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Draft Hydrology and Hydraulics Report

Stormwater Management Master Plan Update (SWMMP) – Phase 1

DRAFT

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1 Introduction

1.1 Purpose of Study

The purpose of the City of Scottsdale (the city or COS) Stormwater Management Master Plan (SWMMP) was to aggregate and update the existing FLO-2D models completed as a part of various Area Drainage Master Studies/Plans (ADMS/ADMP) by the Flood Control District of Maricopa County (FCDMC) within the city. The city wants to evaluate and model existing systems in order to assess the condition of existing drainage infrastructure. This includes assessing adequacy and capacity, developing a comprehensive plan that identifies and characterizes improvements to provide mitigation for the 10-year return period or greater, and to identify and understand implementation timelines and associated costs.

As a part of SWMMP, the city intends to prepare a city-wide FLO-2D model using a combination of multiple FLO-2D and HEC-1 models prepared over the period between 2007 and 2023. Following is a list of previous ADMS/ADMPs and other FLO-2D models within the city's jurisdictional limits or contribute watershed within city limits.

- Desert Mountain (DM)
- Pinnacle Peak South (PPS)
- Pinnacle Peak West (PPW)
- East Shea Corridor (ESC)
- Middle Indian Bend Wash (MIBW)
- Lower Indian Bend Wash (LIBW)
- Upper East Fork Cave Creek (UEFCC)
- Rio Verde (RV)
- Fountain Hills (FH)
- Granite Reef (GR)

Per Michael Baker International's (MBI) research of previous ADMS and per initial scoping meetings with the city, it was identified that Pinnacle Peak South (PPS) ADMS should be revised due to change of flows at apex, to update the grid size to be consistent with other ADMS, to eliminate extensive overlap with Pinnacle Peak West (PPW), and to eliminate other discrepancies identified by the city. The offsite contributing area to PPS was studied by HEC-1 model. There is area along the eastern boundary of the city that is not covered by previous ADMS. The city directed MBI to revise PPS ADMS, convert the PPS offsite model from HEC-1 to FLO-2D model, and prepare a new FLO-2D for area east of PPS ADMS that was not studied by previous ADMS.

The SWMMP will be executed in two (2) phases by MBI as the consultant. Following is a brief list of tasks for the two (2) phases. This report will only include Phase 1 of the project.

Phase-1:

- Data Collection
- Prepare a city-wide FLO-2D model. This task includes rerunning the ADMS models listed in Section 1.1 with new FLO-2D exe and preparing new FLO-2D for some areas.
- Prepare Hydrology and Hydraulics (H&H) Report

Phase-2:

- Identify stormwater infrastructure deficiencies and problem areas.
- Provide mitigation measures for problem areas to identify future Capital Improvement Projects (CIPs) and prepare 15% plans.
- Stake Holder meeting and Public Involvement.
- Identify tasks and define the requirements of the storm water system to achieve compliance with the city's AZPDES permit and make recommendations for conducting post-construction inspections.
- Prepare SWMMP report.

1.2 Authority for Study

Michael Baker International, Inc. (MBI) was contracted by the city under Contract Number 2023-034-COS on March 4, 2024. The contact information for the city Project Manager is provided below:

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1.3 Project Description

The following summarizes the main objectives of this project:

- Rerun of older Area Drainage Master Study (ADMS) and CLOMR models (will be referred to as previous FLO-2D models hereafter) listed Table 1.1 with new FLO-2D executable and with revised/reduced inflows from Reata Wash Apex and other contributing upstream domains. No other changes will be made to the previous ADMS/CLOMR models unless/otherwise stated.
- Update 2014 Pinnacle Peak South (updated model will be referred as New PPS) model with 20-foot grid size, 2020 USGS LiDAR for elevation sampling, and with revised/reduced inflows from Reata Wash Apex.
- Prepare a new FLO-2D model for the unstudied area east of the Reata Wash model (referred to as Rio Verde South - RVS).

The model development will include the following rainfall events and durations as specified in the scope.

- 10-year, 6-hour (10Y6H)
- 100-year, 6-hour (100Y6H)
- 10-year, 24-hour (10Y24H)
- 100-year, 24-hour (100Y24H)

The city-wide FLO-2D models and contributing offsite models include ten (10) FLO-2D domains. The models were linked by writing outflow hydrographs from the upstream models and importing them as inflow hydrographs into the downstream models. More details about model connectivity can be found in Section 7 of the report. Table 1.1 lists the type of study, year, and study area for each model domain. See Figure 1.1 for model domains.

Table 1.1: List of Existing and New ADMS/FLO-2D Studies

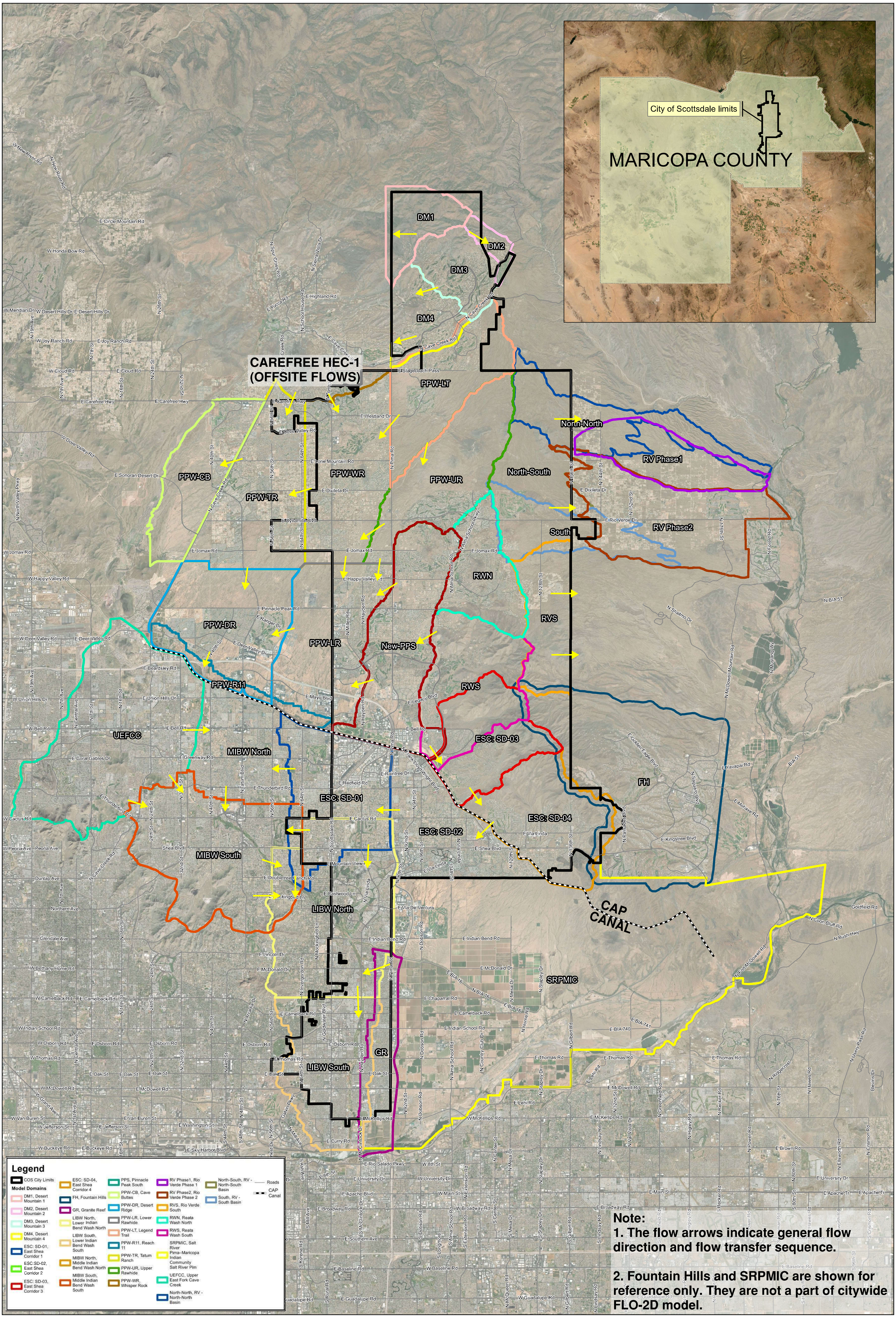
Name of Study	Type of Study & Model	Year of Study (Completed)	Study Area (sm)
Reata Wash (RW)	CLOMR/FLO-2D	2020	22
Old-Pinnacle Peak South (2014 PPS)	ADMS/FLO-2D & HEC-1	2014	43
Pinnacle Peak West (PPW)	ADMS/FLO-2D & HEC-1	2014	97
East Shea Corridor (ESC)	ADMS/P-FLO-2D	2023	51
Upper East Fork Cave Creek (UEFCC)[1]	ADMS/P-FLO-2D	2017	27
Middle Indian Bend Wash (MIBW)[2]	ADMS/P-FLO-2D	2019	34
Lower Indian Bend Wash (LIBW)	ADMS-FLO-2D	2017	31
Granite Reef Wash (GR)	CLOMR/FLO-2D	2022	6.5
Desert Mountain (DM)	ADMS-FLO-2D	2019	18
Rio Verde (RV)	ADMP	2007	40
New Pinnacle Peak South (New PPS)[3]	Hydrology Study/FLO-2D	2025	15.3
Rio Verde South (RVS)[4]	Hydrology Study/FLO-2D	2025	7.9

1. UEFCC is outside the City of Scottsdale limits but contributes flow to Indian Bend Wash, which discharges into MIBW and eventually into LIBW FLO-2D model. Therefore, UEFCC model was treated as an offsite model.

2. A very minor portion of MIBW FLO-2D falls within City of Scottsdale limits, overlapped by the East Shea Corridor FLO-2D domain. The flows from the overlapping area are referenced from the ESC model. Therefore, MIBW contributes flow to Indian Bend Wash and LIBW FLO-2D model and was treated as an offsite model.

3. Updated 2014 PPS model with a new domain boundary, new grid size, offsite flows, and input parameters as a part of the citywide FLO-2D model.

Figure 1.1 : City of Scottsdale SWMMPU – Citywide FLO-2D Domains



Michael Baker INTERNATIONAL

City of Scottsdale

Miles 1 in = 1 miles

NORTH

Scale applicable to 24 x 36 paper size

Figure 1-1 : City of Scottsdale SWMMPU – Citywide FLO-2D Domains

1.4 Location of Study

This study aims to develop a comprehensive citywide FLO-2D model that encompasses the entire jurisdictional limits of the City of Scottsdale. See Figure 1.1 above for a depiction of the jurisdictional limits of the City of Scottsdale.

1.5 Software Specifications and Methodology

The hydrologic and hydraulic modeling for this project, including both existing model reruns and new model runs, was prepared using the FLO-2D Pro Model with the executable dated April 17, 2024 (FLO-2D Pro Build No. 23.10.25). QGIS 3.28.13 and FLO-2D Plugin 0.10.115 were utilized unless specified otherwise.

The parameters and procedures used to develop the FLO-2D models follow the guidelines established in the *Drainage Design Hydrology Manual* (FCDMC, 2018) and *Drainage Design Hydraulic Manual* (FCDMC, 2018),

FLO-2D documentation including the *FLO-2D Data Input Manual - Build 23* (FLO-2D Software, 2023), the *FLO-2D Reference Manual - Build 23* (FLO-2D Software, 2023), and the *FLO-2D QGIS Plugin Technical Reference Manual - Build 23* (FLO-2D Software, 2023) were also utilized for model development.

1.6 Acknowledgements

MBI would like to acknowledge the following partners for their assistance with the analysis and review of the City of Scottsdale SWMMP.

- City of Scottsdale Floodplain Department:
  - Hasan Mushtaq, Ph.D., P.E., CFM, PMP
    Stormwater Engineering Manager/Floodplain Administrator
  - Jennifer Lynch, P.E., CFM
    Reviewer
- Flood Control District of Maricopa County:
  - Mark Frago, AICP, CFM
    Deputy Project Manager
  - Kenneth de Roulhac, PE, CFM
    Reviewer
  - Noah Johnson, CFM
    Reviewer

2. Survey and Mapping Information

2.1 Topographic Mapping Data

Previous FLO-2D models utilized topographic information relevant to model preparation at the time the study was conducted. No changes were made to the topographic information during the model reruns performed in this study unless specified. Table 2.1 lists the year the topographic information used for each study was dated.

Table 2.1: Previous Studies Topographic Information Year

Name of Study	Year
Reata Wash (RW)	2018
Old-Pinnacle Peak South (2014 PPS)	2007
Pinnacle Peak West (PPW)	1993-2010
East Shea Corridor (ESC)	2016
Upper East Fork Cave Creek (UEFCC)	2014
Middle Indian Bend Wash (MIBW)	2014
Lower Indian Bend Wash (LIBW)	2007
Granite Reef Wash (GR)	2007
Desert Mountain (DM)	2016
Rio Verde (RV)	1993-2003

For the new FLO-2D models, New PPS and RVS, the topographic data used to develop grid elevation was obtained from United States Geological Survey (USGS) 2020 3DEP LiDAR data. Grid elevations were obtained using the FLO-2D QGIS plugin average pixel elevation sampling algorithm.

The new models used horizontal datum was North American Datum of 1983 (NAD83) 2010 Epoch, State Plane Arizona Central. The vertical datum was the North American Vertical Datum of 1988 (NAVD88). The FLO-2D models were created using the horizontal datum of NAD83 HARN State Plane, Arizona Central and NAVD88 as the vertical datum.

2.2 Topographic Data Comparison

A high-level review of the topographic data of each study in comparison to USGS 2020 LiDAR data was performed. Some areas were determined to have notable elevation differences. The locations that show elevation difference and additional explanation regarding each model domain are documented in Appendix C. The main outstanding terrain conflicts were due to changes in land use/new developments compared to what was present at the time of the original study, as well as the differences in topography resolution.

2.3 Aerial Photography

The city provided aerial photos for the entire limits of the City of Scottsdale in July 2024. This aerial photography served as the basis for determining the existing conditions of the study area. Aerial photography was also used to verify the topography and Surface Feature Characterization (SFC) data.

2.4 Surface Feature Characterization (SFC) Comparison

The SFC is a shapefile which provides information about land use, structures, and other obstructions. It is an input file that is typically used in FLO-2D to characterize land use. The SFCs for both the New PPS model and Rio Verde South are discussed in detail in the respective sections, and an exhibit of each can be found in Appendix C.

The SFC comparison was performed by comparing the existing SFC files provided by the district that were used in the original ADMS models to the aerial photography provided by the city. The SFC for some of the previous models was not readily available and thus the ADMS ARF files were used to compare building footprints to aerial photography in lieu of comparing original SFC to the aerial photos. The studies that did not have an SFC readily available include Granite Reef and Lower Indian Bend Wash.

A high-level review of the SFCs of each study in comparison to the aerial photography provided by the city was performed. Some areas were determined to have notable land use differences. These locations and differences noticed are documented in Appendix C. The main outstanding land use differences noted were due to new developments that were constructed following the study date. No changes were made to the SFC unless stated in the sub-section for modeling.

2.5 Existing FEMA Floodplain Mapping

There are several flooding sources characterized as FEMA Special Flood Hazard Areas (SFHA) located in the watershed. The project area includes FEMA Zones A, AE, AH, AO, D and X. A map showing these SFHA can be found in Appendix C. The following are definitions for terms related to FEMA SFHA:

- *SFHA:* Areas identified on the Flood Insurance Rate Map are identified as SFHA are defined as the areas that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year. The 1-percent-annual-chance flood is also referred to as the base flood or 100-year flood.

- *Base Flood Elevation (BFE):* The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.
- *Zone A:* Areas subject to inundation by the 1-percent-annual-chance flood event are generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs), or flood depths are available.
- *Zone AE:* Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
- *Zone AH:* An area with flood depths of one (1) to three (3) feet (usually areas of ponding); Base Flood Elevations determined.
- *Zone AO:* An area with flood depths of one (1) to three (3) feet (usually sheet flow on sloping terrain); average flood depths have been determined. For areas of alluvial fan flooding, velocities may have also been determined.
- *Zone D:* Areas in which flood hazards are undetermined, but possible.
- *Zone X (Shaded):* Areas of moderate flood hazard between the limits of the 1-percent-annual-chance floodplain and the 0.2-percent-annual-chance floodplain.
- *Zone X (Unshaded):* Areas of minimal flood hazard outside the 0.2-percent-annual-chance floodplain.

3. Data Collection

The following is a list of the data that was scoped to be collected as a part of this project:

a. City GIS storm drain, culvert, and other utility files as needed.
b. Pertinent drainage reports and ADMS reports from the City and FCDMC.
c. City of Scottsdale, Town of Paradise Valley, Town of Fountain Hills, City of Tempe, City of Phoenix, and Salt River Pima-Maricopa Indian Community (SRPMIC) – stormdrain, waterline, sewer, and other utility as-builts as needed.
d. FCDMC and City of Scottsdale past studies (ADMS and ADMPs) and models shown in.
e. Drainage Studies, HEC-1, and FLO-2D models for SRPMIC area.
f. USGS (2020) 3DEP LiDAR.
g. NRCS Soil data with parameters from FCDMC.
h. SFC layers from past studies from FCDMC.
i. Aerial photography from the city.
j. Flooding Complaints and historic flooding photos that were not collected previously as a part of past ADMS/P studies shall be collected within the city limits during Phase 1.
k. Any recent Hazard Mitigation Plans and Flood Response Plans developed by the City.

MBI approached the above references agencies for data request. SRPMIC was approached and stated that all information pertaining to Granite Reef Study was provided to the city and MBI had already received it. A table containing all data collected as a part of this project can be found in Appendix D.

Additionally, MBI performed site visit in Rio Verde South Watershed to assess field conditions of culverts to inform development of the detailed FLO-2D model. The site visit notes are included in Appendix B.

4. Flooding Complaints

Flooding complaints were gathered during the data collection phase of this project. A meeting between MBI and city Public Works was also held in order to obtain more information regarding flooding complaints throughout the city. Complaints were then organized into three (3) zones as identified in the city's Flood Response Plan: North Flood Zone, Central Flood Zone, and South Flood Zone. See Appendix C for an exhibit of these complaints.

5. Previous Studies

For this project a total of ten previously published FLO-2D studies were collected and analyzed. Table 5.1 lists the type of study, year, study area, number of domains, and grid size for each model domain.

