Doña Ana County Flood Commission
La Union Area Drainage Master Plan
Final Report

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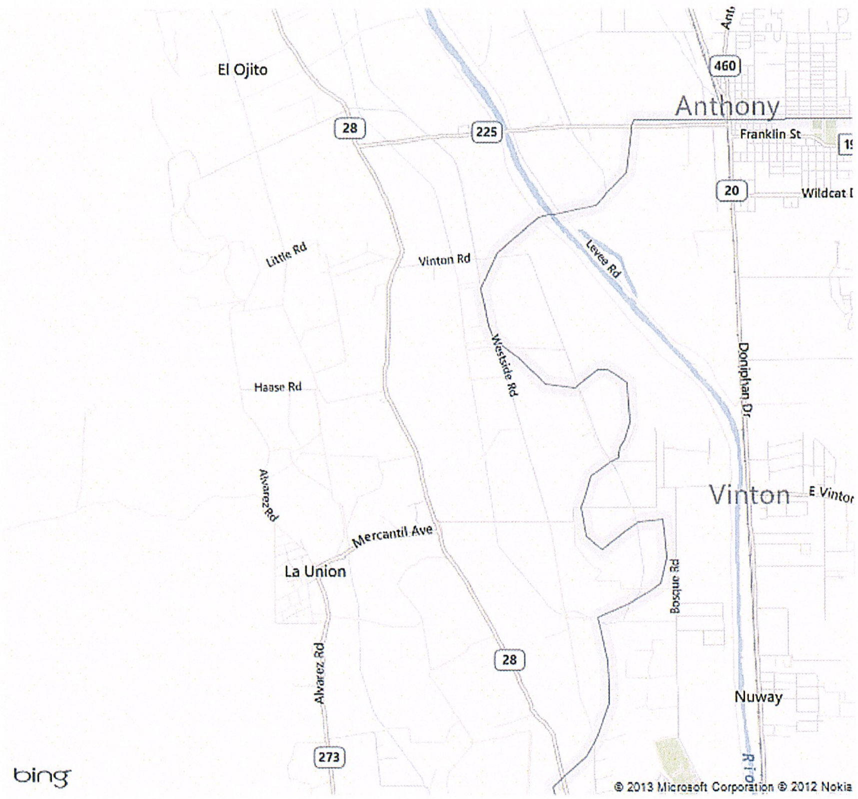
I. Introduction

The Townsite of La Union (See Figure 1) rests on the lower slopes of the Rio Grande Valley immediately adjacent to the west side of the Rio Grande floodplain. Historically, water from the uplands to the west has flowed through this settlement toward the Rio Grande to the east.

The Doña Ana County Flood Commission, realizing there are drainage issues in the Townsite of La Union which need to be addressed, has authorized Larkin Group NM, Inc. (Larkin) to prepare this La Union Area Drainage Master Plan.

Figure 1 Vicinity Map



This Drainage Master Plan will quantify the storm water runoff affecting the La Union area, present preliminary solutions to address the drainage issues and serve as an aide in acquiring funding, prioritizing and planning for future construction projects. The process for this work includes hydrologic studies of the drainage area tributary to the vicinity of La Union; hydraulic analysis of proposed alternatives, including a no-build plan; seeking public input; preparing cost estimates; and developing a master plan for the drainage of the La Union area. This report presents a narrative of the work performed and the results of this study.

II. Background Information

Approximately 300 people live in the immediate La Union Townsite. The development of the Townsite dates from1852 when the lands of the Refugio de los Amoles were granted to the inhabitants by the Mexican government. The government found that these lands had been inhabited and improved by the residents, mostly natives of either Mexico or New Mexico, who had settled the land for its agricultural value. However, the Gadsden Purchase in 1854 placed these lands within the borders of the United States and began a lengthy court battle in which the residents sought to retain their ownership of the granted lands. The final settlement in 1928 allowed the valley residents to retain ownership of the land. Many descendants of those original settlers still reside in La Union and the surrounding area.

Some settlements in the valley east of La Union were destroyed by flooding of the Rio Grande. The construction of the Elephant Butte Dam and the Caballo Dam removed most of the flood threat from the Rio Grande. However, flows from the high deserts to the west continue to cause infrequent, but serious flooding in the area. In addition, flows from the immediate area cause frequent nuisance flooding accompanied by erosion and siltation of the very fine granular soils of the area.

II.1 Previous Studies

The Federal Emergency Management Agency's (FEMA) "Flood Insurance Study Doña Ana County, New Mexico and Incorporated Areas" dated September 6, 1995 was reviewed for this report. A reduced size copy of the current Flood Insurance Rate Map (FIRM) Panel 925 of 1050 (effective September 27, 1991) is included in Appendix A. This FIRM panel shows the north portion of the Townsite in a Special Flood Hazard Area Inundated by 100-year Flood Zone A with no base flood elevations determined.

II.2 Existing Conditions

The present Townsite of La Union is home to approximately 300 residents. The Townsite occupies the lower slopes of the valley immediately west of the Rio Grande floodplain. Nearly all of the area surrounding the Townsite is used for agricultural purposes. The valley floor to the east is heavily farmed, while the higher land to the west is composed of cattle ranches and Federal Lands operated by the Bureau of Land Management (BLM). Much of this land is also used for cattle grazing.

Financed by funds from the Colonias Act, water and sewer systems were constructed in the Townsite. The sewer system is owned by La Union and operated by Doña Ana County while the water system is owned and operated by the La Union Mutual Domestic Sewer & Water Association. A part of the goal of this study is to develop alternatives that interfere as little as possible with these existing systems.

Although La Union is not incorporated, it has organized a governing board similar to those found in villages in New Mexico. This organization and the strong participation of the Board members will aid the Townsite in applying for and qualifying for grants and loans to assist in funding needed improvements.

At present flood flows are mostly discharged to farmland to the east. Some flows probably reach the West Drain operated by the Elephant Butte Irrigation District (EBID). The West Drain is the only viable discharge point for drainage facilities that may be constructed. However, because it has limited capacity, peak flows must be attenuated prior to release to the drain. Water quality standards established for discharge from the drain to the Rio Grande will also require that care be taken to assure EBID the water discharged to the drain at least meets these standards.

II.3 Purpose and Need

Because of its geographical location in the lower slopes of the Rio Grande Valley, La Union is subject to flood flows not only from within the Townsite, but during larger storms substantial flows can be generated in the higher lands to the west that also pass though the Townsite. These large storms present a very real danger of damage within the Townsite as well as possible injury to the residents. Even the smaller rains cause substantial damage from the erosion and deposition of the very fine sandy soils of the area.

For these reasons, it is important that this historic Townsite be protected from damage and danger of flooding, by the construction of suitable flood control facilities.

III. Environmental Issues

As part of this study, Larkin commissioned Zia Engineering and Environmental Consultants, LLC (Zia) to prepare a Desktop Environmental Review of the Townsite of La Union. This review is a very preliminary overview of potential environmental issues that may need to be faced if construction projects are initiated. A copy of Zia's review is included as Appendix B. From this overview it appears that the most likely environmental concerns will be caused by prime farmland and historic buildings. These and other concerns will require coordination with the appropriate governmental agencies during the development of drainage improvements projects. This document was prepared from online or printed resources. No field surveys were made and no attempts were made to consult with interested governmental agencies. A summary of the findings follows.

III.1 Soils

Because of the occurrence of Farmland Soils of Statewide Importance in the La Union area, coordination with the National Resource Conservation Service (NRCS) is recommended. NRCS will provide recommendations if soils deemed to be of Statewide Importance are encountered.

III.2 Paleontology

Areas of high concentrations of resources are mainly in the high desert areas west of the Townsite. If BLM land is used for construction, early coordination is advised. One site has been documented within one mile of the Townsite, but subsequent studies were not able to locate it. The potential for archeological sites in La Union is low.

III.3 Historic Sites

The Little La Union Lateral and the West Drain, as part of the EBID system, are on the National Record. There are approximately 95 houses within La Union that may be eligible for listing. Coordination with the State Historic Preservation Office (SHPO) will be required during any construction within 50 feet of any of these houses.

III.4 Threatened or Endangered Species

The project area contains habitat suitable for two plant, one insect, one reptile, three bird, and one mammal species listed as Threatened or Endangered Species (TSE) that may occur in Doña Ana County. Additionally, Doña Ana County does not contain designated critical habitat for any TSE. Biologic surveys should be made during project design and appropriate coordination carried out with State and Federal agencies.

III.5 Wetlands

Three areas of fresh water ponds are found in the area. It appears the project can be feasibly completed without disturbing these areas or any known wetlands.

