Flood Control District of Maricopa County

Pinnacle Peak West Area Drainage Master Study
Rawhide Wash Alternatives
July 2015

TABLE OF CONTENTS

1. INTRODUCTION 3
1.1. Purpose of Study 3
1.2. Location of Study 3
1.3. Purpose of Report 3
1.4. Existing Conditions 3
1.5. Paradise Ridge Planned Conditions 7
2. ALTERNATIVES EVALUATION 9
2.1. Evaluation Criteria 9
2.2. Build Alternatives 9
2.2.1. Alternative A: Happy Valley In-Line Sediment Basin With Flow Splitter, Downstream Grade Control, & LOMR 9
2.2.2. Alternative B: Happy Valley In-Line Sediment Basin, Main Channel Only, Downstream Grade Control, & LOMR 12
2.2.3. Alternative C: Happy Valley Flow Splitter with Sediment Conveyance in Main Channel and LOMR 14
2.2.4. Alternative D: Main Channel Only with Sediment Conveyance in the Main Channel and LOMR 16
2.2.5. Remnant Hazards for Build Alternatives 16
2.3. No Build Alternative 18
2.4. No Action Alternative 19
3. PEER REVIEW WORKSHOP 19
4. SUMMARY & CONCLUSIONS 20
5. REFERENCES 22

List of Tables

Table 1-1. NFIP Statistics for Rawhide Wash 3
Table 1-2. Damage Cost of Structures Susceptible to Flood Damage – Rawhide Wash Zone AO Area 6
Table 2-1. Alternative A Cost Estimate 10
Table 2-2. Alternative B Cost Estimate 12
Table 2-3. Alternative C Cost Estimate 14
Table 2-4. Alternative D Cost Estimate 16
Table 2-5. Summary of No Build Acreage 18
Table 2-6. No Build Alternative Cost Estimate 18
Table 2-7. No Action Alternative Cost Estimate 19
Table 4-1. Rawhide Wash Alternatives Summary 21

TABLE OF CONTENTS

List of Figures

Figure 1. PPW ADMS Vicinity Map 4
Figure 2. Rawhide Wash Alternatives Analysis Focus Area 5
Figure 3. Base Conditions 100-Year, 24-Hour Hydrographs 6
Figure 4. Base Conditions FLO-2D Model Results in Paradise Ridge 7
Figure 5. Paradise Ridge Conceptual Drainage Plan 8
Figure 6. Alternative A – Happy Valley Sediment Basin With Flow Split Structure 11
Figure 7. Alternative B – Happy Valley Sediment Basin, Main channel Only 13
Figure 8. Alternative C – Happy Valley Flow Split with Sediment Conveyance 15
Figure 9. Alternative D – Main channel Only with Sediment Conveyance 17
Figure 10. Developable Land within Rawhide Wash FEMA Zone AO Floodplain 18

Appendices

Appendix A - Cost Estimate Calculations
Appendix B – Preliminary Sediment Transport Analysis Memo
Appendix C – Floodwall Inventory & Investigation Memo
Appendix D – Risk Assessment & Regulatory Issues
Appendix E – Preliminary Alternatives
Appendix F – Peer Review/Value Engineering Study Report
Appendix G – Digital Data

1. INTRODUCTION

1.1. Purpose of Study

Study Purpose. The purpose of the Pinnacle Peak West (PPW) Area Drainage Master Study (ADMS) is to identify and evaluate flood hazards in the study area and to formulate flood hazard mitigation alternatives. The hydrologic and hydraulic modeling component of the PPW ADMS is completed. The new modeling updates characterizes the flood hazards in the area using current detailed topography, updated precipitation data, and two-dimensional modeling methodologies. The results of these hydrologic and hydraulic analyses are documented in a Technical Support Data Notebook (TSDN) (JEF, 2014b) under separate cover.

Study Team. The Flood Control District of Maricopa County (District) retained JE Fuller/Hydrology and Geomorphology, Inc. (JE Fuller) for the execution of the PPW ADMS project. The District's project manager is Theresa Pinto; AICP, CFM, PMP and the JE Fuller project manager is Pat Quinn; PE, RLS, AVS.

1.2. Location of Study

The PPW ADMS project study area is roughly 95 square miles in size and is located in the northeastern portion of Maricopa County. The study encompasses land within the jurisdiction of the City of Phoenix, City of Scottsdale, Town of Cave Creek, Town of Carefree, and unincorporated Maricopa County. The primary stakeholders affected by the project are the City of Phoenix, City of Scottsdale, Maricopa County, and Arizona State Land Department (ASLD). The study area location and limits are shown on **Figure 1**. The project is bounded by approximately Carefree Highway and Cave Creek Road to the north, the Pinnacle Peak South (PPS) ADMS study area and drainage divide to the east, the Central Arizona Project (CAP) Reach 11 Dikes to the south, and Cave Creek Road and the eastern Cave Creek floodplain limits to the west.

1.3. Purpose of Report

Report Purpose. The purpose of this report is to document conceptual alternatives evaluated specifically for the Rawhide Wash alluvial fan, a significant flood hazard within the study area. The Rawhide Wash alternatives analysis focus area is along Rawhide Wash bounded by Scottsdale Road on the West, Pima Road on the East, Dynamite Boulevard on the North, and Pinnacle Peak Road on the South as depicted in **Figure 2**.

Project Objectives. The project stakeholders consisting of the City of Scottsdale, the City of Phoenix, and the Arizona State Land Department as well as the District Alternatives Work Group conducted a brainstorming meeting on June 23, 2014 with the purpose of formulating flood mitigation alternatives to address the entire Rawhide Wash alluvial fan flood hazard. As a precursor to the meeting, each stakeholder completed a questionnaire to identify the primary objectives for solutions within the focus area. The stakeholders unanimously agree that the **overall objective for any alternative considered should be to mitigate flood hazards associated with the Rawhide Wash alluvial fan, remove the flow-path uncertainty, and revise the FEMA regulatory floodplain from an alluvial fan Zone AO to a Zone A or AE** (riverine flood zone).

Alternative Formulation Process and Documentation. The conceptual alternatives were formulated and evaluated by the overall project team and stakeholders. The following report sections document each step of the alternative formulation process, as follows:

- **Preliminary alternatives** were formulated prior to and during a team brainstorming meeting and assessed at a high level. That analysis is presented in **APPENDIX E** of this document. The preliminary alternatives were generally categorized as Build, No Build, and No Action alternatives.
- **Conceptual Alternatives.** The high level assessment of preliminary alternatives yielded a subset of conceptual alternatives that were advanced to more detailed evaluation and preliminary cost estimation as presented in **Section 2** and **APPENDIX A**, respectively. **APPENDIX B** contains the associated documentation of the preliminary sediment transport analysis. **APPENDIX C** contains the floodwall inventory and investigation memorandum. **APPENDIX D** contains the Rawhide Wash risk assessment and discussion of related regulatory issues.
- **Alternatives Summary.** A side-by-side executive summary is provided in **Section 4** of the resultant conceptual alternatives which are described in **Section 2**.
- **References** for supporting PPW ADMS technical reports, previous studies, and relevant regulatory documents are provided in **Section 5**. **APPENDIX G** contains associated digital data.

1.4. Existing Conditions

Several key characteristics of the Rawhide Wash physical, regulatory, and built environments are integral to the formulation of conceptual flood hazard mitigation alternatives that address the project objectives. These characteristics include the following:

Alluvial Fan Landform. JE Fuller conducted a review of previous studies for the purpose of verifying there are alluvial fan landforms within the PPW study area according to a FEMA Appendix G Stage 1 analysis (FEMA, 2003). The findings of this review are documented in a technical memorandum (JEF, 2012). Eight reports spanning a decade were found to be relevant with most or all of the requirements of Appendix G being met within each of the studies. Although FEMA recognizes Rawhide Wash as an active alluvial fan, JE Fuller did not conduct an Appendix G Stage 2 analysis to verify that Rawhide Wash is in fact an active alluvial fan. Rawhide Wash is considered to be active for the purposes of this report.

FEMA Regulatory Floodplain. Rawhide Wash is one of the largest and most well-known active alluvial fans in Maricopa County. The wash drains approximately 14 square miles of rugged terrain upstream of the apex just north of Happy Valley Road. FEMA recognizes Rawhide Wash as an active alluvial fan with a Zone AO floodplain delineation downstream of the apex. The fan floodplain is the largest in all of Maricopa County and has been mapped on the FEMA Flood Insurance Rate Map (FIRM) panels since 1993. Over 3,000 residential and commercial buildings are within the Zone AO floodplain and a large fraction of these building owners are required to pay premiums for flood insurance policies. **Table 1-1** summarizes the NFIP statistics for the Rawhide Wash alluvial fan floodplain area.

Table 1-1. NFIP Statistics for Rawhide Wash

Properties within the Rawhide Wash Floodplain			
Floodplain	**Total Number of Parcels**	**Land Area of Parcels (Acres/Sq. Miles)**	**Parcels with Structures**
Downstream of Happy Valley Road	4,701	6,789/10.6	3,939
Upstream of Happy Valley Road	200	3,447/5.4	141
Total	**4,901**	**10,236/16.0**	**4,080**
Number of NFIP Policies within Rawhide Wash (2012)			
Phoenix	51		
Scottsdale	2,604		
Unincorporated	61		
Total	**2,716**		

Existing Drainage Infrastructure. There are a number of existing drainage improvements within the focus area that are discussed later in this document. Notable are two new bridges have been constructed within the last decade for the Rawhide Wash main channel at Pinnacle Peak Road and Scottsdale Road. These bridges and the connecting channel in between (Silverstone Channel) were designed to safely convey the full 100-year apex discharge of about 9,700 cfs.

Many of the subdivisions were designed to be resilient to the flood hazard by elevating building pads and through construction of flood walls. JE Fuller conducted an as-built construction drawing investigation to identify what information is available regarding the integrity of the existing flood protection measures (JEF, 2014a). Plans were only available for a subset of all of the walls between Jomax Road and Pinnacle Peak Road. Of these, only a few of the plan sets indicated that the walls were built for flood protection and included scour protection. Limited or no data were available for the rest of the walls. This issue is discussed in more detail later in this report. Copies of the plans collected are presented and summarized in **APPENDIX C**.

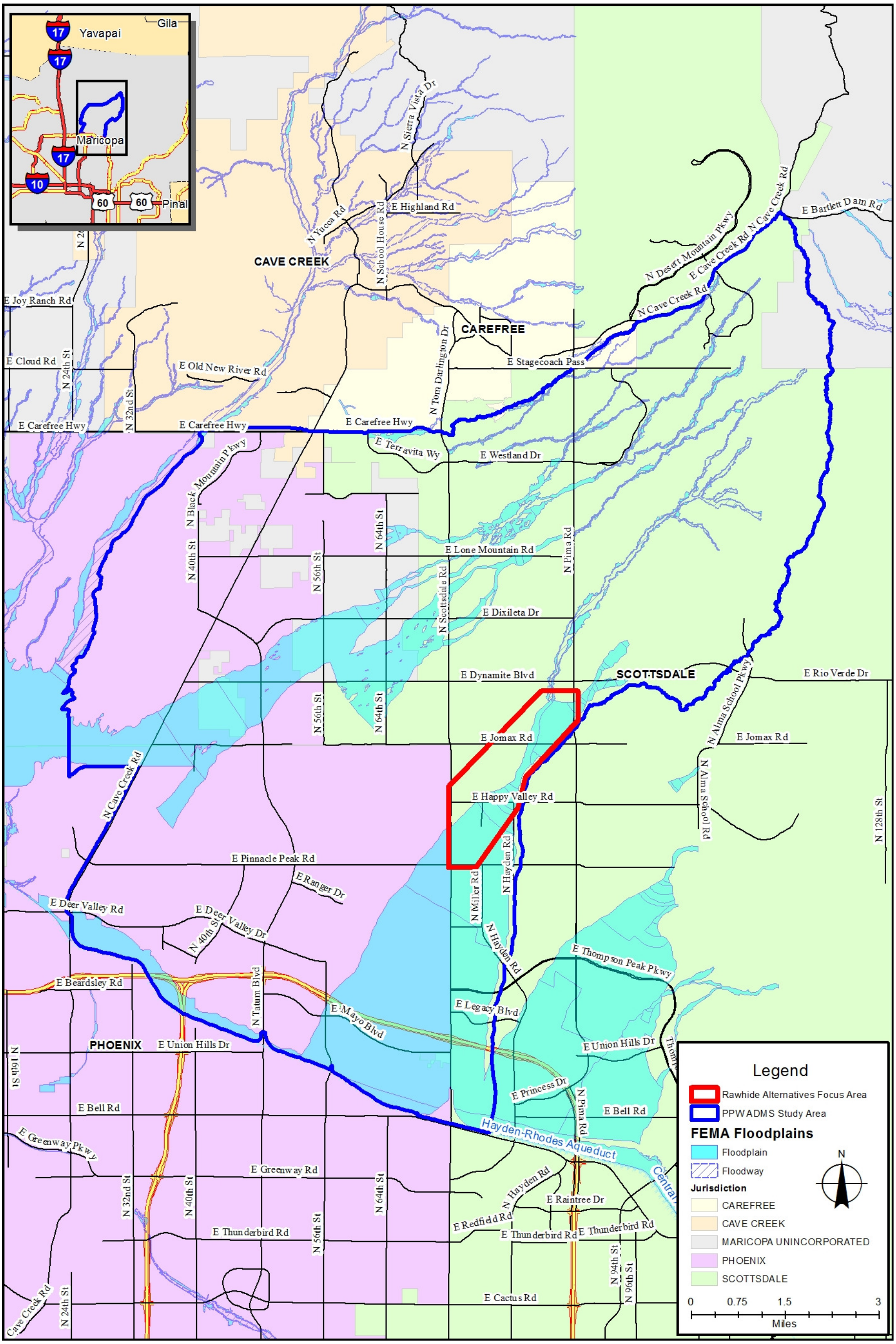


Figure 1. PPW ADMS Vicinity Map

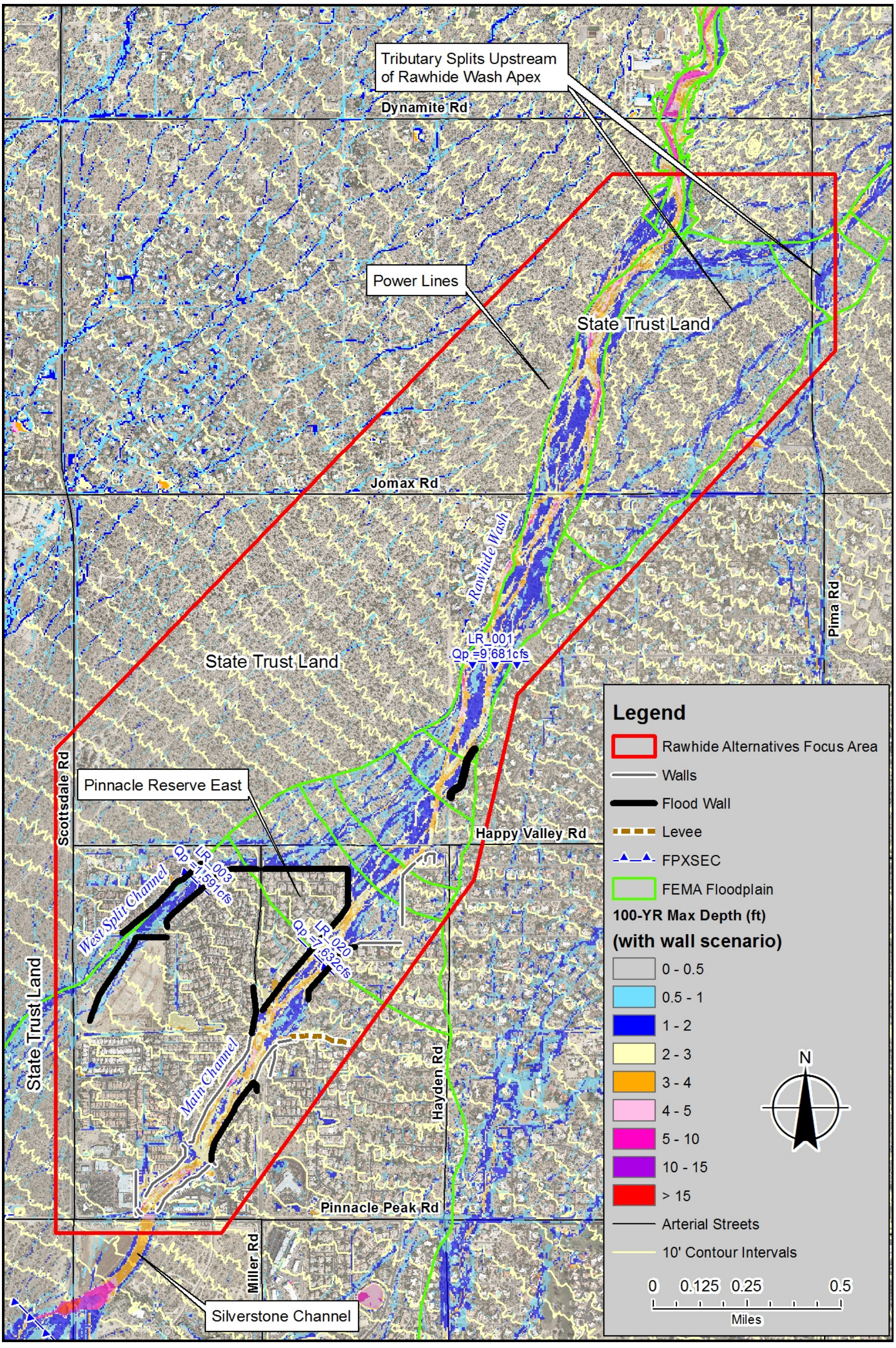


Figure 2. Rawhide Wash Alternatives Analysis Focus Area

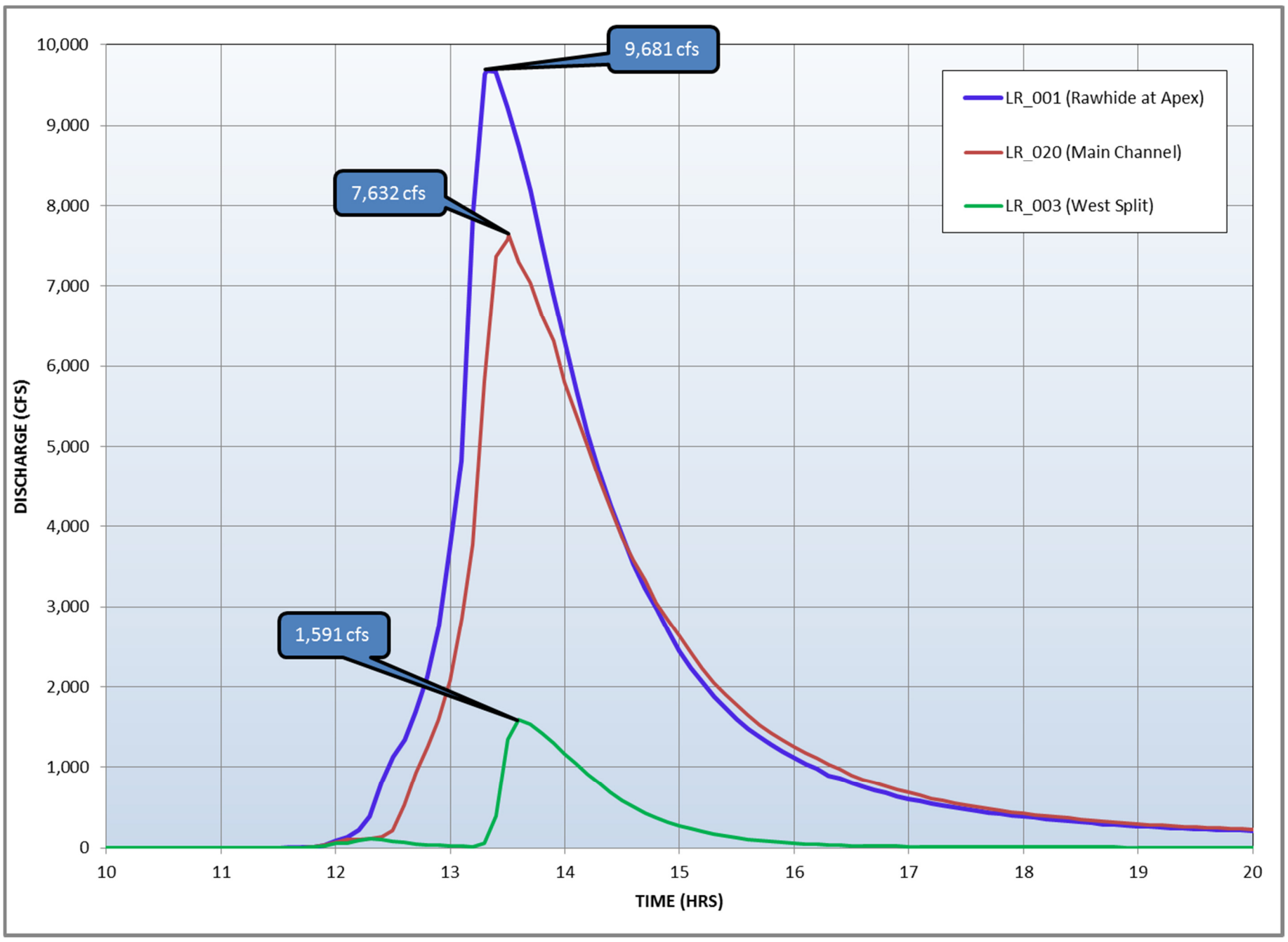


Figure 3. Base Conditions 100-Year, 24-Hour Hydrographs

Peak Discharge and Distribution. Several master planned subdivisions have been built immediately downstream (south) of the fan apex. The Pinnacle Reserve East subdivision bisects the fan into two reaches called the Rawhide Wash Main channel and the West Split channel for the purposes of this report. The base condition 100-year, 24-hour FLO-2D model indicates the Rawhide Wash apex peak discharge is 9,700 cfs, the Main channel peak discharge is 7,600 cfs, and the West Split peak discharge is 1,600 cfs. **Figure 3** shows the resulting 100-year hydrographs for various concentration points (cross sections) within the Rawhide Wash alternatives focus area. The location of each cross section is shown on **Figure 2**. It should be noted that this analysis is based on a fixed bed model of the current conditions.

In reviewing the FLO-2D flood simulation animation, it was observed that the West Split does not start receiving flows until significant stage is reached in Rawhide Wash near the apex. After further investigation, it is estimated that the West Split channel does not receive inflows from Rawhide Wash until the discharge in Rawhide Wash exceeds 3,800 cfs. This is slightly higher than the 10-year peak flow rate for Rawhide Wash. In other words, the West Split rarely receives runoff other than from a relatively small, local drainage area.

The FLO-2D model is a fixed bed model and does not simulate sediment transport or deposition. Therefore, it should be understood that the flow path downstream of the apex is uncertain and can change due to an avulsion by stream piracy or due to aggradation in the main channel particularly for events exceeding the 10-year frequency.

Estimated Flood Damage Costs. JE Fuller estimated the cost of homes susceptible to flooding from Rawhide Wash to recover from flooding over a 50-year design life period. The results of the risk assessment documented in a separate memo (JEF, 2014c) were used for this evaluation. This analysis is based on existing conditions and a fixed-bed assumption. **Table 1-** summarizes the number of structures susceptible to flooding as a result of the Rawhide Wash alluvial fan flood hazard within the existing FEMA AO zone for the **worst case condition** of the three scenarios modeled as part of the PPW ADMS base condition modeling (i.e. without walls, with walls no failure, and with walls with failure) as documented in the TSDN (JEF, 2014b). No damages are assumed to occur for flood depths below 0.5 feet. The flood damage cost associated with the various hazard levels was taken and averaged from the National Flood Insurance Program website, floodsmart.gov. The damage cost reported in **Table 1-2** was computed using a modified version of the average annual loss (AAL) estimation method from the FEMA Hazus-MH Technical Manual with an assumed inflation rate of 2 percent over a 50-year period. A worksheet with the AAL computations is also provided in **APPENDIX D**.

Table 1-2. Damage Cost of Structures Susceptible to Flood Damage – Rawhide Wash Zone AO Area

Hazard Level	Depth of Flooding (feet)	Recurrence Interval and Number of Structures			Damage cost per home per depth range	
		100-year	25-year	10-year		
Low	0.5 – 1.5	459	186	124	$52,000	
Moderate	1.5 – 2.5	62	16	8	$63,000	
High	> 2.5	8	3	2	$68,000	**50-Year Damage Cost**
Very High	> 2.5 w/high vel.	1	0	0	$136,000	
	AAL Contribution	284,540	590,070	539,160	**Total**	**$44,500,000**

1.5. Paradise Ridge Planned Conditions

The Paradise Ridge Planned Community District is within the City of Phoenix bounded by the Central Arizona Project Reach 11 Dike flood pool on the south, Pinnacle Peak Road to the north, Scottsdale Road to the East, and the 64th Street alignment on the west. The land is currently State Trust Land managed by the Arizona State Land Department (ASLD) who has been coordinating the master planning efforts over several years. The latest planning document summarizing the planned drainage infrastructure was prepared in 2010 (Olsson, 2010).

The Paradise Ridge development is important to the Rawhide Wash alternatives development because it occupies a significant portion of the alluvial fan floodplain area and will require significant drainage infrastructure to address flooding and floodplain issues when developed. In particular, if flow path uncertainty below the alluvial fan apex remains, redundant drainage systems will be required for both the Main channel and West Split channels downstream of Scottsdale Road. Additionally, significant fill volumes will be required to raise future building pads above the AO flood zone depth.

The base conditions FLO-2D model developed for PPW ADMS is presented in **Figure 4** and depicts the existing condition flow patterns within the Paradise Ridge planned development. The resulting peak discharge for the three primary inflow concentration points and the existing flows through the SR101L culverts are shown for reference.

Recent discussions with ASLD indicate the development plan and associated drainage infrastructure will likely change. However, the general drainage concept will remain the same; a network of drainage channels that convey on-site and off-site flows through the developed area to the Reach 11 Dike flood pools. **Figure 5** illustrates the planned channel conveyance systems from the 2010 study. The primary concentrated off-site inflows include the Rawhide Wash Main channel under Scottsdale Road (Silverstone Channel), the Rawhide Wash West Split channel, and the Deer Valley Road drainage channel. The various conveyance channels through Paradise Ridge would be divided upstream of SR101L to attempt to maintain the flow characteristics through existing cross-drainage culverts under the highway. Outflow from the culverts would then be conveyed in channels south to the Reach 11 Dike flood pools.

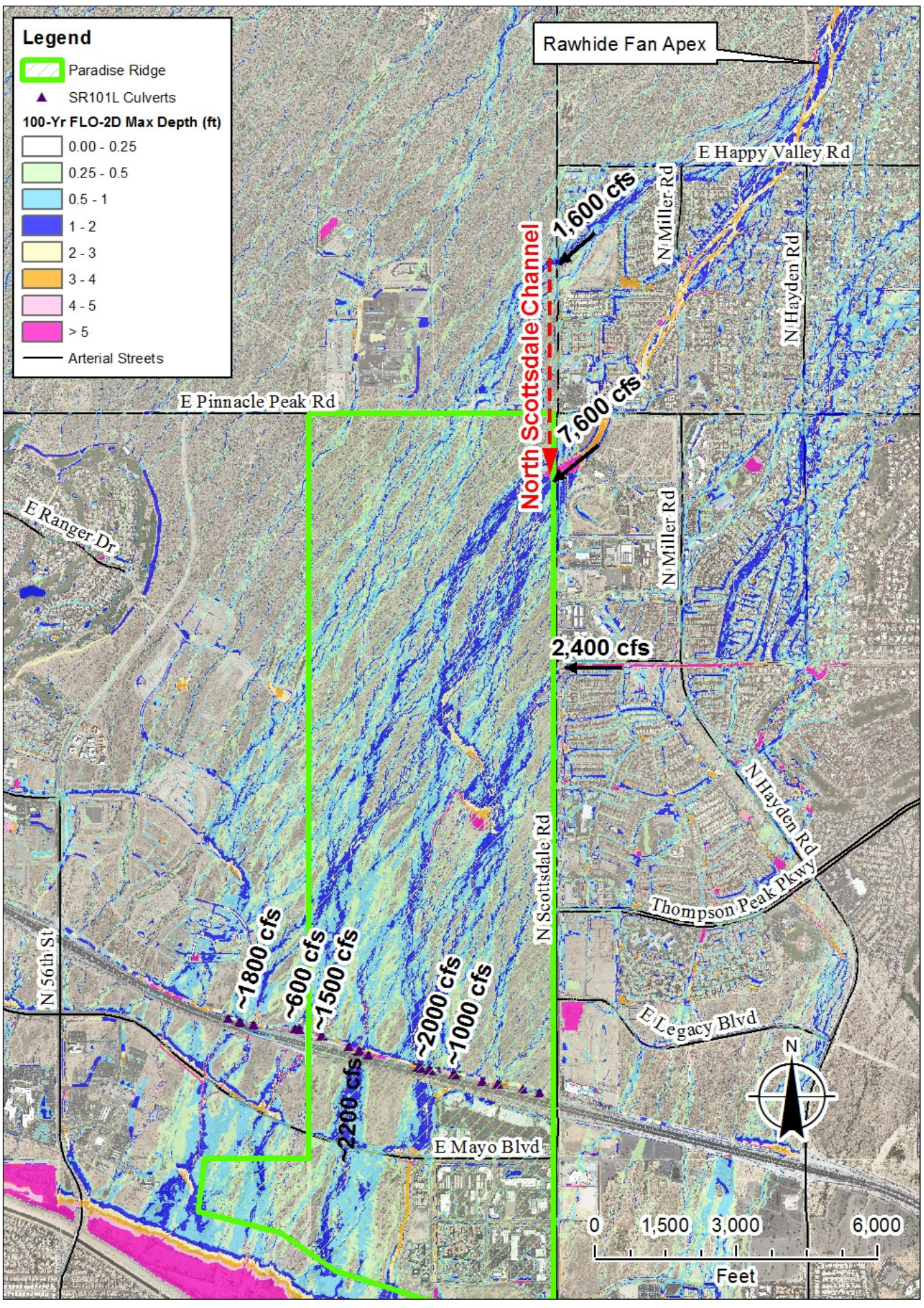


Figure 4. Base Conditions FLO-2D Model Results in Paradise Ridge

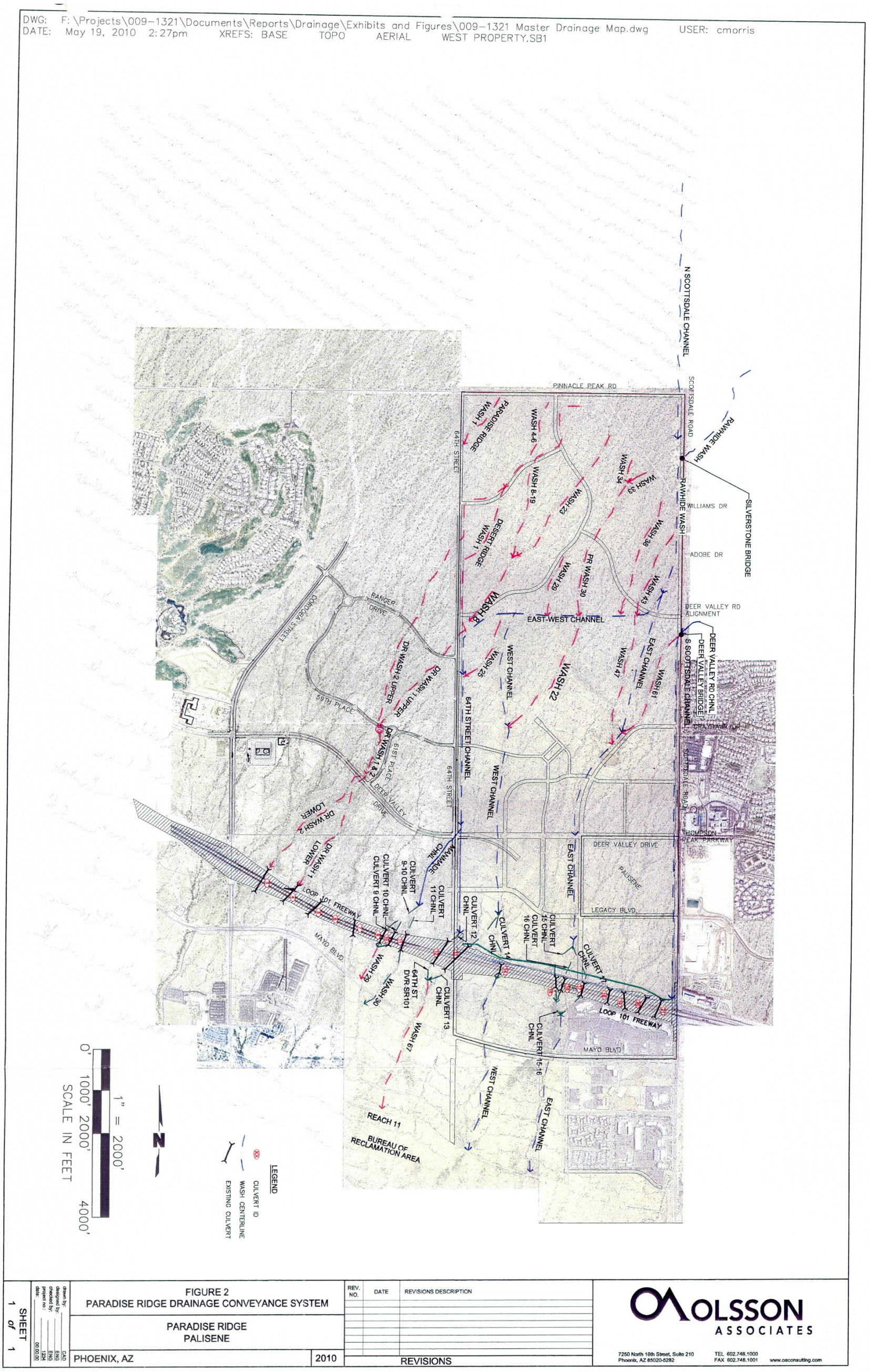


Figure 5. Paradise Ridge Conceptual Drainage Plan

2. ALTERNATIVES EVALUATION

A range of preliminary alternatives were developed and evaluated by the project team and stakeholders. That information is presented in **APPENDIX E.** Several alternatives were eliminated from further assessment due to practical limitations and constraints. These included large dams, underground storm drains, and diversion channels which were rejected due to costs, environmental impacts, and/or public acceptability.

The remaining alternatives were evaluated further and include a concept plan (if applicable) and associated conceptual level cost estimates (see **APPENDIX A**) as described in the following sections. The alternatives carried forward include four Build Alternatives, the No Build alternative, and the No Action alternative.

2.1. Evaluation Criteria

The following criteria were used to evaluate each of the alternatives to identify the best alternatives to carry forward for further analysis.

- **Meets Project Goals** – Assess whether or not the candidate alternative satisfies the dual project goals: 1) remove the Rawhide Wash alluvial fan flow-path uncertainty; and 2) revise the FEMA regulatory floodplain from an alluvial fan Zone AO to a Zone A or AE (riverine flood zone).
- **Public Safety** – The candidate alternative maintains or enhances the safety of the public from flooding hazards.
- **Cost** – The candidate alternative fulfills the flood hazard mitigation function in a cost effective manner.
- **Funding Sources** – There are potential funding sources and viable mechanisms to secure funding for the candidate alternative.
- **Land Ownership** – Land ownership of the footprints required for candidate Build alternatives is such that it may be reasonably implemented.
- **Implementation/Phasing/Constructability** – A reasonable implementation plan for the candidate alternative potentially exists and lends itself to phasing. No constructability fatal flaws are known.
- **Physical/Natural Environmental Impacts** – Beneficial and detrimental impacts to the physical and natural environments are understood and articulated. Detrimental impacts are minimized to the extent practicable.
- **Aesthetics** – The aesthetic characteristics of the candidate alternative are compatible with the environment and acceptable to the community.

2.2. Build Alternatives

The Build alternatives comprise structural measures that mitigate the potential for avulsion at the apex and consequent flow path uncertainty in the Rawhide Wash alluvial fan. Structural mitigation of the alluvial fan avulsion hazard results in reduced floodplain extents and allows for subsequent redelineation of the FEMA regulatory floodplain from the current Zone AO to Zone AE. The following Build alternatives were advanced to conceptual level of evaluation.