Table 5.1: List of Existing ADMS/FLO-2D Studies

Name of Study	Type of Study & Model	Year of Study	Study Area (sm)	# of Sub-Domains	Grid Size	Location with respect to CAP
Reata Wash (RW)	CLOMR/FLO-2D	2020	22	2	20	North-CAP
Old-Pinnacle Peak South (2014 PPS)	ADMS/FLO-2D & HEC-1	2014	43	1	30	North-CAP
Pinnacle Peak West (PPW)	ADMS/FLO-2D & HEC-1	2014	97	8	20	North-CAP
East Shea Corridor (ESC)	ADMS/P-FLO-2D	2023	51	4	15	North-CAP
Upper East Fork Cave Creek (UEFCC)[1]	ADMS/P-FLO-2D	2017	27	1	20	South-CAP
Middle Indian Bend Wash (MIBW)[2]	ADMS/P-FLO-2D	2019	34	2	20	South-CAP
Lower Indian Bend Wash (LIBW)	ADMS-FLO-2D	2017	31	2	20	South-CAP
Granite Reef Wash (GR)	CLOMR/FLO-2D	2022	6.5	1	15	South-CAP
Desert Mountain (DM)	ADMS-FLO-2D	2019	18	4	10	North-CAP
Rio Verde (RV)	ADMP	2007	40	2	25	North-CAP

1. UEFCC is outside COS limits but contributes flow to Indian Bend Wash, which discharges into MIBW and eventually into LIBW FLO-2D model. Therefore, UEFCC model was treated as an offsite model.

2. A very minor portion of MIBW FLO-2D falls within COS limits, overlapped by the East Shea Corridor FLO-2D domain. The flows from the overlapping area are referenced from the ESC model. Therefore, MIBW contributes flow to Indian Bend Wash and LIBW FLO-2D model and was treated as an offsite model.

6. Modeling Standards, Key Decisions

The citywide model is a combination of multiple FLO-2D, and HEC-1 models prepared over a period between 2007 and 2022. Due to the wide-time range of studies and updates to FLO-2D engines, several modeling challenges were encountered. Monthly meetings with FCDMC and the city were held to discuss these challenges. In addition, FCDMC reviewed draft report and models (submitted on 05/04/2025) and provided review comments. Some of comments were discussed and resolved with FCDMC. Following is a list of modeling standards and deviations; key decisions and special issues and resolutions related to the citywide model.

6.1 Modeling Standards

The objective of this modeling effort is to develop and prioritize Capital Improvement Projects. As such, they are not held to the same standards required for a typical Area Drainage Master Study/Plan conducted under FCDMC guidelines. While the COS SWMMPU citywide model utilizes FLO-2D, it is important to note that the comprehensive FLO-2D modeling was specifically designed to support CIP prioritization. Accordingly, this study aims to update the models using the latest FLO-2D executable where applicable.

- The new FLO-2D models for PPS and RVS meet the FCDMC's minimum volume conservation requirements of 0.001%. However, finer model refinements (wash bottom delineation, mountainous area "n" value adjustments, ponded area "n" values) were not performed as they are not within the scope of this study.
- FLO-2D Debug tool and FCDMC's checklist were used for the new models only i.e., New PPS and RVS models to perform QA/QC. Additional QA/QC were performed for the rest of the models and explained in the domain sections as necessary.
- It should be noted that the previous ADMS and CLOMR FLO-2D models have already been reviewed by FCDMC during their respective study phase. The previous FLO-2D models were rerun with the new FLO-2D exe and were reviewed to ensure that there were no fatal errors and that flow transfers between the models were done correctly. Minor errors or warnings were not addressed as a part of COS SWMMPU as they were either existed from previous FLO-2D models, or they are result of use of new executable. Additionally, the level of effort to address these minor comments and resultant change in the results were taken into consideration while addressing the comments.
- Per the scope of the work, the new FLO-2D models (NPPS and RVS) are planning level studies to be utilized for city's future CIP program. The citywide study models use few non-standard parameters. Therefore, the model results will not be made

available on FCDMC's FLO-2D web access tool. It is anticipated that the City or other stakeholders may refine the models during the CIP/design phase as appropriate.

6.2 Key Decisions

The following is a list of key decisions made in monthly progress meetings with FCDMC and the city, through the course of the study which will be discussed in further detail in the appropriate sections of the memo.

- **Long Culverts Approach:** Models north of CAP (PPW, 2014 PPS, Reata Wash models) used long culverts to model the storm drain component. The New PPS model follows the same approach.
- **No Use of Walls:** Most of the previous ADMS FLO-2D models included the walls in their domains. This was discussed in one of the monthly progress meetings (August 29th, 2025), and it was decided that COS SWMMPU will not use walls in the COS citywide model. However, it was decided that if any of the previous ADMS models included levee embankments for the CAP and certain walls along freeways and channels that were hydraulically significant, they would be included in those models. For example, East Shea Corridor subdomains 03 and 04 included CAP embankment in the "no-walls" scenario. Therefore, the CAP embankment was included in those two subdomains of ESC. Likewise, Middle Indian Bend Wash included some walls along the freeways which are included in current study's MIBW models.
- **Flow Exchange:** FEMA-approved Reata Wash models were used to derive flows at the apex estimated by the Reata Wash North domain. Reata Wash CLOMR (dated Aug 2020 prepared by Wood Patel) estimated the 100-year storm event flow at the apex to be approximately 7,170 cfs. This newly estimated flowrate at the apex is less than the previous 100-year flow estimate of 13,065 cfs, which was used by previous ADMS models (old PPS, PPW, ESC, LIBW). However, the Reata Wash North model didn't transfer the flows at apex to Reata Wash South domain. This was discussed with the city, and it was agreed that the flows at the apex from Reata wash North model should be transferred to Reata wash south model. Therefore, flow exchange was set up between Reata Wash North and South models as a part of the citywide model.
- **Channel Modeling Changes:** FLO-2D engine went through significant changes to channel modeling during 2017/2018 timeframe. Due to this, some of the previous ADMS models with channels needed to be rebuilt completely before running with the new FLO-2D executable. Due to the extensive work involved with building the channels, MBI performed a sensitivity analysis on one of the PPW subdomains and concluded that the flowrate in channels was slightly lower with revised/rebuilt

channels run using the new executable. MBI discussed sensitivity analysis results with FCDMC and COS in the monthly meeting held on January 30th, 2025. It was decided to run the older models using the old executable. This resulted in conservative flow rates in channels. This applies to PPW, UEFCC and any other domains with channels that used an older FLO-2D engine. Additional details of the Channel Sensitivity analysis are included in Appendix C.

- **Volume Conservation:** Volume conservation error for ADMS model reruns with new exe and the new models (New PPS and RVS) will be maintained within FCDMC's threshold of 0.001% unless otherwise noted.
- **The original Rio Verde ADMS** was prepared using a FLO-2D and HEC-1 models with NOAA Atlas 2 rainfall depths. This area has very little development within the city limits, and it flows east towards the Verde River. Some portion of the study within the city limits is covered by a HEC-1 model. Since this area does not contribute to other FLO-2D models within the city, and the majority of the watershed was anticipated to be not developed, it was decided by the work group (FCDMC, COS and MBI) to update rainfall depths to NOAA Atlas 14 for the HEC-1 models.
- **NOAA Rainfall Depths:** Per scope NOAA Atlas14 rainfall depths were to be applied to new FLO-2D models created as a part of subject study. The previous ADMS were done during different time frames and thus, each study utilized rainfall depths from NOAA Atlas 14 pertinent to that study. As the current study performed FLO-2D simulation for the four (4) storm events required per study scope, to maintain the same source of rainfall for all four storm events and for all ADMS models, NOAA Atlas 14 (Version 5, Volume 1) obtained from NOAA website has been used for all FLO-2D simulations performed by subject study. This was discussed in one of the monthly progress meetings (March 27th, 2025), and the city concurred with use of NOAA Atlas 14 rainfall depths obtained from NOAA website (will be referred to as NOAA Atlas 14 rainfall depths hereafter). A table listing rainfall depths from previous ADMS models to current study rainfall depths is included in Appendix D and the NOAA rainfall datasets are included in Appendix E. For modeling purposes, the NOAA Atlas 14 maximum point rainfall depth (within each domain/sub-domain) was applied to all the new and previous FLO-2D models. The NOAA rainfall raster was used to sample rainfall depth area reduction factors, and the RAINBUILDING parameter was set to 1. The FCDMC Pattern 1 distribution was used for the 6-hour storm, while the SCS Type II distribution was used for the 24-hour storm.
- **Special Issues and Resolutions:** Few special issues were encountered with some of the models which were coordinated with the city and FCDMC to arrive at

resolutions. The special issues are discussed in individual model descriptions under Section 7 and summarized in Section 8.

7. FLO-2D Modeling

As a part of the current study, ninety-six (96) FLO-2D model simulations were performed. Each ADMS FLO-2D model is discussed in the following sections.

As per the scope, all FLO-2D models are run for the four storm events (10Y6H, 100Y6H, 10Y24H and 100Y24H). The 24-hour storm duration models used a simulation time of 36 hours and the 6-hour storm duration models used a simulation time of 12 hours respectively. The timestep was set to 0.1 hours.

The flowrates for each model are compared for 6-hour and 24-hour storm durations to arrive at governing storm. A model inventory table listing all the FLO-2D simulations and the governing storm for each FLO-2D model is included in Appendix D.

The previous models are rerun with new exe, NOAA Atlas 14 rainfall depths, without walls (unless and otherwise specified) and updated inflows as applicable. No other changes are made to the previous models unless otherwise specified. Typical warnings are noticed in the model runs (ERROR.CHK). A table with typical warning and an explanation of each warning is listed in the table included in Appendix D.

An approach memo was submitted to FCDMC in October 2024 to outline the new domain boundaries for the New PPS and RVS model and FLO-2D modeling methodology and no major comments were received with regards to modeling approach. A response to these comments were provided to FCDMC which is also included in Appendix A for reference.

In February 2025, draft 100Y24H models were submitted for the North CAP models (New PPS, Rio Verde South, Reata Wash, East Shea Corridor and Desert Mountain FLO-2D models and Rio Verde HEC-1 models). FCDMC provided comments for New PPS and Rio Verde South models which are addressed in current model submittal. Responses to comments are included in Appendix A.

Since the city-wide FLO-2D model is a planning level study, the scope of work did not include calibration of models.

7.1 Model Connectivity

Based on the location of the model(s) with respect to Central Arizona Project (CAP) diversion canal, the COS SWMMPU FLO-2D models are categorized as north of CAP and south of CAP models. Refer to Figure 1.1 for a depiction of the models divided by the CAP. The following Table 7.1 and Table 7.2 list model connectivity. Please note that tables only list connectivity between adjacent ADMS models. Each of which contains multiple sub-domains. Detailed discussions on the flow transfer between the domains and sub-domains of each ADMS model, as well as their connections to adjacent domains and sub-domains, are provided in subsequent sections of the report.

7.1.1 North CAP Models Connectivity

Table 7.1 lists the models located north of CAP, including their upstream and downstream connectivity.

Table 7.1: North CAP Models Connectivity

Model Name	Upstream Model	Downstream Model
Desert Mountain	Stand Alone Model	Stand Alone Model
Rio Verde South (RVS)	Stand Alone Model	Stand Alone Model
Rio Verde HEC-1	Stand Alone Model	Stand Alone Model
*Reata Wash (RW)	None	New Pinnacle Peak South (New PPS) and East Shea Corridor (ESC)
New Pinnacle Peak South (New PPS)	Reata Wash (RWS-Condition-2)	Pinnacle Peak West (PPW)
Pinnacle Peak West (PPW)	New Pinnacle Peak South (New PPS)	None
East Shea Corridor (ESC)	Reata Wash (RWS-Condition-1)	MIBW and LIBW

**The Reata Wash South model (RWS) was modeled for two conditions. RWS Condition-1 contributes flow to East Shea Corridor (ESC); RWS Condition-2 contributes flow to New PPS model.*

7.1.2 South CAP Models Connectivity

Table 7.2 lists the models located south of CAP, including their upstream and downstream connectivity.

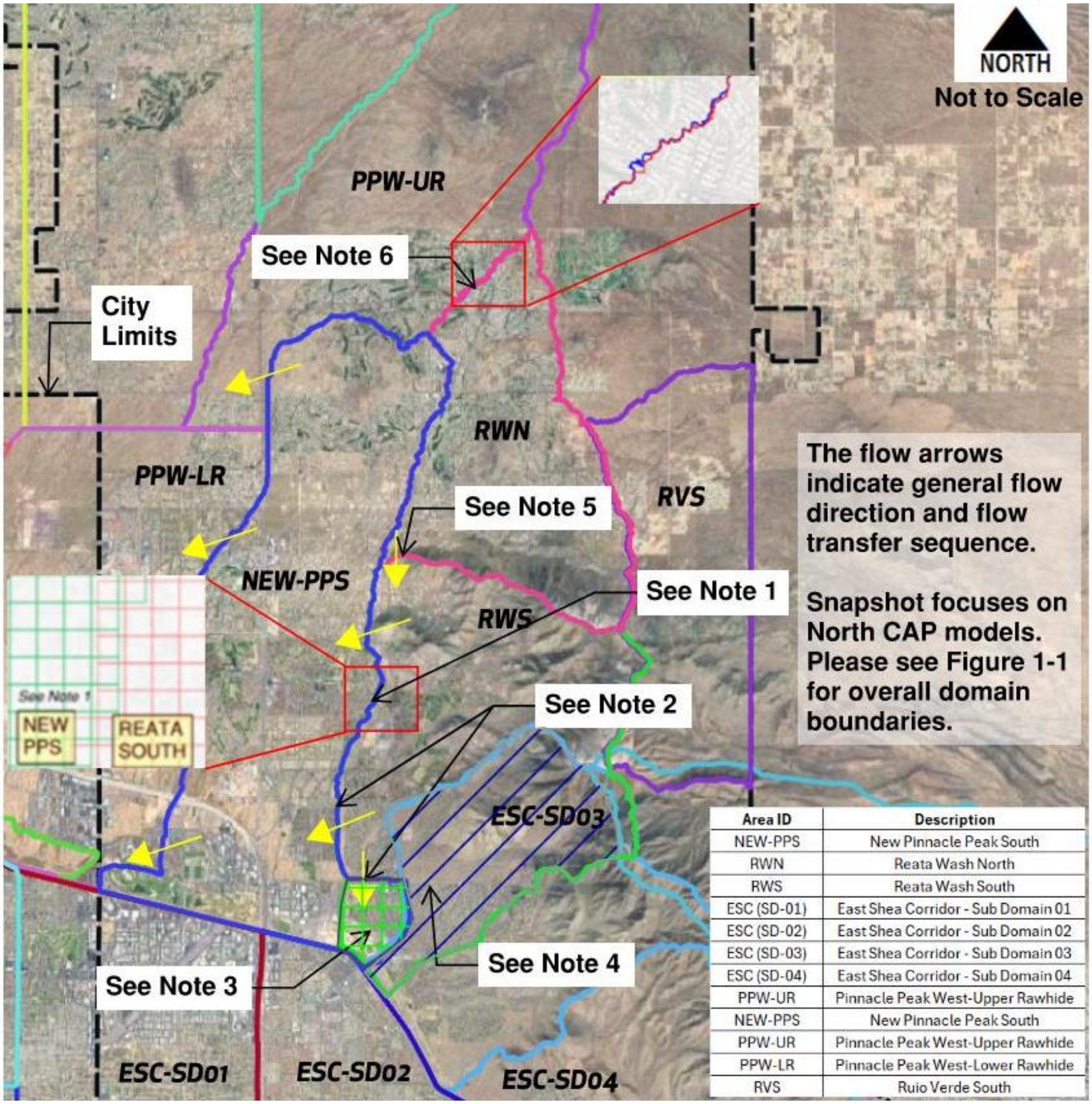
Table 7.2: South CAP Models Connectivity

Model Name	Upstream Model	Downstream Model
Upper East Fork Cave Creek (UEFCC)	None	MIBW
Middle Indian Bend Wash (MIBW)	UEFCC	LIBW
Granite Reef	*Offsite flows from SRPMIC	LIBW
LIBW	Granite Reef, East Shea Corridor, MIBW	None

**The Granite Reef CLOMR FLO-2D models were available for all required storm events along with associated offsite flows.*

7.2 North of CAP Model Boundary Overlaps:

As the various ADMS projects were performed during different time frames, each study established its own study/model boundaries as relevant to that study. Due to this, some of the adjacent studies had overlapping boundaries. For example, there are overlapping areas between Reata Wash South model and East Shea Corridor Model sub-domain SD-03. Likewise, there was an overlapping area between the Reata Wash South model and New PPS model. Figure 7.1 shows the overlapping areas and identities which study should be used for identifying flooding issues to plan mitigation projects if there are overlaps.



Area ID	Description
NEW-PPS	New Pinnacle Peak South
RWN	Reata Wash North
RWS	Reata Wash South
ESC (SD-01)	East Shea Corridor - Sub Domain 01
ESC (SD-02)	East Shea Corridor - Sub Domain 02
ESC (SD-03)	East Shea Corridor - Sub Domain 03
ESC (SD-04)	East Shea Corridor - Sub Domain 04
PPW-UR	Pinnacle Peak West-Upper Rawhide
NEW-PPS	New Pinnacle Peak South
PPW-UR	Pinnacle Peak West-Upper Rawhide
PPW-LR	Pinnacle Peak West-Lower Rawhide
RVS	Ruio Verde South

Figure 7.1 : North CAP Model Boundaries and Flow Transfers

Note 1: *Approximate 1-grid overlap between Reata Wash South (RWS) and New PPS domain for most part along the common boundary. Both domains use 20-ft grid size.*

Note 2: *Flow from RWS to New PPS model was facilitated by FLO-2D flow transfer tool.*

Note 3: *At the southeast corner of the New PPS model there is an overlapping area between New PPS and RWS models. There is flow exchange from RWS to New PPS model along the common boundary. However, at the intersection of east Westworld Way and east McDowell Mountain Ranch Road, flows from New PPS model enter RWS model. To avoid looped flow transfer between the models. The New PPS model domain was extended into RWS domain at the southeast corner. This approach leads to overlapping of models, but it eliminates looped flow transfers between RWS and New PPS models. Since flows are transferred from RWS model to New PPS model, the flows within the overlapping area should be obtained from the New PPS model.*

Note 4: *There is a large overlap between East Shea Corridor-subdomain SD-03 (15-ft grid size) and Reata Wash South domain (20-ft grid size). Flows from a portion of overlapping areas from ESC traverse towards RWS model location along the northerly border. The studies were done during the same time by different consultants. Since RWS covered the overlapping area, it does not depend on ESC SD-03 model for inflows. The flow from ESC SD-03 from overlapping area leaves the grid and doesn't contribute to any downstream models. Thus, the overlapping area between RWS and ESC SD-03 was not an issue. Any mitigation projects in the overlapping area may use conservative flows out of the two studies.*

Note 5: *Flows at the apex from RWN sub domain are transferred to RWS sub domain by using FLO-2D flow transfer tool.*

Note 6: *PPW-UR and RWN domain boundaries match closely. There are areas with negligible gaps which are insignificant in size and are not believed to have any impact on the overall model.*

7.3 New Pinnacle Peak South Model (New PPS)

The revised PPS model will be referred to as the New PPS FLO-2D model. The previous PPS model was developed in 2014 (will be referred as 2014 PPS model hereafter). Current study has updated the 2014 PPS model with a new boundary and grid size. Most of the 2014 PPS modeling aspects were maintained, and no additional FLO-2D components (DATs) were added to the revised model. Refer to Figure 7.2 for the New PPS FLO-2D boundary.