III.6 Air Quality

Occasional instances of non-attainment of air quality standards have occurred in the area. Consultation with the New Mexico Environment Department (NMED) Air Quality Bureau is advised.

III.7 Water Quality

La Union is located within the Mesilla Bolson of the Rio Grande aquifer. Groundwater is generally unconfined and typically moves southward at an average gradient of about 4 to 6 feet/mile. The water table is approximately 10 to 25 feet below the surface in much of the valley-floor area. Construction should be planned to conform to the requirements of NMED Ground Water Quality Bureau and Surface Water Quality Bureau as well as Environmental Protection Agency (EPA) requirements regarding construction activities.

III.8 Floodplains

Most of La Union is designated as Zone X, areas outside the 500-year floodplain or Zone A, areas within the 100-year floodplain with no base flood elevation determined. Regardless of project sponsorship, coordination with the Doña Ana County Flood Commission concerning impacts to existing floodplains is advised.

III.9 Socioeconomics

According to the EPA Environmental Justice Mapper, the population of La Union is between 40% and 100% minority and 10% to 20% are considered in poverty. Project planning should not negatively impact livelihood, and the final outcome of the project should not be to the financial detriment of the Townsite.

III.10 Environmental Justice

According to the Environmental Justice Mapper, hazardous materials are not present within one mile of La Union. Construction and equipment should prevent leakage of oil and hydraulic fluids.

IV. Public Input

During the course of this study two Public Meetings were held for the residents of the La Union area.

The first Public Meeting held on December 5th of 2012 Larkin and Doña Ana County Flood Commission staff conducted a public meeting for input from residents in the La Union area. Approximately 16 area residents attended the meeting and shared photos of the conditions they had to deal with after recent storms (See Appendix C). Larkin provided aerial mapping of the area divided into four large-scale exhibits. The public was then invited to place red dots on the exhibits and describe drainage problems they have experienced.

This process identified many concerns and identified drainage problem areas associated with these concerns, the residents are experiencing during almost every rainfall event. These problems include, but are not limited to, ponding areas (one area causing traffic to seek an alternate route), excessive street flows, sediment deposition, and erosion along roadways. See Table 1 for comment summaries and Figure 2 for a reduced size area photograph with problem areas identified. An additional, larger plot is also provided in the Map Pocket.

Table 1 December 5th, 2012 Public Input Summary

Location	Problem	Location	Problem	Location	Problem
Alvarez @ Visnaga	Flooding	Rosales @ Salome	Flows	Alvarez @ Paloma	Flooding
Salome & La Union	Flooding	Mercantile @ Salome	Erosion	S. Alvarez	Ponding
Sentenario & San Antonio	Flooding	Mercantile @ La Union	Flooding	Golondrina @ Alvarez	Ponding
Salome & Paloma	Flooding	Mercantile @ La Union	Ponding	Mercantile @ Sentenario	High Flows
Along Mercantile	Erosion	Aguila Ave	Ponding	Alvarez @ Visnaga	Ponding
Mercantile & Sentenario	Ponding	Alvarez Rd	Flooding	Sentenario	Ponding
Mercantile & Alvarez	Erosion	Mercantile @ La Union	Ponding	Aguila	Ponding
Alvarez & Visnaga	Ponding	Salome @ La Union	Ponding	Mercantile @ La Union	Ponding
Salome @ Paloma	Ponding	Sentenario @ San Antonio	Ponding	Paloma	Ponding

The second Public Meeting, held on April 17, 2013 presented the results and recommendations of the study and provided an opportunity for the residents of La Union to comment on the proposed projects.

V. Hydrologic Analysis & Methodology

This study analyzed the area for the 10-year (10% probability) and 100-year (1% probability) 24-hour storm events. Both storm events were modeled with Type II and Type III antecedent moisture conditions, using the Type 2-75 storm distribution (See Appendix D). Also for the purpose of this study, the effects of the two existing dams known as La Union Dam A and La Union Dam B (See Existing Hydrology Map) were not included in the hydrologic or hydraulic analysis.

V.1 Climate

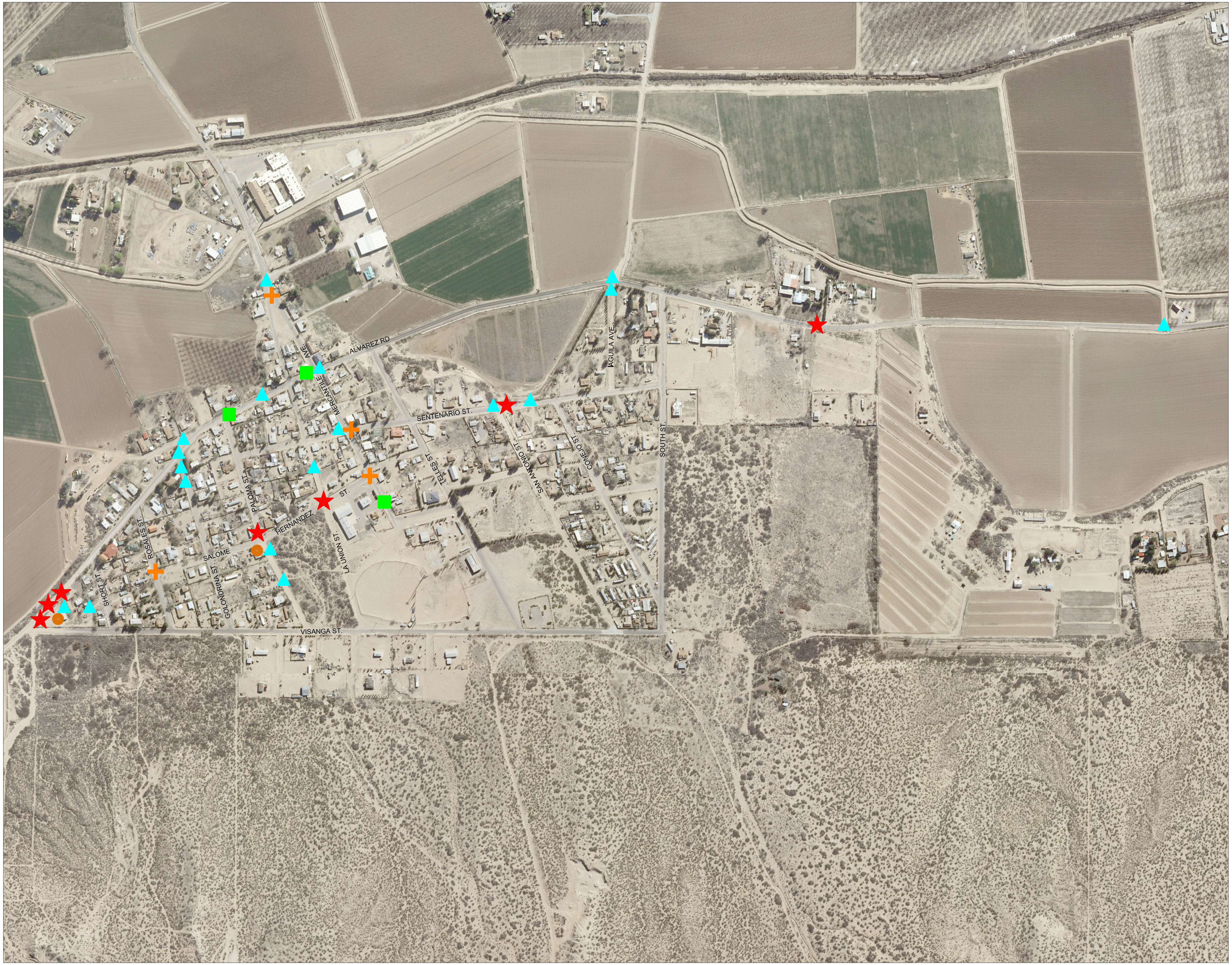
The geographic area is characterized by semiarid climate (See Table 2). As the site is located between Las Cruces, NM and El Paso, TX, the published climate data (www. Wrcc.dri.edu) for both cities has been included for informational purposes.

Table 2 Average Annual Climatic Data for Las Cruces, NM and El Paso, TX

Item	Las Cruces	El Paso
Avg. Maximum Temperature	79°F	77°F
Avg. Minimum Temperature	46°F	49°F
Daily Mean Temperature	56.8°F	63°F
Avg. Annual Precipitation	6.3 inches	8.8 inches

V.2 Rainfall Data

Rainfall depths of 2.38 inches for the 10-year 24-hour event and 3.72 inches for the 100-year 24-hour event were used for this study. These depths were determined using the recently published NOAA Atlas 14, which is available on the Internet in an interactive data extraction format (http://hdsc.nws.noaa.gov/hdsc/pfds). NOAA 14 (See Appendix D) was prepared by the National Weather Service to replace NOAA Atlas 2.