2.2.1. Alternative A: Happy Valley In-Line Sediment Basin With Flow Splitter, Downstream Grade Control, & LOMR

The Happy Valley sediment basin and flow split control structure could be accomplished with several configurations. The configuration shown in **Figure 6** was developed due to its simplicity and relatively small overall footprint. This alternative consists of the following:

- Eastern Containment North of Happy Valley Road – A floodwall was assumed for the purposes of this conceptual evaluation, however, the containment could be accomplished with existing floodwall certification, the construction of an earthen levee or new floodwall, or possibly channelization.
- Excavated Sediment Basin – An excavated sediment basin with 40-ac-ft of volume within a 21-acre footprint will be constructed within the Rawhide Wash main channel. A very gradual side slope of 10H:1V is assumed for all slopes to provide a safe and context sensitive aesthetic appearance.
- Overflow Spillway Weirs – Two soil cement spillway weirs will be constructed to outflow from the sediment basin to the Main channel and West Split. The West Split weir crest will be higher in elevation and smaller in width compared to the Main channel spillway weir to mimic the existing split. Soil cement will be made from native material so the color will blend in with the surrounding soils.
- Splitter Dike – A rip-rap protected earthen dike will be constructed to maintain the split downstream of the overflow weirs. The rip-rap could be covered with sacrificial soil and vegetation to provide a safe and context sensitive aesthetic appearance.
- Western Containment Dike – A rip-rap protected earthen dike is assumed for the purpose of conceptual evaluation, however, containment could be accomplished with a floodwall or possibly channelization. This is necessary to route breakout flows to the west from Rawhide Wash to the new facility.
- Drop Structures – Three soil cement protected drop structures will be constructed at the upstream portion of the basin to convey floodwater and sediment safely into the excavated basin. Each drop accommodates approximately 10 vertical feet with a 50-foot step or splash pad to dissipate energy while providing a safe and context sensitive aesthetic appearance.
- Rip-Rap Protected Cut Slopes – The basin cut slopes parallel to the wash will be protected with rip-rap to prevent erosion during the design event. The rip-rap could be covered with sacrificial soil and vegetation to provide a safe and context sensitive aesthetic appearance.
- Low Flow Box Culvert – A reinforced concrete box culvert (RCBC) will be constructed to outflow from the basin under Happy Valley Road to the Main channel. This structure will allow low flows to drain through the basin, provide some small level of sediment transport through the system, and drain the basin after larger flow events. However, the RCBC should be small enough that it becomes either clogged or ineffective during large flood events and for the 100-year design event to successfully retain large sediment loads within the basin. The RCBC will likely fill over time with sediment so it should be large enough to accommodate small equipment for ease of maintenance.
- Floodwall/Levee Retrofit or Replacement - Based on the floodwall certification investigation, it is anticipated that a number of reaches within the Main and West Split channels do not meet the requirements of 44 CFP 65.10 "Mapping of areas protected by levee systems". CFR 65.10 provides the minimum design, operation, and maintenance standards floodwalls and/or levees must meet and continue to meet in order to be recognized as providing protection from the base flood on FIRM maps. Some level of improvement to the floodwalls is required to ensure that walls have sufficient structural integrity to withstand the base flood flows and potential associated scour. The cost of the needed improvements is difficult to estimate. The costs in **Table 2-1** assume full replacement of floodwalls on both the Main channel and West Split. The actual cost is likely to be less expensive than full replacement.
- Downstream Grade Control – Long-term degradation can be expected downstream of the sediment basin due to relatively clear-water discharges once the sediment has been deposited in the basin. The bed slope of the Main channel reach can be expected to decrease over time until the sediment transport capacity is in equilibrium with the reduced sediment supply. This would be considered an adverse impact as a result of the sediment basin and would need to be mitigated. This will require a number of grade control structures to mitigate the potential for undermining existing improvements and limit the required toe-down depth of bank protection for the floodwall/levee system. A few of the limited floodwall construction plans obtained indicated scour protection was constructed to a toe-down depth of 9-feet. Assuming this was consistent for most of the floodwall system, a 9-foot depth was used for the conceptual alternative

for grade control structures. Based on preliminary equilibrium slope analysis, 16 grade control structures will be needed between Happy Valley Road and Pinnacle Peak Road.

- Scottsdale Road to Reach 11 Dike Flood Pool – Improvements west of Scottsdale Road will be necessary to convey flows from the Main channel and West Split channel to its ultimate outfall in the Reach 11 Dike flood pool. For the purposes of this document, the improvements will focus only on the North Scottsdale Channel construction and land acquisition required (see **Figure 5**). This will include the channel necessary to convey the West Split channel flows under Scottsdale Road, under Pinnacle Peak Road, and to its confluence with the planned extension of the Main channel referred to as the East Channel for Paradise Ridge.

- Conditional Letter of Map Revision (CLOMR/LOMR) – A CLOMR will be prepared and submitted to FEMA in advance of construction of the improvements as part of the process to remap the effective Zone AO floodplain downstream of the Rawhide apex to a Zone AE floodplain based on the proposed improvements. Following construction, a LOMR would be prepared and submitted to FEMA to officially remap the effective floodplain.

A conceptual cost estimate for this alternative was prepared and is summarized in **Table 2-1**. Land acquisition, operations and maintenance (O&M), and design cost estimates are also included. See **APPENDIX A** for a more detailed cost estimate breakdown.

Table 2-1. Alternative A Cost Estimate

Description	Cost
Floodwall/Levee CFR 65.10 Certification Investigation	$400,000
Design	$2,900,000
CLOMR/LOMR	$200,000
Land Acquisition	$1,800,000
Sediment Basin with Flow Split and associated improvements	$9,400,000
Downstream Grade Control	$3,800,000
Los Portones Drive Improvements	$200,000
Floodwall/Levee Full Replacement	$10,300,000
North Scottsdale Channel	$11,700,000
Operation and Maintenance (50-Year Cost)	$5,400,000
TOTAL	**$46,100,000**

Wall/Levee Analysis

- Floodwall/Levee CFR 65.10 Certification Investigation – Analysis of the existing floodwalls is needed to ensure that the walls will withstand the full Rawhide apex flows. There are a number of walls acting as flood walls along the Main channel and West Split channel that could be investigated/evaluated in accordance with the CFR 65.10 requirements for FEMA certification. Certification would allow the FEMA floodplain to be constrained within the channel corridors. The floodwall/levee investigation would consist of measuring the elevation, horizontal location, and dimensions of the existing constructed features of the wall systems. Destructive testing of existing walls would be required to identify the size and spacing of steel reinforcement of the walls and supporting footers/cut-off walls. Excavation of existing toe/bank-protection would be required to measure the elevation, horizontal location, dimension, and material in place. Recommendations would be made to retrofit or replace existing walls, levees, and/or associated toe-protection from scour. This effort is estimated to cost approximately $400,000.

Design Considerations

- Events in excess of 100-year design – The facility should be evaluated for flood events exceeding the 100-year design event with the goal of reducing the potential for adverse impacts as a result of constructing the facility.

- Low flow 'notch' over drop structures – Constructing a low flow 'notch' over the drop structures could create a more natural appearance to the facility. The notch would consist of small depressed section over the crest of each drop and an inset channel within the sloped surface of each drop.

- Low flow 'notch' in overflow weir – An alternative to the Low Flow Box Culvert would be to 'notch' the overflow weir to allow low flows to exit the basin. The notch would have to be well armored to prevent failure of the sediment basin. This low flow notch alternative would have to be analyzed carefully to ensure its function and effectiveness at trapping sediment during large events. The need for grade control on the West Split channel is not anticipated given that the current natural split only occurs for events in excess of the 10-year flood because frequent flood events are the primary mechanism of long-term degradation.

- Future improvements to Happy Valley Road – There may be opportunities to integrate improvements to Happy Valley Road into the sediment basin. For example, Happy Valley Road could be re-aligned toward the southern edge of the basin and bridge or culvert structures could be built under the road to function as the flow split control.

- Jomax containment - All of the alternatives including the Happy Valley basin alternative should be designed to account for a likely future tributary containment feature north of Jomax Road. It is very likely that during the development of the State Trust Land parcels north of Jomax Road on either side of Pima Road, that this tributary will be contained and conveyed to Rawhide Wash. There are two primary splits, one upstream and east of Pima Road, and one downstream and west of Pima Road (refer to **APPENDIX E, Figure E.2**). Currently, most of the breakout flow from the split upstream of Pima Road flows south and does not re-enter the Rawhide Wash main channel. This improvement is not included in the costs shown in **Table 2-1**.

- Los Portones Drive improvements – Some level of improvement to Los Portones Drive would be recommended to prevent breakout flow for infrequent events. More than 30 structures are impacted by the breakout flows. Improvements could range from lowering the road profile to removing the road entirely thus increasing the hydraulic capacity of the Main channel. Enhanced hydraulic capacity would also improve sediment transport continuity through this reach.

One of the most significant disadvantages of this alternative includes the need for grade control downstream of the sediment basin in the Main channel to protect existing infrastructure from long-term degradation. The construction cost and impacted area for each grade control structure will be significant.

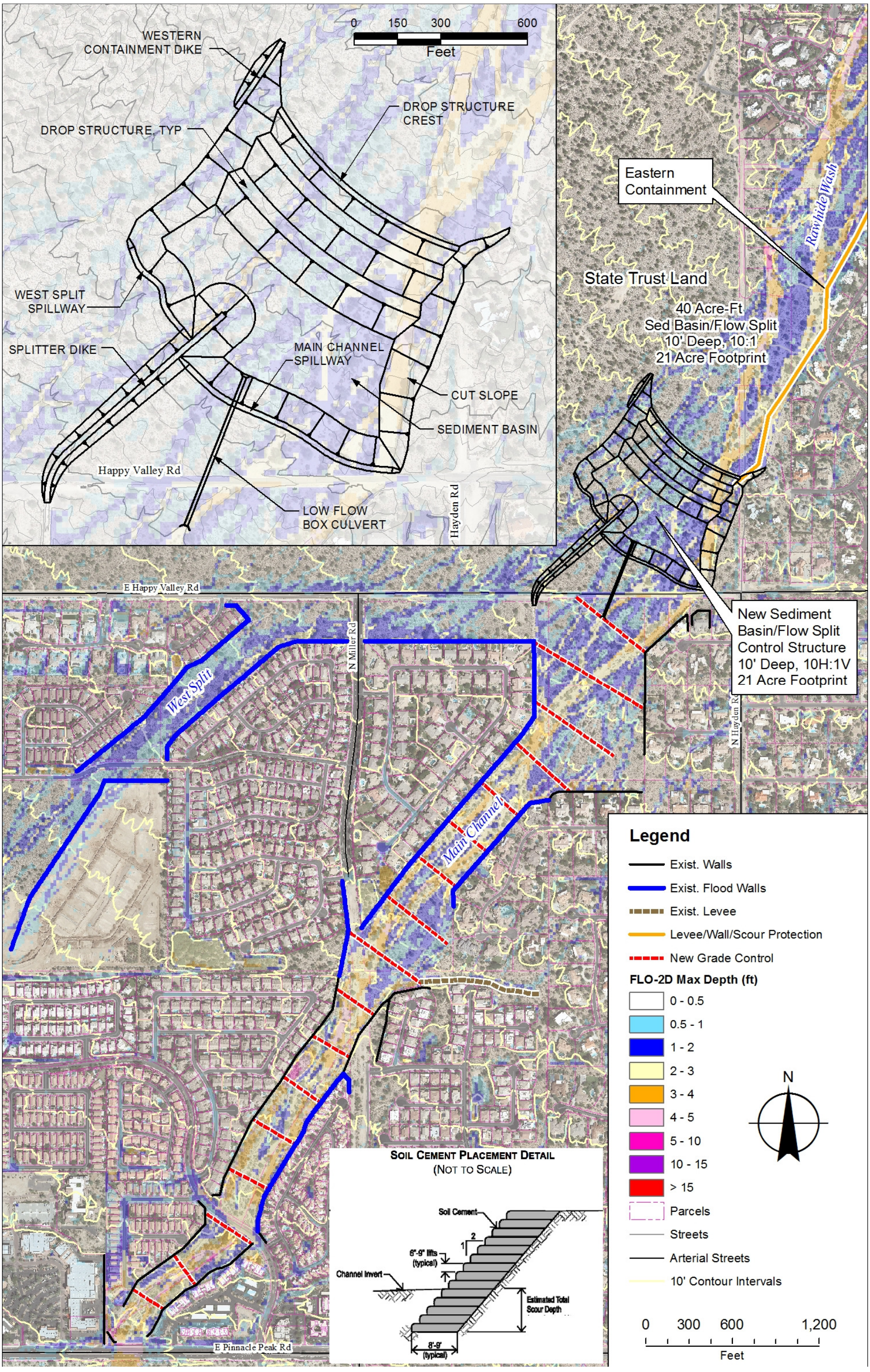


Figure 6. Alternative A – Happy Valley Sediment Basin With Flow Split Structure

2.2.2. Alternative B: Happy Valley In-Line Sediment Basin, Main Channel Only, Downstream Grade Control, & LOMR

Several sediment basin configurations would accomplish the design purpose for this alternative of containing the West Split flows to the Main channel upstream of Happy Valley Road. The configuration shown in **Figure 7** was developed due to its simplicity and its relatively small overall footprint. This alternative consists of the following:

- Eastern Containment North of Happy Valley Road – Same as Alternative A.
- Excavated Sediment Basin – Same as Alternative A.
- Overflow Spillway Weir – Similar to Alternative A but with only one soil cement overflow spillway weir.
- Containment Dike – A rip-rap protected earthen dike will be constructed to contain flows from the West Split to the Main channel. The rip-rap could be covered with sacrificial soil and vegetation to provide a safe and context sensitive aesthetic appearance.
- Western Containment Dike – Same as Alternative A.
- Drop Structures – Same as Alternative A.
- Rip-Rap Protected Cut Slopes – Same as Alternative A.
- Low Flow Box Culvert – Same as Alternative A.
- Downstream Grade Control – Same as Alternative A.
- Scottsdale Road to Reach 11 Dike Flood Pool – Since the West Split channel will not receive flows from Rawhide Wash, the new crossing at Scottsdale Road and the North Scottsdale Channel is not necessary (see **Figure 5**).
- Conditional Letter of Map Revision (CLOMR/LOMR) – Same as Alternative A.
- Containing the West Split flows to the Main channel could be an adverse impact if not mitigated. If properties were flooded along the Main channel as a result of a flood in excess of the 10-year flood, a portion of the flooding could be attributable to the West Split flow diversion. Therefore, the Floodwall/Levee CFR 65.10 Certification Investigation would be recommended as discussed under Regulatory Issues for Alternative A.
- If the Floodwall/Levee Certification Investigation is performed, existing walls with insufficient freeboard, structural integrity, or scour protection and that do not meet the requirements of CFR 65.10 would be recommended for retrofit or replacement. As stated previously, the cost of the needed improvements is difficult to estimate. The costs in **Table 2-2** assume full replacement of floodwalls on both the Main channel. The actual cost is likely to be less expensive than full replacement.

A conceptual cost estimate for this alternative was prepared and is shown in **Table 2-2**. Land acquisition, operations and maintenance (O&M), and design cost estimates are also included.

Table 2-2. Alternative B Cost Estimate

Description	Cost
Floodwall/Levee CFR 65.10 Certification Investigation	$400,000
Design	$1,400,000
CLOMR/LOMR	$200,000
Land Acquisition	$1,600,000
Sediment Basin/Diversion and associated improvements	$8,100,000
Downstream Grade Control	$3,800,000
Los Portones Drive improvements	$200,000
Floodwall/Levee Retrofit or Replacement	$7,100,000
Operation and Maintenance (50-Year Cost)	$4,600,000
TOTAL	**$27,400,000**

Design Considerations

- Consider events in excess of 100-year design – Same as Alternative A.
- Low flow 'notch' over drop structures – Same as Alternative A.
- Low flow 'notch' in overflow weir – Same as Alternative A.
- Future improvements to Happy Valley Road – Same as Alternative A.
- Jomax containment – Same as Alternative A.
- Los Portones Drive improvements – Same as Alternative A.

As with Alternative A, one of the most significant disadvantages of this alternative includes the need for grade control in the Main channel downstream of the sediment basin to protect existing infrastructure from long-term degradation.

Furthermore, all improvement within and adjacent to the Main channel would be more significant (and costly) than Alternative A given the higher design flow rate.

One significant advantage of this alternative is the elimination of the need for redundant drainage infrastructure within Paradise Ridge to accommodate potential avulsion flows down the West Split.

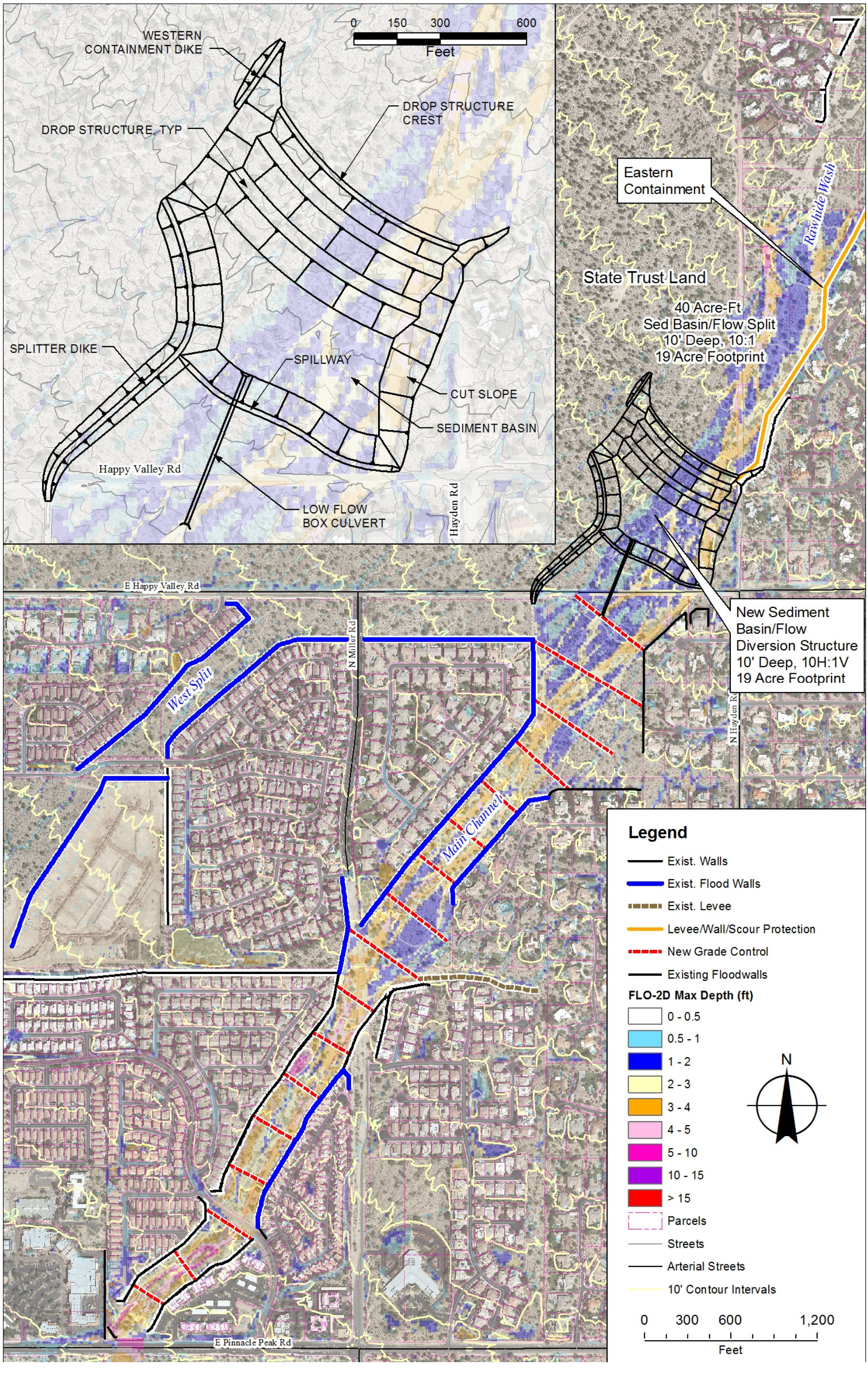


Figure 7. Alternative B – Happy Valley Sediment Basin, Main channel Only

2.2.3. Alternative C: Happy Valley Flow Splitter with Sediment Conveyance in Main Channel and LOMR

Maintaining the current flow split at the Rawhide Wash apex with an engineered structure, but not capturing sediment in a basin, would eliminate the adverse impact of stream degradation downstream of the structure. The configuration shown in **Figure 8** was developed based on the Beardsley Channel flow split structure constructed within the City of Scottsdale. This concept was chosen due to its simplicity and its relatively small overall footprint, although other structural solutions should be evaluated.

An engineered flow split structure may not adequately mitigate flow path uncertainty due to a potential avulsion downstream of the structure. Therefore, this alternative would require detailed analysis of the sediment transport capacity downstream to adequately demonstrate and ensure the system would function as intended. A rudimentary planning-level sediment transport analysis was conducted to determine if there was a fatal flaw with this alternative. The results indicate that the sediment transport capacity down the Main channel can sufficiently convey the sediment load from upstream without significant aggradation and/or an avulsion if certain measures are taken. A relatively small reach of the channel would need to be contained downstream of Happy Valley Road to maintain sediment continuity. The results of this analysis are documented in a separate technical memorandum (JEF, 2014d) which is provided in **APPENDIX B**. This alternative consists of the following:

- Eastern Containment North of Happy Valley Rd – Same as Alternatives A and B.
- Flow Split Structure – The flow split structure could take several forms. A concrete cutoff wall and containment dike is assumed for planning purposes. The concrete cutoff wall could be designed and constructed to maintain the breakout flows to the West Split as shown in **Figure 8.** The cutoff wall would then be transitioned to a rip-rap protected earthen dike to contain the split downstream to the northeast corner of Pinnacle Reserve East. The rip-rap could be covered with sacrificial soil and vegetation to provide a safe and context sensitive aesthetic appearance.
- Sediment Transport Analysis – A detailed sediment transport analysis is needed to model a range of scenarios and input parameters to ensure the sediment pass-through system will perform as designed. Several sediment samples would be needed to adequately model the system.
- Downstream Containment for Sediment Transport – An additional levee or floodwall may be required to prevent aggradation approximately 300-feet downstream of Happy Valley Road (see **Figure 8**). A floodwall was assumed for the purposes of this conceptual evaluation; however, the containment could be accomplished with the construction of an earthen levee or possibly channelization.
- Floodwall/Levee CFR 65.10 Certification Investigation - Same as Alternative A.
- Floodwall/Levee Retrofit or Replacement - Same as Alternative A.
- Scottsdale Road to Reach 11 Dike Flood Pool – Same as Alternative A.
- Conditional Letter of Map Revision (CLOMR/LOMR) – Same as Alternatives A and B.

A conceptual cost estimate for this alternative was prepared and is shown in **Table 2-3**. Land acquisition, operations and maintenance (O&M), and design cost estimates are also included.

Table 2-3. Alternative C Cost Estimate

Description	Cost
Floodwall/Levee CFR 65.10 Certification Investigation	$400,000
Sediment Transport Analysis	$300,000
Design	$2,300,000
CLOMR/LOMR	$200,000
Land Acquisition	$1,000,000
Flow Split Structure and associated improvements	$5,700,000
Los Portones Drive improvements	$200,000
North Scottsdale Channel	$11,700,000
Floodwall/Levee Retrofit or Replacement	$10,300,000
Operation and Maintenance (50-Year Cost)	$600,000
TOTAL	**$32,700,000**

Design Considerations

- Consider events in excess of 100-year design – Same as Alternatives A and B.
- Low flow 'notch' over drop structures – Same as Alternatives A and B.
- Future improvements to Happy Valley Road – Same as Alternatives A and B.
- Jomax containment – Same as Alternatives A and B.
- Los Portones Drive improvements – Same as Alternative A.

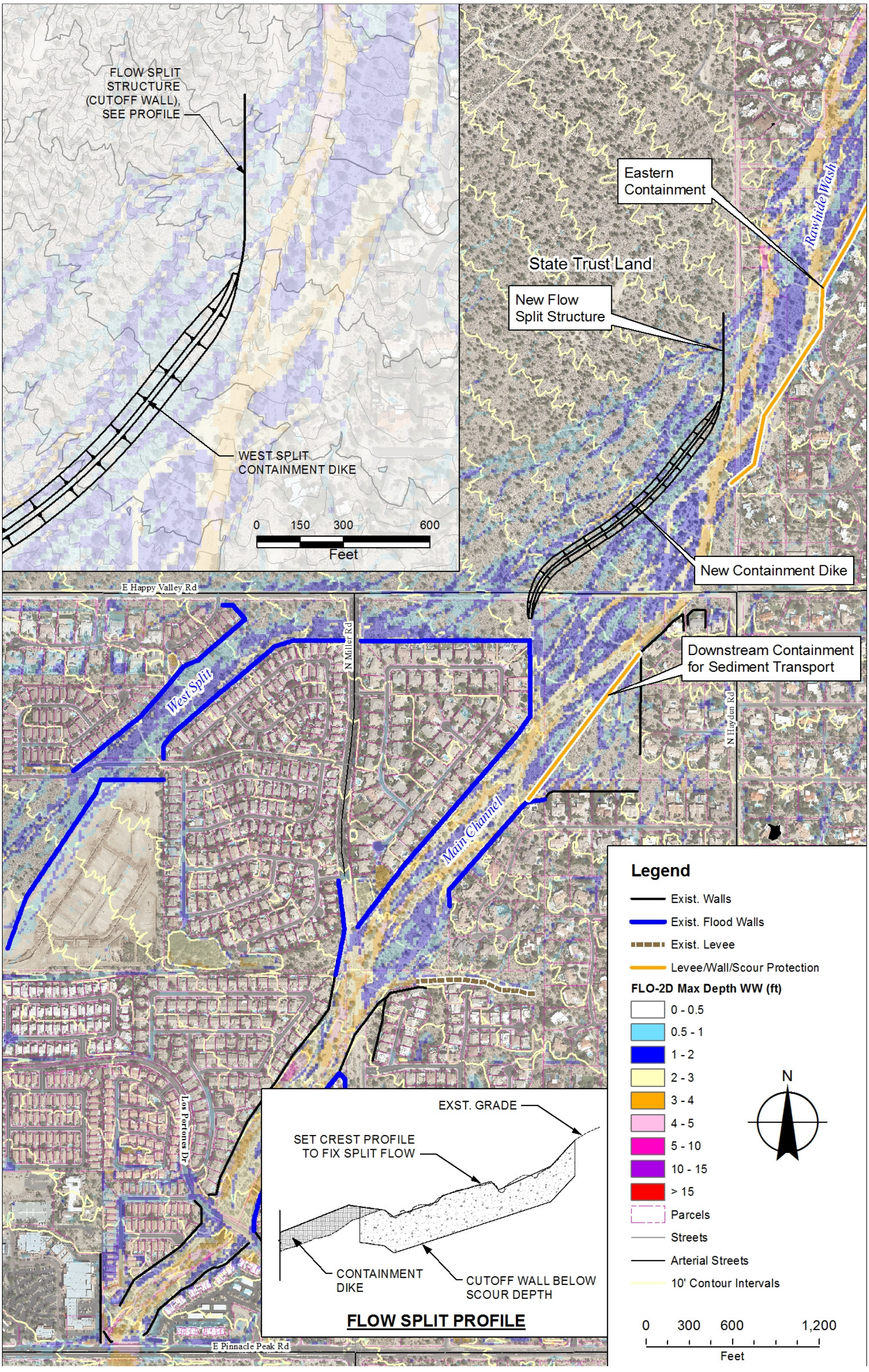


Figure 8. Alternative C – Happy Valley Flow Split with Sediment Conveyance

2.2.4. Alternative D: Main Channel Only with Sediment Conveyance in the Main Channel and LOMR

This alternative is similar to Alternative B in that flow is contained in the Main Channel only and similar to Alternative C in that no sediment basin will be constructed near the apex as shown in **Figure 9**. Similar to Alternative C, this alternative would require detailed analysis of the sediment transport capacity of the Main channel. This alternative consists of the following:

- Eastern Containment North of Happy Valley Rd – Same as Alternatives A, B, and C.
- West Split Containment Dike – The dike could be a rip-rap protected earthen dike to contain the split downstream to the northeast corner of Pinnacle Reserve East. The rip-rap could be covered with sacrificial soil and vegetation to provide a safe and context sensitive aesthetic appearance.
- Sediment Transport Analysis – Same as Alternative C.
- Downstream Containment for Sediment Transport – Same as Alternative C.
- Floodwall/Levee CFR 65.10 Certification Investigation - Same as Alternative B.
- Floodwall/Levee Retrofit or Replacement - Same as Alternative B.
- Scottsdale Road to Reach 11 Dike Flood Pool – Same as Alternative B.
- Conditional Letter of Map Revision (CLOMR/LOMR) – Same as Alternatives A, B, and C.

Pending the results of further sediment transport analysis and modeling, this alternative may also include some provision for grade control, scour protection, and/or extra channel modification (e.g., sediment transport capacity-driven adjustments to the Los Portones Drive roadway crossing).

A conceptual cost estimate for this alternative was prepared and is shown in **Table 2-4**. Land acquisition, operations and maintenance (O&M), and design cost estimates are also included.

Table 2-4. Alternative D Cost Estimate

Description	Cost
Floodwall/Levee CFR 65.10 Certification Investigation	$400,000
Sediment Transport Analysis	$300,000
Design	$1,000,000
CLOMR/LOMR	$200,000
Land Acquisition	$500,000
West Split Containment to the Main Channel only and associated improvements	$5,700,000
Los Portones Drive improvements	$200,000
Floodwall/Levee Retrofit or Replacement	$7,100,000
Operation and Maintenance (50-Year Cost)	$600,000
TOTAL	**$16,000,000**

Design Considerations

- Consider events in excess of 100-year design – Same as Alternatives A and B.
- Future improvements to Happy Valley Road – Same as Alternatives A, B and C.
- Jomax containment – Same as Alternatives A, B, and C.
- Los Portones Drive improvements – Same as Alternative A. May require additional enhancement to perform satisfactorily for sediment pass-through required for Alternative D.

2.2.5. Remnant Hazards for Build Alternatives

Stabilization of the Rawhide Wash alluvial fan apex will remove the active alluvial fan designation from the remaining floodplains downstream. However, other flood hazards within the existing Zone AO floodplain area are due to runoff from within localized areas as well as from the watersheds emanating from the Pinnacle Peak South ADMS area to the east. Any of the Build alternatives are estimated to reduce computed future flood damages by about $25 million, or 60 percent of the total flood damages on the Rawhide Wash alluvial fan. See **APPENDIX D** for further discussion.

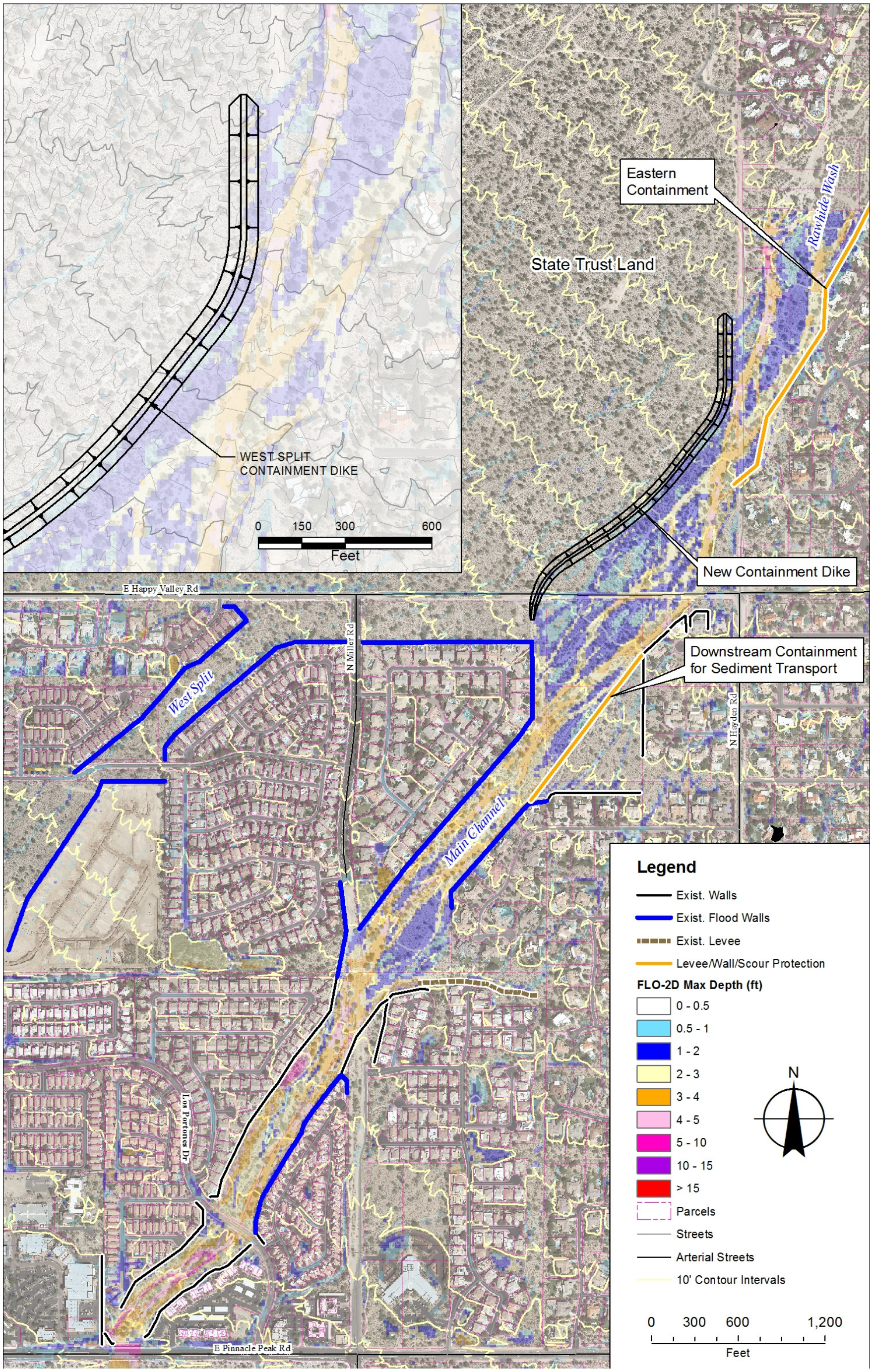


Figure 9. Alternative D – Main channel Only with Sediment Conveyance

2.3. No Build Alternative

The No Build Alternative for Rawhide Wash would consist of re-delineation of the current Zone AO floodplain. The flood damage potential would remain unmitigated. Redelineation may be feasible based upon updated hydrology, new topography, and significant changes to the watershed and floodplain environment due to development. Uncertainty associated with the active alluvial fan would be evaluated through a series of FLO-2D models to simulate the range of potential avulsions downstream of the fan apex. Potential flow path uncertainty scenarios are simulated in the models to block and direct full apex discharges in various directions downstream on the alluvial fan landform to assess impacts to the flood hazards and floodplain.

The expected outcome would be a reduction in the extents of the FEMA 100-year floodplain and the number of homes within the floodplain. This should also allow for a better tool for floodplain management within the area going forward because of a better depiction of the potential flood hazards on the Rawhide Wash alluvial fan as compared to the current regulatory floodplain. See **Appendix D** for further discussion and detail.

Costs associated with the No Build alternative would include the LOMR study. The existing flood hazard and the revised floodplain have a cost to existing residents and future developments. These costs include flood insurance premiums to existing and future property owners, fill to elevate building pads for future development, elevation certificates prepared by registered land surveyors, and the flood-related risk to existing development. All future buildings are assumed to be adequately protected from future flood damages. Flood damages for existing structures are assumed to continue.

Benefits are not entirely certain before completing the LOMR. However, preliminary analyses of potential flow path uncertainty scenarios (see **Appendix D**) suggest that the new floodplain would remove a significant number of existing property owners from being required by their lender to buy flood insurance. In particular, the eastern and distal portions of the floodplain extents are expected to be significantly less extensive based on the preliminary modeling already completed (**Figure 10** and **Table 2-5**). In addition, costs associated with future construction may also be reduced due to a more accurate depiction of the flood hazard. However, the No Build alternative would not reduce the need to provide duplicate design for areas potentially affected by avulsion. For example, drainage infrastructure along both the Main Channel and the West Split would both need to accommodate large discharges.

