaps in the recent 2007 topographic mapping (1309) along the extreme eastern boundary. However, there is comprehensive topography from 1993 (1071) that will accomplish grid element assignment for this upper watershed boundary.

Eastern Watershed Boundary

The eastern watershed boundary was refined using the 2007 topography (1309 and 1310) in combination with the 1993 mapping in 'sliver' gaps as discussed above. Refer to Figure 9.

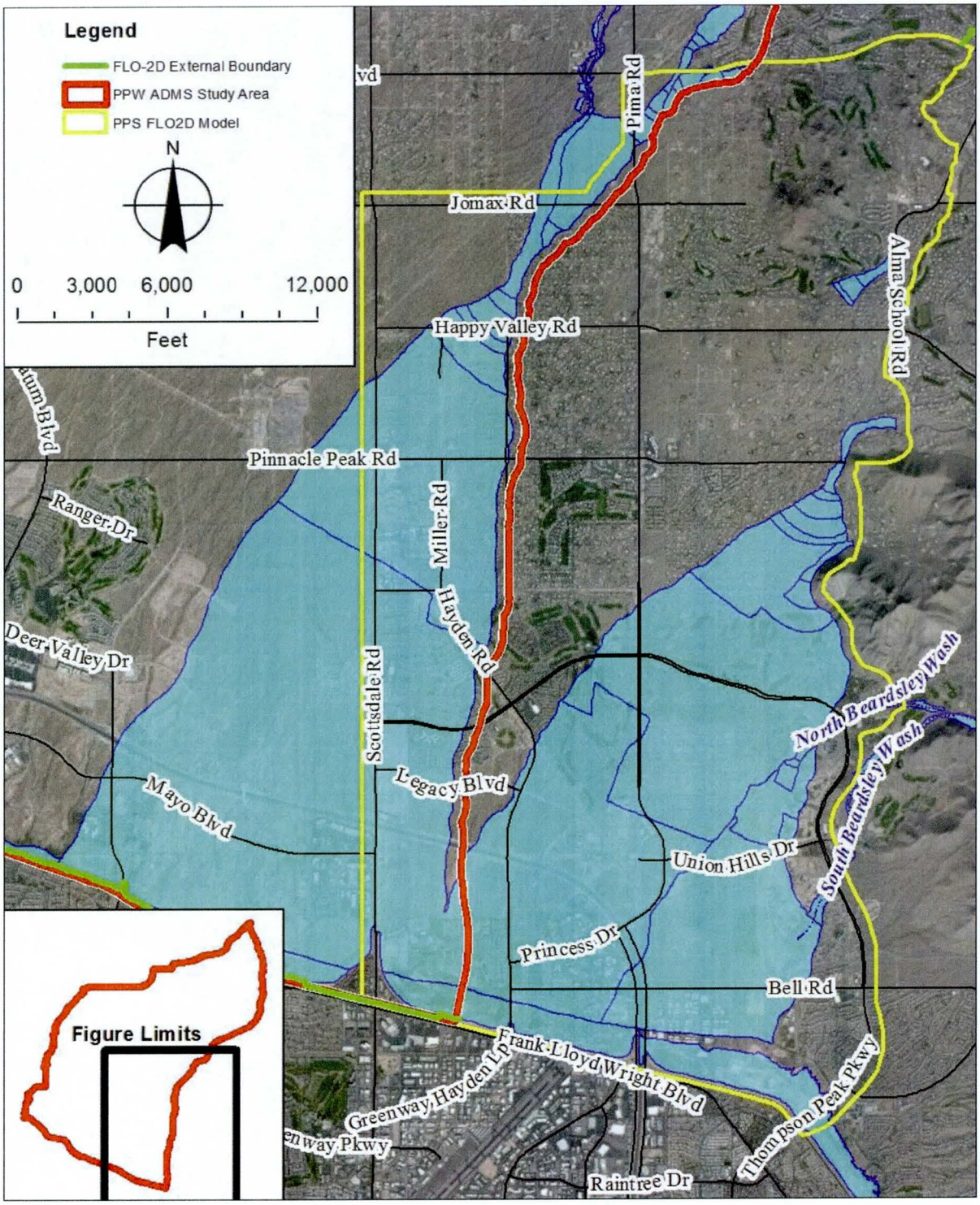


Figure 7. PPS ADMS/P FLO-2D overlap with PPW ADMS

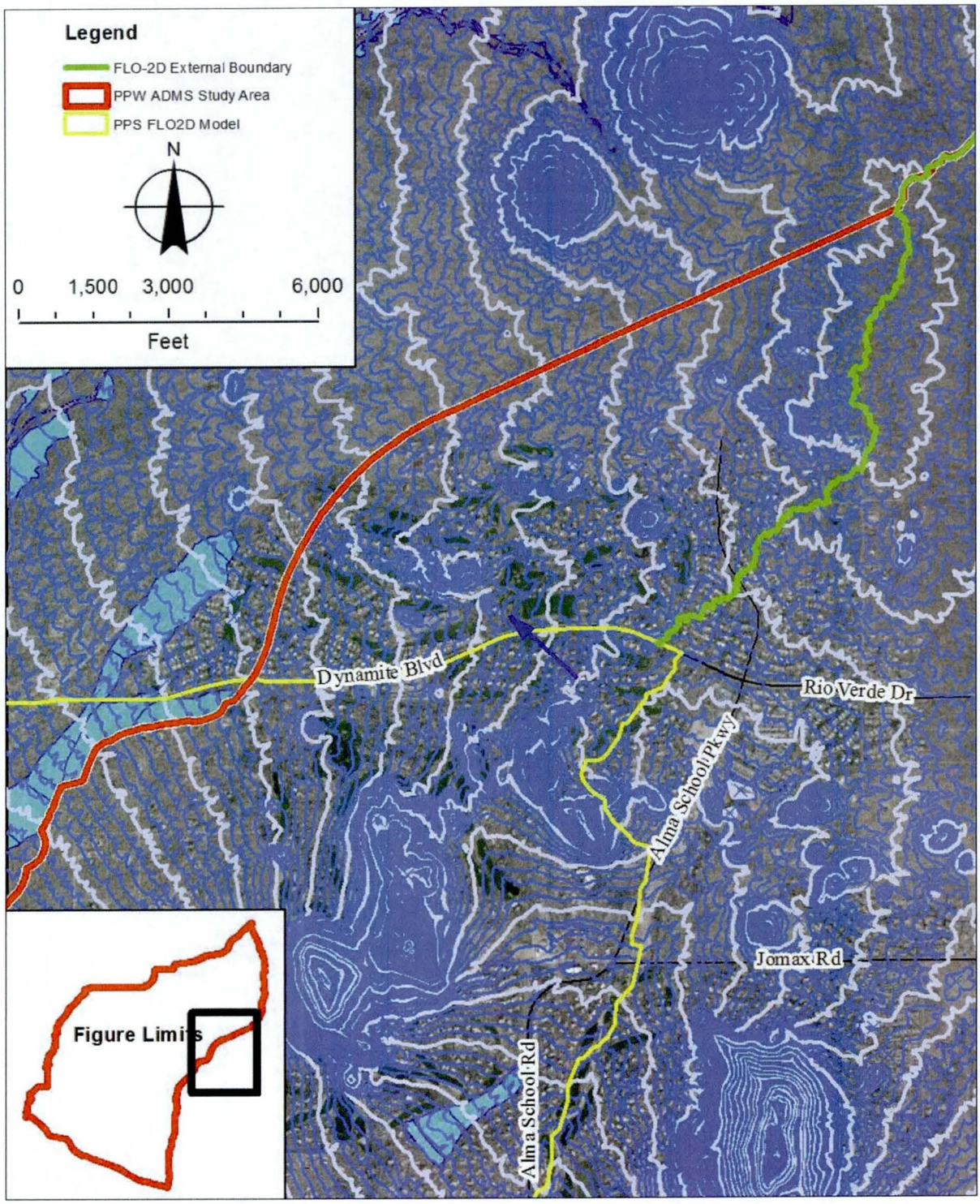


Figure 8. Troon North Subdivision north of the PPS ADMS

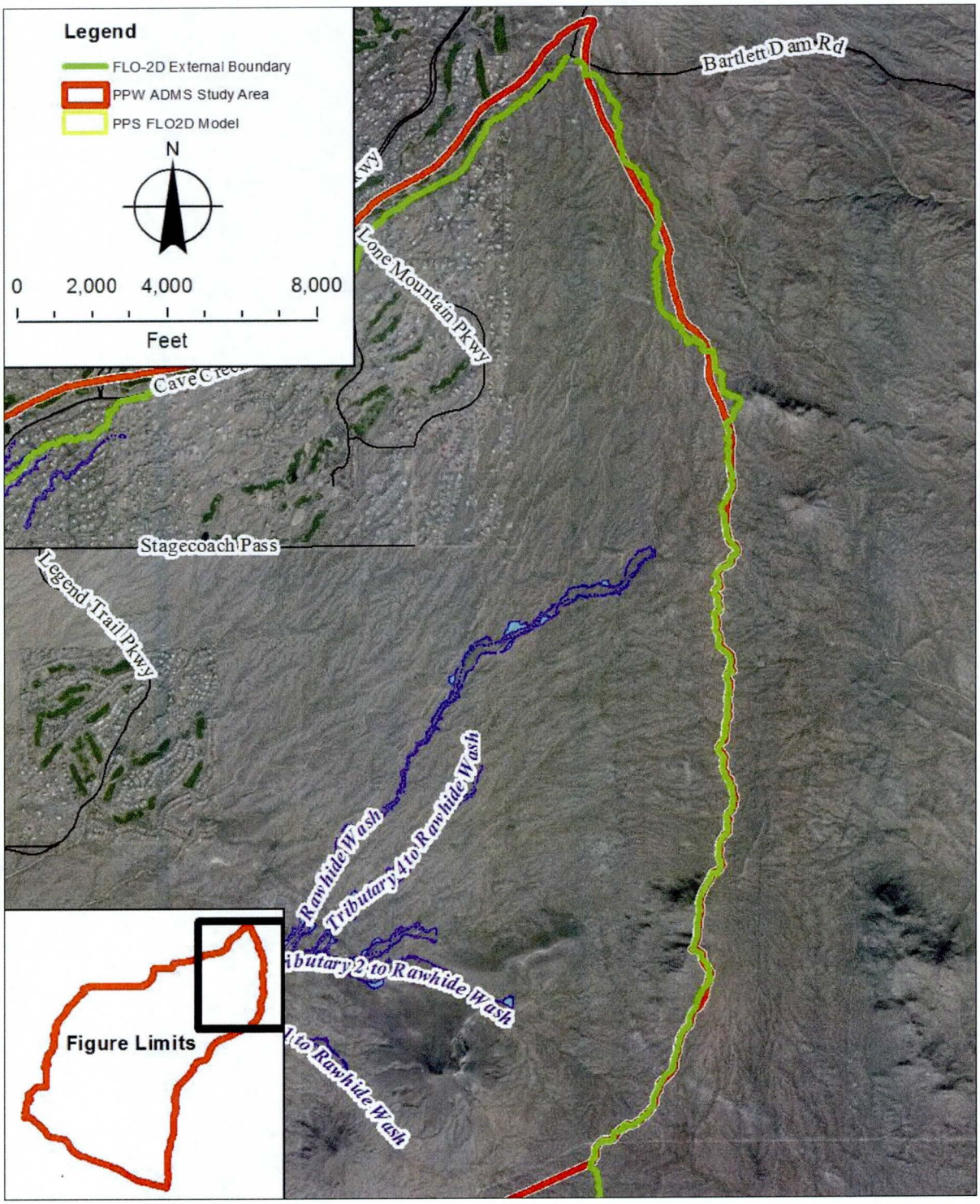


Figure 9. Eastern Watershed Boundary Refinement

Northern Watershed Boundary-East

The northern watershed boundary along the east side of the PPW study area is along Cave Creek Road from Bartlett Dam Road to Mirabel Club Drive. The current PPW study boundary appears to be a 500-foot offset from the Cave Creek Road alignment. However, this area does not drain into the PPW study area and a reduction in model area could be realized by holding the boundary to Cave Creek Road. This area is another area with a 'sliver' gap in the 2007 mapping (1310) as shown in Figure 10. However, we believe the divide is valid and will be field verified.

Unnamed Central Tributary to Cave Creek Upper Watershed

The next segment to the west along the northern PPW study area is along the south watershed boundary of the Unnamed Central Tributary to Cave Creek Upper Watershed. This study was conducted for the Carefree DMP and was subsequently analyzed for the Carefree DMP Update in 2005. The upper watershed is fairly well defined, therefore, it is recommended that the PPW boundary follow the divide (using the latest mapping) as shown in Figure 11.