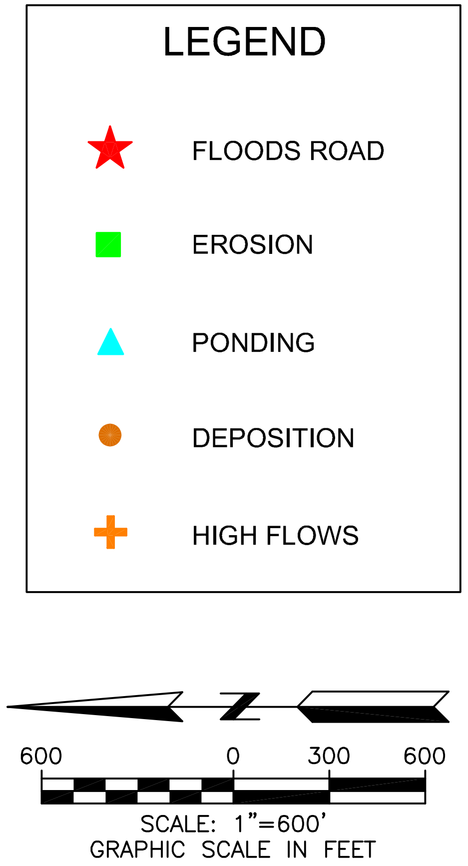


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FIGURE 2 - PUBLIC INPUT SUMMARY

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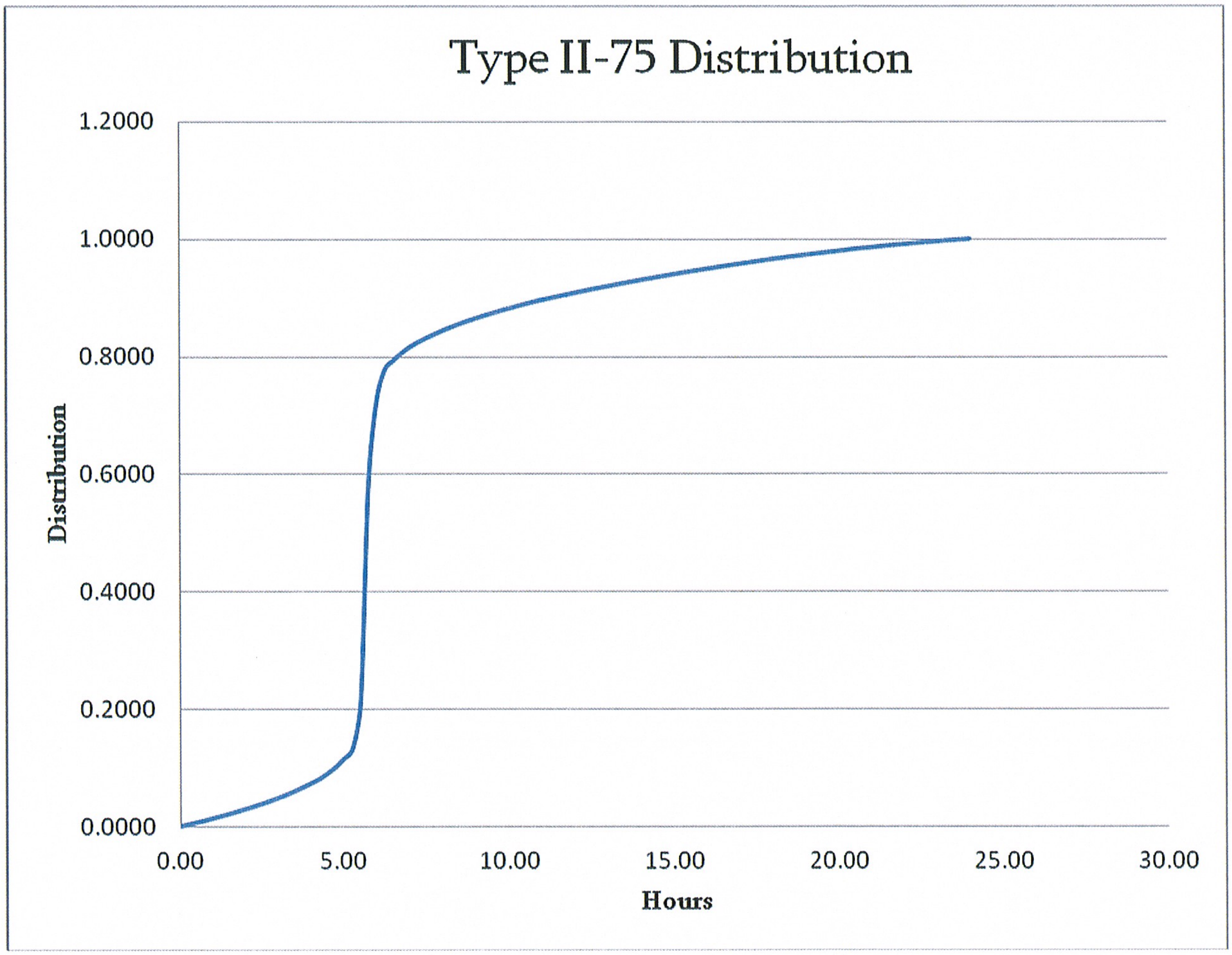
V.2a Rainfall Distribution

The Type II-75 storm distribution (See Figure 3) as developed by the NRCS specifically for modeling storm events in southern New Mexico was applied to the point precipitation values for both the 10-year and 100-year events. This distribution places the storm's peak at approximately 6 hours with 75% of the total precipitation falling in 1 hour surrounding the peak.

Figure 3 Type II-75 Distribution



V.3 Topographic Mapping

Two-foot interval topographic mapping for the project site originated from 2010 digital aerial photography and LiDAR mapping provided by the Doña Ana County Flood Commission. The mapping was prepared using New Mexico State Plane Coordinate System-Central Zone and based on the North American Vertical Datum of 1983. A field inspection was conducted in December 2012 by Larkin personnel in order to catalog existing field conditions and key terrain features that impact the storm flows and their courses.

V.4 Soil Data and Conditions

Soils within the watershed were identified from surface samples and observations using geographic information system (GIS) capabilities and the digital NRCS Soil Survey Geographic Database (SURRGO).

V.4a Soil Groups

Although the aerial extent of specific soil units was derived from GIS data, soil type is typically derived from the NRCS soil surveys. These surveys classify soils into one of four "hydrologic soil groups;" A, B, C or D. Type A soils have a very low runoff potential and are typically very porous soils such as sandy and cobbly soils. Type D soils are soils which have a high runoff potential such as very rocky soils, soils with a well developed desert pavement or soils with a shallow impervious layer. Soils for this study were identified using the NRCS soil survey of Doña Ana County (NRCS, 1977) and the NRCS website for Doña Ana County (NRCS, 2007). The data includes a description of each major association and its characteristics and hydrologic soil group. The majority of the study area is comprised of soils that are within hydrologic soil groups A and B. A summary of the soils in the study area is provided below in Table 3, with detailed descriptions in Appendix E. Figure 4 is a soils map of the study area.

Table 3 NRCS Soil Groups Within Study Area

Soil Symbol	Map Unit Name	Hydrologic Soil Group
Bm	Bluepoint loamy sand, 1 to 5% slopes	A
Bn	Bluepoint loamy sand, 5 to 15% slopes	A
BP	Bluepoint-Caliza-Yturbide complex	A
Gf	Glendale clay loam	B
Pa	Pajarito fine sandy loam	B
RF	Riverwash-Arizo complex	A
SH	Simona-Harrisburg association	D
WP	Wink-Pintura complex	B

V.4b Antecedent Moisture Content

One factor that impacts the curve number estimate is relative soil moisture content. This factor is described by the NRCS using a relative term of "antecedent moisture condition" (AMC). The NRCS has identified three different antecedent moisture conditions; AMC I, AMC II, and AMC III. AMC I is a condition in which the soil moisture has been depleted by a relatively long period of no rainfall and is assumed to represent the condition when the soil has its highest infiltration rate. AMC II is an average condition and is the condition usually assumed to be present in the watershed for most hydrologic studies for drainage design. AMC III is the condition in which soil moisture is high due to recent rainfall or snowmelt. This condition is assumed to be the condition in which the soil infiltration capacity is at its lowest point and is usually used for probable maximum discharge studies which may need to be performed for the design of some of the detention basins identified as a part of this Drainage Master Plan. Soil groups were evaluated at both AMC II and AMC III conditions for this study. Table 4 gives the hydrologic soil groups used in this study along with the corresponding AMC II and AMC III values.