7.3.1 New PPS-Grid Size

It should be noted that the 2014 PPS FLO-2D model used a grid size of 30 feet. The New PPS model has updated the grid size from 30 feet to 20 feet to match the other ADMS FLO-2D models within the city limits.

7.3.2 New PPS-Model Boundary and Flow Transfers

The New PPS FLO-2D boundary is a single domain model with an area of 16.15 square miles and contains 1,125,936 grid cells.

The 2014 PPS FLO-2D model had a large overlap with PPW FLO-2D model. The PPW FLO-2D model is located to the west and downstream of the New PPS FLO-2D model and receives inflows from the New PPS model FLO-2D domain. Similarly, the New PPS is located downstream of the Reata Wash North and South FLO-2D models and receives inflows from the Reata Wash South FLO-2D model. Refer to Figure 7.1 and Figure 7.2 for the domain boundaries and flow transfers.

Since the PPW and Reata Wash FLO-2D domains are already established spatially, the New PPS model fills the gap between them and could only maintain a 1-grid overlap with either the upstream Reata Wash model subdomains or the downstream PPW model subdomains. Therefore, New PPS FLO-2D domain was setup to maintain an exact 1-grid overlap with the PPW model subdomains (PPW-UR and PPW-LR). Consequently, the overlap between the New PPS FLO-2D model and the Reata Wash models is slightly less than 1-grid size. However, the New PPS grids and the Reata wash model grids are aligned close enough to allow the use of FLO-2D automated flow transfer.

The 2014 PPS FLO-2D model received inflows from an offsite HEC-1 model that covered the drainage area east of the PPS model. This offsite HEC-1 model was replaced with FLO-2D models from Reata Wash and Tributaries Hydrology Study - CLOMR application prepared by Wood Patel in May 2020. The CLOMR was prepared to calibrate the contributing flows to Reata Wash, including the flows at the apex of the Reata Wash alluvial fan, and was reviewed and approved by FEMA. The Reata wash watershed area was divided into two FLO-2D models (Reata Wash North and Reata Wash South). Consequently, the flow from the Reata Wash South FLO-2D model Condition-2 was used as inflows for the New PPS model. A culvert daylights at the boundary of New PPS boundary, north of Bell Road and east of N 100th street. To facilitate flow transfer from the culvert a floodplain cross section (FPXSEC-95) was added at the downstream of the culvert in RWS model. The flow from FPXSEC 95 was added to INFLOW.DAT which includes inflow from Reata Wash South condition-1 and from flow from FPXSEC 95.

At few locations along the shared boundary between NPPS and Reata Wash South (RWS), flow from NPPS drains toward RWS, resulting in a cyclic flow pattern. To prevent ponding in these areas, outflow nodes were added along the eastern boundary of NPPS to allow excess water to exit the grid. This is considered interim approach until Reata Wash improvements are constructed, which will reduce flows from NPPS to RWS. This issue was discussed with the City and FCDMC during the comment resolution meeting on July 31, 2025. For additional details, refer to Section 8.

Flow from NPPS typically discharges into PPW-LR. At the southwest tip of NPPS, flow from PPW-LR re-enters the NPPS domain and ponds near the CAP embankment, particularly within the golf course area (see Figure 8.2). Results in this area are considered approximate due to the lack of existing development. Future studies should evaluate and account for flows originating from PPW-LR.

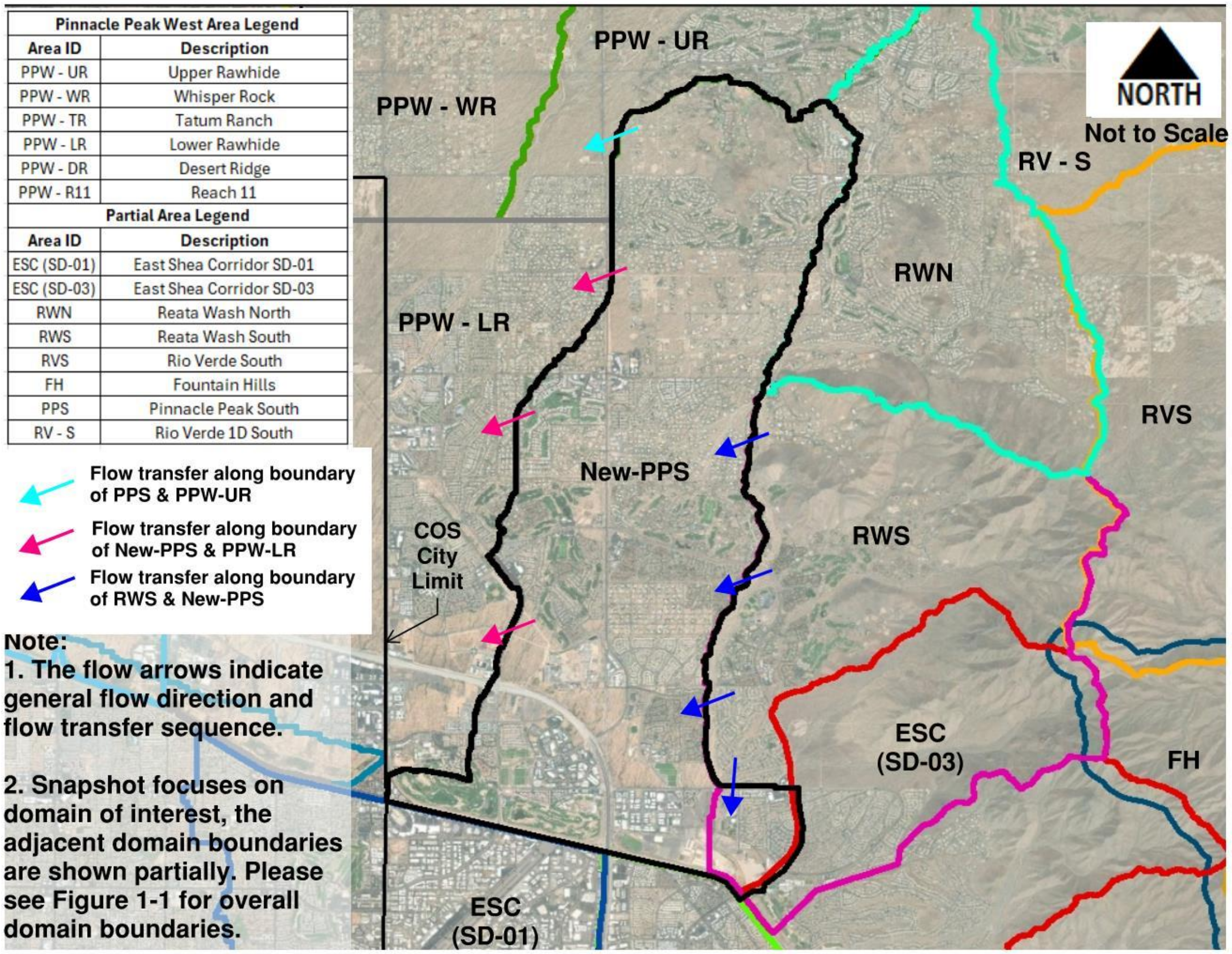


Figure 7.2 : New PPS FLO-2D Model Domain

7.3.3 New PPS-Model Elevation Data (FPLAIN.DAT)

The topographic data used for New PPS model grid elevation sampling was based on USGS 2020 3DEP LiDAR data with a 1-meter resolution. Grid elevations were obtained using the FLO-2D QGIS plugin average pixel elevation sampling algorithm.

7.3.4 New PPS – Area Reduction Factors (ARF.DAT)

Area Reduction Factors (ARF) were used to model the effect of building structures on flow conditions. The blocked areas shapefile was created by extracting building footprints from the 2014 SFC. Additional building footprints identified in the city's building shapefile were added to the blocked areas shapefile, which was then used to sample ARFs.

ARF grid values were obtained using the FLO-2D QGIS plugin reduction factors grid sampling algorithm. Width Reduction Factors were set to zero (0) to be consistent with all FCDMC studies. All ARF values greater than 0.9 were assigned a value of 1 to eliminate minimal open conveyance areas within grids that are mostly blocked by obstructions. Inflow/Outflow grids were modified or removed if they coincide with ARF values to prevent data input conflicts.

7.3.5 New PPS – Roughness and Losses (MANNINGS.DAT & INFIL.DAT)

SFC (Land Use Characterization Map) and Soils shapefiles were obtained from the 2014 PPS ADMS FLO-2D model. According to the 2014 PPS ADMS report, the soils map was obtained from FCDMC, and the land use map was prepared using the city's GIS zoning database. The 2014 PPS ADMS FLO-2D model used higher roughness coefficients and modified SFC parameters, which differ from the typical recommended SFC parameters and roughness coefficients per FCDMC's FLO-2D verification report (May 2016). The New PPS FLO-2D model used the typical FCDMC roughness coefficients and SFC parameters as listed in the following table which match with adjacent ADMS prepared in recent years.

Table 7.3: PPS Model- SFC and Roughness Coefficients

Type Class	Description	IA*	RTIMP	InitSat	Manning's n-value
Asphalt	Streets and parking lots	0.05	95	normal	0.020
Buildings	Physical structures that are flow obstructions	0.05	95	normal	0.024
Concrete	Sidewalks, curb, patios	0.05	98	normal	0.016
Desert Rangeland Bare Ground	Desert Rangeland Bare Ground	0.35	0	dry	0.040
Shade Structures	Parking covers, canopies	0.05	98	normal	0.035
Unpaved road	Gravel and dirt roadways and shoulders	0.10	50	dry	0.026
Urban High Vegetation	Trees	0.10	0	normal	0.065
Urban Low Vegetation	Lawns and low shrubs	0.10	0	normal	0.045
Wash Bottom	Natural wash and river bottoms	0.10	0	dry	0.035

**IA was adjusted to deduct TOLGLOBAL (0.048 inches = 0.004 ft) to arrive at IA-Adjusted value*

Rainfall losses were estimated using Green-Ampt method. Green-Ampt rainfall loss parameters were assigned from the NRCS Soil and SFC files referenced from the 2014 PPS model. The SFC was revised (as detailed in above sections) to include any new developments in the domain by incorporating a roof prints shapefile found on the city

GIS open source. The NRCS Soils file was updated to include spatial infiltration DTHETA Dry, DTHETA Normal, and PSIF parameters by using ArcGIS field calculator import using the *.CAL files provided by the FCDMC. The FCDMC informed MBI that the projects that used soils data developed prior to December 2022 using the 0.10.115 plugin require some of the G&A parameters that needed to be calculated outside the QGIS Plugin. Since the New PPS model uses soils data from 2014 PPS model, DTHETA and PSIF were calculated outside of the Plugin and the Log Area Average Calculations option in QGIS Plugin was left unchecked prior to Green-Ampt spatial sampling. The spatially varied Green-Ampt infiltration values were obtained using the FLO-2D QGIS plugin spatial infiltration sampling algorithm per the following Table 7.4

Table 7.4: New PPS Model- Green and Ampt Parameters Description

Green and Ampt Parameter	Source /Method
Hydraulic Conductivity (XKSAT)	Obtained from the Soils shapefile.
Rock Outcrop (ROCKOUT)	Obtained from the Soils shapefile.
Limiting Soil Depth (SOILD)	Set at a depth of 0.333 ft (4 in).
Initial Saturation (INITSAT)	Obtained from the Soils shapefile.
Moisture Deficit (DTHETA)	A function of XKSAT and INITSAT.
Suction Head (PSIF)	A function of XKSAT.
Vegetation Cover (VC)	Not used to adjust the RTIMP parameter.
Initial Abstraction (IA)	Obtained from the SFC shapefile and adjusted by
Subtracting the TOLGLOBAL value of 0.004 ft (0.048 in)	Obtained from the SFC shapefile and adjusted by
Percent Impervious Area (RTIMP)	Obtained from the SFC shapefile and accounts for ROCKOUT with a maximum value of 100%.

The FLO-2D QGIS plugin spatial infiltration sampling tool with applicable attributes selected is shown following Figure 7.3.

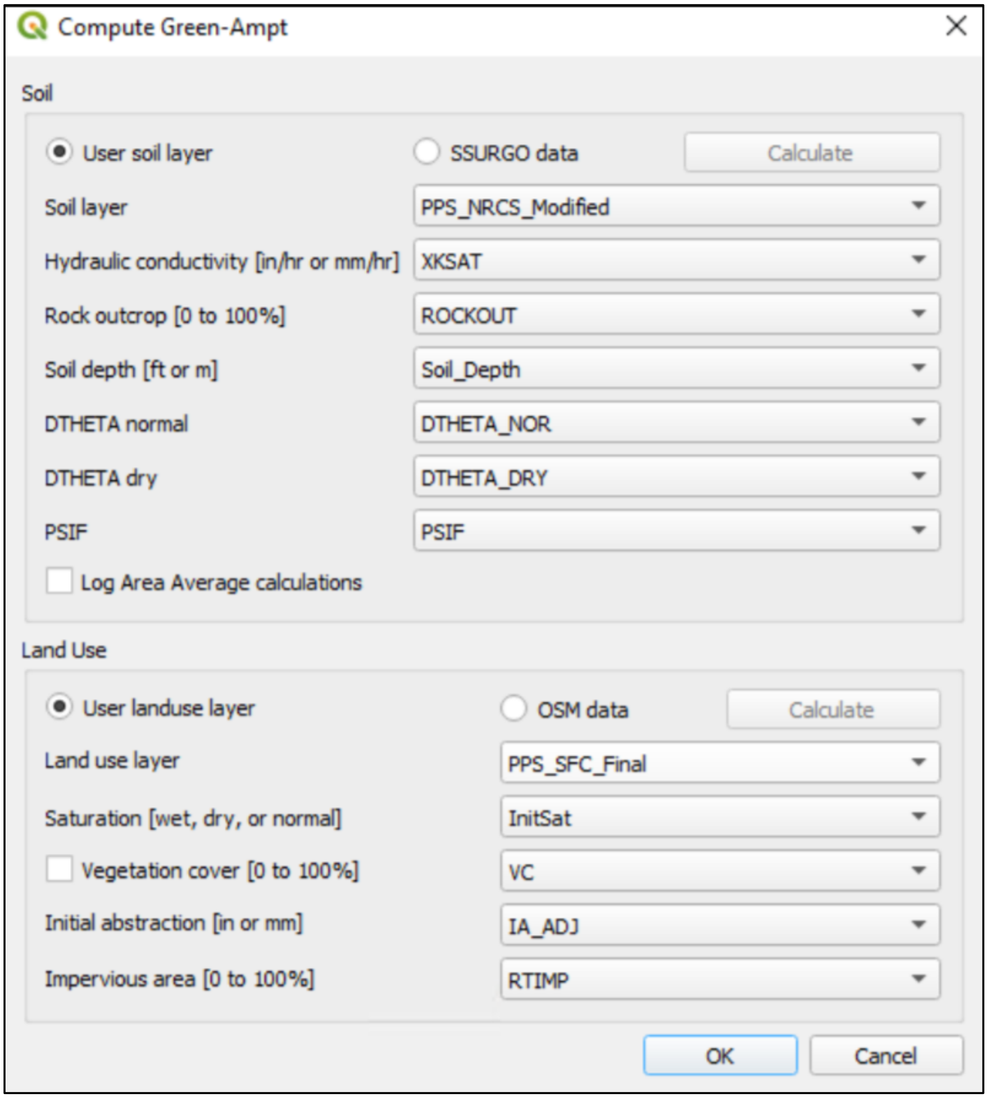


Figure 7.3 : Green-Ampt Sampling Tool

7.3.6 New PPS – Surface Feature Characterization

The New PPS model used 2014 PPS SFC with some modifications. The modifications include a few new buildings that were developed after 2014 PPS model SFC. The new building footprints were obtained from COS GIS dataset (2024). These buildings were incorporated into 2014 SFC to use for New PPS model. It should be noted that the 2014 SFC had a few areas with future development at Loop 101 and Pima road (see Figure 7.5) and at N Alma School Road and E Pinnacle Peak Pkwy (see Figure 7.4). These developments have not happened yet. Upon discussion with the city, MBI was informed that these future development areas are anticipated to occur soon and thus, they should be left as-is in the SFC.

The 2014 SFC shows a coarse outline of the future development. While the SFC may show improvements, these areas do not match the current aerials. Therefore, the mismatch of SFC to aerials is due to future development that is anticipated to occur in the near future. The 2014 SFC shows very coarsely outlined buildings and roads in these future development areas. The desert range land appears to pass through some of these future buildings and roads which is a carryover from 2014 SFC. Due to not having a layout of future developments and due to extensive revisions involved in addressing the SFC refinements, which was not within the scope of current study, no refinements to SFC are made in these future development areas.