There are 3,939 parcels with structures within the Rawhide Zone AO floodplain downstream of Happy Valley Road. Of these, 2,716 of these properties (69%) have flood insurance policies with an average annual premium of $522. Furthermore, there are approximately 3,355 acres of developable land within the area as shown in **Figure 10** and **Table 2-6**. Using information provided by ASLD, it is assumed that approximately one half of this area (~1,675 acres) would be planned for residential development with an average density of 4 dwelling units per acre or 6,700 new residential structures of which about 5,900 would remain in a floodplain area. The assumed build-out time period is 25 years. In a 50-year design life cycle, the cost for annual premiums would include 37.5 years = 25 + (50 years – 25 years)/2. It is assumed that 69% of future residents would pay flood insurance similar to today's existing property owners. Over a 50-year project life with an average annual flood insurance premium of $522/year for existing and future buildings remaining within the floodplain, this translates into almost $60 million in flood insurance premium savings over the No Action alternative.

For planning purposes, the cost to elevate building pads was based on a $10/cubic yard cost, and assuming 2-feet of fill and a 3,000 square foot average building pad resulting in 222 cubic yards per pad. It is assumed that 69% of future properties would pay flood insurance and would likely obtain an elevation certificate which is also summarized. The cost of an elevation certificate is estimated at $750 per lot according to City of Scottsdale personnel.

Table 2-6 summarizes the costs associated with the No Build alternative.

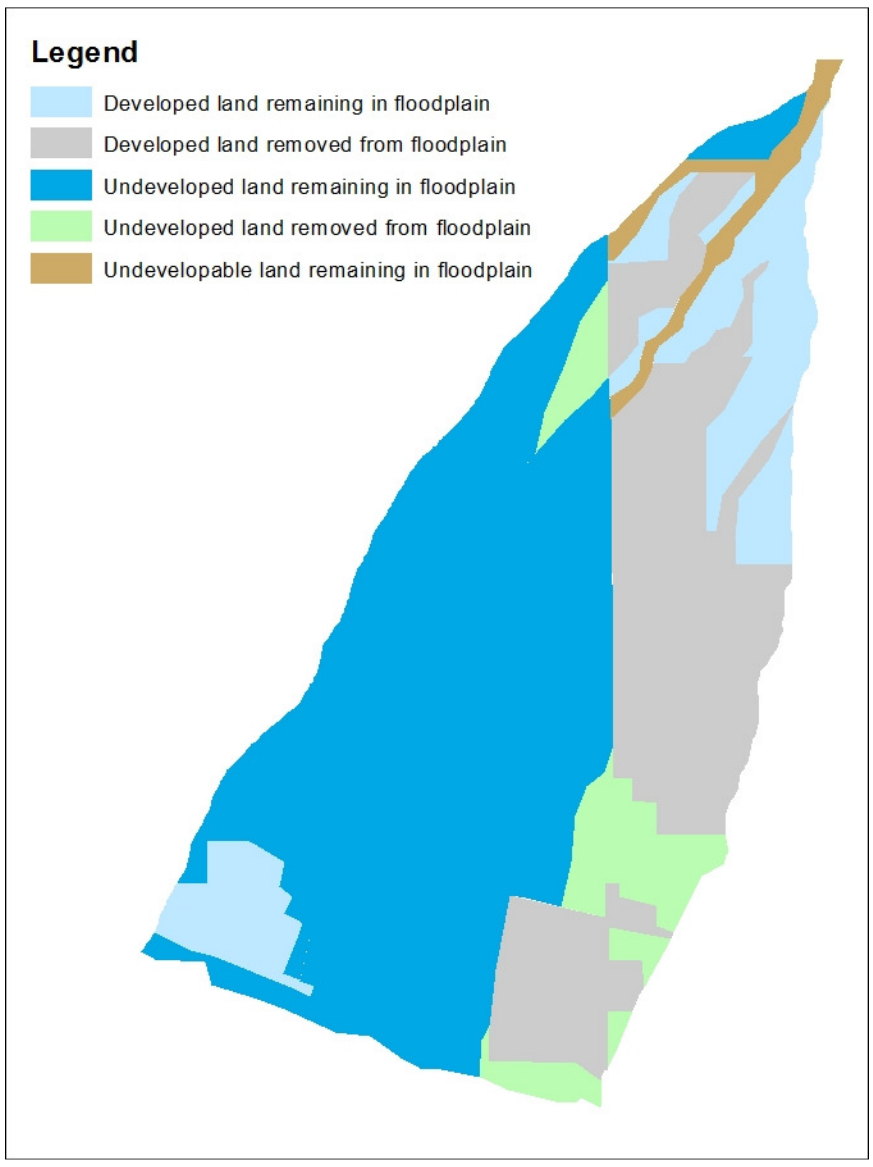


Figure 10. Developable Land within Rawhide Wash FEMA Zone AO Floodplain

Table 2-5. Summary of No Build Acreage

Description	Acres
Developed land remaining in floodplain	748
Developed land removed from floodplain	1498
Undeveloped land remaining in floodplain	2946
Undeveloped land removed from floodplain	409
Undevelopable land remaining in floodplain	153
Total Acreage	5753

Table 2-6. No Build Alternative Cost Estimate

Description	Count/Cost
Existing buildings left in floodplain (748ac/2246ac = 33% of the No Action Alternative)	1,300
Future buildings left in floodplain (half of developable land remaining in floodplain @ 4 DU/ac)	5,892
50 years of Future Flood Damages	$44,500,000
LOMR	$300,000
Fill cost for future buildings (222 CY/lot at $10/CY)	$13,000,000
Elevation certificate cost for future buildings (69% @ $750/lot)	$3,000,000
Existing flood insurance premiums (69% of existing buildings remaining in floodplain @ $522/year for 50-years)	$23,400,000
Future flood insurance premiums (69% of future buildings in floodplain @ $522/year for 37.5 years)	$80,000,000
TOTAL	**$164,000,000**

2.4. No Action Alternative

The No Action Alternative is not a no-cost alternative. The existing flood hazard and the effective Zone AO floodplain have a cost to existing residents and future developments. These costs include flood insurance premiums to existing and future property owners, fill to elevate building pads for future development, elevation certificates prepared by registered land surveyors, and the flood related risk to existing and future development.

There are 3,939 parcels with structures within the Rawhide Zone AO floodplain downstream of Happy Valley Road and approximately 3,355 acres of developable land within the same area as shown in **Figure 10**. It is assumed that 69% of existing and future residents would pay flood insurance similar to today's existing property owners. The costs for flood insurance premiums for existing and future property owners is summarized in **Table 2-7**.

For planning purposes, the cost to elevate building pads was based on a $10/cubic yard cost, and assuming 2-feet of fill and a 3,000 square foot average building pad resulting in 222 cubic yards per pad. It is assumed that 69% of future properties would pay flood insurance and would likely obtain an elevation certificate which is also summarized **in Table 2-7**.

It is assumed that all future development will be built resilient to flooding and that only the existing structures susceptible to flooding show in **Table 1-2** would be damaged over the next 50 years.

Table 2-7. No Action Alternative Cost Estimate

Description	Count/Cost
Existing buildings	3,939
Future buildings (half of developable 3355 ac @ 4 DU/Acre)	6,700
50 years of future flood damages	$44,500,000
Fill cost for future buildings (222 CY/lot at $10/CY)	$15,000,000
Elevation certificate cost for future buildings (69%@$750/lot)	$3,500,000
Existing flood insurance premiums (69%, $522/yr, 50-years)	$71,000,000
Future flood insurance premiums (69%, $522/yr, 37.5-years)	$90,000,000
TOTAL	**$224,000,000**

As seen in **Table 2-7**, the No Action alternative is more expensive than Build alternatives A through D and the No Build alternative. Neither the No Build nor the No Action alternatives address the true flood hazard associated with Rawhide Wash.

3. PEER REVIEW WORKSHOP

Following completion of the draft of this report, the District assembled a peer review/value engineering team to evaluate the alternatives developed for Rawhide Wash. A detailed summary of the workshop and its results is presented in **APPENDIX F**. The complete report is also provided electronically in **APPENDIX G**.

The key findings of the peer review team were:

- Clear advantages of the Main Channel alternatives
- Need for additional flood wall investigation
- Need for additional detailed sediment transport modeling
- Potential reconsideration of offline basin options to reduce downstream flow rates and future infrastructure costs
- Concern about FEMA acceptance of sediment pass-through concept.

These findings will be used in formulating the next steps in the alternatives refinement leading to selection of the preferred alternative.

4. SUMMARY & CONCLUSIONS

Alternative flood control measures to mitigate flood hazards within the Rawhide Wash alluvial fan floodplain were investigated and evaluated. Cost estimates were also developed. Four structural Build alternatives were evaluated as well as the No Build and No Action alternatives.

The components, advantages, disadvantages, and costs for each alternative area summarized in **Table 4-1**. Costs are also presented and categorized as follows:

- **Flood Mitigation Costs**. Costs associated with constructing flood hazard mitigation structures for the Build alternatives (CIP) and operation and maintenance costs (O&M).
- **Property Owner Costs**. Costs to individuals and property owners. These include flood insurance premiums and flood damages.
- **Future Development Costs**. Costs associated with future development (e.g., Paradise Ridge).

As can be seen from examination of the estimated costs, a Build alternative option makes economic sense to reduce flood hazards on the Rawhide Wash alluvial fan. Of the Build alternatives, Alternative D is the least expensive and most attractive choice. However, selection of Alternative D will require additional sediment transport analysis and coordination with FEMA to confirm its adequacy to revise the Zone AO floodplain.

Actual floodwall retrofit/replacement costs are expected to be less than the totals shown in **Table 4-1** because the tabulated costs are based on full replacement, thereby likely decreasing the actual total costs of all the Build alternatives. As noted by the Peer Review Team, further investigation of the flood walls will help clarify the costs, advantages, and disadvantages of each alternative.

Containment of the total runoff from Rawhide Wash to the Main channel has cost advantages and only slight disadvantages. It is possible that floodwall retrofit costs for the Main channel alternatives could prove somewhat more expensive for Alternatives B and D as compared to Alternatives A and C. However, the additional costs of retrofitting floodwalls on the West Split are likely to exceed the differential costs for the Main Channel. Further sediment transport modeling is recommended to confirm the adequacy of the sediment pass through alternatives (B & D) and help quantify scour protection requirements and grade control spacing for all alternatives.

All of the costs presented here are considered preliminary and are expected to change pending the findings of the additional studies suggested. However, the relative costs are considered a good metric to evaluate the preferred path forward to revise the Zone AO floodplain and reduce future flood hazards on the Rawhide Wash alluvial fan. Additional sediment transport modeling and flood wall investigations will help better evaluate alternatives before selection of a preferred concept.

Table 4-1. Rawhide Wash Alternatives Summary

ALTERNATIVE ID	BUILD				NO BUILD	NO ACTION
	A	B	C	D		
Description	**Happy Valley In-Line Sediment Basin With Flow Splitter**	**Happy Valley In-Line Sediment Basin, Main Channel Only**	**Happy Valley Flow Splitter, Main Channel Sediment Conveyance**	**Main Channel Only with Sediment Conveyance**	**Re-delineate Effective Zone AO Floodplain**	**Regulate to Effective Zone AO Floodplain**
Components	Sediment Basin Eastern Containment Floodwall/Levee Western Containment Dike Splitter Dike Downstream Grade Control Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit North Scottsdale Channel CLOMR/LOMR	Sediment Basin Eastern Containment Floodwall/Levee Western Containment Dike West Split Containment Dike Downstream Grade Control Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit CLOMR/LOMR	Eastern Containment Floodwall/Levee Flow Split Cutoff Wall West Split Containment Dike Sediment Transport Analysis Downstream Sediment Containment Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit North Scottsdale Channel CLOMR/LOMR	Eastern Containment Floodwall/Levee West Split Containment Dike Sediment Transport Analysis Downstream Sediment Containment Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit CLOMR/LOMR	LOMR Fill Required for New Development Elev. Cert.s for New Development Existing Flood Insurance Premiums Future Flood Insurance Premiums Flood Damage Exposure	Fill Required for New Development Elev. Cert.s for New Development Existing Flood Insurance Premiums Future Flood Insurance Premiums Flood Damage Exposure
Advantages	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents No need for North Scottsdale Channel	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents No need for North Scottsdale Channel	Reduce FEMA Floodplain Extents	
Disadvantages	Requirement for grade control	Requirement for grade control Likely disruptive Floodwall Retrofit		Likely disruptive Floodwall Retrofit	Flood hazard left un-mitigated Flood Insurance Burden	Flood hazard left un-mitigated Flood Insurance Burden
Implementation	DCR, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Sediment Transport Analysis, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Sediment Transport Analysis, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	LOMR, regulate to new floodplain, majority of existing and future development would still need flood insurance	Regulate to effective floodplain Existing and future development still need flood insurance
50-Year Cost	**$46,100,000**	**$27,400,000**	**$32,700,000**	**$16,000,000**	**$164,000,000**	**$224,000,000**
Implementation Costs	**$46,100,000**	**$27,400,000**	**$32,700,000**	**$16,000,000**	**$300,000[3]**	**$0**
Property Owner Costs	**$0**	**$0**	**$0**	**$0**	**$68,000,000**	**$115,000,000**
Future Development Costs	**$21,000,000[1]**	**$9,000,000[2]**	**$21,000,000**	**$9,000,000**	**$96,000,000**	**$109,000,000**
Existing Structures Removed from Floodplain	**3400**	**3400**	**3400**	**3400**	**3200**	**0**
Existing Developed Acres Removed from Floodplain	**2036**	**2246**	**2036**	**2246**	**1498**	**0**
Future Developable Acres Removed from Floodplain	**620**	**1651**	**620**	**1651**	**409**	**0**

Notes: [1]Estimated Paradise Ridge drainage infrastructure costs. [2]Paradise Ridge drainage infrastructure costs minus N. Scottsdale channel. [3]LOMR cost.

5. REFERENCES

CH2M Hill, 1995, Rawhide Wash Detention Basin Feasibility Study Final Report, March 1995

FEMA, 2003, Guidelines and Specifications for Flood Hazard Mapping Partners – Appendix G: Guidance for Alluvial Fan Flooding Analysis and Mapping, April 2003

HDR, 1999, Final Drainage Report for the Rawhide Detention Basin, (Phase I) Basin Alternatives Analysis, May 1999

JEF, 2012, Memorandum: Pinnacle Peak West ADMS Task 6.1 – Alluvial Fan Landform Verification, prepared by JE Fuller for FCDMC, June 5, 2012

JEF, 2014a, Memorandum: Pinnacle Peak West ADMS Work Assignment No. 3, Task 8.2.1, Floodwall investigation summary memo, prepared by JE Fuller for FCDMC, June 3, 2014

JEF, 2014b, Pinnacle Peak West Area Drainage Master Study PCN 122.01.20 FCD 2011C024 WA #3 Hydrology & Hydraulics Technical Support Data Notebook – DRAFT, prepared by JE Fuller for FCDMC, August 2014

JEF, 2014c, Pinnacle Peak West ADMS Work Assignment No. 3 Task 12.0 Flood Hazard Classification and Task 13.0 Flood Risk Determination, prepared by JE Fuller for FCDMC, September 26, 2014

JEF, 2014d, Memorandum: Pinnacle Peak West ADMS Work Assignment No. 3 Task 15.2, Rawhide Wash Sediment Transport Modeling & Analysis, prepared by JE Fuller for FCDMC, November 25, 2014

LSD, 2013, Application of the Context Sensitive Flood Hazard Mitigation Planning and Design Approach Pinnacle Peak West Area Drainage Master Study, report prepared by Logan Simpson Design, Inc, for FCDMC, December 12, 2013

Olsson Associates, 2010, Paradise Ridge Conceptual Drainage Plan Update, July 15, 2010

USBR, 1988, ACER Technical Memorandum No. 11 Downstream Hazard Classification Guidelines, United States Bureau of Reclamation

COST ESTIMATES

Alternative ID	BUILD				NO BUILD	NO ACTION
	A	B	C	D		
Description	**Happy Valley In-Line Sediment Basin/Flow Splitter**	**Happy Valley In-Line Sediment Basin, Main Channel Only**	**Happy Valley Flow Splitter, Main Channel Sediment Conveyance**	**Main Channel Only with Sediment Conveyance**	**Re-delineate Effective Zone AO Floodplain**	**Regulate to Effective Zone AO Floodplain**
Components	Sediment Basin Eastern Containment Floodwall/Levee Western Containment Dike Splitter Dike Downstream Grade Control Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit North Scottsdale Channel CLOMR/LOMR	Sediment Basin Eastern Containment Floodwall/Levee Western Containment Dike West Split Containment Dike Downstream Grade Control Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit CLOMR/LOMR	Eastern Containment Floodwall/Levee Flow Split Cutoff Wall West Split Containment Dike Sediment Transport Analysis Downstream Sediment Containment Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit North Scottsdale Channel CLOMR/LOMR	Eastern Containment Floodwall/Levee West Split Containment Dike Sediment Transport Analysis Downstream Sediment Containment Los Portones Drive Improvements Floodwall/Levee Investigation Floodwall/Levee Retrofit CLOMR/LOMR	LOMR Fill Required for New Development Elev. Certificates for New Development Existing Flood Insurance Premiums Future Flood Insurance Premiums Flood Damage Exposure	Fill Required for New Development Elev. Certificates for New Development Existing Flood Insurance Premiums Future Flood Insurance Premiums Flood Damage Exposure
Advantages	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents No need for North Scottsdale Channel	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents	Removes Flow Path Uncertainty Reduce FEMA Floodplain Extents No need for North Scottsdale Channel	Reduce FEMA Floodplain Extents	
Disadvantages	Requirement for grade control	Requirement for grade control Likely disruptive Floodwall Retrofit		Likely disruptive Floodwall Retrofit	Flood hazard left un-mitigated Flood Insurance Burden	Flood hazard left un-mitigated Flood Insurance Burden
Implementation	DCR, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Sediment Transport Analysis, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	DCR, Sediment Transport Analysis, Floodwall/Levee Investigation, Design, CLOMR, Construction, Wall Certification, LOMR	LOMR, regulate to new floodplain, majority of existing and future development would still need flood insurance	Regulate to effective floodplain Existing and future development still need flood insurance
65.10 Cert.	$400,000	$400,000	$400,000	$400,000	LOMR - $300,000	
Sed. Transport	$-	$-	$300,000	$300,000	Future Fill - $13 M	Future Fill - $15 M
Design	$2,900,000	$1,400,000	$2,300,000	$1,000,000	Future Elev Cert - $3 M	Future Elev Cert - $3.5 M
C/LOMR	$200,000	$200,000	$200,000	$200,000		
Land Acquisition	$1,800,000	$1,600,000	$1,000,000	$500,000	Future Flood Damage - $44.5 M	Future Flood Damage - $44.5 M
Sed Basin/Splitter	$9,400,000	$8,100,000	$5,700,000	$5,700,000		
Grade Control	$3,800,000	$3,800,000	$-	$-	Existing Flood Insurance - $23.4 M	Existing Flood Insurance - $71 M
Los Portones Dr	$200,000	$200,000	$200,000	$200,000	Future Flood Insurance - $80 M	Future Flood Insurance - $90 M
Floodwall Replace	$10,300,000	$7,100,000	$10,300,000	$7,100,000	Subtotal Flood Insurance – $103.4 M	Subtotal Flood Insurance – $161 M
N Scottsdale Chl	$11,700,000	$-	$11,700,000	$-		
50-yr O&M	$5,400,000	$4,600,000	$600,000	$600,000		
50-Year Cost	**$46,100,000**	**$27,400,000**	**$32,700,000**	**$16,000,000**	**$164,000,000**	**$224,000,000**

ALTERNATIVE A – Happy Valley In-line Sediment Basin/Flow Splitter

FLOW SPLIT CONTROL STRUCTURE AND SEDIMENT BASIN CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 134,000	$ 134,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 533,000	$ 533,000
4	CONTINGENCY (30%)	1	LS	$ 1,997,000	$ 1,997,000
5	CLEARING AND GRUBBING	25	AC	$ 3,000	$ 75,000
6	EXCAVATION	65,000	CY	$ 8	$ 520,000
7	SOIL CEMENT - DROP STRUCTURES & SPILLWAY WEIRS	25,900	CY	$ 70	$ 1,813,000
8	RIPRAP, D50=12 INCH - CUT SLOPES	16,800	CY	$ 80	$ 1,344,000
9	FILL - SPLITTER AND WEST CONTAINMENT DIKES	33,800	CY	$ 10	$ 338,000
10	RIPRAP, D50=12 INCH - SPLITTER AND WEST CONTAINMENT DIKES	7,500	CY	$ 80	$ 600,000
11	7-FT CONCRETE FLOOD WALL - EAST CONTAINMENT WALL	11,550	SF	$ 55	$ 635,250
12	RIPRAP, D50=12 INCH - EAST CONTAINMENT WALL	3,480	CY	$ 80	$ 278,400
13	12'X8' RCBC - LOW FLOW OUTLET	6,000	SF	$ 71	$ 426,000
14	LANDSCAPING	25	AC	$ 25,000	$ 625,000
	TOTAL BASE PRICE				**$ 9,369,000**

Opinion of Cost

The opinions of cost shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project budgeting and implementation from the information available at the time the opinion was prepared. The final costs of the project will depend on actual labor and material costs, competitive market conditions, actual site conditions, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the opinions of cost presented herein. Construction costs are presented in 2014 dollars.

FLOW SPLIT CONTROL AND SEDIMENT BASIN CONCEPTUAL COST ESTIMATE (CONT.)

O&M COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	ANNUAL SEDIMENT REMOVAL/OTHER O&M	1	YR	$ 100,000	$ 100,000
2	50-YR SEDIMENT REMOVAL/OTHER O&M	50	YR	$ 100,000	$ 5,000,000
3	ANNUAL DOWNSTREAM CHANNEL O&M	1	YR	$ 6,000	$ 6,000
4	50-YR ANNUAL DOWNSTREAM CHANNEL O&M	50	YR	$ 6,000	$ 300,000
5	ANNUAL EAST CONTAINMENT O&M	1	YR	$ 2,480	$ 2,480
6	50-YR EAST CONTAIMENT O&M	50	YR	$ 2,480	$ 124,000
	TOTAL BASE PRICE				**$ 5,400,000**

LAND ACQUISITION

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	LAND ACQUISITION - FLOW SPLIT STRUCTURE	25	AC	$ 50,000	$ 1,250,000
2	LAND ACQUISITION - N SCOTTSDALE CHANNEL	10	AC	$ 50,000	$ 516,529
	TOTAL BASE PRICE				**$ 1,800,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COSTS)	1	LS	$ 1,900,000	$ 1,900,000

ALTERNATIVE A – Happy Valley In-line Sediment Basin/Flow Splitter (cont.)

DOWNSTREAM CONVEYANCE INVESTIGATION CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 24,000	$ 24,000
3	HYDRAULIC, STRUCTURAL, & GEOTECHNICAL ENGINEERING	1	LS	$ 52,000	$ 52,000
4	CONTINGENCY (30%)	1	LS	$ 70,000	$ 70,000
5	AS-BUILT GEOMETRY SURVEY	15	DAY	$ 1,200	$ 18,000
6	SCOUR TOE-DOWN EXCAVATION/BACKFILL AND MEASUREMENTS	30	EA	$ 1,500	$ 45,000
7	SAWCUT EXISTING WALL, MEASUREMENTS, REPLACE IN KIND	22	EA	$ 7,500	$ 165,000
8	LEVEE BORINGS AND TESTING	5	EA	$ 1,000	$ 5,000
	TOTAL BASE PRICE				**$ 400,000**

MAIN CHANNEL GRADE CONTROL STRUCTURES CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 54,000	$ 54,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 216,000	$ 216,000
4	CONTINGENCY (30%)	1	LS	$ 808,000	$ 808,000
5	CLEARING AND GRUBBING	13	AC	$ 3,000	$ 39,000
6	EXCAVATION	33,000	CY	$ 8	$ 264,000
7	SOIL CEMENT - GRADE CONTROL STRUCTURES	33,000	CY	$ 70	$ 2,310,000
8	REVEGETATION	13	AC	$ 6,000	$ 78,000
	TOTAL BASE PRICE				**$ 3,800,000**

DESIGN

ITEM	DESCRIPTION	TOTAL	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 300,000	$ 300,000

FLOODWALL REPLACEMENT - MAIN CHANNEL AND WEST SPLIT

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 147,000	$ 147,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 587,000	$ 587,000
4	CONTINGENCY (30%)	1	LS	$ 2,201,000	$ 2,201,000
5	CLEARING AND GRUBBING	5	AC	$ 3,000	$ 15,000
15	8-FT CONCRETE FLOOD WALL REPLACEMENT - MAIN CHANNEL	86,560	SF	$ 55	$ 4,760,800
16	RIPRAP, D50=12 INCH - MAIN CHANNEL REPLACEMENT	3,600	CY	$ 80	$ 288,000
17	6-FT CONCRETE FLOOD WALL REPLACEMENT - WEST SPLIT	38,400	SF	$ 55	$ 2,112,000
18	RIPRAP, D50=8 INCH - WEST SPLIT REPLACEMENT	2,000	CY	$ 80	$ 160,000
	TOTAL BASE PRICE				**$ 10,321,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 700,000	$ 700,000

NORTH SCOTTSDALE CHANNEL WEST OF SCOTTSDALE ROAD (NAME FROM PARADISE RIDGE DOCUMENTS)

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 450,000	$ 450,000
3	CHANNELIZATION	4,500	LF	$ 1,000	$ 4,500,000
4	PINNACLE PEAK ROAD CULVERT OR BRIDGE	1	LS	$ 2,700,000	$ 2,700,000
5	SCOTTSDALE ROAD CULVERT OR BRIDGE	1	LS	$ 2,700,000	$ 2,700,000
6	CONTINGENCY (30%)	1	LS	$ 1,350,000	$ 1,350,000
	TOTAL BASE PRICE				**$ 11,700,000**

ALTERNATIVE B – Happy Valley In-line Sediment Basin, Main Channel Only

SEDIMENT BASIN - MAIN ONLY CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 115,000	$ 115,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 459,000	$ 459,000
4	CONTINGENCY (30%)	1	LS	$ 1,721,000	$ 1,721,000
5	CLEARING AND GRUBBING	21	AC	$ 3,000	$ 63,000
6	EXCAVATION	55,000	CY	$ 8	$ 440,000
7	SOIL CEMENT - DROP STRUCTURES & SPILLWAY WEIRS	17,500	CY	$ 70	$ 1,225,000
8	RIPRAP, D50=12 INCH - CUT SLOPES	13,440	CY	$ 80	$ 1,075,200
9	WEST CONTAINMENT DIKE	46,800	CY	$ 10	$ 468,000
10	RIPRAP, D50=12 INCH - WEST CONTAINMENT DIKE	6,750	CY	$ 80	$ 540,000
11	7-FT CONCRETE FLOOD WALL - EAST CONTAINMENT WALL	17,710	SF	$ 55	$ 974,050
12	12'X8' RCBC - LOW FLOW OUTLET	6,000	SF	$ 71	$ 426,000
13	LANDSCAPING	21	AC	$ 25,000	$ 525,000
	TOTAL BASE PRICE				**$ 8,100,000**

Opinion of Cost

The opinions of cost shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project budgeting and implementation from the information available at the time the opinion was prepared. The final costs of the project will depend on actual labor and material costs, competitive market conditions, actual site conditions, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the opinions of cost presented herein. Construction costs are presented in 2014 dollars.

SEDIMENT BASIN - MAIN ONLY CONCEPTUAL COST ESTIMATE (CONT.)

O&M COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	ANNUAL SEDIMENT REMOVAL/OTHER O&M	1	YR	$ 84,000	$ 84,000
2	50-YR SEDIMENT REMOVAL/OTHER O&M	50	YR	$ 84,000	$ 4,200,000
3	ANNUAL DOWNSTREAM CHANNEL O&M	1	YR	$ 6,000	$ 6,000
4	50-YR ANNUAL DOWNSTREAM CHANNEL O&M	50	YR	$ 6,000	$ 300,000
5	ANNUAL EAST CONTAINMENT O&M	1	YR	$ 2,480	$ 2,480
6	50-YR EAST CONTAIMENT O&M	50	YR	$ 2,480	$ 124,000
	TOTAL BASE PRICE				**$ 4,600,000**

LAND ACQUISITION

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	LAND ACQUISITION - FLOW SPLIT STRUCTURE	21	AC	$ 50,000	$ 1,050,000
2	LAND ACQUISITION - N SCOTTSDALE CHANNEL	10	AC	$ 50,000	$ 516,529
	TOTAL BASE PRICE				**$ 1,600,000**

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 600,000	$ 600,000

DOWNSTREAM CONVEYANCE INVESTIGATION CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 24,000	$ 24,000
3	HYDRAULIC, STRUCTURAL, & GEOTECHNICAL ENGINEERING	1	LS	$ 52,000	$ 52,000
4	CONTINGENCY (30%)	1	LS	$ 70,000	$ 70,000
5	AS-BUILT GEOMETRY SURVEY	15	DAY	$ 1,200	$ 18,000
6	SCOUR TOE-DOWN EXCAVATION/BACKFILL AND MEASUREMENTS	30	EA	$ 1,500	$ 45,000
7	SAWCUT EXISTING WALL, MEASUREMENTS, REPLACE IN KIND	22	EA	$ 7,500	$ 165,000
8	LEVEE BORINGS AND TESTING	5	EA	$ 1,000	$ 5,000
	TOTAL BASE PRICE				**$ 400,000**

MAIN CHANNEL GRADE CONTROL STRUCTURES CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 54,000	$ 54,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 216,000	$ 216,000
4	CONTINGENCY (30%)	1	LS	$ 808,000	$ 808,000
5	CLEARING AND GRUBBING	13	AC	$ 3,000	$ 39,000
6	EXCAVATION	33,000	CY	$ 8	$ 264,000
7	SOIL CEMENT - GRADE CONTROL STRUCTURES	33,000	CY	$ 70	$ 2,310,000
8	REVEGETATION	13	AC	$ 6,000	$ 78,000
	TOTAL BASE PRICE				**$ 3,800,000**

DESIGN

ITEM	DESCRIPTION	TOTAL	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 300,000	$ 300,000

FLOODWALL REPLACEMENT - MAIN CHANNEL ONLY

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 102,000	$ 102,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 406,000	$ 406,000
4	CONTINGENCY (30%)	1	LS	$ 1,520,000	$ 1,520,000
5	CLEARING AND GRUBBING	5	AC	$ 3,000	$ 15,000
15	8-FT CONCRETE FLOOD WALL REPLACEMENT - MAIN CHANNEL	86,560	SF	$ 55	$ 4,760,800
16	RIPRAP, D50=12 INCH - MAIN CHANNEL REPLACEMENT	3,600	CY	$ 80	$ 288,000
	TOTAL BASE PRICE				**$ 7,100,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 500,000	$ 500,000

ALTERNATIVE C – Happy Valley Flow Splitter, Main Channel Sediment Conveyance

FLOW SPLIT CONTROL STRUCTURE ONLY COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 81,000	$ 81,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 322,000	$ 322,000
4	CONTINGENCY (30%)	1	LS	$ 1,208,000	$ 1,208,000
5	CLEARING AND GRUBBING	10	AC	$ 3,000	$ 30,000
6	EXCAVATION	1,000	CY	$ 8	$ 8,000
9	FILL - SPLITTER AND WEST CONTAINMENT DIKES	17,500	CY	$ 10	$ 175,000
10	RIPRAP, D50=12 INCH - CONTAINMENT DIKE	15,500	CY	$ 80	$ 1,240,000
11	CONCRETE CUTOFF WALL	470	CY	$ 600	$ 282,000
12	7-FT CONCRETE FLOOD WALL - EAST CONTAINMENT WALL	11,550	SF	$ 55	$ 635,250
13	RIPRAP, D50=12 INCH - EAST CONTAINMENT WALL	3,480	CY	$ 80	$ 278,400
14	8-FT CONCRETE FLOOD WALL - MAIN CHAN CONTAINMENT WALL	8,855	SF	$ 55	$ 487,025
15	RIPRAP, D50=12 INCH - MAIN CONTAINMENT WALL	2,660	CY	$ 80	$ 212,800
16	12'X8' RCBC - LOW FLOW OUTLET	6,000	SF	$ 71	$ 426,000
17	LANDSCAPING	10	AC	$ 25,000	$ 250,000
	TOTAL BASE PRICE				**$ 5,700,000**

Opinion of Cost

The opinions of cost shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project budgeting and implementation from the information available at the time the opinion was prepared. The final costs of the project will depend on actual labor and material costs, competitive market conditions, actual site conditions, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the opinions of cost presented herein. Construction costs are presented in 2014 dollars.

FLOW SPLIT CONTROL STRUCTURE ONLY COST ESTIMATE (CONT.)

O&M COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	ANNUAL WEST SPLIT CONTAINMENT O&M	1	YR	$ 3,800	$ 3,800
2	50-YR WEST SPLIT CONTAIMENT O&M	50	YR	$ 3,800	$ 190,000
3	ANNUAL DOWNSTREAM CHANNEL O&M	1	YR	$ 6,000	$ 6,000
4	50-YR ANNUAL DOWNSTREAM CHANNEL O&M	50	YR	$ 6,000	$ 300,000
5	ANNUAL EAST CONTAINMENT O&M	1	YR	$ 2,480	$ 2,480
6	50-YR EAST CONTAIMENT O&M	50	YR	$ 2,480	$ 124,000
	TOTAL BASE PRICE				**$ 600,000**

LAND ACQUISITION

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	LAND ACQUISITION - FLOW SPLIT STRUCTURE	10	AC	$ 50,000	$ 500,000
2	LAND ACQUISITION - N SCOTTSDALE CHANNEL	10	AC	$ 50,000	$ 516,529
	TOTAL BASE PRICE				**$ 1,000,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRCTION COST)	1	LS	$ 1,600,000	$ 1,600,000

DOWNSTREAM CONVEYANCE INVESTIGATION CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 24,000	$ 24,000
3	HYDRAULIC, STRUCTURAL, & GEOTECHNICAL ENGINEERING	1	LS	$ 52,000	$ 52,000
4	CONTINGENCY (30%)	1	LS	$ 70,000	$ 70,000
5	AS-BUILT GEOMETRY SURVEY	15	DAY	$ 1,200	$ 18,000
6	SCOUR TOE-DOWN EXCAVATION/BACKFILL AND MEASUREMENTS	30	EA	$ 1,500	$ 45,000
7	SAWCUT EXISTING WALL, MEASUREMENTS, REPLACE IN KIND	22	EA	$ 7,500	$ 165,000
8	LEVEE BORINGS AND TESTING	5	EA	$ 1,000	$ 5,000
	TOTAL BASE PRICE				**$ 400,000**

NORTH SCOTTSDALE CHANNEL WEST OF SCOTTSDALE ROAD (NAME FROM PARADISE RIDGE DOCUMENTS)

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 450,000	$ 450,000
3	CHANNELIZATION	4,500	LF	$ 1,000	$ 4,500,000
4	PINNACLE PEAK ROAD CULVERT OR BRIDGE	1	LS	$ 2,700,000	$ 2,700,000
5	SCOTTSDALE ROAD CULVERT OR BRIDGE	1	LS	$ 2,700,000	$ 2,700,000
6	CONTINGENCY (30%)	1	LS	$ 1,350,000	$ 1,350,000
	TOTAL BASE PRICE				**$ 11,700,000**

FLOODWALL REPLACEMENT - MAIN CHANNEL AND WEST SPLIT

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 147,000	$ 147,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 587,000	$ 587,000
4	CONTINGENCY (30%)	1	LS	$ 2,201,000	$ 2,201,000
5	CLEARING AND GRUBBING	5	AC	$ 3,000	$ 15,000
15	8-FT CONCRETE FLOOD WALL REPLACEMENT - MAIN CHANNEL	86,560	SF	$ 55	$ 4,760,800
16	RIPRAP, D50=12 INCH - MAIN CHANNEL REPLACEMENT	3,600	CY	$ 80	$ 288,000
17	6-FT CONCRETE FLOOD WALL REPLACEMENT - WEST SPLIT	38,400	SF	$ 55	$ 2,112,000
18	RIPRAP, D50=8 INCH - WEST SPLIT REPLACEMENT	2,000	CY	$ 80	$ 160,000
	TOTAL BASE PRICE				**$ 10,321,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 700,000	$ 700,000

ALTERNATIVE D –Main Channel Only with Sediment Conveyance

WEST SPLIT CONTAINMENT, NO SEDIMENT BASIN COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 82,000	$ 82,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 325,000	$ 325,000
4	CONTINGENCY (30%)	1	LS	$ 1,218,000	$ 1,218,000
5	CLEARING AND GRUBBING	10	AC	$ 3,000	$ 30,000
6	EXCAVATION	1,000	CY	$ 8	$ 8,000
9	WEST SPLIT CONTAINMENT DIKES	21,000	CY	$ 10	$ 210,000
10	RIPRAP, D50=12 INCH - CONTAINMENT DIKE	19,000	CY	$ 80	$ 1,520,000
12	CONCRETE FLOOD WALL - EAST CONTAINMENT WALL	11,550	SF	$ 55	$ 635,250
13	RIPRAP, D50=12 INCH - EAST CONTAINMENT WALL	3,480	CY	$ 80	$ 278,400
14	CONCRETE FLOOD WALL - MAIN CHAN CONTAINMENT WALL	8,855	SF	$ 55	$ 487,025
15	RIPRAP, D50=12 INCH - MAIN CONTAINMENT WALL	2,660	CY	$ 80	$ 212,800
16	12'X8' RCBC - LOW FLOW OUTLET	6,000	SF	$ 71	$ 426,000
17	LANDSCAPING	10	AC	$ 25,000	$ 250,000
	TOTAL BASE PRICE				**$ 5,700,000**

Opinion of Cost

The opinions of cost shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project budgeting and implementation from the information available at the time the opinion was prepared. The final costs of the project will depend on actual labor and material costs, competitive market conditions, actual site conditions, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the opinions of cost presented herein. Construction costs are presented in 2014 dollars.