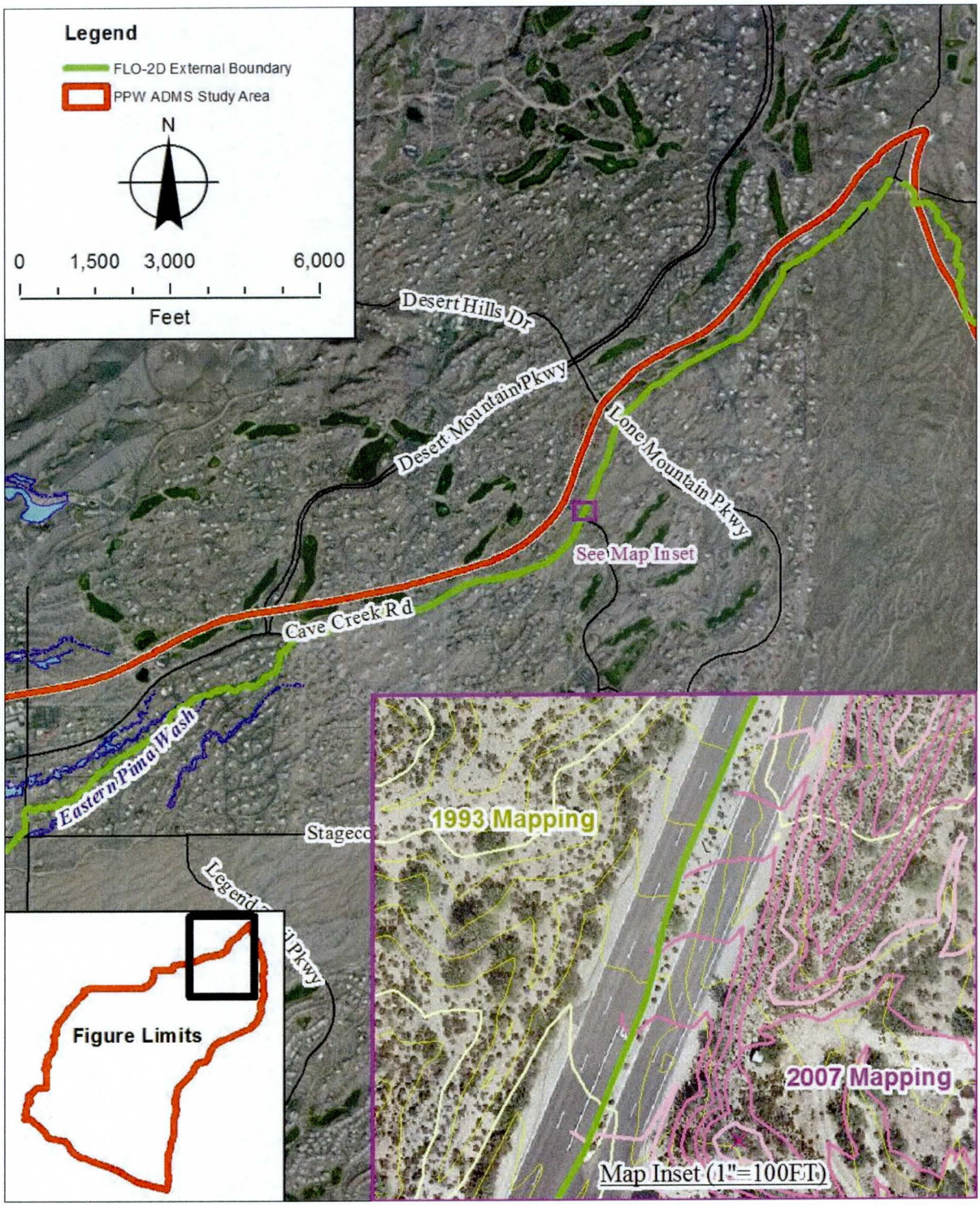


Figure 9. Northern Boundary Along Cave Creek Road

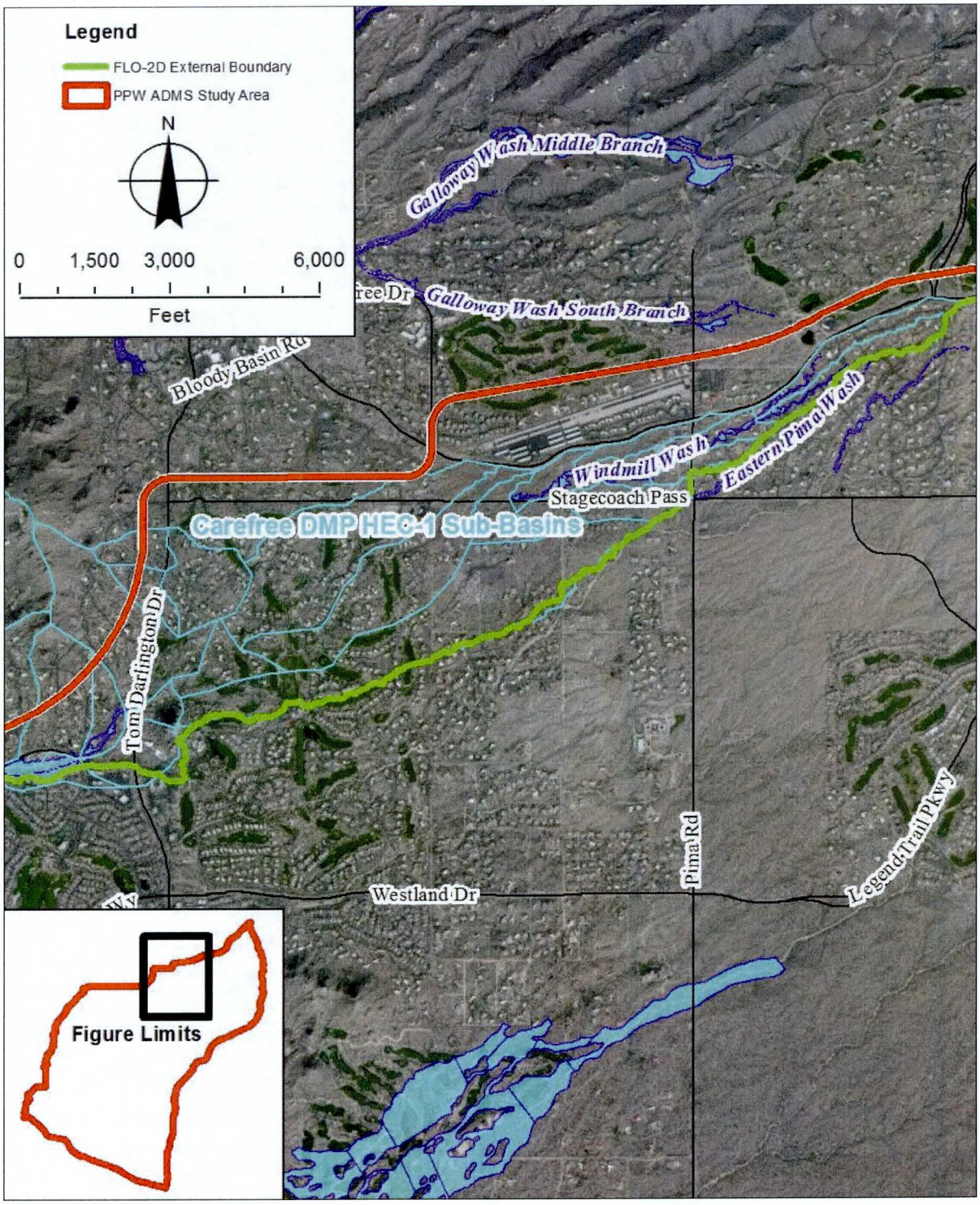


Figure 10. Unnamed Central Tributary to Cave Creek Upper Watershed

Carefree DMP FLO-2D for Unnamed Central Tributary to Cave Creek

The northern boundary should coincide with the south FLO-2D model developed for the Unnamed Central Tributary to Cave Creek (Carefree DMP Update). The outflows from the Carefree DMP Update FLO-2D model will then be input for the PPW FLO-2D models. This will require ensuring the HEC-1 input model as well as the Carefree FLO-2D model are run with the correct rainfall (NOAA14) and with the desired frequencies and durations. See Figure 11.

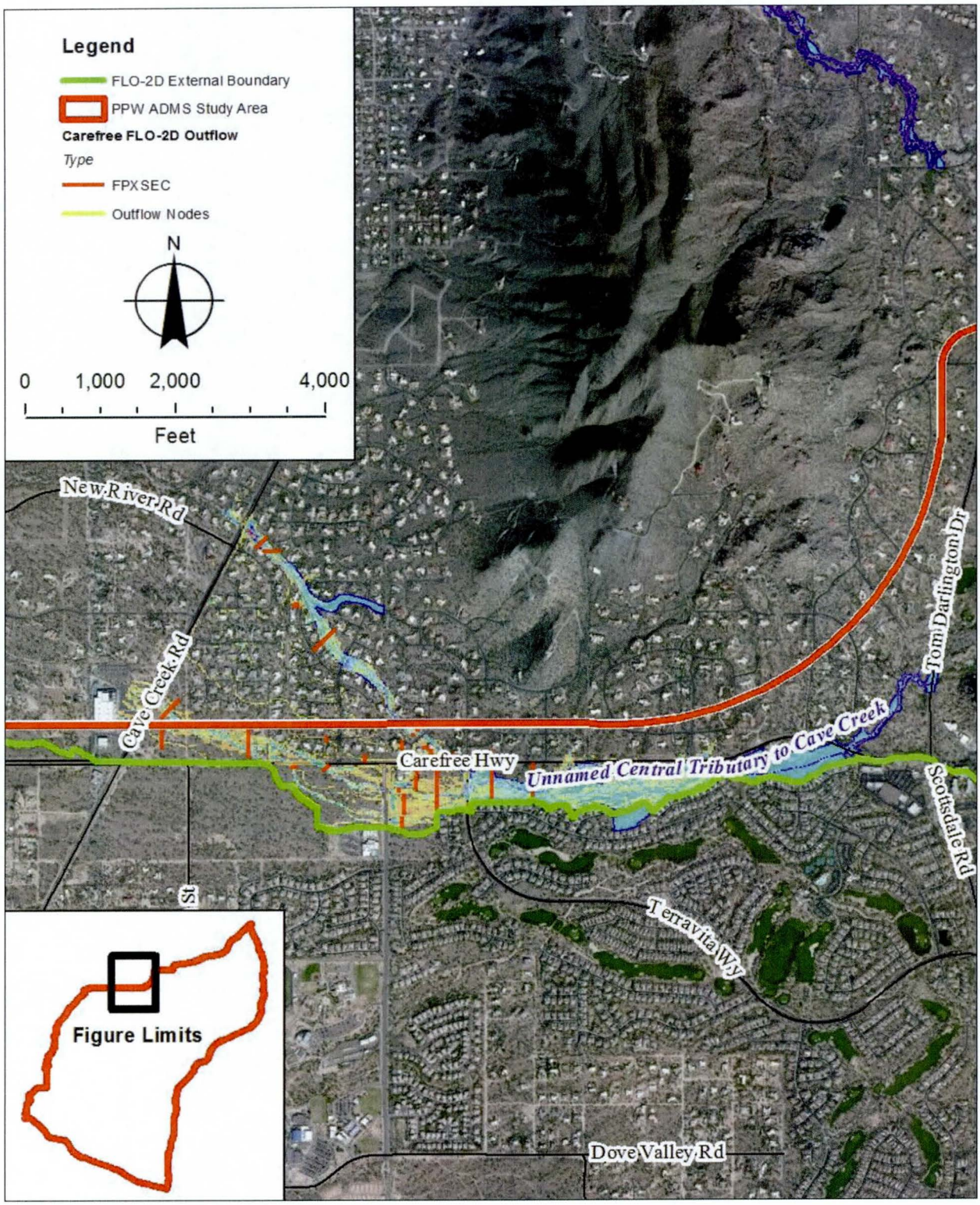


Figure 11. Carefree DMP FLO-2D Model at North Edge of PPW Study Area

Northern Watershed Boundary-West

The northern PPW boundary is located along just north of the northern edge of the 2010 topographic mapping (1311) from approximately Cave Creek Road all the way west to Cave Creek, immediately north of the Carefree Highway. It is suggested that this line be shifted within the mapping limits as shown in Figure 12.

General External Boundary Discussion

Given the size of the PPW study area, it is recommended that careful consideration be made to the external FLO-2D model limits. Typically, FLO-2D model limits are set based on a buffer from the physical watershed ridge thus allowing the FLO-2D model to determine contributing watershed based on assigned grid element elevations. The current PPW study area is nearly 100 square miles. Adding an arbitrary 500 foot buffer adds an additional 4.5 square miles. It is recommended that for this study, the external boundary be set to the actual watershed limits to reduce the number of internal models and/or the number of grid elements thus minimizing model run times.

Field Verification Items

Some field verification will be required prior to a final determination of the external FLO-2D model boundary. Some of the verification items are highlighted below.

- Investigate if cross drainage structures exist anywhere at intersection of Carefree Hwy/Scottsdale Rd (Tom Darlington).
- Investigate if cross drainage structures exist anywhere at intersection of Cave Creek Road/Bartlett Dam Road.
- Verify no cross drainage structures on Cave Creek Road from Bartlett Dam Road to Mirabel Club Drive.

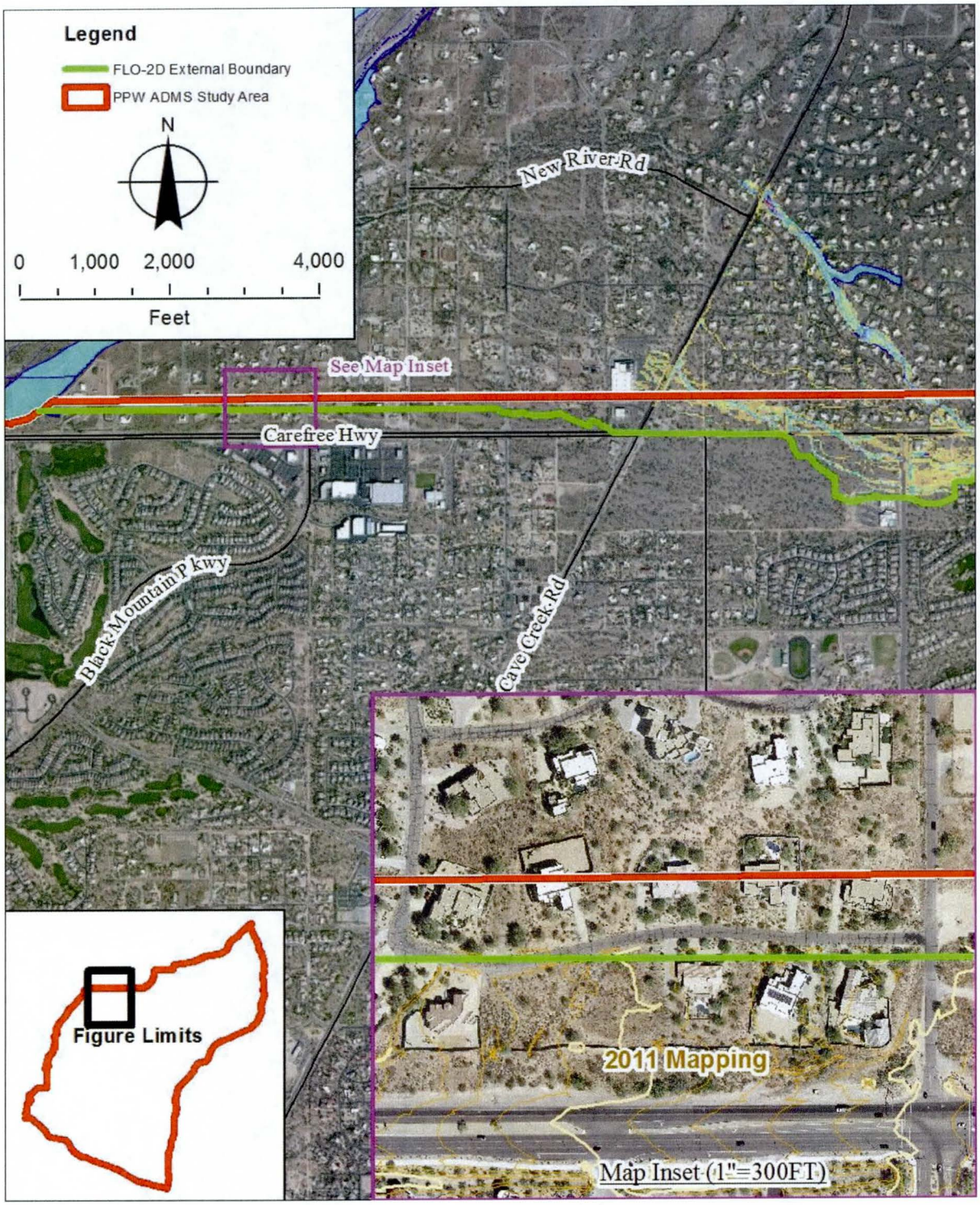
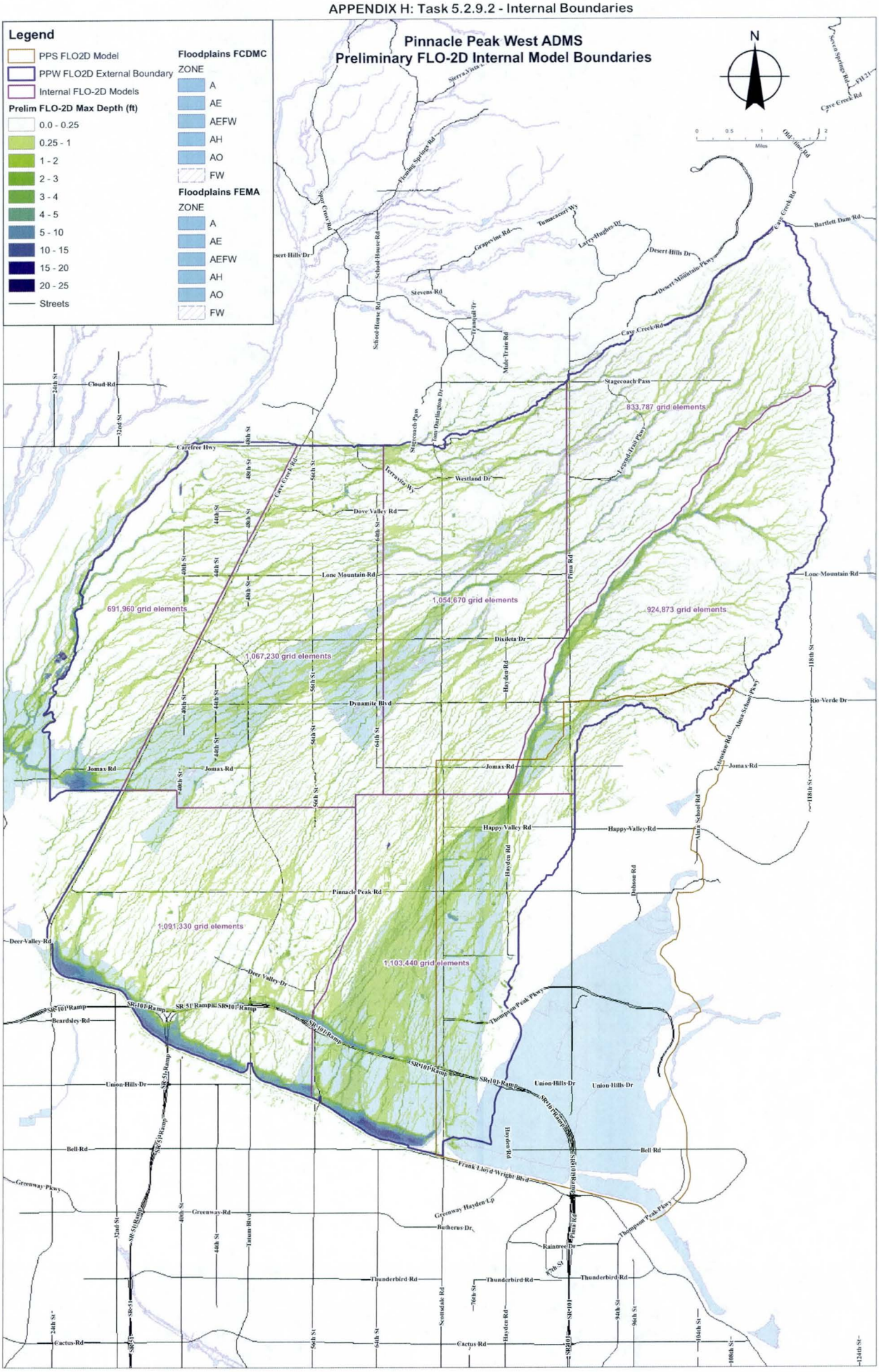


Figure 12. Northern Boundary north of Carefree Highway

APPENDIX H: Task 5.2.9.2 - Internal Boundaries



APPENDIX I: Task 5.2.9.3 – Model Integration

5.2.9.3 Model Integration – Alejandro Riano/ Rob Lyons

Decision – The team decided that a one grid element overlap will be used for Model Integration using outflow nodes (OUTNQ.OUT). This approach was named Approach C in the handout JEF distributed at the meeting, also shown in the Figure 1 below.