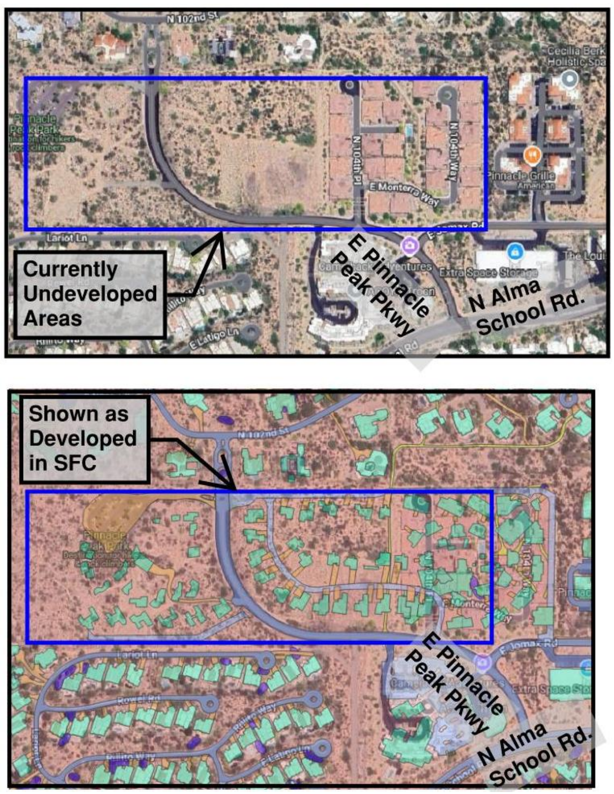


Figure 7.4 : New PPS SFC Detail at N Alma School Rd and E Pinnacle Peak Pkwy

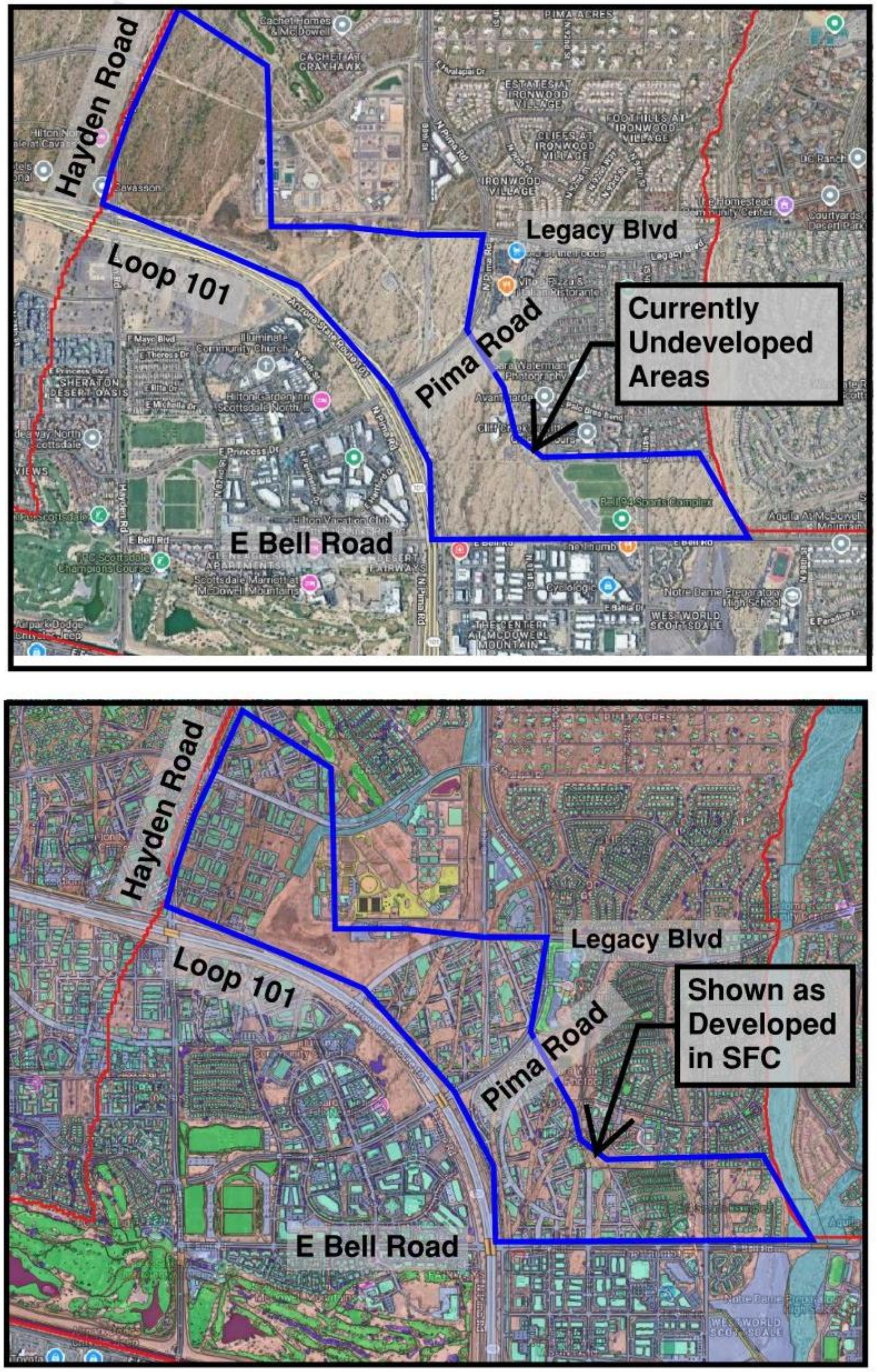


Figure 7.5 : New PPS SFC Detail at Loop 101 and Pima Road

7.3.7 New PPS – Hydraulic Structures (HYSTRUC.DAT)

Hydraulic structures with culvert diameters of 36 inches or greater were modeled in the 2014 PPS model using rating tables. Since the New PPS has a smaller boundary compared to the 2014 PPS model, the hydraulic structures that were within the New PPS boundary were included in the model along with the associated rating tables. Some new and significant culvert crossings installed after 2014 PPS model were incorporated into the New PPS model after discussion with the city. With the updated model, some of the culvert rating tables needed to be extended. With the updated QGIS plugin capabilities, the culverts that required extension of rating tables were modeled using Generalized Culvert Equation (GCE).

For the new culverts that were incorporated into New PPS models, Generalized Culvert Equations was used for single and multiple barrel culverts (pipe or box). The model includes a total of two-hundred and thirty-six (236) hydraulic structures, out of which eight (8) are modeled using generalized culvert equations (GEC) and two-hundred and twenty-eight (228) are modeled using rating tables.

The previous PPS, PPW, and Reata North and South FLO-2D models used a simplified storm drain modeling approach by incorporating them as long culverts. During one of the monthly coordination meetings with the city and FCDMC (September 26th, 2024), it was noted that most ADMS FLO-2D models north of CAP employed this simplified approach. Consequently, it was concluded that New PPS FLO-2D models will follow the same methodology for modeling some of the storm drains. Therefore, the New PPS model used this approach and incorporated long culverts using the data from the 2014 PPS model.

7.3.8 New PPS – Rainfall (RAIN.DAT)

Rainfall depths were obtained from NOAA Atlas 14 rainfall data obtained from the NOAA website. Models were developed for 10Y6H, 100Y6H, 10Y24H and 100Y24H storm events, as specified in the scope. The NOAA Atlas 14 maximum point rainfall depth was applied to the New PPS FLO-2D domain. The NOAA rainfall raster was used to sample rainfall depth area reduction factors, and the RAINBUILDING parameter was set to 1. The FCDMC Pattern 1 distribution was used for the 6-hour storm, while the SCS Type II distribution was used for the 24-hour storm.

7.3.9 New PPS – Walls (LEVEE.DAT)

As discussed in the Key Decisions Section of the report, walls will not be included in current study FLO-2D models unless otherwise noted. Therefore, the New PPS model does not include walls (LEVEE.DAT) in the model runs.

7.3.10 New PPS – Channels (CHAN.DAT)

The 2014 PPS model incorporated 1D channels. The New PPS models included these channels in the model as well. With a smaller grid size of 20-ft (compared to 2014 PPS model 30-ft grid size), the channel definition was refined with floodplain elements. However, some of the channels were narrow and shallow, which were better defined by 1D channels. Therefore, the New PPS model included 1D channels.

7.3.11 New PPS – Control and Tolerances (CONT.DAT and TOLER.DAT)

The area reduction factor, rainfall, infiltration, hydraulic structures and channel switches were turned on as applicable. A shallow n-value of 0.2 and a limiting Froude Number of 0.95 were used for the New-PPS model runs. The 24-hour storm duration models used a simulation time of 36 hours and the 6-hour storm duration models used a simulation time of 12 hours. The timestep was set to 0.1 hours. A TOLGLOBAL value of 0.004 ft (0.048 in), a Courant value of 0.6, and a TIME_ACCEL value of 0.1 were used.

7.3.12 New PPS – Model Refinements and Results

Minor model refinements were made by modifying elevations at steep elevation locations, and Froude numbers to address instabilities. However, detailed wash bottom “n” assignment, mountainous “n” value revisions or ponding areas “n” adjustments are not performed as a part of this exercise. The project scope does not include calibration/validation. Due to the reduced flows at the apex, revised grid size, revised roughness co-efficient(s) to match with typical FCDMC’s recommended values, no walls scenario, use of latest 2020 USGS LiDAR data, the flows between 2014 PPS and current PPS model are not directly comparable.

Some volume conservation errors are noticed in New PPS models. Out of the four modeled events/durations, the 10Y24H model showed a maximum volume conservation error of 0.0013% at the end of simulation and an error of 0.000054% at the peak. Since the max. error occurs past the peak time, it does not impact the peak flowrates and thus is assumed to not have impacts on the overall model stability and minimal impact on the results. FLO-2D debug tool and FCDMC’s review checklist were used to perform QA/QC of the model inputs/outputs. FLO-2D model results, post processed inputs/outputs and FCDMC checklist are included in the submittal.

From the modeled storm durations i.e. 6-hour and 24-hour duration storms, the 24-hour storm duration shows higher flow rates for New PPS models. Therefore, for New PPS model 24-hour duration was the governing storm. Therefore, post processed results for 10Y24H and 100Y24H for New PPS model are included in the submittal. The FCDMC FLO-2D checklist was used to review the model inputs and outputs.

7.4 Rio Verde South Model (RVS)

Rio Verde South (RVS) is a stand-alone new model that covers the unstudied area east of Reata wash model. The majority of RVS model area is undeveloped. There are some low to medium density residential areas in the north half of the domain. There are no inflows into RVS model from other FLO-2D models. The runoff generated by the area covered by RVS FLO-2D model flows west to east towards Rio Verde river. Therefore, it does not contribute to other FLO-2D models within the city.

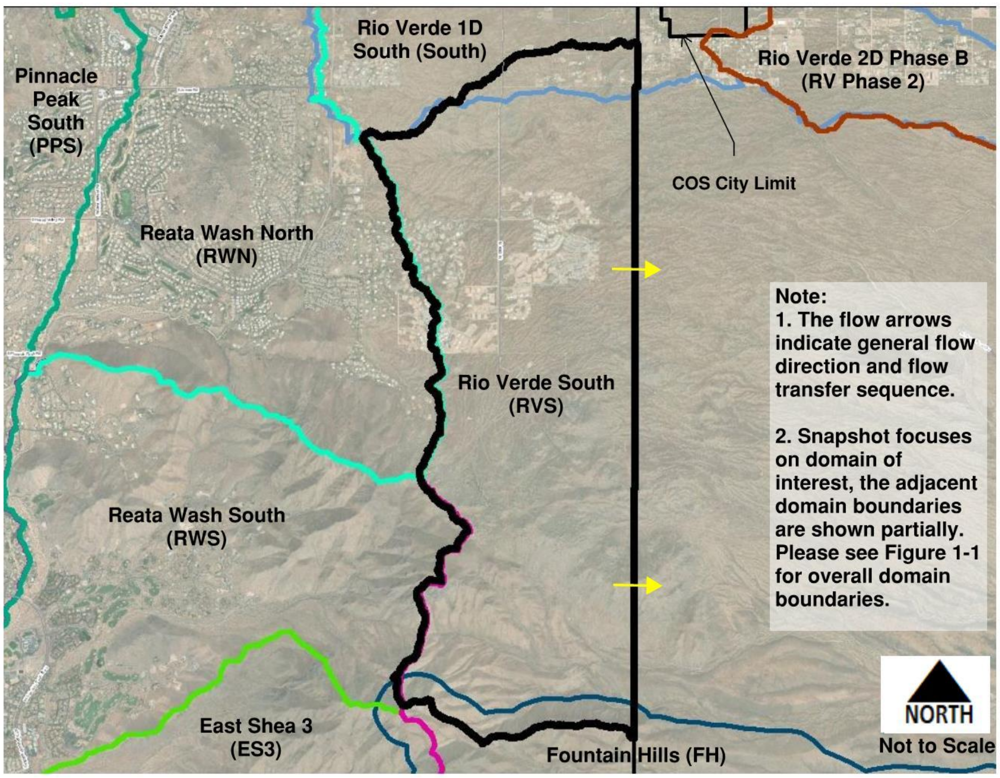


Figure 7.6 : Rio Verde South FLO-2D Model Domain

7.4.1 RVS – Model Elevation Data (FPLAIN.DAT)

The topographic data used for RVS model grid elevation sampling is based on USGS 2020 3DEP LiDAR data with a 1-meter resolution. Grid elevations were obtained using the FLO-2D QGIS plugin average pixel elevation sampling algorithm.

7.4.2 RVS – Surface Feature Characterization (SFC)

Since RVS is a new FLO-2D domain, it does not have a detailed SFC like the previous ADMS FLO-2D models. FCDMC was contacted to check the availability of SFC for RVS study area. However, MBI was informed that since this area was not covered by previous ADMS, FCDMC does not have a readily available SFC. Therefore, according to the project scope, a coarser land use characterization was used for the RVS FLO-2D model. COS zoning categories were obtained from the COS GIS open source which were used to assign land use/land cover. Based on these zoning categories, appropriate land use types are assigned to SFC parameters.

7.4.3 RVS – Area Reduction Factors (ARF)

The COS GIS datasets “Roof Prints” were utilized to incorporate blocked areas for RVS model. The methodology for obtaining ARFs was the same as the New PPS model. Please refer to the New PPS model for further details about ARFs.

7.4.4 RVS – Roughness and Losses (MANNINGS.DAT & INFIL.DAT)

The RVS model used typical FCDMC roughness coefficients and SFC parameters as listed in Table 7.5. For land classes not listed in Table 2 of the FCDMC’s FLO-2D verification report, estimates are made using FCDMC’s Hydrology Manual (Table 4.6) to obtain initial abstraction and impervious rates. Initial saturation conditions and Manning’s roughness coefficients are assigned to the closest suitable type/class, as listed in the following table.

Table 7.5: RVS Model- SFC Parameters and Roughness Coefficients

Type Class	Description	*IA**	RTIMP	InitSat	Manning’s n-value
Residential Developments – RVS Model					
Very Low Density Residential	40,000 SF and greater lot size	0.30	5	dry	0.035
Low Density Residential	12, 000 - 40,000 SF lot size	0.30	15	dry	0.032
Mountain Bare Ground	Mountain Bare Ground	0.25	0	dry	0.05/0.2
Hillslope Bare Ground	Hillslope Bare Ground	0.15	0	dry	0.045
Medium Low Density Residential	12, 000 - 6,000 SF lot size	0.25	30	normal	0.03

**IA was adjusted to deduct TOLGLOBAL (0.048 inches = 0.004 ft) to arrive at IA-Adjusted value*

The soils data for 2014 PPS model covered the RVS study area. Therefore, the 2014 PPS model soils shapefile along with the RVS SFC was used to sample Green and Ampt parameters for RVS model. The Green and Ampt parameters and sampling methodology was the same as described in New PPS model section.

7.4.5 RVS – Hydraulic Structures (HYSTRUC.DAT)

For the RVS model, culverts (diameter ≥ 36-inches) were included in the model to match adjacent ADMS models. The culvert data was based on the COS stormdrain GIS datasets. The model includes a total of thirty-two (32) hydraulic structures, out of which twenty-nine (29) are modeled using generalized culvert equations (GEC) and three (3) are modeled using rating tables. A site visit was performed to collect culvert data that was not available from GIS datasets. Majority of the culverts were modeled using generalized culvert equation, few culverts used rating tables. The site visit photos and locations are attached in Appendix E.

7.4.6 RVS – Rainfall (RAIN.DAT)

Rainfall depths were obtained from NOAA Atlas 14 rainfall data obtained from the NOAA website. The rainfall depth reduction factors follow the same methodology as defined in New PPS model section of the report.

7.4.7 RVS – Walls (LEVEE.DAT)

Walls are not included in RVS model. Therefore, there was no LEVEE.DAT component in RVS FLO-2D inputs.

7.4.8 RVS – Control and Tolerances (CONT.DAT and TOLER.DAT)

The area reduction factor, rainfall, infiltration, hydraulic structures switches were turned on as applicable. A shallow n-value of 0.2 and a limiting Froude Number of 0.95 were used for the RVS model runs. The 24-hour storm duration models used a simulation time of 36 hours and the 6-hour storm duration models used a simulation time of 12 hours. The timestep was set to 0.1 hours. A TOLGLOBAL value of 0.004 ft (0.048 in), a Courant value of 0.6, and a TIME_ACCEL value of 0.1 were used.

7.4.9 RVS – Model Refinements and Results

No model refinements are performed as a part of this exercise. The project scope does not include calibration/validation. The submittal includes RVS FLO-2D models, supporting data used for model preparation and FCDMC checklist.

For RVS model, 24-hour duration storm was the governing storm. Therefore, post processed results for 10Y24H and 100Y24H for RVS model are included in the submittal.

7.5 Desert Mountain Model (DM)

The Desert Mountain Area Drainage Master Study (DM ADMS) was completed in 2019. This study was performed with the purpose of identifying and evaluating flood hazards within an 18 square mile area in the very northern portion of the City of Scottsdale. The study area is located in the steep, rocky foothills of the New River Mountains.

DM ADMS utilized a grid size of 10 feet and consisted of four sub-domains: Domain 1 (DM 01), Domain 2 (DM 02), Domain 3 (DM 03), and Domain 4 (DM 04). The original study ran 10Y6H, 25Y6H and 100Y6H storm events with walls.

The flow from DM watershed discharges towards Cave Creek Wash and does not contribute to other ADMS models within the city limits. DM 01 and DM 02 are independent sub domains. DM 03 provides inflow to DM 04. FLO-2D automated flow transfer tool was used to obtain inflow hydrograph from DM 03 to include into DM 04 model run. See Figure 7.7 for a depiction of this study's location and subdomains.

As a part of the current study, the four (4) sub domains of DM model were rerun using new FLO-2D executable, with NOAA Atlas 14 rainfall depths and without walls scenario. The FLO-2D model files of the four storm events of the four (4) DM sub domains are included as digital data files of the submittal package.

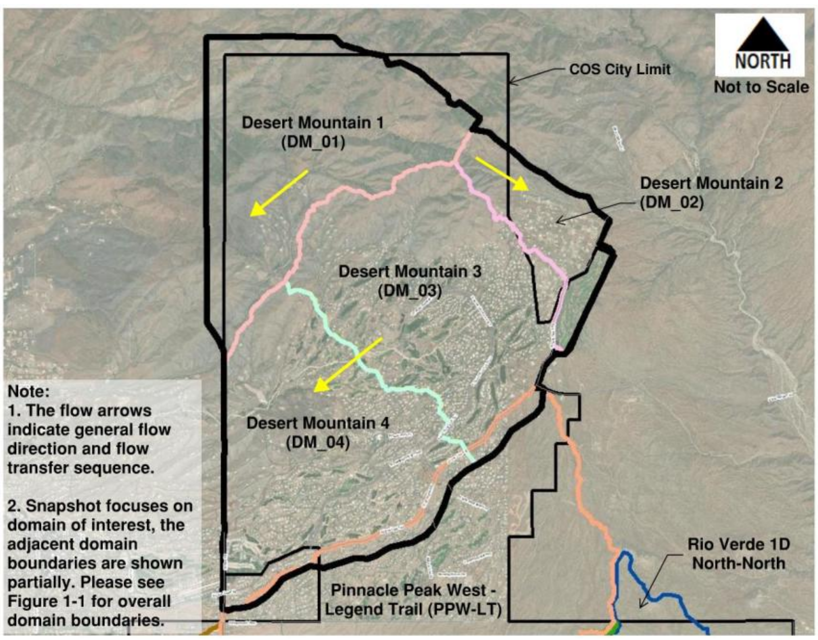


Figure 7.7 : Desert Mountain FLO-2D Model Domain

Various DM model runs/reruns had volume conservation percentage differences. All volume conservation percentages are below the FCDMC acceptable threshold of 0.001%. Therefore, no changes were made to the model. Refer to Appendix D for a table summarizing volume conservation errors by model. No fatal data input errors were encountered in any model runs or reruns. Typical warnings (Impervious area warning and Initial abstraction warning) are noticed in ERROR.CHK file. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

Post processed results for DM domain governing storm (10Y24H and 100Y24H) are included as digital data files of the submittal package.