WEST SPLIT CONTAINMENT, NO SEDIMENT BASIN COST ESTIMATE (CONT.)

O&M COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	ANNUAL WEST SPLIT CONTAINMENT O&M	1	YR	$ 3,800	$ 3,800
2	50-YR WEST SPLIT CONTAIMENT O&M	50	YR	$ 3,800	$ 190,000
1	ANNUAL DOWNSTREAM CHANNEL O&M	1	YR	$ 6,000	$ 6,000
2	50-YR ANNUAL DOWNSTREAM CHANNEL O&M	50	YR	$ 6,000	$ 300,000
3	ANNUAL EAST CONTAINMENT O&M	1	YR	$ 2,480	$ 2,480
4	50-YR EAST CONTAIMENT O&M	50	YR	$ 2,480	$ 124,000
	TOTAL BASE PRICE				**$ 600,000**

LAND ACQUISITION

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	LAND ACQUISITION - WEST SPLIT CONTAINMENT DIKE	10	AC	$ 50,000	$ 500,000
	TOTAL BASE PRICE				**$ 500,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 500,000	$ 500,000

DOWNSTREAM CONVEYANCE INVESTIGATION CONCEPTUAL COST ESTIMATE

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	AZPDES / SWPPP / OTHER PERMITS	1	LS	$ 15,000	$ 15,000
2	MOBILIZATION	1	LS	$ 24,000	$ 24,000
3	HYDRAULIC, STRUCTURAL, & GEOTECHNICAL ENGINEERING	1	LS	$ 52,000	$ 52,000
4	CONTINGENCY (30%)	1	LS	$ 70,000	$ 70,000
5	AS-BUILT GEOMETRY SURVEY	15	DAY	$ 1,200	$ 18,000
6	SCOUR TOE-DOWN EXCAVATION/BACKFILL AND MEASUREMENTS	30	EA	$ 1,500	$ 45,000
7	SAWCUT EXISTING WALL, MEASUREMENTS, REPLACE IN KIND	22	EA	$ 7,500	$ 165,000
8	LEVEE BORINGS AND TESTING	5	EA	$ 1,000	$ 5,000
	TOTAL BASE PRICE				**$ 400,000**

FLOODWALL REPLACEMENT - MAIN CHANNEL ONLY

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	CONSTRUCTION STAKES, LINES, AND GRADES	1	LS	$ 102,000	$ 102,000
2	AZPDES / SWPPP / 404 PERMITTING	1	LS	$ 50,000	$ 50,000
3	MOBILIZATION	1	LS	$ 406,000	$ 406,000
4	CONTINGENCY (30%)	1	LS	$ 1,520,000	$ 1,520,000
5	CLEARING AND GRUBBING	5	AC	$ 3,000	$ 15,000
15	8-FT CONCRETE FLOOD WALL REPLACEMENT - MAIN CHANNEL	86,560	SF	$ 55	$ 4,760,800
16	RIPRAP, D50=12 INCH - MAIN CHANNEL REPLACEMENT	3,600	CY	$ 80	$ 288,000
	TOTAL BASE PRICE				**$ 7,100,000**

DESIGN

ITEM	DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT COST	TOTAL
1	DESIGN (ASSUME 10% OF CONSTRUCTION COST)	1	LS	$ 500,000	$ 500,000

Memorandum

DATE: November 25, 2014

TO: Theresa Pinto, Project Manager, FCDMC

FROM: Pat Quinn, PE, RLS, AVS
Peter Acton, EIT

RE: Pinnacle Peak West ADMS Work Assignment No. 3
Task 15.2 Rawhide Wash Conceptual Alternatives
Sediment Transport Modeling and Analysis

Purpose of Sediment Transport Modeling and Analysis

Sediment transport modeling using HEC-RAS v4.1.0 was performed in order to assess sediment throughput in Rawhide Wash between Jomax Road and Pinnacle Peak Road resulting from potential construction of levees and constriction of flow in the vicinity. In particular sediment loading impacts in the wash resulting from removal of the avulsion north of Happy Valley Road by means of potential levee construction, termed avulsion levee for this memo, were assessed. Impacts both upstream and downstream of the zone of potential construction were also analyzed to assess areas in which further sediment mitigation would be required. The purpose of this modeling task was to help identify if there are any fatal flaws associated with the no sediment basin alternative for Rawhide Wash.

Development of Sediment Transport Model

The HEC-RAS model developed by JE Fuller for Rawhide Wash to evaluate flood wall capacities previously for the PPW ADMS was used to evaluate sediment transport continuity within the reach of Rawhide Wash between Jomax and Pinnacle Peak Roads. This HEC-RAS model was developed from the same topography and roughness characteristics used in the FLO-2D modeling for the project.

Inflow hydrographs from FLO-2D modeling performed by JE Fuller in the area was used to establish the quasi-steady inflow hydrographs for the HEC-RAS sediment transport modeling. The 100-year and 10-year peak discharge was 9,666 cfs and 2,923 cfs, respectively. Both inflow hydrographs were used for this analysis, and a third hydrograph series was developed by using two 10-Year hydrographs in succession. These three hydrographs (maximum stream power, channel-forming discharge, and repeated channel-forming discharge) represent the extremes of possible sediment transport outcomes. Sediment inflow was established by extending the model far upstream and allowing infinite scour to occur. This method resulted in the establishment of an equilibrium sediment load at the most upstream point of modeling concern.

The HEC-RAS sediment routine utilizes user-defined movable bed limits. These limits were established individually for each cross-section based on cross-section geometry as well as aerial imagery, and they were selected to best approximate the extents in which scour can occur. Aggradation was permitted anywhere within the wetted perimeter (beyond the scour limits), and this practice is commonly used when modeling alluvial systems. No reach specific sediment gradation data were available. However, field observations have been made in the area by JE Fuller personnel. Based on those observations, sediment grain size was set as poorly graded sand (D_{50} = 2.0 mm). The Yang sediment transport function within HEC-RAS was selected for this analysis. This function was developed for sands and gravels, and it has been shown to adequately approximate sediment transport in alluvial systems in Arizona.

Modeling was first performed to assess sediment loading impacts resulting from the addition of the avulsion levee (see **Figure B.1**). Thereafter, the addition of mitigation structures (e.g., grade control, additional levees) were incorporated as needed to address issues of excess aggradation/degradation elsewhere.

Model Results and Discussion

The addition of the avulsion levee along its entire length presented minimal impacts with regards to sediment transport for the 10-year, 100-year and 10-year sequence events. Aggradation did not exceed 0.5 feet, and degradation did not exceed 0.77 feet adjacent to the levee (for all runs), and values reported are within the range of model variability and uncertainty. The hydraulic properties relevant to sediment transport of the wash (e.g., velocity, wetted perimeter, hydraulic depth, longitudinal slope) did not vary significantly with the introduction of the levee, thus sediment continuity of this section was maintained.

An area of excess sediment deposition was identified downstream of the avulsion levee approximately 700 feet downstream of Happy Valley Road. While this area did not indicate excess deposition during the 10-Year event, deposition greater than 1.5 feet was observed during the 100-Year event. Further investigation indicated that during high flow events utilization of an addition parallel channel substantially increases the cross-sectional area of the flow. This abrupt transition translated into an abrupt decrease in velocity, thereby greatly reducing the sediment transport capacity. The removal of a large portion of suspended and bed-load sediment subsequently caused significant scour downstream, as the wash scoured the bed in order to re-establish the equilibrium sediment transport load. A final model simulation was performed to assess construction of an additional levee aimed at isolating the secondary flow channel and preventing flow from entering it during the 100-Year event. Introduction of this levee allowed for consistent hydraulic properties (e.g., flow width, hydraulic depth, velocity) and sediment transport to be maintained. A map indicating the locations of both proposed levees in relation to the entire modeled reach of Rawhide Wash is shown in **Figure B.1**. A close-up view of the locations of the two proposed levees is shown in **Figure B.2**.

The results of this analysis indicate that the construction of a levee to isolate the avulsion upstream of Happy Valley Road would not significantly impact sediment transport in the reach, and that sediment mitigation approaches (e.g., sediment basin, grade control) are not necessary should the levee be constructed. Further, this analysis reveals the need to further channelize the wash downstream of Happy Valley Road in order to maintain sediment continuity. The change in bed elevation with the proposed levees for the three hydrograph scenarios are shown in **Figure B.3.**

This analysis provided general locations in which mitigation is required in order to maintain sediment transport continuity through the Rawhide Wash between Jomax Road and Pinnacle Peak Road. The analysis also demonstrates

that with the addition of two levees along the reach, sediment transport continuity can be maintained without significant erosion or deposition, effectively preventing avulsion of Rawhide Wash.

Conclusion

Sediment transport continuity was assessed in Rawhide Wash. Based on this preliminary sediment transport analysis, continuity was maintained in the wash with the addition of the two aforementioned levees. Additional analysis of sediment transport continuity along Rawhide Wash would be required should construction of the proposed levees be advanced further. In particular, additional geotechnical data, evaluation of other sediment transport functions, additional hydrograph combinations and/or frequencies, and potential variations of roughness would be required. Additional means of assessing and modeling sediment transport and long-term trends (e.g., Uncertainty Analysis, Equilibrium Slope) should be utilized to confirm the results of these preliminary analyses. In particular, the District has recommended HEC-6T as the preferred modeling tool to use for additional analyses.

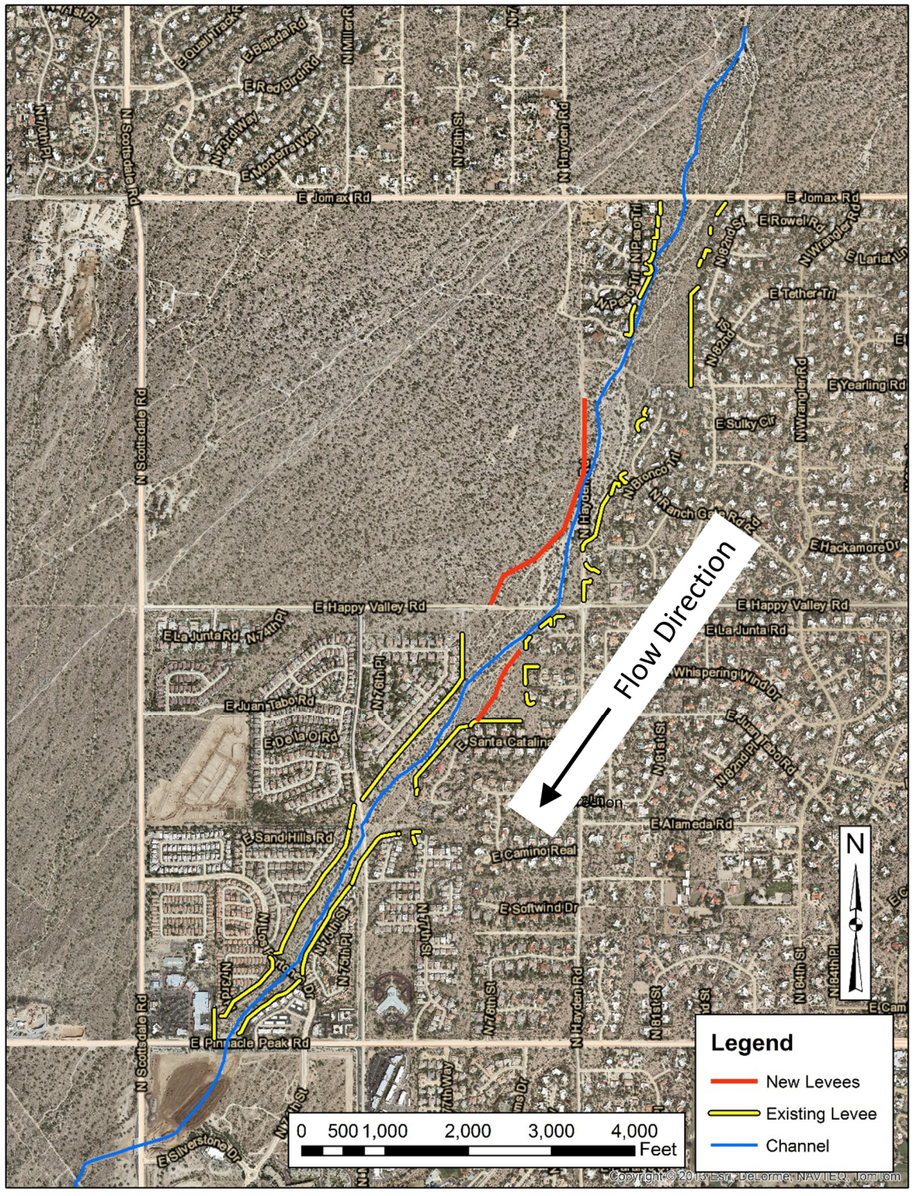


Figure B.1. Rawhide Wash Overview Map

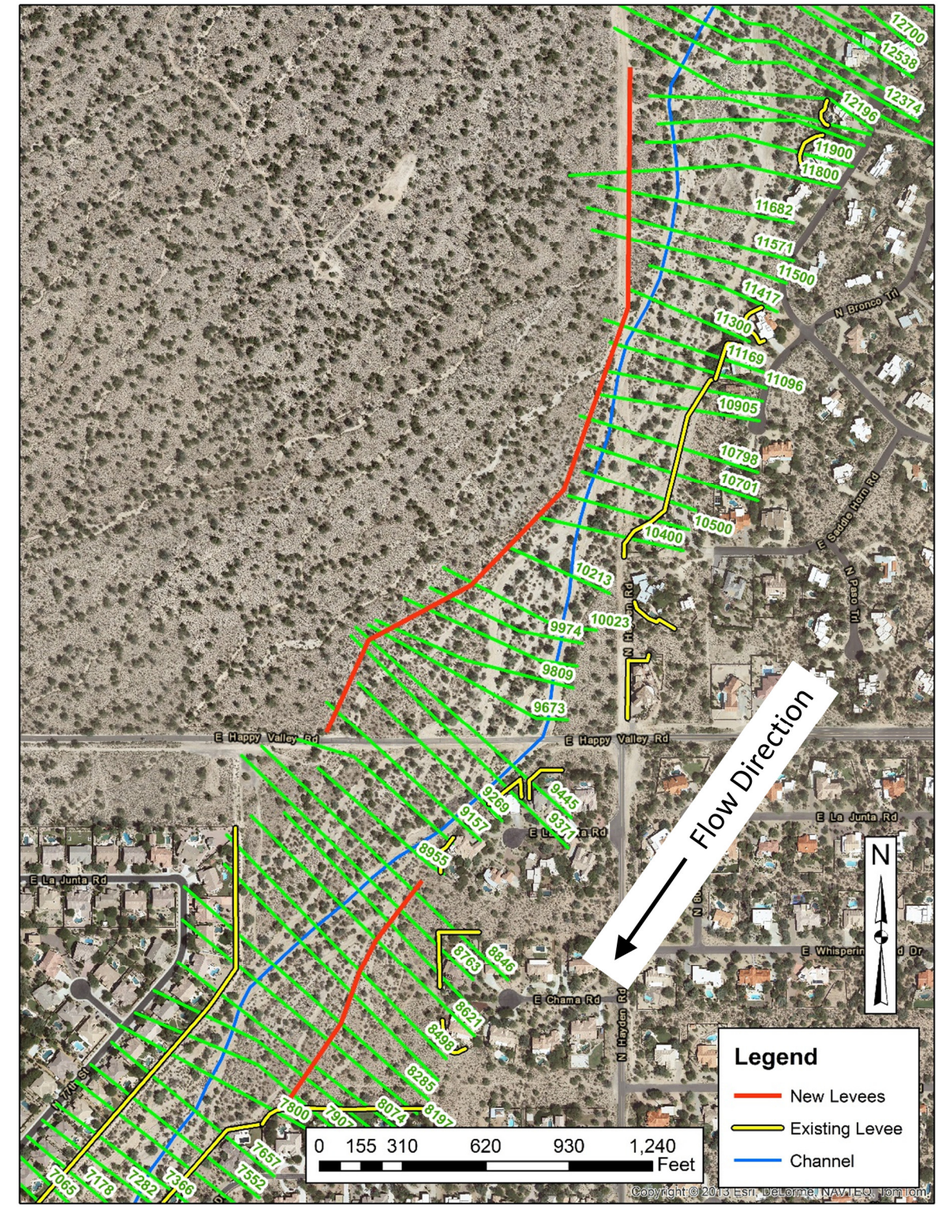


Figure B.2. Detailed View of Proposed Levee Locations

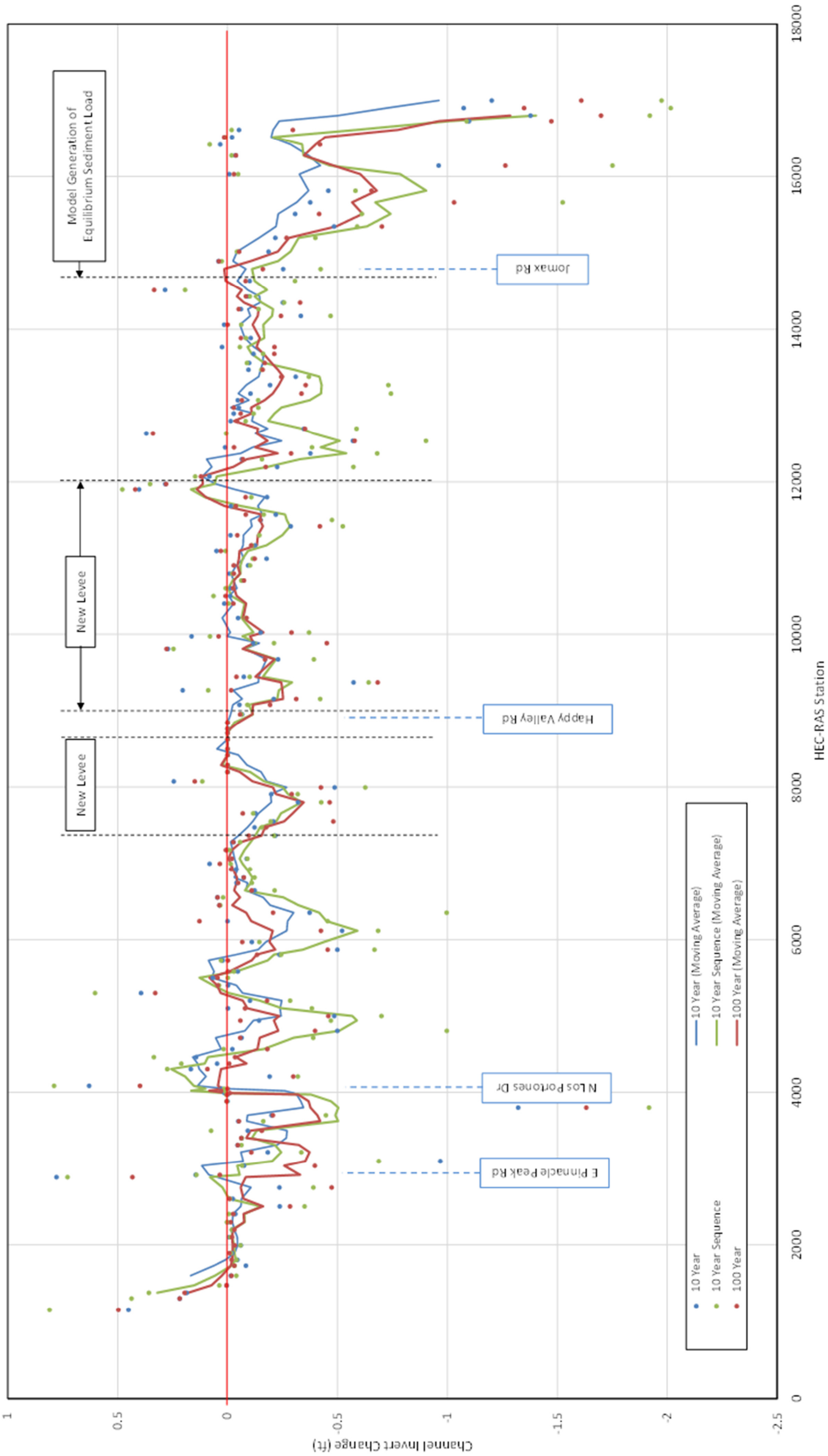


Figure B.3. Channel Invert Change with Proposed Levees

DATE: June 3, 2014
TO: Theresa Pinto, Project Manager, FCDMC
FROM: Mike Kellogg, RG, CFM, GISP; Pat Quinn, PE, RLS, AVS
RE: Pinnacle Peak West ADMS Work Assignment No. 3, Task 8.2.1

PURPOSE

Task 8.2.1 is an investigation of potential flood walls and major flood control improvements within the Rawhide Wash system between Jomax Road and Pinnacle Peak Road (2 linear miles), hereafter referred to as the study reach (Figure C.). The task is comprised of two primary objectives:

1. Collect as-built or other engineering data for any existing floodwalls or other flood control structures within the study reach.
2. Perform a field inspection of the structures within the reach to verify their existing condition integrity and to verify the information obtained from the engineering data collected in objective 1.

Two-dimensional hydrologic and hydraulic modeling (FLO-2D software) of the study reach is currently underway under a separate task within Work Assignment No. 3. Preliminary FLO-2D results were incorporated into Task 8.2.1 as described later in this memorandum. The preliminary FLO-2D results indicate a significant channel breakout of Rawhide Wash upstream of Happy Valley Road. The breakout flows in a southwesterly direction between several residential developments. The breakout channel and the adjacent developments were included in this analysis.

DATA COLLECTION

Document research was conducted within the City of Scottsdale (COS) and Flood Control District of Maricopa County (District) records. With the assistance of Mr. Kirk Wheeler (COS), JE Fuller (JEF) staff collected available as-built and other engineering plans for the wall structures within the study reach. Most of the study reach is comprised of master-planned developments that include perimeter walls surrounding the entire development. Information on the perimeter walls were available for most of these developments. There are a few locations within the study reach that are composed of single-lot parcels with individual perimeter walls. Engineering plans for the single-lot perimeter walls were not available through the COS, thus were not assessed for this study. Figure C.2 shows the major subdivisions within the study reach. Construction dates of the subdivisions range from the mid-1980s through the present. Copies of all collected as-built and engineering plans are included in Appendix C-1.

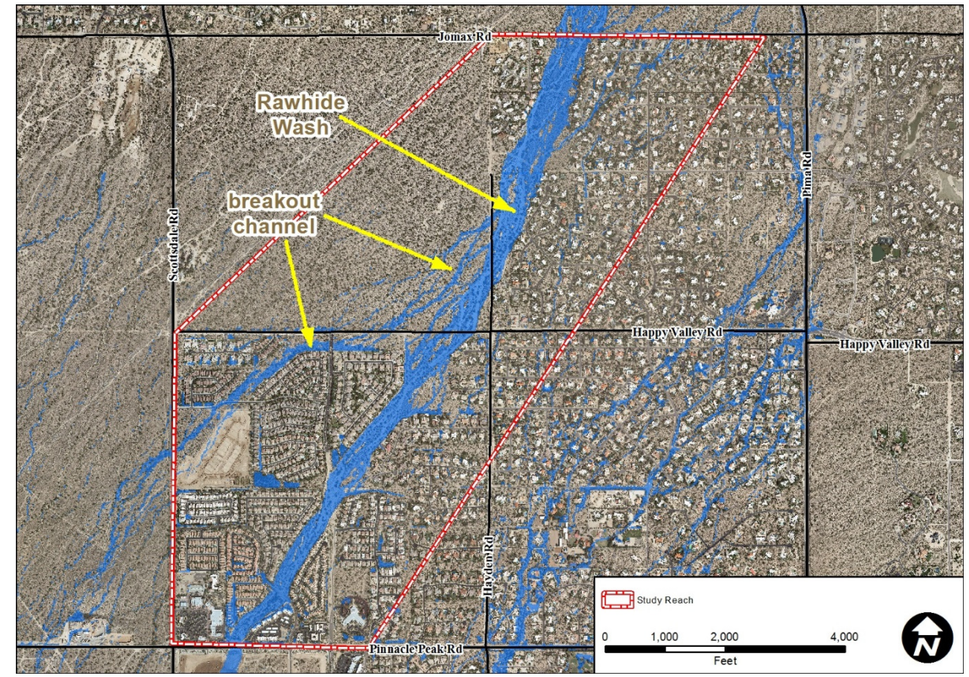


Figure C.1. Study Reach

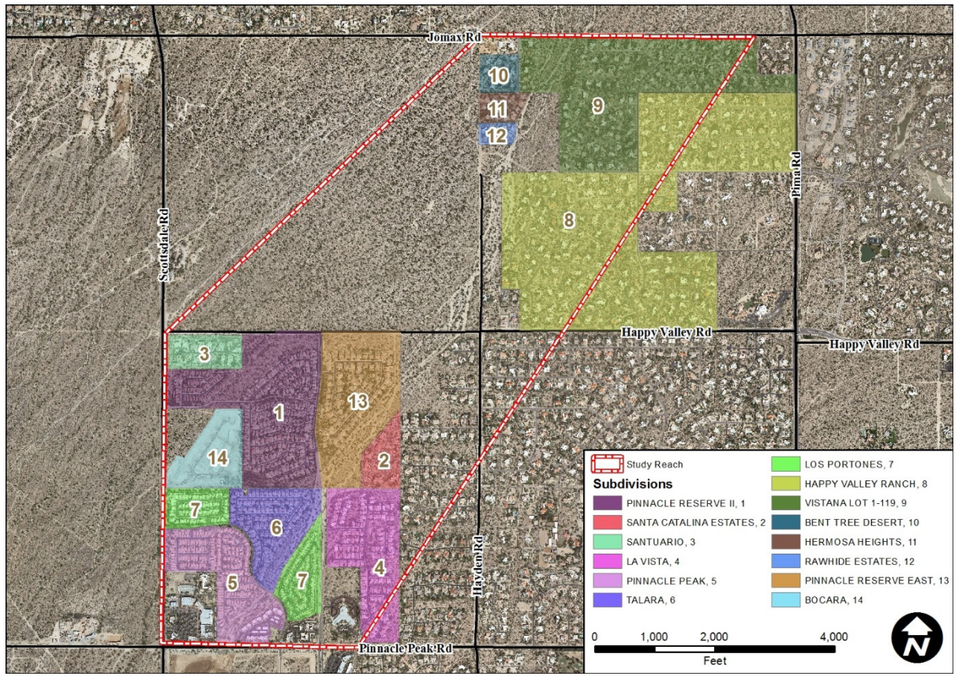


Figure C.2. Major subdivisions within the study reach

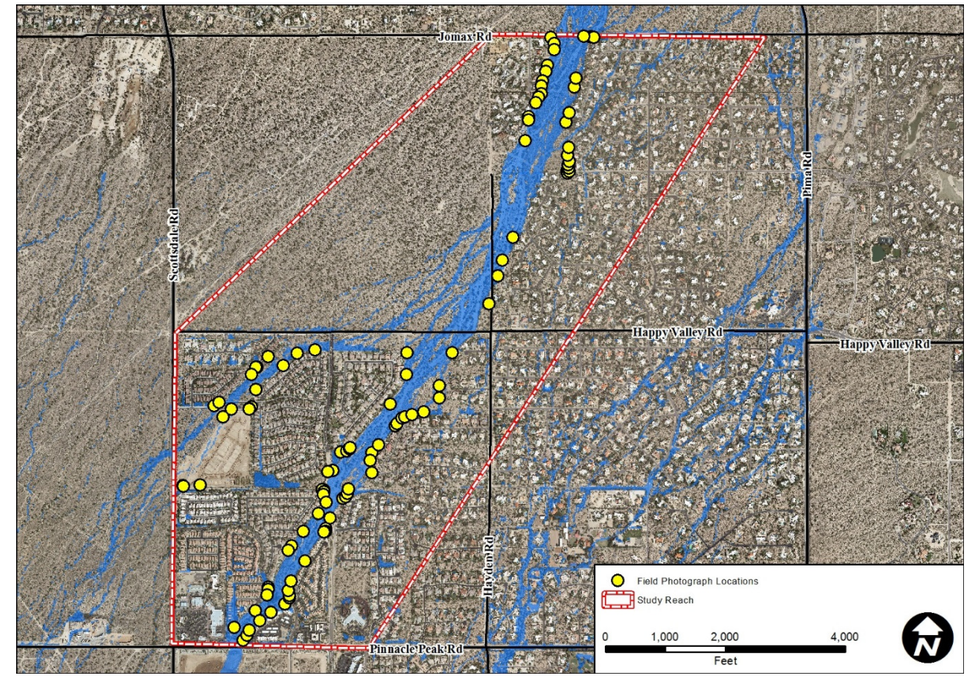


Figure C.3. Field photograph locations

FIELD INVESTIGATIONS

Field investigations of the study reach were conducted by JEF staff on April 23 and May 1, 2014. The investigations were comprised of walking Rawhide Wash and the breakout channel to observe and photograph the perimeter walls in addition to field verifying the as-built plans. Figure C. shows the field photograph locations. The photographs are included in Appendix C-2.

Field verification of the as-built plans was inconclusive as none of the perimeter wall foundations or adjacent scour protection structures shown on the as-built plans were exposed. This suggests that Rawhide Wash has not experienced any long-term scour of the channel bed since construction of the walls. Without access to the wall foundations or adjacent scour protection structures it is not possible to visually distinguish between engineered floodwalls and standard masonry walls.

FLOODWALLS

Not all the perimeter walls adjacent to Rawhide Wash or the breakout channel are identified as “floodwalls” in the as-built plans. It was important for this analysis to differentiate between floodwalls and non-floodwalls. It was assumed that if a wall was identified as a floodwall in the plan documents, it was engineered to resist toppling and/or scour resulting from flooding in Rawhide Wash. Perimeter walls not identified in the plans as floodwalls were assumed to be standard masonry walls that were not engineered to the higher standards of floodwalls. The perimeter walls with as-built plans were delineated in GIS and are shown in Figure C.4.

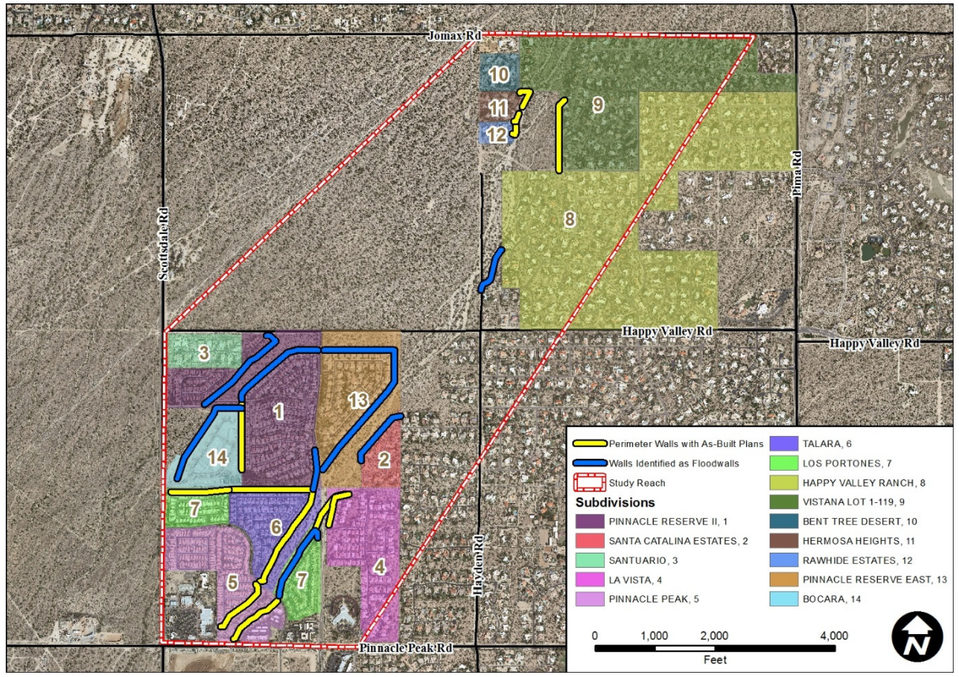


Figure C.4. Walls with as-built plans/identified floodwalls

Figure C.5. Preliminary FLO-2D results intersected with the delineated walls

Preliminary FLO-2D Results

ArcGIS tools were used to intersect the delineated walls shown in Figure C.4 with the preliminary FLO-2D results[1]. The purpose of the analysis was to spatially link the FLO-2D hydraulic data results with the individual walls. The delineated walls were intersected with the FLO-2D grid elements creating individual 20-foot wall segments, then attributed with the maximum depth and maximum velocity output data at each of the intersected grid elements. The results are depth and velocity data for each individual wall segment. This information will aid in future project FLO-2D models that might include scenarios in which individual walls will be simulated to "fail" due to hydraulic output data that meet threshold conditions for wall failure.

An example of the results are shown in Figure C.5 for a portion of the Pinnacle Reserve East subdivision perimeter wall immediately south of Happy Valley Road.

AS-BUILT AND ENGINEERING PLANS

The following pages contain the as-built plans for each floodwall. The pages are organized by subdivision and contain only pages with the floodwall design information. The complete plan documents are included in Appendix G. Note that the floodwall detail sheet for Pinnacle Reserve East contains the following reference: "STRUCTURAL FLOODWALL SEE RAWHIDE WASH/DESERT GREENBELT FLOODWALL PLANS FOR PINNACLE RESERVE (COS CASE #1995-E-95)". At the request of JEF, Mr. Wheeler attempted to locate Case #1995-E-95 within the COS records. The search proved unsuccessful. JEF staff searched the District library records for any reference to the document title, also without success. A District document titled "City of Scottsdale Desert Greenbelt Project, Rawhide Wash Preferred Alternative" was found however, and contains conceptual drawings of a series of floodwall alternatives for Rawhide Wash. The drawings included floodwalls with adjacent reno mattresses for slope protection. This same design concept (floodwall with reno mattress) was used for several of the constructed floodwalls within the study reach. The Desert Greenbelt report is included in Appendix G as a reference.

[1] FLO-2D models: LR and UR (with levee, no failure scenario)

SUMMARY

Research at both the COS and the District resulted in the collection of several engineering as-built plans that indicate many of the perimeter walls surrounding the subdivisions within the study reach that were constructed as floodwalls. A field investigation conducted to verify and document the presence of the floodwalls was inconclusive as none of the structures had exposed foundations and no exposed bank protection structures were found. The preliminary project FLO-2D modeling results were intersected with the delineated walls to link depth and velocity data for each 20-foot wall segment. It is anticipated that these results will potentially be used later in the project to refine wall failure scenario FLO-2D models.