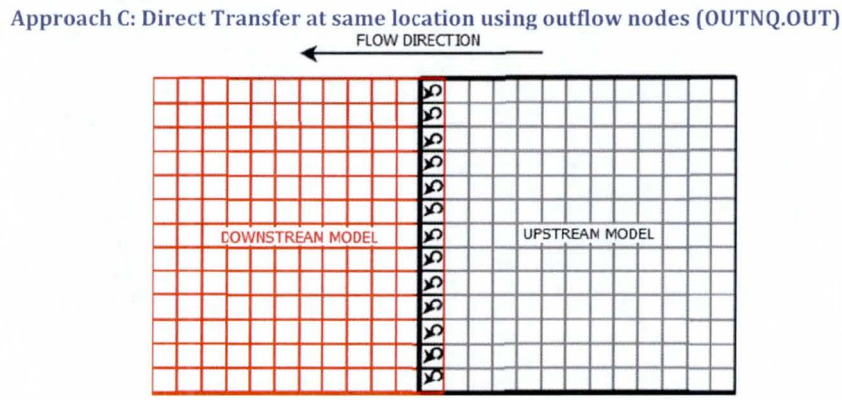


Figure 1. Approach C

Discussion – Alejandro started the discussion by provided a demonstration of issues the District has run into regarding flow transfer from one FLO-2D model to another. The District has been using the floodplain cross section input file (FPXSEC.DAT) on individual grid elements to extract flow hydrographs in upstream models (HYCROSS.OUT) and then transfer to the downstream model. The District has discovered that caution should be used in selecting the flow direction as significant errors (double counting) can occur. The District also pointed out that the current FLO-2D executable conducts a direct sum of the hydrograph in the direction of the flow selected, and the two adjacent vector direction instead of the previous 'Vector Component' method. This will result in conservative results for the purposes of extracting design peak discharges. However, if FPXSEC.DAT output is used for flow transfer, this will bias the results in the downstream model.

Rob distributed a hand-out to meeting attendees demonstrating the various methods of model integration that the JEF team has considered and the pros and cons of each approach. Unfortunately, no single approach was identified that would have no hydraulic bias and straight-forward pre-and post-processing. Most of the approaches were immediately deemed unsatisfactory by the team leaving only two choices, Approach F (the same approach the District has been using with FPXSEC.DAT) and Approach C, as shown in Figure 1. Although Approach F may be the most hydraulically accurate, the team agreed that the extra work required to execute this approach for PPW would be significant. Furthermore, the team recognizes that revisions of internal sub FLO-2D model boundaries will be very likely and an approach needs to be selected that will minimize the effort required for revision of model input and post-processing model output. Given the number of expected sub FLO-2D models and the number of interior flow transfer grid elements, it was decided that Approach C was the best choice for the project.

The team recognizes that the results along the transfer boundary, perhaps 3 grid elements wide, will not be 100-percent accurate. Therefore, the team will attempt to select an internal boundary location in areas of less concern than others, e.g. avoid areas with structures or walls.

APPENDIX I: Task 5.2.9.3 – Model Integration

The District would like clarification from Jim O'Brien regarding the computations of outflow for grid elements assigned with OUTFLOW.DAT. Specifically, which adjacent, upstream grid elements contribute to outflow elements. JEF mentioned that Jim could revise the FLO.EXE to write an INFLOW.DAT file directly for the downstream model for Approach C with relatively little effort. The District agreed that this seems like a worthwhile investment for this project and others.

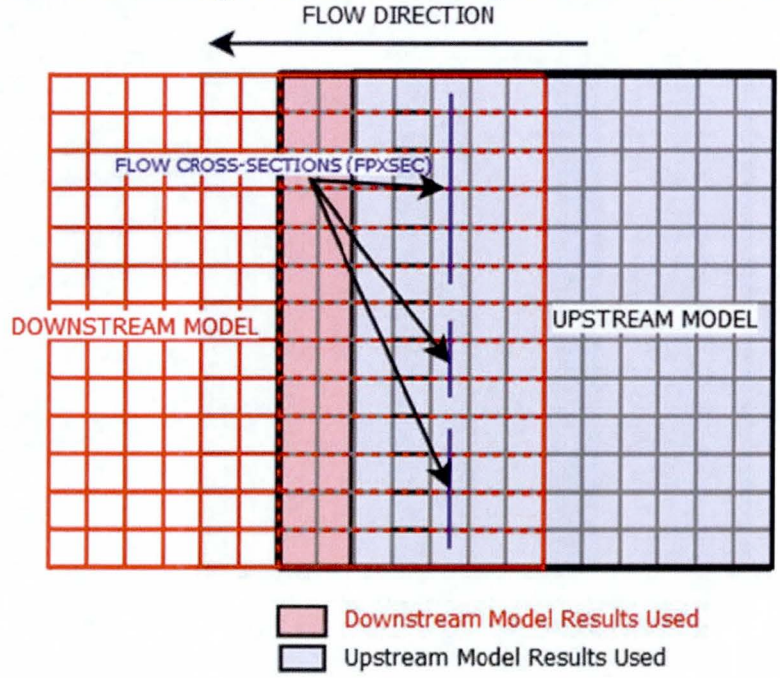
Rob passed out a map with very preliminary internal sub FLO-2D models shown. Given the grid element size selected of 20' and an ideal sub-model size of approximately 1 million grid elements, at least 7 models will be needed for the PPW ADMS. The internal boundaries will be refined further with the Model Integration Approach C in mind.

Action Items

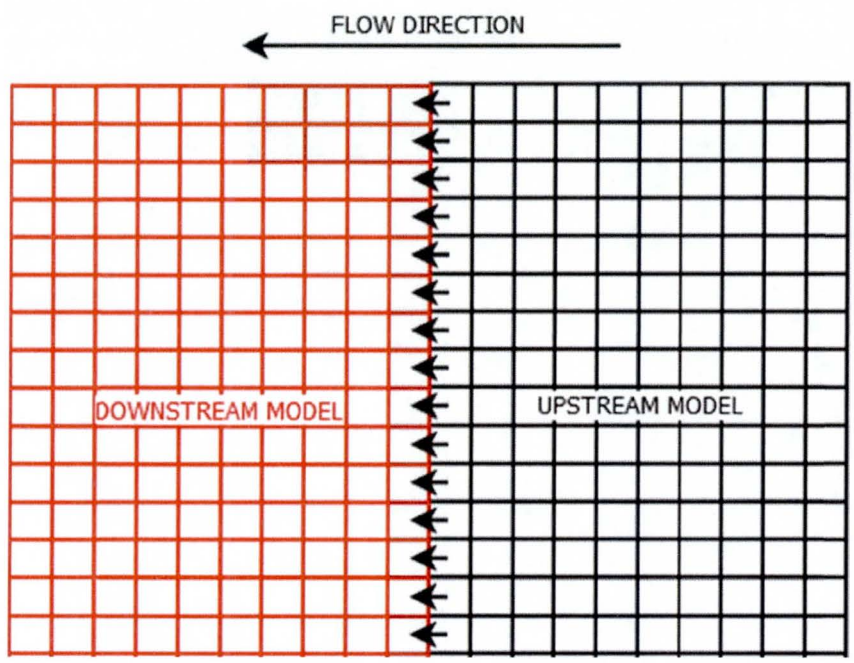
1. JEF will follow up with Jim O'Brien to verify the outflow computations. JEF will forward Jim's response to the District.
2. JEF will follow up with Jim O'Brien to see if he can get started on revising FLO.EXE to directly write the INFLOW.DAT file for downstream models from the upstream model output.

APPENDIX I: Task 5.2.9.3 – Model Integration

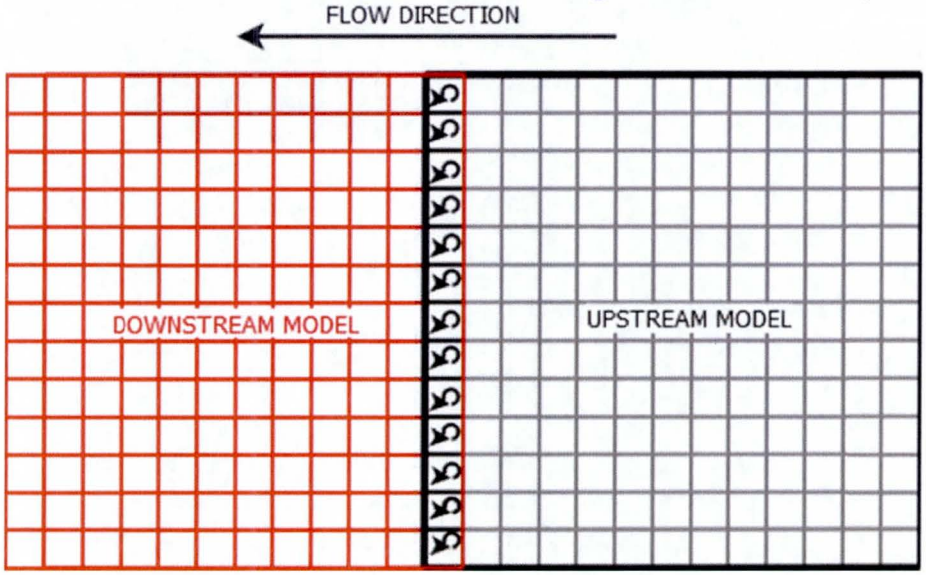
Approach A: Flow transfer using Standard Floodplain Cross-sections (FPXSEC.DAT)



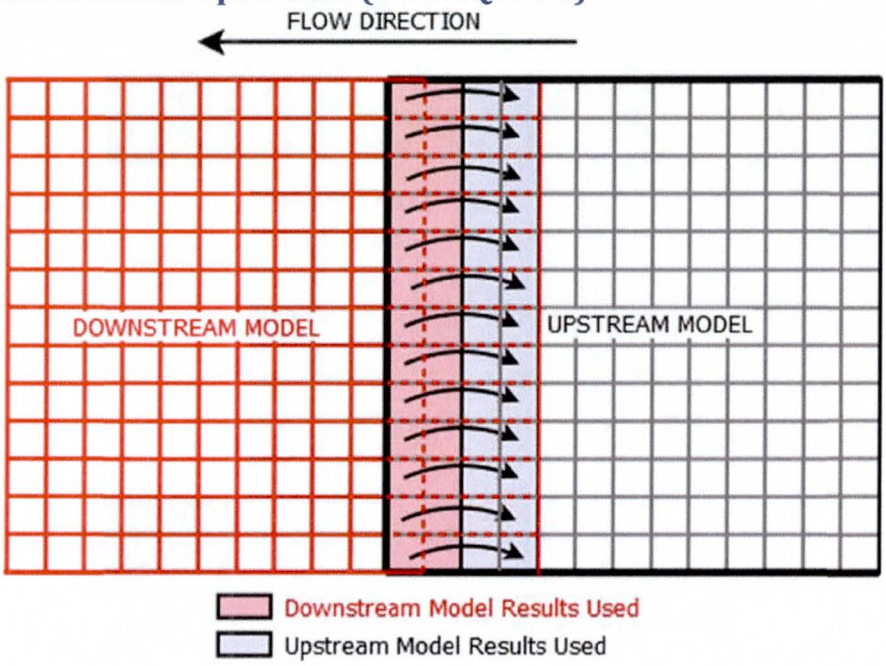
Approach B: Direct Transfer to adjacent cells using outflow nodes (OUTNQ.OUT)



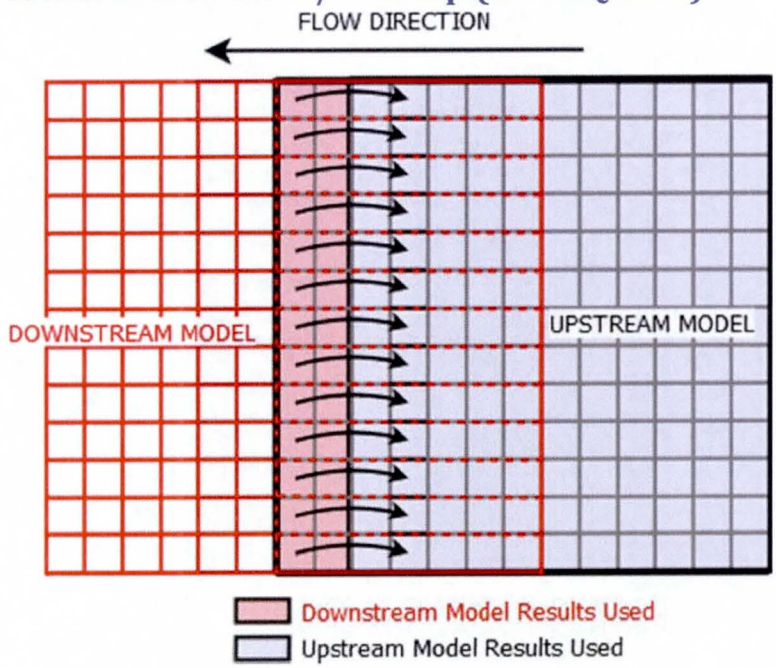
Approach C: Direct Transfer at same location using outflow nodes (OUTNQ.OUT)



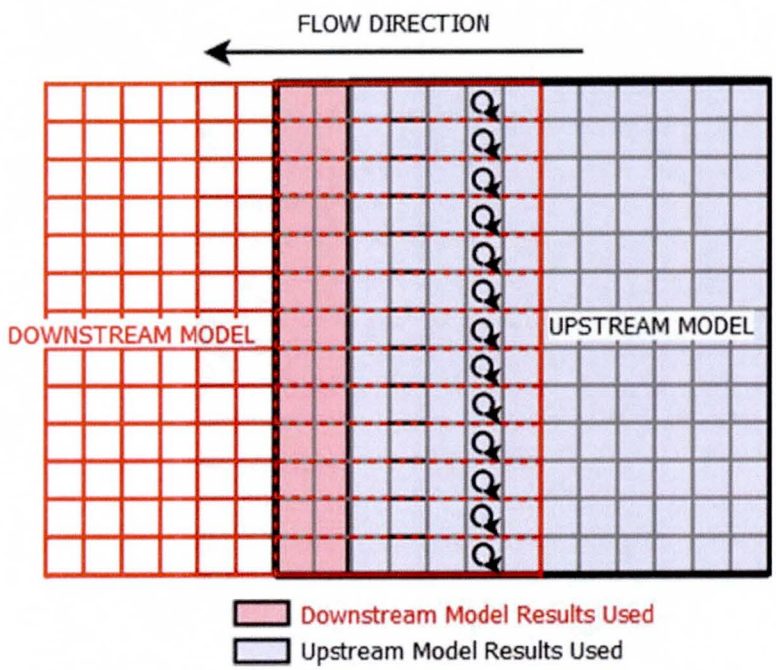
Approach D: Shift location upstream (OUTNQ.OUT)



Approach E: Same location transfer w/ overlap (OUTNQ.OUT)



Approach F: Same interior location transfer w/ overlap using single cell FPXSEC.DAT and HYCROSS.OUT



Model Integration Issue	Approach					
	A	B	C	D	E	F
Outflow Node Elevation Lowering Bias	◕	◕	◕	◐	◐	◕
Hydrograph Timing and/or Over Attenuation Bias	◐	◐	○	◕	◕	◐
Resultant Hydraulic Bias	○	◐	◐	○	◐	◐
Possible missing flow transfer/Hydrograph Distribution Bias	◐	◕	◕	◕	◕	◕
Pre-processing Complexity	◐	◐	◐	◐	◐	◐
Post-processing Complexity	◐	◕	◐	◐	◐	◐
Effect on total number of grid elements	◕	◕	◐	◐	◕	◕

Legend

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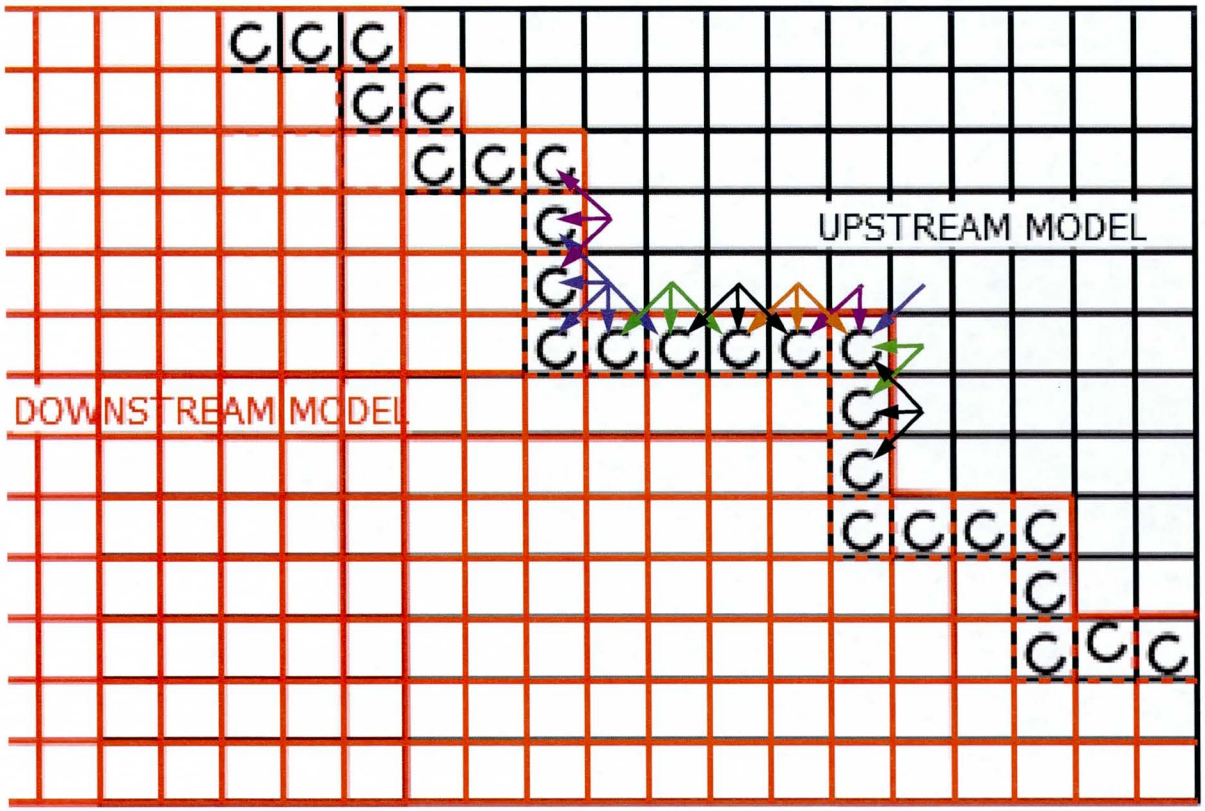
APPENDIX I: Task 5.2.9.3 - FLO-2D Outflow elements (OUTFLOW.DAT) clarification:

The following excerpts have been taken from the FLO-2D Data Input Manual, Version 2009.06. These excerpts were extracted to assist in the understanding of which upstream grid elements contribute to outflow elements and identify additional outflow element considerations. The Figure below illustrates which upstream elements could potentially contribute to an outflow element.

