PRELIMINARY DRAINAGE REPORT

September 24, 2019
1st Revision: November 13, 2019
2nd Revision: December 19, 2019

SCOTTSDALE ENTRADA

Scottsdale, Arizona

Prepared for:
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OSCAR E. GARCIA
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ARIZONA, U.S.A.
Expires 6-30-2021

47-DR-2019
12/31/2019

Preliminary Drainage Report

For

Scottsdale Entrada

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1.0 INTRODUCTION

1.1 SCOPE

Coe & Van Loo Consultants II, LLC (CVL) has been contracted by Bridge Banyan Qualified Opportunity Zone Business I, LLC (client) to provide engineering services in support of Scottsdale Entrada development (the site). Please see Figure 1 for the Vicinity Map. The purpose of this report is to provide hydrologic and hydraulic analysis for the proposed development. In addition, this report addresses on-site drainage and stormwater storage retention requirements.

This report is focused on providing preliminary design information, evaluation, and analysis for statistical flood events up to and including the 100-year storm. The scope of this assessment does not include, neither did CVL's client request, the evaluation of storm-water runoff resulting from storm events exceeding the 100-year frequency event. Hence, it should be noted that a storm event exceeding the 100-year frequency may cause or create the risk of greater flood impact than is addressed and presented in this assessment.

The procedures used herein are derived from, and performed with, currently accepted engineering methodologies and practices. Additionally, the criteria for this evaluation are designed to conform to currently applicable ordinances, regulations and policies as set forth by the City of Scottsdale and Maricopa County.

1.2 SITE DESCRIPTION

The site is located within the City of Scottsdale and is comprised of multiple vacant car dealerships with three retention basins to the north and a swale along the eastern boundary. The majority of the site is asphalt and buildings, with little open space, and is bordered on the north by residential developments, on the east by the Arizona Cross Cut Canal, on the south by McDowell Road, and on the west by 64th Street. Furthermore, the site is located within the southwest quarter of Section 34, Township 2 North, Range 4 East of the Gila and Salt River Base and Meridian, Maricopa County, Arizona (Figure 1).

1.3 REGULATORY JURISDICTION

The development is designed to meet the drainage requirements as stated in City of Scottsdale's *Design Standards & Policies Manual* [1] in conjunction with the Flood Control District of Maricopa County

(FCDMC), *Drainage Design Manuals for Maricopa County, Arizona, Volume I* [2], *Hydrology, Volume II, Hydraulics* [3], and *Drainage Policies and Standards Manual for Maricopa County, Arizona* [4].

1.4 Proposed Redevelopment

The proposed redevelopment will consist of commercial buildings, residential buildings, parking structures, and parking lots. Similar to the existing condition, CVL will maintain the drainage concept of runoff crossing parcel limits and owner limits. By allowing the runoff to cross parcels limits, the site will continue to drain to the northern retention basins and the eastern swale. Runoff will be conveyed through the site within the roadway, parking lot, and storm drain systems. The ultimate outfall for the site will be the existing storm drain system in the northeast corner of the site, as it is in the existing condition. An association will be responsible for maintenance of any and all drainage systems (storm drains and catch basins).

2.0 Hydrologic Setting

2.1 Existing On-Site Drainage Conditions

A portion of the site drains into the eastern of the three basins (R-3) through wall openings. The remaining portion of the site drains into the swale east of the site through a scupper or catch basin storm drain system. No retention or detention is provided within the site. In addition, there are currently seven parcels and two "common areas" within the proposed redevelopment area with four separate owners. The site runoff crosses existing parcels and ownership within the existing condition.

2.2 Off-Site Watershed Conditions

Off-site flows are currently conveyed around the site through the existing basin system on the north end of the site. This system was modified to include a stormdrain as part of the Oak Street Storm Drain System [5] in 1998 following the S-T-P Papago Flood Control Project by Kimley-Horn [6] inlet in order to convey the off-site runoff north. The Area Drainage Master Study (ADMS) completed for the Lower Indian Bend Wash (LIBW) [7] shows the design and capacity of the Oak Street system, excerpted in Appendix A.

The current site design allows the on-site flows to mix with off-site flows in order to match the historical drainage patterns. However, first flush retention will be provided, at a minimum, to prevent water pollution from entering the Oak Street stormdrain system and ultimately the Indian Bend Wash. The existing basins will not be affected by the development and the improvements made to the site will not affect the current management of the off-site runoff. No updated off-site management is required for this site.

3.0 Flood Zone Information

The Maricopa County, Arizona and Incorporated Areas Flood Insurance Rate Map (FIRM), panel number 04013C2230L, Map Revised October 16, 2013 [8], indicates the majority of the site falls within Zone X (unshaded). The east side of the site falls within a Zone A.

Zone X (unshaded) is defined by FEMA as:

> "The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood"

Zone A is defined by FEMA as:

> "Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply."

Refer to Figure 2 for a copy of the Flood Insurance Rate Map (FIRM).

A Letter of Map Revision (LOMR) has been approved by the City of Scottsdale and is being prepared for submittal to FEMA in order to revise the existing Zone A floodplain ponding limits. See excerpts in Appendix B.

4.0 Proposed Drainage Plan

4.1 On-site Hydrology

The on-site drainage plan is based on the redevelopment drainage requirements as stated in Sec. 37-50 of the Scottsdale Revised Code (SRC) [9] and Chapter 4-1.201(C) of the Design Standards & Policies Manual [1]. The calculated first flush volumes required are greater than pre-development vs. post-development volumes required for the site (see Appendix C). Therefore, first flush retention will be provided, at a minimum, in the existing basins. The on-site delineations are based on the layout provided for the preliminary site design.

4.2 On-site Runoff Management Plan

The onsite drainage concept will provide proper retention for “sites that have been previously developed” as required by the City of Scottsdale [1] [9]. The drainage sub-basins are delineated using the preliminary building layout and elevation points provided. For the Pre-Development vs Post-Development calculation, the 100-year runoff coefficients are based on the City of Scottsdale’s Design Standards & Policies Manual [1]. Effectively, a coefficient of 0.86 is used for the commercial portion of the site (“Commercial & Industrial Areas”), 0.94 is used for the high density residential portions of the site (“Apartments & Condominiums”), 0.45 is used for retention areas ("Desert Landscaping"), and 0.95 is used for all impervious areas (“Paved Streets, Parking Lots, Roofs, Driveways, etc.”).

The required first flush retention volumes for the site will be provided by the existing basins (R-1, R-2, & R-3). No grading changes are proposed for these basins. Based on the most recent survey, the basins provide a total existing volume of 4.09 acre-feet, which satisfies retention requirements (see Appendix C).

On-site runoff will reach the basins through a combination of surface runoff and a system of catch basins and stormdrains. During final engineering design, flow paths, storm drain inlets and pipe sizing will be provided as necessary to convey the flow into the retention. All catch basins will have a maximum ponding of 6 inches prior to surface overflow occurring. Additionally, a 2-foot deep standalone retention basin (R-4) is proposed on-site. See Plate 1 for locations and watershed delineations.

Table 1: Relationship of Watersheds to Basins

Watershed ID	Basin ID
1	R-1
R-1	
2A	R-2
2B	
2C	
R-2	
3A	R-3
3B	
3C	
R-3	
R-4	R-4

Existing storm infrastructure in the southeast portion of the site will be amended as/if needed to conform to the new onsite runoff management plan during final design.

4.3 Retention

Add retention basin summary table which identifies Vr, Vp, Top, Bottom overflow elevations and drain time analysis. Call out dry-wells as needed.

The retention concept is to provide retentio t flush runoff (refer to Appendix C for calculations) per City of Scottsdale stand County requirements [2] [3]. The equation that governs this volume is:

V_r = required first flush storage volume required, in acre-ft

C = 0.82, the weighted average runoff coefficient for the disturbed area of the proposed development

P = required precipitation depth of 0.5 inches

A = disturbed area of the proposed development, in acres

The existing retention basins are divided into three separate retention areas (R-1, R-2, and R-3) due to the existing topography. The historical drainage pattern will be maintained by basins R-1, R-2, and R-3, which are de-watered by a combination of infiltration and a positive gravity draining outfall. The outfall elevation is 1261.70'. The first flush will be retained within the basins and will not continue downstream. Basin R-4 will be designed with a maximum depth of 2 feet and side slopes no steeper than 4:1. Side slopes of 6:1 will be maintained adjacent to pedestrian walkways and right-of-ways. Additionally, basin R-4 will be designed in close coordination with the landscape architect to allow for an aesthetically pleasing and hydraulically efficient facility.

5.0 Storm Water Pollution Prevention Plan

During final engineering design, the Storm Water Pollution Prevention Plan (SWPPP) will be prepared and submitted for approval.

6.0 Summary and Conclusions

1. The retention basins are designed to retain storm water for calculated first flush storage volumes.
2. Off-site flows do not affect the site, no improvements are required. No updated off-site management is required for this site.
3. According to the FIRM panel number 04013C2230L, Map Revised: October 16, 2013, the majority of the site is located in Zone X (unshaded), with the eastern side being in a Zone A floodplain.
4. A Letter of Map Revision (LOMR) has been approved by the City of Scottsdale. The LOMR will be submitted to FEMA in order to revise the existing Zone A floodplain ponding limits.

7.0 References

[1] Scottsdale, City of, "Design Standards and Policies Manual," Scottsdale, 2018.

[2] Flood Control District of Maricopa County, Arizona, "Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology," December 14, 2018.

[3] Flood Control District of Maricopa County, Arizona, "Drainage Design Manual for Maricopa County, Volume II, Hydraulics," December 14, 2018.

[4] Flood Control District of Maricopa County, Arizona, "Drainage Policies and Standards," Revised August 22, 2018.

[5] EEC/MKE, "Drainage Report for Oak Street Storm Drain," 1998.

[6] Kimley-Horn and Associates, "STP Papago Regional Flood Control Project Watershed Study," 1997.

[7] Gavan & Barker, Inc., "Lower Indian Bend Wash Area Drainage Master Study," December 2017.

[8] Federal Emergency Management Agency (FEMA), "National Flood Insurance Program, Flood Insurance Rate Map, Maricopa County, Arizona and Incorporated Areas, Panel Numbers 04013C2230L," Revised October 16, 2013.

[9] Scottsdale, City of, "Scottsdale Revised Code of Ordinances," Scottsdale, 2019.

FIGURES

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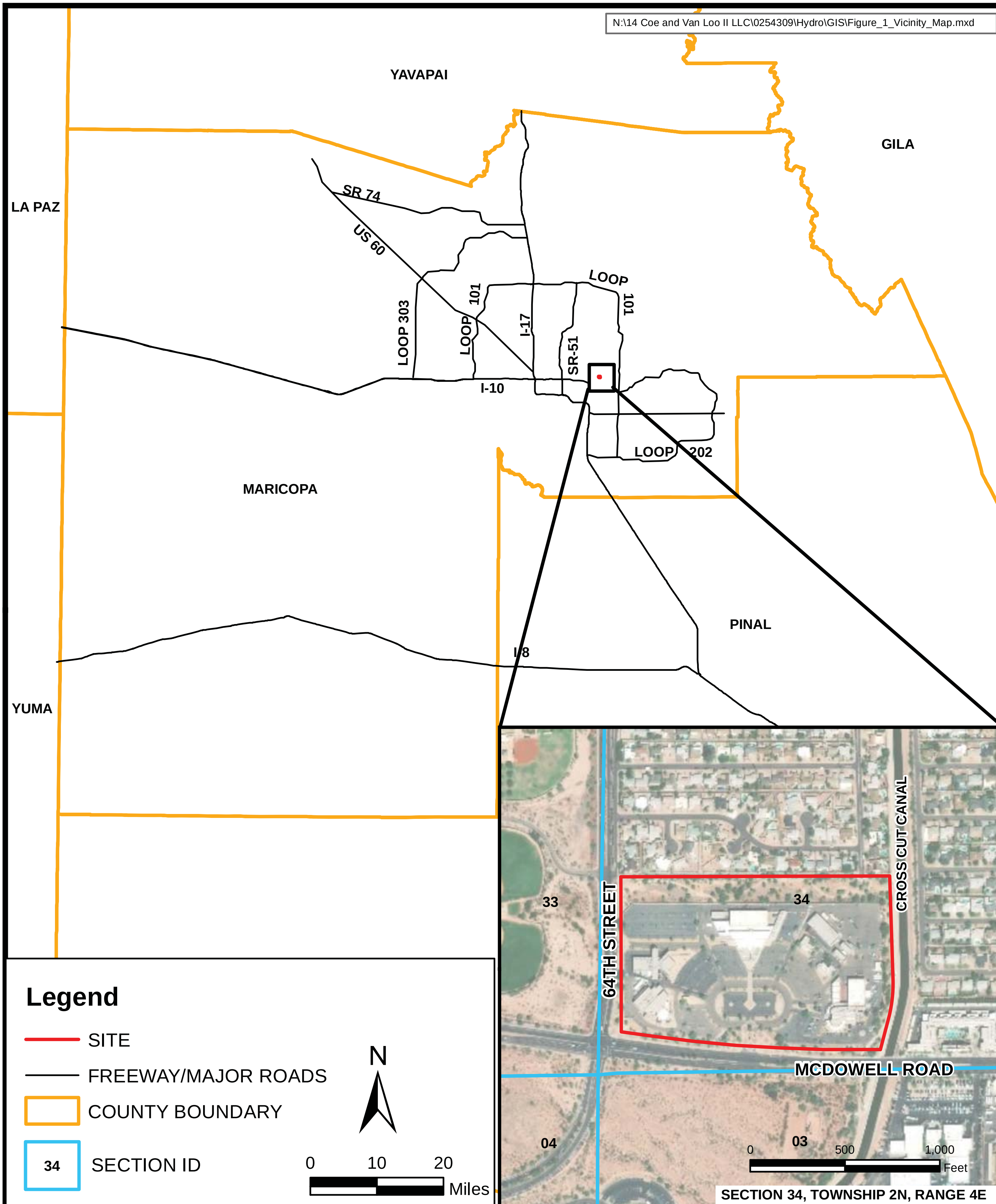

Legend

- SITE
- FREEWAY/MAJOR ROADS
- COUNTY BOUNDARY
- 34 SECTION ID

N

0 10 20 Miles

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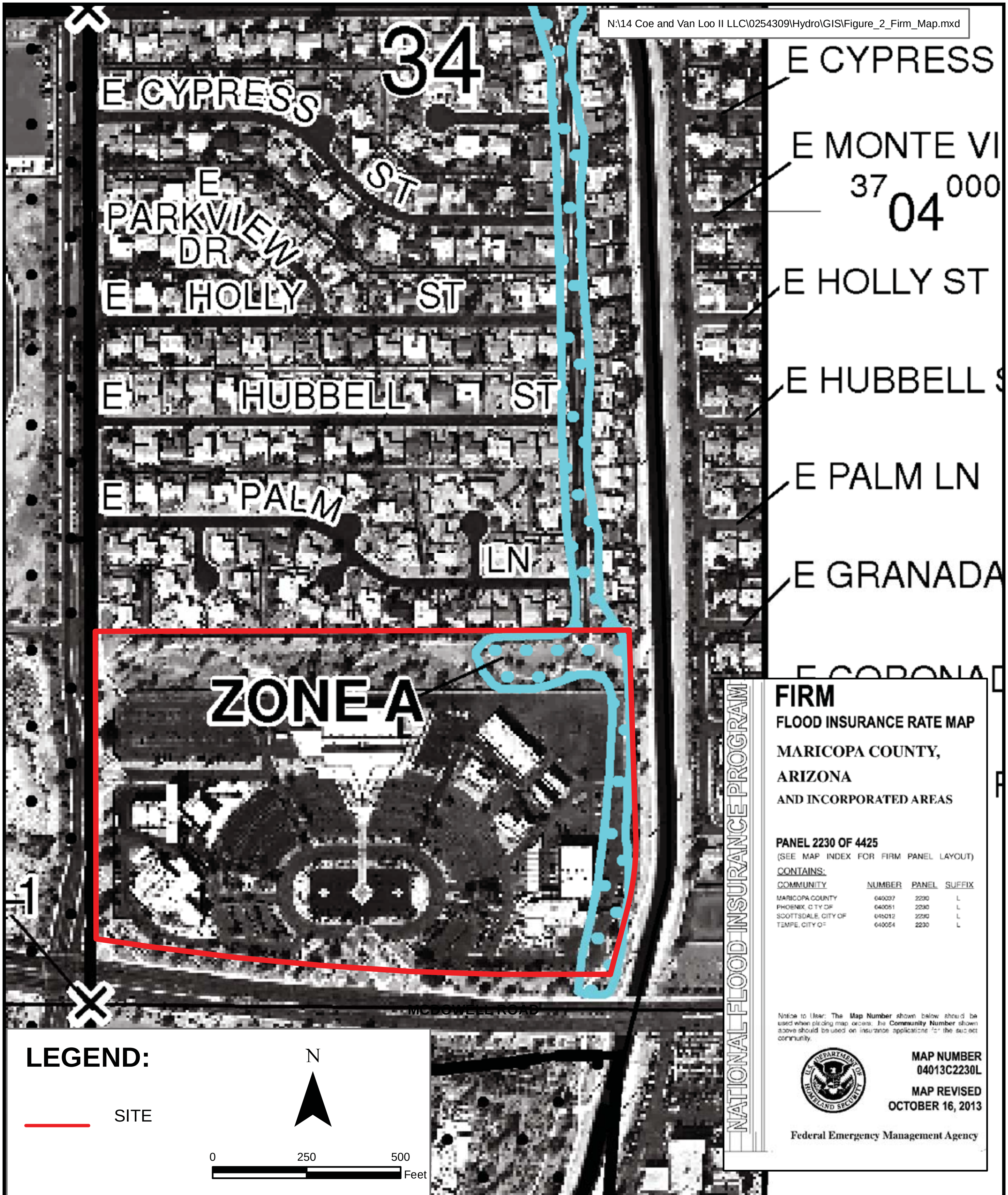
SCOTTSDALE ENTRADA

JOB NO.
14-02543-09

VICINITY & LOCATION M

47-DR-2019
12/31/2019



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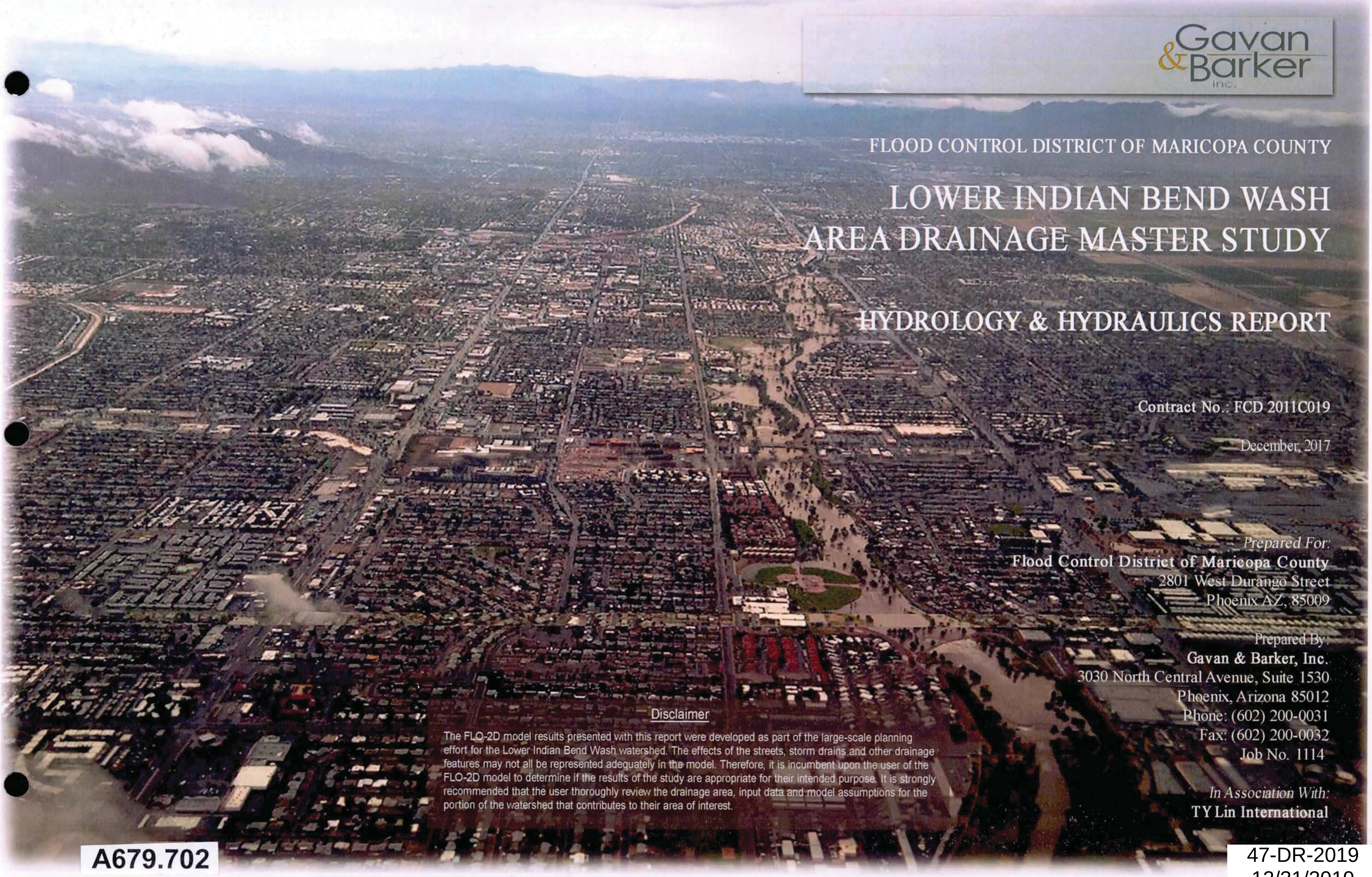
SCOTTSDALE ENTRADA	JOB NO. 14-0254309
FIRM MAP	

47-DR-2019
12/31/2019

APPENDIX A

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY LOWER INDIAN BEND WASH AREA DRAINAGE MASTER STUDY – HYDROLOGY AND HYDRAULIC REPORT EXCERPTS

CVL



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LOWER INDIAN BEND WASH AREA DRAINAGE MASTER STUDY

HYDROLOGY & HYDRAULICS REPORT

Contract No.: FCD 2011C019

December, 2017

Prepared For:
Flood Control District of Maricopa County
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Phoenix AZ, 85009

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In Association With:
TY Lin International

Disclaimer

The FLO-2D model results presented with this report were developed as part of the large-scale planning effort for the Lower Indian Bend Wash watershed. The effects of the streets, storm drains and other drainage features may not all be represented adequately in the model. Therefore, it is incumbent upon the user of the FLO-2D model to determine if the results of the study are appropriate for their intended purpose. It is strongly recommended that the user thoroughly review the drainage area, input data and model assumptions for the portion of the watershed that contributes to their area of interest.