7.6 Rio Verde HEC-1 Model

The Rio Verde Area Drainage Master Plan (RV ADMP) was completed in 2007 with the goal of being a regulatory solution for rapidly developing one-acre single-family lot residences and subdivisions that were bringing road crossings, stock tanks, diversions, and other human induced changes to the watershed that redistributed flooding. RV ADMP is generally bounded by the Tonto National Forest on the north, the McDowell Mountain Regional Park to the south, the Verde River to the east, and approximately the 115th Street alignment to the west. The total watershed area is about 40 square miles.

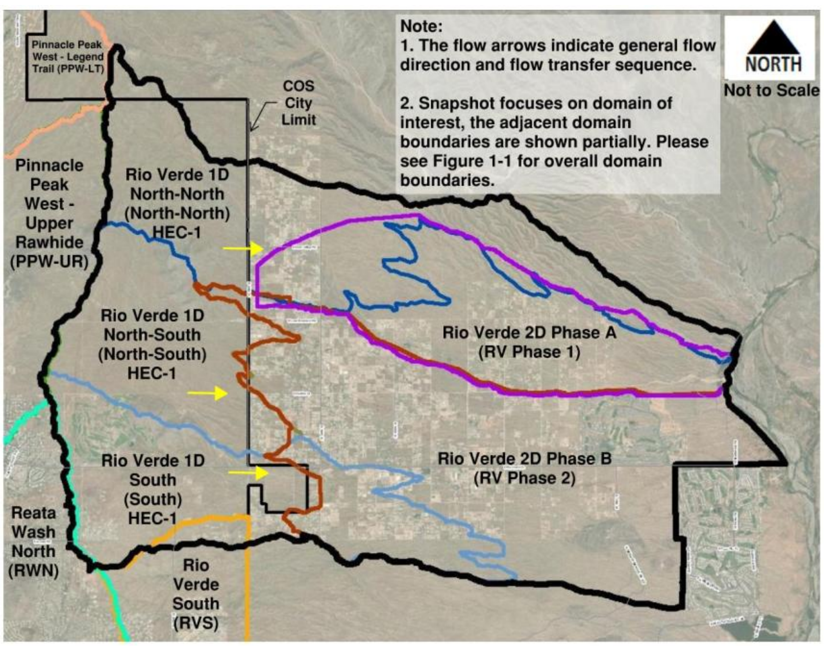


Figure 7.8 : Rio Verde ADMS 1D/2D Model Domain

This study was divided into two parts, one of which utilized 1-D modeling and the other utilized 2-D modeling. Please see **Figure 7.8** for Rio Verde ADMS model (1D and 2D) limits. As mentioned earlier in the key decisions section, the FLO-2D model was not updated for this project as the FLO-2D domain is outside the city limits, and only the Rio Verde HEC-1 model which includes an area within the city limits and which consists of three domains: north-north, north-south, and south, was updated to revise rainfall depths from NOAA Atlas 2 to NOAA Atlas 14. These flows do not contribute to other FLO-2D models within the city. No other changes were made to the HEC-1 models. The revised HEC-1 model results are included in this submittal.

The following table provides a comparison of 2007 ADMS NOAA Atlas 2 rainfall depths to current study's NOAA Atlas 14 rainfall depths.

Table 7.6: Rio Verde ADMS List of Rainfall Depths

Basin	Model	Area (sq. miles)	100-Year Event	Point Precipitation (in)	Areal Reduction Factor	Point Precipitation with Aerial Reduction Factor (in)
North-North	2001 Model	15.54	6-Hour	3.40	0.9235	3.140
			24-Hour	4.42	0.9231	4.080
	Dibble Model[1]	9.87	6-Hour	3.48	0.9408	3.273
			24-Hour	4.65	0.9408	4.375
	MBI Model[2]	9.92	6-Hour	3.25	0.9408	3.060
			24-Hour	5.32	0.9408	5.007
North-South	2000 Model	13.74	6-Hour	3.41	0.9284	3.166
			24-Hour	4.60	0.9285	4.271
	Dibble Model[1]	5.69	6-Hour	3.48	0.9658	3.331
			24-Hour	4.63	0.9660	4.472
	MBI Model[2]	5.73	6-Hour	3.25	0.9658	3.138
			24-Hour	5.32	0.9660	5.139
South	1995 Model	17.00	6-Hour	3.40	-	-
			24-Hour	4.40	-	-
	Dibble Model[1]	8.08	6-Hour	3.44	0.9477	3.260
			24-Hour	4.58	0.9520	4.358
	MBI Model[2]	8.16	6-Hour	3.22	0.9477	3.047
			24-Hour	5.25	0.9520	4.994

1. *Dibble Model used NOAA Atlas 2 Rainfall Depths*
2. *MBI Model used NOAA Atlas 14 Rainfall Depths*

7.7 Reata Wash Model

The Reata Wash and Tributaries Hydrology Study CLOMR was completed in 2020 and the purpose of the study was to better define the 100-year peak discharges contributing to Reata Wash. The study area is located just northeast of State Route 101 in the McDowell Mountain Range.

The Reata Wash FLO-2D model was approximately 22 square miles, utilized a grid size of 20 feet, and was divided into two subdomains: Reata Wash North (RWN) and Reata Wash South (RWS). The original study ran 100Y6H and 100Y24H storm events.

There is no upstream contributing flow to RWN domain. However, the flow from RWS domain contributes flow to both New Pinnacle Peak South and East Shea Corridor models. Please see Figure 7.9 for Reata Wash FLO-2D domains.

The RWN model estimated the flow rate at the apex of Reata Wash. The flow from the apex continues into the RWS model. However, the CLOMR models did not perform the flow transfer from the RWN model to the RWS model. This was discussed with FCDMC and the city, and reached a consensus that for this project the flow transfer should be performed by revising the boundary conditions of the RWN model (OUTFLOW.DAT) and the RWS model (INFLOW.DAT).

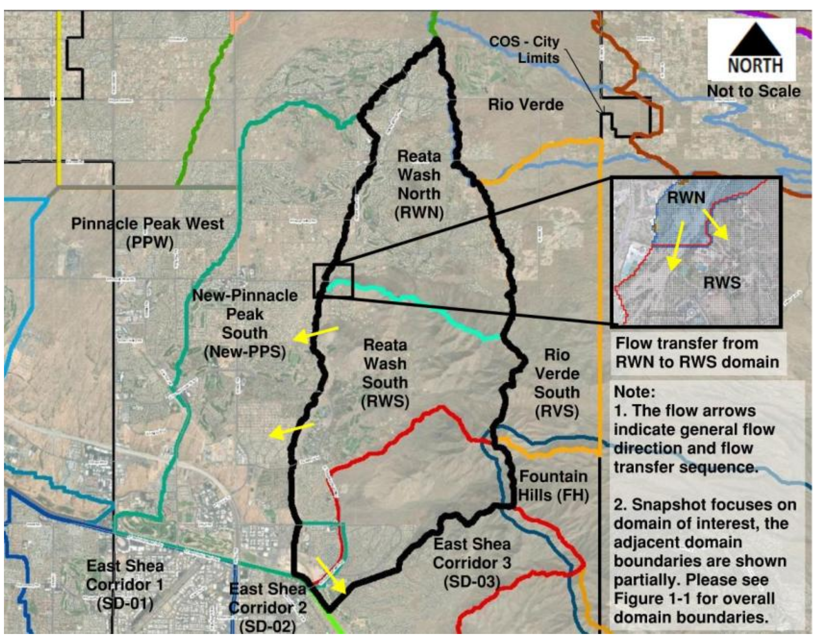


Figure 7.9 : Reata Wash FLO-2D Model Domain

Per the approved CLOMR for Reata wash and tributaries hydrology study, the approved flowrate at Reata wash apex (at Pinnacle Road) is 7,170 cfs. Per the current study model rerun with NOAA rainfall data and with new exe, the flowrate at the apex is 7,105 cfs. It is to be noted that the 2014 PPS ADMS model and other previous downstream ADMS models that received flows from apex used a flowrate of 13,065 cfs at the apex.

After the flow was transferred from RWN to RWS, the outflow boundary condition of RWS was modified to allow flow into the New PPS model to mimic existing condition.

The flows from existing RWS splits at several locations into the New PPS model located west and returns to Reata Wash at a few locations downstream. This impacts the inflows to further downstream ESC model. To avoid looped flow exchanges, MBI in concurrence with FCDMC and the city, decided to create and run the following two conditions for RWS:

1. Condition-1: Please see Figure 7.10, which depicts the Condition-1 flow transfer mechanism. Condition-1 illustrates the planned Reata wash improvements designed to contain and convey flows within Reata wash without spilling into the New PPS model. This condition assumes that the majority of the flows travel south based on the Reata Wash future improvements. This model will be used to obtain inflows for the ESC model. This was considered a conservative approach for inflows into the ESC domain, other models downstream of the ESC domain, and for the RWS model itself.

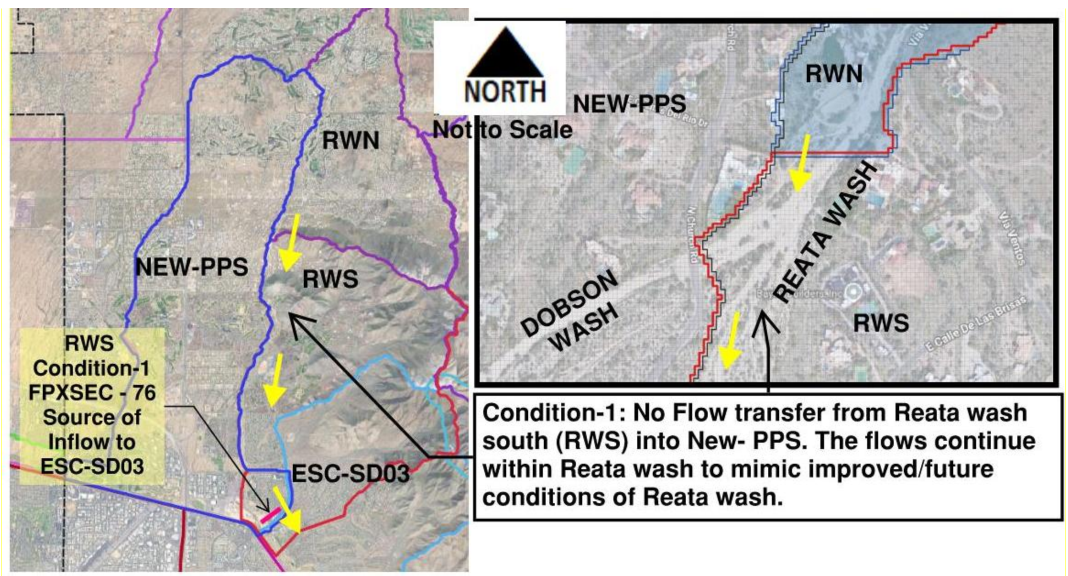


Figure 7.10 : Reata Wash Flow Transfer Condition-1

2. **Condition-2:** Please see Figure 7.11, which depicts the Condition-2 flow transfer mechanism. Flows from the existing RWS model enter the PPS model at several locations, including Dobson Wash. At two locations, minor flow from the PPS model returns to the Reata Wash model. To avoid looped flow transfers, the flow returning to the Reata Wash model downstream was not considered for this modeling exercise. However, at the intersection of east Westworld Way and east McDowell Mountain Ranch Road, flows from New PPS model enter RWS model. To address this issue, the New PPS model was extended towards RWS watershed at Bell Road bridge to model co-mingling flows. Using Condition-2 inflows to model New PPS and other models downstream of New PPS was a conservative approach.

   This approach resulted in the use of conservative flows for New PPS, RWS, and ESC models as well as all the downstream models that receive flows from these models.

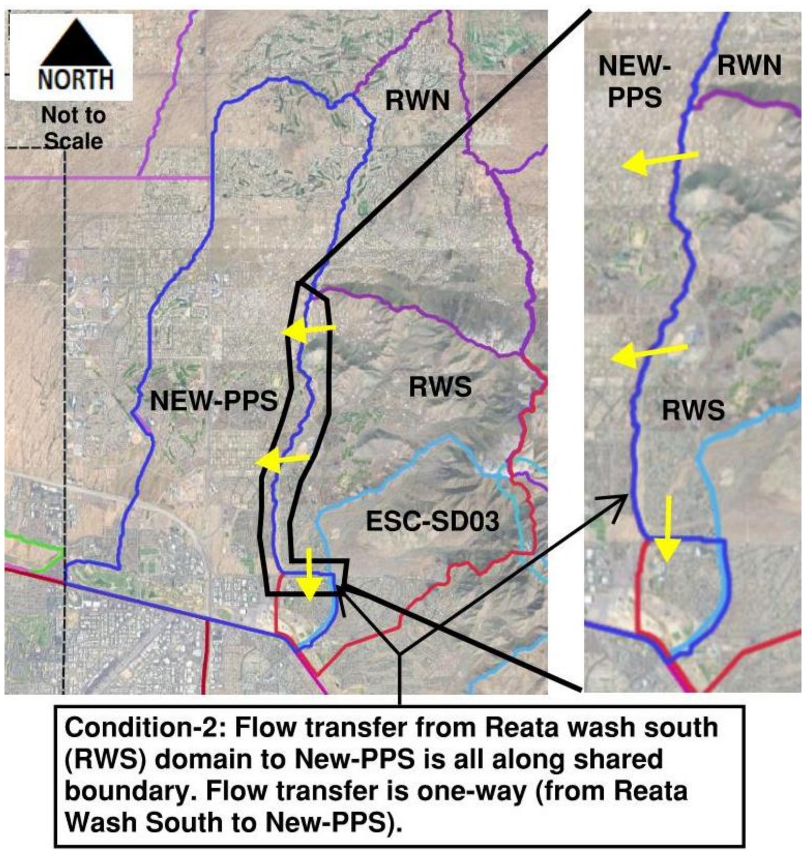


Figure 7.11 : Reata Wash Flow Transfer Condition-2

When developing these models, boundary conditions were adjusted, additional cross sections were added, rainfall data was updated to NOAA Atlas 14, and models were run using the new executable. No walls were represented, and no other changes were made.

Due to connecting RWN and RWS models, the flowrates per current modeling exercise for RWS model are not directly comparable to the FEMA approved 2020 CLOMR model flowrates.

RWS model has few warnings regarding long culverts and other hydraulic structures which were in the FEMA approved CLOMR models also reviewed by FCDMC. No changes were made to the model to address these warnings as they are believed to have minimal to no impact on overall model results.

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

Post processed results for Reata Wash model sub domain governing storm (10Y24H and 100Y24H) are included in Appendix E.

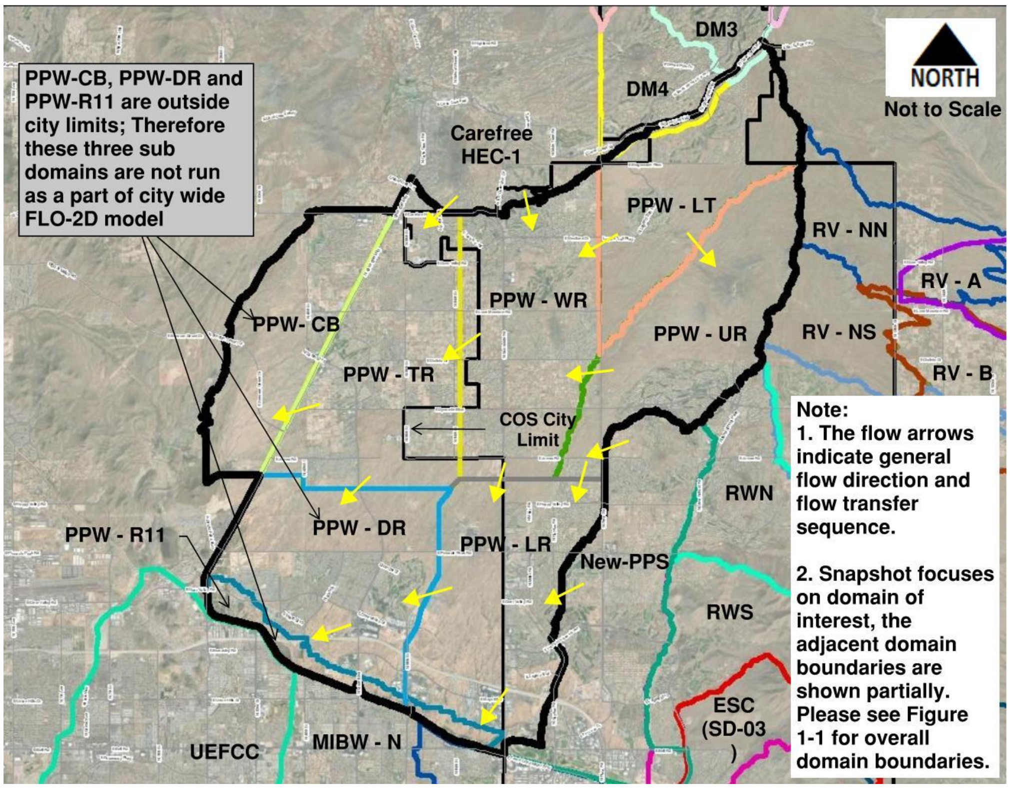
7.8 Pinnacle Peak West Model (PPW)

The Pinnacle Peak West Area Drainage Master Study (PPW ADMS) was completed in 2014. The goal of this study was to enhance and detail the flood hazard assessment in the study area by utilizing updated input data and use of advanced two-dimensional modeling techniques. This approach supported the development of a comprehensive flood hazard mitigation strategy to address the identified risks.