"This outflow is equal to the sum of the inflow from the contiguous elements that are not outflow nodes."

"The floodplain elevation of the outflow node is automatically set to an elevation lower (0.25 ft or 0.1 m) than the lowest upstream grid element unless it is already lower than all the upstream grid elements."

"The OUTNQ.OUT file contains a summary of the maximum discharge, time of peak and the discharge hydrograph for each floodplain outflow element."



Memo

Stantec

To:	JE Fuller Hydrology & Geomorphology	From:	Mike Gerlach Phoenix AZ Office
File:	181300290	Date:	February 19, 2013

Reference: Appendix J: Drainage Facility Inventory and Drainage Channel Modeling Approach Evaluation

PURPOSE

The Pinnacle Peak West (PPW) ADMS watershed is approximately 100 square miles in size. The watershed is partially urbanized with varying zones of residential and commercial development. Associated with the development is a drainage infrastructure system composed of culverts, storm drains, basins, channels and other features that in some locations redirect runoff from its natural flow pattern. Documentation of the drainage infrastructure and, more importantly, understanding the impacts to the runoff in the watershed, is a critical first step in the modeling of the study area.

This memorandum summarizes the results of Tasks 5.2.11.1, 5.2.11.2, and 5.11.2.3 in Work Assignment number 1. The purpose of Task 5.2.11.1 and 5.2.11.2 is to inventory and collect data on the significant drainage facilities and obstructions in the PPW ADMS project area. The purpose of Task 5.2.11.3 is to evaluate and recommend which modeling approach to use for the constructed channels in the study area. The two approaches are considered; using the 1-D channel approach in FLO-2D and simulating channels using floodplain elevations.

TASK 5.2.11.1 AND 5.2.11.2 DRAINAGE FACILITY INVENTORY

The drainage infrastructure within the study area includes culverts, bridges, drainage channels, storm drains and detention/retention basins. In addition, perimeter walls surrounding residential and/or commercial developments function as drainage elements in that these elements can redirect runoff from the historic path or restrict the amount of runoff that can pass the wall through constructed openings. For Tasks 5.2.11.1 – 5.2.11.3, the inventory of the drainage infrastructure was limited to just culverts, wall openings and drainage channels. Development of the inventory followed a three step process.

1. Identify the number and the location of each element within the watershed.

    a. Culverts – from the detailed topographic mapping there are nearly 8,000 features described as headwalls and 753 features described as pipes. Assuming that all the headwalls are associated with culverts, there are approximately 4,000 culverts within the watershed. This is the total

number of culverts regardless of size and significance from a drainage perspective. Through the use of preliminary FLO-2D modeling of the watershed combined with interpretation of the terrain and aerial photography, the number of culverts inventoried for inclusion in the detailed hydrology model is 585.

b. Wall openings – there is approximately 600 miles of features in the detailed topographic mapping described as walls. However, individual wall openings are not identified as a unique feature in the mapping. During preliminary field investigations, it was observed that wall openings in perimeter walls tend to match up with culvert crossings and roadway dip sections. Therefore, using the culvert locations coupled with preliminary FLO-2D modeling and wall features from the detailed mapping, an initial list of nearly 125 wall openings was identified. These were verified in the field for a total number of 97 wall openings.

c. Drainage Channels – in the detailed topographic mapping for the project area there are 275 features identified as concrete which include engineered drainage channels. After a detailed review of the mapping and aerial photography, 62 of the 275 features were selected as actual drainage channels with a total length of 36 miles.

2. Prepare a listing of physical properties to document. This listing, referred to as a data dictionary includes the physical size of the feature as well as any hydraulic characteristics such as sediment accumulation or accumulation. The data dictionary for each feature type is summarized in Table 1.

3. Field survey each drainage element. The location of each element was recorded using a Trimble Juno 3D Handheld GPS (Juno 3D). The Juno 3D is a Roving GPS unit with a horizontal accuracy of less than one meter. The Trimble TerraSync software is used to post-process the coordinate data which is then exported to a shapefile. At each observation, the fields of the data dictionary are populated and representative photographs are taken of the feature. This data is associated with the coordinates and included as attributes in the shapefile.

Table 1 – Drainage Facility Inventory Data

Drainage Facility	ID	Type	No. of Barrels	Shape	Diameter [in]	Span [ft]	Rise [ft]	Invert [ft]	Depth [ft]	Top Width [ft]	Bottom Width [ft]	Material	Channel Material	Bank Material	Vegetation	Inlet or Outlet Type	Headwall Type	Apron	Deposition	Deposition Depth [in]	Scour	Scour Depth [in]	Condition
Culvert	√	√	√	√	√	√	√	√				√				√	√	√	√	√	√	√	√
Channel	√			√					√	√	√		√	√	√								√
Wall	√			√	√	√	√	√				√			√				√	√	√	√	√

The Juno 3D does not have sufficient vertical accuracy to capture elevations associated with each feature. Therefore, a combination of field measurements and elevation data from the detailed mapping were used to approximate the culvert inlet and outlet invert elevations. For culverts with headwalls, that process was as follows:

- The total height of the headwall was measured in the field.
- From the digital terrain model breaklines that define the headwall, the maximum elevation along the headwall feature was adopted for the headwall elevation.
- The invert elevation for the culvert was then calculated as the headwall elevation minus the headwall height.

For culverts without headwalls, the invert elevation wash calculated as follows:

- The height from the center of the roadway to the culvert invert was measured in the field using a Philadelphia Rod and hand level.
- From the digital terrain model breaklines that define the roadway centerline, the elevation at the observation point was estimated.
- The invert elevation for the culvert was then calculated as roadway centerline elevation minus the measured height.

At several locations, this calculation process resulted in an adverse slope for the culvert. In general, this is due to the accuracy associated with the mapping process. For these instances, the upstream invert elevation was adopted and the downstream invert elevation was based on the upstream invert elevation and the average slope of the wash within the vicinity of the culvert.

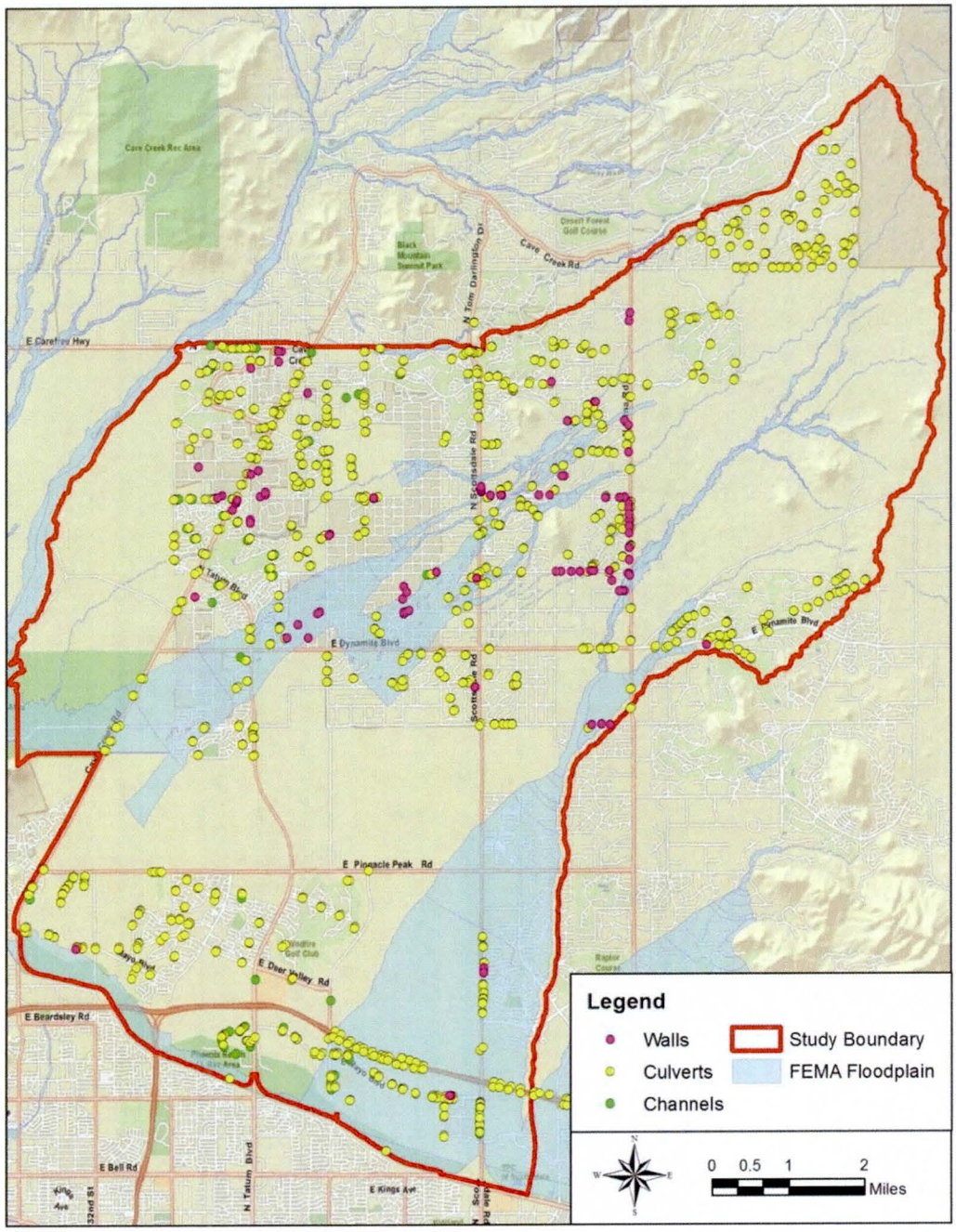
Elevation data for the wall openings and the channels was not obtained. For the channels, obtaining channel invert elevations for 36 miles is not practical. Depending on the selected modeling approach, elevation data to describe the channel hydraulics will be based on the detailed mapping data for the watershed. For the wall openings, the hydraulic capacity of the opening is not a function of slope, just the size of the opening itself. For modeling purposes, the rating curve representing the hydraulic capacity of the opening will be relative to the FLO-2D floodplain grid element elevations.

Field survey of culverts was only performed for those culverts outside of the ADOT Loop 101 right of way. Attribute information for the culverts within the ADOT right of way were obtain from design drawings. Multiple plan sets cover the section of the Loop 101 within the study area. The different plan sets reference different vertical datums and different units of measure (English and metric). For the metric plan sets, several easily accessible culverts were measured in the field to confirm the dimensions. All dimensions reported in the inventory database are in feet. For the plan sets with different vertical datums, elevation adjustments were made through a comparison of the detailed topographic mapping for this project and the specified elevation of key physical features from the design drawings. In general, the elevation difference is approximately 2 feet. This is consistent with the conversion between NGVD 29 and NAVD 88.

The field inventory data is organized into a file geodatabase. A separate feature class is included for each drainage feature (culverts, walls and channels). The spatial distribution of the features is shown in Figure 1. Along with the geodatabase are the field photos for each feature. The photos are hyperlinked to the elements in the geodatabase.

Reference: Appendix J: Drainage Facility Inventory and Drainage Channel Modeling Approach Evaluation

Figure 1 – Data Inventory Overview



TASK 5.2.11.3 – CHANNEL MODELING APPROACH

There are two basic approaches for simulating constructed channels with FLO-2D. The most basic is to rely on floodplain elevations to define the channel geometry and conveyance. The second is to use the one-dimensional channel data set. Each approach has strengths and weakness which are a function of several factors including grid size, channel complexity, channel size and adjacent FLO-2D modeling elements such as levees and area reduction factors. Another factor that can influence the selection of a method is the degree of difficulty representing the channel conveyance in FLO-2D.

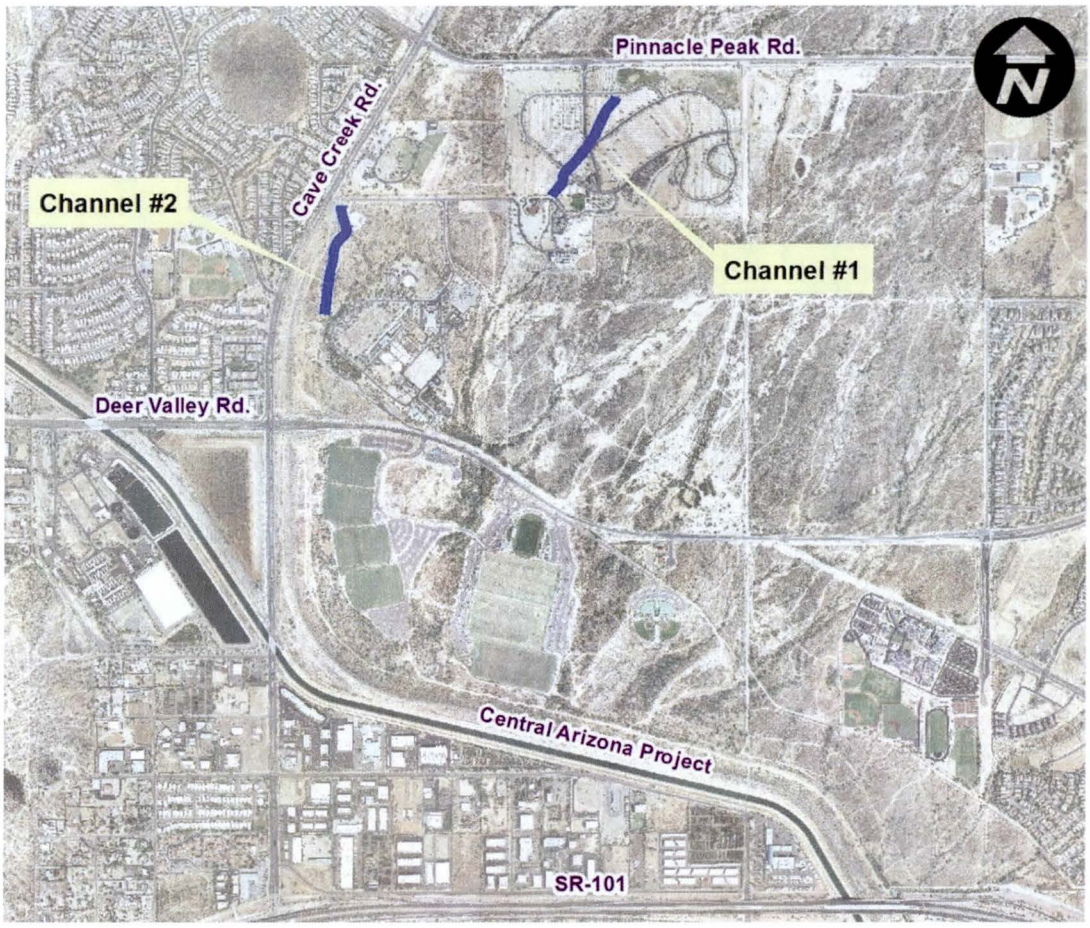
To evaluate the strengths and weaknesses of each method for this project, FLO-2D models were developed for two different constructed channels. The channels were selected for the channel inventory based on the bottom width relative to the selected grid size for the study. The selected grid size is 20 feet. It is assumed that channels with bottom widths greater than 20 feet will be well represented using just the floodplain grid elements. Therefore, the evaluation of modeling approaches focuses on channels with bottom widths less than 20 feet.

The physical characteristics of each channel are listed in Table 2. The key difference between the two channels is the bottom width. The bottom width for channel 1 is 18 feet, just under the grid cell size. The bottom width for channel 2 is 8 feet, significantly smaller than the grid cell size. Both of the channels are located in the southwestern portion of the study area as shown in Figure 2.