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REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE NO. 15594 MARK T. GAVAN Date Signed 12-28-17 ARIZONA, U.S.A. Expires 12-31-20

REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE NO. 53942 OMER KAROVIC Date Signed 12-28-17 ARIZONA, U.S.A. Expires 12-31-18

REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE NO. 47673 REYNOLD A. KRAFT Date Signed 12-28-17 ARIZONA, U.S.A. Expires 03-31-20

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1.0 INTRODUCTION

1.1 PURPOSE OF STUDY

The purpose of the Lower Indian Bend Wash (LIBW) Area Drainage Master Study/Plan (ADMS/P) is to identify/quantify flooding hazards within the study area and to develop solutions to mitigating the identified flooding problems. This is the first comprehensive master drainage study that has been done for the lower part of the Indian Bend Wash watershed. The study will determine the adequacy of the existing drainage infrastructure by modeling the surface runoff using the latest FLO-2D modeling software and utilizing the embedded Storm Water Management Model (SWMM) to analyze the storm drain infrastructure.

1.2 PURPOSE OF REPORT

The purpose of the Lower Indian Bend Wash (LIBW) Hydrology and Hydraulics Report is to organize, document and summarize the hydrologic and hydraulic modeling efforts that were performed as part of the LIBW ADMS/P. Included in this report is documentation and results from the FLO-2D model that was developed to analyze the watershed. Also included is documentation of the SWMM model used to evaluate the existing storm drain system.

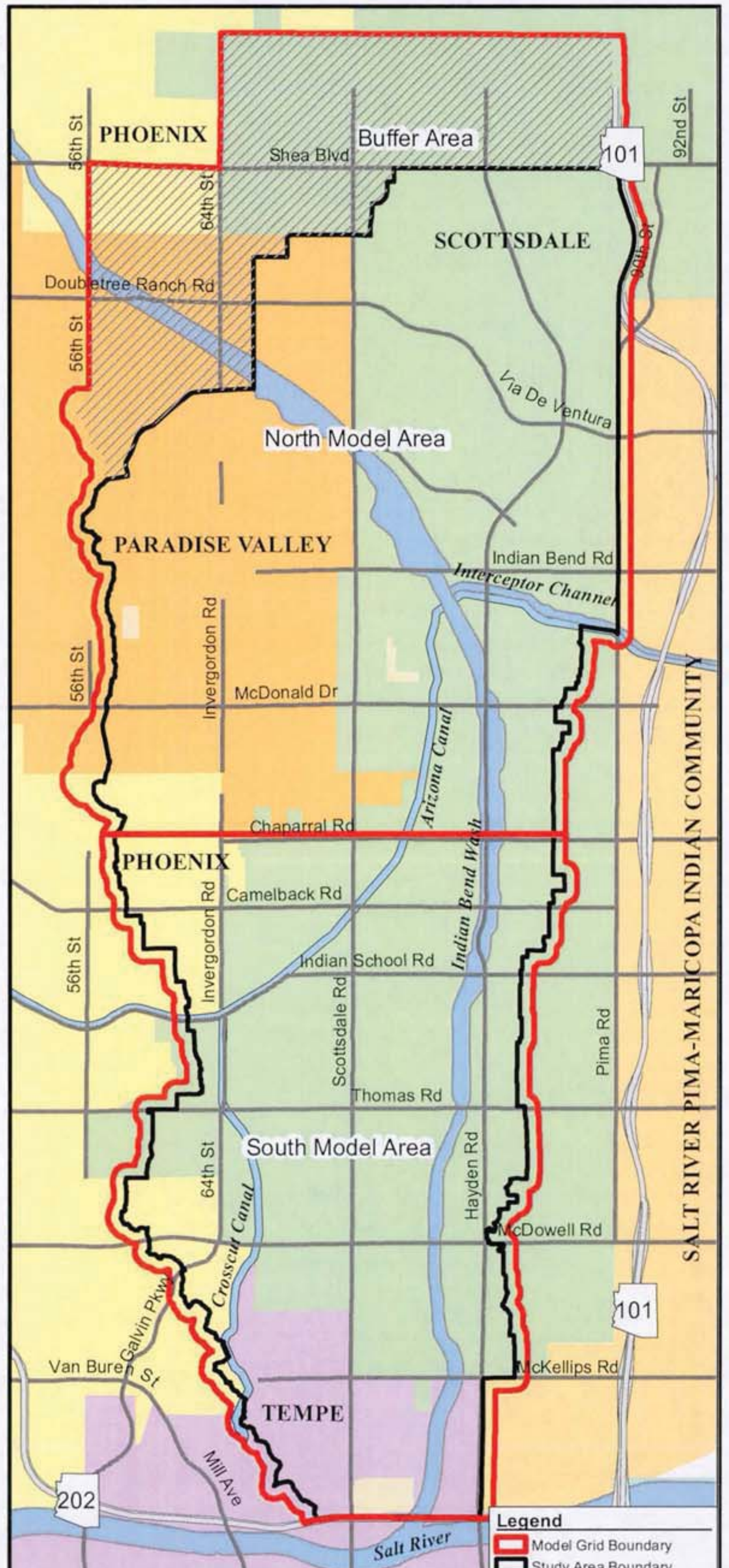

Figure-1: Study Area Map

1.3 STUDY AREA

The study area encompasses approximately 31 square miles and represents the watershed for the lower portion of Indian Bend Wash (IBW). The 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. Refer to Figure-1 for the study area and city boundaries.

IBW and the canals both represent significant drainage features in the study area. IBW runs from north to south and is the main conveyance channel for the area. The Arizona Canal and the Crosscut Canal are both elevated irrigation canals that impound runoff along their upstream sides. Refer to Figure-1 for the location of IBW, the Arizona Canal and the Crosscut Canal.

There is approximately 6 square miles of buffer area that was modeled as part of the hydrologic analysis. The buffer area was included to better define the inflows into the LIBW study area from the offsite hydrology model. Including the buffer area, the total area of the FLO-2D model is about 37 square miles. In order to limit the size of the FLO-2D models, the study area was divided into two models. The north model incorporates the buffer area and the area north of Chaparral Road, while the south model consists of the area south of Chaparral Road. Refer to Figure-1 for the North and South model boundaries.

1.4 AUTHORITY

Gavan & Barker Inc. was contracted by the Flood Control District of Maricopa County (District) under Contract No. FCD2011C019 to perform professional engineering services for the LIBW ADMS/P on February 22, 2012. The engineering services included data collection, hydrologic & hydraulic analysis as well as development of alternative flood mitigation measures to address the identified flooding problems. The hydrologic and hydraulic analysis was done in association with TY Lin International (TY Lin). TY Lin was responsible for the development of the FLO-2D model for the north part of the study area (North Model). This report along with the hydrologic and hydraulic analysis is part of the third assignment (Work Assignment #3) that was released under the LIBW ADMS/P contract. The notice to proceed date for the work assignment was April 30, 2013.

1.5 COMPUTER HARDWARE SPECIFICATIONS

The following tables show the specifications of the primary computers that were used to run the north and south LIBW FLO-2D models.

Operating System	Windows 7 / 8 Pro / 10
Processor	Intel Core I7 (2.80 GHz)
Number of Processors	2 x Quad Core (8)
System/Processor Type	64-bit
Memory (RAM)	16.00 GB

Table-1: Gavan & Barker Computer Specifications (South Model)

Operating System	Windows 7
Processor	Intel Xeon (3.47 GHz)
Number of Processors	2 x Quad Core (8)
System/Processor Type	64-bit
Memory (RAM)	24.00 GB

Table-2: TY Lin Computer Specifications (North Model)

2.0 TOPOGRAPHIC MAPPING

2.1 MAPPING DATA

The topographic mapping data used to develop the LIBW FLO-2D models was obtained from the District. The mapping is on the North American Vertical Datum of 1988 (NAVD '88) and consists of 2-foot interval contours that were developed specifically for this project. The contours are based on aerial photography that was flown on November 2, 2007. Inherent to 2-foot contour mapping, finer detail such as street crowns, curbs, gutters and valley gutters are not always clearly represented. Since this type of detail is very useful in determining flow depths and direction with FLO-2D modeling, the District had the mapping company add curb and gutter breaklines and street crown breaklines to the topographic data. With the addition of this new detail, streets were better represented in the FLO-2D models.

2.2 AERIAL PHOTOGRAPHY

The aerial photography used for the study area was also obtained from the District. Two different sets of aerials were used in order to develop the FLO-2D models. The first aerial was the 2007 photography, which matches the topographic mapping. This aerial was used to determine conditions at the time the topographic survey was flown. The second aerial, which was flown in 2012, was used to make adjustments to the surface data based on new development that has occurred since 2007.

2.3 LAND SURFACE CHARACTERIZATION

In addition to developing the aerial topographic mapping data, the District also developed the Land Surface Characterization (LSC) shapefile. The LSC shapefile includes the land coverages for the entire study area that were used to develop the FLO-2D models. Similar to the topographic data, the original LSC shapefile was based on the 2007 aerial photography. However, to incorporate new development that has occurred since then, the District updated the shapefile based on 2012 aerial photography. The FLO-2D modeling data reflects the updated LSC shapefile information. Refer to Appendix D for the Land Surface Characterization Map.

3.0 HYDROLOGY

3.1 FLO-2D MODELING METHODOLOGY

The FLO-2D analysis conducted for the LIBW hydrology was developed using the District's most current guidance for parameter development and modeling techniques. The most current District's version of the FLO-2D software, with a release date of February 28, 2017 (*Pro-Model - Build No. 16.06.16*) was used. GIS programs (ArcGIS 10.3 and Manifold Systems 8.0) and text editing software (TextPad and Excel) were used as pre-processing tools to develop the FLO-2D input parameters.

3.2 UPSTREAM (OFFSITE) FLO-2D MODEL

A larger, 45' grid FLO-2D model for the upstream (offsite) Indian Bend Wash watershed was developed as part of this ADMS/P. Hydrographs developed with the offsite model were used as inflow hydrographs to the LIBW hydrology model. Refer to Figure-2 for the offsite model watershed boundary as well as Appendix A for the Flow Transfer Exhibit that shows the major inflows from the offsite model to the study area. The offsite hydrology model was documented in the *"Lower Indian Bend Wash ADMS/P: Offsite Hydrology Study – Technical Memorandum"*, prepared by TY Lin International, dated February 27, 2015.

3.3 FLOW EXCHANGE: OFFSITE MODEL TO NORTH MODEL

Four different types of flow exchange were used to transfer hydrographs from the upstream, offsite model to the study area model. The first and most used type was to transfer flow from the offsite floodplain grids to floodplain grids in the study area model. The second type was an exchange from floodplain grids in the offsite model to a 1D channel cross section in the study area model. The third type was a transfer of flow from hydraulic structures in the offsite model to discharge at a grid in the study area model and the fourth type was a flow exchange between two 1D channel cross sections. Refer to the flow transfer exhibit in Appendix A for the major flow exchange locations between the upstream, offsite model and the study area model.

As stated above, the floodplain-to-floodplain grid exchange was the primary method of transferring flow from the offsite model to the study area model. This was performed using the flow exchange tool within FLO-2D. This tool was initiated by establishing outflow grids

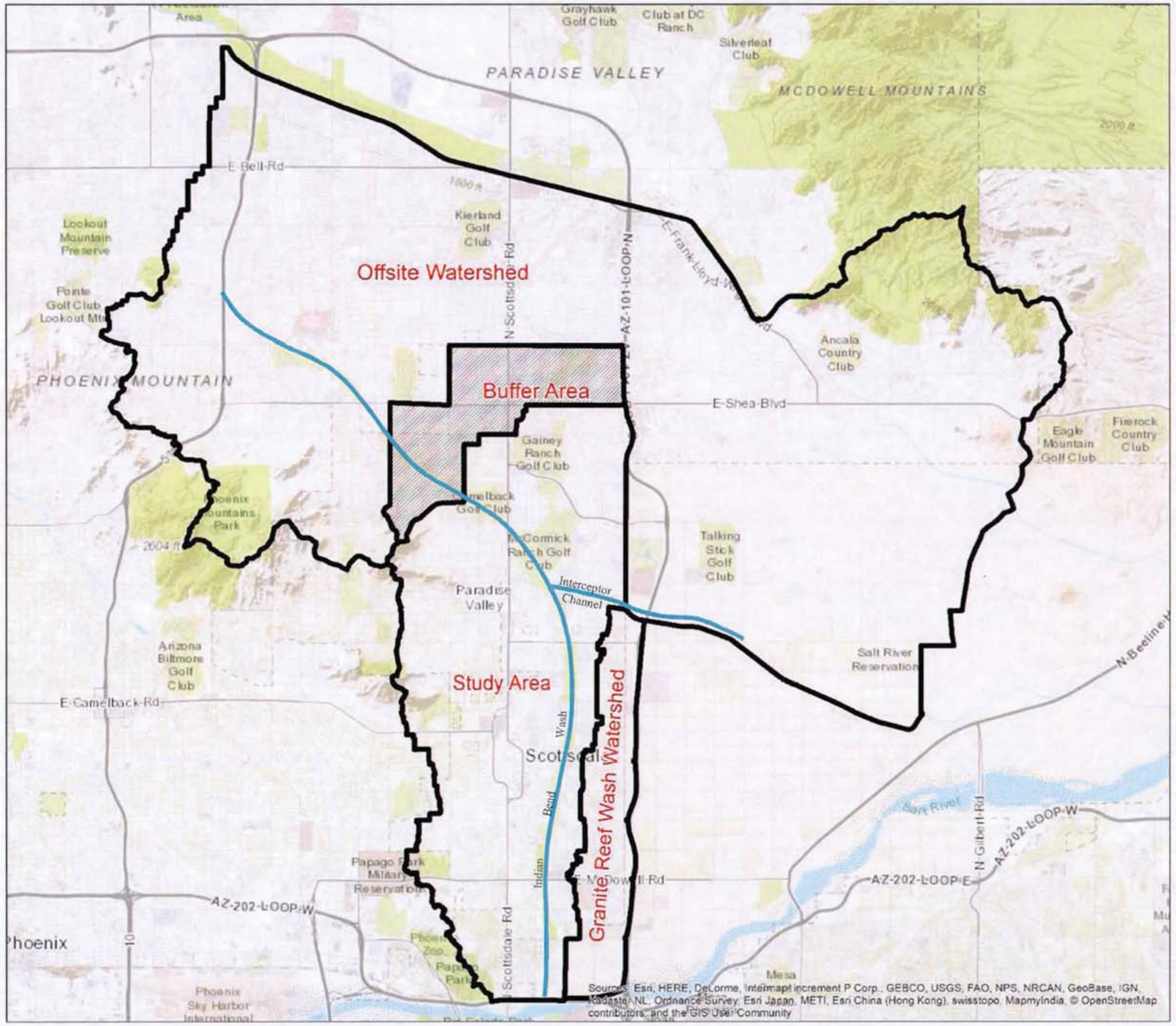

Figure-2: Watershed Map

in the offsite model to report inflow for the corresponding, overlapping grids on the upstream end of the study area model. In models where the grid size is the same in both models, the tool creates a direct grid-to-grid exchange. But in this case the offsite model has a 45' grid and the study area model has a 20' grid. For this situation the tool divides the outflow hydrograph from the 45' grid into equal hydrographs for inflow to the smaller, overlapping grids of the study area model. Depending on the alignment of the overlapping grids, this can result in dividing the outflow hydrograph into as many as nine or as few as four equal inflow hydrographs.

An issue was discovered however with the flow exchange tool. In some cases, where the flow exchange tool overlapped multiple rows of inflow grids, flow in the upper rows was trapped and resulted in instances of unreasonable flow depths and numerical instability. The solution was to combine multiple rows of inflow grids into a single row which eliminated the problem with the trapped flow. This was done by eliminating the upper rows of inflow grids; leaving just one single row of downstream grids. Depending on the alignment of the grids, this required the elimination of either one row or two rows of inflow grids. The hydrographs for each remaining downstream grid was then either doubled or tripled based on the number of grids that were removed immediately upstream of that grid. Levees were then applied along the upstream side of the remaining inflow grids to prevent backflow.

In the case of the Indian Bend Wash inflow at 56th Street, all of the grids in the offsite model that represent flow in the wash were added together to produce one single hydrograph. This hydrograph was used as input to the Indian Bend Wash 1D channel in the study area.

In regard to hydraulic structures, there are only two from the offsite area that cross into the study area model. One is the 68th Street storm drain that discharges to the study area model at the Mescal Park detention basin. The other is the storm drain outlet from the Cactus Park detention basin that discharges into an open channel in the study area model at 70th street, just upstream of Mescal Street. The hydrographs associated with these two hydraulic structures were obtained from the offsite model's HYDROSTRUCT.OUT file.

Lastly, the fourth type of flow exchange was used for the Interceptor Channel along the north side of the Arizona Canal. The Interceptor Channel was modeled as a 1D channel in both the offsite and study area models. The flow exchange was done at a common cross section at Pima Road where the inflow hydrograph was obtained from the offsite model in the HYCHAN.OUT file.

3.4 FLOW EXCHANGE: NORTH MODEL TO SOUTH MODEL

Three different types of flow exchange were used to transfer hydrographs from the north model to the south model. Similar to the flow exchange between the offsite model and the north model, the most used flow exchange was to directly transfer floodplain grid hydrographs from the north model to the south model. The second flow exchange type was to transfer flow from the north model 1D channel to the south model 1D channel and the third type of exchange was to transfer flow from the north model SWMM storm drain to the south model SWMM storm drain. Refer to the flow transfer exhibit in Appendix A for the major flow exchange locations between the north and south FLO-2D models.

As stated above, the floodplain-to-floodplain grid exchange was the most used method of transferring flow from the north model to the south model. This was performed using the flow exchange tool within FLO-2D. This tool was initiated by establishing outflow grids in the north model to report inflow for the corresponding, overlapping grids in the south model. Unlike the flow exchange between the offsite model and the north model, the grid sizes in the north model and south model are both 20' grids and therefore the tool creates a direct grid-to-grid flow exchange file. When the north model is run, one of the output files it creates is the INFLOW1_DS.DAT, which contains all the grid-to-grid flow exchange hydrographs. This file was then transferred to the south model project folder and renamed as the INFLOW.DAT file.

Unlike the floodplain grid-to-grid transfer, the flow exchange between the 1D channels is done manually. When the north model is run, FLO-2D generates the 1D channel hydrograph in the HYCHAN.OUT file. The hydrograph from the most downstream cross section is extracted, and used as the inflow hydrograph for the most upstream cross section in the south model. This hydrograph, obtained from the HYCHAN.OUT file, was also added to the INFLOW.DAT file in the south model.