Subdivision: Santa Catalina Estates

IMPROVEMENT PLANS FOR SANTA CATALINA ESTATES

A PORTION OF THE SOUTHWEST QUARTER OF THE NORTHEAST QUARTER OF SECTION 11,TOWNSHIP 4 NORTH, RANGE 4 EAST OF THE GILA AND SALT RIVER BASE AND MERIDIAN, IN MARICOPA COUNTY, ARIZONA

ZONING: R1-43 ESL

1997
CITY OF SCOTTSDALE
GENERAL CONSTRUCTION NOTES
FOR PUBLIC WORKS CONSTRUCTION

1. ALL CONSTRUCTION IN THE PUBLIC RIGHTS-OF-WAY OR IN EASEMENTS GRANTED FOR PUBLIC USE MUST CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS (MAG) UNIFORM STANDARD SPECIFICATIONS AND UNIFORM STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION AS AMENDED BY THE LATEST VERSION OF THE CITY OF SCOTTSDALE (COS) SUPPLEMENTAL STANDARD SPECIFICATIONS AND SUPPLEMENTAL STANDARD DETAILS. IF THERE IS A CONFLICT, THE LATTER SHALL GOVERN.
2. THE ENGINEERING DESIGNS ON THESE PLANS ARE ONLY APPROVED BY THE CITY IN SCOPE AND NOT IN DETAIL. IF CONSTRUCTION QUANTITIES ARE SHOWN ON THESE PLANS, THEY ARE NOT VERIFIED BY THE CITY.
3. APPROVAL OF PLANS IS VALID FOR SIX (6) MONTHS. IF AN ENCROACHMENT PERMIT FOR THE CONSTRUCTION HAS NOT BEEN ISSUED WITHIN SIX MONTHS, THE PLANS SHALL BE RE-SUBMITTED TO THE CITY FOR RE-APPROVAL.
4. A PUBLIC WORKS INSPECTOR WILL INSPECT ALL WORKS WITHIN THE CITY OF SCOTTSDALE RIGHTS-OF-WAY AND IN EASEMENTS. NOTIFY INSPECTION SERVICES 24 HOURS PRIOR TO STARTING OF CONSTRUCTION (TELEPHONE 391-5750).
5. WHENEVER EXCAVATION IS TO BE DONE, CALL THE 'BLUE STAKE CENTER', 263-1100. TWO WORKING DAYS BEFORE EXCAVATION IS TO BEGIN. THE CENTER WILL SEE THAT THE LOCATION OF THE UNDERGROUND UTILITY LINES IS IDENTIFIED FOR THE PROJECT. CALL 'COLLECT' IF NECESSARY.
6. ENCROACHMENT PERMITS ARE REQUIRED FOR ALL WORK IN PUBLIC RIGHTS-OF-WAY AND EASEMENTS GRANTED FOR PUBLIC PURPOSES. AN ENCROACHMENT PERMIT WILL BE ISSUED BY THE CITY UPON RECEIPT OF PAYMENT OF A BASE FEE PLUS A FEE FOR INSPECTION SERVICES TO BE PROVIDED BY THE CITY. COPIES OF ALL PERMITS SHALL BE RETAINED ON-SITE AND SHALL BE AVAILABLE FOR INSPECTION AT ALL TIMES. FAILURE TO PRODUCE THE REQUIRED PERMITS WILL RESULT IN IMMEDIATE WORK STOPPAGE UNTIL THE PROPER PERMIT DOCUMENTATION IS OBTAINED.
7. ALL EXCAVATION AND GRADING WHICH IS NOT IN THE PUBLIC RIGHTS-OF-WAY OR NOT IN EASEMENTS GRANTED FOR PUBLIC USE MUST CONFORM TO CHAPTER 70, EXCAVATION AND GRADING, OF THE LATEST EDITION OF THE UNIFORM BUILDING CODE PREPARED BY THE INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS. A PERMIT FOR THIS GRADING MUST BE SECURED FROM THE CITY FOR A FEE ESTABLISHED BY THE UNIFORM BUILDING CODE.

SPECIAL NOTES

1. THE CONTRACTOR SHALL NOTIFY THE DEVELOPER AT LEAST 48 HOURS IN ADVANCE FOR ANY STAKING OR RESTAKING REQUIRED.
2. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO OBTAIN PERMITS REQUIRED AT HIS OWN EXPENSE.
3. THE CONTRACTOR WILL MAKE EXPLORATORY EXCAVATIONS AND LOCATE ALL EXISTING UNDERGROUND FACILITIES SUFFICIENTLY IN ADVANCE OF CONSTRUCTION TO PERMIT THE REVISION OF THESE PLANS IF NECESSARY DUE TO A CONFLICT BETWEEN A FACILITY PROPOSED HEREIN AND AN EXISTING FACILITY.
4. IT IS THE CONTRACTOR'S 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. CONTRACTOR SHALL ADEQUATELY PROTECT AND MAINTAIN SUCH UTILITIES.
5. THE ENGINEER DOES NOT ASSUME ANY LIABILITY FOR ERRORS OF LINE AND/OF GRADE ON ANY STAKING WHICH HAS BEEN DISTURBED IN ANY WAY. NOR DOES THE ENGINEER ASSUME ANY LIABILITY FOR ERRORS OF LINE AND/OR GRADE ON ANY STAKING THAT HAS BEEN IN PLACE FOR A PERIOD OF 24 HOURS OR MORE WITHOUT THE COMMENCEMENT OF CONSTRUCTION FOR WHICH IT WAS SET.
6. THE CONTRACTOR SHALL NOTIFY THE DEVELOPER'S ENGINEER BEFORE BACKFILLING WATER AND/OR SEWER SERVICES IN ORDER THAT THE ENGINEER MAY VERIFY THE AS-BUILT LOCATION OF THE SERVICE.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PRESERVING ALL STAKES AND CONTROL AND SHALL TAKE STEPS NECESSARY TO ENSURE THAT THE STAKES AND CONTROL ARE NOT DISTURBED OR TAMPERED WITH. IF STAKES ARE DISTURBED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COST INCURRED TO RESTAKE.
8. ANY QUESTIONS RELATIVE TO THE ACCURACY OF IMPROVEMENT INSTALLATION SHALL NOT BE RAISED SUBSEQUENT TO COMPLETION OF THE WORK UNLESS ALL SURVEY STAKES ARE MAINTAINED INTACT. SHOULD SUCH STAKES NOT BE PRESENT AND VERIFIED AS TO THEIR ORIGIN, NO CLAIM FOR ADDITIONAL COMPENSATION FOR CORRECTION SHALL BE PRESENTED TO ANY PARTY AND SUCH WORK SHALL BE CORRECTED BY THE CONTRACTOR AT HIS OWN EXPENSE.
9. THE DEVELOPER AND ALL FUTURE PARTIES OF INTEREST HEREBY INDEMNIFY THE CITY OF SCOTTSDALE FROM ANY AND ALL LIABILITIES ASSOCIATED WITH DAMAGES RESULTING FROM THE PERFORMANCE OF FAILURE OF THE SEWER SYSTEM.

NAOS PROTECTION PLAN

N.A.O.S. PROTECTION PLAN -THE LIMITS OF DISTRUBANCE SHALL BE STAKED AND ROPED-OFF WITH YELLOW ROPE AS PER THE PLANS BY THE OWNER AND APPROVED BY THE LANDSCAPE ARCHITECT PRIOR TO CONSTRUCTION. CONTRACTOR SHALL MAINTAIN ALL CONSTRUCTION ACTIVITY TO WITHIN THE APPROVED LIMITS AND SHALL BE RESPONSIBLE FOR MAINTAINING THE INTEGRITY OF THE LIMITS ON A DAILY BASIS. ALL AREAS BEYOND THE LIMIT OF DISTURBANCE DAMAGED BY THE WORK OF THIS CONTRACT SHALL BE RESTORED TO ORIGINAL CONDITIONS AT CONTRACTOR'S OWN EXPENSE. ALL RESTORATION WORK WILL BE AS PER THE EXISTING REVEGETION AND IRRIGATION PLAN SPECIFICATIONS AND/OR AT THE DIRECTION OF THE LANDSCAPE ARCHITECT.

FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

COMMUNITY NUMBER	PANEL # PANEL DATE	SUFFIX	DATE OF FIRM INDEX	FIRM ZONE	BASE FLOOD ELEVATION (IN AO ZONE, USE DEPTH)
045012	1235 7-19-01	F	7-19-01	AO	1 FOOT V = 5 FPS

ENGINEER'S CERTIFICATION:

The lowest floor elevation(s) and/or floodproofing elevation(s) on this plan are sufficiently high to provide protection from flooding caused by a one-hundred year storm, and are in accordance with City of Scottsdale Revised Code, Chapter 37-Floodways & Floodplains Ordinance.

4/8/02

CITY OF SCOTTSDALE REAPPROVAL

REAPPR	SHEET REVISED	DESCRIPTION
△	#2 AND #5	DELETE 14' FLDWL LOT 1 SHT 5 & REV. D.E. LOTS 6,7,8,9 SHT 2
PAVING	4/8/02	TRAFFIC N/A
G&D	4/8/02	PLANNING 4/8/02
W&S	4/8/02	FIRE 4/8/02

ENGINEERING COORDINATION MANAGER (OR DESIGNEE) 4-8-02 DATE

GENERAL NOTES:

1. PRIOR TO THE START OF GRADING, DUST CONTROL PERMIT (HEAVY MOVING EQUIPMENT PERMIT) MUST BE OBTAINED FROM MARICOPA COUNTY DIVISION OF AIR POLLUTION CONTROL. PHONE 507-1727.
2. ALL EXCAVATION AND EMBANKMENT TO BE CONSTRUCTED IN ACCORDANCE WITH SPECIFICATIONS CONTAINED IN THE SOIL INVESTIGATION REPORT FOR THIS SUBDIVISION.
3. CUTS AND FILLS SHALL BE ROUNDED TO BLEND WITH THE ADJACENT UNDISTURBED TOPOGRAPHY.
4. AN ENGINEERING SITE PLAN FOR EACH LOT MUST BE PREPARED AND SUBMITTED TO THE CITY FOR REVIEW AND APPROVAL AT THE TIME APPLICATION FOR BUILDING PERMIT IS MADE.
5. ALL RIP-RAP TO BE 4" - 6" THICK PER M.A.G. SPECIFICATION 220.4 PLACED OVER GEOFABRIC TYPE R-340 OR EQUAL. ALL CUT AND FILL SLOPES SHALL BE 2:1.
6. ALL RIP RAP, DISTURBED ROCK FACES AND BOULDERS SHALL BE TREATED WITH A DESERT VARNISH (EONITE OR EQUIVALENT).
7. ALL SIGNS REQUIRE SEPERATE PERMITS AND APPROVALS
8. ALL LOTS SHALL CONFORM TO THE FIRE DEPARTMENTS GUIDELINES FOR EMERGENCY VEHICLE ACCESS.

CONSTRTUCTION NOTES FOR RENO MATTRESS

CELLS ARE 6'X 9'X 9' AND 6'X 12'X 9'
ROCK FILL IS D_{50} -6"
NOMINAL MESH OPENING: 3¼" X 4½"
WIRE FOR NETTING: 0.118"
WIRE FOR SELVEDGES: 0.150"
WIRE FOR TYING: 0.087"
FASTENERS: 0.120"
ZINC: 0.80 OZ/SQ.FT
UNIT WEIGHT OF STONE FILL: 160 LB/FT^3

ALL WIRE (EXCEPT FASTENERS) SHALL BE IN ACCORDANCE WITH ASTM A 641 CLASS 3 AND SOFT TEMPER

GALVANIZED FASTENERS SHALL HAVE A TENSILE STRENGTH OF 200,000 TO 280,000 PSI AND THE WEIGHT OF ZINC COATING IS 0.80 OZ. PER SQ.FT. PER ASTM A 641 CLASS 3

STAINLESS STEEL FASTENERS SHALL HAVE A TENSILE STRENGTH OF 240,000 PSI PER ASTM A 313, TYPE 302 CLASS 1

N.A.O.S. TABLE

LOT NO	LOT SIZE (SQ.FT)	NAOS (SQ.FT.)
1	44,052	20,489
2	42,122	20,797
3	42,271	16,077
4	42,423	16,474
5	42,416	18,594
6	41,403	18,468
7	52,129	26,373
8	62,741	31,960
9	47,677	27,761
10	44,004	19,508
11	51,059	19,199
12	54,516	23,199
TOTAL	566,813	258,899 (41.7%)

N.A.O.S. REQUIRED - 25% OF 14.25 ACRES- 3.56 ACRES
N.A.O.S. PROVIDED - 41.7% OF 14.25 ACRES- 5.94 ACRES

BENCHMARK

GLO BRASS CAP UP .37' AT INTERSECTION OF HAPPY VALLEY ROAD AND HAYDEN ROAD C.O.S. DATUM (NAVD88) ELEV.-2016.00

I HEREBY CERTIFY THAT ALL ELEVATIONS REPRESENTED ON THIS PLAN ARE BASED ON THE ELEVATION DATUM FOR THE CITY OF SCOTTSDALE BENCHMARK PROVIDED ABOVE.

R.J. GULINO

DEVELOPER

FRANCOIS MARTINET
FORAN, USA INC.,
7349 PASEO DEL SUR
SCOTTSDALE, ARIZONA 85258

ENGINEER

R.J. GULINO INC.
ENGINEERING SURVEYING
4411 NORTH SADDLEBAG TRAIL
SCOTTSDALE, ARIZONA 85251
(602) 990-7550

QUANTITIES

PAVING AND DRAINAGE

FILL	NONE
EXCAVATION: CUT=	2100 CY
PAVEMENT: 2" AC/6" ABC	3200 SY
18" RIBBON CURB	2450 LF
SURVEY MONUMENT	8 EA
ADJUST MANHOLE FRAME TO GRADE	7 EA
STREET SIGNS W/BASE & POST	1 EA
~~CMU FLOOD WALL W/GABION MATTRESS~~	~~1122 LF~~
RENO MAT DRAINAGE SWALE, W/6" CONC C.O. WALL	668 SQ. YDS. / 280 LF
WATER	
8" D.I.P. WATER LINE	992 LF
6" D.I.P. WATER LINE	508 LF
1" WATER SERVICE	12 EA
8" GATE VALVE	5 EA
6" GATE VALVE	1 EA
FIRE HYDRANT, COMPLETE	1 EA
2" CURB STOP & FLUSHING PIPE	1 EA
8" X6"X6" TEE	1 EA
8" 90° BEND	1 EA
8" 45° BEND	2 EA
8" 1/8 BEND	11 EA.
8" 1/16 BEND	5 EA.
SEWER	
8" PVC SEWER LINE	1360 LF
4" SEWER SERVICE TAP	12 EA
48" DIAMETER MANHOLE	8 EA
60" DIAMETER MANHOLE	1 EA

NOTE: THESE QUANTITIES LISTED ARE APPROXIMATE. CONTRACTOR SHALL MAKE HIS OWN DETERMINATION OF THE QUANTITIES AND BASE HIS BID ON HIS OWN ESTIMATE.

PRESSURE FLOW TEST RESULTS

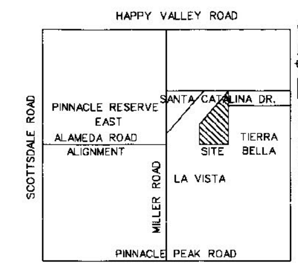
ALLIANCE FIRE PROTECTION CO.
TEST DATE 08/03/00

PRESSURE HYDRANT	FLOWING HYDRANT
8701 E. SANTA CATALINA DR.	8600 E. SANTA CATALINA DR.
APPROX. 600' W/OF HAYDEN	APPROX.1200' W/OF HAYDEN
SP. - 102 P.S.I.	G.P.M. - 1222
RP.- 60 P.S.I.	

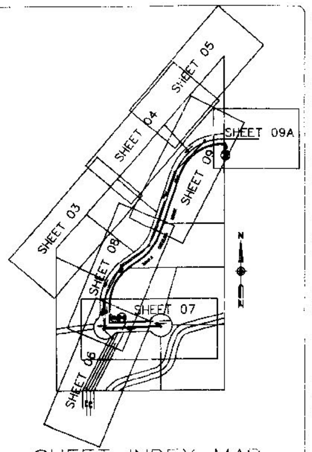
MEGALUG TABULATION

FOR POLYWRAPPED D.I.P. CL. 350

ITEM	QUANTITY	MEGALUGS EACH ITEM	TOTAL
VALVES	4	2 EACH (L-40')	8
FIRE HYDRANT	2	5 EACH	10
CURB STOP	1	1 EACH (L-30')	1



VICINITY MAP
N.T.S.



SHEET INDEX MAP
N.T.S.

NO CONFLICT SIGNATURE BLOCK

UTILITY	UTILITY COMPANY	NAME OF COMPANY REPRESENTATIVE	TELEPHONE NUMBER	DATE SIGNED
WATER				
SANITARY SEWER				
ELECTRIC	[illegible]	[illegible]	[illegible]	[illegible]
TELEPHONE	Qwest	[illegible]		
NATURAL GAS	SOUTHWEST GAS	VIVIAN HUNSAKER	(602) [illegible]-5277	3-08-01
CABLE TV	COX COMMUNICATIONS	ROGER YENSEN	(623)322-7086	3/30/01
OTHER				
OTHER				

ENGINEER'S CERTIFICATION

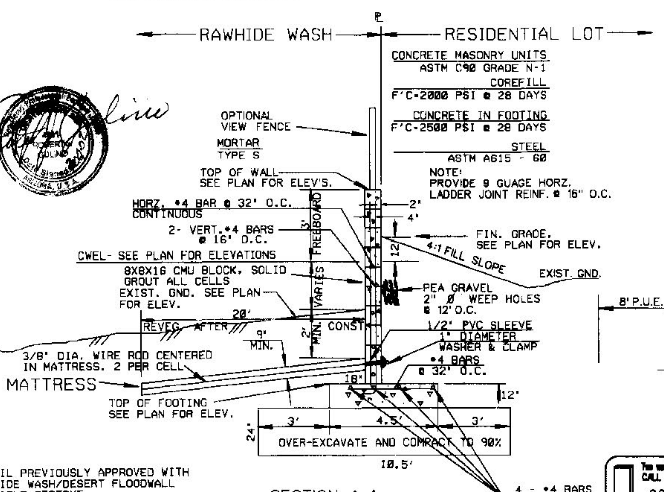
I ROBERT J. GULINO, BEING THE PERSON RESPONSIBLE FOR DESIGNING THE FACILITIES NECESSARY TO SERVE THIS DEVELOPMENT, HEREBY CERTIFY THAT ALL OF THE UTILITY COMPANIES LISTED ABOVE, HAVE REVIEWED THIS PROJECT PROPOSAL AND ALL CONFLICTS HAVE BEEN RESOLVED AT THIS POINT. 'NO CONFLICT' FORMS HAVE BEEN OBTAINED FROM EACH UTILITY COMPANY AND ARE INCLUDED IN THIS SUBMITTAL. I ALSO CERTIFY THAT ALL ONSITE TRANSFORMERS, CABLE BOXES AND OTHER PUBLIC/PRIVATE UTILITY APPERTENANCES ARE PLACED SUCH THAT THEY DO NOT NEGATIVELY IMPACT THE USE OR INTENDED USE OF ANY DEDICATED EASEMENTS OR FACILITIES DEVELOPED WITH THIS PROJECT INCLUDING BUT NOT LIMITED TO STORMWATER STORAGE BASINS, SIGHT DISTANCE EASEMENTS AND NAOS OR OTHER OPEN SPACE EASEMENTS.

SIGNATURE 4-10-01 DATE

MARICOPA COUNTY

IN ACCORDANCE WITH AAC R18-4-119, ALL MATERIALS ADDED AFTER JANUARY 1, 1993 WHICH MAY COME INTO CONTACT WITH DRINKING WATER SHALL CONFORM TO NATIONAL SANITATION STANDARDS 60 AND 61.

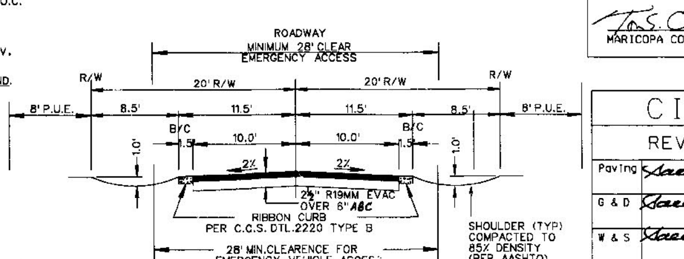
2001634, 2001635 4/10/01
MARICOPA COUNTY DEPT. OF ENVIRONMENTAL SERVICES DATE



SECTION A-A
TYPICAL FLOOD WALL DETAIL
N.T.S.

NOTE: THIS WALL DETAIL PREVIOUSLY APPROVED WITH PLANS FOR RAWHIDE WASH/DESERT FLOODWALL PLANS FOR PINNACLE RESERVE C.O.S. CASE 1996-E-95. 39-PP-36#3 AND 36-ZN-93#3

Two working days before you dig, CALL FOR THE BLUE STAKES 602-263-1100 Blue Stake Center CALL COLLECT



SANTA CATALINA DRIVE

CITY OF SCOTTSDALE

REVIEW & RECOMMENDED APPROVAL BY:

Paving	5-23-01	Traffic	N/A
G & D	5-23-01	P	5/24/01
W & S	5-23-01	Fire	5-25-01

Engineering Coordination Manager (or Designee) 5-24-01 Date

REVISIONS

DESIGNED BY: RJG
DRAWN BY: RJG
CHECKED BY: RJG

R.J. GULINO, INC.
ENGINEERING - SURVEYING

IMPROVEMENT PLANS
SANTA CATALINA ESTATES

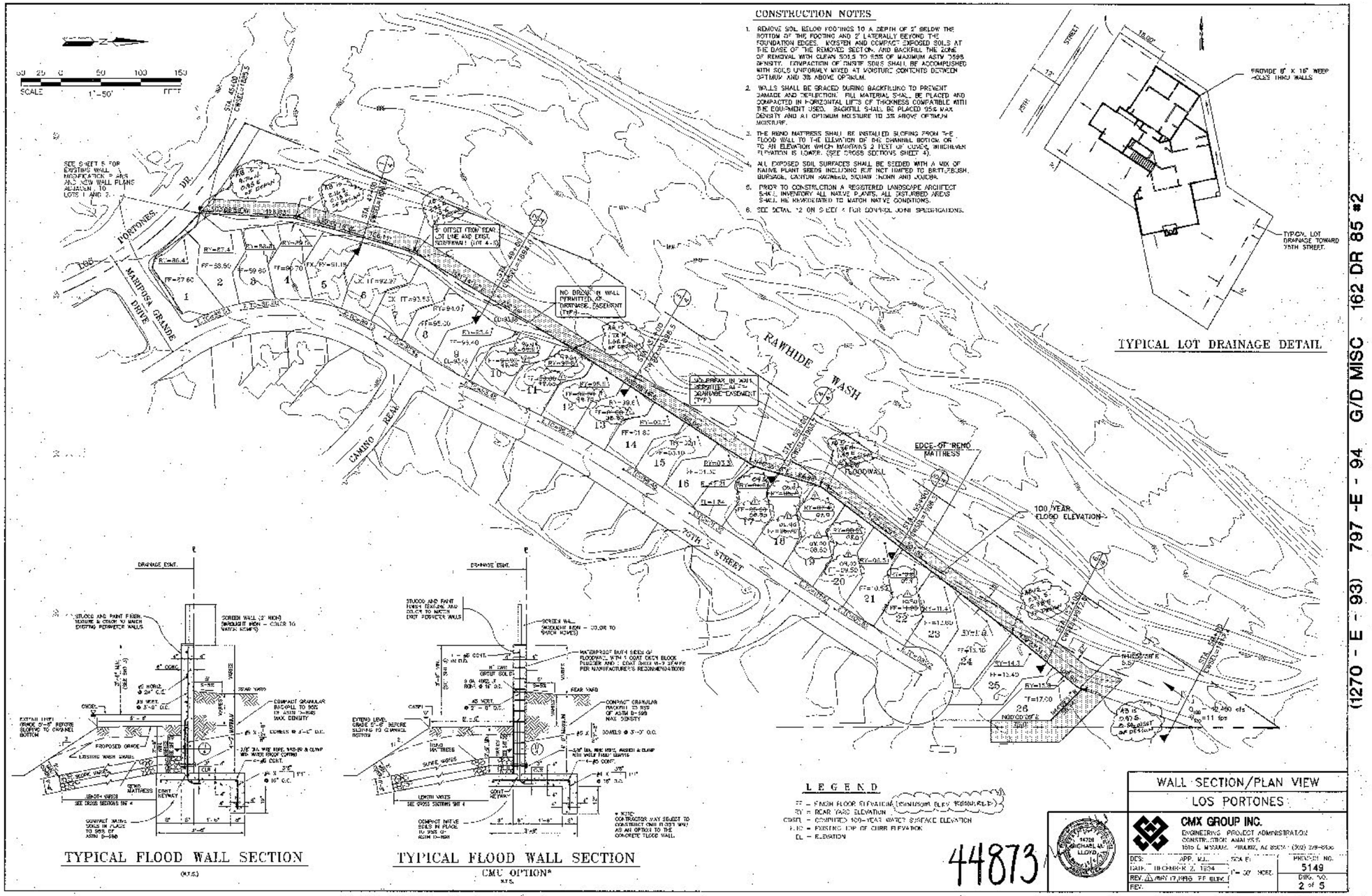
DATE: JULY 7, 2000
JOB NO.: 99514
SHEET 1 OF 9

4018 - 00

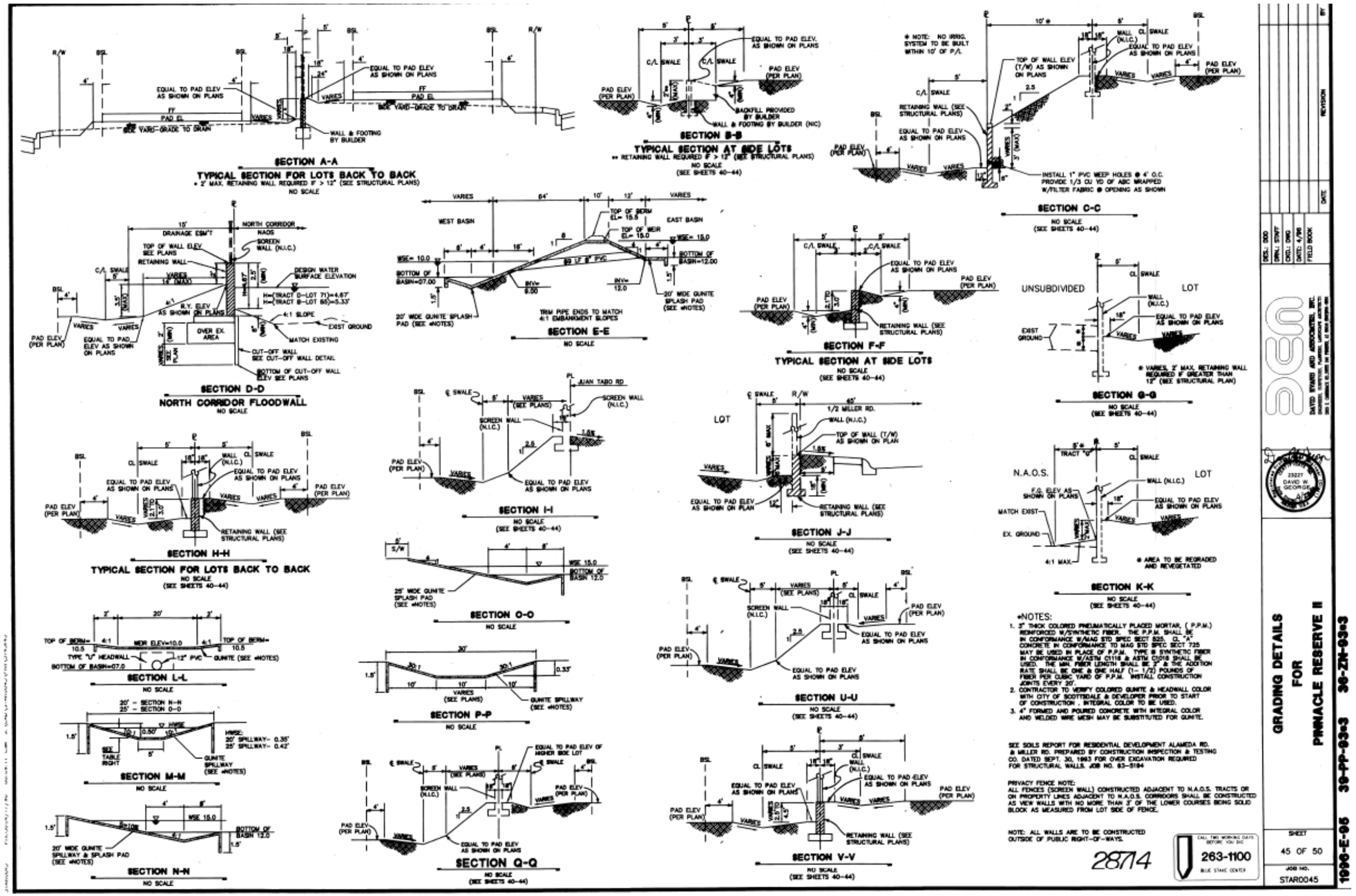
41309

EXWORK-99611-IMPROV01.DGN

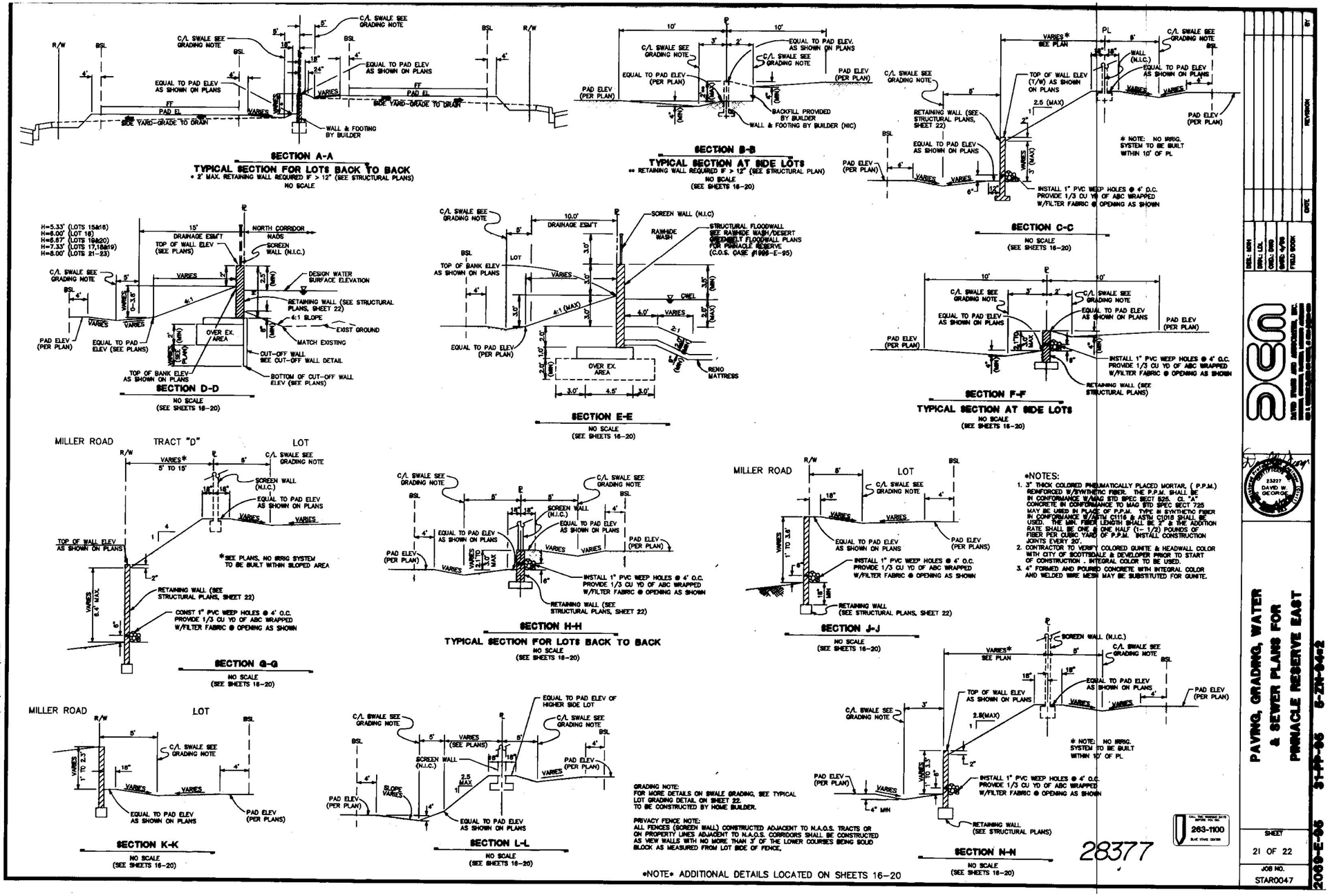
Subdivision: Los Portones



Subdivision: Pinnacle Reserve II



Subdivision: Pinnacle Reserve East



Subdivision: Bacara

STRUCTURAL NOTES

(APPLY UNLESS NOTED OTHERWISE ON DRAWINGS)

CODE

1. 2012 International Building Code with City of Scottsdale amendments.

DESIGN LOADS

1. Lateral Loads:
   a. Wind: 90 MPH 3 second gust. Exposure C
   b. Soil Pressure: See Foundation Notes Below.

FOUNDATIONS

1. Soil report by Western Technologies, Inc. dated 8/24/2012, Job No. 2122JY064 with addendums No. 1 dated 12/5/2012 & No. 2 dated 2/20/2013.
2. Place flood wall concrete only on clean, firm, inspected bearing material. All footing excavations must be inspected by a qualified geotechnical engineer to insure proper foundation bearing.
3. Lateral soil pressures for flood wall design:
   a. Allowable active pressure: 30 pcf.
   b. Ultimate passive pressure: 480 pcf to 7200 psf max.
4. Refer to soils report for site grading, subgrade soil preparation, and fill and compaction requirements.
5. Flood wall excavations are designed for dry conditions and must remain dry during construction.
6. Flood wall excavations shall be free of loose debris from caving before placing concrete.

CONCRETE

1. Minimum 3000 psi compressive strength at 28 days with Type II cement per ASTM C150; aggregate per ASTM C33, 1" minimum rock. Replace cement with fly-ash at a rate of 15% to 20% by weight of the total cementitious materials. Fly-ash shall conform to ASTM C618, Type F.
2. Maximum slump 4 1/2".
3. ACI codes, recommendations and practices apply.
4. Mechanically vibrate all concrete.
5. Drypack shall be one part cement and 2-1/2 parts sand with just enough water to hydrate cement and form a ball showing moisture on the surface when squeezed. It shall be rammed in tight to maximum density attainable. Minimum 28-day strength to be 5000 psi.
6. Contractor shall take precautions to insure that concrete is not contaminated by loose dirt due to caving excavation.
7. Locate flood wall control joints at 60'-0" max.
8. Max. free drop of conc. shall NOT exceed 6'-0".

REINFORCING

1. ASTM A615, Grade 60, deformed bars, except #2 bars. CRSI and ACI manuals apply.
2. Clear concrete coverages per details.
3. Lap splices in concrete 36 bar diameters.
4. Lap splices in masonry 50 bar diameters.
5. Provide bent corner reinforcing to match and lap with horizontal reinforcing at corners and intersections of walls per ACI Detailing Manual (SP-66), latest edition.
6. Place reinforcing per ACI 318-05 and CRSI Standards.

MASONRY

1. Hollow concrete block units: Grade N. Type 1. 1900 psi minimum compressive strength. Wall design strength. f'm = 1500 psi.
2. Mortar: Type S, 1800 psi.
3. Grout: 2000 psi. A maximum of 18% by weight of the total cementious materials may be replaced by fly-ash, provided the fly-ash conforms to ASTM A618, Type F. Mechanically vibrate grout immediately after pouring.
4. Lay units in running bond. Corners shall have a standard bond by overlapping units.
5. Provide ladder type #9 gage continuous joint reinforcing at 16" vertical spacing in walls.
6. See details for wall reinforcing.
7. Maximum grout lift without cleanouts 5'-0" in block walls.
8. Provide masonry control joints at 20'-0" o.c. maximum spacing. Provide one (1) vertical reinforcing at each side of expansion and control joints. Place bond beam reinforcing continuous through expansion and control joints, wrapping bars with 1/8" thick bond breaking tape 2'-0" both sides of joint. Do not splice bond beam reinforcing within 6'-0" of an expansion or control joint.

SUPPLEMENTARY NOTES

1. Verify all dimensions and conditions prior to starting work. Notify the Struct. Eng. of any discrepancies or inconsistencies.
2. Verify in field all existing conditions shown on drawings.
3. Establish and verify all openings with appropriate trades and drawings.
4. Provide all necessary temporary bracing, shoring, guying, or other means to avoid excessive stresses and to hold structural elements in place during construction.
5. Options are for the contractor's convenience. He shall be responsible for all changes necessary if he chooses an option and shall coordinate all details. The cost of additional design work necessitated by selection of an option shall be borne by the contractor. Options shall not delay construction schedule.
6. The cost of additional design work due to errors or omissions in construction shall be borne by the contractor.
7. Any engineering design provided by others and submitted for review shall bear the seal and signature of an Engineer registered in Arizona. If this engineering design requires special structural inspection, they shall be responsible for the inspection.
8. Details on the Structural Drawings are typical. Verify all dimensions with the Civil Drawings.
9. Dimensions on the Structural Drawings are exact with the exception of masonry dimensions which are nominal. Verify all dimensions with the Civil Drawings.