Table 2 – Channel Data

Data	Channel 1	Channel 2
Shape	Trapezoid	Trapezoid
Channel Material	Shotcrete	Earthen
Bank Material	Shotcrete	Earthen
Depth [ft]	4.0	3.5
Top Width [ft]	34	28
Bottom Width [ft]	18	8
Length [ft]	1,320	1,280
Vegetation	None	Minor

Figure 2 – Channel Location



For each channel, two models are developed. In the first model the channel is represented using floodplain grid cells only. In the second, the one-dimensional channel data set is used to define the channel geometry. The models created for each channel are kept to a minimum size to simplify the analysis to the extent possible. Complicating factors such as structures and culverts are not considered as part of the analysis.

FLO-2D INPUT DATA

Grid – A grid size of 20 feet was used for both test cases. The Grid Developer System (GDS) and the ground surface data provided by the District were used to develop the FLO-2D grid and determine the floodplain elevations. To minimize potential boundary effects, both grids include a few hundred feet of buffered area around the test channels. The resulting grids contain 11,000 and 6,739 cells for the channel 1 and 2, respectively.

N-Values –Roughness coefficients were selected to account for vegetation and surface roughness conditions. Roughness coefficients for each grid cell were determined by examination of aerial imagery. In general, the terrain for both test areas is relatively uniform surface with minimal vegetation and gently sloped from north east to south west. Based on this observation, a roughness coefficient of 0.04 was selected for all cells within both test areas except for the shotcrete lined channel in the channel 1 model. In that model, the cells defining the channel are assigned an n-value of 0.025.

Rainfall – Rainfall data for both test cases is the 100-year, 6-hour point rainfall depth for the PPW ADMS watershed distributed in time using Pattern No. 1 as specified in the Hydrology Manual. The resulting average, point rainfall depth for both test cases is 3.369 inches.

Inflow hydrographs – The preliminary Pinnacle Peak West FLO-2D model developed by the District was utilized to determine input peak flows from the contributing area upstream of the test cases. A total of three input flow locations, two for the first test case and one for the second, were identified and selected from the Districts FLO-2D model. The peak flow from that model, with a 50-foot grid cell size are distributed to the 20-foot grid cell size used for this analysis using the same approach as is recommended for accepting flow from the Pinnacle Peak South FLO-2D model (detailed in previous sections of this overall document). However, the preliminary model does not include floodplain cross sections at the desired locations of input for the test cases. Therefore, a synthetic inflow hydrograph is used and that hydrograph is normalized using the peak flows.

Floodplain Cross Section – To aid with interpretation of FLO-2D model results, floodplain cross sections were placed at key locations along the test channels. A total of five cross sections were located along the channels, three for channel 1 and two for channel 2. These cross sections were utilized only on the simulations where channel geometry was capture using floodplain elevations. For the model simulations with the 1-D channel elements, the channel results were used to evaluate the model.

Channels – For the one-dimensional channel models, channel geometry was taken from the results of the data inventory. That geometry is listed in Table 2. The PROFILES tool provided with FLO-2D was then used to interpolate the channel shape across the grid cells along the length of channel included in the simulation. This results in adjustments to the floodplain elevations along the length the channel based on the

new slope. In addition, channel bed elevations were adjusted at the downstream side of the channel to allow the flow to be properly transitioned into the floodplain.

For the approach using only the floodplain grid cell elevations derived through the elevation interpolation process, floodplain elevation adjustments along the channel length are only made at roadway crossings.

RESULTS

Summary results for each channel model, for both modeling approaches, are provided in Figures 3 through 12. Model input and output files for each test case are provided digitally as an attachment to this document. Figures 3 and 4 show comparisons of the runoff hydrographs at the floodplain cross sections for channel model 1 and 2 respectively. In addition, flow depth and velocity results for each test case and modeling approach are provided in Figures 5 through 12. The location of each floodplain cross section is shown in Figure 5 for channel model 1 and Figure 9 for channel model 2

Channel Model 1

In general, both approaches for channel model 1 yield relatively similar results. The peak discharge in the channel with the one-dimensional channel model approach is approximately 700 cfs compared to a peak of approximately 750 cfs for the floodplain grid cell approach. The time distribution of runoff between the two approaches is similar, but there are some notable differences that can be seen from Figure 3.

- Runoff for the one-dimensional channel approach is lagged behind the floodplain grid model approach.
- The slope of the rising and receeding limbs of the one-dimensional channel approach are not as steep as the floodplain grid approach.
- The shape of the runoff hydrographs along the length of the channel segment for the one-dimensional channel model is more consistent than for the floodplain grid cell only approach.

Differences in the timing and slope of the rising and receeding limbs between the two modeling approaches is likely due to the entrance conditions to the channel and how flow is transferred from the floodplain elements at the head of the one-dimensional channel reach into the channel elements. For channel model 1, the channel serves as the outlet for a two cell detention basin (see Figure 5). Flow stored in the detention basin is drained through a culvert that discharges into the channel. However, for the purposes of this analysis, the culvert is not included in the model and the associated floodplain grid elevations were adjusted to allow flow stored in the basin to simply drain out through the channel. For this transition to work properly with the one-dimensional model approach, the cross sections defining the channel geometry at the head of the

channel segment have to be extended into the basin slightly and the bank elevations lowered to allow flow to transition from the floodplain elements into the channel elements.

Differences in the shape of the runoff hydrographs along the length of the channel are likely due to differences in channel conveyance along the length of the channel as represented in the two approaches. For the one-dimensional model approach, the cross sectional geometry defining the channel is regular and consistent along the entire length. This is, of course, to be expected given the prismatic nature of the channel. Thus, there is very little difference in the runoff hydrograph as flow is routed along the channel. Correspondingly, maximum channel velocities for the one-dimensional model approach are relatively uniform along the length ranging from 4 to 10 fps. For the floodplain grid element only approach, however, channel conveyance varies along the length due to the floodplain elevations to the grid elements through the elevation interpolation process. The result is a non-uniform channel bed slope and channel velocities that range from 5 to 18 fps.

Channel Model 2

For channel model 2, there is a significant difference between the two modeling approaches. The peak discharge in the channel with the one-dimensional channel model approach is approximately 180 cfs compared to a peak of approximately 100 cfs for the floodplain grid cell approach. The time distribution of runoff between the two approaches as shown in Figure 4 is very different with the main difference being an increase in discharge along the length of the channel with the one-dimensional modeling approach as compared to a decrease in discharge along the channel length with the floodplain grid cell only approach. The reason peak flow is reduced along the length of the channel for the floodplain grid cell only approach is due to the irregularity in the floodplain elevations defining the channel. The bottom width for channel 2 is only 8 feet. The smaller size of this channel combined with the alignment relative to the grid results in a non-uniform profile. This results in a loss of conveyance at points along the channel simply due to the elevation averaging process.

Figure 3 - Channel # 1 Runoff Hydrograph Comparison

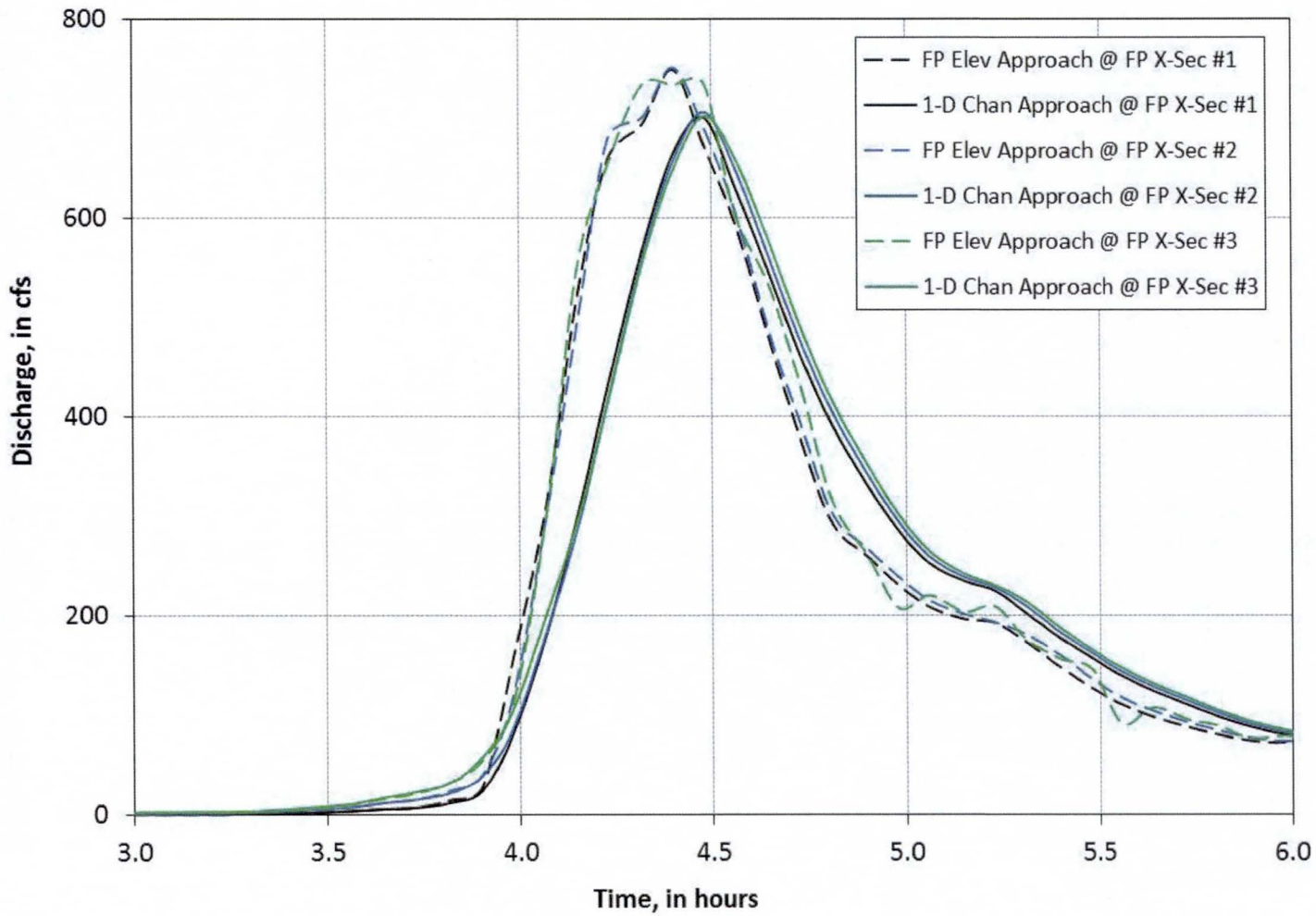


Figure 4 - Channel # 2 Runoff Hydrograph Comparison

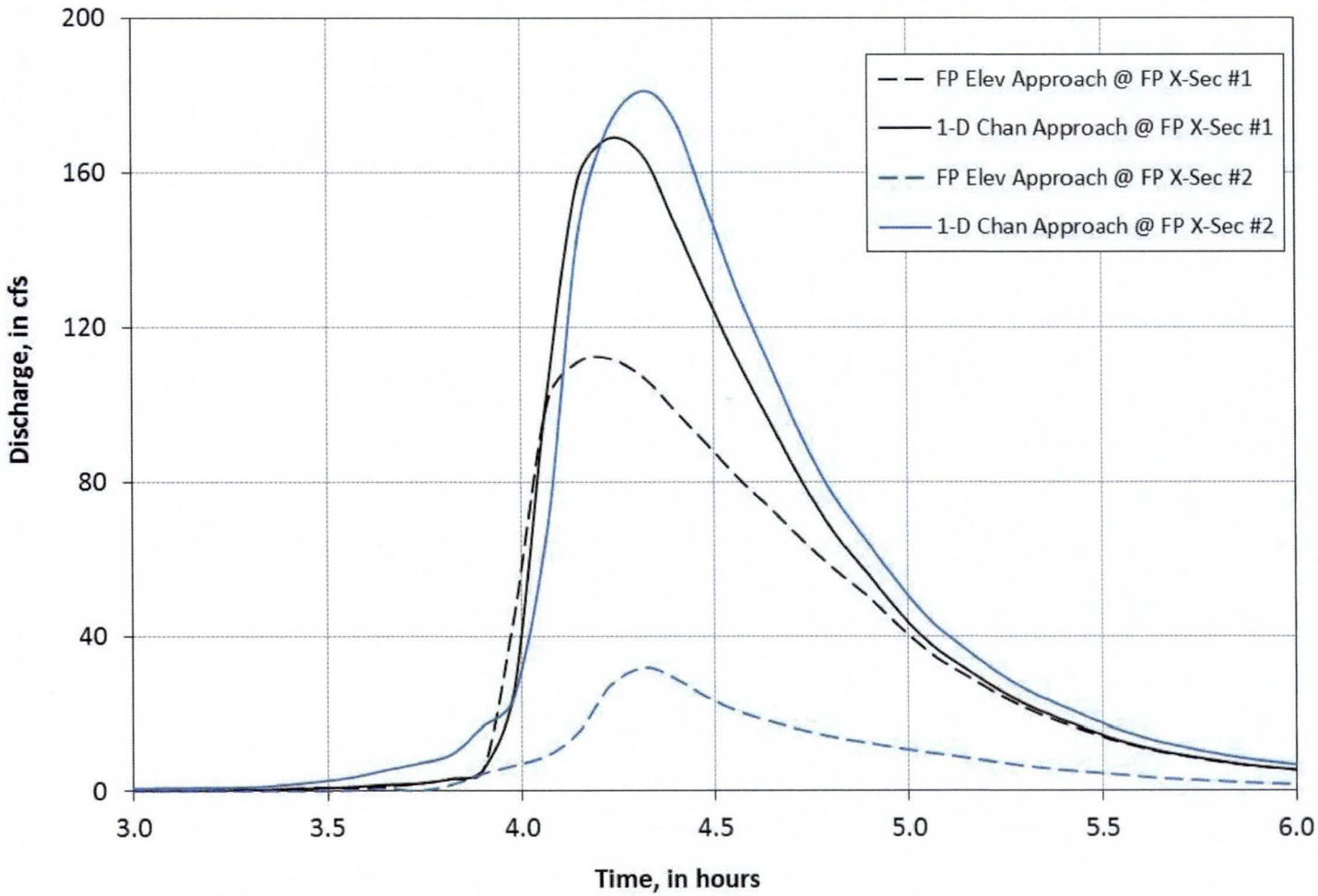
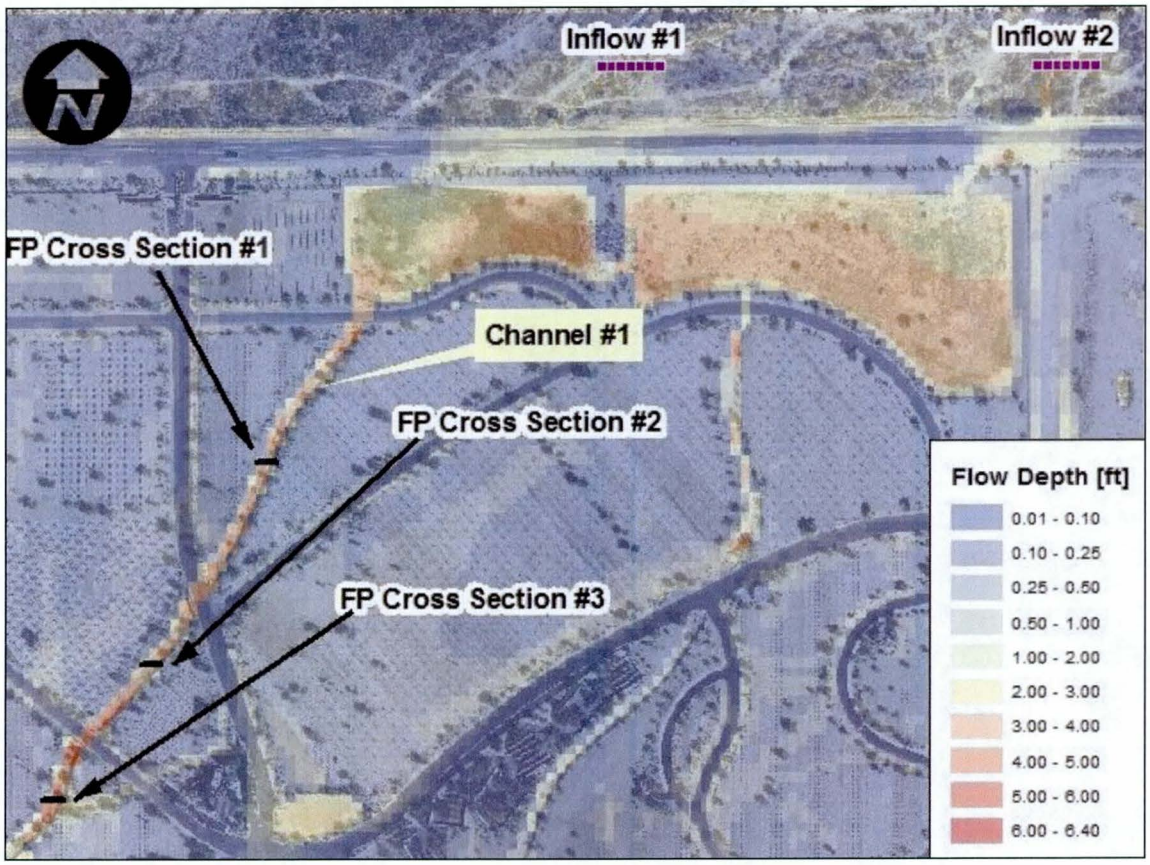
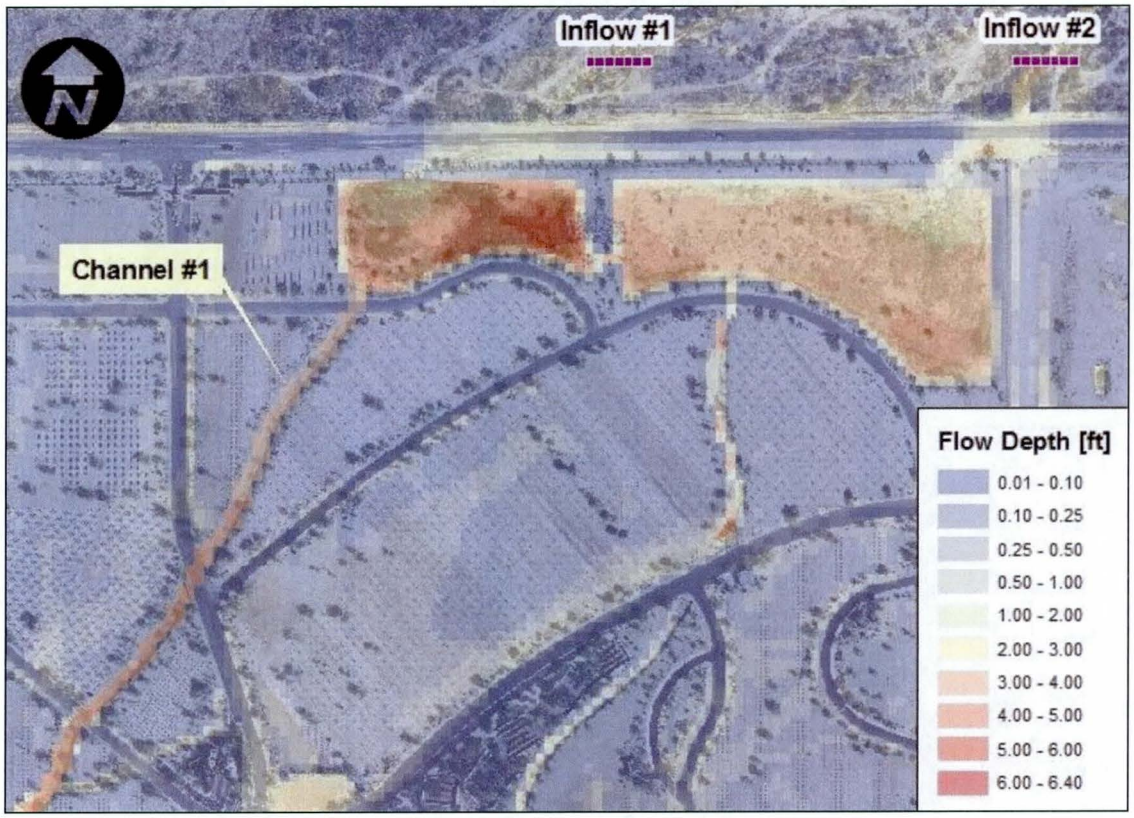