PPW ADMS watershed area is 97 square miles and is located in the northeastern portion of Maricopa County and encompasses land within the jurisdiction of the City of Phoenix, City of Scottsdale, Town of Cave Creek, Town of Carefree, and unincorporated Maricopa County. The project is bound by approximately the Carefree Highway and Cave Creek Road to the north, the PPS ADMS study area to the east, the CAP Reach 11 Dikes to the south, and Cave Creek Road and the eastern Cave Creek floodplain limits to the west.

The original PPW ADMS utilized a grid size of 20 feet and consisted of eight subdomains as shown in Figure 7.12. The original study ran the 10Y24H, 25Y24H and 100Y24H storm events.

While subdomains CB, DR, and R-11 were a part of the original PPW study, these subdomains were not rerun as part of this project. This was due to these subdomains being located outside the city limits and flow from these models are all moving west away from the city limits. The models that were rerun with current modeling exercise include sub domains LT, UR, WR, and LR.



Pinnacle Peak West Area Legend	
Area ID	**Description**
PPW - LT	Legend Trail
PPW - UR	Upper Rawhide
PPW - WR	Whisper Rock
PPW - TR	Tatum Ranch
PPW - LR	Lower Rawhide
PPW - CB	Cave Buttes
PPW - DR	Desert Ridge
PPW - R11	Reach 11
Partial Area Legend	
Area ID	**Description**
MIBW - N	Middle Indian Bend Wash North
ESC (SD-03)	East Shea Corridor SD-03
RWN	Reata Wash North
RWS	Reata Wash South
RVS	Rio Verde South
FH	Fountain Hills
PPS	Pinnacle Peak South
UEFCC	Upper East Fork Cave Creek
RV - A	Rio Verde 2D Phase A
RV - B	Rio Verde 2D Phase B
RV - NN	Rio Verde 1D North-North
RV - NS	Rio Verde 1D North-South
RV - S	Rio Verde 1D South
DM3	Desert Mountain 3
DM4	Desert Mountain 4

Figure 7.12 : Pinnacle Peak West FLO-2D Domain

PPW reruns received the updated inflows from the New PPS model. See Figure 7.12 for a depiction of PPW domain boundaries and how it connects to New PPS. In addition to inflows from New PPS, PPW model received offsite inflows from Carefree HEC-1 model. Since the current study was scoped to run 10Y6H, 100Y6H, 10Y24Hh and 100Y24H storm events, offsite inflows from Carefree HEC-1 were not available from original PPW ADMS. Therefore, the 10Y6H and 100Y6H storm events were created for Carefree HEC-1 model. As the original ADMS HEC-1 model inflows were available for 10Y24H and 100Y24H models, no changes are made to inflows from Carefree HEC-1 model for model reruns. Following the approach used by the original PPW model runs, the 10Y6H and 100Y6H flows are added into PPW model subdomains WR and TR. Following table lists flow transfers between PPW subdomains.

Table 7.7: PPW Sub Domains Inflow Source

PPW-Sub Domain Name	Inflow Source
PPW-LT	No Inflows
PPW-UR	PPW-LT (Inflow1_DS.DAT) and PPS (Inflow1_DS.DAT)
PPW-WR	HEC-1 (North), PPW-LT (Inflow2_DS.DAT), and PPW-UR (Inflow3_DS.DAT)
PPW-TR	HEC-1 (North), PPW-WR (Inflow5_DS.DAT)

PPW models encountered multiple channel errors when attempting to run with the new executable without extensive rebuilding of 1-D channels. The channel issues were attributed to the change of FLO-2D engine in 2017-2018 timeframe when channel routine went through revisions due to which channels from older FLO-2D models do not run with new exe without significant changes to channel components. A channel sensitivity analysis was performed for one of the PPW sub domains (PPW-CB) by re-building channels to resolve channel error to rerun using new exe.

Compared to the results from 2014 ADMS models, the flowrates using newly built channels and use of new exe showed lower flows in channels and areas downstream of channels. The flowrates in cross sections in areas upstream of channels were comparable between the old and the new exe runs. To avoid rebuilding of channels it was decided that the PPW models would be run with the old/original executable. This is considered a conservative approach with regards to channel flows. An exhibit with a comparison of flows from sensitivity analysis is included in Appendix C and the PPW-CB sensitivity analysis using new engine run is included in Appendix E. The channel sensitivity analysis run showed a volume conservation error 0.0067%, however the impact on peak flow in the channel due to the volume conservation error is considered minimal.

Walls were removed from all models. Rainfall values for all models were updated to NOAA Atlas 14 values. No other changes were made to the models.

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

PPW model reruns had volume conservation issues which were below the FCDMC acceptable threshold of 0.001%. Therefore, no changes were made to the models. Refer to Appendix D for a table summarizing volume conservation errors by model.

Post processed results for PPW sub domain governing storm (10Y24H and 100Y24H) are included in Appendix E.

7.9 East Shea Corridor Model (ESC)

East Shea Corridor Area Drainage Master Study (ESC ADMS) was performed with the purpose of identifying and characterizing existing drainage, flooding sources and flooding hazards in order to evaluate flood mitigation alternatives within the study area. This study was completed in 2023. The study encompasses portions of the City of Scottsdale, the City of Phoenix, and the Town of Paradise Valley. The far-eastern portion of the study area is located within the Scottsdale McDowell Sonoran Preserve, which includes natural desert landscape and the McDowell Mountains. In general, the study area is bounded on the west by the Middle Indian Bend Wash ADMS study area, to the south by portions of Lower Indian Bend Wash ADMS study area and the Salt River Pima-Maricopa Indian Community (SRP-MIC) east of SR101, the McDowell Mountains to the northeast, and portions of the CAP canal to the north.

The original study was approximately 51 square miles, utilized a grid size of 15 feet, and consisted of four subdomains: SD-01, SD-02, SD-03, and SD-04. The original study ran 10Y24H and 100Y24H models.

ESC ADMS models obtained inflows at Thomson Peak Pkwy from the 2014 PPS model. The 100Y24H storm event inflow was approximately 5,541 cfs. It should be noted that the 2014 PPS model used existing/undeveloped Reata wash condition. However, the inflows into ESC from apex are based on RWS Condition-1 which mimics the future/improved condition of Reata wash which will contain and convey Reata wash and its tributaries without any flow splits into New PPS model. Therefore, the inflows into ESC for current study are higher than inflows from 2014 PPS ADMS model. Following Table 7.8 lists the inflows from RWS model Condition-1 flows (from RWS model FPXSEC – 76) into ESC SD-03 model.

Table 7.8: Inflows from RWS Model to ESC SD-03 Model

Inflow from RWS Condition-1 (FPXSEC-76)	Flowrate (cfs)
10Y6H	717
100Y6H	4,813
10Y24H	1,037
100Y24H	6,618

Flow transfer from the RWS Condition-1 model to ESC SD-03 at Thompson Peak Parkway has been performed by adding inflow points at five grids (944732, 944733, 944734, 943595 and 942457) to spread the flow across multiple grids. Please see Figure 7.13 for location where inflows are added to SD-03 from RWS model.

The flow transfer sequence between ESC models was from SD-03 to SD-04 to SD-02 to SD-01. All the subdomains were connected to facilitate automated flow transfer. Surface flow ultimately leaves SD-01 and SD-02 and enters into MIBW North (MIBW-N), MIBW South (MIBW-S, and LIBW North (LIBW-N) subdomains. See Figure 7.13 below for a depiction of the ESC domain boundaries and model connectivity.

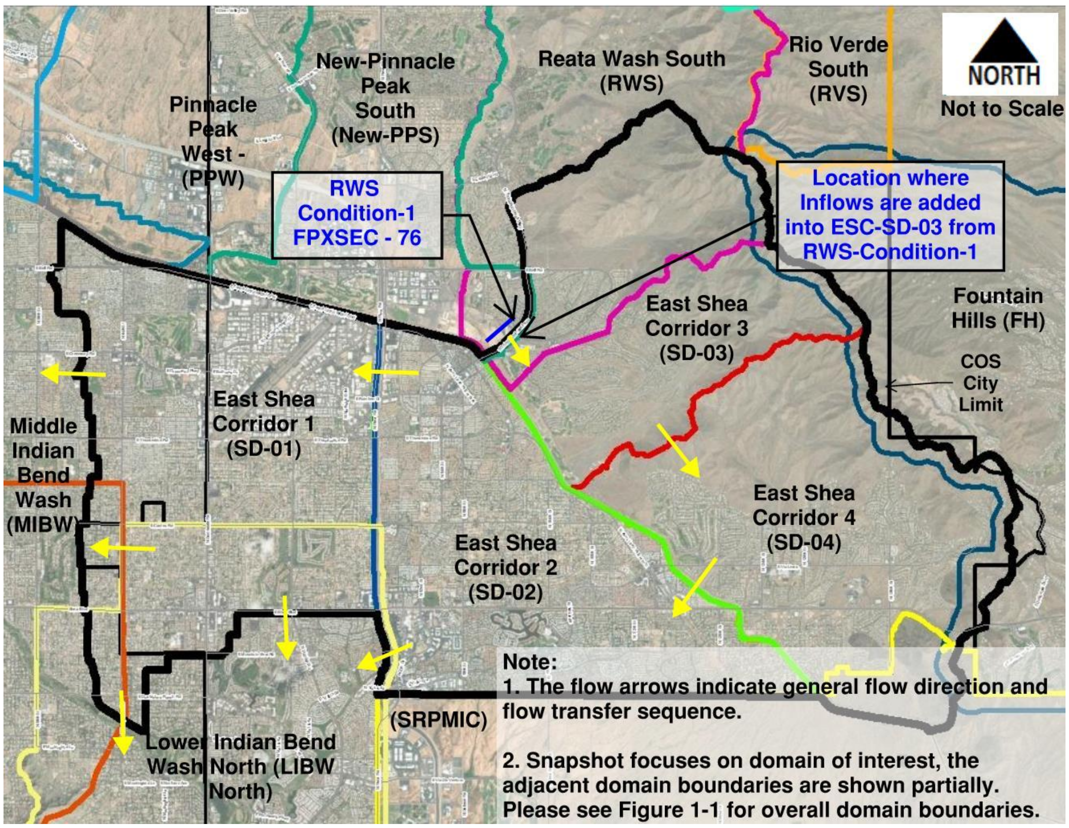


Figure 7.13 : East Shea Corridor FLO-2D Domain

ESC ADMS models were originally run with walls and without walls. The models without walls included LEVEE.DAT to model significant embankment features such as the Gateway Loop Levee in the northern portion of SD-03 and the CAP canal embankment in SD-03 and SD-04. Therefore, for ESC subdomains the models without walls will still include LEVEE.DAT to include significant embankments. All ESC models were rerun with the new executable. Rainfall data for all models was updated to use NOAA Atlas 14.

Due to the change in inflows at Thomson Peak Pkwy, removing the wall component from the model, and updating the rainfall values, the flows from updated models are not comparable to 2023 ESC ADMS models.

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

ESC SD-01 model runs/reruns had volume conservation issues. All volume conservation errors are below the FCDMC acceptable threshold of 0.001%. Therefore, no changes were made to the model. Refer to Appendix D for a table summarizing volume conservation errors by model.

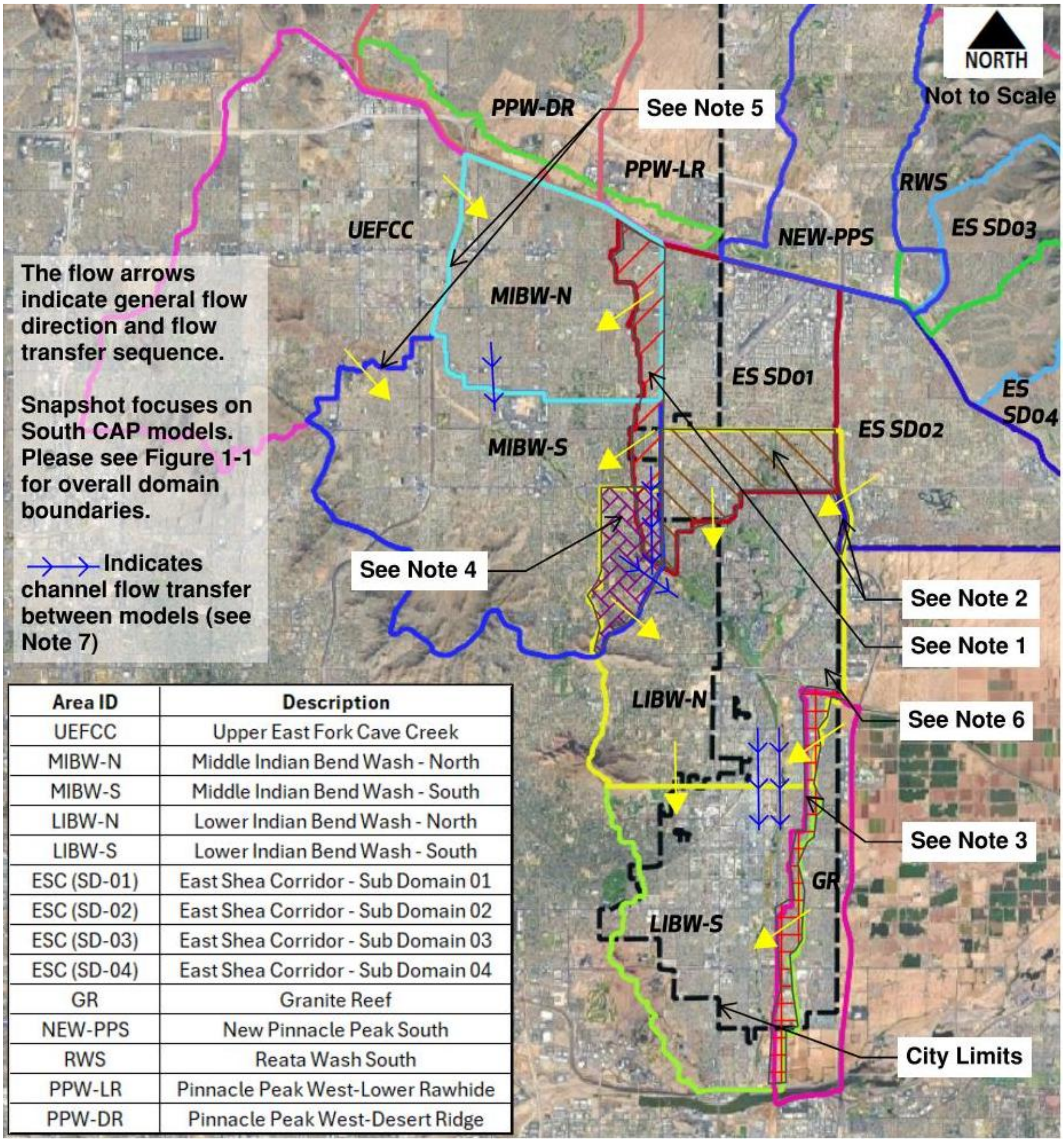
Post processed results for ESC model sub domain governing storm (10Y6H and 100Y6H) are included as digital data files of the submittal package.

As the citywide model consists of multiple ADMS models prepared during different time frames, some of the model boundaries overlap with each other. One such overlap happens between East Shea Corridor sub-domain - 03 (ESC SD-03) and Reata Wash South sub-domain (RWS). This issue was discussed with the city during monthly meeting (07/31/2025). Due to the difference in water surface elevations between models prepared during different time frames it was decided to use the conservative results (East Shea Corridor – 2025 city wide model) in the area where WSE discrepancy is identified. In addition, the location with discrepancy in WSE is located next to CAP embankment where no development is anticipated. Therefore, it was concluded that no additional modeling will be performed as a part of current study to address the WSE discrepancy, instead the conservative model results shall be used for identifying areas of mitigation.

FCDMC has been notified of the resolution in an email (08/06/2025) followed up with a meeting (08/13/2025) to agree upon the resolution. FCDMC instructed MBI to include this in the report to clarify the issue and resolution. A copy of email coordination is included in Appendix A.

7.10 South of CAP Model Boundary Overlaps

Similar to the North CAP models, the south CAP models also have overlaps as the ADMS projects were conducted at different times. East Shea Corridor ADMS is dated 2022 and uses a 15-ft grid size. It overlaps with a portion of MIBW and LIBW model boundaries. Likewise, Granite Reef and MIBW overlap with LIBW model boundaries. Since the southern models flow into Lower Indian Bend Wash/channel, to avoid duplication of rain, the overlapping areas use zero rain in certain models. Following Figure 7.14 shows the south CAP model boundaries, overlaps and explains methodology used for zeroing out of rain and flow transfers. Please see the notes followed by the figure which provides further details of flow transfers between models.



Area ID	Description
UEFCC	Upper East Fork Cave Creek
MIBW-N	Middle Indian Bend Wash - North
MIBW-S	Middle Indian Bend Wash - South
LIBW-N	Lower Indian Bend Wash - North
LIBW-S	Lower Indian Bend Wash - South
ESC (SD-01)	East Shea Corridor - Sub Domain 01
ESC (SD-02)	East Shea Corridor - Sub Domain 02
ESC (SD-03)	East Shea Corridor - Sub Domain 03
ESC (SD-04)	East Shea Corridor - Sub Domain 04
GR	Granite Reef
NEW-PPS	New Pinnacle Peak South
RWS	Reata Wash South
PPW-LR	Pinnacle Peak West-Lower Rawhide
PPW-DR	Pinnacle Peak West-Desert Ridge

Figure 7.14 : South CAP Model Boundaries and Flow Transfers

Note 1*: The East Shea Corridor sub domain SD-01 (ESC SD-01, 15-ft grid size) overlaps with MIBW-N and MIBW-S (20-ft grid size). To avoid double counting of rain, the overlapping areas/grids of MIBW-N and MIBW-S are assigned zero rainfall depth. There was minimal flow transfer from ESC SD-01 into MIBW-N and MIBW-S. Due to the differing* *grid sizes, a custom-made Python script was utilized to facilitate flow transfer between domains of different grid sizes.*

Note 2: *East Shea Corridor sub domains SD-01 and SD-02 (ESC SD-01 and ESC SD-02, 15-ft grid size) overlap with LIBW-N (20-ft grid). The overlapping area/grids of LIBW-N use zero rain depth to avoid double counting of rain. ESC SD-01 and SD-02 discharge flows into LIBW-N. Due to differing grid sizes, a custom-made python script was used to facilitate flow transfer between domains of different grid sizes.*

Note 3: *Granite Reef (15-ft grid size) overlaps with LIBW-N and LIBW-S (20-ft grid). The overlapping area/grids of LIBW-N and LIBW-S use zero rain depth to avoid double counting of rain. There was flow transferred from Granite Reef domain into LIBW-N and LIBW-S. Due to varying grid sizes, a custom-made python script was used to facilitate flow transfer between domains of different grid sizes. In addition to grid-to-grid flow transfer, there were stormdrain flow transfers between the models which were done manually and discussed in detail in LIBW model description section 7.14.*

Note 4: *MIBW-S (20-ft grid size) overlaps with LIBW-N (20-ft grid). The overlapping area/grids of LIBW-N use zero rain depth to avoid double counting of rain. There was flow transferred from MIBW-S into LIBW-N. Since the grid sizes of MIBW-S and LIBW-N are the same, FLO-2D flow transfer tool was used to transfer flows from MIBW-S to LIBW-N.*

Note 5: *UEFCC (20-ft grid size) was an offsite ADMS that was not within the city's jurisdictional boundary, but it contributes flows to MIBW (20-ft grid size) which in turn flows into LIBW-N. Since UEFCC was an offsite model, only the storm event/durations that were not run as a part of the original ADMS were run as a part of current study. Since UEFCC project was performed before MIBW, the outflow boundary condition was not set up to allow automated flow transfer between UEFCC and MIBW. Therefore, a custom-made python script was used by current study to facilitate flow transfer from UEFCC to MIBW-N and MIBW-S sub domains.*

Note 6: *There was flow contributed from AZ Canal (Interceptor Channel) to LIBW-N. This flow transfer was available in original LIBW ADMS which was maintained in current study reruns using new FLO-2D exe.*

Note 7: *In addition to grid-to-grid flow transfer, there was channel transfer between the models which was done manually. The channel flow transfer occurs from ESC SD-01 to LIBW-N; from MIBW-N to MIBW-S; from MIBW-S to LIBW-N and from LIBW-N to LIBW-S.*

7.11 Granite Reef Model (GR)

The Granite Reef Wash Conditional Letter of Map Revision (CLOMR) was completed in November of 2022 (Granite Reef CLOMR, 2022). The purpose of the Granite Reef Wash CLOMR was to re-delineate the Granite Reef Wash Floodplain based on the implementation of the Granite Reef Watershed Drainage and Flood Control Improvements. Granite Reef Wash is in the southeastern part of the City of Scottsdale and extends for two miles from Thomas Road downstream to McKellips Road.