Storm drain flow was also exchanged between the north and south models. The storm drain where this occurs runs from the south model into the north model along the upstream (west) bank of the Arizona Canal. The SWMM outflow hydrograph from the north model was extracted and used as the inflow hydrograph for the most upstream SWMM junction in the south model. This hydrograph was input into the south model using SWMM's direct inflow time series method. To accomplish this the outflow hydrograph from the north SWMM model was used to create a new external data input file (AZCANALSDINFLOW.DAT). This data file was then placed in the project folder for the south model so that it can be used by FLO-2D to add the inflows to the storm drain.

3.5 INFLOW FROM GRANITE REEF WATERSHED

There are several existing storm drains in the study area that collect upstream runoff in the Granite Reef Wash watershed which lies east of the study area. They all outlet to IBW and include storm drain pipes in Jackrabbit Road, Chaparral Road, Camelback Road and Indian School Road. The flows that enter from the Granite Reef watershed represent diversions of flow into the study area. To account for the diverted flow, inflow hydrographs were added to the upstream end of the storm drains at the eastern boundary of the FLO-2D model. The inflow hydrographs were obtained from the City of Scottsdale's FLO-2D model for the Granite Reef Wash watershed. The City's hydrology model was documented in the report entitled *"Granite Reef Wash Watershed Update: Hydrologic Study"*, prepared by TY Lin International, dated April, 2017.

The Flow Transfer Map in Appendix A shows the location of the storm drain inflows from the Granite Reef Wash watershed. Appendix A also includes the 100-year, 6-hour inflow hydrographs. The 100-year storm drain inflows are significant, including 130 cfs at Jackrabbit Road, 150 cfs at Chaparral Road, 32 cfs at Camelback Road and 230 cfs combined flow in the Indian School Road dual 72-inch pipes. The storm drain inflow at Jackrabbit Road was added to the north model, and the others were added to the south model.

This flow exchange between the Granite Reef Watershed and the north and south models was accomplished in a similar manner as the storm drain flow exchange between the north and south models. The five SWMM outflow hydrographs from the Granite Reef Watershed model were used as inflow hydrographs for the most upstream SWMM junctions in the north and south models. In the north model, the inflow hydrograph for the Jackrabbit Road storm drain is being transferred with the JACKRABBITSDINFLOW.DAT file. In the south model, the inflow hydrographs for the Chaparral and Camelback storm drains are being transferred with the CHAPARRALSDINFLOW.DAT, CAMELBACKSDINFLOW.DAT files. The Indian School Road storm drain inflow hydrographs are transferred with the NORTHINDIANSCHOOLSDINFLOW.DAT and SOUTHINDIANSCHOOLSDINFLOW.DAT files.

3.6 BUFFER AREA FLO-2D MODEL

As documented in the *"Lower Indian Bend Wash ADMS/P: Offsite Hydrology Study –Technical Memorandum,"* the offsite model is a large grid size model with minimal added definition (i.e. no buildings, channels, walls, etc.). To better define the inflow into the LIBW study area, a buffer area was added to the north model that provides a transition zone (i.e. buffer area) between the large 45' grid offsite model and the 20' grid study area. It was modeled using the same procedures as the study area which helps concentrate and define the largely distributed, shallow sheet flows in the offsite model for transfer into the more refined study area model. Refer to the study area map in Figure-1 for the location of the buffer area.

In addition to including the upstream buffer area, the FLO-2D model also covers a 200-foot wide strip around the study area. The study area boundary was drawn along the approximate watershed boundary. When the FLO-2D model was created, the study area boundary was offset 200 feet to incorporate any contributing areas that might exist outside the delineated watershed boundary to make sure that the entire contributing drainage area is captured. Refer to Figure-1 for the study area boundary and the model area boundary.

3.7 STUDY AREA FLO-2D MODEL

The LIBW study area encompasses a total of 37 square miles (including the buffer area). Due to its large size, the study area was divided into two separate FLO-2D models. The north FLO-2D model encompasses approximately 23 square miles; covering the buffer area and the portion of the study area that lies north of Chaparral Road. The south FLO-2D model covers the remaining 14 square miles south of Chaparral Road. Refer to the study area map in Figure 1 for the boundaries of the north and south FLO-2D models.

3.7.1 Grid Size

Prior to modeling the 37 square mile study area, a focused area study was performed to determine, among other things, the most applicable grid size for the FLO-2D model. Three different grid sizes were analyzed (15'x15', 20'x20' and 25'x25') and the results indicated that a 20'x20' grid system would be most appropriate for the overall FLO-2D model. Therefore, the north and south FLO-2D models were developed using a 20'x20' grid size.

The focused area study is documented in the *Lower Indian Bend Wash Area Drainage Master Study/Plan: Focused Area Study Technical Memorandum* prepared by TY Lin International, dated July 27, 2012.

The grid geometry data for the FLO-2D model area is contained within the GRID.shp file as well as the FPLAIN.DAT and CADPTS.DAT files. Refer to the electronic files included on the CD in Appendix O of this report.

3.7.2 Average Grid Elevation

The primary attribute for each grid element is the average grid elevation, which is unique to each grid element. The grid elevation along with its roughness coefficient, infiltration parameters and area reduction factors determines the flow characteristics specific to each grid.

Grid elevations for the north and south FLO-2D models were obtained from the updated Lower Indian Bend Wash mapping provided by the District. Elevations were assigned to each grid element in order to characterize the topography of the study area. Since the grid elements can only be assigned a single elevation, an average for the 20'x20' grid area must be determined. This requires the surface to be "sampled" before assigning an average elevation to the grid.

To sample the surface, a Triangulated Irregular Network (TIN) was created for the study area. The TIN was used to create a Digital Elevation Map (DEM), in ESRI ASCII grid format. The District's guidance suggests using a DEM grid size that is no more than 25% of the model grid size. So based on a 20'x20' grid element, a 4'x4' DEM grid size was chosen for the sample surface. Once completed, the DEM was overlaid with the model grid elements and the 25 DEM points falling within each grid element were averaged to produce the elevation for each FLO-2D grid. Refer to Appendix G for the grid elevation maps.

3.7.3 Spatially Varied Manning's N-Value

A Manning's n-value (roughness coefficient) was assigned to each grid element based on the corresponding land cover type as defined in the updated LSC shapefile provided by the District. To determine the Manning's n-values for each grid element, the LSC shapefile was overlaid with the grid element polygons using GIS software to create a spatially varied roughness coefficient. For grid elements falling on two or more cover types (i.e. different roughness coefficients), an area-weighted roughness value was assigned to that grid element. Refer to the Land Surface Characterization Map in Appendix D and Table-3 for the various land cover types and the associated Manning's n-values found in the study area. Refer to Appendix G for the manning's n-value maps.

3.7.4 Limiting Froude Number

In addition to assigning Manning's n-values to each grid element in the model, three limiting Froude numbers were used to control the flow regimes (i.e. sub critical or super critical flow) on the floodplain grids. Most of the grid elements in the model were assigned a

Cover Type	IA (in)	RTIMP (%)	InitSat	n	Feature Description
Agriculture	0.50	0	Normal	0.055	Farm Fields
Urban High Vegetation	0.10	0	Normal	0.065	Trees
Urban Low Vegetation	0.10	0	Normal	0.045	Lawns and Low Shrubs
Urban Bare Ground	0.20	0	Dry	0.035	Urban Bare Ground
Mountain Bare Ground	0.25	0	Dry	0.050	Mountain Bare Ground
Concrete	0.05	98	Normal	0.016	Sidewalks, Curbs and Patios
Asphalt	0.05	95	Normal	0.020	Streets and Parking Lots
Buildings	0.05	95	Normal	0.024	Physical Structures that are Flow Obstructions
Shade Structures	0.05	98	Normal	0.035	Parking Covers and Canopies
Water	0.00	100	Saturated	0.040	Lakes, Canals and Ponds
Unpaved Road	0.10	50	Dry	0.026	Gravel and Dirt Roadways and Shoulders
Wash Bottom	0.10	0	Dry	0.035	Natural Wash and River Bottoms

Table-3: Land Surface Characterization Summary Table

limiting Froude number of 0.95. By assigning a limiting Froude number less than 1.0, the model results are based on sub critical flow. In the event that a Froude number greater than 0.95 is calculated during the simulation, the FLO-2D program automatically increases the assigned Manning's n-value until the corresponding Froude number is at or below 0.95. The maximum adjusted n-value that was used for each floodplain grid during the simulation is reported in the FPLAIN.RGH file.

In steep mountainous areas and paved streets, where super critical flow can be expected to occur, a limiting Froude number greater than 0.95 was applied. All of the grid elements that are representative of mountainous areas (Camelback Mountain, Papago Buttes and Mummy Mountain) were assigned a limiting Froude number of 1.0 and all of the grid elements that represent streets were assigned a limiting Froude number of 1.3.

3.7.5 "SHALLOWN" Assignment

The FLO-2D user's manual suggests applying a global variable known as "SHALLOWN" to replace the grid specific n-value with a higher n-value to model shallow flow depths less than 3 feet. It was found, however, that the assignment of "SHALLOWN" significantly slows down the movement of water in the streets (a typical SHALLOWN value of 0.130 was tested in the model) which tended to limit the interception of runoff at the storm drain inlets. To better represent the amount of water that gets to the inlets and hence, the amount of water intercepted at the inlets, it was decided to remove the SHALLOWN from the model and use the grid specific n-value at all flow depths. Removing SHALLOWN resulted in more reasonable estimates of the interception at the storm drain inlets.

3.7.6 Rainfall

Per the District's Drainage Design Manual, the NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico and Utah) was used to determine the point rainfall depth parameters for the north and south FLO-2D models.

Four different storms were used to analyze the LIBW study area. The storms and their minimum and maximum point rainfall values are listed in Table-4. The isopluvial maps for Maricopa County indicate that rainfall for the four storms is spatially varied across the study area. The rainfall depths are higher in the northern part of the watershed with the greatest depths found on Mummy Mountain and Camelback Mountain. Conversely, the rainfall depths were generally lower in the southern part of the study area.

Storm Event	Maximum (inches)	Minimum (inches)
100-yr, 24-hr	3.70	3.44
100-yr, 6-hr	2.68	2.49
10-yr, 24-hr	2.38	2.22
10-yr, 6-hr	1.76	1.62

Table-4: Rainfall Depth

Each grid element in the two FLO-2D models was assigned a rainfall depth based on its corresponding location within the study area. The District provided an ESRI ASCII Grid data file for each storm event. Using GIS software, this rainfall data was used to assign a rainfall depth to each FLO-2D grid. This procedure was followed for each of the four storms that were modeled.

The 6-hour local and 24-hour general storm distributions were obtained from the District's Drainage Design Manual and used for this study. The SCS Type II distribution was applied to the 24-hour general storms and the Pattern No. 1 distribution was applied to the 6-hour local storms. All rainfall data for the FLO-2D models is contained within the RAIN.DAT file. Refer to Appendix F for the rainfall maps.

Unlike HEC-1, there is no option in FLO-2D for interpolating hydrographs to simulate depth-area rainfall reduction for multiple points of interest in the watershed. So point rainfall values were assigned to each grid element without any reduction in depth due to watershed size. For the most part, this has little effect since most of the points of interest within the study area have relatively small watersheds and therefore the corresponding depth-area reduction factor is also small. For estimates of peak discharge on Indian Bend Wash (IBW) however, the effect is more significant. For example, at the confluence with the Salt River, IBW has a watershed area of about 100 square miles (offsite area and study area). The corresponding depth-area reduction would be about 15% for the 24-hour storm. So, for this example, the model overestimates rainfall by about 15% which results in a fairly conservative estimate of peak discharge on IBW.

3.7.7 Rainfall Losses

The Green-Ampt method was used to estimate losses associated with infiltration. FLO-2D applies the Green-Ampt infiltration equation to all water on the grid; including rainfall and runoff from upstream grids. Therefore, when compared to HEC-1, which applies losses only to rainfall, FLO-2D tends to produce higher estimates of infiltration losses.

The data to estimate rainfall losses (infiltration parameters) was obtained from two sources:

- The District's GIS coverage for soils prepared by using the Natural Resources Conservation Service (NRCS) 2010 soils data for the State of Arizona (2010)

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- The updated LSC shapefile

Several different soil types exist in the study area. Refer to the Soils Map in Appendix E for an exhibit showing the different soil types found within the study area as well as a table showing the associated XKSAT, PSIF, DTHETA and percent Rock Outcrop.

In addition to the soil parameters, the land use parameters including IA, RTIMP and Initial Saturation were obtained from the LSC shapefile and used to determine the rainfall loss parameters for each individual grid element. Refer to the Land Surface Characterization Map in Appendix D for the infiltration parameters for the various land cover types found within the LIBW study area.

Rock outcrop was applied to the grids using the RTIMP parameter based on the NRCS estimates found in the soils shapefile provided by the District. The final RTIMP assignment assumed for each grid was set to either the percent rock outcrop or the land use percent impervious, whichever was greater. For example, in mountainous areas where roads, sidewalks and buildings overlap the rock outcrop, the greater RTIMP associated with the impervious land use was applied to the grid.

FLO-2D requires a minimum surface detention value (TOL) to reduce model run times by not performing calculations at extremely shallow depths. This value essentially represents an initial abstraction (IA) for the model. Because of this, the IA values associated with the various land surface cover types were adjusted to account for TOL. TOL was set to 0.05 inches and subtracted from the IA values for each land type (except for "Water" which remained at 0.00).

The soils and LSC shapefiles were overlaid with the model grid elements and GIS software was used to assign the spatially variable rainfall loss parameters for each grid element. For grid elements falling on two or more cover types or soils, an area-weighted parameter value (IA, RTIMP, etc.) was assigned to that grid element. The only exception to this is the estimation of XKSAT, which was area-weighted based on the following formula:

$$\overline{XKSAT} = 10^{\left(\frac{\sum A_i \log(XKSAT_i)}{A_{GE}}\right)}$$

Where:

$XKSAT_i$ is obtained from the NRCS soils shapefile
A_i is the area within the grid element that is covered by the $XKSAT_i$
A_{GE} is the total grid element area

PSIF and DTHETA were determined based on Figure 4.3 in the District's Hydrology Manual using the composite XKSAT values for each grid element. XKSAT was not adjusted for vegetation cover in accordance with District guidance for FLO-2D models.

3.7.8 *Limiting Infiltration Depth*

The FLO-2D function for "limiting infiltration depth" was employed to control the amount of infiltration loss in the model. The Green-Ampt infiltration equation in FLO-2D is applied to the water depth on each individual grid cell. It calculates infiltration for the rainwater that falls on each grid cell plus any additional runoff that reaches the grid cell from upstream grids. Therefore, when compared to HEC-1, which only applies infiltration losses to rainfall, FLO-2D tends to produce higher estimates of infiltration loss. To prevent excessive infiltration that would result in less runoff, the limiting infiltration depth parameter in FLO-2D was utilized. Applying the limiting infiltration depth to each grid element effectively stops runoff from infiltrating once water has infiltrated to a specified depth.

To establish an appropriate limiting infiltration depth, single basin HEC-1 models were developed for both the north and south study areas using the rainfall for each of the four design storms as well as the averaged Green-Ampt parameters that were used in the FLO-2D models. The single basin HEC-1 models cover 21.4 and 13.1 square miles of the north and south FLO-2D area models, respectively. They are slightly less than the total watershed areas of the north and south FLO-2D models because they do not include the area covered by Indian Bend Wash. The results of the HEC-1 analysis are summarized in Table-5.

The corresponding FLO-2D rainfall loss is reported as the "Overland Flow – Water Lost to Infiltration & Interception" in the SUMMARY.OUT file. The goal was to match the rainfall loss as calculated by HEC-1 to the "Water Lost to Infiltration & Interception" as calculated in the FLO-2D model. This was accomplished through a trial and success approach where the limiting

Storm Event	HEC-1 Rainfall Loss		FLO-2D Losses	
	Total Loss (in)	Total Loss (ac-ft)	Limiting Infiltration Depth (in)	Water Lost to Infiltration and Interception (ac-ft)
North Study Area				
100-yr, 24-hr	1.65	1885	8.0	1816
100-yr, 6-hr	0.91	1040	4.0	975
10-yr, 24-hr	1.20	1371	5.5	1294
10-yr, 6-hr	0.75	857	3.5	853
South Study Area				
100-yr, 24-hr	1.26	880	7.5	841
100-yr, 6-hr	0.71	496	4.0	471
10-yr, 24-hr	0.92	643	5.5	627
10-yr, 6-hr	0.57	398	3.0	368

Table-5: HEC-1 and FLO-2D Loss Summary Table

infiltration depth was adjusted until the results "Water Lost to Infiltration & Interception" was approximately equal to the rainfall loss obtained with HEC-1. To achieve this, the Limiting Infiltration Depth parameter in FLO-2D was adjusted until the infiltrated volume reported in FLO-2D reasonably matched the calculated HEC-1 infiltration loss.

Using this approach, separate limiting infiltration depths were determined for the north and south study areas. Refer to Table-5 for a summary of the limiting infiltration depths that were used in the FLO-2D models as well as their corresponding "Water Lost to Infiltration and Interception" volume. Refer to the Digital Data in Appendix O for the HEC-1 model files.

3.7.9 Modeling of Buildings (ARFs)

Obstructions to storage are represented by area reduction factors (ARFs). ARF's are used to reduce the available storage on each grid element by representing houses, shopping centers, office buildings or any other structures that prevent flow from occupying the grid. ARF values are applied to each individual grid element from a range of 0 (fully open) to 1 (completely blocked).

The updated LSC file that was provided by the District included a building layer. The layer represents the footprint of the buildings, such as homes and shopping centers that are found within the LIBW study area. This layer was superimposed on the FLO-2D grid elements shapefile and spatially varied ARF values were calculated for each grid element using GIS software. Similar to the n-value estimation, around building edges, the ARF values were area-weighted. For example, if 75% of a grid element was covered by a building, that grid element would be assigned an ARF value of 0.75. The ARF data for the FLO-2D model can be found in the ARF.DAT file. Refer to Appendix G for the ARF maps.

Since FLO-2D only requires ARF values greater than zero, the ARF.DAT file only contains grid elements that have an ARF value that is greater than zero. Per the District's guidance, the width reduction factors (WRFs) were not used with this model.

3.7.10 Modeling of Walls (Levees)

Unlike ARFs, which are obstructions to storage, levees were used to represent obstructions to flow that are caused by walls. The levees are specified along the sides of the grid elements. If the water level on the grid is lower than the top of the levee elevation, the levee prevents flow from being exchanged with the adjacent grid elements.

The levee data was created using the "wall" shapefile provided by the District. The "wall" shapefile lists all of the walls that were identified as part of the topographic mapping effort described in Section 2.1, including residential and commercial block walls, sound barrier walls, retaining walls, etc. Before the "wall" shapefile was used to create the FLO-2D levee file, it was reviewed in ArcMap and revised to remove walls that no longer exist as well as add walls that have been constructed since the "wall" shapefile was developed. As with the topographic data described in Section 2.1, the "wall" shapefile was created using the 2007 aerial photography. So, based on a comparison with 2012 aerial photography, there were a number of walls and construction fences identified that no longer exist. There were also a number of walls that did not have an impact on drainage patterns; such as short segments of wall, trash enclosures and walls around backyard pool pumps. In order to best represent drainage flow paths within the study area, all of the residential walls were left in the wall shapefile. The wall shapefile was then converted into the LEVEE.DAT file with the FLO-2D GDS program.

The LEVEE.DAT file represents the obstructions to flow in the watershed and is used by FLO-2D to confine flow and thereby better define the watershed drainage patterns. While the creation of the LEVEE.DAT file is automatic in GDS, the conversion results in numerous irregularities that have to be corrected in order to produce a LEVEE.DAT that functions correctly in FLO-2D and properly represents the obstructions to flow that are introduced by the walls. Some of the corrections were made on a global basis while others were made on a more specific basis that focused on particular areas within the watershed.

Global Corrections to LEVEE.DAT file:

- *Levees On or Bordering Outflow Nodes* – Levees were removed from the LEVEE.DAT file if they were either on or bordered the outflow nodes. This was necessary to run the updated FLO-2D program.
- *Levee Elevation Errors* – There were numerous locations where the top of wall elevation (top of levee), given with the "wall" shapefile, was lower than its corresponding grid elevation which results in a computational error in FLO-2D. To correct this problem, all top of levee elevations within the watershed were revised and set to six feet above the corresponding grid elevation. The 6 feet is representative of a 6-foot high block wall which is the most common wall height in the study area.
- *Levees Associated with Buildings* – All levees were removed from the model that were either on or bordered grid cells that are occupied by buildings (grid cells with an ARF value of 0.95 or greater). This was done because the building grid elevations were higher than the top of levee elevation which results in FLO-2D computational errors.

In addition to these global corrections, there were many other more specific corrections that were made to the LEVEE.DAT file which focused on areas where there are significant concentrations of flow (i.e. areas that have maximum flow depths greater than one foot). It is important to point out that the issues described below exist throughout the LEVEE.DAT file, but correcting the entire file would require an inordinate amount of effort. So instead of correcting the entire file, the levee file revisions were limited to those areas that are impacted by significant flows; that is areas that have depths of flow greater than one foot. Making these corrections required an iterative approach of refining the LEVEE.DAT file and running FLO-2D to identify areas of concentrated flow.