Figure 5 – Flow Depth (Channel # 1 Simulated Using Floodplain Elevations)



Reference: Appendix J: Drainage Facility Inventory and Drainage Channel Modeling Approach Evaluation

Figure 6 – Flow Depth (Channel # 1 Simulated Using 1-D Approach)



Reference: Appendix J: Drainage Facility Inventory and Drainage Channel Modeling Approach Evaluation

Figure 7 – Flow Velocity (Channel # 1 Simulated Using Floodplain Elevations)

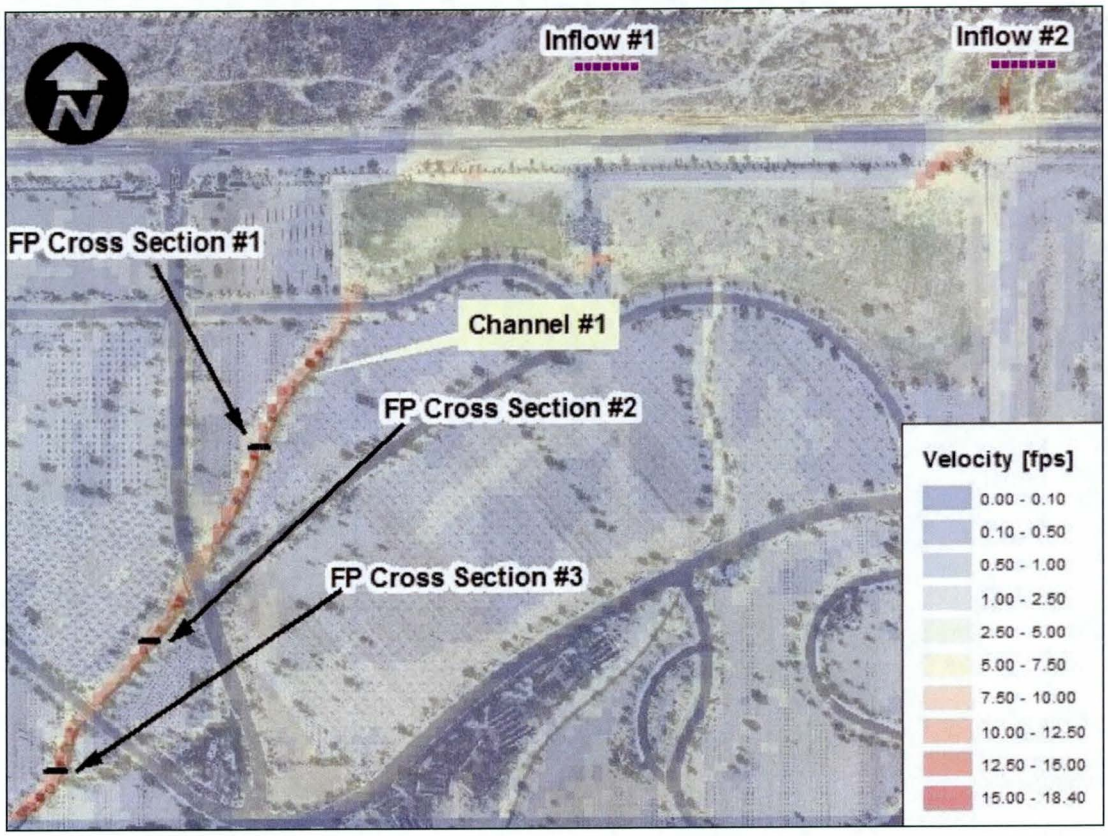


Figure 8 – Flow Velocity (Channel # 1 Simulated Using 1-D Approach)

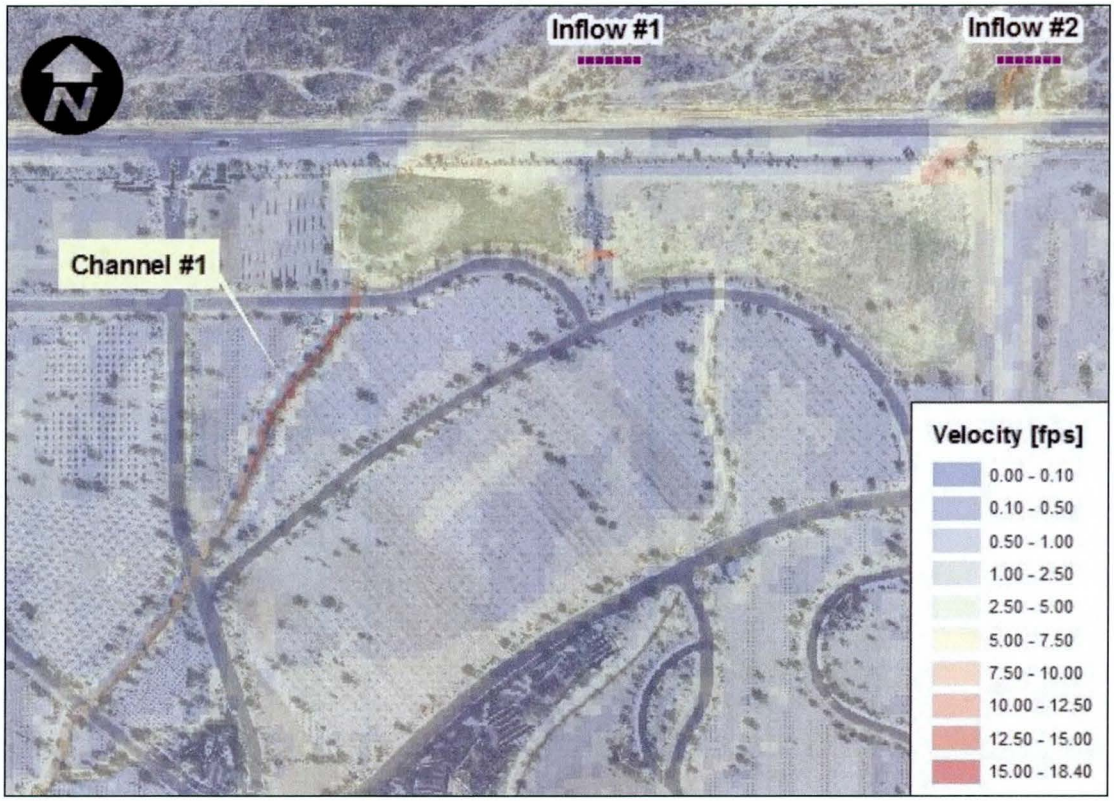


Figure 9 – Flow Depth (Channel # 2 Simulated Using Floodplain Elevations)

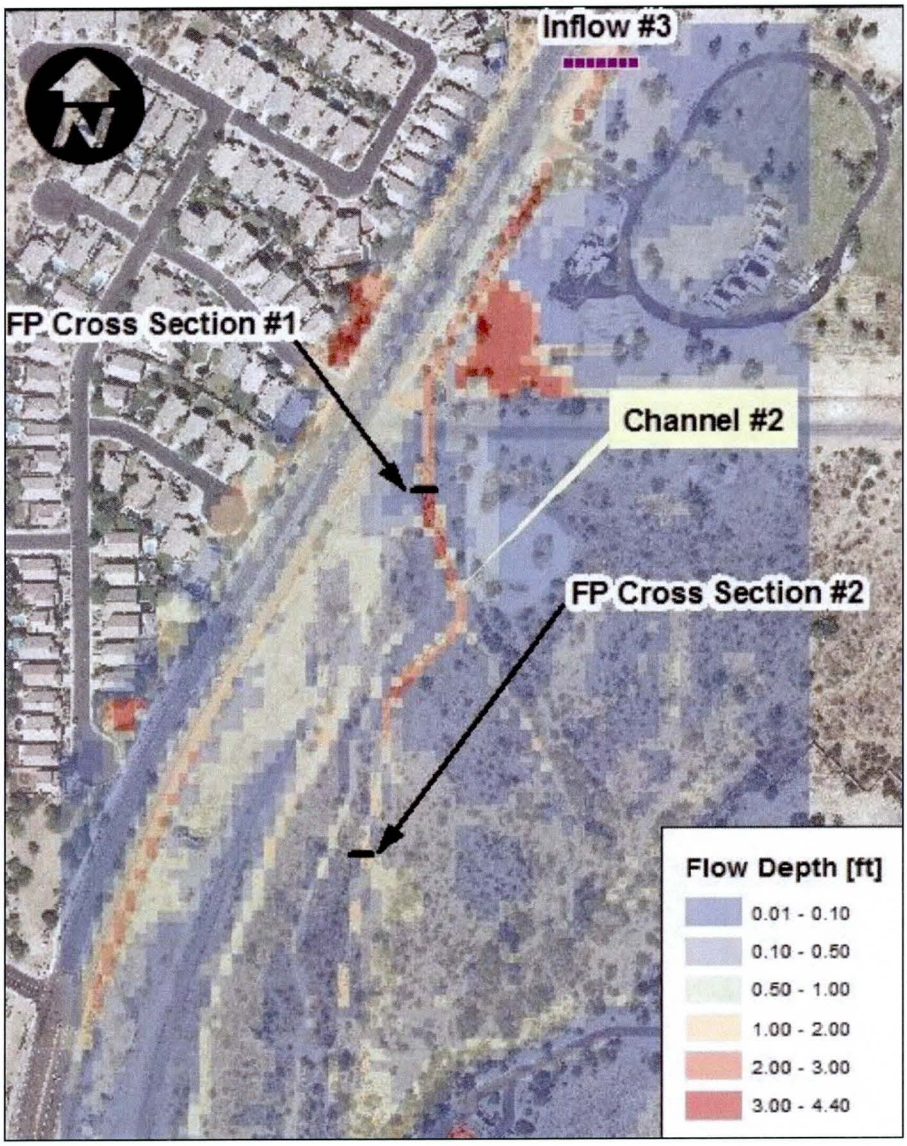


Figure 10 – Flow Depth (Channel # 2 Simulated Using 1-D Approach)

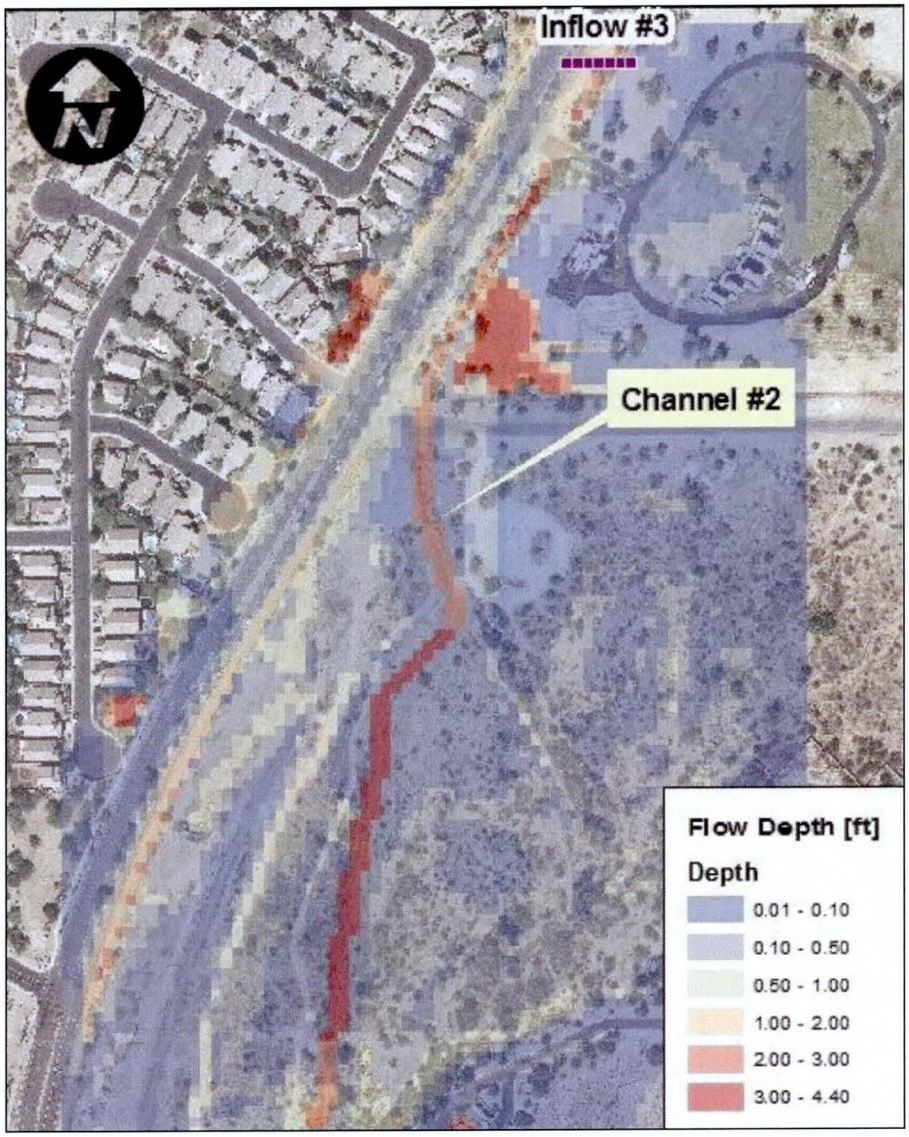


Figure 11 – Flow Velocity (Channel # 2 Simulated Using Floodplain Elevations)