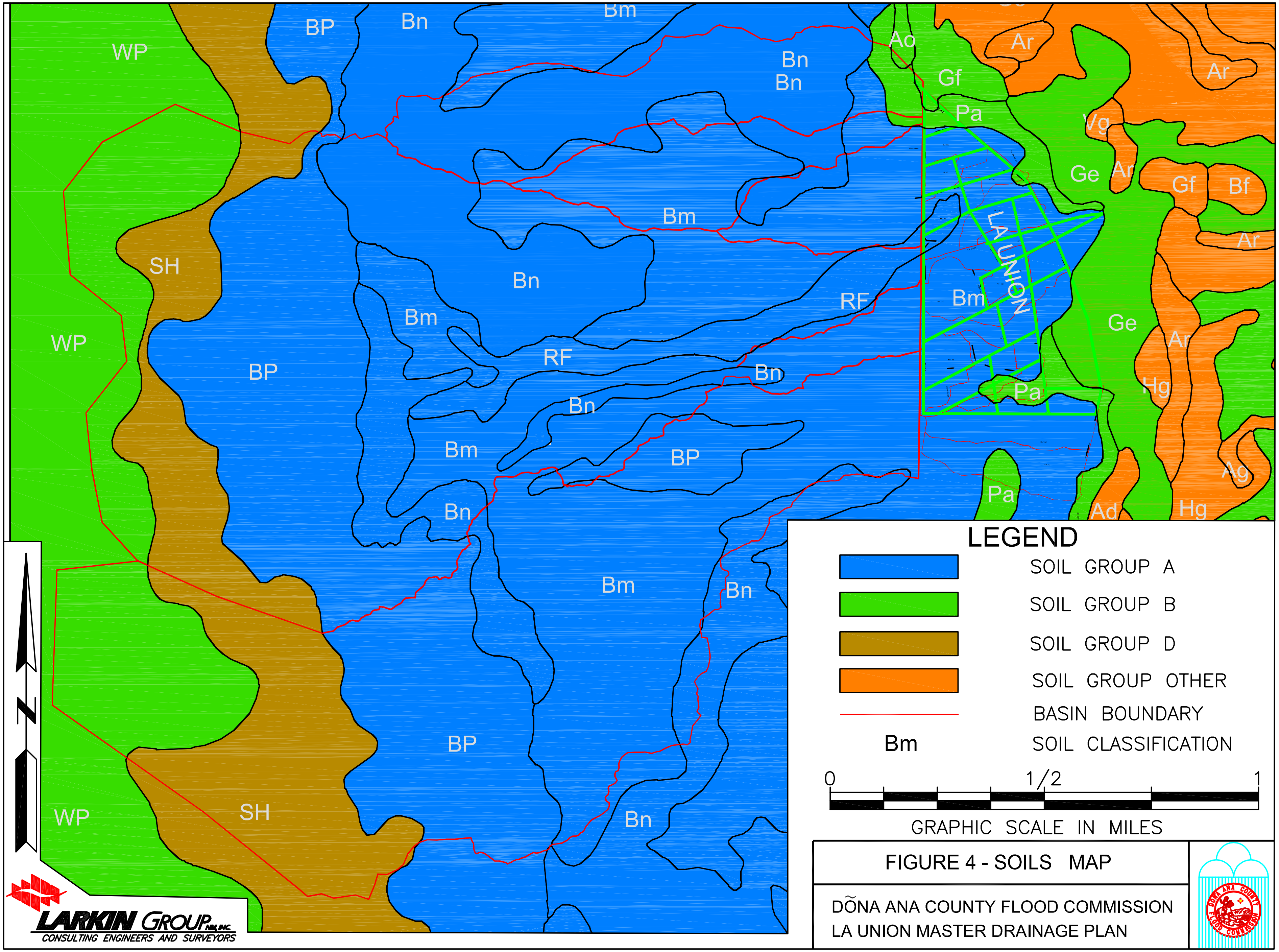


FIGURE 4 - SOILS MAP

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Table 4 NRCS Soil Groups With Curve Numbers

Hydrologic Soil Group	AMC Type II Curve Number	AMC Type III Curve Number
A	60	78
B	73	85
D	84	94

V.4c Sediment Bulking

Two soil samples were taken during the December 5th, 2012 site trip. Sample A was taken east of the intersection of La Union Street and Visanga Street, while Sample B was taken in the arroyo west of the intersection of Alvarez Road and Visanga Street. The resulting gradation curves can be found in Appendix E. For the purpose of this study, hydraulic models were not bulked for sediment transport to provide a clear water comparison of the proposed options. Final design of the preferred option should include an appropriate bulking factor.

V.5 Numerical Models and Methodology

As per Doña Ana County Flood Commission (DACFC) drainage criteria, the hydrologic analysis was conducted with the U. S. Army Corp of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) Version 3.5 and based on the SCS methodologies. Land use, slopes and drainage divides used for the modeling effort were based on orthophotographic mapping and 2-foot interval contours provided by the DACFC.

V.5a Lag Time

Lag time is a time estimate for the peak runoff for the basin to travel to the discharge point for that particular basin. Each basin was divided into overland flow, shallow concentrated flow, and channelized. A travel time was calculated for each of these flow types by classifying flow as either overland flow or shallow concentrated flow. The upper extent of the sub-basin is characterized as overland flow, while the remainder of the basin is classified as Shallow Concentrated Flow or Concentrated Flow. Using the flow type, the flow path slope and the length, the velocity and lag time were computed for each sub-basin. Lag time is also affected by the AMC at the time of the storm event; therefore, lag times were calculated for both AMC II and AMC III. Detailed calculations can be found in Appendix D.

V.5b Loss Method

Curve number (CN) values were selected, per Technical Release 55 (TR-55) methodology, to reflect the soil types mapped by the NRCS. Modeling assumed a hydrologic soil condition for watersheds in fair to poor condition having moderate potential to infiltrate runoff due to soil surface, vegetative cover and minimal compaction due to human activity. The CN values provided by TR-55 are for antecedent moisture condition (AMC II). Average conditions were adjusted according to Table 10-1 of the National Engineering Handbook Part 630 to AMC III curve numbers to reflect the high antecedent moisture condition for this analysis. Refer to the curve number calculations that can be found in Appendix D for additional information.

V.5c Routing

This study utilized the Muskingum-Cunge procedure for channel routing. This method is appropriate for natural channels such as arroyos in the study area. The channel cross-section geometry required for this method was derived from the topographic base map. Mannings "n" values for the main arroyo channels were assumed to be 0.030 for both the channel bottom and overbank areas.

V.5d Input Parameters Summary

The following table is a summary of the basin input parameters for the HEC-HMS existing conditions hydrologic model. Detailed calculations can be found in Appendix D.