Corrections to LEVEE.DAT file focused on specific areas:

- *Gaps in Levees* – There were numerous locations where the LEVEE.DAT file indicated gaps in walls that did not exist. Using the 2012 aerial photography these gaps were removed in the LEVEE.DAT file in order to properly represent the effect of the walls on the drainage patterns.

- *Levees Erroneously Blocking Flow* – There were many locations where levees had to be removed and/or adjusted in certain grid cells to prevent improper blockage of flow. These locations tended to be where walls run along both sides of narrow features like alleys, smaller drainage ways and the narrow separations between homes. The problem occurs when the "wall" shapefile data has more than one wall located in the same grid cell. In these instances GDS creates levee assignments that do not always correctly reflect the location of the walls and in some cases result in improper blockages of flow. So adjustments were made to the LEVEE.DAT file to correct many of these improper levee assignments.

- *Missing Levees* – There were multiple locations where levee segments had to be added to the LEVEE.DAT file to properly represent the walls in the watershed. In some cases these added levees represented walls that were inadvertently left out of the "wall" shapefile. In other cases they were added to correct issues in the GDS levee assignments. For example, in the case described above for narrow features like alleys where walls run along both sides of the alleyway, GDS would often omit one of the walls if they both fell within the same grid element. In this example levees were added to grid cells along the other side of the alley to properly confine the flow within the alley.

- *Drainage Openings in Walls* – Gaps in the levees were created in order to represent drainage openings in the walls. These are openings that allow runoff to either flow through or under the wall. The gaps were identified by inspecting the maximum flow depths computed with FLO-2D. In locations where water ponds to a depth of more than one foot, an inspection of the wall was conducted either by reviewing photography or making field visits to verify the presence of a wall opening. In all but one case, the wall openings appeared large enough to pass the anticipated flow so a gap was provided in the levee to represent the drainage opening. The one exception is a wall located at the end of 70th Street, just south of Glenrosa Avenue where there are 12 – 8"x4" wall openings that seem undersized compared to the flow that reaches the wall. At this location the wall opening was modeled with a hydraulic structure. Refer to hydraulic structure number 70ST-1 in Appendix H.

Once these corrections to the LEVEE.DAT file were made, a number of levees remained in the file that do not impact the drainage flow paths. So even though all of the residential walls were added to the LEVEE.DAT file, not all of the walls were found to significantly affect the flow within the study area. The following procedure was followed to identify and make further corrections to the LEVEE.DAT file:

1) A model without the LEVEE.DAT file was run and a maximum depth raster was created,
2) A model with the LEVEE.DAT file that already had the aforementioned changes incorporated was run and a second maximum depth raster was created,
3) All grid cells that had a maximum depth of flow greater than 1.5 feet were identified. In addition, the two maximum depth rasters were compared and grid cells that had maximum depths that varied more than 0.5 feet (regardless of whether it was higher or lower) were also identified,
4) The LEVEE.DAT file was analyzed and corrected to match the "wall" shapefile for the grid cells that were identified as having depths greater than 1.5 feet and where maximum depths varied by more than 0.5 feet,
5) Then a new model was run with the corrected LEVEE.DAT file and a new maximum depth raster was developed,
6) This maximum depth raster was then compared to the original maximum depth raster (Step 1) and areas were identified for which the maximum depth varied by more than 0.5 feet
7) Steps 4 through 6 were repeated three times to make sure the walls were adequately modeled.

This procedure helped ensure that the LEVEE.DAT file reasonably represents the effect that the walls have on drainage flow patterns in the model.

3.7.11 Modeling of Canal Banks (Levees)

There are two major canals that transverse the LIBW study area. They are the Arizona Canal which crosses the LIBW study area from east-to-west and can be found in both the north and south model and the CrossCut Canal which runs north-to-south and is only found in the south model. Both the Arizona and the CrossCut Canal have elevated banks. In most cases, the canal banks are 20-40 feet wide and provide maintenance access as well as pedestrian and bicycle pathways. In some areas, however, the banks are only 20-30 feet wide and are oriented diagonally to the grids which resulted in averaged grid elevations that are lower than the actual elevation of the canal bank. The averaged grid elevations were found to be as much as 1.5 feet lower in some areas. This misrepresentation of the overtopping elevation of the canal banks results in a significant underestimation of the storage capacity behind the canal. In order to accurately represent the canal overtopping elevation, the FLO-2D levee component was utilized to better define the top of bank elevations along the canal.

The canal levee components were created by drawing a polyline over the upstream and downstream canal banks and then assigning elevations to that line by sampling the Digital Terrain Model (DTM) surface using GIS. Once this polyline with the elevations was created, it was converted to levee components using the FLO-2D GDS program and appended to the LEVEE.DAT file that was previously developed for the modeling of walls. Following this procedure assures that the ponding behind the two elevated canals will be modeled accurately by preventing water from spilling into the canal (or out of it) at elevations that are lower than the actual top of bank elevations.

3.7.12 Modeling of Canals

From inspection of the 2007 mapping data, the water levels in the two canals (Arizona and Crosscut) appear to be at their normal operating level. The grid elevations that represent the canals were established using these normal water surface elevations. Therefore, the conveyance and storage capacity of the canals is limited to the freeboard depth between the top of bank and the canal water surface elevation. This is representative of actual conditions because the canals operate at normal levels for most of the year with only a short period of time when they are drained for maintenance purposes.

The conveyance and storage capacities of the Arizona and CrossCut Canal, above the normal operating water level, were incorporated into the FLO-2D model. The Arizona Canal flows east to west bisecting the LIBW watershed, whereas the CrossCut Canal flows north to south from the Arizona Canal to the southern boundary of the study area. Water that enters the Arizona Canal east of IBW is discharged to IBW, whereas water that enters the canal west of IBW is conveyed west in the Canal out of the study area. Similarly, the water that enters the CrossCut Canal is conveyed south in the Canal out of the study area. The following are the three primary reasons why it is important to include the canal storage and conveyance in the model:

1) The U.S. Army Corps of Engineers assumed that the Arizona Canal provided floodwater conveyance in their design of the IBW Side Drain System and the Interceptor Channel (see below)
2) The downstream canal bank is generally higher than the upstream bank. So if the canal were to be artificially filled in to the level of the downstream canal bank by raising the grid elevations; the water surface elevations associated with the ponding upstream of the canal would be artificially high.
3) In the event of large floods, there are designated low spots in the downstream bank that were designed for floodwaters to discharge from the canal. If the canal were to be artificially filled in, floodwaters will simply spill across the canal and would not necessarily be conveyed to the designated low spots; effectively discharging flow downstream of the canal where none otherwise would occur.

The Corps of Engineer's design of the Interceptor Channel (east of IBW) and the Side-Drain system (west of IBW) along the upstream side of the Arizona Canal incorporate the capacity of the Canal in their hydraulic design. In the design of the Interceptor Channel, the Corps calculated that the Arizona Canal has a conveyance capacity of 2500 cfs between Pima Road and IBW. The capacity is based on the Salt River Project (SRP) draining the canal of all the irrigation water prior to the arrival of the flood flows. The following excerpt is from Section 5.08-e. of the *Design Memorandum No. 4 – Feature Design for Interceptor Channel:*

> "It is a firm Salt River Project policy to open wasteway gates and empty Arizona Canal at the earliest time that it can be determined that significant runoff will reach the canal. The Salt River Project has an operational system of sufficient sophistication to be responsive and reliable with respect to canal operation. The Los Angeles District has coordinated closely with the Salt River Project during project studies for flood control in the Phoenix area. Based on these contacts, evaluation of available data and information, and inspection of tier flood operation facilities, it is concluded: (1) that the Salt River Project has both the intention and the capacity to operate the Arizona Canal in a manner that will be compatible with the flood control function of the Indian Bend Wash Project; and (2) that irrigation water would be drained from the canal prior to the arrival of major floodflows."

In the design of the Side-Drain system, west of IBW, the Corps included the capacity of the Arizona Canal above the normal operating level to be available for flood flow conveyance. The Side-Drain system (Reach 1-4) along with the capacity of the Arizona Canal above its normal operating level has the capacity to convey the 100-year peak discharge without the downstream bank of the canal being overtopped. The following excerpt is from Section 5.01-b. of the *Design Memorandum No. 5 – Feature Design for Side Channels System:*

> "The proposed project would relieve ponding west (uphill) of the Arizona Canal resulting from 50-year floodflows in the upper reach (Reach 1), and 25-year floodflows in the lower reaches (Reach 2 through 4). The top of the existing east (downhill) levee is about 3 to 3-1/2 feet above the irrigation design flow conditions. Under project conditions a 100-year flood would raise the water in the canal about 1-1/2 feet, assuming the canal is conveying its irrigation design discharge. This would allow for a freeboard of about 1-1/2 feet to 2 feet for the downhill levee. Therefore, although some ponding would occur west of the canal during the occurrence of the 100-year flood under project conditions the floodwater would not overtop the downhill levee, and the areas located south and east of the canal would be provided protection from flood events up to and including the 100-year flood."

To incorporate the Arizona and CrossCut Canals as conveyance canals; modifications to the FLO-2D grid elevations had to be made. The primary modification of grid elevations occurred at bridged roadway crossings. At these locations, the grids that are representative of the crossing roadway were depressed to match the grid elevations found in the canal upstream and downstream of the bridge. In this manner, water that is conveyed in the canal upstream of the bridged crossing continues through the depressed grid elevations to the downstream section of the canal.

3.7.13 FLO-2D Modeling Controls

The modeling controls for FLO-2D can be found in the CONT.DAT and TOLER.DAT files. The CONT.DAT file contains the system and global modeling parameters in addition to specifying the output files that are produced by the model. The TOLER.DAT file defines the tolerance and numerical stability values, which are required for the numerical calculations to achieve stability. Figure-3 shows all of the control variables that were used for this study.

4.0 HYDRAULICS

4.1 HYDRAULIC STRUCTURES

Hydraulic structures were used to incorporate culverts and small storm drain systems into the north and south FLO-2D models. These types of structures are used to convey flow under roads, through residential neighborhoods and underneath leveed embankments and walls. Incorporating these structures are important in order to model outlet structures for ponding areas and direct flow to the appropriate location.

4.1.1 Culverts

As part of this study, all culverts 36-inches and larger were incorporated into the north and south FLO-2D models. Culverts that are smaller than 36-inches in diameter were also included if they were found to be associated with ponding areas such as behind berms/levees or outlets from retention basins. In addition to circular culverts, box culverts, elliptical culverts and arch culverts with equivalent diameter of 36-inches or greater were also included in the models.

The culverts were identified from aerial photographs, as-built plans and field visits. Since the two models combine to cover over 37 square miles; the initial FLO-2D runs were used to isolate areas of ponding, which were then examined for the presence of culverts or any other type of hydraulic structures (i.e. wall openings or storm drain inlets). The data for the culverts was collected from multiple sources; as-built plans were found for some culverts at the City of Scottsdale, while data for others was obtained from City of Phoenix stormwater GIS shapefiles as well as the City of Tempe quarter-section maps. However, most of the data for the culverts (size, shape, number of barrels, etc…) was gathered with field measurements during site visits.

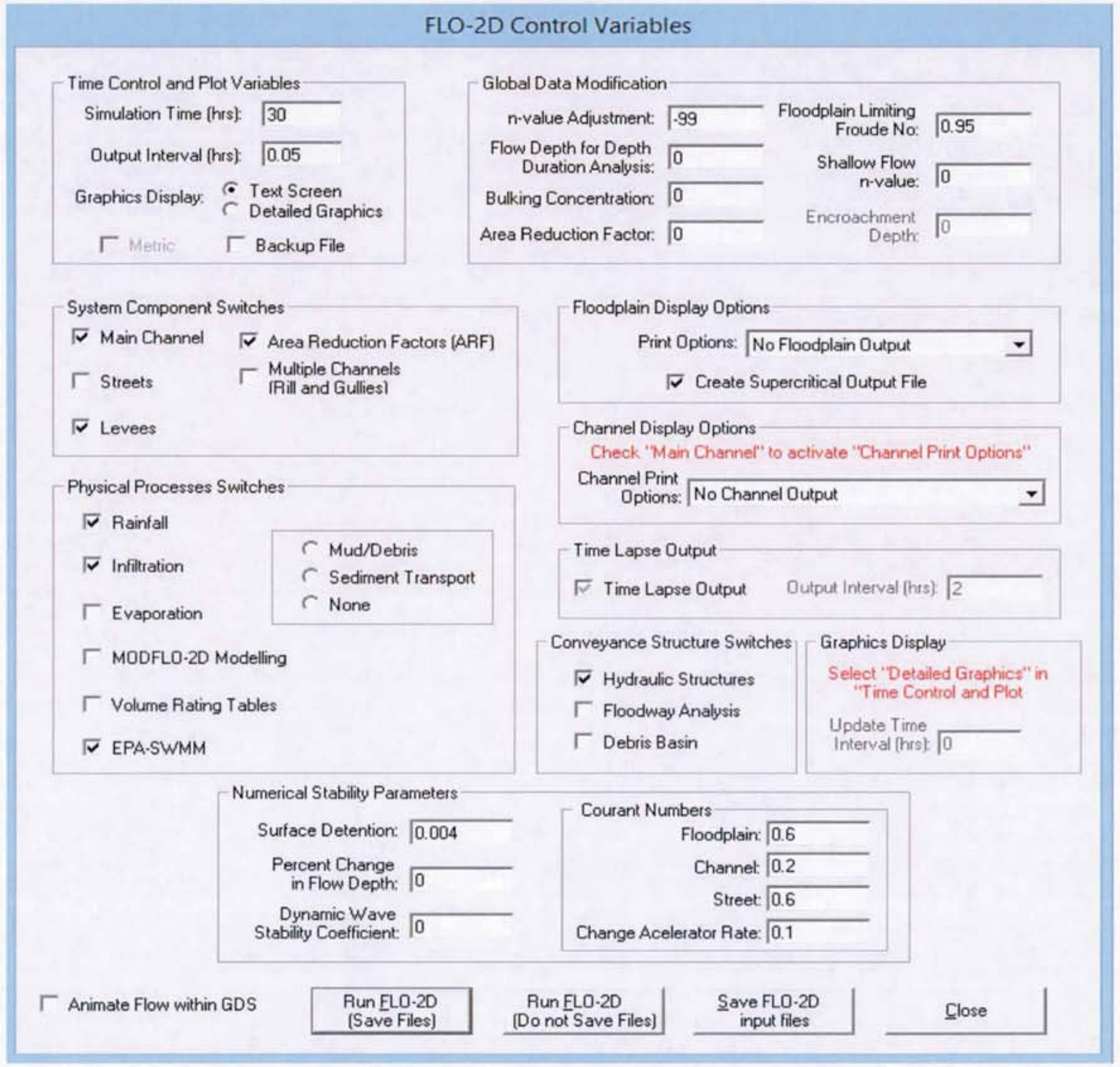

Figure-3: Sample FLO-2D Control Variables

In order to model the culverts as hydraulic structures within FLO-2D, the inflow/outflow grid numbers and the depth-discharge rating table are required. The inflow and outflow grid numbers were based on the location of the culvert. However, it is important to note that the inflow and outflow grids do not necessarily correspond with the grids at which the culvert inlet and outlet are physically located. The culvert inflow grid was placed in the grid cell that has the lowest elevation in the vicinity of the culvert inlet. This procedure of assigning grid numbers was done to make sure that the culvert was placed in the low spot, to represent the actual field condition of the culvert inlet. In addition to placing the culvert inlet in the low spot, for a number of culverts the grid cells surrounding the inlet and outlet were depressed to drain water to and from the culvert and better match the grid elevations to the surface contours around the culvert entrance and exit. The culvert rating tables were developed for inlet control and are based on the *Federal Highway Administration's Hydraulic Design Series Number 5 (FHWA HDS-5)* publication on *"Hydraulic Design of Highway Culverts."* Refer to Appendix H for the culvert inventory as well as the procedure and rating tables that were used to develop the FLO-2D **HYSTRUC.DAT** files and Appendix I for the hydraulic structure results hydrographs.

Depending on the upstream inlet configuration of the culvert, a trash rack/access barrier clogging factor was applied during the development of the rating tables. Trash racks/access barriers are commonly found at the culvert entrance to keep debris and people from entering the culvert. For the culverts in the watershed that were found to have a trash rack/access barrier at the entrance, a clogging factor of 50% was applied to the calculated interception discharge (i.e. if a 36-inch culvert can intercept 50.8 cfs without considering clogging, the clogging factor reduces the interception capacity to 25.4

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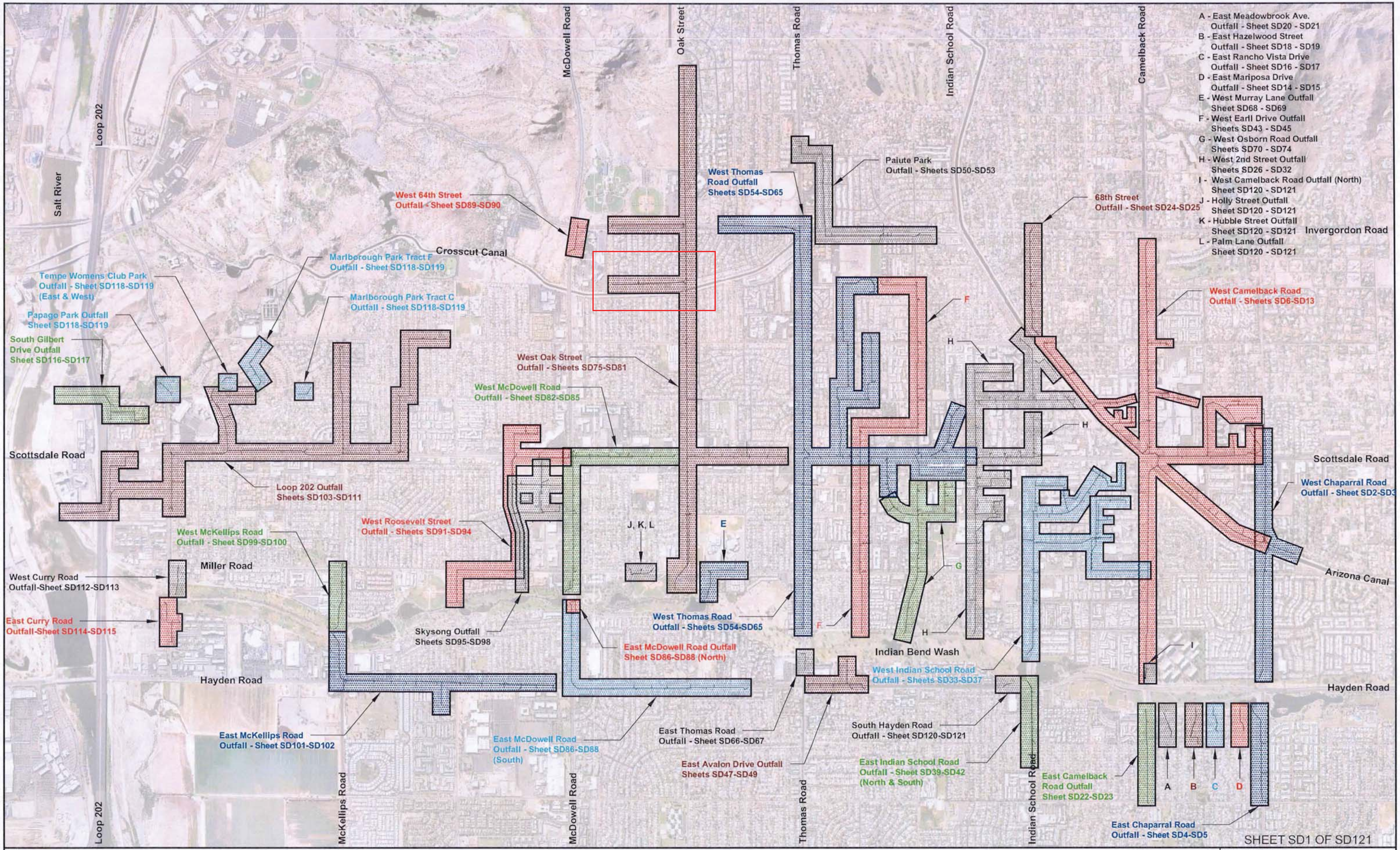
Appendix K: Storm Drain Results Exhibits