The original study was for approximately 6.5 square miles, utilized a grid size of 15 feet, and consisted of a single domain. The original study ran 10Y6H, 50Y6H, 100Y6H and 100Y24H storm events.

Flow discharges from this model on the northwest and west side of the domain into Lower Indian Bend Wash study area. See Figure 7.15 for a depiction of this study and the how it connects to the surrounding studies.

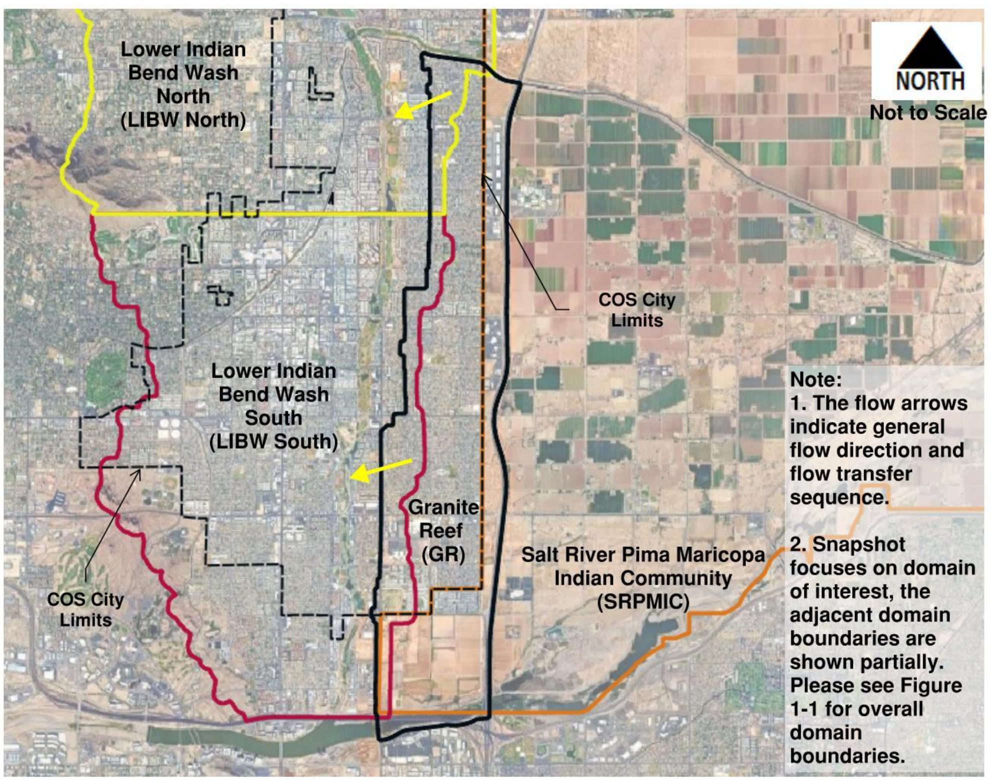


Figure 7.15 : Granite Reef CLOMR FLO-2D Model Domain

Existing Granite Reef models were rerun with the new executable and a new run was created for the 10-year, 24-hour storm event. All model runs for Granite Reef are run without walls using NOAA Atlas 14 rainfall depths as listed in the rainfall depths inventory table included in Appendix D.

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

Post processed results for Granite Reef model sub domain governing storm (10Y6H and 100Y6H) are included as digital data files of the submittal package.

7.12 Upper East Fork Cave Creek Model (UEFCC)

The purpose of the Upper East Fork Cave Creek (UEFCC) Area Drainage Master Study Update (ADMSU) was to identify and quantify existing condition flood hazards and drainage issues. UEFCC ADMSU was completed in December 2017. The UEFCC ADMSU study area is located within the jurisdiction of the City of Phoenix and is approximately bound by the CAP to the north, the Phoenix Mountain Preserve (North Mountain/Shaw Butte) to the south, Arizona State Route 51 (SR-51) to the east and Cave Creek Wash to the west.

The study area was approximately 27 square miles, utilized a grid size of 20 feet, and consisted of a single domain. Models (100Y6H and 100Y24H) for this study were provided to MBI by Kimley-Horn and Associates, Inc, as Kimley-Horn updated these models in 2019 for the Middle Indian Bend Wash Area Drainage Master Study/Plan.

While this study is not located within the City of Scottsdale city limits, this study contributes flows from the east side of the domain to both the north and south domains in Middle Indian Bend Wash and thus was relevant to this project. See Figure 7.16 for a depiction of this study and the how it connects to the surrounding studies.

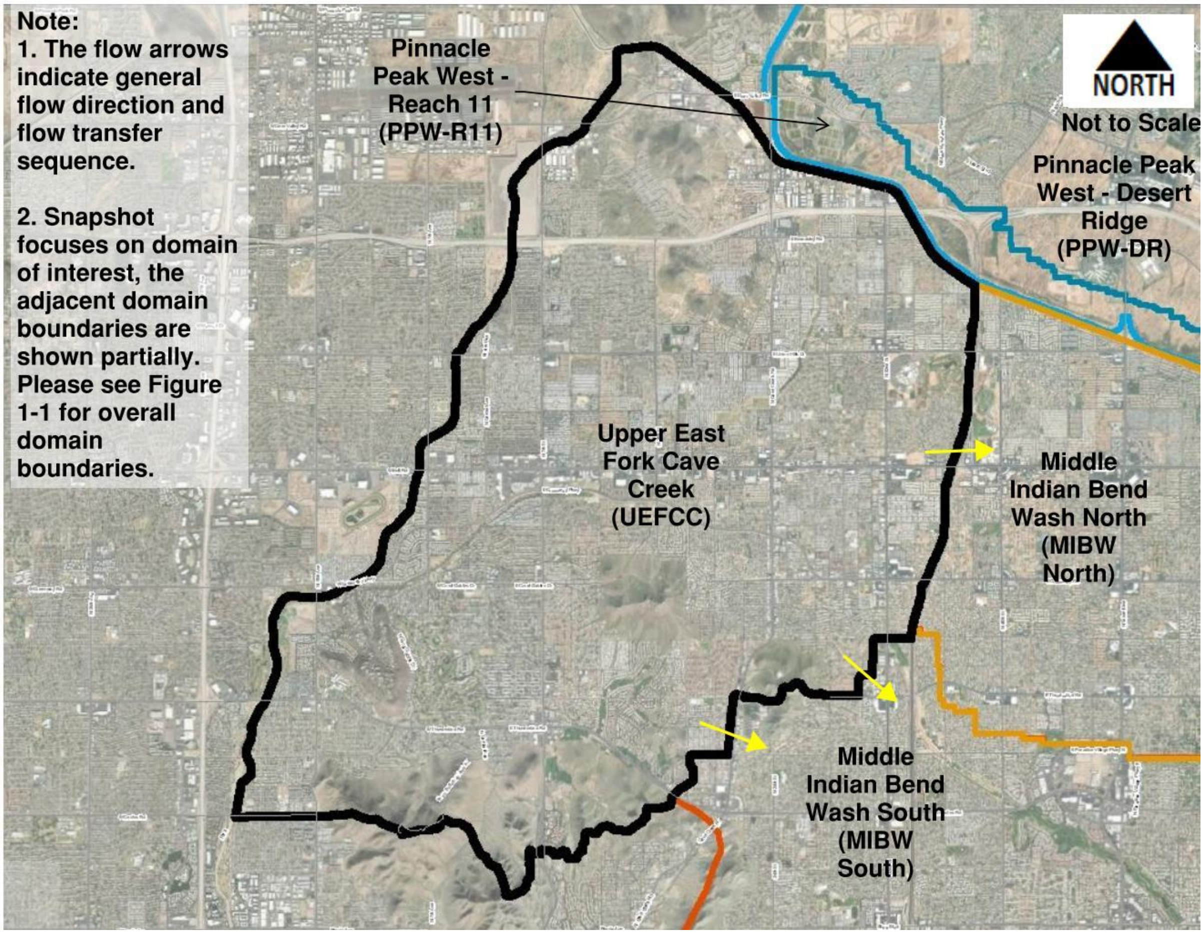


Figure 7.16 : Upper East Fork Cave Creek FLO-2D Model Domain

Existing UEFCC models were put to run with the new FLO-2D executable, but both existing models encountered errors in 1-D channels that prevented the runs from completing. Due to a limited scope and this model not falling within the city limits, it was determined that both existing models would be rerun with the original executable used (build 16.06.16). New runs were created for the 10Y6H and 10Y24H storm events using the old executable. All model runs for Granite Reef are run without walls using NOAA Atlas 14 rainfall depths as listed in the rainfall depths inventory table included in Appendix D. Flow transfer was performed using a python script between the UEFCC model and the MIBW model.

No fatal data input errors were encountered in any model runs. The original ADMS models (100Y6H and 100Y24H) had some volume conservation errors in the order of 0.0003% to 0.0004%. The new 10Y6H model run shows 0.012% volume conservation error. Since this was an offsite model and not within the city limits, the volume conservation issue was not resolved for this model as it appears to have minimal impacts on the results. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

7.13 Middle Indian Bend Wash Model (MIBW)

The purpose of the Middle Indian Bend Wash Area Drainage Master Study/Plan (MIBW ADMS/P) was to identify flooding problems in the study area due to changes that have occurred since the 1978 Paradise Valley-Scottsdale-Phoenix Study and the 2000 Scottsdale Road Corridor Drainage Master Plan. MIBW ADMS/P was finalized in August 2019.

The MIBW ADMS/P study area is primarily located within the City of Phoenix and the City of Paradise Valley but has a small portion of area within the City of Scottsdale. The study area is bordered by two adjacent District studies, UEFCC ADMS to the west and the LIBW ADMS to the southeast and ESC ADMS to the east.

The study area was approximately 34 square miles, utilized a grid size of 20 feet, and consisted of two domains: North and South. The original study report states that only the 100-year, 6-hour storm event was run for each domain, as it was the governing storm.

Both domains in this study directly receive inflow from UEFCC (west of MIBW) and very minor flows from ESC SD-01. The South domain of this study directly contributes to LIBW's north domain. See Figure 7.17 for a depiction of this study and the how it connects to the surrounding studies.

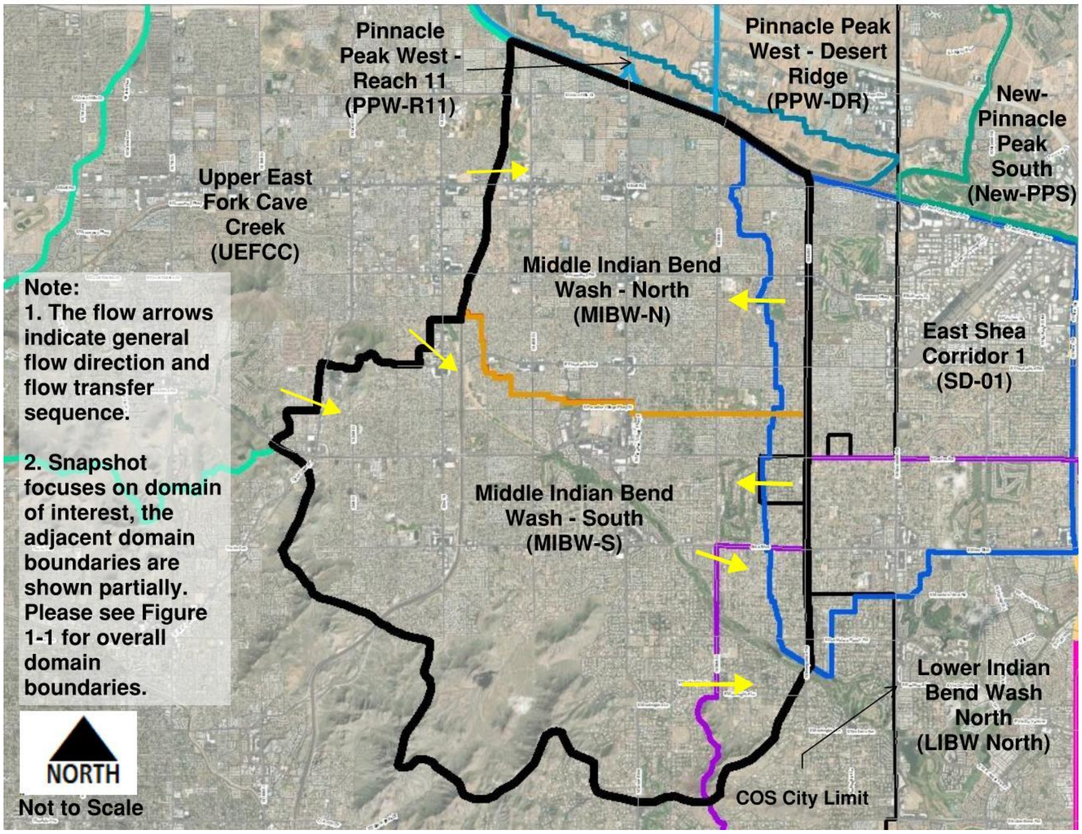


Figure 7.17 : Middle Indian Bend Wash FLO-2D Model Domain

The existing MIBW model was rerun with the new executable and new model runs were created for 10Y6H, 10Y24H and 100Y24H storm events. All models were run using NOAA Atlas 14 rainfall depths.

Walls were present in the original ADMS model. To maintain consistency with all other models, most walls in the original ADMS model were removed before the model was rerun with the new executable. However, some walls were maintained as necessary at channels and depressed roads/freeways to prevent major flows from passing through. Flow transfer from UEFCC was performed using a Python script, and flow transfer from MIBW to LIBW was done using the FLO-2D flow transfer automation tool

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D.

7.14 Lower Indian Bend Wash Model (LIBW)

The purpose of the Lower Indian Bend Wash (LIBW) Area Drainage Master Study/Plan (ADMS/P) was to identify/quantify flooding hazards within the study area and to develop solutions to mitigate the identified flooding problems. This study was completed in December 2017.

The LIBW ADMS/P study area is roughly bounded by Shea Boulevard on the north, Loop 202 on the south, and the ridgeline through the Papago Buttes, Camelback Mountain and Mummy Mountain on the west. On the eastern side it is bounded by Pima Road/Loop 101 above the Arizona Canal and the ridgeline between Indian Bend Wash and Granite Reef Wash below the Arizona Canal. It encompasses parts of five jurisdictions: the cities of Phoenix, Scottsdale and Tempe as well as the Town of Paradise Valley and the Salt River Pima-Maricopa Indian Community.

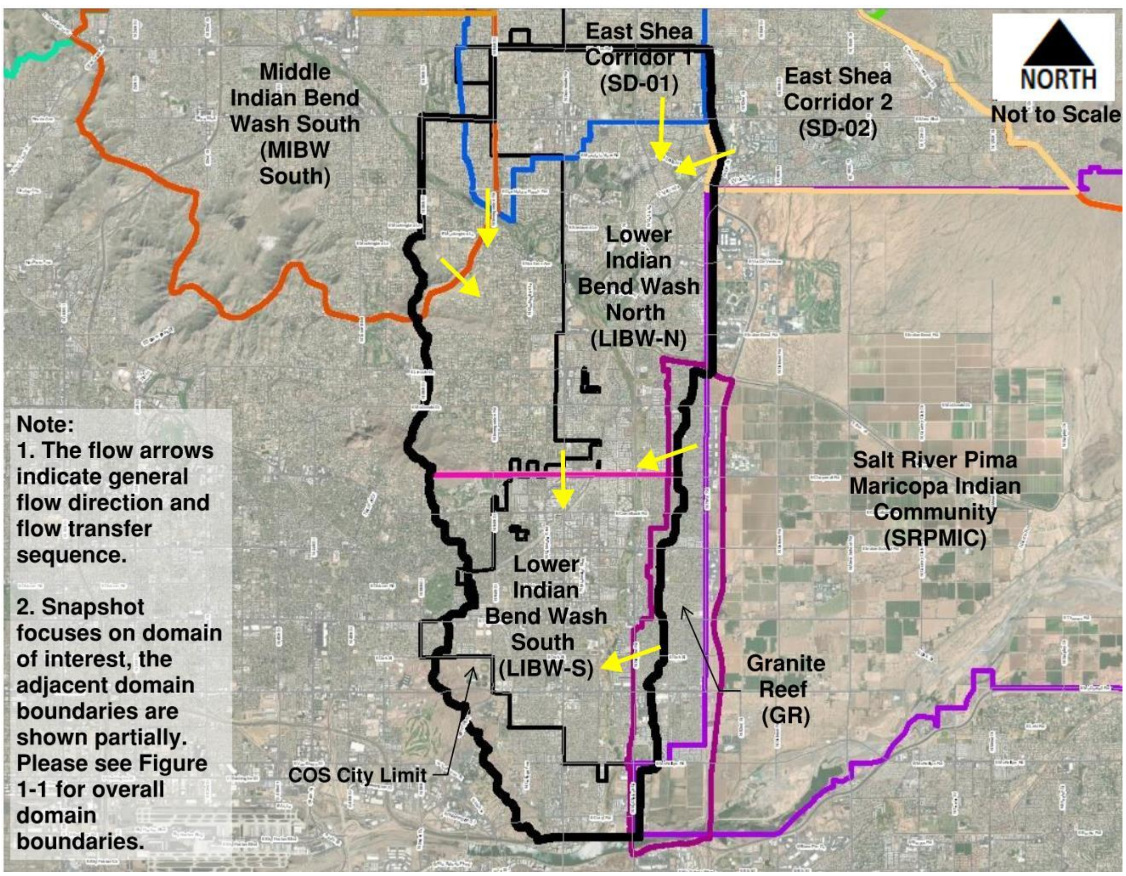


Figure 7.18 : Lower Indian Bend Wash FLO-2D Model Domain

The LIBW study area was approximately 31 square miles, utilized a grid size of 20 feet, and consisted of two domains: North and South. The original ADMS included 10Y6H, 100Y6H, 10Y24H and 100Y24H storm events all of which were rerun using new executable, without walls, with NOAA Atlas 14 rainfall depths and updated inflows from contributing upstream models. Flow transfer from the East Shea Corridor domains and Granite Reef to LIBW was performed using a Python script, and flow transfer from MIBW to LIBW was done using the FLO-2D flow transfer automation tool.