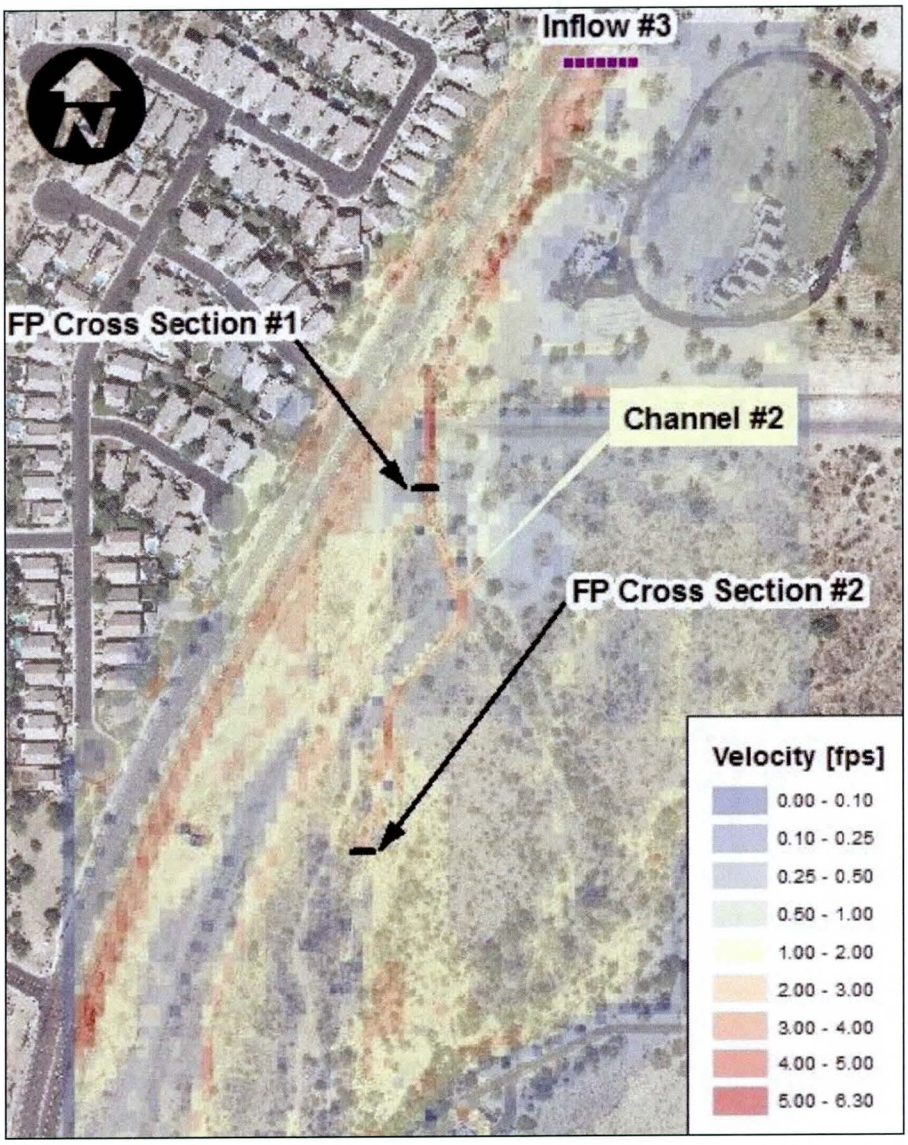
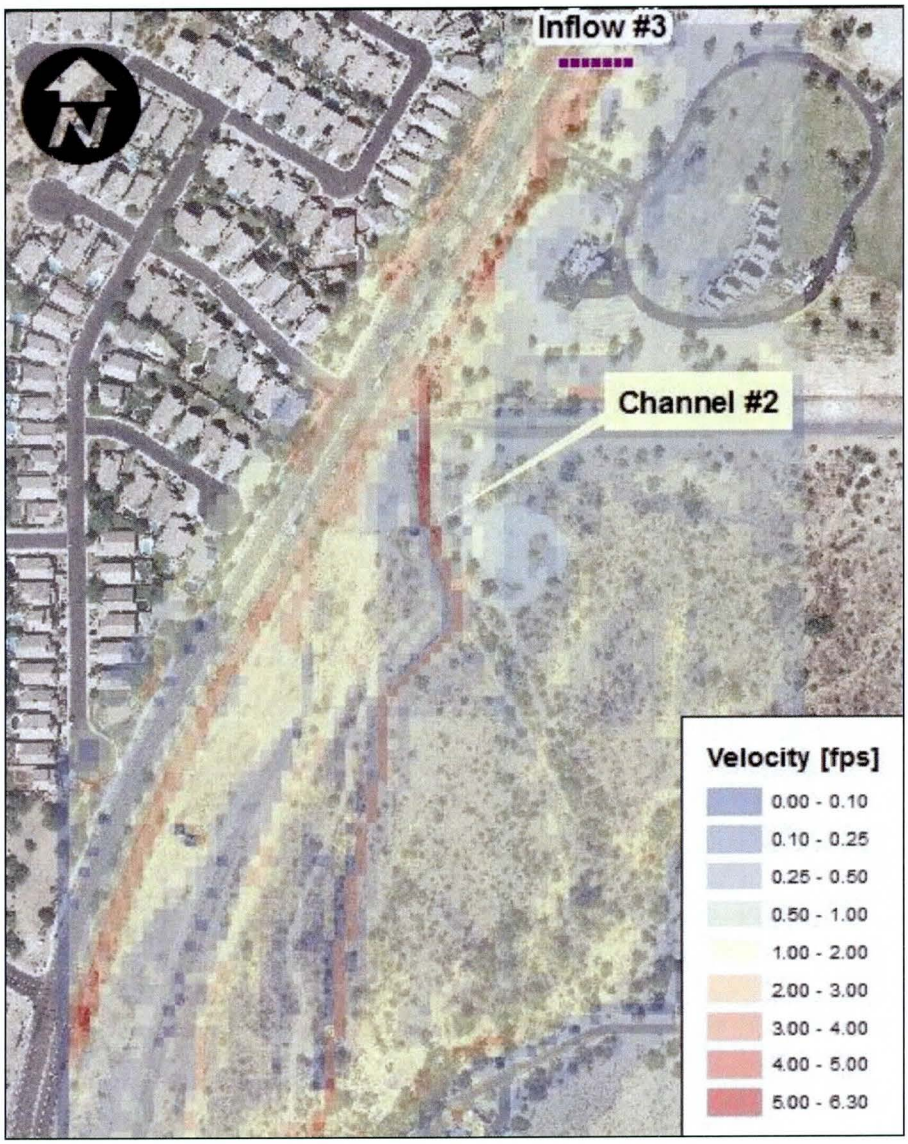


Figure 12 – Flow Velocity (Channel # 2 Simulated Using 1-D Approach)



CONCLUSIONS

Two different size channels were investigated to evaluate the use of 1-D channel approach in FLO-2D versus simulation of the channels using floodplain elevations. For both test cases and modeling approaches, a 20 foot grid size was used. For the chosen FLO-2D grid size and the channel characteristics, the model results are as expected.

For channel model 1, the channel geometry is relatively uniform with a bottom width is just smaller at 18 feet than the FLO-2D cell size. With an average depth of approximately 4 feet, the top width is, on average, 34 feet. The channel alignment is from northeast to southwest and fairly straight. For the simulated inflow, the channel capacity is, in general, adequate to convey the full flow. Comparing the runoff hydrographs at three separate locations along the channel shows that both approaches yield fairly similar results. The key difference between the two approaches is the maximum channel velocity. The maximum velocity for the elements that define the channel in the floodplain elevation approach is approximately 18 fps. However, the velocity along the length is not uniform and varies from the maximum to a minimum of approximately 5 fps. The variability in floodplain velocity along the length of the channel is due to a non-uniform sloping profile that results from the elevation interpolation process. For the 1-D channel approach the velocity range is 4 to 10 fps. The change in velocity along the length is fairly uniform, with reaches of nearly constant velocity that correspond to reaches of uniform bed slope.

For channel model 2, the channel geometry is less uniform than channel model 1. The average bottom width is only 8 feet with an average depth of 3.5 feet. In general, the entire channel cross section is contained within a single cell. Though the conveyance capacity of the channel is less than the simulated inflow, there is a significant difference in the results between the two approaches and specifically, the volume of flow that breaks out of the channel. In the hydrograph comparison shown in Figure 4, the peak discharge in the channel increases in the downstream direction using the 1-D channel approach. For the floodplain elevation approach the peak discharge decreases in the downstream direction as flow breaks out of the channel elements. At the upstream end the peak discharge is in the channel simulated with floodplain elevations is approximately 30% less than for the 1-D channel simulation. At the downstream the peak discharge in the channel is approximately 90% less for the floodplain elevation approach compared to the 1-D channel approach.

For the sizes of channels simulated in these test cases, the 1-D approach yields reasonable and consistent results compared to the floodplain elevation approach. Significant edits would need to be made to the floodplain elevations in order to simulate the capacity of the channels using floodplain elements alone. These edits would be very labor intensive as the adjustments must look to the local grid cell for cross sectional conveyance capacity equivalence of simulating a trapezoidal channel with a rectangular element and simultaneously along the entire channel length to achieve a

uniform profile. The necessary edits to adequately represent the channel can be weighed against the effort necessary to code the 1-D channel data for each grid cell along the channel. The 1-D channel data can be a labor intensive and time consuming effort. However, given that the engineered channels have a prismatic shape, implementation time can be minimized through simple spreadsheet processing using a template shape and known channel slope. It is likely that the implementation time of the 1-D channel application will be less than the floodplain editing process that would be required to simulate these smaller engineered channels with floodplain elements only. Furthermore, use of the 1-D channel approach will increase the confidence that the channel conveyance for all the engineered channels is adequately captured on the first run. From a model runtime perspective, it is not anticipated that use of 1-D channels will have a significant impact on the model performance. For this watershed, model run time will be dictated by the ponding conditions that are expected. Therefore, it is recommended that 1-D channels be used to simulate the engineered channels within the watershed.

STANTEC CONSULTING SERVICES INC.

Mike Gerlach, PE
Associate - Water Resources
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Attachment: Attachment

c. Cc List

Memorandum

DATE: August 21, 2012

TO: Theresa Pinto, FCDMC

FROM: Rob Lyons, PE, CFM

RE: APPENDIX K: Task 5.2.13.1-7 – Pinnacle Peak West ADMS Model Verification

The preferred approach for any hydrologic model verification is to calibrate the model to known events if possible. FLO-2D offers the ability to model actual historic rainfall events both spatially and temporally. The resulting hydrographs, flow paths, flow depths and/or water surface elevation output can be compared to actual stream gage data, high water marks, or other known flood data to verify the hydrologic and hydraulic parameters selected for the model. JE Fuller/Hydrology & Geomorphology, Inc. (JEF) has investigated and collected a number of data sets for use in future hydrologic and hydraulic modeling verification for the Pinnacle Peak West (PPW) ADMS. This memorandum summarizes the model verification data collected and/or available for this purpose.

GARR, Gage Data, Streamflow

JEF reviewed the District maintained rain gage data for several storms affecting the PPW ADMS area. Several storms have occurred in the recent years within the study area have had either a substantial rainfall intensity, total precipitation depth, known flooding occurrences, or some combination of each. Storms of interest include:

- August 3, 2005
- August 24, 2006
- September 9, 2006
- July 31, 2007
- January 28, 2008
- January 21, 2010

Figure 1 depicts the location of District maintained rain gages within or near the ADMS boundary. The storm total precipitation depth is also shown for each of the storms of interest. The District has already obtained Gage Adjusted Radar Rainfall (GARR) for each of these storm events. It is understood that some or all of these storms will eventually be run in the project FLO-2D models to

compare to known flooding information that was observed on the ground during or immediately following the storm event.

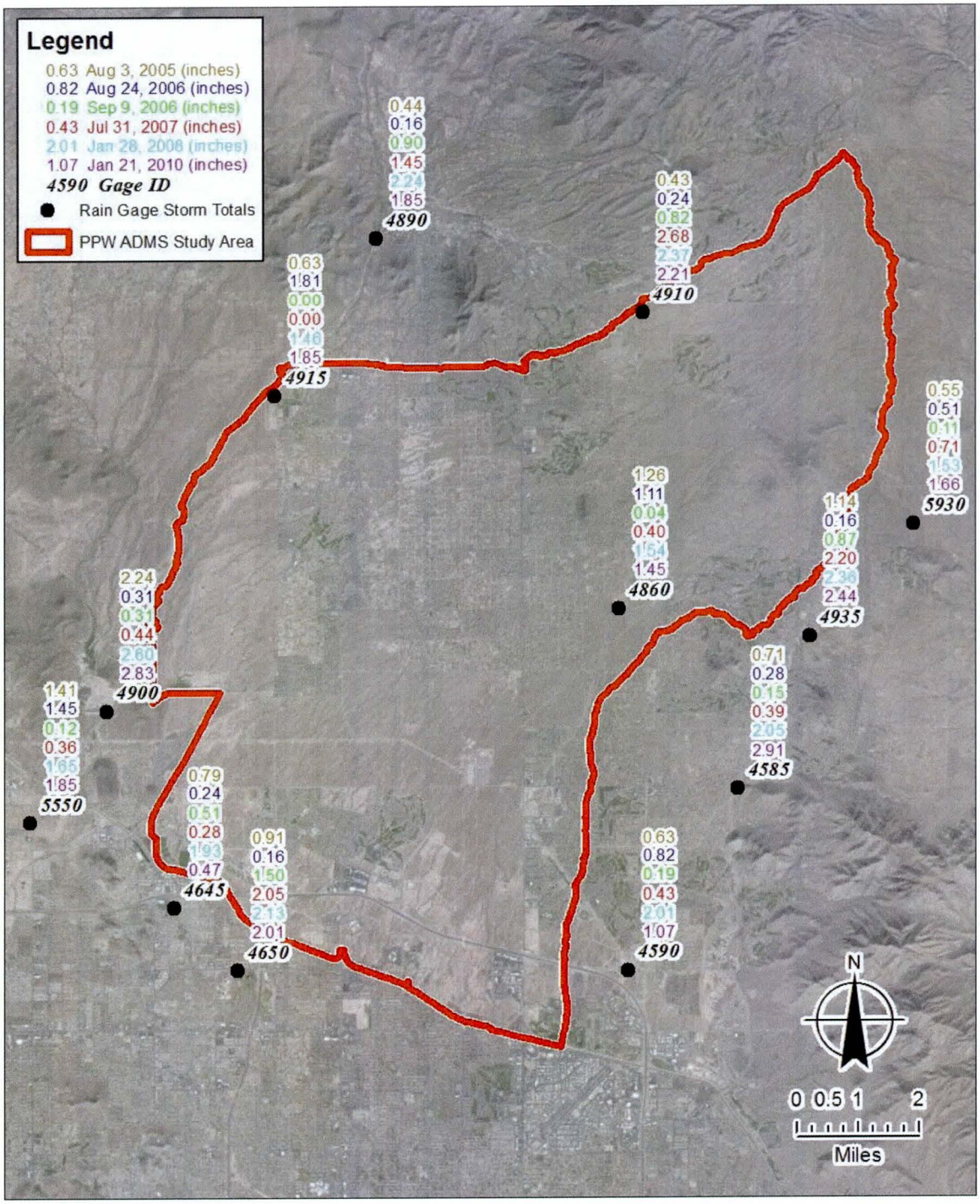

Figure 1. Rain Gage Storm Totals in the Vicinity of the PPW ADMS

There are currently two streamflow gages in the study area - Rawhide Wash (FCD ALERT Gage ID 4863) and Stagecoach Wash (FCD ALERT Gage ID 4913). The Rawhide Wash gage was installed in July 1999. The maximum flow rate recorded during these 12+ years of record is 446 cfs from the 9.2 square mile drainage area. This occurred on September 9, 2006. The next highest peak flow was 382 cfs which occurred on July 31, 2007. During the 12+ years of record, in 8 of those years no flow was recorded at all. According to the FCD ALERT web page for the Rawhide Wash gage, the maximum flow rate of 446 cfs is less than the 2-year flood.

The Stagecoach Wash station was installed in June 2001. During the 11 years this station has been operating, only one significant flow event has been recorded. That event occurred on July 31, 2007 when a peak flow rate of 802 cfs was recorded from the 1.12 square mile drainage area. According to the ALERT web page for Stagecoach Wash, this correlates to greater than a 100-year runoff event based on a Bulletin 17B frequency analysis of the gage record. Unfortunately, the station did not accurately record the hydrograph associated with this event. The peak was estimated based on high water marks following the flood. All flow events recorded in other years at this station were less than 50 cfs. The rainfall recorded at the Stagecoach Wash rain gage was 2.56 inches in one hour which also corresponds to a little more than the 100-year, 1-hour rainfall event at this location.

No stream gage data flood frequency analysis was conducted by JEF for these gages.

Anecdotal Verification

No public meetings or public outreach were conducted or are planned at the time of this memorandum; therefore, no anecdotal evidence has yet been uncovered. However, it is fully anticipated that some evidence will become available as the ADMS progresses and will be used for model verification if applicable.

Drainage Complaints

Reports of past drainage complaints were collected from the City of Scottsdale, City of Phoenix, and Maricopa County. Each jurisdiction maintains records of complaints made by residents and of any action that was taken. The type and nature of each complaint varies widely. Many drainage complaints are related to local drainage problems such as clogged culverts or grading permit violations. JEF sorted through all complaints collected and identified complaints that identified flooding or erosion type problems that resulted from one of the six storms of interest mentioned previously. The resulting complaints are shown spatially in Figure 2.