SHEET SD1 OF SD121

Flood Control District of Maricopa County

Gavan & Barker Inc. Civil Engineering & Landscape Architecture

TYLIN INTERNATIONAL engineers | planners | scientists

LOWER INDIAN BEND WASH ADMS/P

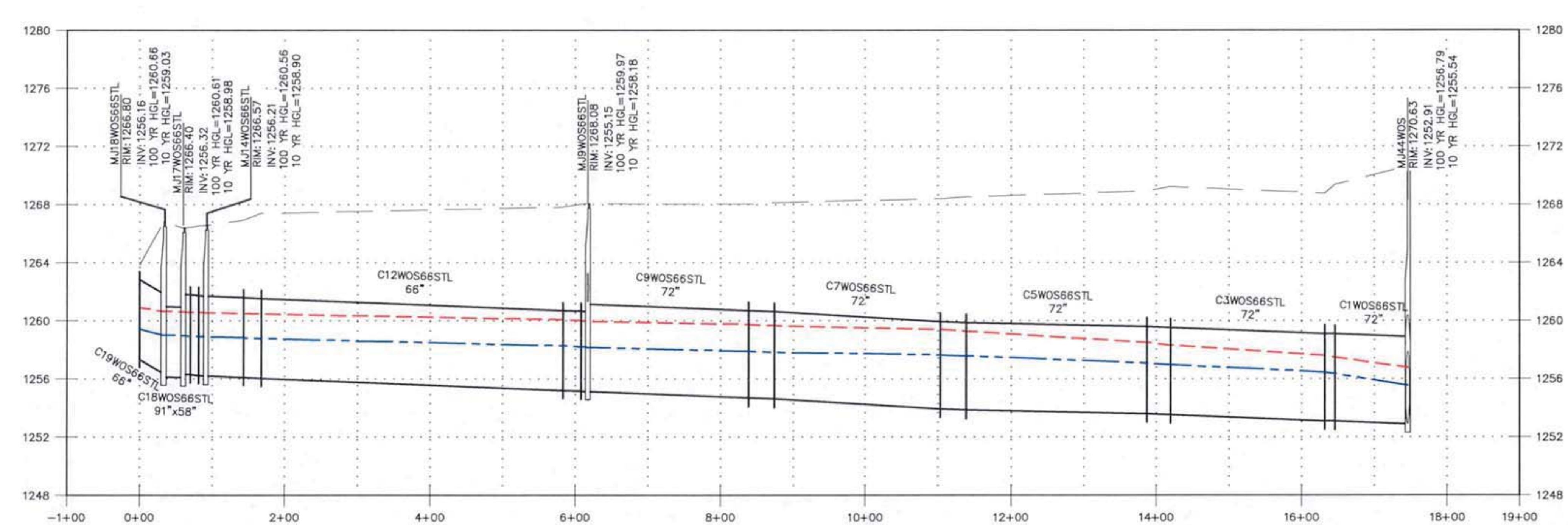
STUDY AREA-SOUTH

500 0 500 1000

Scale: 1"=2000' Horizontal

SWMM Outfall:		
Storm Drain Key Map		
	By	Date
Prepared		
Checked		

47-DR-2019
12/31/2019



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Legend (Plan)
- Inlet & SWMM Identifier
- Manhole & SWMM Identifier
- Outlet & SWMM Identifier
- Storm Drain Pipes

Legend (Profile)
- Ground Elevation
- Hydraulic Grade Line (100yr, 6-hr)
- Hydraulic Grade Line (10yr, 6-hr)

LOWER INDIAN BEND WASH ADMS/P
STUDY AREA-SOUTH

Scale: 1"=200' Horizontal
1"=10' Vertical

SWMM Outfall:
WOSIBWOUTFALL
(West Oak Street S.D. Outfall)

	By	Date
Prepared		
Checked		

47-DR-2019
12/31/2019

Inlet Summary Table

SWMM Name		Curb High / Soffit High Inflow	FLO-2D/SWMM Model							
			100-yr, 24-hr		100-yr, 6-hr		10-yr, 24-hr		10-yr, 6-hr	
Inlet	Connector Pipe		Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max
		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
I63CP1WOS	C63CP1WOS	3.1	5.6	5.6	5.9	5.9	2.0	2.0	2.3	2.3
I64CP1WOS	C64CP1WOS	3.1	4.7	4.7	5.0	5.0	2.6	2.6	3.0	3.0
I65CP1WOS	C65CP1WOS	4.4	8.7	8.7	8.8	8.8	8.2	8.2	8.4	8.4
I60CP1WOS	C60CP1WOS	4.4	13.4	13.4	13.6	13.6	10.4	10.4	11.3	11.3
I61CP1WOS	C61CP1WOS	3.1	6.2	6.2	6.4	6.3	4.5	4.5	5.0	5.0
I56CP1WOS	C56CP1WOS	10.7	24.2	24.1	27.5	27.3	10.3	10.3	12.8	12.8
I54CP1WOS	C54CP1WOS	4.5	13.0	13.0	13.1	13.1	5.0	5.0	7.3	7.3
I41CP1WOS	C41CP1WOS	17.4	5.0	5.0	6.1	6.1	2.5	2.5	3.2	3.2
I39CP1WOS	C39CP1WOS	17.4	10.0	10.0	11.1	11.1	6.9	6.8	8.1	8.1
I38CP2WOS	C38CP2WOS	32.2	6.0	6.0	7.0	7.0	3.8	3.8	4.3	4.2
I37CP1WOS	C37CP1WOS	11.3	3.4	3.4	4.3	4.2	1.4	1.4	1.9	1.9
I35CP1WOS	C35CP1WOS	17.4	1.9	1.9	2.4	2.4	1.1	1.1	1.3	1.3
I34CP1WOS	C34CP1WOS	11.3	3.3	3.2	3.9	3.9	1.4	1.4	1.8	1.8
I33CP1WOS	C33CP1WOS	11.3	5.7	5.7	6.4	6.4	3.5	3.5	4.0	4.0
I30CP1WOS	C30CP1WOS	32.2	0.8	0.8	1.4	1.3	0.4	0.4	0.4	0.4
I27CP1WOS	C27CP1WOS	17.4	3.6	3.6	4.9	4.9	0.6	0.6	0.9	0.9
I20CP2WOS	C20CP2WOS	17.4	2.6	2.6	3.3	3.3	1.5	1.4	1.8	1.8
I20CP1WOS	C20CP1WOS	17.4	8.5	8.5	9.6	9.6	6.4	6.4	7.0	7.0
I18CP1WOS	C18CP1WOS	11.3	6.0	6.0	7.1	7.1	3.7	3.7	4.6	4.6
I16CP1WOS	C16CP1WOS	17.4	6.3	6.4	8.2	8.1	2.9	2.9	3.8	3.8
I15CP1WOS	C15CP1WOS	17.4	3.7	3.7	4.7	4.5	1.8	1.8	2.3	2.3
I8CP9WOSOSL	C8CP9WOSOSL	17.4	0.9	0.9	1.2	1.2	0.5	0.5	0.6	0.6
I8CP8WOSOSL	C8CP8WOSOSL	6.3	0.8	0.8	0.9	0.9	0.4	0.4	0.5	0.5
I8CP5WOSOSL	C8CP5WOSOSL	7.8	15.5	15.5	15.8	15.8	14.3	14.2	14.5	14.5
I8CP3WOSOSL	C8CP3WOSOSL	7.8	14.0	14.0	14.5	14.5	9.1	9.1	12.5	11.7
I19WOS66STL	C19WOS66STL	79.3	64.5	64.7	74.8	75.0	39.2	39.1	47.7	47.7
I26CP1WOS	C26CP1WOS	32.2	2.3	2.3	2.9	2.9	1.2	1.2	1.5	1.5
I26CP3WOS	C26CP3WOS	32.2	6.1	6.1	7.2	7.2	3.8	3.8	4.5	4.5
I2CP1WOSSRL	C2CP1WOSSRL	17.4	4.1	4.1	5.4	5.3	1.7	1.7	2.4	2.4
I3CP1WOSSRL	C3CP1WOSSRL	11.3	1.8	1.8	2.2	2.2	1.2	1.2	1.4	1.4
I4CP1WOSSRL	C4CP1WOSSRL	32.2	36.2	36.2	51.4	40.9	18.4	18.4	22.3	22.3
I5CP1WOSSRL	C5CP1WOSSRL	7.8	4.0	4.0	5.1	5.1	1.5	1.5	1.9	1.9
I6CP1WOSSRL	C6CP1WOSSRL	32.2	11.3	11.1	13.4	13.3	4.5	4.5	5.5	5.5
I7CP1WOSSRL	C7CP1WOSSRL	32.2	26.1	26.0	30.5	30.6	13.3	13.3	15.4	15.3
I8CP1WOSSRL	C8CP1WOSSRL	7.8	2.9	2.9	4.5	4.5	1.0	1.0	1.0	1.0
I10CP1WOSSRL	C10CP1WOSSRL	7.8	1.3	1.3	1.5	1.5	0.8	0.8	1.0	1.0
I11CP1WOSSRL	C11CP1WOSSRL	17.4	9.1	9.1	11.8	11.8	2.9	2.9	3.5	3.5
I13CP1WOSSRL	C13CP1WOSSRL	20.0	8.5	8.5	10.4	10.3	4.6	4.6	5.7	5.7
I13CP2WOSSRL	C13CP2WOSSRL	11.3	1.8	1.8	2.1	2.0	1.2	1.2	1.5	1.5
I14CP1WOSSRL	C14CP1WOSSRL	32.2	3.9	3.9	4.8	4.7	2.3	2.3	2.8	2.8
I14CP2WOSSRL	C14CP2WOSSRL	11.3	0.3	0.3	0.4	0.4	0.2	0.2	0.2	0.2
I15CP1WOSSRL	C15CP1WOSSRL	32.2	14.4	13.8	13.7	12.8	7.5	7.5	9.3	9.3
I15CP2WOSSRL	C15CP2WOSSRL	11.3	7.8	8.1	8.1	8.5	2.6	2.6	3.2	3.2
I12CP1WOSSRL	C12CP1WOSSRL	20.0	34.6	34.6	39.4	39.5	19.9	20.0	23.0	23.0
I31CP9WOS	C31CP9WOS	4.5	5.9	28.5	6.8	28.0	3.4	20.6	4.8	24.2

Inlet Summary Table

SWMM Name		Curb High / Soffit High Inflow	FLO-2D/SWMM Model							
			100-yr, 24-hr		100-yr, 6-hr		10-yr, 24-hr		10-yr, 6-hr	
Inlet	Connector Pipe		Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max
		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
I31CP10WOS	C31CP10WOS	10.2	13.0	13.0	13.5	13.5	9.3	9.3	10.5	10.5
I31CP11WOS	C31CP11WOS	8.7	11.0	11.0	11.5	11.5	7.9	7.9	8.9	8.9
I31CP8WOS	C31CP8WOS	7.3	9.0	9.0	9.4	9.4	6.9	6.9	7.5	7.5
I31CP7WOS	C31CP7WOS	10.2	12.9	12.8	13.4	13.4	9.0	9.0	10.2	10.2
I31CP5WOS	C31CP5WOS	5.8	4.8	4.8	5.2	5.2	3.4	3.4	4.0	3.9
I31CP2WOS	C31CP2WOS	18.9	11.7	11.6	13.9	13.8	5.4	5.4	6.6	6.6
I31CP6WOS	C31CP6WOS	4.8	9.3	56.8	9.8	57.5	3.4	40.0	4.8	46.6
I31CP4WOS	C31CP4WOS	4.8	3.7	64.6	4.6	66.7	1.0	42.9	1.2	50.4
I5CP1WOSOSL	C5CP1WOSOSL	8.7	3.1	3.1	3.9	4.2	0.8	0.8	1.1	1.1
I2CP1WOSOSL	C2CP1WOSOSL	5.2	8.3	7.9	8.3	8.0	4.9	4.9	5.5	5.5
I5CP3WOSOSL	C5CP3WOSOSL	11.3	2.9	2.9	3.1	3.1	2.3	2.3	2.4	2.4
I7CP1WOSOSL	C7CP1WOSOSL	5.2	2.5	2.6	3.9	3.9	0.1	0.1	0.3	0.3
I6CP2WOSOSL	C6CP2WOSOSL	11.3	13.4	13.3	13.6	13.5	8.5	8.5	9.2	9.2
I9CP1WOSOSL	C9CP1WOSOSL	10.5	2.3	2.3	2.9	2.9	1.1	1.1	1.3	1.3
I19CP2WOS	C19CP2WOS	11.3	4.6	4.6	5.6	5.6	2.3	2.3	3.1	3.1
I28CP2WOS	C28CP2WOS	5.8	5.2	5.2	5.4	5.4	4.2	4.2	4.5	4.5
I29CP2WOS	C29CP2WOS	5.8	2.7	2.7	3.4	3.3	1.1	1.1	1.4	1.4
I6CP1WOS64STL	C6CP1WOS64STL	7.8	6.0	6.0	7.0	7.0	3.3	3.3	4.0	4.0
I6CP2WOS64STL	C6CP2WOS64STL	11.3	0.6	0.6	0.8	0.8	0.3	0.3	0.3	0.3
I5CP1WOS64STL	C5CP1WOS64STL	11.3	0.7	0.7	0.9	0.9	0.4	0.4	0.4	0.4
I4CP1WOS64STL	C4CP1WOS64STL	11.3	13.6	13.6	18.0	16.7	3.2	3.2	5.3	5.3
I3CP1WOS64STL	C3CP1WOS64STL	35.8	21.7	21.7	25.3	25.4	7.2	7.2	9.2	9.2
I1CP2WOS64STL	C1CP2WOS64STL	35.8	48.0	47.8	51.0	51.0	25.8	25.7	31.6	31.4
I1CP1WOS64STL	C1CP1WOS64STL	11.3	3.5	51.2	9.2	60.2	0.2	25.9	0.3	31.6
I1CP3WOS64STL	C1CP3WOS64STL	11.3	0.2	0.8	0.2	1.0	0.1	0.5	0.1	0.6
I1CP4WOS64STL	C1CP4WOS64STL	3.8	0.7	0.7	0.8	0.8	0.4	0.4	0.5	0.5
I48BCP1WOS	C48BCP1WOS	17.4	1.3	1.3	1.6	1.6	0.7	0.7	0.9	0.9
I48ACP1WOS	C48ACP1WOS	5.2	2.2	2.2	2.4	2.4	1.6	1.6	1.8	1.8
I45CP1WOS	C45CP1WOS	7.6	16.4	30.1	17.9	31.9	10.2	21.7	11.6	23.6
I45CP2WOS	C45CP2WOS	8.7	13.6	13.6	14.0	14.0	11.6	11.6	12.1	12.1
I46CP1WOS	C46CP1WOS	17.4	12.7	12.7	15.8	15.8	3.5	3.5	4.8	4.8
I47CP1WOS	C47CP1WOS	17.4	7.7	7.6	9.4	9.4	3.4	3.4	4.1	4.1
I15WOS66STL	C15WOS66STL	8.4	11.7	74.7	15.8	89.4	3.5	41.9	5.5	52.3
I13WOS66STL	C13WOS66STL	7.6	11.2	85.0	14.1	102.1	5.5	46.6	7.1	58.4
I12WOS66STL	C12WOS66STL	8.7	10.2	95.3	10.9	114.4	8.6	54.9	9.1	67.4
I11WOS66STL	C11WOS66STL	7.6	7.4	100.7	11.7	123.8	1.3	55.7	1.7	68.8
I10WOS66STL	C10WOS66STL	8.7	10.1	110.4	10.9	133.6	1.7	56.6	4.1	71.4
I9CP1WOS66STL	C9CP1WOS66STL	7.6	6.7	15.3	7.6	16.6	3.7	11.1	4.8	12.6
I9CP2WOS66STL	C9CP2WOS66STL	8.7	8.7	8.6	9.0	9.0	7.4	7.4	7.9	7.8
I8WOS66STL	C8WOS66STL	7.6	12.4	135.8	15.2	161.0	5.3	70.4	7.4	88.3
I7WOS66STL	C7WOS66STL	8.7	9.5	144.8	10.3	170.5	7.4	77.6	8.0	96.1
I6WOS66STL	C6WOS66STL	7.6	18.8	162.4	22.1	190.6	9.4	85.0	12.7	105.9
I5WOS66STL	C5WOS66STL	8.7	9.7	171.2	10.3	199.4	8.2	92.6	8.7	114.0
I3WOS66STL	C3WOS66STL	8.7	6.4	180.5	7.3	209.5	4.0	95.5	4.5	117.0
I4WOS66STL	C4WOS66STL	7.6	3.6	174.9	5.1	203.3	0.8	92.7	1.3	115.0

INLET SUMMARY TABLE NOTES:

1. The curb high/soffit high inflow discharge were calculated according to the procedures outlined in the District's Hydraulics Manual.
2. The inflow discharge is the peak hydrograph discharge taken from the SWMMQIN.OUT file.
3. The pipe Max Discharge is the peak hydrograph discharge taken from the 'Link Results' in the SWMM.RTP file.

SHEET SD80 OF SD121

Flood Control District of Maricopa County

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LOWER INDIAN BEND WASH ADMS/P

STUDY AREA-SOUTH

SWMM Outfall:
WOSIBWOUTFALL
(West Oak Street S.D. Outfall)

	By	Date
Prepare		
Checke		

47-DR-2019
12/31/2019

Pipe Discharge Summary Table

Conduit Name	Normal Depth Capacity	FLO-2D/SWMM Model Discharge			
		100-yr, 24-hr	100-yr, 6-hr	10-yr, 24-hr	10-yr, 6-hr
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
C41WOS	967.2	411.7	479.2	202.9	245.1
C42WOS	983.5	408.4	474.3	204.1	242.5
C43WOS	967.0	407.1	472.4	203.5	245.6
C44WOS	1026.7	406.3	476.5	204.8	245.4
C45WOS	590.5	207.0	235.1	99.2	117.3
C46WOS	247.5	177.3	203.2	77.9	94.0
C47WOS	248.4	164.6	188.4	74.4	89.2
C48AWOS	249.6	158.9	182.0	71.8	85.9
C48BWOS	245.3	157.3	181.1	70.9	84.7
C48CWOS	272.7	156.6	180.5	70.6	84.2
C48DWOS	62.1	69.8	75.6	36.9	41.8
C49WOS	110.3	69.8	75.6	36.8	41.7
C50WOS	104.2	69.8	75.6	36.8	41.7
C51WOS	104.1	69.5	75.6	36.7	41.7
C52WOS	83.6	69.1	75.2	36.9	41.9
C53WOS	36.4	68.5	74.7	37.1	42.1
C54WOS	76.7	68.4	74.7	37.2	42.2
C55WOS	76.9	58.1	62.5	34.5	38.4
C56WOS	60.9	55.9	60.1	34.5	38.4
C57WOS	60.8	41.5	43.2	26.4	29.0
C58WOS	60.2	38.6	42.2	26.4	28.9
C59WOS	30.1	38.6	40.3	26.4	28.9
C60WOS	30.3	38.5	39.3	26.4	28.9
C61WOS	7.9	25.1	25.8	16.6	18.0
C62WOS	15.2	18.8	19.4	12.4	13.2
C63WOS	88.3	18.7	19.4	12.8	13.5
C64WOS	37.3	13.2	13.6	10.8	11.3
C65WOS	17.6	8.7	8.8	8.2	8.4
C1WOS	231.3	751.2	854.8	392.9	479.0
C2WOS	262.6	751.2	854.8	408.4	475.8
C3WOS	258.4	751.2	854.8	411.1	495.3
C4WOS	241.1	751.3	854.8	408.8	503.9
C5WOS	183.4	677.3	776.0	334.6	465.7
C6WOS	262.5	678.0	776.0	328.6	458.8
C7WOS	422.2	678.4	775.8	374.1	444.8
C8WOS	382.0	678.9	775.7	363.6	445.4
C9WOS	379.6	679.3	778.4	389.2	460.4
C10WOS	379.0	678.5	782.3	358.2	433.6
C11WOS	171.6	678.4	782.4	353.9	427.3
C12WOS	105.9	678.1	782.2	354.5	427.1
C13WOS	217.7	678.3	782.4	353.9	427.5
C14WOS	783.2	676.8	782.4	354.0	427.4
C15WOS	790.6	675.1	782.2	353.1	428.4
C16WOS	791.7	669.9	780.2	350.8	429.3
C17WOS	763.1	656.6	777.7	349.2	426.4