Table 5 Existing Hydrologic Analysis Input Parameters

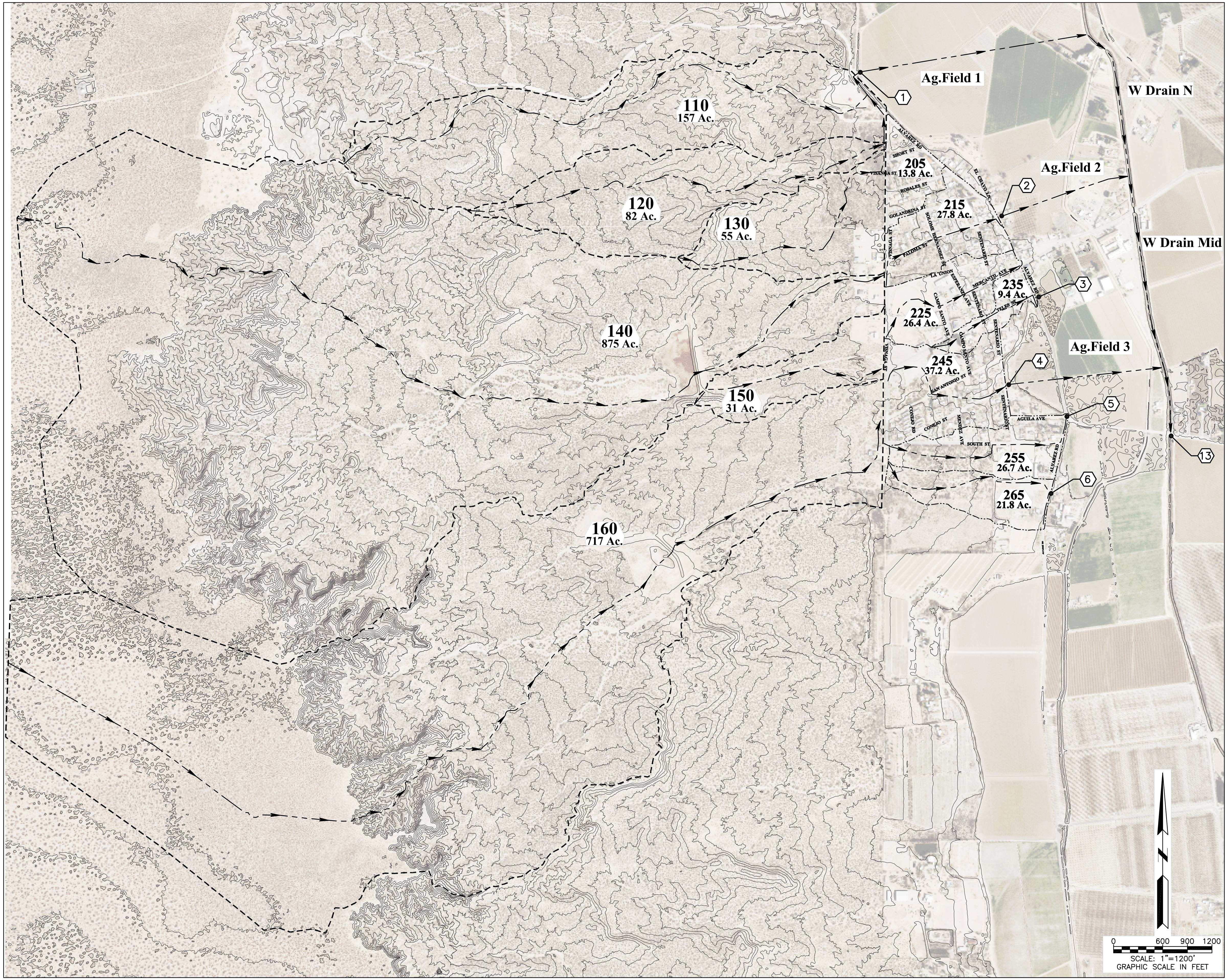
Basin	Area (sq.mi.)	CN		T lag (min)		Impervious (%)
		AMC II	AMC III	AMC II	AMC III	AMC II & III
110	0.25	61	78	102	65	0
120	0.13	60	78	79	51	0
130	0.09	60	78	56	37	0
140	1.37	65	81	199	135	0
150	0.05	60	78	75	48	0
160	1.12	66	82	321	214	0
205	0.02	68	83	36	27	16
215	0.04	64	81	45	33	15
225	0.04	63	80	51	37	12
235	0.02	63	80	35	26	14
245	0.06	67	83	40	30	14
255	0.04	63	80	57	40	7
265	0.03	66	82	60	43	3

V.6 Hydrologic Analysis Results

In order to determine the drainage affecting the La Union area, and evaluate the effectiveness of proposed improvements, Larkin performed a HEC-HMS analysis of the three-square-mile contributory watershed for the La Union area. This analysis was routed to and compared at Analysis Point AP 13, the point where Aguila Avenue crosses the West Drain. A summary of the major flow paths and preliminary flow rates is presented in Figure 5. See Appendix D for detailed calculations and analysis methodologies.

Table 6 Existing Hydrologic Analysis Summary

Basin	Area (ac)	Q_{10} (cfs)		V_{10} (ac-ft)		Q_{100} (cfs)		V_{100} (ac-ft)	
		AMC II	AMC III	AMC II	AMC III	AMC II	AMC III	AMC II	AMC III
110	157	31.3	81.1	7.8	13.5	69.3	164.5	16.9	26.4
120	82	19.9	52.2	4.0	7.0	44.1	105.7	8.6	13.8
130	55	17.9	46.0	2.7	4.7	39.9	92.6	5.8	9.3
140	875	182.8	260.4	79.3	81.1	362.9	518.6	156.8	158.3
150	31	8.0	21.1	1.5	2.7	17.7	42.7	3.3	5.3
160	717	59.1	144.7	38.8	67.0	127.3	285.6	83.9	131.5
205	14	11.8	21.1	1.2	1.6	22.4	38.0	2.2	3.0
215	28	17.3	32.7	2.1	3.0	33.5	60.4	4.0	5.5
225	26	13.7	27.0	1.9	2.8	27.0	50.6	3.6	5.1
235	9	7.2	13.5	0.7	1.0	13.9	24.8	1.4	1.9
245	37	26.9	50.4	3.0	4.3	52.0	91.8	5.6	7.7
255	27	11.4	24.5	1.7	2.7	23.4	47.2	3.4	5.0
265	22	8.7	19.1	1.4	2.2	18.4	37.0	2.8	4.1



LEGEND

- **1X0** OFF–SITE DRAINAGE BASIN LABEL
- **2X5** ON–SITE DRAINAGE BASIN LABEL
- **XX Ac.** DRAINAGE BASIN AREA (ACRES)
- DRAINAGE BASIN BOUNDARY
- ANALYSIS POINT (AP)
- HISTORICAL FLOWS
- FLOW DIRECTION
- EXISTING CONTOURS (10 FT. INTERVAL)

AMC III

ANALYSIS POINT	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC–FT)	100 yr. Volume (AC–FT)
AP 1	173.7	351.9	26.9	52.4
AP 2	260.7	520.1	84.0	163.8
AP 3	38.6	72.0	3.8	6.9
AP 4	146.7	287.0	73.9	144.4
AP 5	24.5	47.2	2.7	5.0
AP 6	19.1	37.0	2.2	4.1
AP 13	441.3	867.1	182.3	358.7

AMC II

ANALYSIS POINT	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC–FT)	100 yr. Volume (AC–FT)
AP 1	66.2	145.4	15.7	33.6
AP 2	183.4	363.9	81.4	160.7
AP 3	19.8	38.9	2.6	5.0
AP 4	59.2	130.5	43.2	92.8
AP 5	11.4	23.4	1.7	3.4
AP 6	8.7	18.4	1.4	2.8
AP 13	256.3	516.2	138.4	285.9

AMC III

SUB BASIN	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC–FT)	100 yr. Volume (AC–FT)
110	81.1	164.5	13.5	26.4
120	52.2	105.7	7.0	13.8
130	46.0	92.6	4.7	9.3
140	260.4	518.6	81.1	158.3
150	21.1	42.7	2.7	5.3
160	144.7	285.6	67.0	131.5
205	21.1	38.0	1.6	3.0
215	32.7	60.4	3.0	5.5
225	27.0	50.6	2.8	5.1
235	13.5	24.8	1.0	1.9
245	50.4	91.8	4.3	7.7
255	24.5	47.2	2.7	5.0
265	19.1	37.0	2.2	4.1

AMC II

SUB BASIN	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC–FT)	100 yr. Volume (AC–FT)
110	31.3	69.3	7.8	16.9
120	19.9	44.1	4.0	8.6
130	17.9	39.9	2.7	5.8
140	182.2	362.9	79.3	156.8
150	8.0	17.7	1.5	3.3
160	59.1	127.3	38.8	83.9
205	11.8	22.4	1.2	2.2
215	17.3	33.5	2.1	4.0
225	13.7	27.0	1.9	3.6
235	7.2	13.9	0.7	1.4
245	26.9	52.0	3.0	5.6
255	11.4	23.4	1.7	3.4
265	8.7	18.4	1.4	2.8

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REVISIONS
BY____ DATE____ DESCR.____
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BY____ DATE____ DESCR.____

DATE ____ SCALE ____
DRAWN GTM
CHECKED DVO
APPROVED DVO

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Figure 5 EXISTING HYDROLOGY

VI. Hydraulic Analysis & Methodology

For the purposes of this study the hydraulic analysis was broken into separate analyses and methodologies; routing through the dams was performed with HEC-HMS, pipe flows were determined by calculating pipe losses, and street flows and open channel flows were calculated by normal depth calculations. Again for all methodologies, the effects of the two existing dams known as La Union Dam A and La Union Dam B were not included in the hydraulic analysis. The point where Aguila Avenue crosses the West Drain was selected as Analysis Point 13 (AP-13) in order to more efficiently compare the results of the proposed improvements. The results of this analysis are presented later and the model files are included on a compact disk as Appendix H.

VI.1 Numerical Models and Methodology

For the purposes of this study the analysis was conducted as follows:
Stage-storage routing with HEC-HMS was used to route flows through the proposed dam structures. A spreadsheet was produced to calculate the capacity of a ported outlet tower as the water surface rises. As the water surface increases, the ports change from weir flow to orifice flow conditions for each water surface elevation. Flow Master calculations of normal depth flows were used for street flows and open channel flows.