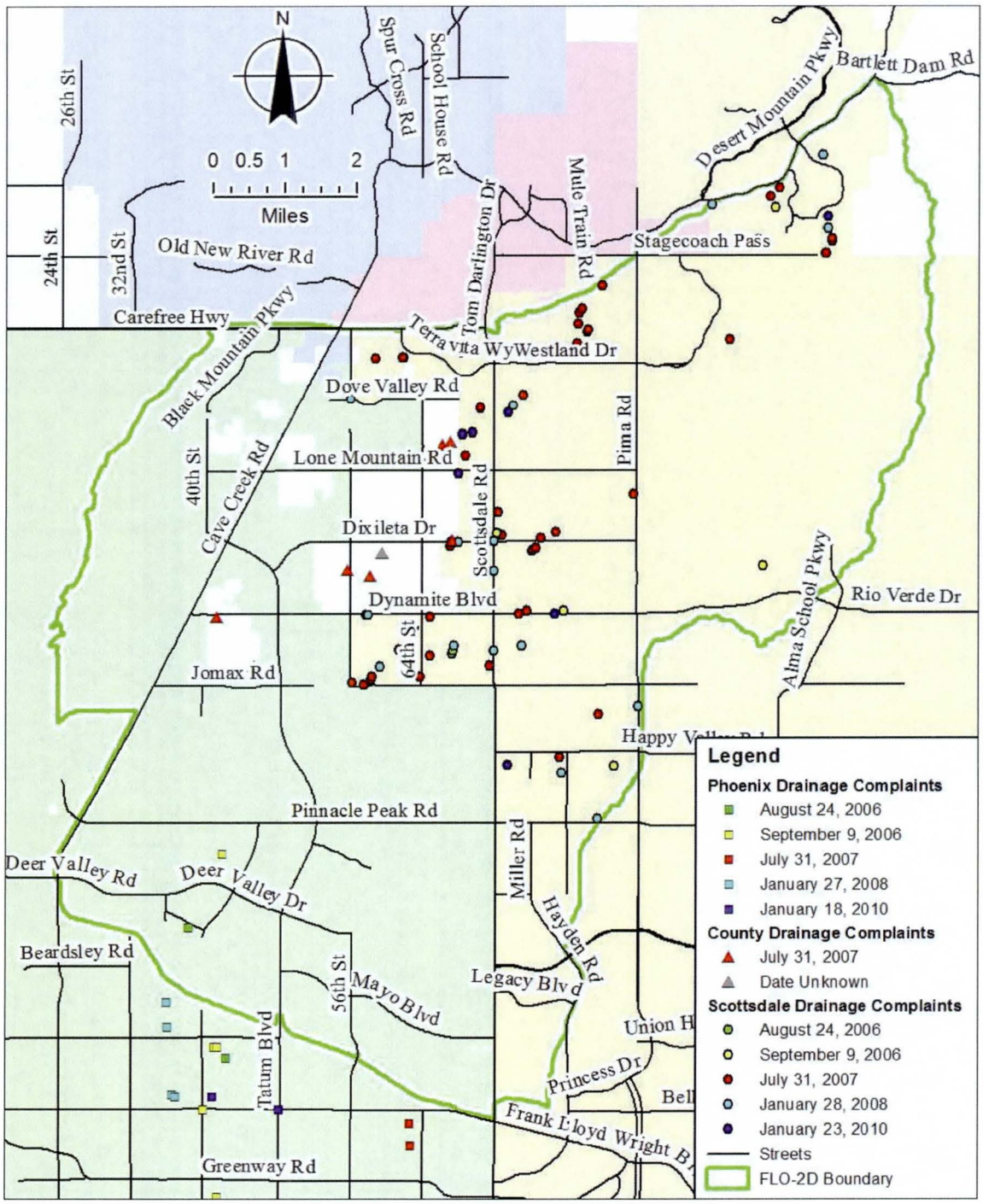

Figure 2. Past Drainage Complaints within the PPW ADMS

These complaints could be useful in model verification depending on what type of additional data can be found. JEF was provided summary data only for past drainage complaints. It is possible that additional information such as detailed descriptions of flooding locations, ponding depths, high water marks, flood photographs, etc , can be obtained from each Jurisdiction's complaint files for

the locations of interest. Therefore, it is recommended that additional research is conducted for these locations in the next work assignment. Furthermore, it may be worthwhile to add these locations to the notification list for public outreach. Residents who have experienced past flooding may be more inclined to participate in the project if they have first-hand experience with flood hazards in the area. This approach was found beneficial for the Hohokam ADMS.

NFIP Claims

Tim Murphy provided NFIP summary data within the PPW ADMS area to Theresa Pinto via email Thursday, June 07, 2012. The NFIP information has been summarized below.

The NFIP flood loss data is broken down by the zip codes within the study area. The loss data includes the zip code for where the property owner lived, not necessarily the zip code (or address) of the property that suffered the loss.

Table 1: Flood Loss Data by Zip Code

Zip Code	Number of Paid Losses				Dollar Value of Claims				Number of Claims without Payment			
	Scottsdale	Phoenix	County	TOTALS	Scottsdale	Phoenix	County	TOTALS	Scottsdale	Phoenix	County	Total
85050	0	1	0	**1**	0	1,631		**1,631**	0	0	0	**0**
85054	0	0	0	**0**	0	0		**0**	0	2	0	**2**
85255	6	0	0	**6**	28,054	0		**28,054**	19	0	0	**19**
85262	3	0	0	**3**	13,553	0		**13,553**	2	0	0	**2**
85266	6	0	0	**6**	132,910	0		**132,910**	0	0	0	**0**
85331	0	0	14	**14**	0	0	242,856	**242,856**	1	2	24	**27**
TOTALS	**15**	**1**	**14**	**30**	**174,517**	**1,631**	**242,856**	**419,004**	**22**	**4**	**24**	**50**

- Scottsdale is as of August 31, 2009
- Phoenix Data is as of June 30, 2008
- County data is as of 2011

As of 3/31/2012 there are 8,604 NFIP policies in force in the City of Scottsdale and the amount of premiums collected is $3,934,244. The total amount paid out in the City of Scottsdale is $817,783.30.

A zip code map within the study area is presented in Figure 3 for reference. According to Ashley Couch via Theresa Pinto, 30 Scottsdale residents experienced flood damage from the July 2007 storm. However, the City received over 100 drainage complaints as a result of the storm. Of the 30 properties with flood damage, only 2 of them had flood insurance coverage.

Upon further inquiry with Tim Murphy, the project team discovered that obtaining geographic specific parcel level NFIP claim data violates the Federal Privacy Act. Therefore, no past site specific flooding information will be available for model verification from past NFIP claims.

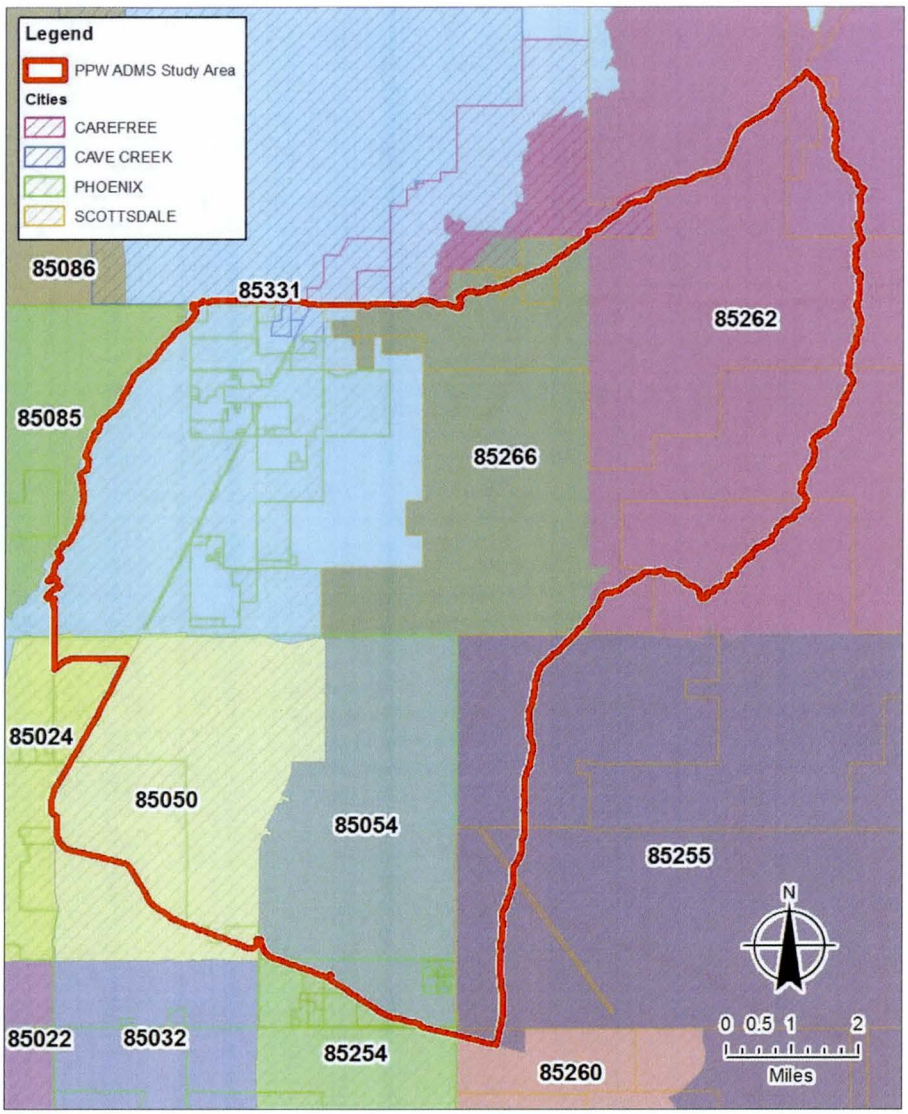

Figure 3. Zip Code Map within PPW ADMS

News Reports

JEF attempted to search the online archives of the primary network and news agencies within the Phoenix Metro area including Fox News, ABC News, and AZCentral (affiliated with NBC and the Arizona Republic). The searches for Fox, ABC, and NBC resulted in no useful information regarding the six storms of interest. AZCentral has an online archive of past Arizona Republic articles going back to 1999. The archives were searched for flooding during a 30 day period of time starting at each storm of interest's start date. Unfortunately, relatively little useful information is available from the articles obtained.

One notable finding from an article dated August 2, 2007[1] reported road closures on Pima Road, north of Lone Mountain and Happy Valley at Hayden Road. Both locations are within the project area. The article also noted a 10 people, vehicle rescue from a wash at Carefree Highway and Terravita Way. This is likely the Unnamed Central Tributary to Cave Creek. Although the flow rate and flood depths are unknown at these three locations, GARR FLO-2D models should at least result in some significant flow within these areas.

Arizona Department of Public Services Crash Data was researched to determine the type of data captured for historic vehicular accidents. Example database entries were reviewed and JEF determined very little weather related or detailed descriptions are available. The website saferoadmaps.org is a mapping application of the crash data focusing on fatalities resulting from crashes. Only two fatalities were reported within the project area (as of 08/2010 data), both had either clear or overcast weather conditions noted.

An amateur video search was conducted on Youtube.com and revealed only one likely video[2] possibly within the study area. The video is of a flooding event as a result of the August 2-3, 2005 event. A message was sent to the video poster 'PoleVaulter' asking for more information. No response has been received at the time of this memorandum.

Task 5.2.13.7 – First Responders

Maintenance personnel for Phoenix, Scottsdale, and Maricopa County were contacted to identify any information they could provide related to the storms of interest. Each Jurisdiction's maintenance department retains maintenance records in a different way.

Scottsdale

The Scottsdale Maintenance department tracks maintenance activities in a GIS database including dates and activities resulting from flooded roadways. Unfortunately, this data is only useful in confirming roadway flooding. No specific information is available regarding the time or quantity of flooding.

Phoenix

The Phoenix Street Transportation Department, Street Maintenance Division is responsible for responding to flooded roadways, placing flooding signs and barricades to warn motorists. The Maintenance Division keeps records of the location of sign placement, direction, and general time duration of the work crew. Only records for the 2005, 2007, and 2008 storm events were provided. This information can assist with the general location of flooded roads during these storms and narrows the time window down for verification of inundation to several hours.

Maricopa County

The Northeast District Operation & Maintenance Department of Maricopa County keeps similar records as that of Phoenix. The records indicate the limits of the flooded roadway, the time of the barricade request, and the time of barricade placement on the road.

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[1] Storms Keep Workers Hopping, August 2, 2007, Scottsdale Republic North,
[2] http://www.youtube.com/watch?v=JkWh50e7_X8&feature=plcp

The Phoenix and Maricopa County data sets were digitized to depict the spatial locations of each record. All three jurisdictional data sets are presented in Figure 4 (with data shown for all storm events). Although this data cannot be used alone for quantitative GARR FLO-2D model calibration, it can at least be used to verify the approximate location of flooding.

Summary and Recommendations

Relatively little hard evidence of flood depths or discharge resulting from the six storms of interest was uncovered during this cursory investigation. Therefore, the model verification for the PPW ADMS FLO-2D modeling is going to be heavily reliant on anecdotal evidence collected during public outreach activities. Therefore, we recommend the following activities be conducted during the next work assignment:

- Further drainage complaint research for complaints resulting from the storms of interest
- Invite past complainants to public meetings/workshops
- Solicit past flood problems from residents during public meetings or on the project websites (e.g. www.floodtalk.org)
- As a last resort, conduct further research of the News Media for past flood video footage

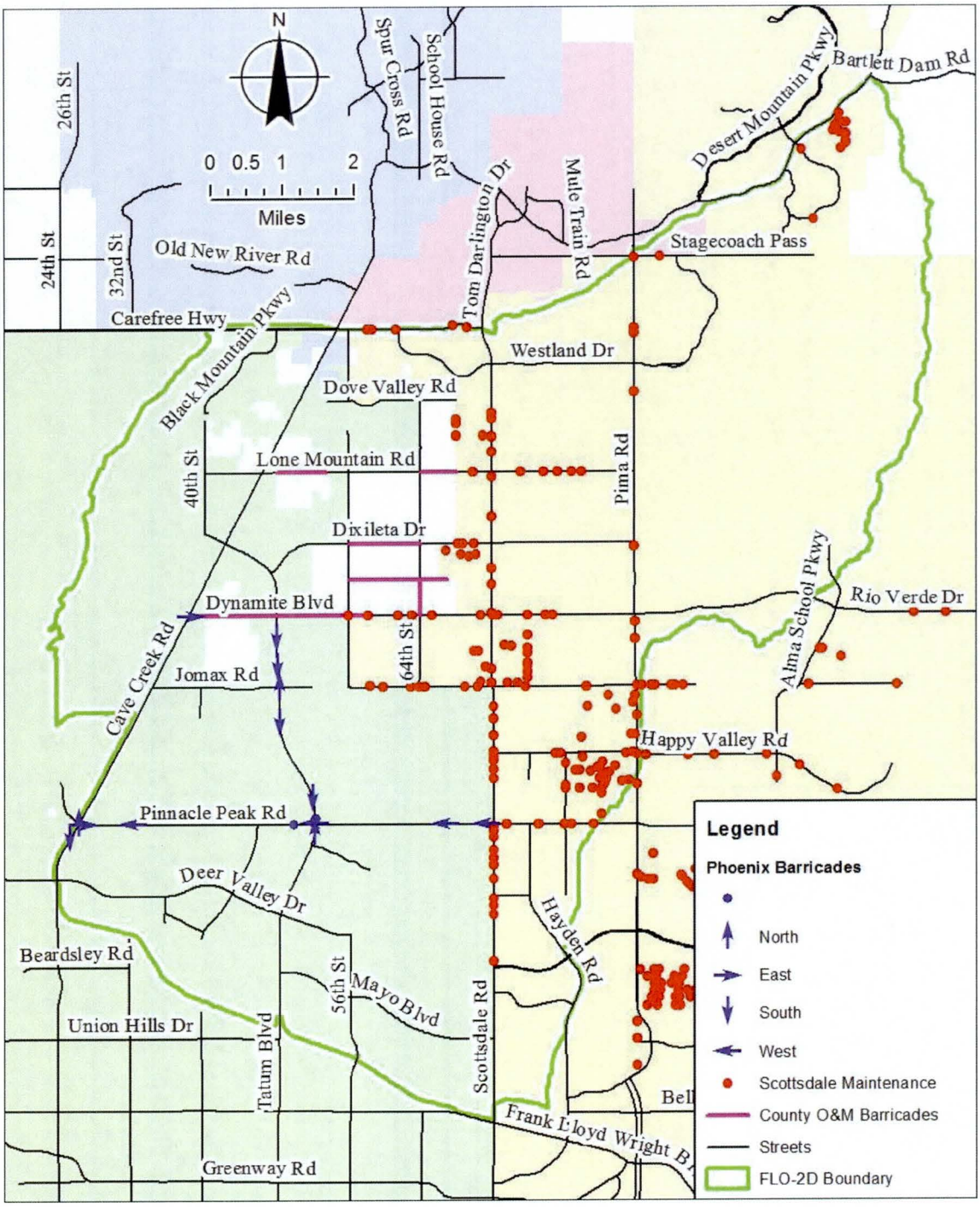

Figure 4. Location of Storm/Flood Related Response & Maintenance Activities