FLOOD WALL DESIGN NOTES

1. The structural design of these flood walls are based on all soil on retention or wash areas being replaced immediately after scour event to original grade elevations.
2. Solid 6'-0" high masonry fence wall is shown on these drawings. See Civil and/or Architectural drawings for optional view fence.
3. Building or driveways shall NOT occur within 25 feet of flood wall.

SPECIAL INSPECTION

Special inspection is to be provided in addition to the inspections conducted by the Department of Building Safety and shall not be construed to relieve the Owner or his authorized agent from requesting the periodic and called inspections required by Section 109 of the International Building Code. The special inspector shall be approved by the City Building Official prior to starting work.

SPECIAL INSPECTION IS REQUIRED FOR THE FOLLOWING WORK:
(PER IBC SECTION 1704)

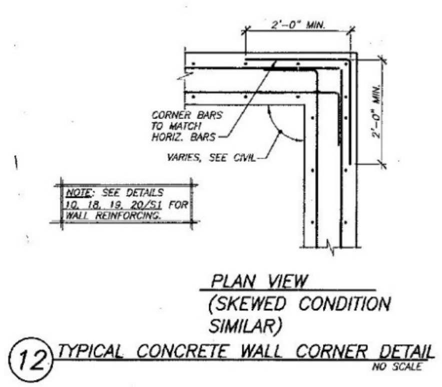
CONCRETE:
During the taking of test specimens and placing of reinforced concrete and pneumatically placed concrete.

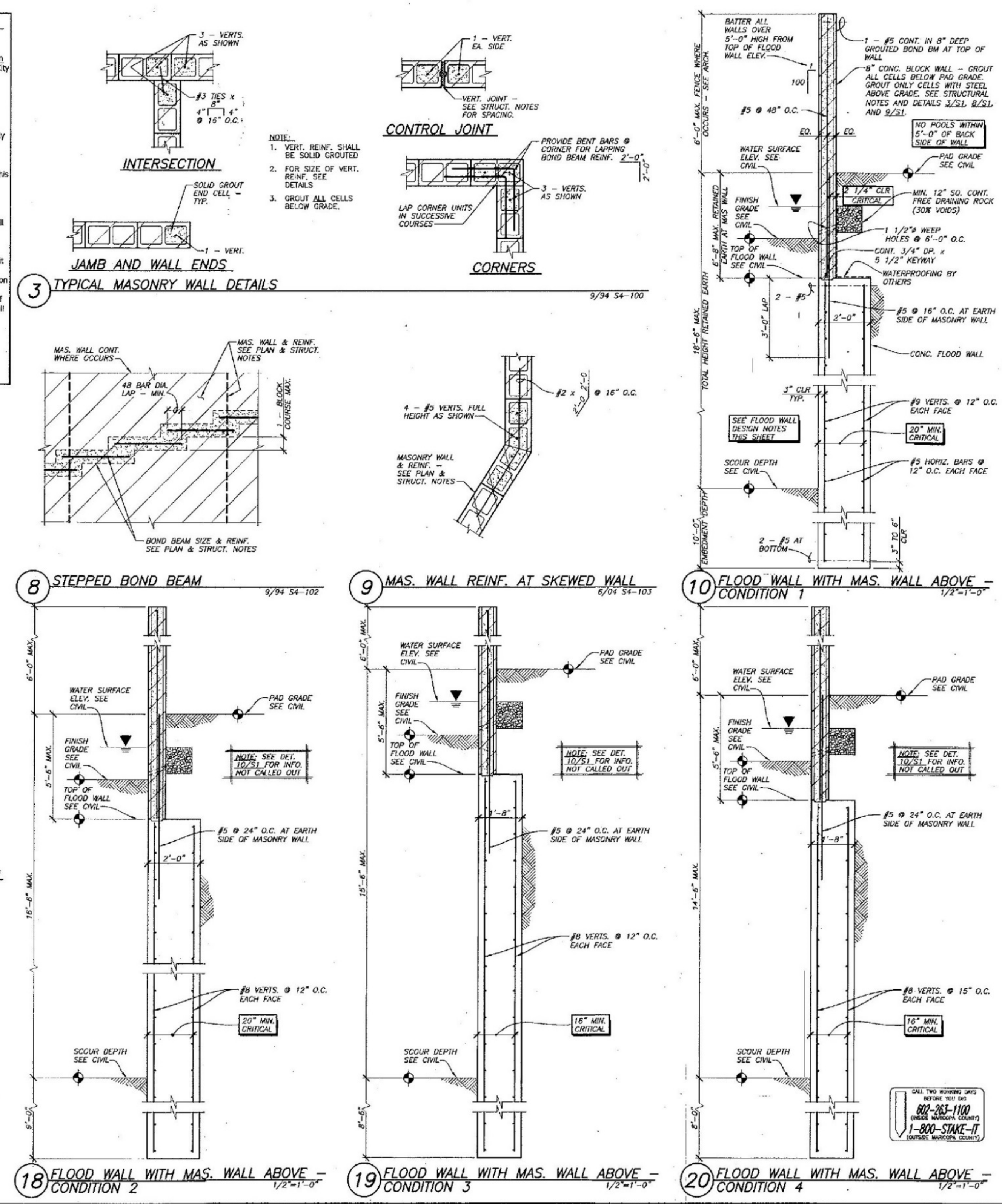
REINFORCING STEEL:
During placing of reinforcing steel for all concrete required to have special inspection. This inspection may be done on a periodic basis in accordance with IBC Table 1704.4.

STRUCTURAL MASONRY: (Unit-strength tests)

1. During sampling and placing of all masonry units, placement of reinforcement, inspection of grout space, immediately prior to closing of cleanouts and during all grouting operations.
2. Special inspection for the placing of the units shall be performed in accordance with IBC Section 1704.5 on a periodic basis.
3. The specified compressive strength of masonry, f'm, shall be verified by the "Unit Strength Method" as required by IBC Section 2105.2.2.1.
   a. The block units shall be tested for compressive strength prior to construction for each 5,000 square feet of wall area.
   b. Separate grout and mortar testing is required for each 5,000 square feet of wall area. Mortar shall be tested in accordance with ASTM C780. Grout shall be tested in accordance with ASTM C1019.

SITE GRADING, EXCAVATION AND FILLING:
During earthwork excavations, grading and filling operations inspection to satisfy requirements of Chapter 18 and Section 1704.7 of the International Building Code. A qualified geotechnical engineer shall be responsible for this special inspection.





REVISIONS	BY

This drawing is an instrument of service. It is the property of GERVASIO & ASSOC. INC. and may not be reproduced or reproduction hereof used without permission.

GERVASIO & ASSOC. INC.
CONSULTING ENGINEERS
77 E. THOMAS ROAD, SUITE 120
PHOENIX, ARIZONA 85012
(602) 285-1720 FAX 285-1530

Registered Professional Engineer (Structural) — Certificate No. 3700 — Joseph A. Gervasio — Arizona, U.S.A. — Expires 12/31/14

Project: BACARA - FLOOD WALLS
NEC SCOTTSDALE & ALAMEDA ROADS, SCOTTSDALE, ARIZONA

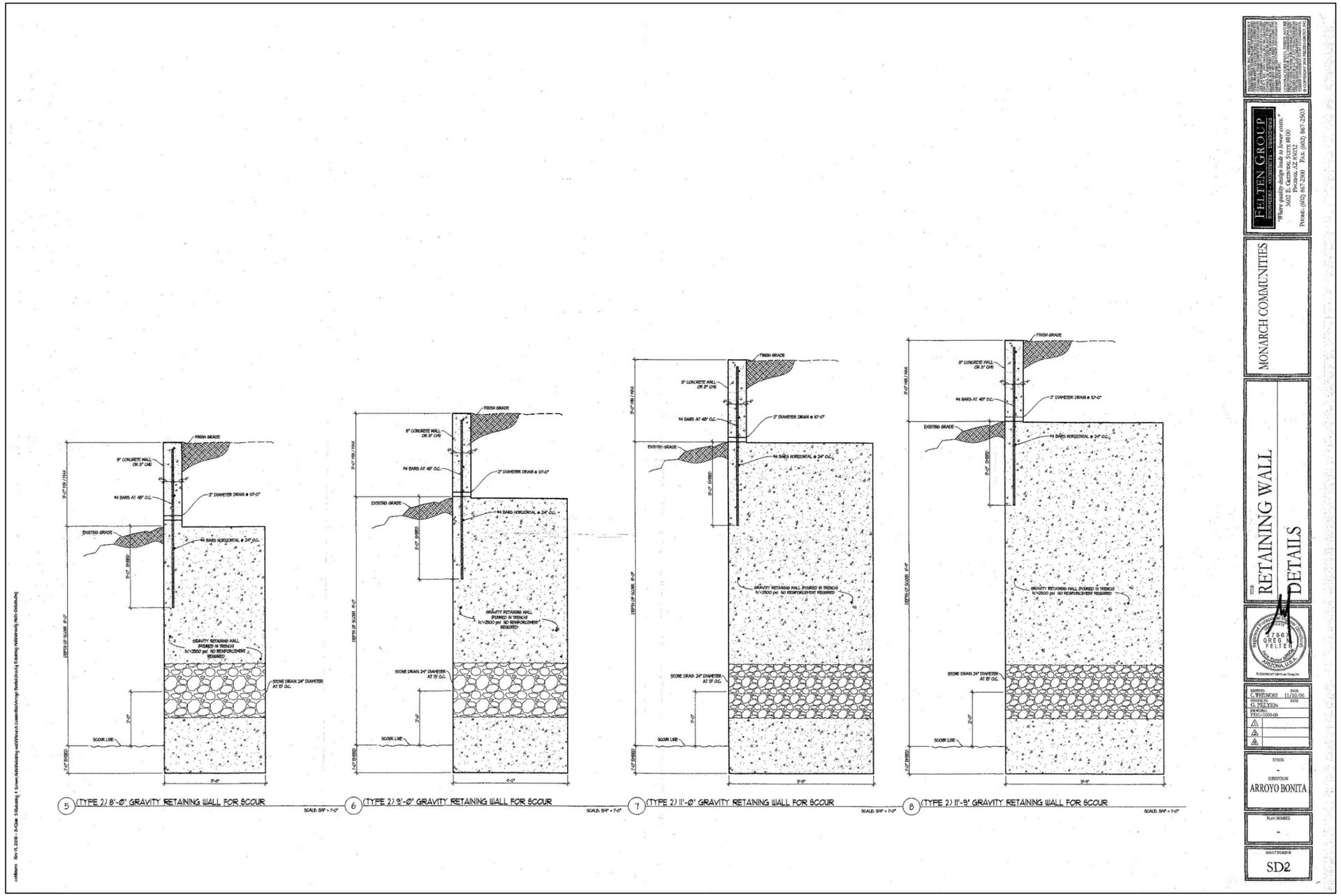
Client: CAMELOT HOMES INC.
6607 N. SCOTTSDALE RD., STE. H-100, SCOTTSDALE, ARIZONA 85250

Sheet Title: STRUCTURAL NOTES & DETAILS

Date: 2/27/13
Scale: AS NOTED
Drawn: EMK | Checked: MAS, RB
Job Number: 3013S
Sheet: S1 of 1 Sheets

G&A #3013S

Subdivision: Parcel APN 212-08-410; Address: 8014 E Saddlehorn Road



APPENDIX C-1

ENGINEERING PLANS

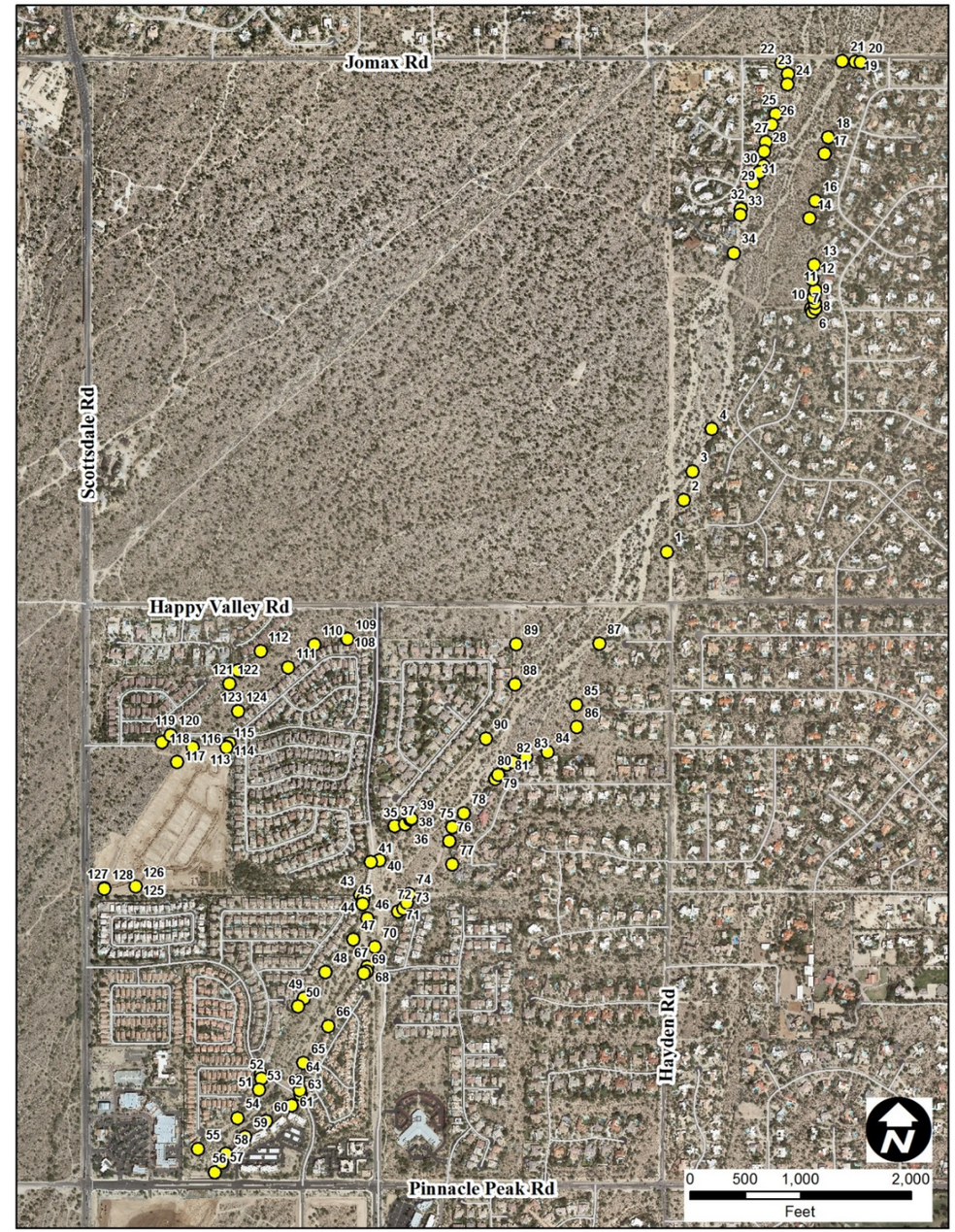
Provided with Digital Data in Appendix G

APPENDIX C-2

FIELD PHOTOGRAPHS

Provided with Digital Data in Appendix G

Photograph Number Index Map



Appendix D presents documentation of several sets of analyses and discussion which were performed during the development of the alternatives for Rawhide Wash. They are presented here for documentation and reference.

Rawhide Wash Risk Assessment

JE Fuller performed a localized risk assessment for the Rawhide Alternatives Focus Area to identify structures that may be susceptible to flooding or flood damage. The hazard criteria are documented in the risk assessment memo (JEF, 2014c). Flood damages are assumed to occur only when flow depths adjacent to structures exceeds 0.5 feet.

Four FLO-2D model scenarios were run to compare the number of buildings within each of these four risk categories that considered increasingly severe failure scenarios of the existing built environment (walls and levee-like embankments). The scenarios ranged from 'no failure' to 'full failure' for the purpose of assessing increasing risk of flood damage, as follows:

- With Walls, With Levees, No Wall/Levee Failure – The model for this scenario includes the walls identified as floodwalls from as-built and constructions plans collected from the City of Scottsdale and all other walls were modeled as flow barriers in FLO-2D (i.e., all walls are hypothetically considered to be floodwalls) without any failure. Similarly, existing levee-like embankments were modeled as flow barriers without any failure. This model 'no failure' scenario considered the existing built environment (i.e., walls and levee-like embankments) fully intact for the model duration and yielded results indicating 56 structures are susceptible to flood damage according to the hazard criteria. Most of these are due to flows escaping the Main channel at Los Portones Drive.

- With Walls, With Levees, With Wall Failure/No Levee Failure – The model for this scenario includes the walls identified as floodwalls from as-built and constructions plans collected from the City of Scottsdale and all other walls were modeled as flow barriers in FLO-2D (i.e., all walls are hypothetically considered to be floodwalls). However, the walls were failed in the model when 2-ft of flow depth accumulated against the wall. The existing levee-like embankments were modeled as flow barriers without any failure. This model scenario considered the existing levee-like embankments intact and the walls failed if/when 2-ft of depth surcharged against the walls. With the addition of the wall failure mechanism, this model scenario results indicate 94 structures are susceptible to flood damage (an additional 38 structures compared to the first 'no failure' scenario).

- Without Walls, With Levees, No Levee Failure – The model for this scenario does not include walls. Existing levee-like embankments are modeled intact. This model scenario results indicate 176 structures are susceptible to flood damage (an additional 120 structures compared to the 'no failure' scenario).

- Without Walls, Without Levees – The model for this scenario does not include walls and levees. This 'full failure' scenario modeled the Rawhide Wash Focus Area without the existing built environment (i.e., no floodwalls and no levee-like embankments). This assumes that all of the walls and levee-like embankments fail and completely wash away. While this is an unlikely hazard scenario, it is included here for comparison and to document the potential FEMA regulatory implications associated with the existing floodwalls and levees along the Main Channel and West Split. This model scenario results indicate 209 structures are susceptible to flood damage (an additional 153 structures compared to the 'no failure' scenario).

The results for each of the four model scenarios run as part of the localized risk assessment are summarized in **Table D-2**. A graphical depiction of the risk assessment for each model scenario is shown in **Figure D-1** through **D-4**.

Table D-5-1. Number of Structures Susceptible to Flood Damage – Rawhide Wash Focus Area

Model Scenario Description	*Flood Hazard Building Totals				Total
	Low	Medium	High	Very High	
With Walls, With Levees and No Wall/Levee Failure	44	9	3	0	56
With Walls, With Levees and Wall Failure/No Levee Failure	81	10	3	0	94
Without Walls, With Levees and No Levee Failure	143	28	5	0	176
Without Walls, Without Levees	169	35	5	0	209

*Low: 6"<D<18", Medium: 18"<D<30", High: D>30" or Building in Tech Memo 11 (USBR, 1988) Judgment Zone,
Very High: Building in Tech Memo 11 High Danger Zone
D=Highest Flood Depth Adjacent to Building
No hazard assumed for flow depths below 0.5 feet.

As can be clearly seen from these analyses, the performance and regulatory requirements for the flood walls and levees significantly affect the number and degree of flood hazards in the focus area. The regulatory issues and implications are discussed further in the following section.

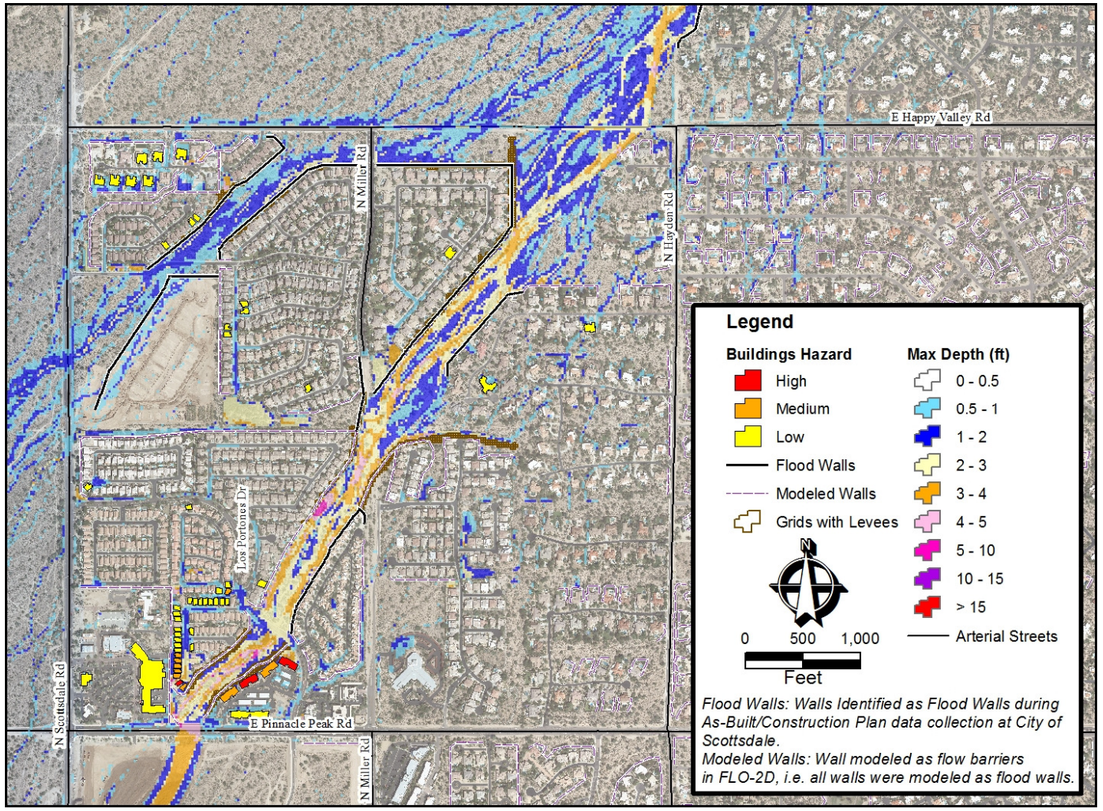


Figure D-1. With Wall, With Levee, No Wall/Levee Failure Model Results Structures Susceptible to Flooding

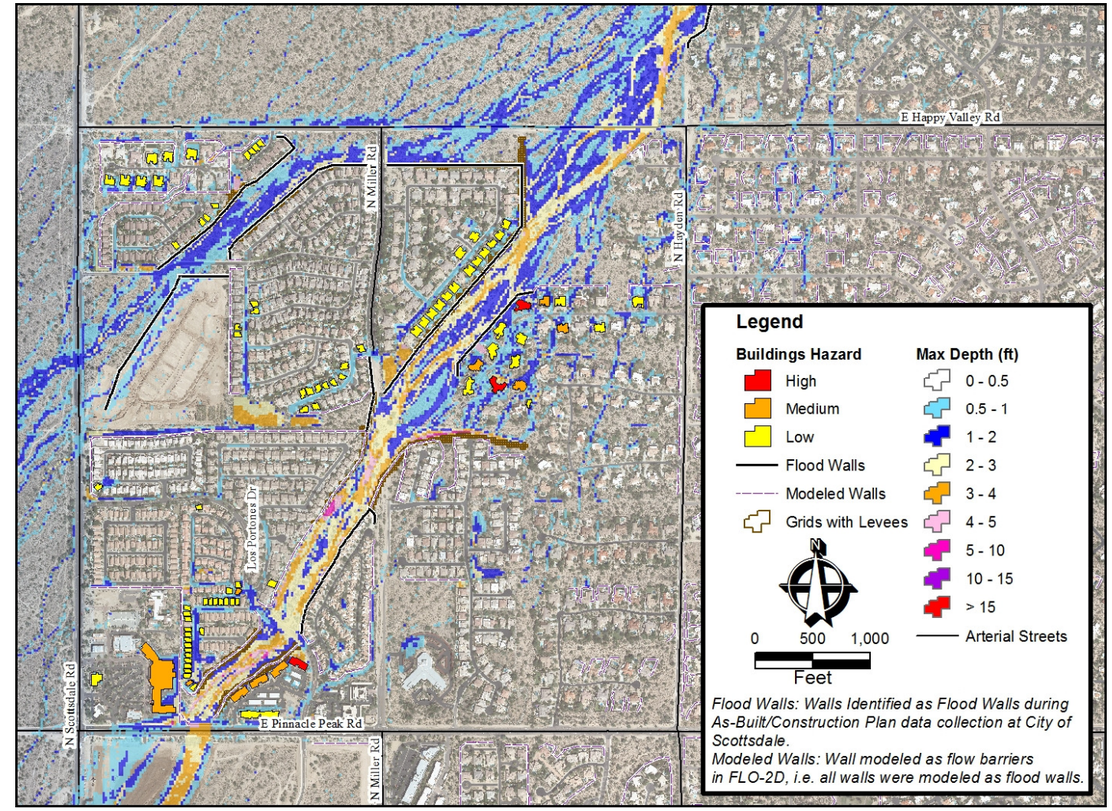


Figure D-2. With Wall, With Levee, With Wall Failure/No Levee Failure Model Results Structures Susceptible to Flooding

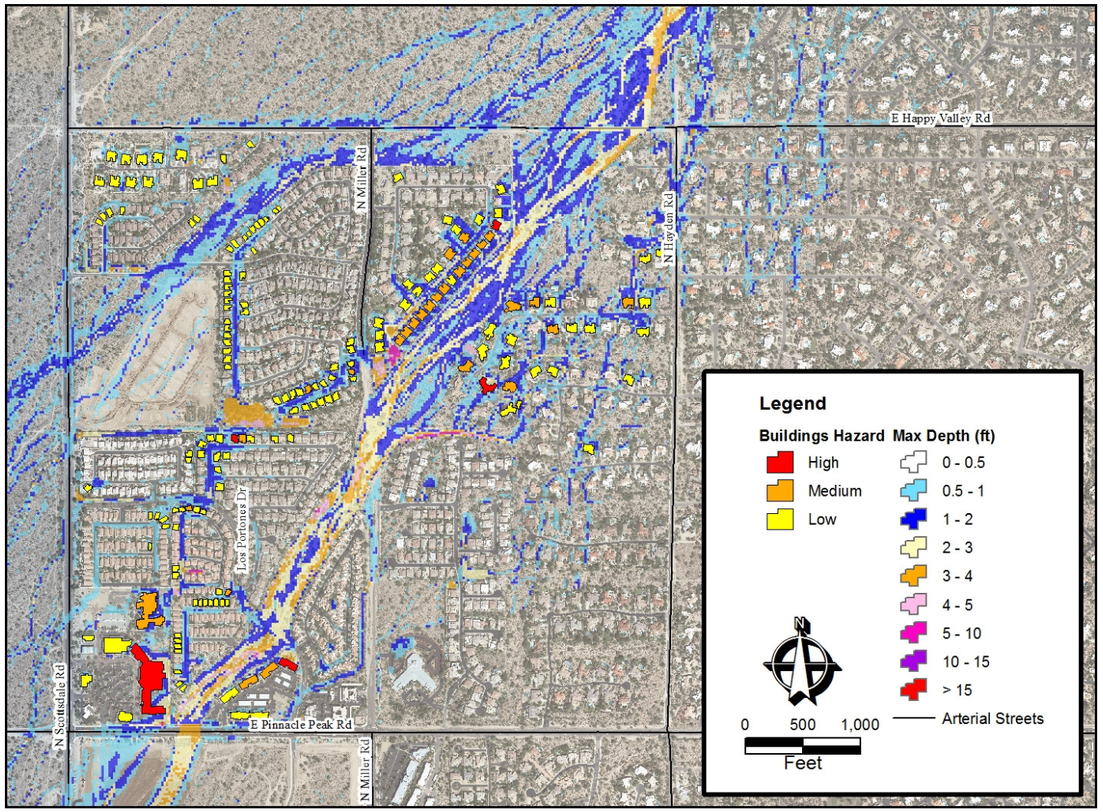


Figure D-3. Without Walls, With Levees, No Levee Failure Model Results Structures Susceptible to Flooding

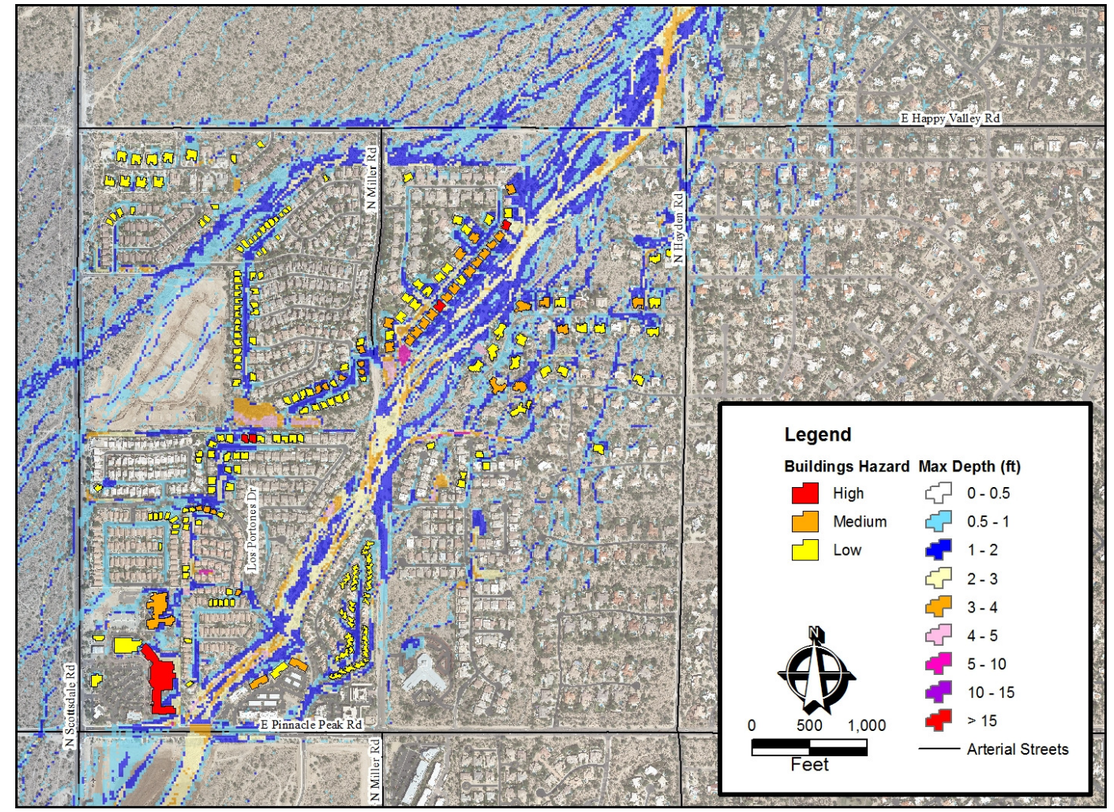


Figure D-4. Without Walls, Without Levees Model Results Structures Susceptible to Flooding

Regulatory Implications of Structural Alternatives

Without knowing if any of the walls along the Main channel and West Split channel would meet FEMA criteria for a certifiable levee or floodwall, JE Fuller conducted a comparative hydraulic analysis of both channels based on each of two assumed conditions:

- With existing floodwalls/levees containment intact – The full base condition 100-year, 24-hour FLO-2D model peak discharges of 7,600 cfs for the Main channel and 1,600 cfs for the West Split were modeled using HEC-RAS with existing floodwalls/levees intact.
- With no floodwall/levee containment – The channel containment discharge was computed at the Finished Floor Elevation (FFE) of the lowest adjacent structure at each cross section using HEC-RAS. The floodwalls/levees were hypothetically removed from the HEC-RAS model allowing flows to escape channel confinement.

This hydraulic analysis of comparative containment conditions indicated there are reaches within both channels with severely limited containment of flows from a FEMA regulatory perspective without the protection of the existing floodwalls and/or levees. **Figure D-5** and **D-6** depict examples of cross sections through the Main and West Split channels to illustrate the nature of this regulatory issue.

National Flood Insurance Program (NFIP) Implications

A primary objective of all flood mitigation alternatives for Rawhide Wash is to remove the Zone AO floodplain and replace it with a narrower Zone AE floodplain. Stakeholders need to recognize the NFIP implications of achieving this objective. A number of properties could potentially be subject to increased flood insurance premiums.

It can be seen from **Figure D-1** through **D-4** that as many as 153 additional structures would be potentially susceptible to a flooding hazard in the regulatory flood (100-year flood) if the existing walls and embankments were not in place; however, complete and simultaneously catastrophic full failure is not a likely flooding hazard scenario. The 'full failure' scenario is relevant in terms of the regulatory issues surrounding certifiability of the floodwalls and levee-like embankments and the consequent impacts to flood insurance premiums.

Title 44 of the Code of Federal Regulations (44 CFR) Section 65.10 provides minimum design, operation, and maintenance standards levee systems must meet and continue to meet in order to be recognized as providing protection from the base flood on a Flood Insurance Rate Map (FIRM). Levee owners must provide appropriate data and documentation to demonstrate the levees are compliant with 44 CFR Section 65.10 requirements in order for the levee to be certified. Similarly, the procedures to be followed and types of information FEMA needs to recognize on a FIRM that walls and levees provide adequate protection from the base flood in an area subject to alluvial fan flooding is described in 44 CFR Section 65.13. The data and documentation requirements are substantial and would require additional engineering analyses in the case of the Rawhide Wash walls and levee-like structures. For example, due to the lack of as-built plans for the walls, a wall profile survey to ascertain top of wall elevations, destructive testing to determine wall reinforcement, and trenching to measure depth of toe down and scour protection would be necessary. Certifiability of these structures is key to the nature of any future changes to the floodplain delineations and NFIP premiums in Rawhide Wash. **Table D-5-2** provides current NFIP statistics for Rawhide Wash.

Table D-5-2. NFIP Statistics for Rawhide Wash

Properties within the Rawhide Wash Floodplain			
Floodplain	**Total Number of Parcels**	**Land Area of Parcels (Acres/Sq. Miles)**	**Parcels with Structures**
Downstream of Happy Valley Road	4,701	6,789/10.6	3,939
Upstream of Happy Valley Road	200	3,447/5.4	141
Total	**4,901**	**10,236/16.0**	**4,080**
Number of NFIP Policies within Rawhide Wash (2012)			
Phoenix	51		
Scottsdale	2,604		
Unincorporated	61		
Total	**2,716**		

Over 2,700 property owners within the Zone AO Rawhide Wash Focus Area floodplain are currently paying flood insurance. An additional 2,000+ properties within the Zone AO Rawhide Wash floodplain are not. The certifiability status of the walls and levees has resultant implications to the regulatory floodplain zone designation and extents, number of properties potentially impacted, and the NFIP insurance premiums.

If the walls and levees are certifiable and an apex control structure constructed to remove alluvial fan uncertainty, then revisions to the regulatory floodplain would include redelineation of the effective Zone AO floodplain to a revised Zone AE floodplain. As a result, based on the localized Rawhide Wash risk assessment, 56 home owners who may currently be paying comparatively low flood insurance rates with an elevation certificate in the effective Zone AO floodplain could potentially be required to pay increased premiums if they are below the base flood elevation (BFE) in a revised Zone AE floodplain. Most of these structures are being flooded by flows escaping the Main channel at Los Portones Drive. Another large fraction are located outside the current AO zone northwest of the West Split channel.

If the walls and levees are not certifiable, then revisions to the regulatory floodplain could result in a change from Zone AO to Zone AE but with wider floodplain extents compared to the 'with certified wall/levee' condition. Based on the localized Rawhide Wash risk assessment, 209 structures would potentially have increased flood insurance rates if the walls and levees are not certifiable.