Pipe Discharge Summary Table

Conduit Name	Normal Depth Capacity	FLO-2D/SWMM Model Discharge			
		100-yr, 24-hr	100-yr, 6-hr	10-yr, 24-hr	10-yr, 6-hr
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
C18WOS	788.4	676.8	776.7	350.9	423.3
C19WOS	779.6	685.3	773.1	350.0	420.1
C20WOS	772.8	675.7	771.0	349.6	417.9
C21WOS	785.0	691.6	766.0	346.0	413.9
C22WOS	587.4	659.4	766.0	346.2	413.2
C23WOS	322.4	530.1	590.8	272.7	324.2
C24WOS	1594.3	530.1	590.9	273.3	324.2
C25WOS	1122.0	529.9	591.1	273.8	324.1
C26WOS	483.6	608.9	590.7	273.9	331.5
C27WOS	1248.7	522.8	586.2	274.3	322.3
C28WOS	1248.7	521.6	578.0	275.3	324.3
C29WOS	2369.9	517.0	572.3	271.3	320.8
C30WOS	1196.9	517.8	580.9	268.5	322.0
C31WOS	1183.6	516.0	587.4	265.3	321.0
C32WOS	1181.9	440.3	509.3	217.0	264.3
C33WOS	1205.2	439.9	511.0	216.7	263.7
C34WOS	1217.5	432.7	507.2	213.3	258.5
C35WOS	1219.0	428.2	501.5	211.5	256.3
C36WOS	1217.9	426.4	498.5	210.6	255.3
C37WOS	987.9	425.8	496.2	209.7	254.6
C38WOS	963.1	423.3	492.6	209.1	253.2
C39WOS	965.1	419.1	487.6	206.9	250.0
C40WOS	624.3	406.9	468.5	202.6	245.3
C1WOS64STL	267.6	89.7	106.5	38.7	48.2
C2WOS64STL	183.1	38.2	45.5	13.3	17.0
C3WOS64STL	126.8	38.5	45.7	13.5	17.2
C4WOS64STL	14.5	17.0	21.4	6.4	8.0
C5WOS64STL	10.1	6.9	8.2	3.5	4.2
C6WOS64STL	14.3	6.4	7.6	3.5	4.2
C1WOS66STL	179.3	205.7	239.2	106.7	128.4
C2WOS66STL	164.0	179.5	202.2	98.4	123.3
C3WOS66STL	188.6	180.5	209.5	95.5	117.0
C4WOS66STL	194.8	174.9	203.3	92.7	115.0
C5WOS66STL	137.0	171.2	199.4	92.6	114.0
C6WOS66STL	188.5	162.4	190.6	85.0	105.9
C7WOS66STL	232.2	144.8	170.5	77.6	96.1
C8WOS66STL	188.5	135.8	161.0	70.4	88.3
C9WOS66STL	189.0	124.0	147.6	65.2	81.5
C10WOS66STL	106.2	110.4	133.6	56.6	71.4
C11WOS66STL	151.2	100.7	123.8	55.7	68.8
C12WOS66STL	151.1	95.3	114.4	54.9	67.4
C13WOS66STL	149.8	85.0	102.1	46.6	58.4
C14WOS66STL	147.4	75.0	89.8	41.9	52.3
C15WOS66STL	167.9	74.7	89.4	41.9	52.3
C16WOS66STL	150.2	65.2	75.6	39.2	47.8

Pipe Discharge Summary Table

Conduit Name	Normal Depth Capacity	FLO-2D/SWMM Model Discharge			
		100-yr, 24-hr	100-yr, 6-hr	10-yr, 24-hr	10-yr, 6-hr
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
C17WOS66STL	106.2	65.0	75.4	39.1	47.8
C18WOS66STL	149.2	64.9	75.2	39.1	47.7
C19WOS66STL	575.8	64.7	75.0	39.1	47.7
C1WOSSRL	904.4	156.2	190.2	74.9	89.2
C2WOSSRL	354.3	155.9	189.4	74.9	88.7
C3WOSSRL	147.2	158.2	182.4	75.2	89.0
C5WOSSRL	145.0	115.8	138.7	55.0	66.0
C6WOSSRL	147.7	112.7	134.7	54.0	64.2
C7WOSSRL	159.5	101.9	119.2	49.6	58.8
C8WOSSRL	182.7	76.4	88.6	36.3	43.8
C9WOSSRL	185.1	73.8	84.5	35.6	42.9
C10WOSSRL	161.1	73.9	84.4	35.6	42.9
C11WOSSRL	90.5	73.1	83.4	35.3	42.6
C12WOSSRL	138.7	64.0	71.4	32.9	39.3
C13WOSSRL	53.0	29.6	33.2	13.6	16.5
C14WOSSRL	35.4	22.0	23.2	9.8	12.3
C15WOSSRL	15.2	19.1	19.2	8.6	10.7

Inlet Summary Table

SWMM Name		Curb High / Soffit High Inflow	FLO-2D/SWMM Model							
			100-yr, 24-hr		100-yr, 6-hr		10-yr, 24-hr		10-yr, 6-hr	
Inlet	Connector Pipe		Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max	Inflow	Pipe Max
		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
I1WOS66STL	C1WOS66STL	7.6	10.8	205.7	12.9	239.2	2.0	106.7	3.8	128.4
I1CP1WOS66STL	C1CP1WOS66STL	8.7	9.7	9.7	10.3	10.4	6.8	6.8	7.5	7.5
I6ACP1WOSOSL	C6ACP1WOSOSL	17.4	16.2	16.2	20.1	20.1	5.9	5.9	7.6	7.6

INLET SUMMARY TABLE NOTES:

1. The curb high/soffit high inflow discharge were calculated according to the procedures outlined in the District's Hydraulics Manual.
2. The inflow discharge is the peak hydrograph discharge taken from the SWMMQIN.OUT file.
3. The pipe Max Discharge is the peak hydrograph discharge taken from the 'Link Results' in the SWMM.RTP file.

PIPE DISCHARGE SUMMARY TABLE NOTES:

1. The normal depth capacity discharges were obtained from the SWMM.RPT file.
2. The pipe discharge is the peak hydrograph discharge taken from the 'Link Results" in the SWMM.RTP file.

Gavan & Barker Inc.

TYLIN INTERNATIONAL
engineers | planners | scientists

LOWER INDIAN BEND WASH ADMS/P
STUDY AREA-SOUTH

SWMM Outfall:
WOSIBWOUTFALL
(West Oak Street S.D. Outfall)

	By	Date
Prepare		
Checke		

47-DR-2019
12/31/2019

APPENDIX B

SCOTTSDALE ENTRADA LETTER OF MAP REVISION EXCERPTS

CVL

June 22, 2019
Revised: October 15, 2019

SCOTTSDALE ENTRADA

Scottsdale, AZ

Prepared for:

Bridge Banyan Qualified Opportunity Zone Business I, LLC
2411 3rd St, Unit E
Santa Monica, CA 90405

Prepared by:

Coe & Van Loo Consultants, Inc.
4550 N 12th Street
Phoenix, AZ 85014
Contact: Oscar Garcia
602.285.4876

Job #:1-14-0254309

Registered Professional Engineer (Civil)
CERTIFICATE NO. 66356
OSCAR E. GARCIA
Date Signed 10-15-19
ARIZONA, U.S.A.
Expires 6-30-2021

CVL CONSULTANTS

LETTER OF MAP REVISION

47-DR-2019
12/31/2019

LETTER OF MAP REVISION
FOR
SCOTTSDALE ENTRADA
CITY OF SCOTTSDALE, ARIZONA

October 15, 2019

Prepared for:

Bridge Banyan Qualified Opportunity Zone Business I, LLC
2411 3rd St, Unit E
Santa Monica, CA 90405

Prepared by:

Coe & Van Loo II, L.L.C.
4550 N. 12th Street
Phoenix, AZ 85014
(602) 264-6831

CVL Job Number: 1.14.0254309

Registered Professional Engineer (Civil)
CERTIFICATE NO.
66356
OSCAR E.
GARCIA
Date Signed 10-15-19
ARIZONA, U.S.A.
Expires 6-30-2021

47-DR-2019
12/31/2019

LETTER OF MAP REVISION
FOR
SCOTTSDALE ENTRADA

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Registered Professional Engineer (Civil)
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OSCAR E. GARCIA
Date Signed 10-15-19
ARIZONA, U.S.A.
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47-DR-2019
12/31/2019

Registered Professional Engineer (Civil)
CERTIFICATE NO. 66356
OSCAR E. GARCIA
Date Signed 10-15-19
ARIZONA, U.S.A.
Expires 6-30-2021

47-DR-2019
12/31/2019

Tables

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CD

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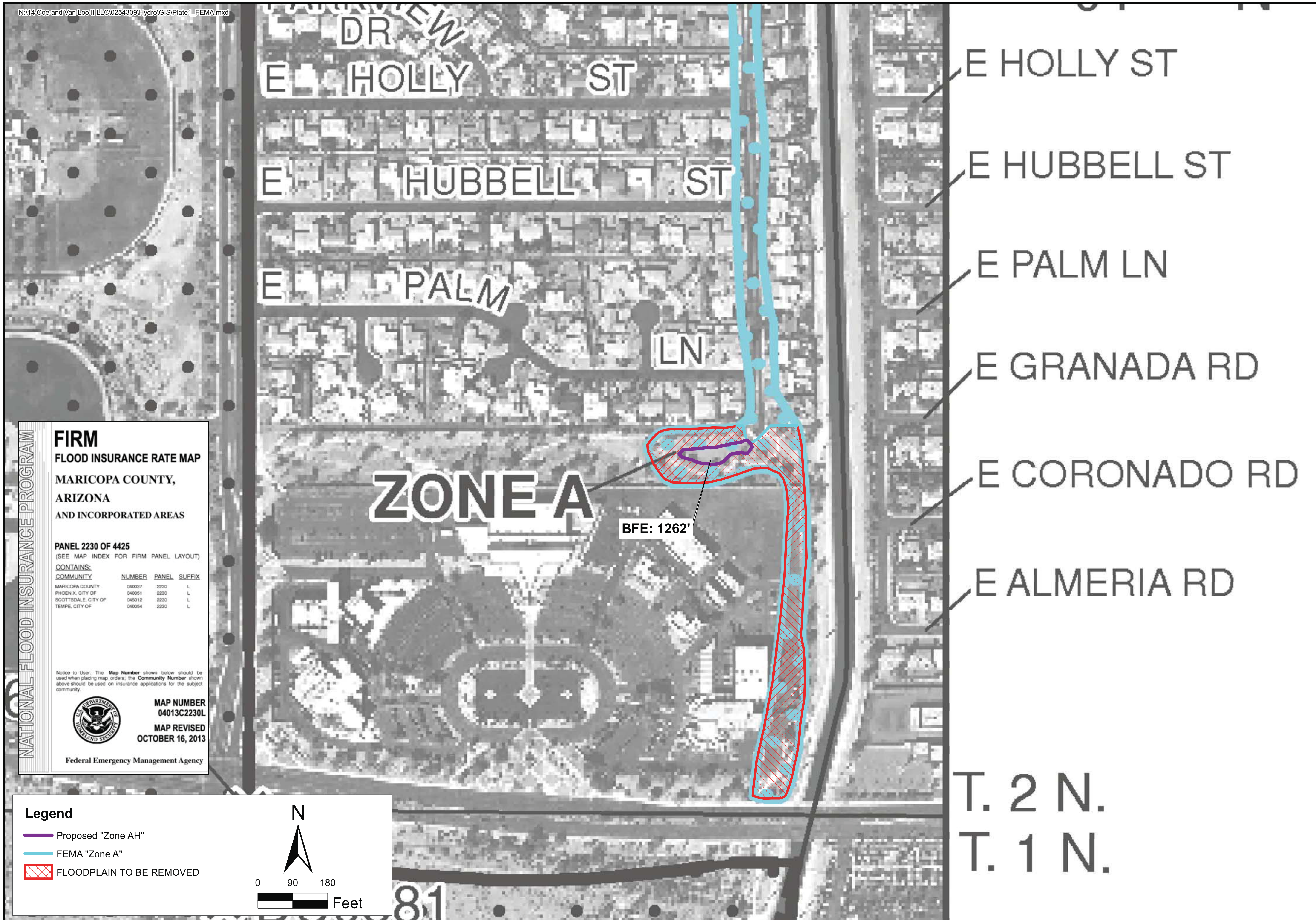
12/31/2019



4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

CVL CONSULTANTS

ANNOTATED FIRM MAP

SCOTTSDALE ENTRADA - LOMR

JOB NO.
14-0254309

PLATE 1

47-DR-2019
12/31/2019

APPENDIX C

ON-SITE HYDROLOGY

NOAA Atlas 14, Volume 1, Version 5
Location name: Scottsdale, Arizona, USA*
Latitude: 33.4681°, Longitude: -111.9396°
Elevation: 1273.11 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.179** (0.151-0.217)	**0.235** (0.198-0.284)	**0.320** (0.269-0.385)	**0.385** (0.322-0.461)	**0.473** (0.389-0.564)	**0.542** (0.440-0.643)	**0.611** (0.487-0.723)	**0.683** (0.535-0.808)	**0.778** (0.593-0.922)	**0.851** (0.636-1.01)
10-min	**0.273** (0.230-0.331)	**0.357** (0.302-0.432)	**0.487** (0.409-0.586)	**0.586** (0.490-0.702)	**0.720** (0.592-0.859)	**0.825** (0.669-0.979)	**0.930** (0.741-1.10)	**1.04** (0.814-1.23)	**1.18** (0.902-1.40)	**1.30** (0.968-1.54)
15-min	**0.339** (0.285-0.409)	**0.443** (0.375-0.535)	**0.604** (0.507-0.726)	**0.727** (0.607-0.870)	**0.893** (0.734-1.07)	**1.02** (0.830-1.21)	**1.15** (0.918-1.37)	**1.29** (1.01-1.52)	**1.47** (1.12-1.74)	**1.61** (1.20-1.91)
30-min	**0.456** (0.384-0.551)	**0.596** (0.505-0.721)	**0.813** (0.683-0.977)	**0.978** (0.817-1.17)	**1.20** (0.989-1.43)	**1.38** (1.12-1.64)	**1.55** (1.24-1.84)	**1.73** (1.36-2.05)	**1.98** (1.51-2.34)	**2.16** (1.62-2.57)
60-min	**0.564** (0.476-0.682)	**0.738** (0.625-0.892)	**1.01** (0.845-1.21)	**1.21** (1.01-1.45)	**1.49** (1.22-1.77)	**1.70** (1.38-2.02)	**1.92** (1.53-2.28)	**2.15** (1.68-2.54)	**2.45** (1.86-2.90)	**2.68** (2.00-3.18)
2-hr	**0.654** (0.562-0.777)	**0.848** (0.726-1.01)	**1.14** (0.973-1.35)	**1.36** (1.15-1.60)	**1.66** (1.39-1.95)	**1.89** (1.56-2.21)	**2.13** (1.73-2.49)	**2.38** (1.89-2.77)	**2.70** (2.10-3.16)	**2.96** (2.25-3.48)
3-hr	**0.708** (0.604-0.844)	**0.909** (0.779-1.09)	**1.20** (1.02-1.43)	**1.42** (1.21-1.69)	**1.74** (1.45-2.06)	**2.00** (1.64-2.35)	**2.27** (1.83-2.66)	**2.54** (2.02-2.98)	**2.93** (2.25-3.44)	**3.24** (2.43-3.82)
6-hr	**0.853** (0.743-0.999)	**1.08** (0.946-1.27)	**1.39** (1.21-1.62)	**1.64** (1.41-1.90)	**1.97** (1.68-2.28)	**2.24** (1.87-2.57)	**2.51** (2.07-2.89)	**2.79** (2.26-3.22)	**3.18** (2.50-3.67)	**3.48** (2.68-4.04)
12-hr	**0.958** (0.841-1.11)	**1.21** (1.06-1.41)	**1.54** (1.35-1.78)	**1.80** (1.56-2.07)	**2.14** (1.84-2.46)	**2.41** (2.04-2.76)	**2.68** (2.24-3.08)	**2.96** (2.44-3.40)	**3.33** (2.68-3.84)	**3.62** (2.86-4.21)
24-hr	**1.16** (1.04-1.30)	**1.47** (1.32-1.65)	**1.90** (1.70-2.13)	**2.25** (2.00-2.51)	**2.72** (2.41-3.04)	**3.10** (2.72-3.45)	**3.49** (3.05-3.89)	**3.89** (3.37-4.34)	**4.45** (3.81-4.97)	**4.89** (4.15-5.47)
2-day	**1.25** (1.12-1.40)	**1.60** (1.44-1.79)	**2.10** (1.88-2.35)	**2.50** (2.23-2.79)	**3.06** (2.71-3.41)	**3.50** (3.08-3.91)	**3.97** (3.48-4.44)	**4.45** (3.87-4.99)	**5.13** (4.41-5.76)	**5.68** (4.83-6.40)
3-day	**1.32** (1.18-1.48)	**1.69** (1.52-1.90)	**2.22** (1.99-2.49)	**2.65** (2.37-2.96)	**3.26** (2.89-3.63)	**3.74** (3.30-4.17)	**4.26** (3.72-4.75)	**4.80** (4.16-5.36)	**5.56** (4.76-6.22)	**6.17** (5.24-6.92)
4-day	**1.39** (1.25-1.56)	**1.78** (1.60-2.00)	**2.35** (2.10-2.62)	**2.81** (2.50-3.13)	**3.46** (3.06-3.85)	**3.98** (3.51-4.43)	**4.54** (3.97-5.06)	**5.14** (4.45-5.73)	**5.98** (5.12-6.67)	**6.66** (5.64-7.45)
7-day	**1.54** (1.38-1.72)	**1.97** (1.76-2.20)	**2.59** (2.32-2.90)	**3.10** (2.76-3.47)	**3.82** (3.39-4.26)	**4.40** (3.88-4.90)	**5.01** (4.39-5.59)	**5.67** (4.92-6.33)	**6.59** (5.64-7.36)	**7.33** (6.21-8.21)
10-day	**1.67** (1.50-1.87)	**2.14** (1.92-2.40)	**2.83** (2.53-3.15)	**3.37** (3.01-3.76)	**4.14** (3.67-4.61)	**4.76** (4.19-5.30)	**5.41** (4.74-6.03)	**6.10** (5.30-6.80)	**7.07** (6.06-7.88)	**7.84** (6.66-8.76)
20-day	**2.06** (1.85-2.29)	**2.64** (2.38-2.94)	**3.49** (3.13-3.88)	**4.13** (3.69-4.58)	**4.99** (4.44-5.53)	**5.65** (5.01-6.27)	**6.32** (5.59-7.02)	**7.00** (6.16-7.79)	**7.92** (6.90-8.83)	**8.63** (7.46-9.63)
30-day	**2.40** (2.15-2.67)	**3.09** (2.77-3.43)	**4.07** (3.64-4.51)	**4.81** (4.30-5.33)	**5.81** (5.17-6.44)	**6.58** (5.83-7.27)	**7.37** (6.50-8.15)	**8.16** (7.17-9.03)	**9.24** (8.05-10.2)	**10.1** (8.70-11.2)
45-day	**2.78** (2.51-3.10)	**3.59** (3.23-3.98)	**4.72** (4.25-5.25)	**5.57** (4.99-6.18)	**6.67** (5.96-7.40)	**7.51** (6.69-8.33)	**8.35** (7.41-9.26)	**9.19** (8.11-10.2)	**10.3** (9.03-11.5)	**11.1** (9.70-12.4)
60-day	**3.09** (2.79-3.42)	**3.99** (3.59-4.42)	**5.24** (4.72-5.80)	**6.15** (5.53-6.81)	**7.34** (6.58-8.13)	**8.22** (7.34-9.10)	**9.10** (8.09-10.1)	**9.96** (8.82-11.0)	**11.1** (9.76-12.3)	**11.9** (10.4-13.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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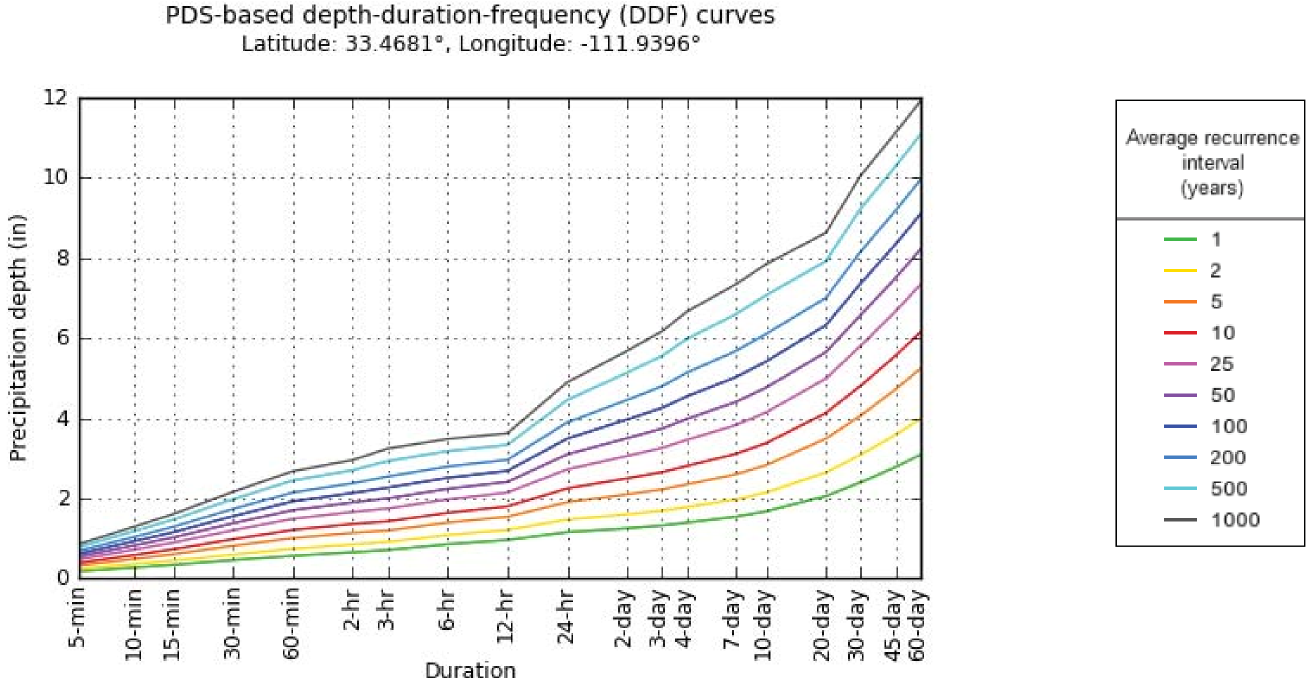
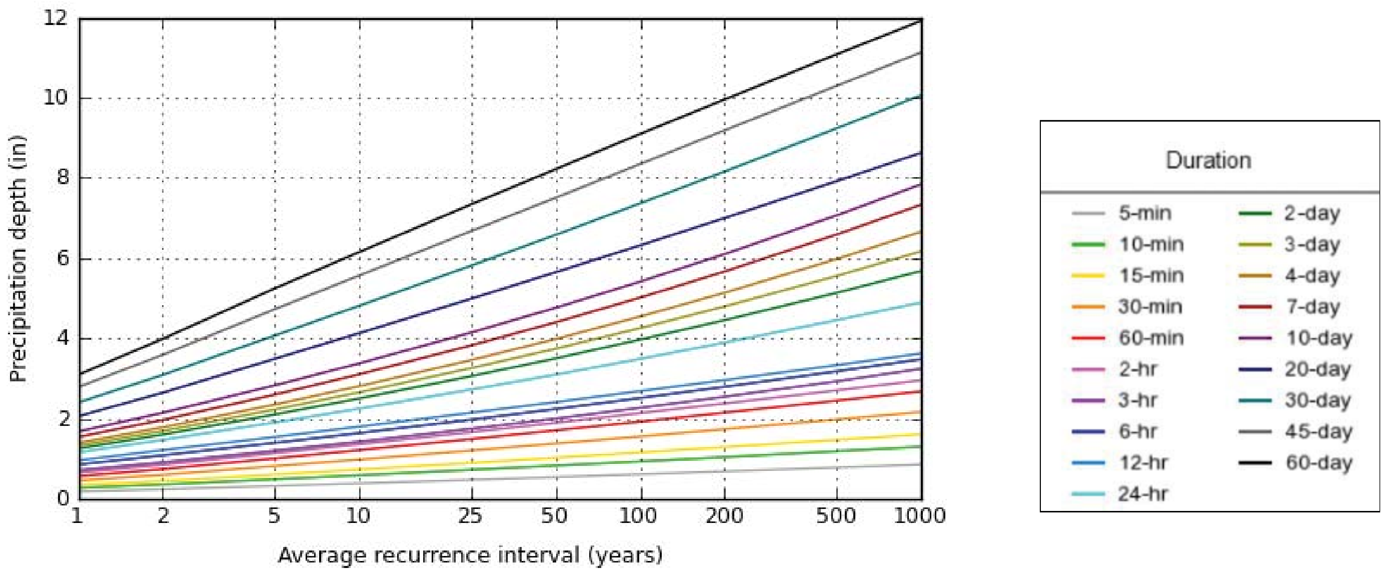
PF graphical