VII. Study Results

Given the characteristics of storms in the La Union area and the relatively low Curve Numbers from AMC II, for the purposes of this study it would be more conservative and more practical to base improvement design on AMC III conditions. Table 7 presents a summary of the resulting flow rates evaluated at several analysis points (AP) with AP 13 being the Aguila Avenue crossing of the West Drain.

Table 7 Study Summary

Analysis Point	Q Existing (cfs)		Q-One Dam (cfs)		Q-Two Dams (cfs)	
	10-YR	100-YR	10-YR	100-YR	10-YR	100-YR
AP 1	174	352	128	196	187	269
AP 2	261	520	32	60	33	60
AP 3	39	72	39	72	13	25
AP 4	147	287	50	92	50	92
AP 5	25	47	25	47	24	47
AP 13	441	876	130	196	269	422

The one dam option will require the construction of a dam that would be a jurisdictional structure as per New Mexico Dam Safety Bureau, but would produce the most benefit for the citizens of La Union and Elephant Butte Irrigation District. Please see the following exhibits for the results and Appendices D and F for the calculations.

VIII. Elephant Butte Irrigation District West Drain

Water draining from La Union or the highlands to the west of La Union now drains to the valley floor. Most flows are blocked by the Little La Union Lateral and simply pond in the fields until they infiltrate or evaporate. However, very large flows, such as those resulting from a 100-year storm over top the Little La Union Lateral and flow into the West Drain. The West Drain provides a drainage outlet for irrigation flows and storm water flows. This drain provides drainage for the west side of the Rio Grande valley floor and the highlands that drain into the valley floor from near San Miguel to east of Santa Teresa, where it crosses under the Rio Grande and finally discharges to the Rio Grande near Doniphan Dr. and Racetrack Drive. The drain runs approximately 30 miles from its beginning near San Miguel to the crossing of the Rio Grande. In this length, the drain has the potential of accumulating a very large flow during rainy weather. In discussions with Elephant Butte Irrigation District (EBID) flow restriction points along this reach were discussed. The most stringent control is at the siphon under the Rio Grande. At this point the design capacity is approximately 140 cfs, but the observed actual capacity is approximately 90 cfs. This is far less than the potential flow in the drain and causes extensive flooding. For this reason EBID cannot allow any increase in flow in the drain.

Because the drainage area under study in this master plan is quite small in relation to the drainage area tributary to the West Drain, drainage facilities planned under this study will not have a major effect on the operation of the drain. However, in view of the seriousness of the flooding along the lower reaches of the drain an analysis point was established in the drain at the southeast corner of the study area. Flows from a 100 year storm with various alternative plans for drainage were routed to this point. See Table 7 for these results.

Under current conditions the 100 year flow from the drainage area of this study is 876 cfs. With the one-dam concept the flow would be 196 cfs and with the two dam concept as set out in the report the peak flow from the La Union area would be 422 cfs. The two dam concept as described is predicated on the dams being small enough to be non-jurisdictional under the requirements of the New Mexico Dam Safety Bureau. Therefore, either plan set out in this study would make a positive contribution to the flooding problems of the West Drain by reducing the flow rate in the 100 year event.

While it is understood that EBID cannot allow any increase in flow in the West Drain, either of these options would actually reduce the flows from the 100 year event and remove pollutants that are now getting into the West Drain.

IX. Storm Water Quality

Given the existing soil conditions, the primary storm water quality concerns will be sediment and floatables. The ponds proposed for the one pond and two pond options could be fitted with ported towers or hooded outlets to effectively reduce both pollutants. Flow from the urban area of La Union would not pass through these ponds since the ponds must be above the community to protect it from flooding. However, flows from the community could be carried to different pond locations (See Figure 6) as discussed with EBID, near the drain to allow settling of the silt and capture of the floatables by ported towers or hooded outlets, before the flow is discharged to the drain.

X. Consideration of Alternatives and Recommendations

Three alternatives are presented for consideration a no-build alternative, a one pond alternative and a two pond alternative. It is understood that construction of the preferred alternative will require close coordination and timing with EBID improvements in West Drain channel improvements. *It is also understood that, given the current condition and capacity of the West Drain, that no drainage improvements can be tied into the EBID system until the West Drain is improved.*

The no-build alternative would not have an immediate financial cost. However, it would not meet the purpose and need, to protect this historic town site from damage and danger caused by flooding from the higher land to the west. The damage could include the loss of historic structures and artifacts from this historic site, as well as damage to the homes and businesses of the residents. Of course, the danger could include injury or the loss of life if persons were caught in a major flood at this site. Therefore, a no-build alternative that does not meet the purpose and need of this study is not acceptable and will not be recommended.

The Alternate 1 plan would provide for the construction of short diversion channels and two ponds of 43.3 acre-feet and 49.5 acre-feet. See Figure 11. Their size would not place them under the jurisdiction of the New Mexico Dam Safety Commission. The north pond would be located on the same site as for the one-pond plan. The outlet pipe would also follow the same route as for the one-pond plan. The second pond would be located west of Visnaga Road and near the intersection of San Antonio and Visnaga. The outlet pipe would flow east on San Antonio, angle southeast to Conejo St. between Mendez Avenue and Sentenario St.,then turn north on Sentenario St. to Commercial where it would turn east to the West Drain. The construction cost of this plan is estimated to be $6.3 million.

The Alternate 2 (See Fig. 9)plan would consist of construction of an interceptor ditch to intercept flows from the arroyo flowing from the agriculture pond designated La Union B along with the other arroyo flows from the high lands to the west, construction of a 150 acre-foot detention pond west of Visnaga St. near the north edge of the community, and construction of a 36 inch diameter storm drain east from the dam along Rosales St. to Alvarez Road, To La Union St. and east along Commercial St. to the West Drain. This storm drain will allow construction of inlets north of Rosales St. to reduce flooding in the far north corner of La Union. The pond would be equipped with a ported tower outlet to allow removal of floatables and the pond would allow settling of silt. Construction of this plan is estimated to cost $ 6.9 million.

Both of the two build alternatives we have presented includes a plan to reduce damage and inconvenience from smaller local storms that currently cause considerable damage to the community. This plan utilizes improved road ditches, inverted crowns on some streets, and infiltration basins to allow the storm water to infiltrate into the ground. Design of the infiltration basins has not been completed under this master plan. We anticipate that the capacity will be sufficient to handle flows from a moderate storm based on visual examination of the soils, but in the event that the capacity is not sufficient, excess water could be allowed to flow to the ponds shown in Figure 6 as "Possible Ponding Locations" for settling and removal of floatables before discharge to the West Drain.

A preliminary evaluation of the two soil samples (See Appendix E for gradation curves), taken on the December 5th, 2012 site visit, indicates that the existing materials might be suitable for the production of a cost-effective soil cement design mix. This could be used for the construction of economical erosion control structures. It also indicates that the soil would be suitable for infiltration basins.