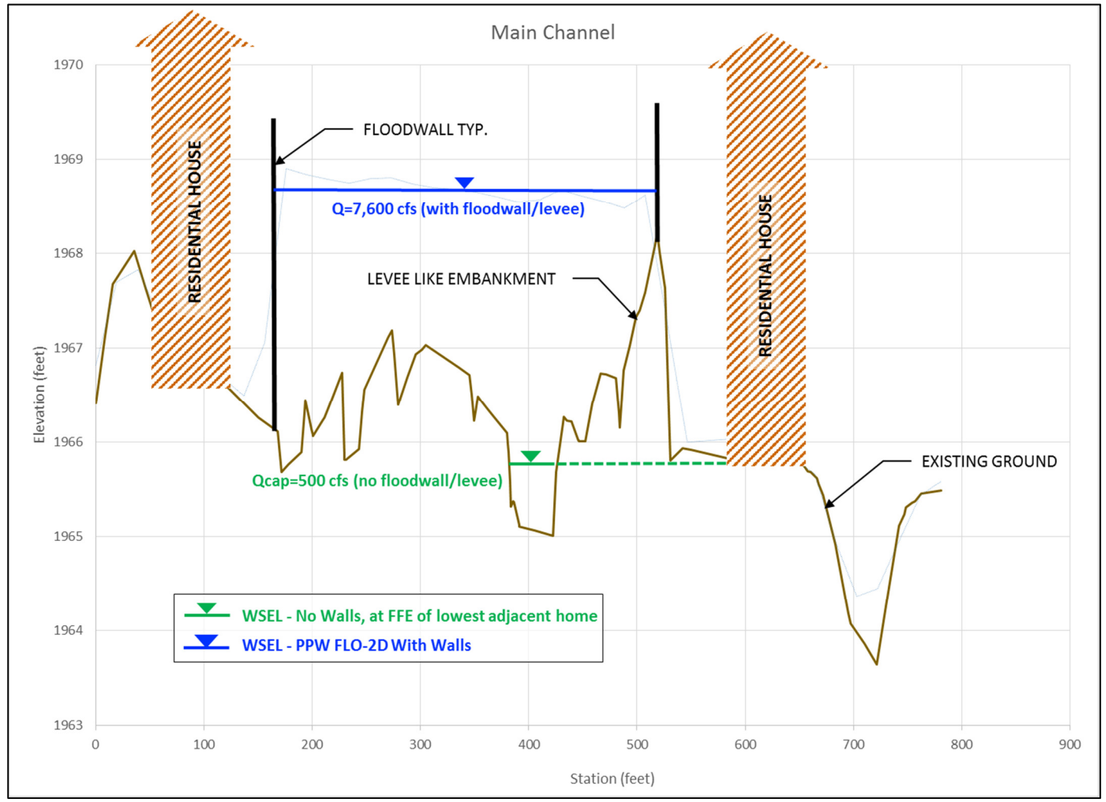


Figure D-5. Main Channel Containment Analysis Results

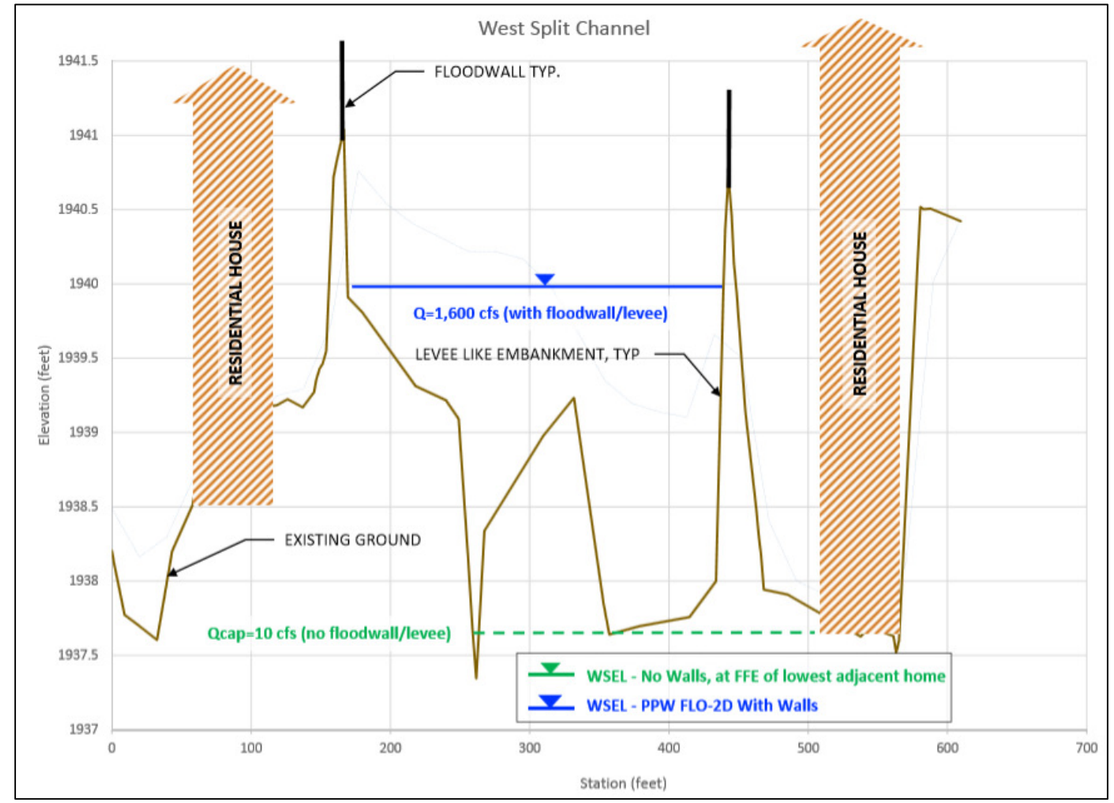


Figure D-6. West Split Containment Analysis Results

No Action vs. No Build – Current AO Zone vs. FLO-2D Results

In order to demonstrate the differences between the No Build and No Action alternatives, additional FLO-2D models of the Rawhide Wash fan were developed. In particular, three flow path uncertainty scenarios were investigated – 1) a West avulsion scenario, 2) a Main channel avulsion scenario, and 3) an East avulsion scenario. The avulsions were accomplished in FLO-2D by adding 'virtual' levees added to the model to force flows down each of the three potential flow paths. The composite 'worst case' result of the three avulsion scenarios plus the three with wall, without wall, and with wall failure scenarios developed as part of the ADMS modeling are shown in **Figure D-7** along with the current FEMA AO Zone boundaries. As can be seen there are large portions of the current AO Zone area that have maximum flow depths less than 0.5 feet implying that the current floodplain exaggerates the actual flood hazard over most of the Rawhide Wash alluvial fan landform.

Figure D-8 shows another type of comparison. The worst case composite maximum flow depths and velocities were compared with the FEMA AO zone depths and velocities. Areas shown in black represent areas where both the worst case maximum flow depth and flow velocity from the FLO-2D analysis are greater than FEMA zone values. Areas in gray are where either the FLO-2D flow depth or flow velocity exceeds the FEMA zone values. In the white areas, the FLO-2D worst case values are both less than the FEMA zone values.

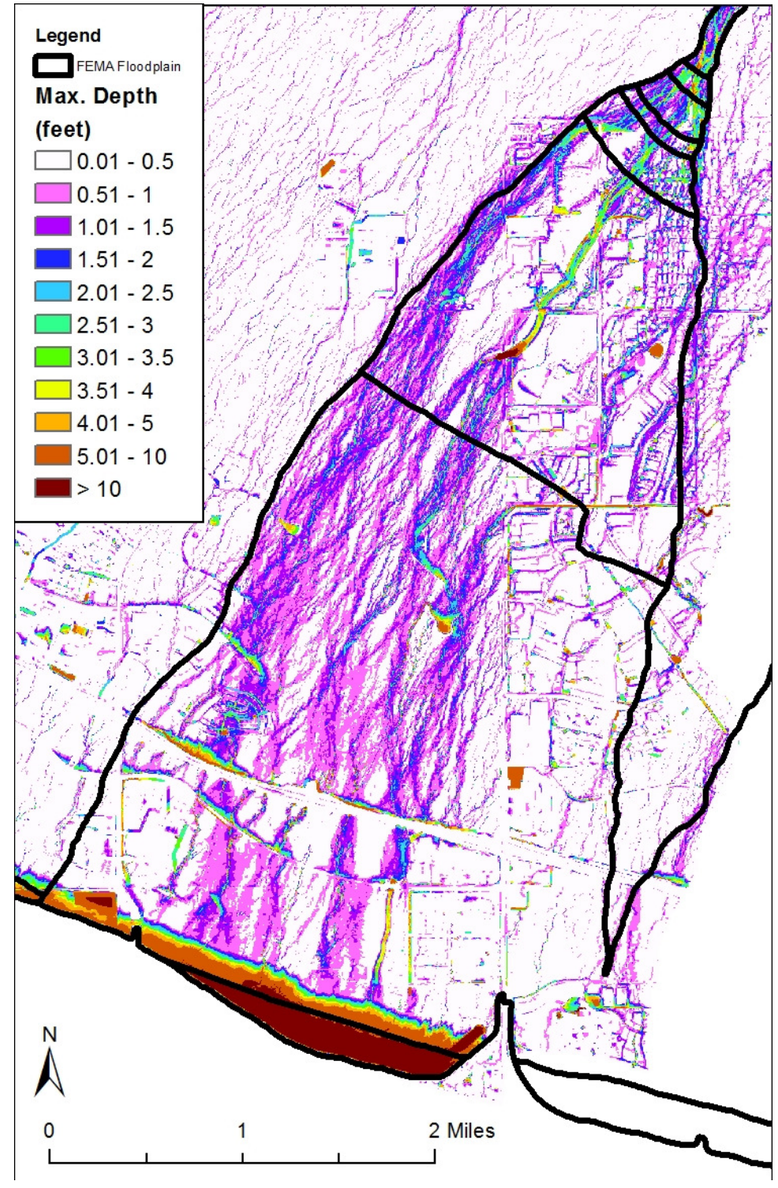


Figure D-7. No Action vs. No Build Flood Hazards

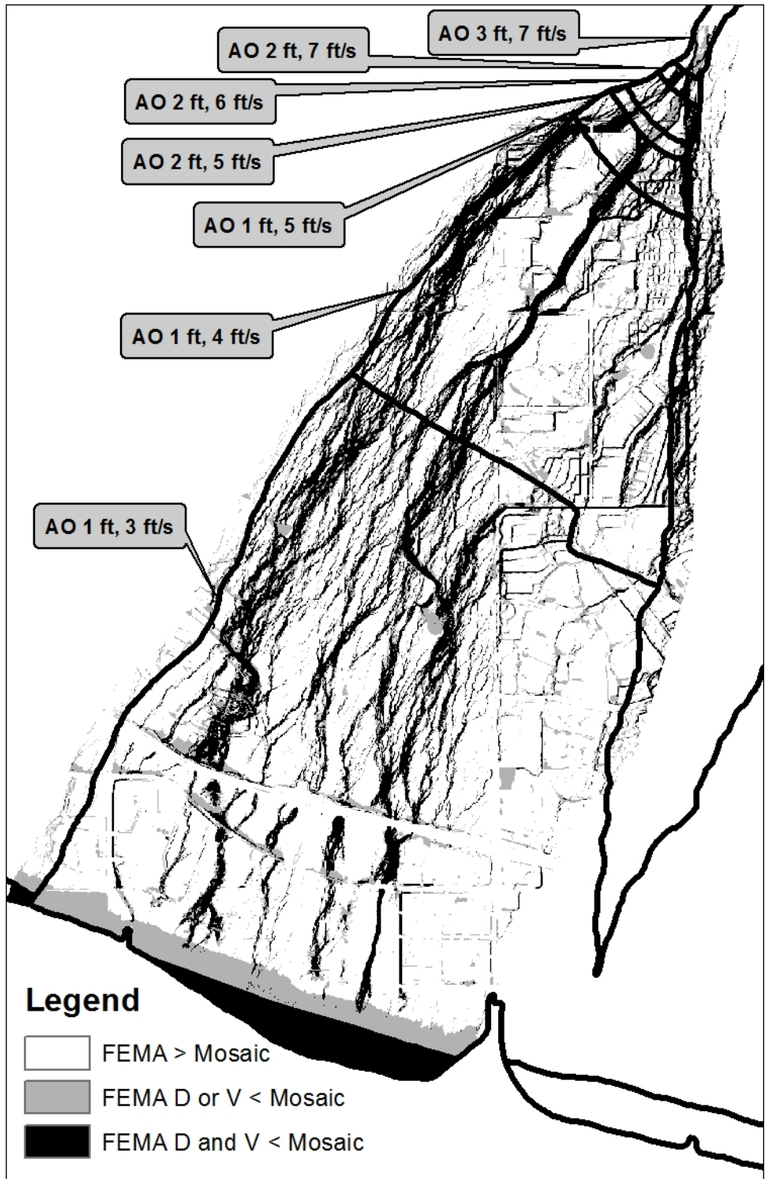


Figure D-8. Comparison of FEMA vs. Worst Case Flood Hazards

Flood Damage Estimates

Potential flood damages to structures at risk of flooding were estimated. Structures at risk of flooding were identified as discussed above and in the PPW ADMS Work Assignment 3 Task 12.0 Flood Hazard Classification and Task 13.0 Flood Risk Determination memorandum (JEF, 2014c). The resulting number of structures were then used to compute estimated flood damages over a 50-year period using a modified average annual loss (AAL) method from the FEMA Hazus-MH Technical Manual. The modification was to account for the use of only the 10-year, 25-year, and 100-year flow depths available from the ADMS FLO-2D modeling. The additional frequencies normally used in the Hazus AAL method were not available. **Table D-4-3** presents the flood damage calculations for the Rawhide Wash existing AO zone floodplain area downstream of the fan apex. It can be seen that 50-year flood damage potential exceeds $44 million.

The future 50-year flood damages were also estimated for the Build alternatives. Given that all four build alternatives will effectively contain the full apex discharge within either the Main channel only (Alternatives B & D) or both the Main channel and West Split, all structures at risk in the area generally bounded by Scottsdale Road, Pima Road, Happy Valley Road, and Pinnacle Peak Road are assumed to be removed from flood hazard and thereby future flood damages. However, portions of the current AO Zone floodplain area south of Pinnacle Peak Road and east of Scottsdale Road remain at some level of flood risk as most of the flooding in these areas actually results from local flows and watersheds emanating from the Pinnacle Peak South ADMS area to the east. This computation also assumes that all future construction will be built to be free from future flood damage. The structures benefited by the Build alternatives were subtracted from the future flood damages resulting in about $25 million in flood damage reduction over a 50-year period if the Build alternative were to be implemented. **Table D-4-4** shows the with Build alternative future flood damage computations.

Table D-5-3. 50-year Flood Damage Estimate for Rawhide Wash AO Floodplain Area

Damage Cost per Home per Flood Depth Range			
Low	Moderate	High	Very High
0.5-1.5 Ft.	1.5-2.5Ft.	>2.5 Ft.	>2.5 Ft. with high velocity
$ 52,000	$63,000	$68,000	$136,000

		Number of Homes in Flood Depth Range						
		Low	Moderate	High	Very High (w/ Velocity)			
Return Period	Frequency	0.5-1.5 Ft.	1.5-2.5Ft.	>2.5 Ft.	>2.5 Ft.	Economic Loss	AAL Contribution	AAL/ Economic Loss
10-year	0.1	124	8	2	0	$7,088,000	$ 539,160	0.08
25-year	0.04	186	16	3	0	$10,884,000	$ 590,070	0.05
100-year	0.01	459	62	8	1	$28,454,000	$ 284,540	0.01
						AAL Total	**$1,413,770**	

Inflation Rate	2%
Project Life Span in Years	50
Present Value of Flood Damage	**$44,425,751**

Table D-5-4. 50-year Flood Damages for Build Alternatives

Damage Cost per Home per Flood Depth Range			
Low	Moderate	High	Very High
0.5-1.5 Ft.	1.5-2.5Ft.	>2.5 Ft.	>2.5 Ft. with high velocity
$52,000	$63,000	$68,000	$136,000

		Number of Homes in Flood Depth Range						
		Low	Moderate	High	Very High (w/ Velocity)			
Return Period	Frequency	0.5-1.5 Ft.	1.5-2.5Ft.	>2.5 Ft.	>2.5 Ft.	Economic Loss	AAL Contribution	AAL/ Economic Loss
10-year	0.1	47	3	1	0	$ 2,701,000	$ 240,810	0.09
25-year	0.04	89	10	1	0	$ 5,326,000	$ 248,130	0.05
100-year	0.01	162	40	4	0	$11,216,000	$ 112,160	0.01
						AAL Total	**$ 601,100**	

Inflation Rate	2%
Project Life Span in Years	50
Present Value of Flood Damage	**$18,888,730**

PRELIMINARY ALTERNATIVES FORMULATION

Appendix E presents the analysis of preliminary alternatives developed and from which the Build Alternatives presented in the main report were derived. The following sections describe the preliminary alternatives development and evaluation.

Characteristics of Alluvial Fan Flooding

Known problems associated with alluvial fan flooding include spatial uncertainty of the flow distribution, lack of containment within the relatively flat topographic relief laterally across the fan, rapid avulsive movement of defined flow paths, flooding along undefined flow paths, sheet flooding, distributary flow, scour, and landform aggradation. In addition, the steep channel slopes between the fan apices and the fan toes result in high flow velocities with enough energy to move significant volumes of sediment and debris episodically during rare floods.

The highly dynamic nature of the alluvial fan flooding presents real challenges in the design of engineered flood control measures to contain and convey 100-year discharges from apex to outfall without creating unwanted sediment aggradation or degradation impacts. Further complexity is added as flood hazards change in type and severity with geographic position on the fan depending on whether the area of interest is located at the apex, mid-fan, or near the outfall; and with the occurrence of flood events of frequencies other than the 100-year event.

In the case of the Rawhide Wash alluvial fan, the physical system has been significantly altered by land development with the construction of custom houses, master planned communities, and associated drainage infrastructure; particularly in the fan area east of Scottsdale Road. In contrast, the portion of the Rawhide Wash alluvial fan west of Scottsdale Road lies within undeveloped State Trust Land so that fan processes occur in a mostly natural state.

Candidate Alternatives Strategies

Three general alternative strategies will be used to approach the flood hazard mitigation goals for Rawhide Wash. These include the '**Build'** strategy comprising structural storage/conveyance elements, **'No Build'** which involves floodplain redelineation without structural components, and **'No Action'** which employs the current floodplain management strategy.

Build

In order to effectively achieve the dual design goals of reducing the uncertainty of alluvial fan avulsion potential at the apex and reducing the regulatory floodplain throughout the fan landform, a whole-fan Build alternative strategy would be required. The dual functions needed for a whole-fan approach to the alternatives formulation include storage and conveyance. Candidate storage options include in-line and off-line detention and sediment basins with or without splitter structures. Candidate conveyance options include underground pipes and channelization with or without leveed containment of one or both channel banks. The whole-fan approach to alternatives formulation comprises strategic combinations of the various storage and conveyance options which together effectively control alluvial fan uncertainty at the apex and convey discharge and sediment from the apex to the outfall. **Table E.1** lists the candidate storage and conveyance components for consideration in formulating combined whole-fan strategies for the Rawhide Wash flood hazard mitigation alternatives.

In addition to structural storage and conveyance components, the whole-fan strategy will also require with-project hydrologic/hydraulic modeling to address the design goal of modifying the FEMA regulatory floodplain. The with-project condition models will result in reduced floodplain extents and will be implemented through the appropriate FEMA processes to revise the current effective Zone AO designation.

No Build

The No Build alternative for Rawhide Wash would involve redelineation of the current Zone AO floodplain without construction of any storage and/or conveyance components. The need for redelineation is justified based upon the updated hydrology, new topography, and significant changes to the watershed and floodplain environment due to development. Redelineation also provides updated regulatory floodplain for the local jurisdictions and a better depiction of the existing flood hazards in the area compared to the No Action alternative. Additionally, the No Build alternative does not eliminate the alluvial fan uncertainty. As a result downstream development including Paradise Ridge will require expensive duplicative elements to accommodate full apex flows because of the avulsion potential downstream of the fan apex.

No Action

The No Action alternative contrasts with the structural whole-fan alternatives described above in that the No Action alternative involves continuing to regulate the current Zone AO floodplain as is. Residents will continue to pay National Flood Insurance Program (NFIP) premiums in perpetuity. New construction will be required to elevate per current drainage ordinances and regulations based on the current Zone AO floodplain delineation. Drainage infrastructure for the Paradise Ridge development will also require expensive duplicative elements to accommodate full apex flows because of the avulsion potential downstream of the fan apex.

Table E.1. Candidate Storage and Conveyance Components

Build - Storage	Build - Conveyance
Dynamite In-line Basin - Full Attenuation (**Figure E.1**)	Happy Valley Diversion Channel/Levee (**Figure E.8**)
Jomax In-line Sediment Basin (**Figure E.2**)	Fully Excavated Channel (**Figure E.9**)
Jomax In-line Sediment Basin + Off-line Attenuation Basin (**Figure E.3**)	Underground Pipes (**Figure E.10**)
Happy Valley In-line Sediment Basin (**Figure E.5**)	Leveed Containment * - Existing Flood Wall Certification
Happy Valley In-line Sediment Basin + Off-line Attenuation Basin (**Figure E.6**)	Leveed Containment * - New Flood Walls
Happy Valley In-line Stepped Sediment + Splitter Structure (**Figure E.7**)	Leveed Containment * - Earth Embankment
No Storage Facility	No Conveyance Facility
No Build - New FEMA Floodplain Delineation	
No Action - Current regulatory practices, flood insurance, and flood hazard un-mitigated	

Build

Several alternatives were considered and developed to varying levels of analysis detail. Some of the alternatives were deemed ineffective or impractical at a fairly high level while others were advanced to a more detailed level of evaluation. The following sections describe the preliminary alternatives considered.

Dynamite In-line Detention Basin

The Dynamite In-Line Detention Basin alternative consists of constructing a large basin on a one-square mile State Trust Land parcel on the southwest corner of Dynamite Boulevard and Pima Road. JE Fuller developed a conceptual basin footprint for a below grade basin (i.e. no earthen embankment or dam) and evaluated two prior basin design plans from past studies in 1995 (CH2M Hill) and 1999 (HDR), both of which attempted to balance earthwork with an earthen dam of approximately 40-feet in height. The below grade basin option was sized to capture the entire 100-year runoff volume of 1,540 acre-feet which required a 60-foot drop in grade at the upstream end. The previously designed basins were sized to attenuate the 100-year runoff and release approximately 700 – 900 cfs, and to accommodate sediment storage. The advantage of this alternative is it reduces or eliminates the need for any further flood hazard mitigation alternatives downstream of Jomax Road as the existing drainage infrastructure is sufficient to handle relatively small releases from the basin and runoff from tributary areas downstream of the structure.

The latest cost for the construction of the previously designed basins was estimated to be over $30 million not including land costs. All three basin footprints are relatively large as shown **Figure E.1** and would consequently result in costly land acquisition. Using the below grade basin footprint of 150 acres and a very rough land acquisition cost per acre for the area of $50,000 (estimate provided by ASLD), the land required for the basin could cost as much as $7.5 million. There are two electrical power transmission lines bisecting the parcel that would be difficult to relocate or accommodate with the construction of a large detention basin. Furthermore, it is understood that the community acceptance of a large structure in the area is low based on the results from the Context Sensitive Flood Hazard Mitigation (CSFHM) Community Context evaluation (LSD, 2013) and past planning experiences within the area. This alternative was abandoned due to cost, context sensitivity criteria, and power line constraints.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, constructability, environmental impacts and aesthetics.

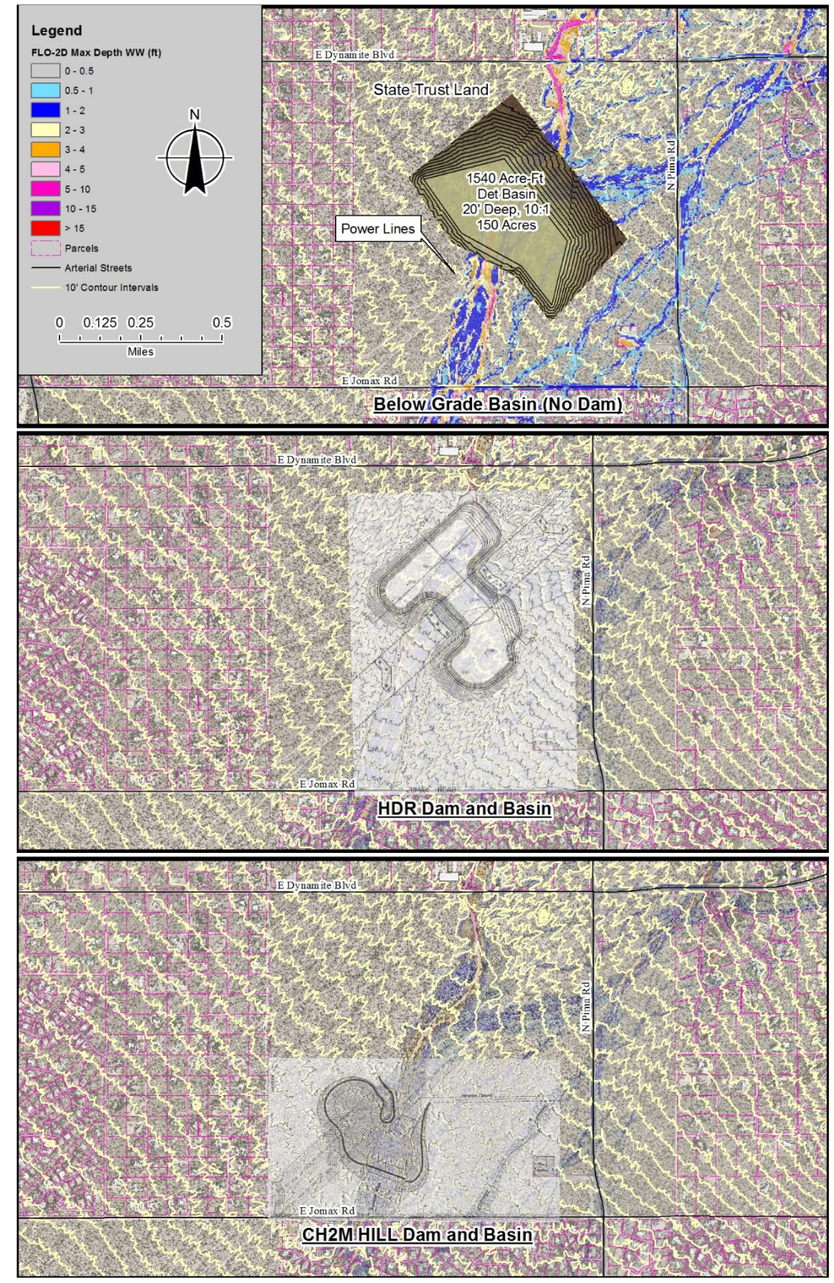


Figure E.1. Dynamite Inline Detention Basins

Jomax In-Line Sediment Basin

The primary mechanisms causing the uncertainty of alluvial fan flood hazards is the potential for a channel avulsion due to aggradation or stream piracy. Both can alter the primary flow path below the fan apex. Therefore, controlling sediment deposition and preventing stream piracy is required to mitigate this uncertainty. The Jomax In-Line Sediment Basin alternative consists of several components that comprise a full mitigation solution as shown in **Figure E.2**. Several components of this alternative will also be required in other alternatives and will be described in this section as follows:

Tributary Containment North of Jomax Road – A tributary enters Rawhide Wash north of Jomax Road from the east. This tributary has an effective FEMA Zone AO fan floodplain delineated and also shows breakouts based on the FLO2-D modeling conducted for this study. It may be prudent to control this tributary flow with a channel, embankment, or floodwall as part of a full flood mitigation solution.

Jomax In-Line Sediment Basin – A sediment basin is needed to control sediment to eliminate the mechanisms of flow path uncertainty associated with the Rawhide Wash alluvial fan. The sediment basin capacity requirement was estimated at 40 acre-feet based on the two previous designs (CH2M HILL, 1995; HDR, 1999) for the Dynamite detention basins. The maximum design sediment load of these previous designs was 20 acre-feet. This volume was doubled to account for sediment distribution inefficiencies within the basin. It is likely some appurtenant road improvements may be required on Jomax Road to control outflow from the basin.

Eastern Containment North of Happy Valley Road – Containment of Rawhide Wash breakout flows near the fan apex to the southeast will be needed to eliminate flow path uncertainty in that direction. There are some existing discontinuous walls, one of which was designed as a floodwall, which may be sufficient with some type of augmentation.

Western Containment North of Happy Valley Road – The containment of Rawhide Wash breakout flows near the fan apex to the west will be needed to route floodwater and sediment into the flow splitter at Happy Valley Road and prevent channel avulsion to the west. This can be achieved with a channel, embankment, or floodwall.

Happy Valley Road Flow Split Control Structure – A flow split control structure will be needed north of Happy Valley Road to 'fix' the existing flow split to maintain the existing conditions of the Rawhide Wash natural system. The proportion of total inflow routed to the Main channel and West Split channel will be determined considering existing conditions and existing infrastructure/containment/capacity along each channel. There is a significant amount of sediment that can be generated from the approximate 1-mile reach of Rawhide Wash between Jomax Road and Happy Valley Road. Therefore, some level of sediment storage may also be needed within the flow splitter control structure.

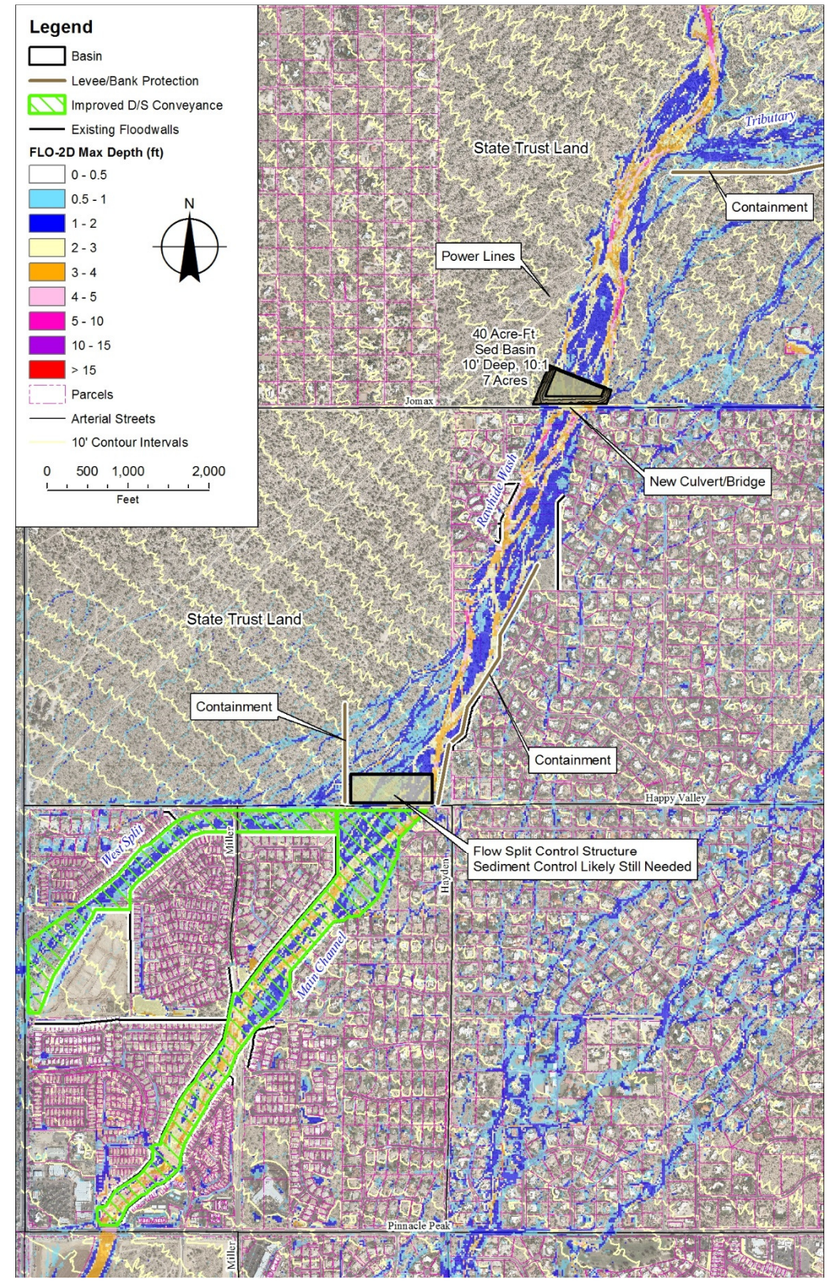


Figure E.2. Jomax Inline Sediment Basin

Improved Downstream Conveyance – As discussed previously, the existing capacity of the Main channel and West Split channel downstream of Happy Valley Road is not sufficient to convey the 100-year flood even though significant infrastructure has been designed and built to protect residential properties along both channels. There are several ways to improve the conveyance capacity as listed below:

- Excavated channel(s)
- Storm drains below the channel(s)
- Certify floodwalls
- Construct new floodwalls
- Construct new levees

Improvement of downstream conveyance is not necessary to removal of the Zone AO floodplain; thus, such improvements are more of a regulatory consideration and not a design requirement or condition of this alternative. The various conveyance improvement alternatives are additional design features that could be implemented in a phased manner.

Scottsdale Road to Reach 11 Dike Flood Pool – Improvements west of Scottsdale Road will be necessary to convey flows from the Main channel and West Split channel to its ultimate outfall in the Reach 11 Dike flood pool. Although this area is outside of the Rawhide alternatives focus area, these improvements will be necessary for the full fan solution.

The disadvantages of a sediment basin at Jomax Road is that a flow split control structure is still needed at Happy Valley Road and would require that two undeveloped State Trust Land parcels be impacted. Furthermore, additional sediment storage will likely be needed at Happy Valley Road to handle the sediment generated from the 1-mile plus reach of natural channel between Jomax Road and Happy Valley Road.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, implementation, constructability, and environmental impacts.

Jomax In-Line Sediment Basin and Off-Line Detention Basin

The Jomax In-Line Sediment Basin and Off-Line Detention Basin alternative is the same alternative as the previous Sediment Basin option, but with the addition of an Off-Line Detention Basin as shown in **Figure E.3**. The basin would be located to the east of Rawhide Wash to avoid the power line corridor and would require a long lateral weir structure to adequately reduce the peak discharge. The basin would be located below grade (i.e. no earthen embankment or dam) and sized to capture 100 acre-feet at the peak of the flood hydrograph as illustrated in **Figure E.4**. The 100-acre-feet target was established using very approximate hydrograph volume computation to limit the 100-year peak discharge downstream to approximately 7,000 cfs (from 9,700 cfs). Based on preliminary conversations with the City of Scottsdale, it was assumed that 7,000 cfs could be safely conveyed downstream with minimal flooding of existing residential and commercial properties. Furthermore, 7,000 cfs would reduce the size and cost of downstream improvements that would be needed to safely convey floodwater through the developed area. However, all of the same improvements would still be needed. They are listed below for reference.

- Tributary Containment North of Jomax Road
- Jomax In-Line Sediment Basin
- Eastern Containment North of Happy Valley Road
- Western Containment North of Happy Valley Road
- Happy Valley Road Flow Splitter Control Structure
- Improved Downstream Conveyance
- Scottsdale Road to Reach 11 Dike Flood Pool

With the peak flow reduction, it is possible that breakout flows to the West Split channel could be eliminated and the Improved Downstream Conveyance would be limited to the Main channel. This would need to be evaluated further.

The cost for the construction of the Off-Line basin would likely be upwards of $5 million and requires a footprint of approximately 25 acres. Using the approximate land acquisition cost per acre for the area of $50,000, the land required for the basin could cost more than $1.2 million. Furthermore, it is understood that the community acceptance of a large structure in the area is low based on the results from the CSFHM community context evaluation and past planning experiences within the area. This alternative was abandoned due to scale, cost, and because it does not meet the context sensitivity criteria.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, constructability, environmental impacts and aesthetics.