NOAA Atlas 14, Volume 1, Version 5

Created (GMT): Fri Jun 14 21:30:06 2019

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Maps & aerials

Small scale terrain

47-DR-2019
12/31/2019

SCOTTSDALE ENTRADA

First Flush Retention Basin Volume Calculations

Retention [(1)] Sub-Watershed ID	Drainage Area A (acres)	Runoff [(2)] Coefficient C	Precipitation [(3)] P (inches)	Volume [(4)] Required V_{req} (acre-ft)	Retention Basin[(5)] ID	Basin Depth D (ft)	Bottom Area A_{BOTT} (acres)	Top Area A_{TOP} (acres)	Volume[(6)] Provided V_P (ac-ft)
1	2.67	0.82	0.50	0.09					
R-1	1.41	0.82	0.50	0.05	R-1	-	-	-	0.31
SUB TOTAL	4.08			0.14					0.31
2A	1.86	0.82	0.50	0.06					
2B	2.79	0.82	0.50	0.10					
2C	2.50	0.82	0.50	0.09					
R-2	1.93	0.82	0.50	0.07	R-2	-	-	-	1.19
SUB TOTAL	9.08			0.31					1.19
3A	6.98	0.82	0.50	0.24					
3B	5.32	0.82	0.50	0.18					
3C	0.84	0.82	0.50	0.03					
R-3	1.43	0.82	0.50	0.05	R-3	-	-	-	2.59
SUB TOTAL	14.56			0.50					2.59
R-4	1.25	0.82	0.50	0.04	R-4	2.0	0.12	0.27	0.37
SUB TOTAL	1.25			0.04					**0.37**
TOTAL[(7)]	**28.97**			**0.99**					**4.46**

Reference: City of Scottsdale Design Standards & Policies Manual, 2018.

Notes:

1. Areas delineated based on proposed conditions.
2. Weighted Average Runoff Coefficient (C-value) = **0.82**, **s**ee Pre vs Post calculations.
3. Required precipitation depth, P= 0.50 inches, per Scottsdale DSPM
4. V_{req} = A x C x (P/12) = volume required for retention in acre-ft.
5. Proposed retention basins per Drainage Map.
6. Basins R-1, R-2, & R-3 are per existing conditions and most recent survey data. $V_P = D \times (A_{TOP} + A_{BOTT})/2$= retention volume provided in acre-ft for basin R-4.
7. The first flush volumes are greater than pre vs. post volumes for the site. Therefore, first flush retention will be provided, at a minimum, in the existing basins.

SCOTTSDALE ENTRADA
Pre vs Post Retention Basin Volume Calculations

	Retention [1] Sub-Watershed ID	Drainage Area A (acres)	Runoff [2] Coefficient C	Precipitation [3] P (inches)	Volume [4] Required V_{req} (acre-ft)
Pre-Development	Landscaping	2.32	0.45	2.13	0.19
	Pavement/Concrete/Buildings	21.05	0.95	2.13	3.55
	Retention	5.60	0.45	2.13	0.45
	TOTAL	**28.97**			**3.73**
Post-Development	1	2.67	0.95	2.13	0.45
	R-1	1.41	0.45	2.13	0.11
	SUB TOTAL	4.08			0.56
	2A	1.86	0.86	2.13	0.28
	2B	2.79	0.86	2.13	0.43
	2C	2.50	0.95	2.13	0.42
	R-2	1.93	0.45	2.13	0.15
	SUB TOTAL	9.08			1.29
	3A	6.98	0.95	2.13	1.18
	3B	5.32	0.94	2.13	0.89
	3C	0.84	0.45	2.13	0.07
	R-3	1.43	0.45	2.13	0.11
	SUB TOTAL	14.56			2.25
	R-4	1.25	0.45	2.13	0.10
	SUB TOTAL	1.25			0.10
	TOTAL	**28.97**			**4.19**

Pre vs Post

EQUATION:

Vr = ΔC (P/12) A

Vr = Required storage volume

P = 100-yr, 2-hr precipitation amount

A = Area

ΔC = Cpost - Cpre

$$C = \frac{\sum C_n A_n}{\sum A_n}$$

Weighted Average Cpre Calculation: 0.81

Weighted Average Cpost Calculation: **0.82**

Vr = **0.01** acre-ft

Reference: City of Scottsdale Design Standards & Policies Manual, 2018

Notes:

1. Areas delineated based on a historical aerial photograph for the existing condition and on proposed land use for the proposed condition.
2. Estimated 100-year C-Value of **0.86** for commercial areas (Scottsdale DSPM "Commercial & Industrial Areas"), **0.45** for retention basins (Scottsdale DSPM "Desert landscaping"), **0.94** for residential areas (Scottsdale DSPM "Apartments & Condominiums"), and **0.95** for paved streets, parking lots, roofs, etc (Scottsdale DSPM).
3. Estimated 100-year, 2-hour precipitation depth, P= 2.13 inches per NOAA 14 PRECIPITATION FREQUENCY ESTIMATES.
4. V_{req} = A x C x (P/12) = volume required for retention in acre-ft.
5. The first flush volumes are greater than pre vs. post volumes for the site. Therefore, first flush retention will be provided, at a minimum, in the existing basins.

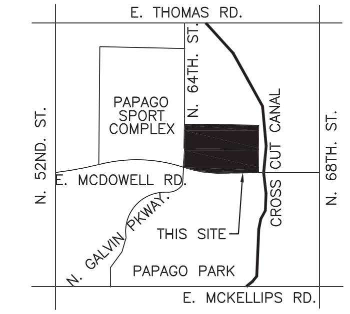
APPENDIX D

PRELIMINARY GRADING & DRAINAGE PLANS

GRADING AND DRAINAGE MASTER PLANS FOR SCOTTSDALE ENTRADA

A PORTION OF LAND LOCATED IN THE SOUTHWEST QUARTER OF SECTION 34, TOWNSHIP 2 NORTH, RANGE 4 EAST, OF THE GILA AND SALT RIVER BASE AND MERIDIAN, MARICOPA COUNTY, ARIZONA

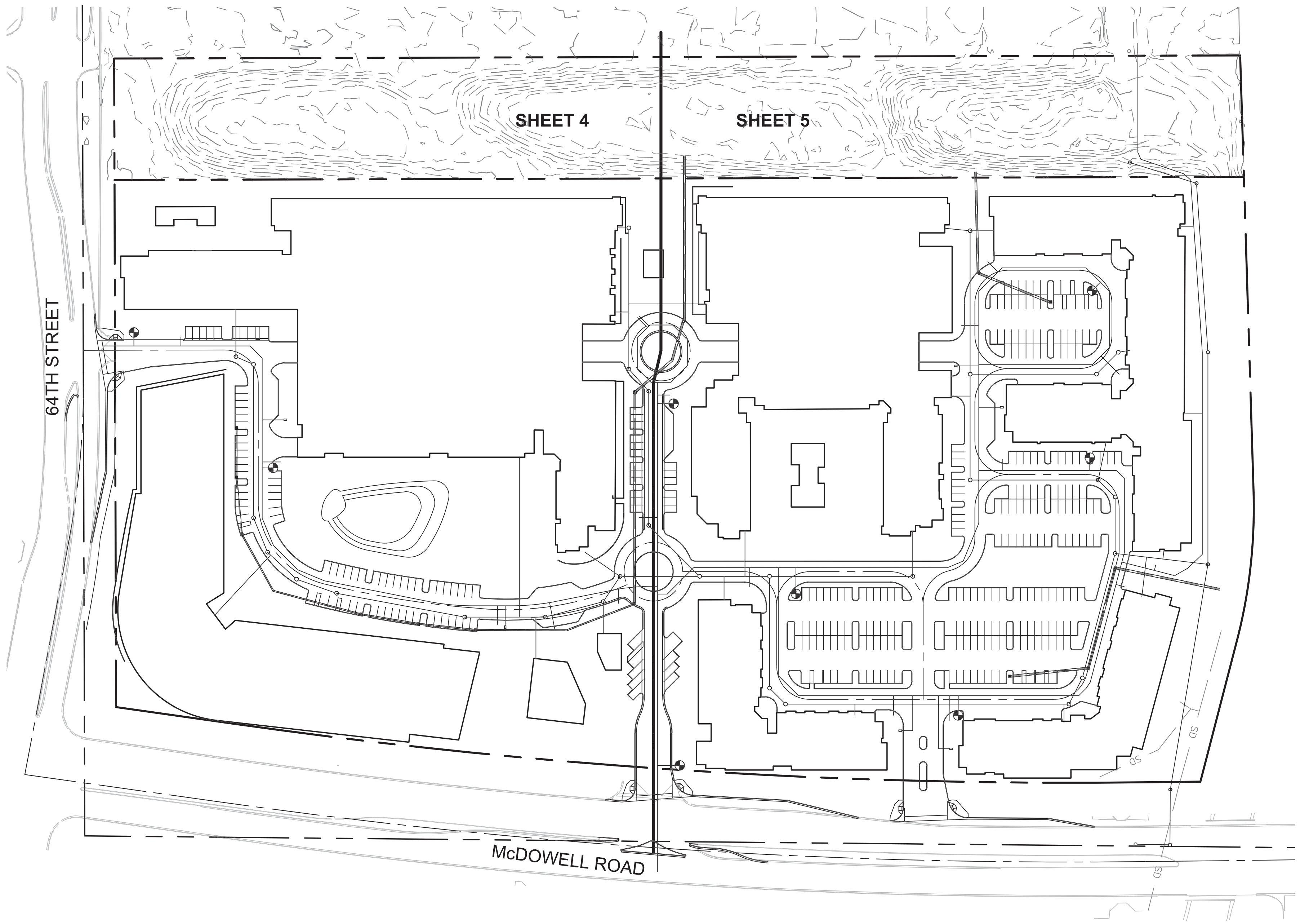
Preliminary



VICINITY MAP
(NOT-TO-SCALE)

SHEET INDEX

1..........COVER SHEET
2..........GENERAL NOTES
3..........OVERALL SITE
4-5.......GRADING AND DRAINAGE PLANS



OWNERS

McDOWELL 64 LLC
8601 N. SCOTTSDALE RD.
SCOTTSDALE, AZ 85253

CAR COLLECTION LLC
5665 N. SCOTTSDALE RD.,
SUITE 135
SCOTTSDALE, AZ 85253

McDOWELL 6620 LLC
5665 N. SCOTTSDALE RD.,
SUITE 135
SCOTTSDALE, AZ 85250

McDOWELL 6500 LLC
5665 N. SCOTTSDALE RD.,
SUITE 135
SCOTTSDALE, AZ 85250

ENGINEER

COE & VAN LOO CONSULTANTS, INC.
4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
PHONE: (602) 264-6831
FAX: (602) 264-0928
CONTACT: HEIDI TILSON
EMAIL: HTILSON@CVLCI.COM

BASIS OF BEARING

THE BASIS OF BEARINGS IS GRID NORTH, ACCORDING TO DIRECT OBSERVATION ON THE ARIZONA STATE PLANE COORDINATE SYSTEM, PROJECTION OF THE CENTRAL ZONE, NAD-83.

BENCHMARK

THE SOUTH WEST 1/4 CORNER SECTION 34, TOWNSHIP 2 NORTH, RANGE 4 EAST

ELEVATION 1284.45

Preliminary

80' 40' 0 80'
SCALE: 1" = 80'

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GRADING & DRAINAGE PLANS
SCOTTSDALE ENTRADA
SCOTTSDALE, ARIZONA

48284
HEIDI A. TILSON
11-13-19
ARIZONA, U.S.A.

SHEET 01 OF 05

CVL Contact: HEIDI TILSON

Printed By: Juanl Print Date: November 14, 2019 Filename: N:\14 Coe and Van Loo II LLC\0254309\CADD\DS.MGRAD.01-04.dwg

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12/31/2019

ENGINEER'S GENERAL NOTES (3/9/2018)

1. THESE PLANS ARE NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS THE APPROVAL BLOCK HAS BEEN SIGNED BY THE APPROPRIATE AGENCIES. ALL MATERIALS AND WORKMANSHIP SHALL COMPLY WITH THE CURRENT MARICOPA ASSOCIATION OF GOVERNMENTS (M.A.G.) SPECIFICATIONS AND STANDARD DETAILS TOGETHER WITH ANY SUPPLEMENTS OF THE REVIEWING AGENCY AND WITH GENERALLY ACCEPTED CONSTRUCTION PRACTICES.

2. PRIOR TO CONSTRUCTION, THE ENGINEER AND APPLICABLE AGENCY MUST APPROVE ANY ALTERATION OR VARIANCE FROM THESE PLANS. ANY VARIATIONS FROM THESE PLANS SHALL BE PROPOSED ON CONSTRUCTION FIELD PRINTS AND TRANSMITTED TO THE ENGINEER.

3. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO OBTAIN ALL REQUIRED PERMITS AT HIS OWN EXPENSE.

4. ANY INSPECTION BY THE CITY, COUNTY, ENGINEER, OR OTHER JURISDICTIONAL AGENCY SHALL NOT IN ANY WAY RELIEVE THE CONTRACTOR FROM ANY OBLIGATION TO PERFORM THE WORK IN STRICT COMPLIANCE WITH APPLICABLE CODES AND AGENCY REQUIREMENTS.

5. THE CONTRACTOR SHALL MAKE NO CLAIM AGAINST THE OWNER OR THE SURVEYOR REGARDING ALLEGED INACCURACY OF CONSTRUCTION STAKES SET BY THE SURVEYOR UNLESS ALL SURVEY STAKES SET BY THE SURVEYOR ARE MAINTAINED INTACT AND CAN BE VERIFIED AS TO THEIR ORIGIN. IF, IN THE OPINION OF THE SURVEYOR, THE STAKES ARE NOT MAINTAINED INTACT AND CANNOT BE VERIFIED AS TO THEIR ORIGIN, ANY REMEDIAL WORK REQUIRED SHALL BE PERFORMED AT THE SOLE EXPENSE OF THE RESPONSIBLE CONTRACTOR OR SUBCONTRACTOR.

6. THE CONTRACTOR SHALL NOTIFY THE DEVELOPER AT LEAST 48 HOURS IN ADVANCE FOR ANY STAKING OR RESTAKING REQUIRED.

7. THE CONTRACTOR SHALL NOTIFY THE ENGINEER AT LEAST 48 HOURS IN ADVANCE FOR ANY INSPECTIONS AND/OR TESTING FOR ENGINEER OF RECORD SERVICES.

8. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PRESERVING ALL STAKES AND CONTROL SET BY THE DEVELOPERS SURVEYOR, AND SHALL TAKE STEPS NECESSARY TO INSURE THAT THE STAKES AND CONTROL ARE NOT DISTURBED OR TAMPERED WITH. IF STAKES SET BY THE DEVELOPERS SURVEYOR ARE DISTURBED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COST INCURRED TO RESTAKE.

9. NOTHING CONTAINED IN THE CONTRACT DOCUMENTS SHALL CREATE, NOR SHALL BE CONSTRUED TO CREATE, ANY CONTRACTUAL RELATIONSHIP BETWEEN THE ENGINEER AND THE CONTRACTOR OR ANY SUBCONTRACTOR.

10. CONTRACTOR MUST CONTACT THE DESIGN ENGINEER FOR ANY NOTED DISCREPANCIES IN THE DESIGN PRIOR TO THE ITEM BEING CONSTRUCTED. FAILURE OF CONTRACTOR TO NOTIFY THE ENGINEER AND APPROVING AGENCY IN ADVANCE FOR ALTERNATIVE DESIGN SHALL RESULT IN CONTRACTOR ACCEPTANCE OF ALL COSTS RELATED TO POTENTIAL REMOVAL AND REWORK OF SAID ITEMS.

11. THE ENGINEER SHALL NOT BE RESPONSIBLE FOR COORDINATING THE RELOCATION OF UTILITIES, POWER POLES, ETC.

12. THE ENGINEER SHALL NOT BE RESPONSIBLE FOR CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES, OR FOR SAFETY PRECAUTIONS OR PROGRAMS UTILIZED IN CONNECTION WITH THE WORK. THE ENGINEER IS NOT RESPONSIBLE FOR THE CONTRACTOR'S FAILURE TO CARRY OUT THE WORK IN ACCORDANCE WITH THE CONTRACT DOCUMENTS NOR ANY COSTS INCURRED, WHETHER INITIAL OR ADDITIONAL TO CORRECT, MODIFY, OR ALTER ANY CONSTRUCTION COMPLETED CONTRARY TO THE CONTRACT DOCUMENTS.

13. A THOROUGH ATTEMPT HAS BEEN MADE TO SHOW THE LOCATIONS OF ALL OVERHEAD AND UNDERGROUND UTILITY LINES IN THE WORK AREA ACCORDING TO INFORMATION PROVIDED BY THE AGENCY OPERATING EACH FACILITY. LOCATIONS SHOWN ARE APPROXIMATE ONLY, AND ARE NOT RELIABLE FOR CONSTRUCTION PURPOSES. CALL AZ811 AT 811 OR 602-263-1100 TO HAVE LOCATIONS MARKED PRIOR TO CONSTRUCTION. THE CONTRACTOR SHALL PROTECT AND MAINTAIN ALL EXISTING UTILITIES ON THE SITE. ANY DAMAGE TO EXISTING UTILITIES, WHETHER SHOWN ON THE PLANS OR NOT, SHALL BE REPAIRED/REPLACED AT THE CONTRACTOR'S EXPENSE. EXISTING SURFACE FEATURES AND FENCING NOT SCHEDULED FOR DEMOLITION OR REMOVAL SHALL BE REPLACED IN KIND.