This study was the most downstream of the studies within the project area south of CAP. The North domain of this study receives flows from three surrounding previous studies: East Shea Corridor (Domains SD-01 and SD-02), Granite Reef, and Middle Indian Bend Wash (South domain). In addition to surface flows, there are some channels that continue through multiple models. Therefore, the channel flows are transferred manually from ESC SD-03 to LIBW-N and from MIBW-S to LIBW-N domains.

The LIBW-S domain receives flows from LIBW-N domain and Granite Reef model. Channel flows from LIBW-N are transferred manually to LIBW-S models. See Figure 7.18 for a depiction of this study and how it connects to the surrounding studies.

There are few stormdrain networks that continue west from Granite Reef to LIBW domains and from East Shea Corridor to LIBW-N domain. Therefore, stormdrain flows are manually transferred from East Shea Corridor and Granite Reef models to both LIBW-N and LIBW-S models. Following table lists the flow transfers from East Shea Corridor and Granite Reef to LIBW models.

Table 7.9: Stormdrain Flow Transfers to LIBW-N Model

ID	SD Flow Connection	Structure Name			Hydrograph File name
		GR Model	ES01 Model	LIBW-N Model	
1	GR ->LIBW-N	EJRIBWOUTFALL	-	PJ10EJR	JackrabbitSDInflow.dat
2	ES01 ->LIBW-N	-	O43	MJ44SR	ScottsdaleSDInflow.dat

Table 7.10: Stormdrain Flow Transfers to LIBW-S Model

ID	SD Flow Connection	Structure Name			Hydrograph File name
		GR Model	LIBW-N Model	LIBW-S Model	
1	GR ->LIBW-S	ECHRIBWOUTFALL	-	MJ7ECHR	ChaparralSDInflow.DAT
2	GR ->LIBW-S	ECRIBWOUTFALL	-	PJ13ECR	CamelbackSDInflow.DAT
3	GR ->LIBW-S	NEISRIBWOUTFALL	-	PJ12NEISR	NorthIndianSchoolSDInflow.DAT
4	GR ->LIBW-S	SEISRIBWOUTFALL	-	PJ9SEISR	SouthIndianSchoolSDInflow.DAT
5	GR ->LIBW-S	SEMDRIBWOUTFALL	-	PJ10SEMDR	McDowellSDInflow.DAT
6	GR ->LIBW-S	EMRIBWOUTFALL	-	PJ3EMR	McKellipsSDInflow.DAT
7	LIBW-N->LIBW-S	-	I26WCHR	PJ1WCHRNACL	AZCanalSDInflow.DAT

The Lower Indian Bend Wash (LIBW) ADMS model (2017) utilized a time acceleration factor of 1.0. The latest FLO-2D software recommends a value of 0.1, with the manual indicating that lower values (0.1 to 2.0) generally enhance model stability. Based on feedback from FCDMC, MBI conducted a sensitivity analysis comparing time acceleration values of 1.0 and 0.1. The results showed no impact on model outcomes or stability for either setting. Few grids located along the model boundary and some grids immediately next to buildings resulted in high Froude numbers. Floodplain cross sections at the boundary were compared from both the cases and the flow change is insignificant in both cases indicating that Time Acceleration doesn't impact the Froude number for these models.

Based on the sensitivity analysis, the time acceleration parameter did not affect model results or stability. As a result, models using a time acceleration value of 1.0 are considered appropriate for current analysis and planning purposes. These findings were shared with FCDMC, who concurred with the conclusion. No changes were made to the previously submitted LIBW model(s) time acceleration settings. Documentation of this coordination is provided in Appendix A.

No fatal data input errors or volume conservation errors were encountered in any models runs. Some typical warnings were reported in ERROR.CHK. A list of warnings/issues and their explanations/resolutions is listed in a table included in Appendix D. Post processed results for Lower Indian Bend Wash model sub domain governing storm (10Y6H and 100Y6H) are included as digital data files of the submittal package.

8 Special Issues and Typical Warnings/Errors

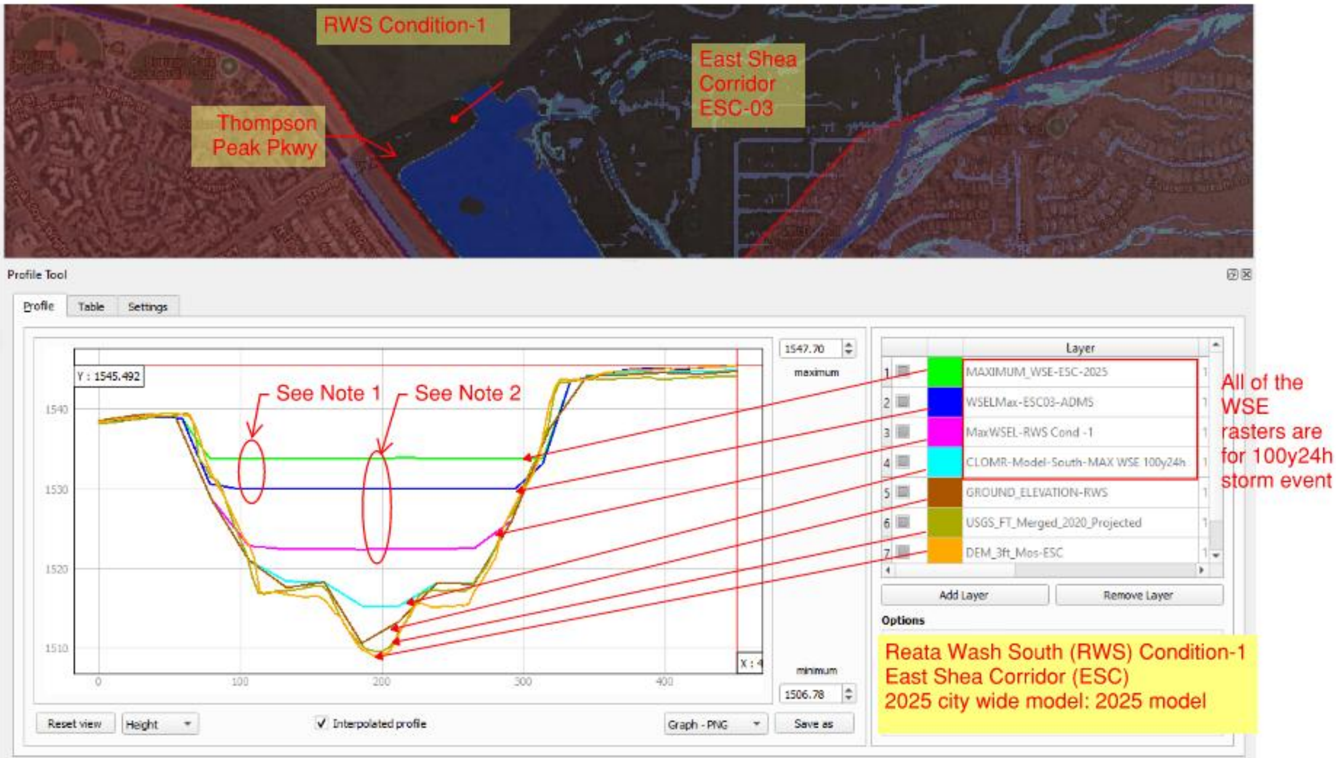
This Section discusses special issues and resolutions and typical errors/warnings during modeling phase.

8.1 Special Issues and Resolutions

The following is a list of special issues and resolutions that were coordinated with the city and FCDMC during the comment resolution process. These issues were discussed in individual model descriptions Section 7. However, they are summarized here to provide a comprehensive list of issues and resolutions and for ease of reference.

- **Water Surface Elevation (WSE) Differences between overlapping models**

As the citywide model consists of multiple ADMS models prepared during different time frames, some of the model boundaries overlap with each other. One such overlap happens between East Shea Corridor sub-domain - 03 (ESC SD-03) and Reata Wash South sub-domain (RWS). This issue was discussed with the city during monthly meeting (07/31/2025). Due to the difference in water surface elevations between models prepared during different time frames it was decided to use the conservative results (East Shea Corridor – 2025 city wide model) in the area where WSE discrepancy is identified. In addition, the location with discrepancy in WSE is located next to CAP embankment where no development is anticipated. Therefore, it was concluded that no additional modeling will be performed as a part of current study to address the WSE discrepancy, instead the conservative model results shall be used for identifying areas of mitigation.



Location of Comparison: Thompson Peak Parkway

Note -1: The difference between max WSE of East Shea Corridor sub-domain 03 (ESC-03) from original ADMS model and 2025 model is about 4-ft. The higher WSE in ESC 2025 model is attributed to higher inflow into the ESC-03 model (approximately 5500 cfs -ADMS vrs. 6600 cfs - 2025 model - Inflow from Reata Wash South Condition-1);

Note -2: RWS Condition -1 max WSE is lower than ESC-03 max WSE for both ESC ADMS and the 2025 model - Reata Wash and ESC are previous models and 2025 model didn't change any input parameters to cause the WSE difference. However, 2025 RWS model is updated to include flows at apex. It should be noted that the CLOMR RWS model didn't include flows at apex. while the flows at apex were calculated in CLOMR Reata Wash North model, they were not referenced as inflows into Reata wash South model.

Note -3: The CLOMR max WSE for RWS is lower than RWS Condition-1 max WSE - as explained in note 2 CLOMR RWS model does not include flows at the apex and thus the WSE is lower than 2025 RWS Condition-1 WSE.

Figure 8.1 : RWS Condition-1 and ESD SD-03 Models WSE Difference

FCDMC has been notified of the resolution in an email (08/06/2025) followed up with a meeting (08/13/2025) to agree upon the resolution. FCDMC instructed MBI to include this in the report to clarify the issue and resolution. A copy of email coordination is included in Appendix A.

- **Time Acceleration Parameter for older models**

The Lower Indian Bend Wash (LIBW) ADMS model (2017) utilized a time acceleration factor of 1.0. The latest FLO-2D software recommends a value of 0.1, with the manual indicating that lower values (0.1 to 2.0) generally enhance model stability. Based on feedback from FCDMC, MBI conducted a sensitivity analysis comparing time acceleration values of 1.0 and 0.1. The results showed no impact on model outcomes or stability for either setting. Few grids located along the model boundary and some grids immediately next to buildings resulted in high Froude numbers. Floodplain cross sections at the boundary were compared from both the cases and the flow change is insignificant in both cases indicating that Time Acceleration doesn't impact the Froude number for these models.

Based on the sensitivity analysis, the time acceleration parameter did not affect model results or stability. As a result, models using a time acceleration value of 1.0 are considered appropriate for current analysis and planning purposes. These findings were shared with FCDMC, who concurred with the conclusion. No changes were made to the previously submitted LIBW model(s) time acceleration settings. Documentation of this coordination is provided in Appendix A.

- **New Pinnacle Peak South (NPPS) and Reata Wash South (RWS) model flow exchanges and boundary conditions**

Flow from Reata Wash South (RWS) typically discharges into the New Pinnacle Peak South (NPPS) model. However, in certain areas, NPPS also discharges back into RWS, resulting in cyclic flow exchange. This scenario is uncommon and can introduce model instability and additional complexity. Because the boundaries of previous models are already established, resolving these cyclic exchanges would require significant changes and overlapping of model domains. To prevent ponding in these areas, outflow nodes were added along eastern boundary of NPPS to allow excess water to exit the grid. This is considered interim approach until Reata wash improvements are constructed. Which will reduce the flows from NPPS to RWS. This was discussed with the city and FCDMC during comment resolution meeting on July 31, 2025.

Additionally, the RWS model was developed under two conditions-reflecting scenarios with and without Reata Wash improvements. As the conservative results (Condition-1) are used for planning, the cyclic flow does not affect the RWS model outcomes.

- **New Pinnacle Peak South (NPPS) and Pinnacle Peak West Lower Rawhide (PPW-LR) model flow exchanges and boundary conditions**

Flow from NPPS typically discharges into PPW-LR. At the southwest tip of NPPS, flow from PPW-LR re-enters the NPPS domain and ponds near the CAP embankment, particularly within the golf course area (see Figure 8.2). Results in this area are considered approximate due to the lack of existing development. Future studies should evaluate and account for flows originating from PPW-LR.

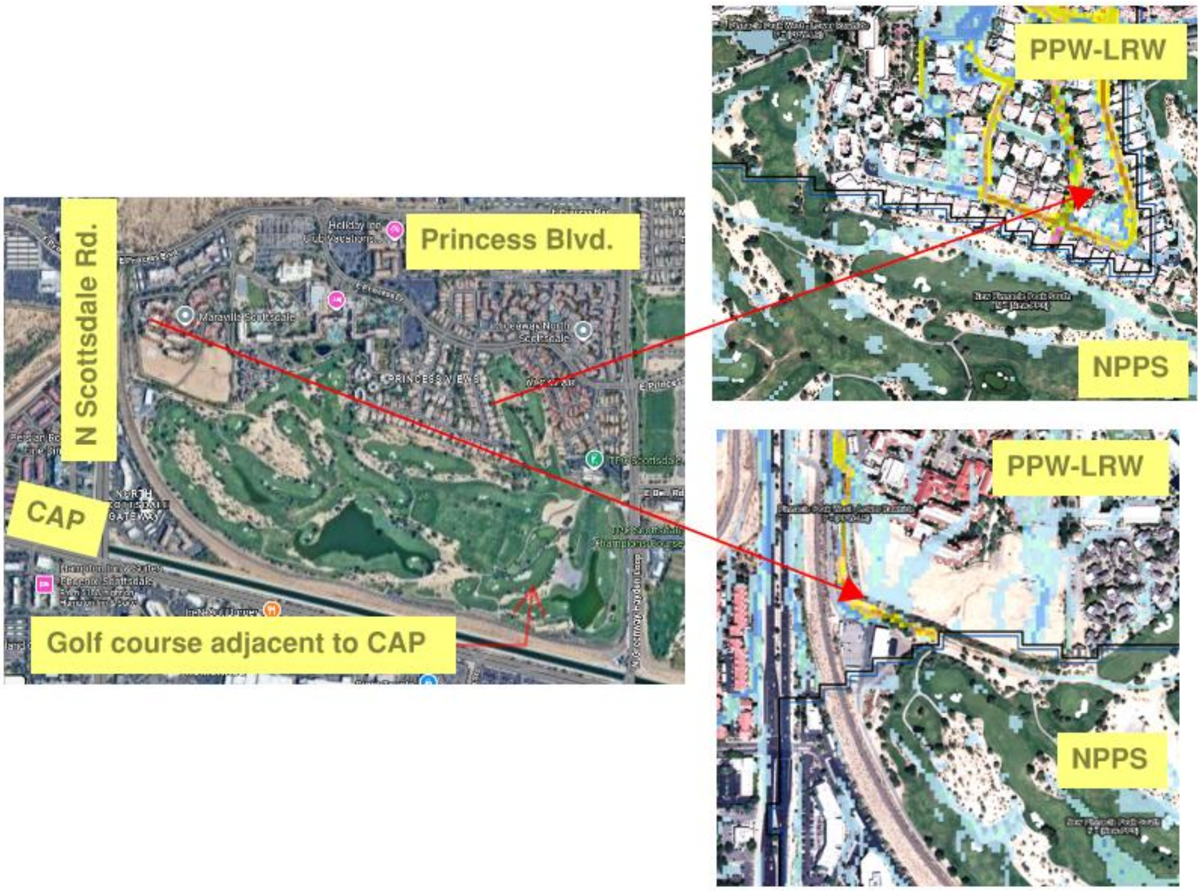


Figure 8.2 : NPPS and PPW LR Models Flow Transfer

8.2 Typical Warnings/Errors

The FLO-2D models report some typical warnings in ERROR.CHK files and CHAN.CHK (if models include Channels). These are typical warnings meant to alert the modeler to perform some standard checks. Likewise, current study model runs included typical warnings listed in ERROR.CHK. Most of these warnings are related to data input files that were created for the original study. The scope of this project does not include changes to previously created data input files that are not related to fatal errors that prevent the models from running. Some of the typical warnings are listed along with an explanation in a table included in Appendix D. Some of the warnings are due to the use of the new FLO-2D engine that does additional checks of model inputs. The older engines didn't have these checks. Therefore, these warnings didn't appear in previous/original ADMS model runs.

9 Conclusions

- The primary goal of the Phase 1 study is to create a comprehensive citywide FLO-2D model. This has been achieved by developing a new model domain for Rio Verde south, developing a revised model for Pinnacle Peak South, updating the other models within the city limits with NOAA Atlas 14 rainfall depth using new FLO-2D engine.
- Typically, the walls were removed from the original model except at a few locations along freeways, channels, CAP embankment and levees that had significant hydraulic impacts.
- With reduction of flows at Reata wash apex, a lot of the models are expected to show different peak discharges in the downstream watershed that receive flows from Reata Wash. In addition, the city-wide FLO-2D model does not include walls unlike some of the previous ADMS studies. Therefore, the flows from previous ADMS models are not directly comparable to flows derived from subject study. The models were primarily run for the 100Y6H,100Y24H, 10Y6H, 10Y24H storm events.
- Certain domain boundaries were adjusted to avoid large overlaps in the modelling domain.
- The models and the results are meant for planning purposes and are not expected to be used for final design/construction without further model refinements and validation.
- The modeling results from this study shall be further evaluated in Phase 2 to assess the current capacity of the overall drainage infrastructure and to develop flood mitigation solutions.

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