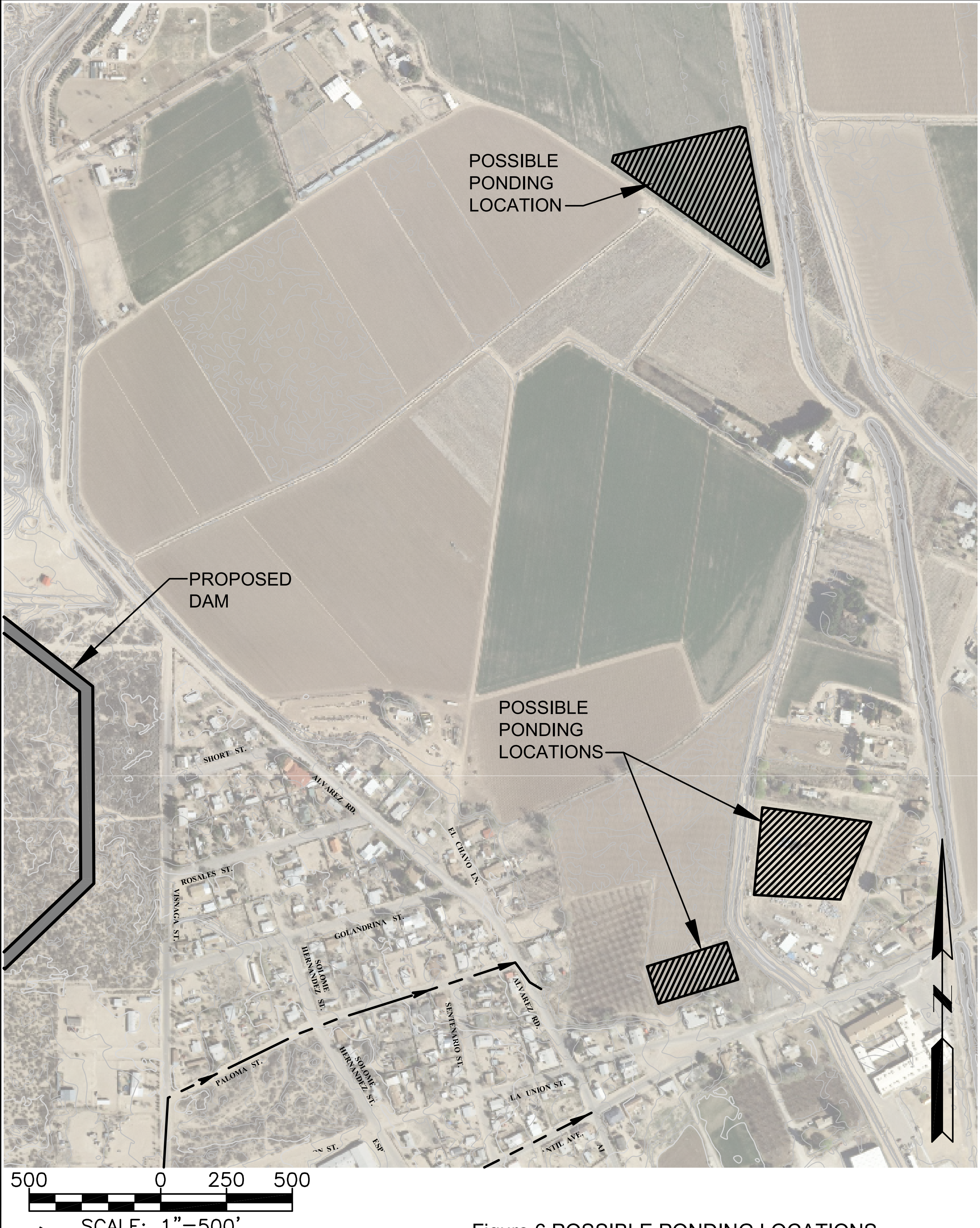

Figure 6 POSSIBLE PONDING LOCATIONS

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Property west of the Townsite where the detention ponds would be constructed is owned partly by the US government and partly by Sam Crossett. With the two pond concept one pond would be constructed on Federal land and the other would be built on Crossett land. The one pond concept calls for the construction of one pond on Federal land. However, a diversion ditch would be constructed to divert flows from the southern arroyos to the pond. Part of this ditch would be constructed on Crossett land.

Staff members of the Doña Ana County Flood Commission have interviewed Mr. Crossett. He has expressed a strong preference for the one pond concept because it could be constructed with the diversion ditch some distance to the west of the Townsite. This would provide Mr. Crossett with more land below the ditch and therefore protected from flooding and suitable for development. It would also reduce the amount of land that would be required from Mr. Crossett's property. This could represent a financial savings to the County.

Cost estimates for the two build alternatives are provided in Appendix G. Because the reduction in flow to the West Drain with the one dam alternative is at least as great as for the two dam alternative, the one dam alternative requires less total land and uses mostly Federal land for the ponding area, the one dam alternative provides more developable land which could increase the economy of the Townsite area, and the One Dam alternative is preferred by the owner of the lands needed for the two dam alternative, we are recommending that first priority be given to the development of the one dam alternative in spite of the fact that it's construction cost is greater than the two dam alternative.

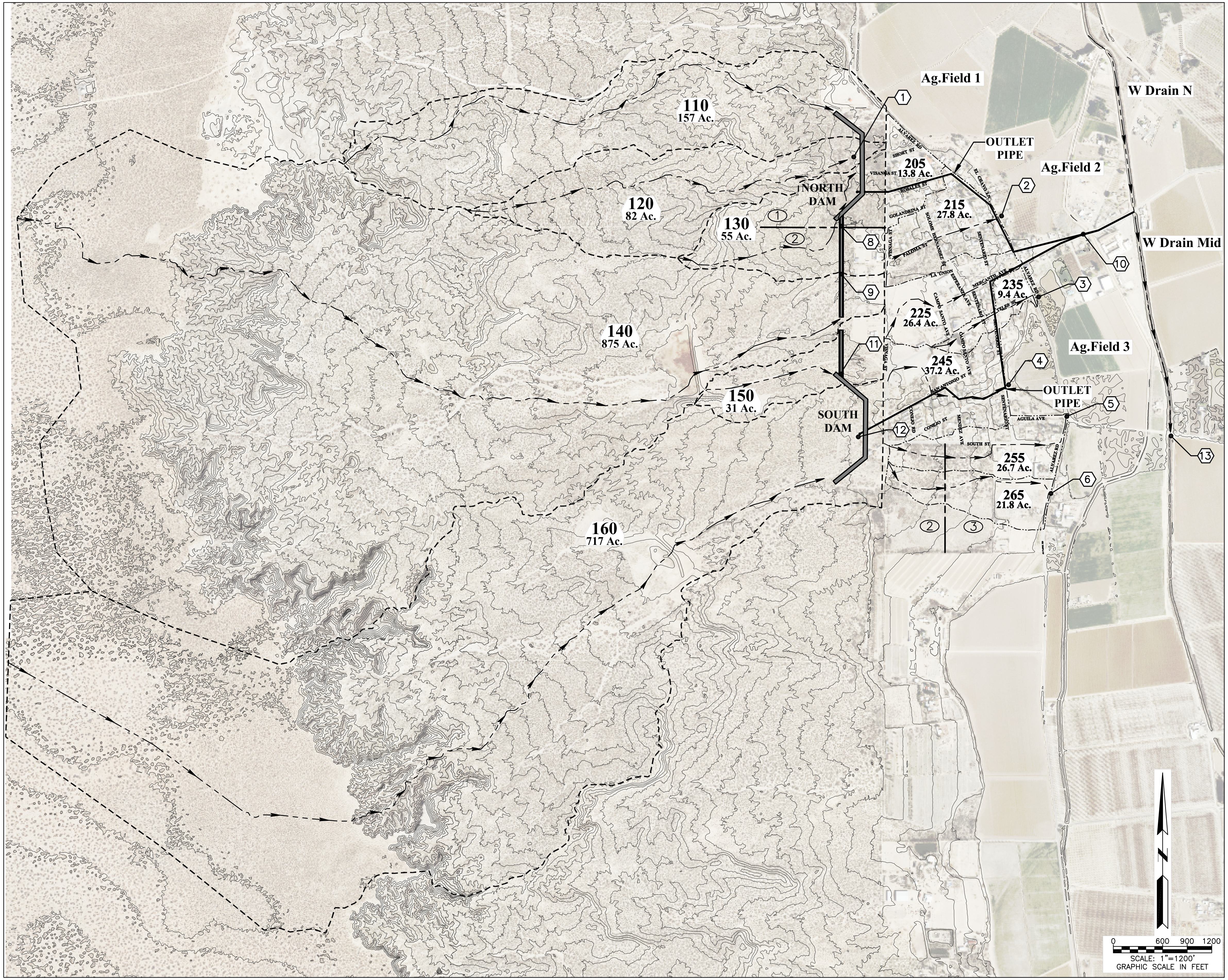
Alternative for Discussion / Exploration

La Union Dam A and La Union Dam B currently exist and may not have been designed for the 100-year storm event. However, they are located on basins that produce 285 cfs and 518 cfs, respectively, and it might be cost-effective to discuss upgrading these structures with the NRCS.

XI. Recommendations

Based upon the analysis presented above, Larkin provides the following conclusions and recommendations:

1. No build. The no-build solution is always an option, but this option does not meet the purpose of the Doña Ana County Flood Commission nor does it serve the needs of the residents of the Townsite.
2. The construction of a diversion channel and a detention dam with an outfall pipe to the West Drain (See Figure 10 page 22) would protect the Townsite from storm water flows from the 100-year event. The construction of this outfall pipe will provide the opportunity to install drop inlets in the Rosales Street area, addressing a noted problem area and reducing the existing Zone A floodplain.
3. The construction of two smaller diversion channels and two smaller detention dams with outfall pipes to the West Drain (See Figure 9, page 21) would protect the community from storm water flows from the 100-year event. The construction of these outfall pipes would also provide the opportunity to install drop inlets in the Rosales Street area, addressing a noted problem area and reducing the existing Zone a floodplain.
4. The current drainage philosophy is to use a 2% crown road cross-section to divert storm water runoff off the street to roadside bare earth drainage swales. Converting the existing street section to an inverted crown section (See Pages 24, 25 and 26) will protect the community during the more frequent smaller events and reduce the current sediment transport situation. See Preliminary Street Flow Capacities for street capacities and possible locations for infiltration galleries. Pending the preferred detention dam option, the current streets could be modified with a combination of standard curb and gutter and inverted crown sections to reduce the flooding problems the residents currently experience.