14. IT IS THE CONTRACTOR'S SOLE RESPONSIBILITY TO VERIFY THE PRESENCE AND LOCATION OF ANY AND ALL EXISTING OVERHEAD AND/OR UNDERGROUND UTILITIES THAT MAY INTERFERE WITH THIS CONSTRUCTION, WHETHER OR NOT SAID UTILITIES ARE SHOWN ON THE CONSTRUCTION PLANS FOR THIS PROJECT. THE CONTRACTOR SHALL MAKE EXPLORATORY EXCAVATIONS (POTHOLING) AND LOCATE EXISTING UNDERGROUND FACILITIES SUFFICIENTLY IN ADVANCE OF CONSTRUCTION TO PERMIT THE OWNER TO DIRECT THE ENGINEER TO MAKE REVISIONS OF THESE PLANS, IF NECESSARY, DUE TO CONFLICT BETWEEN PROPOSED FACILITIES AND EXISTING FACILITIES.

15. OWNER/CONTRACTOR IS RESPONSIBLE FOR SURVEY VERIFICATION OF EXISTING HORIZONTAL AND VERTICAL CONDITIONS PRIOR TO START OF CONSTRUCTION. A DEVIATION IN EXISTING CONDITIONS MUST BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE CONSTRUCTION STARTS. THE ENGINEER WILL NOT BE RESPONSIBLE FOR REMOVAL, REPLACEMENT, OR OTHER MODIFICATIONS THAT MAY BE REQUIRED AS A RESULT OF EXISTING CONDITIONS NOT PROPERLY VERIFIED AND CONFIRMED. SHOULD AN ERROR BE FOUND IN THE HORIZONTAL AND VERTICAL CONDITIONS, THE ENGINEER SHALL BE NOTIFIED AND CONSTRUCTION WILL NOT PROCEED UNTIL REVISIONS/MODIFICATIONS HAVE BEEN PREPARED AND SUBMITTED BY THE ENGINEER.

16. THE CONTRACTOR SHALL VERIFY THE LOCATION, ELEVATION, CONDITION, AND PAVEMENT CROSS-SLOPE OF ALL EXISTING SURFACES AT POINTS OF TIE-IN AND MATCHING, PRIOR TO COMMENCEMENT OF GRADING, PAVING, CURB AND GUTTER, OR OTHER SURFACE CONSTRUCTION. SHOULD EXISTING LOCATIONS, ELEVATIONS, CONDITIONS, OR PAVEMENT CROSS-SLOPES DIFFER FROM THAT WHICH IS SHOWN ON THESE PLANS, THE CONTRACTOR SHALL NOTIFY THE ENGINEER ACCORDINGLY. THE CONTRACTOR ACCEPTS RESPONSIBILITY FOR ALL COSTS ASSOCIATED WITH CORRECTIVE ACTION IF THESE PROCEDURES ARE NOT FOLLOWED.

17. APPROVAL OF THESE PLANS SHALL NOT PREVENT THE REVIEWING AGENCY FROM REQUIRING THE CORRECTION OF ERRORS IN THE PLANS WHERE SUCH ERRORS ARE SUBSEQUENTLY FOUND TO BE IN VIOLATION OF ANY LAW, ORDINANCE, OR OTHER HEALTH/SAFETY ISSUE.

18. THE CONTRACTOR IS RESPONSIBLE FOR PROTECTING ALL STORM DRAIN PIPES, STORM WATER RETENTION PIPES AND DRAINAGE FACILITIES DURING ALL STAGES OF CONSTRUCTION. THE DEPTH OF COVER ON THE STORM DRAIN PIPE IS DESIGNED FOR FINAL GRADE. THEREFORE, EXTRA CARE SUCH AS BERMING OVER PIPES, FLAGGING, OR SIGNAGE SHOULD BE USED DURING CONSTRUCTION IN ORDER TO MAINTAIN COVER OR PROTECT THE PIPES.

ENGINEER'S GENERAL NOTES (CONT.)

19. ALL CONDUITS (BOX CULVERT, REINFORCED CONCRETE PIPE, CAST-IN-PLACE PIPE, AND/OR CORRUGATED METAL PIPE) SHOWN ON THESE PLANS ARE DESIGNED FOR STANDARD HIGHWAY LOADINGS. THE STANDARD SATISFACTORY MINIMUM COVER REQUIREMENTS AS ESTABLISHED BY THE CONDUIT MANUFACTURER MAY NOT ALWAYS BE ADEQUATE DURING CONSTRUCTION. WHEN CONSTRUCTION EQUIPMENT, FREQUENTLY HEAVIER THAN TRAFFIC LOADS FOR WHICH THE CONDUIT HAS BEEN DESIGNED, IS TO BE DRIVEN OVER OR CLOSE TO THE BURIED CONDUIT, IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO PROVIDE THE ADDITIONAL COVER REQUIRED TO AVOID DAMAGE TO THE CONDUIT. THE ADEQUACY OF THE COVER REQUIREMENTS FOR CONDUITS SHALL BE ANALYZED AND CHECKED BY THE CONTRACTOR TO ADDRESS LOADING CONDITIONS IMPOSED BY THE CONSTRUCTION ACTIVITY. ANY CONDUIT DAMAGED BY CONSTRUCTION ACTIVITY SHALL BE REPLACED AT THE CONTRACTOR'S EXPENSE.

20. THE ESTIMATED QUANTITIES SHOWN ARE FOR INFORMATIONAL PURPOSES ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COMPLETENESS AND ACCURACY OF A DETAILED ESTIMATE BASE ON THESE PLANS, CURRENT CODES, AND SITE VISITATION.

21. ALL EARTHWORK CONSTRUCTION SHALL CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS (M.A.G.) STANDARD DETAILS AND SPECIFICATIONS, INCLUDING ANY SUPPLEMENTS THERETO AND THE SOILS REPORT PREPARED BY:

COMPANY: WESTERN TECHNOLOGIES INC.
PROJECT NO.: 2125JI062
DATED: 05-21-2015

DATA FOR EARTHWORK CALCULATIONS IS PROVIDED IN THE SOILS REPORT AND (IF APPLICABLE) ANY SUPPLEMENTS THERETO.

22. THIS PLAN IS APPROVED SUBJECT TO COMPLETION OF THOSE LINES LABELED "EXISTING" WHICH HAVE BEEN PROPOSED AS A PART OF ANOTHER DEVELOPMENT. THE DEVELOPER OF THIS PROJECT MAY BE REQUIRED TO CONSTRUCT THOSE LINES PER THE REVIEWING AGENCY'S REQUIREMENTS PRIOR TO RECEIVING SERVICE FOR THIS PROJECT.

ENGINEER'S GRADING NOTES (3/9/2018)

1. THE ENGINEER MAKES NO REPRESENTATION OR GUARANTEE REGARDING EARTHWORK QUANTITIES OR THAT THE EARTHWORK FOR THIS PROJECT WILL BALANCE DUE TO THE VARYING FIELD CONDITIONS, CHANGING SOIL TYPES, ALLOWABLE CONSTRUCTION TOLERANCES, AND CONSTRUCTION METHODS THAT ARE BEYOND THE CONTROL OF THE ENGINEER.

2. PRIOR TO BIDDING THE WORK, THE CONTRACTOR SHALL THOROUGHLY SATISFY HIMSELF AS TO THE ACTUAL CONDITIONS, REQUIREMENTS OF WORK, AND EARTHWORK QUANTITIES, IF ANY. NO CLAIM SHALL BE MADE AGAINST THE OWNER OR ENGINEER FOR ANY EXCESS OR DEFICIENCY THEREIN ACTUAL OR RELATIVE.

3. FINISHED GRADES SHOWN ON THESE PLANS ARE THE FINAL FINISHED GRADES. CONTRACTOR IS RESPONSIBLE FOR OVER-EXCAVATING LANDSCAPE AREAS TO ALLOW FOR PLANTING, DRYWELL, AND UTILITY TRENCHING SPOILS AND FOR THE FINAL LANDSCAPE TREATMENT (DECOMPOSED GRANITE, LAWN, ETC).

4. IF PAD CERTIFICATIONS ARE PERFORMED, IT IS UNDERSTOOD THAT THE CERTIFICATION PROVIDES ONLY A REPRESENTATIVE ELEVATION OF THE AVERAGE GRADE OF EACH LOT, BUILDING, OR UNIT PAD, AND SHALL NOT BE CONSTRUED TO INCLUDE YARD AND STREET SUBGRADE CERTIFICATION OR CERTIFICATION THAT THE ENTIRE PAD IS LEVEL, THAT IT WAS CONSTRUCTED IN THE DESIGNED LOCATION, OR WAS GRADED TO THE CROSS-SECTION SET FORTH ON THE PLANS OR AS DESIGNATED IN THE SOILS REPORT.

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SCOTTSDALE, ARIZONA

48284
HEIDI A.
TILSON
11-13-19
ARIZONA, U.S.A.

02 SHEET OF 05

CVL Contact: HEIDI TILSON

NO. XXXXXXX

Call at least two full working days before you begin excavation.
ARIZONA 811
Arizona Blue Stake
Dial 8-1-1 or 1-800-...
In Maricopa County

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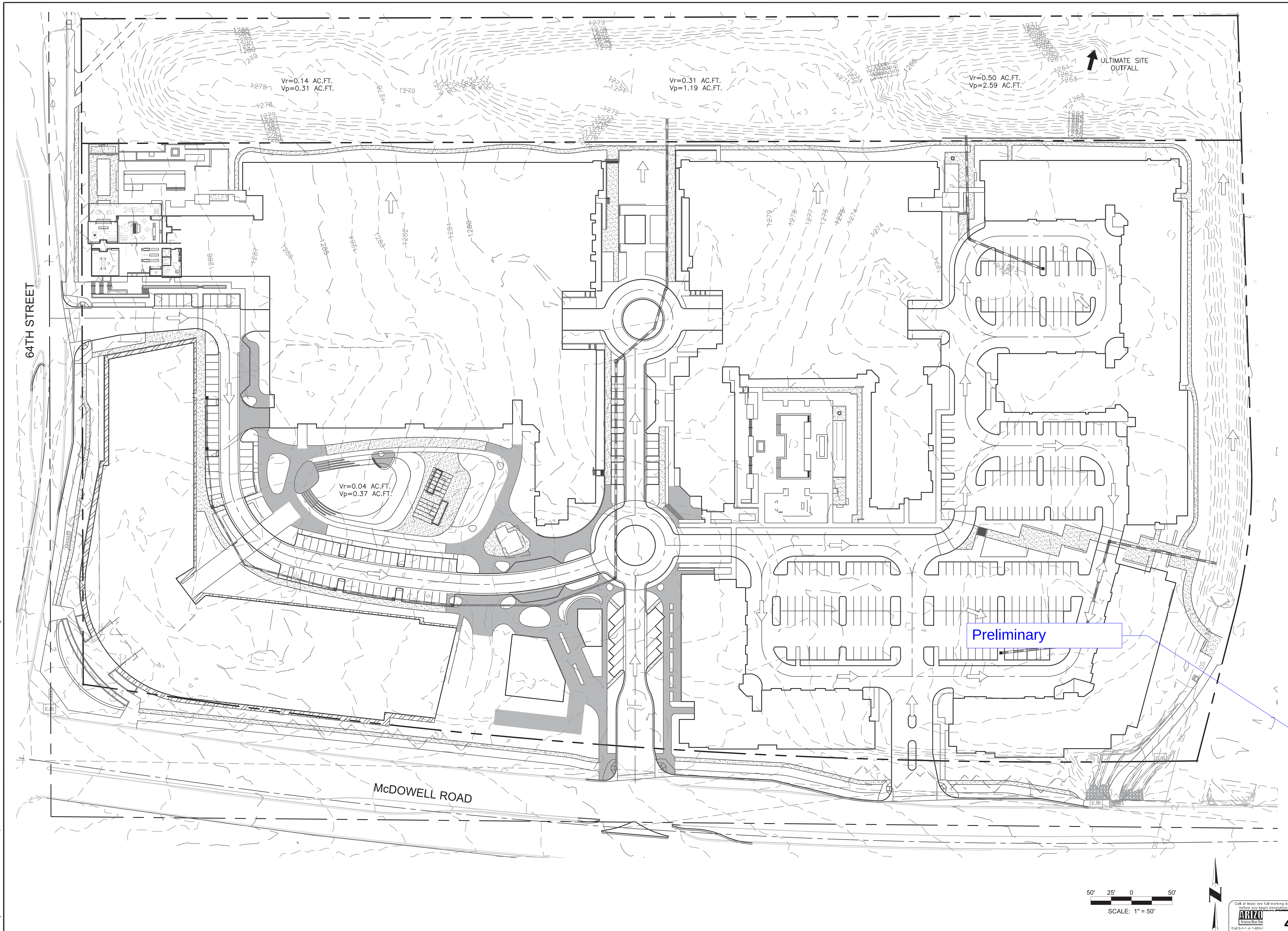
12/31/2019



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SCOTTSDALE, ARIZONA

HEIDI A. TILSON 48284
ARIZONA, U.S.A.

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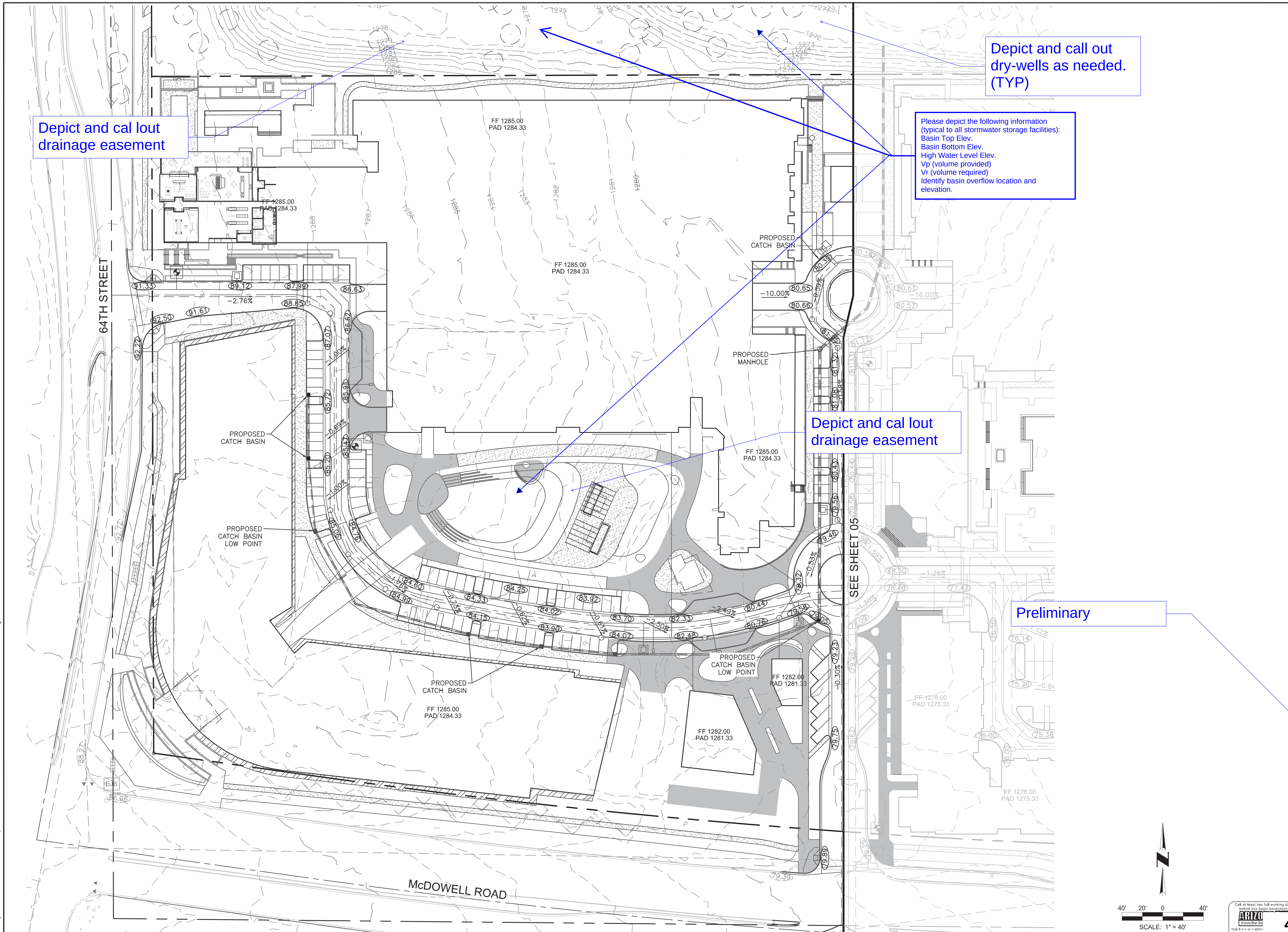

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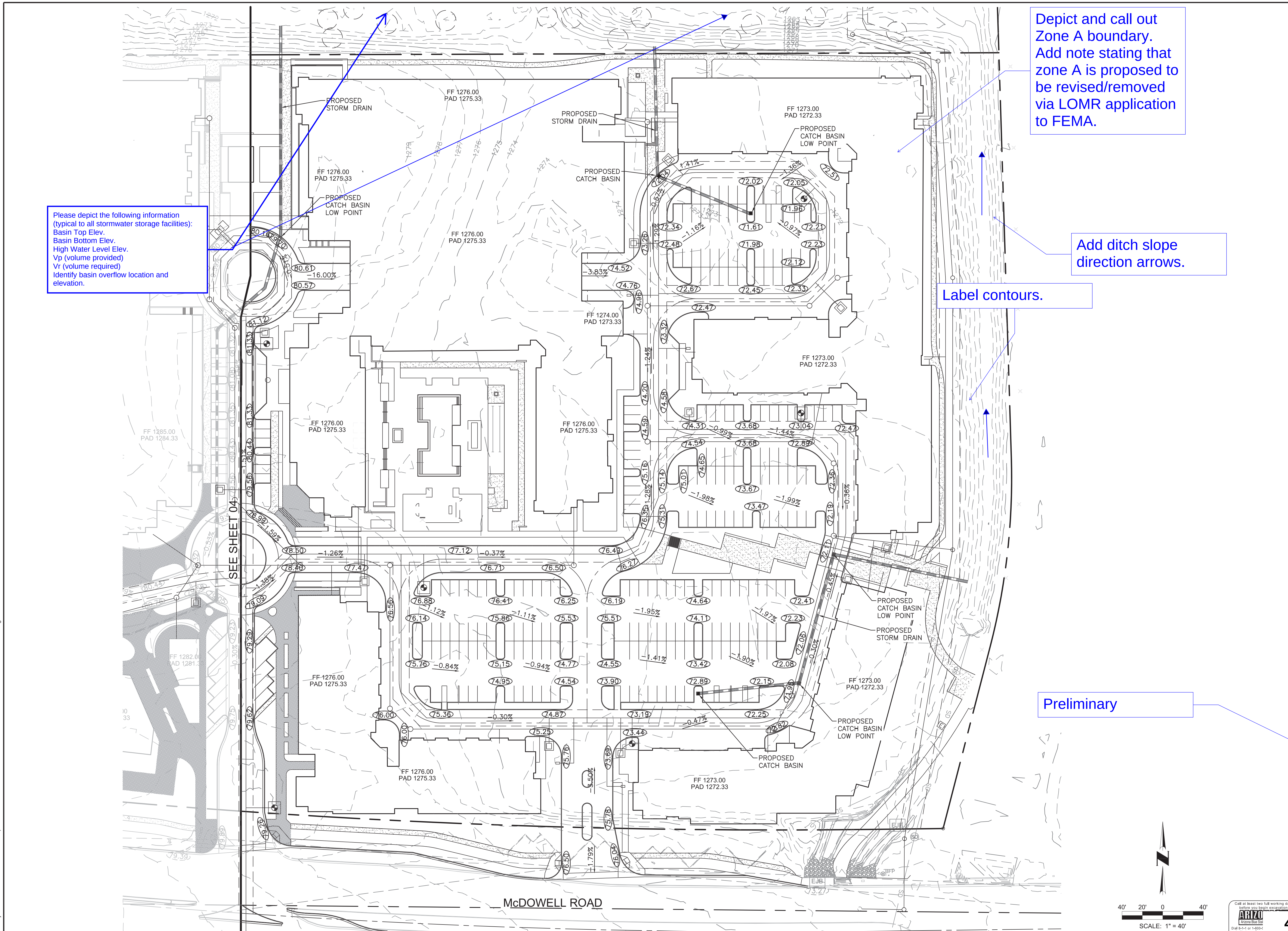

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PLATE 1

DRAINAGE MAP

47-DR-2019
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