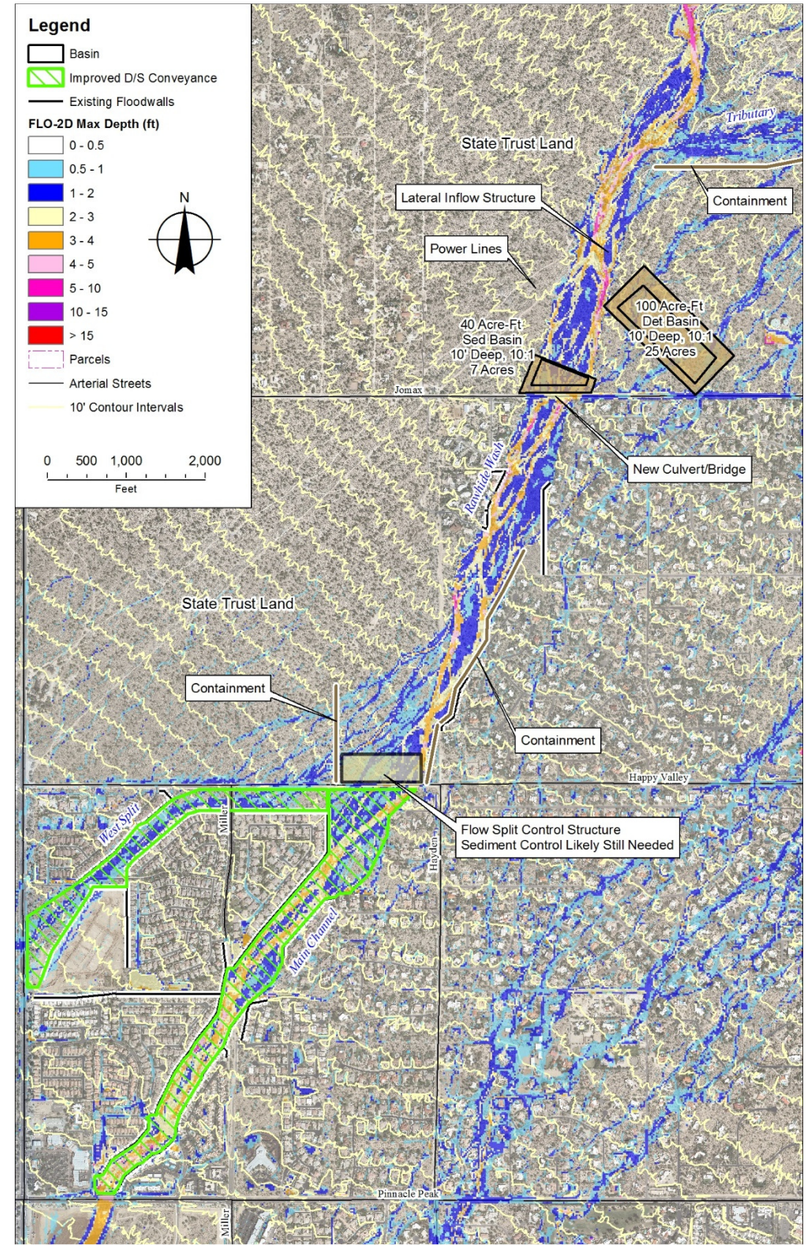


Figure E.3. Jomax Sediment and Offline Detention Basin

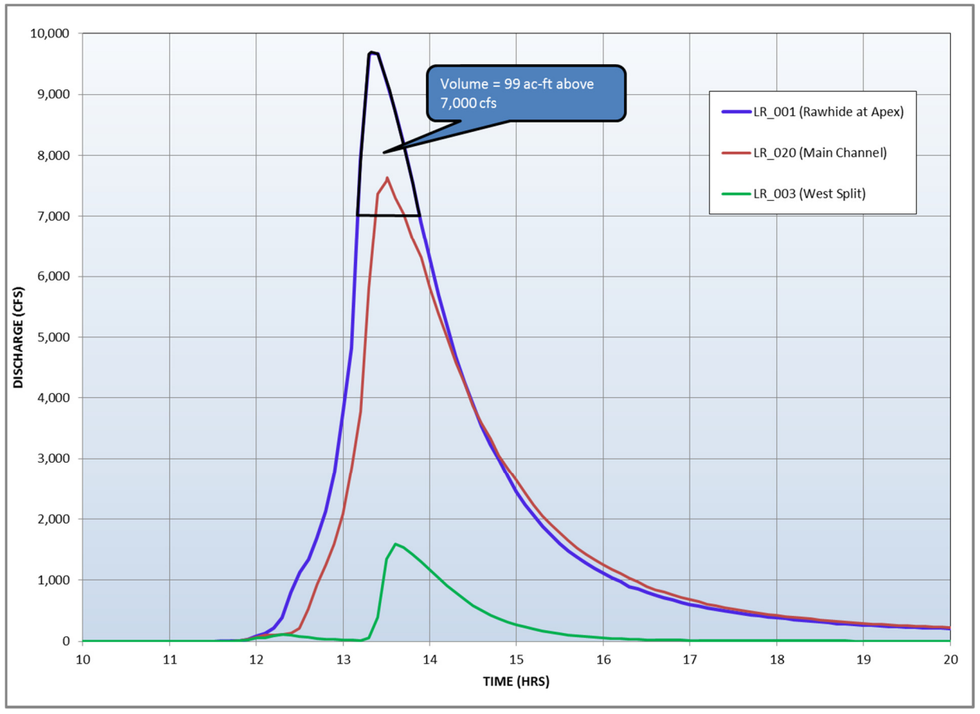


Figure E.4. Offline Detention Volume Requirements

<u>Happy Valley In-Line Sediment Basin</u>

The Happy Valley In-Line Sediment Basin is similar to the Jomax In-Line Sediment Basin but with the basin located just north of Happy Valley Road as shown in **Figure E.5**. Controlling the sediment deposition would mitigate flow path uncertainty associated with the Rawhide Wash alluvial fan. The sediment basin would also include outflow features to maintain the split between the Main channel and the West Split channel. Furthermore, the same downstream improvements would be needed to safely convey floodwater through the developed area as listed below for reference.

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Western Containment North of Happy Valley Road
- Happy Valley Road Flow Split Control Structure
- Improved Downstream Conveyance
- Scottsdale Road to Reach 11 Dike Flood Pool

The Happy Valley Road location has the advantage of combining the sediment basin and flow split control structure to one location while reducing the total impacted area and is located in a portion of State Trust Land that is not planned for development (because it is within a flood high hazard area already).

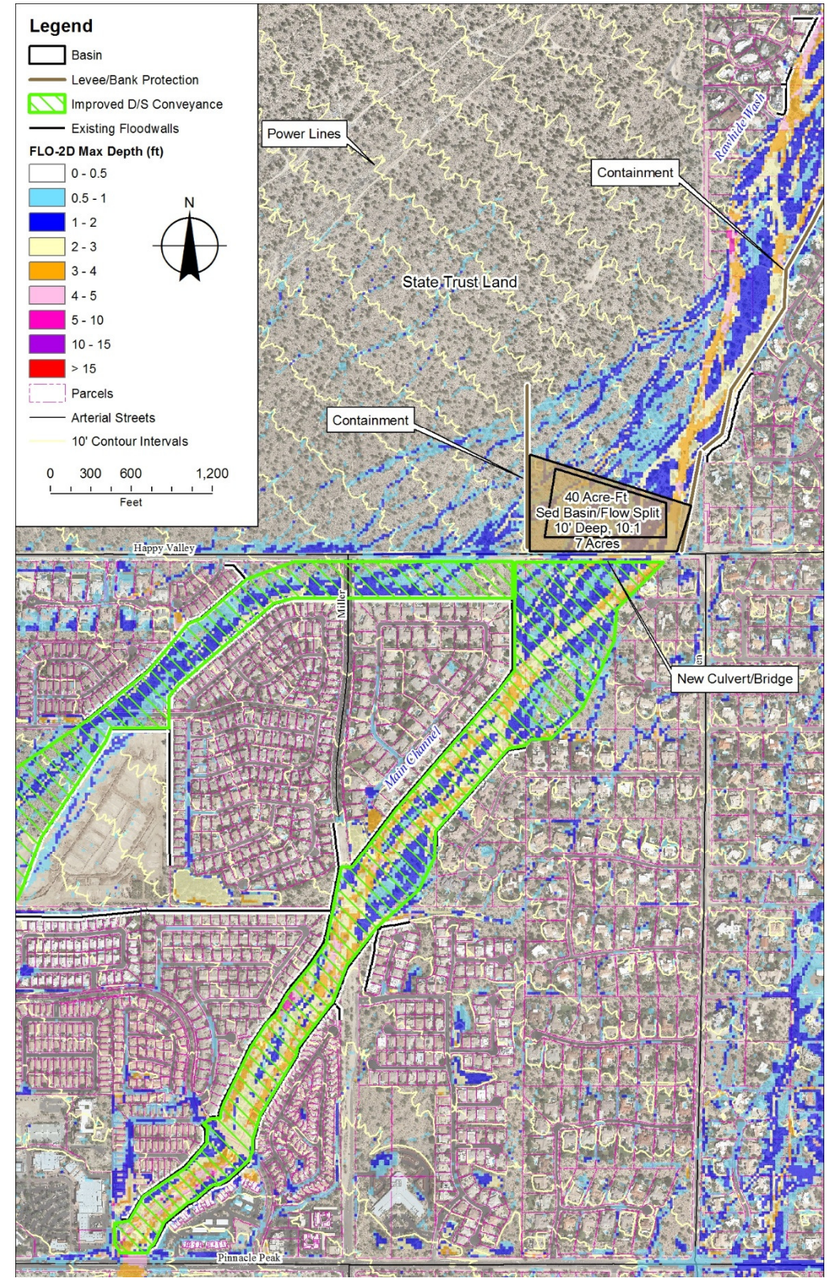


Figure E.5. Happy Valley Sediment Basin

Happy Valley In-Line Sediment Basin and Off-Line Detention Basin

The Happy Valley In-Line Sediment Basin and Off-Line Detention Basin alternative is the same as the previous Sediment Basin only option, but with the addition of an Off-Line Detention Basin as shown in **Figure E.6**. This alternative is similar to the Jomax Off-line Basin alternative in function. However, the basin would be located to the west of Rawhide Wash. The basin would require a long lateral weir structure to adequately reduce the peak discharge. The basin would be located below grade (i.e. no earthen embankment or dam) and sized to capture 100 acre-feet at the peak of the flood hydrograph. This would limit the 100-year peak discharge downstream to approximately 7,000 cfs (from 9,700 cfs) thus reducing the size and cost of downstream improvements that would be needed to safely convey floodwater through the developed area. However, all of the same improvements would still be needed listed below for reference.

- Happy Valley Road In-Line Sediment Basin
- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Western Containment North of Happy Valley Road
- Happy Valley Road Flow Splitter Control Structure
- Improved Downstream Conveyance
- Scottsdale Road to Reach 11 Dike Flood Pool

As with the Jomax Off-Line basin alternative, the cost for the construction of the Off-Line basin would likely approach $5 million with a land acquisition cost as much as $1.2 million. Furthermore, it is understood that the community acceptance of a large structure in the area is low based on the results from the CSFHM community context evaluation and past planning experiences within the area. This alternative was abandoned due to scale, cost, and because it does not meet the context sensitivity criteria.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, constructability, environmental impacts and aesthetics.

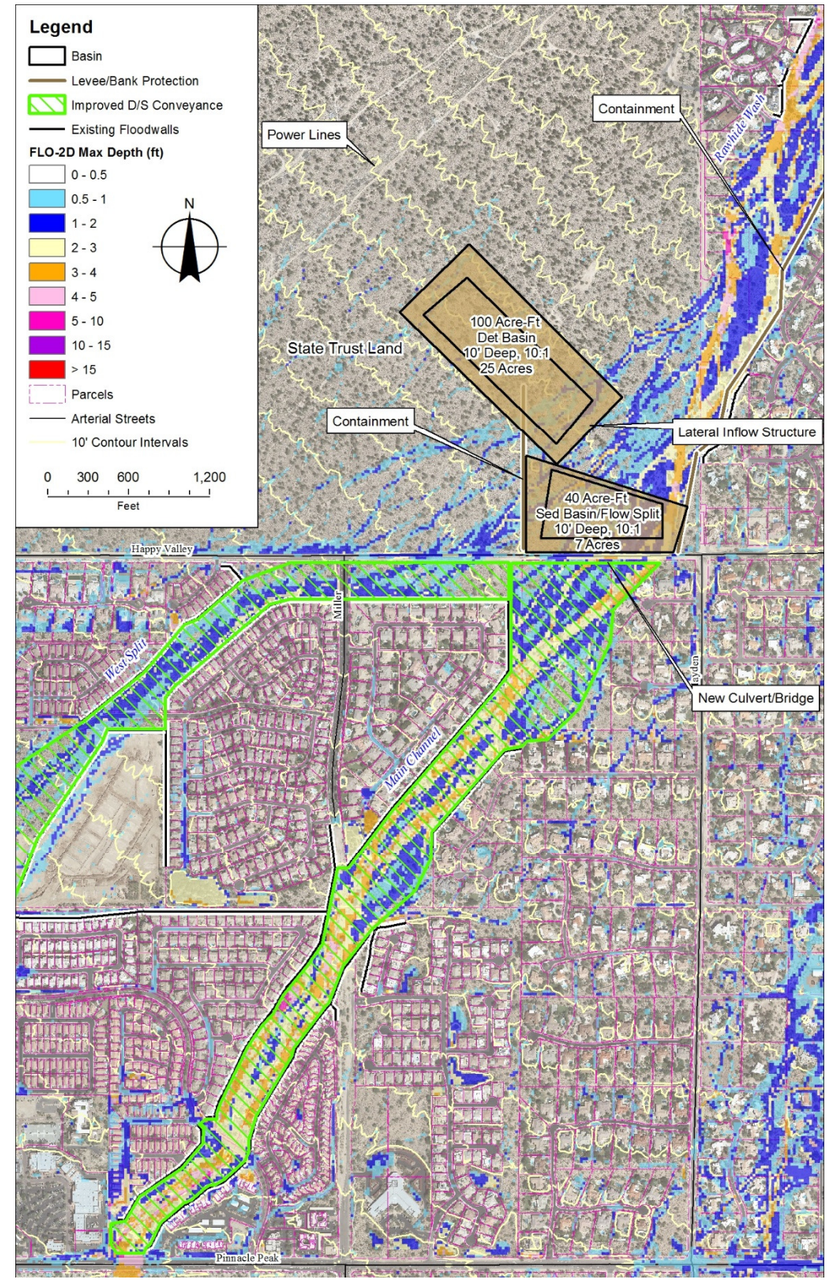


Figure E.6. Happy Valley Sediment/Offline Detention Basin

Happy Valley In-Line Stepped Sediment Basin

The Happy Valley In-Line Stepped Basin alternative is a variation of the In-Line Sediment basin alternative. Instead of a relatively deep sediment basin, a more natural looking series of broad drop structures could be constructed to reduce bed slope and force sediment to drop out and be distributed more naturally along the fan apex as shown in **Figure E.7**. The community acceptance of a medium scale, natural structure is expected to be better than for the below-grade structure.

The disadvantages of this alternative is the footprint is much larger taking up approximately 55 acres that could result in a land acquisition cost as much as $25 million. Furthermore, the design would be more complex and the maintenance could be more difficult and/or costly.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, land ownership, and implementation.

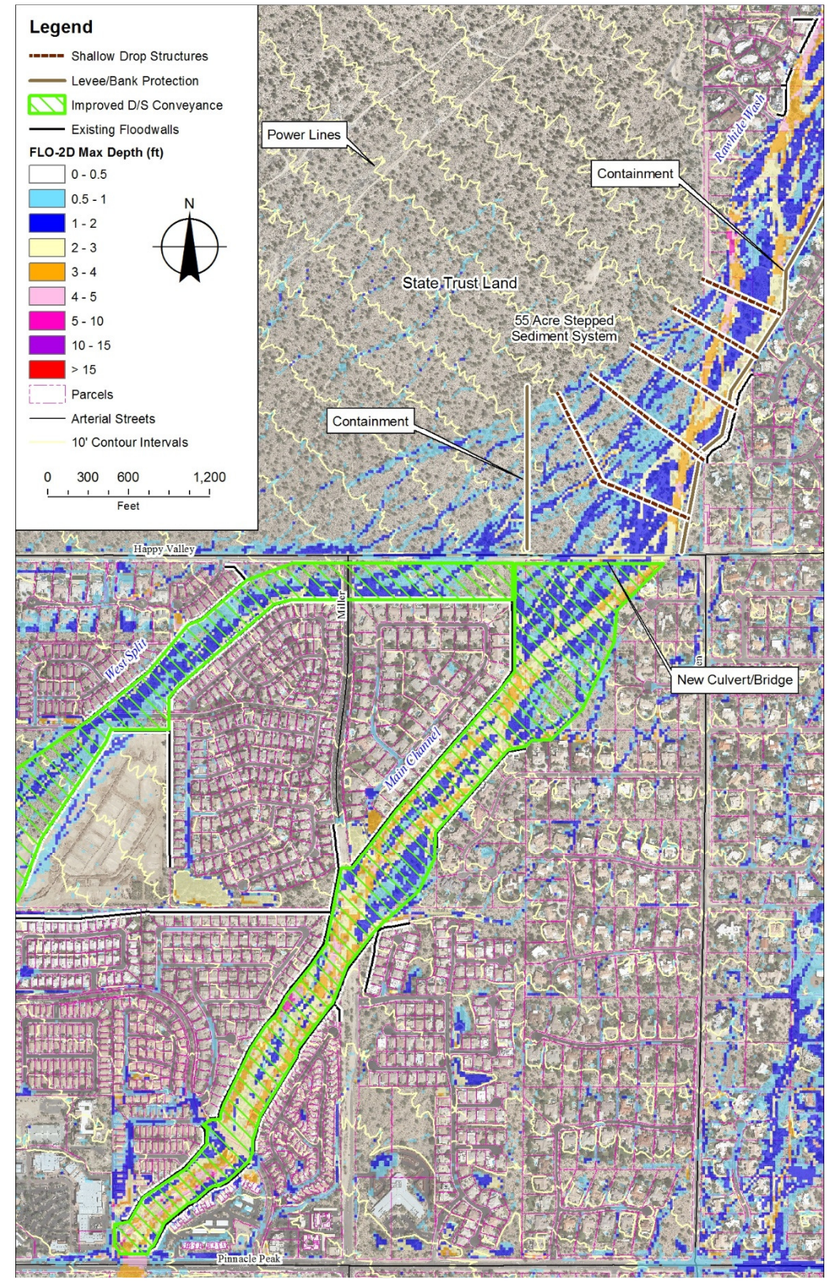


Figure E.7. Happy Valley Stepped Sediment Basin

Happy Valley Diversion Channel/Levee

The Happy Valley Diversion Channel/Levee alternative entails the construction of either a diversion channel, levee embankment, or combination of both to divert Rawhide Wash in part or in its entirety along Happy Valley Road to the west under a new bridge under Scottsdale Road (see **Figure E.8**) and a bridge for the future Miller Road northerly extension planned by the City of Scottsdale. Lateral outflow structures could be built to maintain some amount of flow to one or both of the Main and West Split channels. The following additional improvements would still be needed for a complete mitigation solution:

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Scottsdale Road to Reach 11 Dike Flood Pool

The disadvantages of this alternative is the footprint would be about 40 acres that could result in a land acquisition cost as much as $2 million and located along approximately 1-mile of Happy Valley Road frontage which is undesirable for access to future development. If sediment from Rawhide Wash could be adequately transported along the diversion, the alluvial fan apex would simply be relocated to Scottsdale Road and Happy Valley Road until further improvements were made west of Scottsdale Road. This alternative would require more than a mile of an additional drainage conveyance facility west of Scottsdale Road. Furthermore, it is understood that the community acceptance of a new large structure in the area is low based on the results from the CSFHM community context evaluation and past planning experiences within the area.

This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: cost, land ownership, implementation, constructability, physical/environmental impacts and aesthetics.

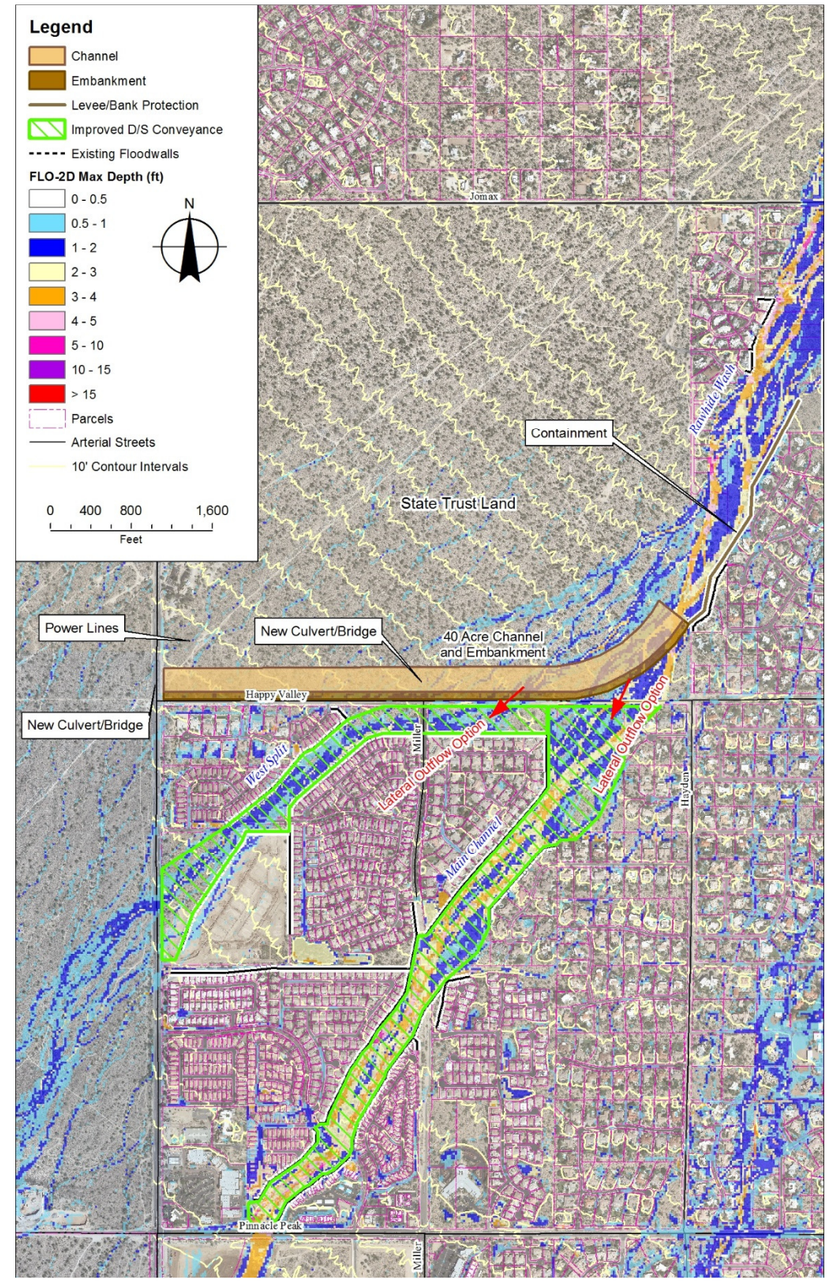


Figure E.8. Happy Valley Diversion Channel/Levee

Improved Downstream Conveyance Alternatives

As outlined in **Table E.1**, there are several alternative options for conveyance of floodwater downstream from the alluvial fan apex to Scottsdale Road and the future Paradise Ridge Planned Community District. Improvement of downstream conveyance is not necessary to removal of the Zone AO floodplain; thus, such improvements are more of a regulatory consideration and not a design requirement or condition of this alternative. The various conveyance improvement alternatives are additional design features that could be implemented in a phased manner. The following sections present a series of conveyance alternatives.

Fully Excavated Channel

A fully excavated channel would consist of excavating/channelizing the Main and/or West Split channel from Happy Valley Road to Pinnacle Peak Road to safely convey floodwater through the developed area without relying on existing walls or embankments to contain the flows (**Figure E.9**). A fully excavated channel would have to be armored to prevent bank erosion. Portions of the existing floodwall erosion protection measures may be adequate but would require exploratory excavation to reveal type, size, material, dimensions, and toe-down depth. The City of Scottsdale has a Natural Area Open Space (NAOS) ordinance that limits the disturbance of natural wash corridors. However, there is an exception for large washes (100-year discharge of 2,000 cfs or more) that could be utilized as long as any hardened improvements are covered with sacrificial soil and revegetated.

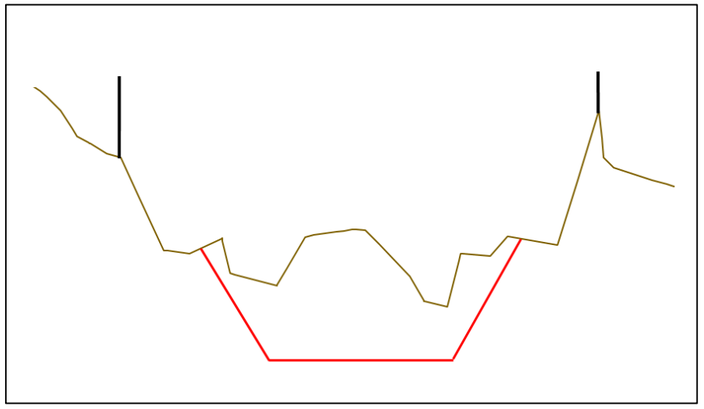


Figure E.9. Conceptual Fully Excavated Channel Section

An excavated channel would have to be designed to account for adequate sediment transport as well as flood capacity. The channel would need to be constructed from north of Happy Valley Road at or above the apex to Pinnacle Peak Road. Allowing the sediment to be delivered all the way to Scottsdale Road would then likely move the apex from its current location north of Happy Valley Road to just downstream of Scottsdale Road until channelization or other improvements are constructed west of Scottsdale Road. Alternatively, the excavated channel could be constructed in conjunction with the Happy Valley In-Line Sediment Basin however this would likely increase the cost due to the additional need for grade control to mitigate long-term degradation. The following additional improvements would still be needed for a complete mitigation solution:

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Happy Valley Road Flow Splitter Control Structure
- Western Containment North of Happy Valley Road
- Scottsdale Road to Reach 11 Dike Flood Pool

Based on results from the CSFHM community context and past planning experiences within the area, it is anticipated that construction in the wash from Happy Valley Road to Pinnacle Peak Road would have low acceptance. This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: land ownership, constructability, physical/environmental impacts and aesthetics.

Underground Pipes

This alternative consists of large diameter multi-barrel pipes constructed underneath the Main channel and/or the West Split channel to safely convey floodwater through the developed area without relying on existing walls or embankments to contain the flows (**Figure**). The following additional improvements would still be needed for a complete mitigation solution:

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Happy Valley Road In-Line Sediment Basin
- Happy Valley Road Flow Splitter Control Structure
- Western Containment North of Happy Valley Road
- Scottsdale Road to Reach 11 Dike Flood Pool

The District provided a rough construction cost estimate for a 4 barrel, 10-ft diameter storm drain under the channel of $25-30 million. Although no costs were estimated for the other alternatives to increase the conveyance capacity, they are all assumed to be less costly than the underground pipe option. Furthermore, the a large scale underground facility may be difficult to obtain environmental permitting of construction in the wash from Happy Valley Road to Pinnacle Peak Road would be costly and complicated. This alternative failed to advance to conceptual alternative consideration as it failed the following evaluation criteria: land ownership, constructability, physical/environmental impacts and aesthetics.

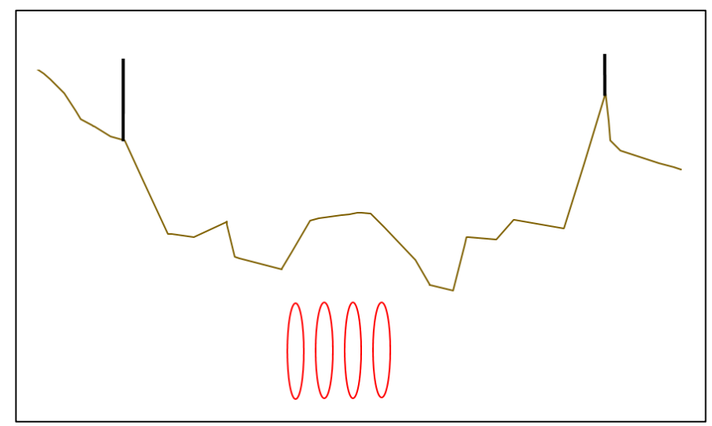


Figure E.10. Conceptual Underground Pipe Section

Leveed Containment with Existing Flood Wall Certification

This alternative consists of obtaining as-built drawings of all the walls along the Main and West Split channels to determine if they meet Code of Federal Regulations (CFR) 65.10, *Mapping of areas protected by levee systems*, for adequate freeboard and structural resistance to flooding and scour. The intent of this alternative is to change the effective Zone AO floodplain to Zone AE and demonstrate to FEMA that adequate flood protection is in-place to remove improved properties from the flood hazard of Rawhide Wash. As discussed previously, a data collection effort was conducted (JEF, 2014a) to obtain as-built construction drawings for the walls within the Rawhide Wash alternative study area (see **APPENDIX C**). Plans were only available for a subset of all of the walls. Of these, only a few of the plan sets indicated that the walls were built for flood protection and included scour protection. Limited or no data were available for the remainder of the walls. Therefore, post construction as-built plans would need to be developed.

This effort would consist of measuring the elevation, horizontal location, and dimensions of existing constructed features part of the wall system including raised embankments, levees, or levee-like structures beneath existing floodwalls. Destructive testing of existing walls would be required to identify the size and spacing of steel reinforcement of the walls and supporting footers/cut-off walls. Excavation of existing toe/ bank-protection would be required to measure the elevation, horizontal location, dimension, and material in place. No true 'As-Built' drawings were located during the data collection effort. The plans available were final, sealed, construction plans, but not stamped or otherwise demarcated as 'As-Built' which is required by FEMA. Therefore, some level of verification would also be required for walls with comprehensive construction plan data available. Based on the data obtained, a structural, geotechnical, and hydraulic evaluation would be conducted to determine if the existing infrastructure is adequate to meet the requirements of CFR 65.10. The general requirements include adequate freeboard, resistance to hydrostatic pressure, and scour protection. The following additional improvements would still be needed for a complete mitigation solution:

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Happy Valley Road In-Line Sediment Basin
- Happy Valley Road Flow Splitter Control Structure
- Western Containment North of Happy Valley Road
- Scottsdale Road to Reach 11 Dike Flood Pool

It is anticipated that the outcome of this As-Built investigation/ evaluation would be that portions of the walls along the Main and West Split channels do not meet the requirements and that some level of improvement would be needed to certify the deficient walls and/or associated scour protection.

The disadvantages of this alternative is that it would be difficult to estimate the level of improvement that would be required to the various deficient walled reaches. Destructive testing and reconstruction of existing walls would require close coordination with stakeholders, local property owners, and home owners associations.

Leveed Containment with New Flood Walls

This alternative consists of the construction of new flood walls with sufficient freeboard and scour protection to meet the CFR 65.10 regulations to remove improved properties from the flood hazard of Rawhide Wash. This alternative would eliminate the need for a post construction As-Built investigation and the associated destructive testing of existing walls. This alternative would consist of designing and building a new floodwall system (likely on the wash side of existing walls) down the entire Main Channel of Rawhide Wash from Happy Valley Road to Pinnacle Peak Road and the West Split channel from Happy Valley Road to Scottsdale Road. An additional option of this alternative is to eliminate breakout flows to the West Split channel allowing the entire apex discharge to flow down the Main channel given that the infrastructure from Pinnacle Peak Road to Scottsdale Road was designed for the full apex discharge. The following additional improvements would still be needed for a complete mitigation solution:

- Tributary Containment North of Jomax Road
- Eastern Containment North of Happy Valley Road
- Western Containment North of Happy Valley Road
- Happy Valley Road In-Line Sediment Basin
- Happy Valley Road Flow Splitter Control Structure
- Scottsdale Road to Reach 11 Dike Flood Pool

The disadvantages of this alternative include a relatively high construction cost, low community acceptance, adverse impact to the NAOS requiring offsite mitigation, and the creation of a 'no man's land' space between walls that could be a public safety hazard.

Leveed Containment with New Earthen Embankments

This alternative is similar to the previous new flood wall alternative but would consist of construction of new earthen levees instead of floodwalls. The new levees would be constructed on the wash side of existing walls.

The disadvantages of this alternative include a high construction cost, low community acceptance, and adverse impact to the NAOS requiring offsite mitigation. However, this alternative is less expensive than new flood walls.

No Build

The No Build Alternative for Rawhide Wash would involve re-delineation of the current Zone AO floodplain using updated hydrology, new topography, and reflecting significant changes that have occurred in the watershed and floodplain environment due to development since the effective study was completed in the early 1990's. It is uncertain to what extent the floodplain limits would change if redelineated based on the new hydrology and topography, but without any consideration given to structural alluvial fan apex control. Redelineation also provides updated regulatory floodplain for the local jurisdictions and a better depiction of the existing flood hazards in the area compared to the No Action alternative. **Figure D-8** in **APPENDIX D** shows how the current floodplain both under- and over-represents the true flood hazards. Additionally, the No Build alternative does not eliminate the alluvial fan uncertainty. As a result downstream development including Paradise Ridge will require expensive duplicative elements to accommodate full apex flows because of the avulsion potential downstream of the fan apex.

No Action

The No Action alternative contrasts with the structural whole-fan alternatives described above in that City of Phoenix and the City of Scottsdale will continue to regulate the Zone AO floodplain as is. Existing residents will continue to pay NFIP premiums that could be subject to rate increases. New construction will be required to elevate per current drainage ordinances and regulations. Furthermore, actual existing flood hazards to existing buildings would be left unmitigated. Drainage infrastructure for the Paradise Ridge development will also require expensive duplicative elements to accommodate full apex flows because of the avulsion potential downstream of the fan apex.

PEER REVIEW/VALUE ENGINEERING STUDY REPORT

APPENDIX F contains the Executive Summary from the Peer Review/VE Team. Their complete Report is provided electronically in **APPENDIX G**.

Executive Summary

Background

A Peer Review / Value Engineering (VE) study was conducted for the Flood Control District of Maricopa County (District) Rawhide Wash Project, which included a pre-meeting on May 27, 2015 at RHA offices and workshop on June 1-2, 2015 at District offices.

Project Goals

Overall project goals were discussed in order to educate the peer review / VE study team on the important elements within the project. They include the following:

- Mitigate alluvial fan flood hazard
- Remove flow path uncertainty
- Revise FEMA regulatory floodplain
- Manage capital costs
- Gain FEMA FLO-2D approval
- Minimize flood insurance risk

Workshop Objectives

In addition, workshop objectives were identified at the pre-meeting which included:

- Next steps for build alternative implementation
- Pre-design tasks and additional analyses needs to determine which structural components the build alternative needs to have (timing of tasks, what analysis should be done first, what tasks can be completed during the design phase, etc.)
- Identify the major scope items for DCR
- Implications of putting all apex flow down the main channel
- The Silverstone bridge/channel hydraulic performance in the interim condition at State Land interface
- Roadway/utility crossing considerations at Happy Valley Road and Los Portones Road
- Effectiveness of these build alternatives to mitigate the flood hazard and address the uncertainty with the sediment

Project Description

The Rawhide Wash floodplain is one of the largest in Maricopa County and covers more than 10 square miles from approximately Jomax and Pima roads to the southwest past Loop 101. Rawhide Wash was mapped a 100-year regulatory floodplain by the Federal Emergency Management Agency (FEMA) and designated as an active alluvial fan. During large storms, stormwater and sediment can travel at high speeds from nearby mountains and spread out into multiple, shallow stream and washes. These streams and washes can shift during storm events, which results in an unprecedented path of floodwater and a high risk of flooding.

Due to the high flood risk to people and properties in the Rawhide Wash floodplain, this area is being considered for possible regional flood control measures to reduce the flooding risk. The District and its city partners considered three potential options for Rawhide Wash: No Action, No Build and Build. The Build Option is the only option that would reduce the flood hazard and risk.

The purpose of the Peer Review / VE Study was to evaluate the four Build Options presented in the Pinnacle Peak West ADMS, Rawhide Wash Alternatives report (JE Fuller / Hydrology & Geomorphology, Inc., May 2015) and present recommendations for the District and JE Fuller to consider for Build Option selection and advancement.

Description of the Study

The study was conducted in accordance with the SAVE International® Value Methodology, found in the support data section of this report. The peer review / VE team consisted of District and City of Scottsdale staff, and consultant subject matter experts in specialized disciplines.

Proposed New Build Options, Considerations for Advancing a Build Option, and Other Considerations are found in the study results section of this report. This identifies the ideas brainstormed during the study, indicating the areas of opportunity for improving the value, performance or functions of the project. A complete list of all of the ideas is located in the Support Data section of this report.

Summary of Results

The peer review / VE team brainstormed 22 ideas. Of those, several ideas were combined into proposed new Build Options for the District and design team to consider. In addition, the peer review / VE team identified "next steps" for advancing a Build Option as well as other considerations to address the workshop objectives.

The description and further discussion of the *Proposed New Build Options*, *Considerations for Advancing a Build Option*, and *Other Considerations* are included in the study results section of this report. The peer review / VE team had a limited amount of time during the workshop to evaluate and present alternative ideas. It is important that the District and its design consultant further vet the ideas that have been suggested for further consideration by performing more technical, cost and other appropriate analyses.

A presentation of the peer review / VE study recommendations and findings was given to decision makers and stakeholders on June 2, 2015.

Peer Review / VE Study Team

- Ed Raleigh, Flood Control District of Maricopa County
- Pat Ellison, Flood Control District of Maricopa County
- Nerijus Baronas, City of Scottsdale
- Roger Baele, AECOM
- Mark Gavan, Gavan & Barker
- Ash Patel, Wood / Patel
- Hari Raghavan, Atkins
- Patrice Miller, RHA, CVS Team Facilitator

APPENDIX G DIGITAL DATA

Due to the file sizes, Appendix G is available on file at the Flood Control District of Maricopa County.

PDF of this report
HEC-RAS models used in Sediment Transport Analysis
Engineering plans collected as part of Floodwall Inventory
Field photographs taken as part of Floodwall Inventory
FLO-2D models associated with alternatives analyses
Miscellaneous GIS data associated with alternatives
Peer Review/Value Engineering Study Report and supporting documents