LEGEND

- **1X0** OFF-SITE DRAINAGE BASIN LABEL
- **2X5** ON-SITE DRAINAGE BASIN LABEL
- **XX Ac.** DRAINAGE BASIN AREA (ACRES)
- DRAINAGE BASIN BOUNDARY
- (X) ANALYSIS POINT (AP)
- HISTORICAL FLOWS
- FLOW DIRECTION
- EXISTING CONTOURS (10 FT. INTERVAL)

AMC III

ANALYSIS POINT	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC-FT)	100 yr. Volume (AC-FT)
AP 1	187.4	269.1	100.5	202.4
AP 2	32.7	60.4	3.0	5.5
AP 3	13.5	24.8	1.0	1.9
AP 4	50.4	91.8	4.3	7.7
AP 5	24.5	47.2	2.7	5.0
AP 6	19.1	37.0	2.2	4.1
AP 8	261.7	522.4	85.7	167.5
AP 9	260.4	518.6	81.1	158.3
AP 10	269.5	422.9	167.3	342.3
AP 11	21.1	42.7	2.7	5.3
AP 12	96.8	157.9	59.6	126.5
AP 13	269.1	421.9	166.3	341.5

AMC III

SUB BASIN	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC-FT)	100 yr. Volume (AC-FT)
110	81.1	164.5	13.5	26.4
120	52.2	105.7	7.0	13.8
130	46.0	92.6	4.7	9.3
140	260.4	518.6	81.1	158.3
150	21.1	42.7	2.7	5.3
160	144.7	285.6	67.0	131.5
205	21.1	38.0	1.6	3.0
215	32.7	60.4	3.0	5.5
225	27.0	50.6	2.8	5.1
235	13.5	24.8	1.0	1.9
245	50.4	91.8	4.3	7.7
255	24.5	47.2	2.7	5.0
265	19.1	37.0	2.2	4.1

PROPERTY OWNERSHIP KEY

1. UNITED STATES OF AMERICA
2. SAM E. CROSSETT
3. CAROL MYRE

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BY______ DATE______ DESCR.______
BY______ DATE______ DESCR.______

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SCALE______ CHECKED DVO
APPROVED DVO

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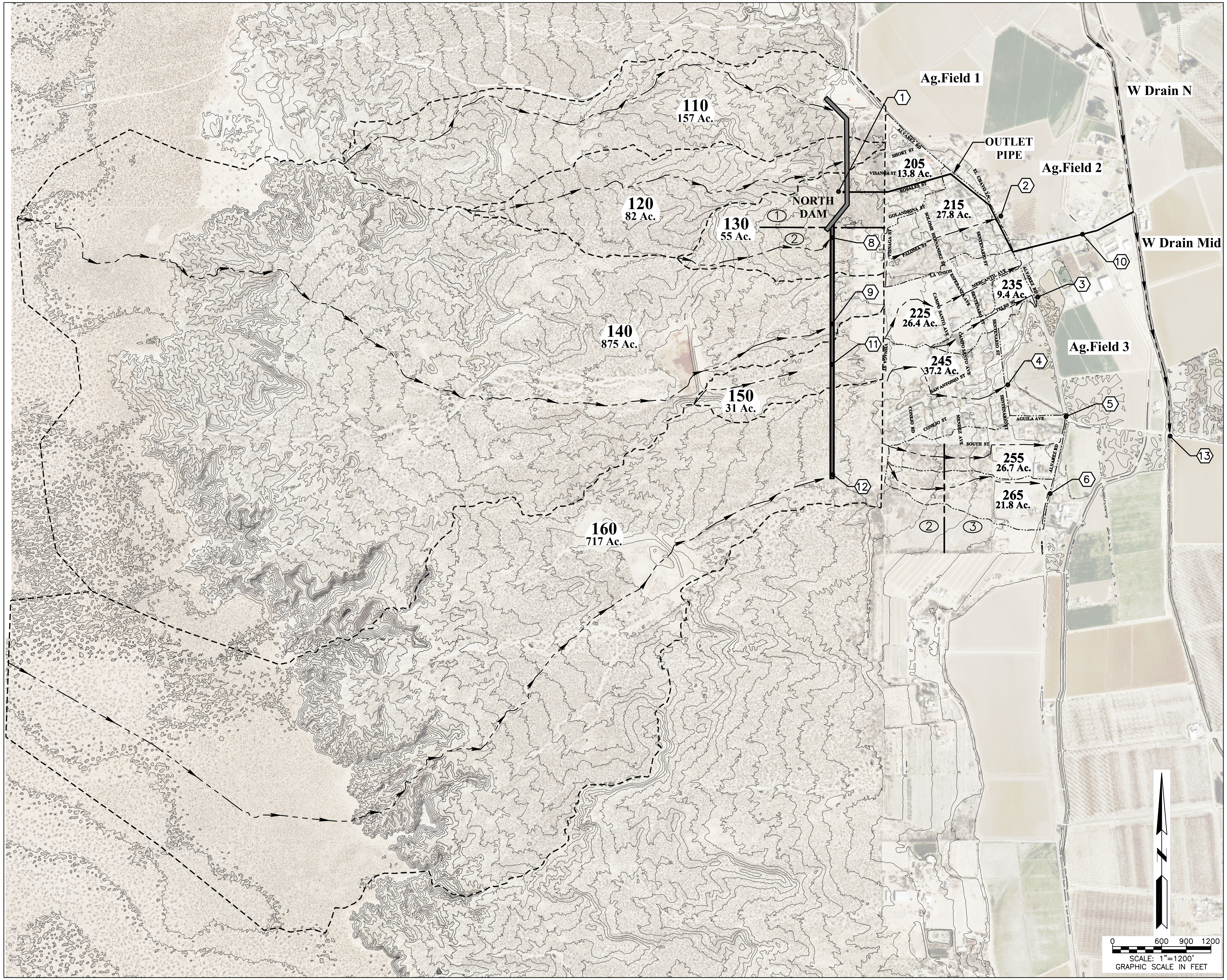
LA UNION MASTER DRAINAGE PLAN

Figure 7 PROPOSED HYDROLOGY - OPTION 1



LEGEND

- **1X0** OFF-SITE DRAINAGE BASIN LABEL
- **2X5** ON-SITE DRAINAGE BASIN LABEL
- **XX Ac.** DRAINAGE BASIN AREA (ACRES)
- DRAINAGE BASIN BOUNDARY
- ANALYSIS POINT (AP)
- HISTORICAL FLOWS
- FLOW DIRECTION
- EXISTING CONTOURS (10 FT. INTERVAL)

AMC III

ANALYSIS POINT	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC-FT)	100 yr. Volume (AC-FT)
AP 1	128.5	196.0	138.0	237.9
AP 2	32.7	60.4	3.0	5.5
AP 3	38.6	72.0	3.8	6.9
AP 4	50.4	91.8	4.3	7.7
AP 5	24.5	47.2	2.7	5.0
AP 6	19.1	37.0	2.2	4.1
AP 8	371.0	744.1	155.2	304.1
AP 9	369.2	738.6	150.6	294.9
AP 10	130.1	196.1	142.1	245.1
AP 11	145.8	286.6	69.6	136.7
AP 12	144.7	285.6	67.0	131.5
AP 13	129.7	196.1	140.6	242.4

AMC III

SUB BASIN	10 yr. cfs	100 yr. cfs	10 yr. Volume (AC-FT)	100 yr. Volume (AC-FT)
110	81.1	164.5	13.5	26.4
120	52.2	105.7	7.0	13.8
130	46.0	92.6	4.7	9.3
140	260.4	518.6	81.1	158.3
150	21.1	42.7	2.7	5.3
160	144.7	285.6	67.0	131.5
205	21.1	38.0	1.6	3.0
215	32.7	60.4	3.0	5.5
225	27.0	50.6	2.8	5.1
235	13.5	24.8	1.0	1.9
245	50.4	91.8	4.3	7.7
255	24.5	47.2	2.7	5.0
265	19.1	37.0	2.2	4.1

PROPERTY OWNERSHIP KEY

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Figure 8 PROPOSED HYDROLOGY - OPTION 2

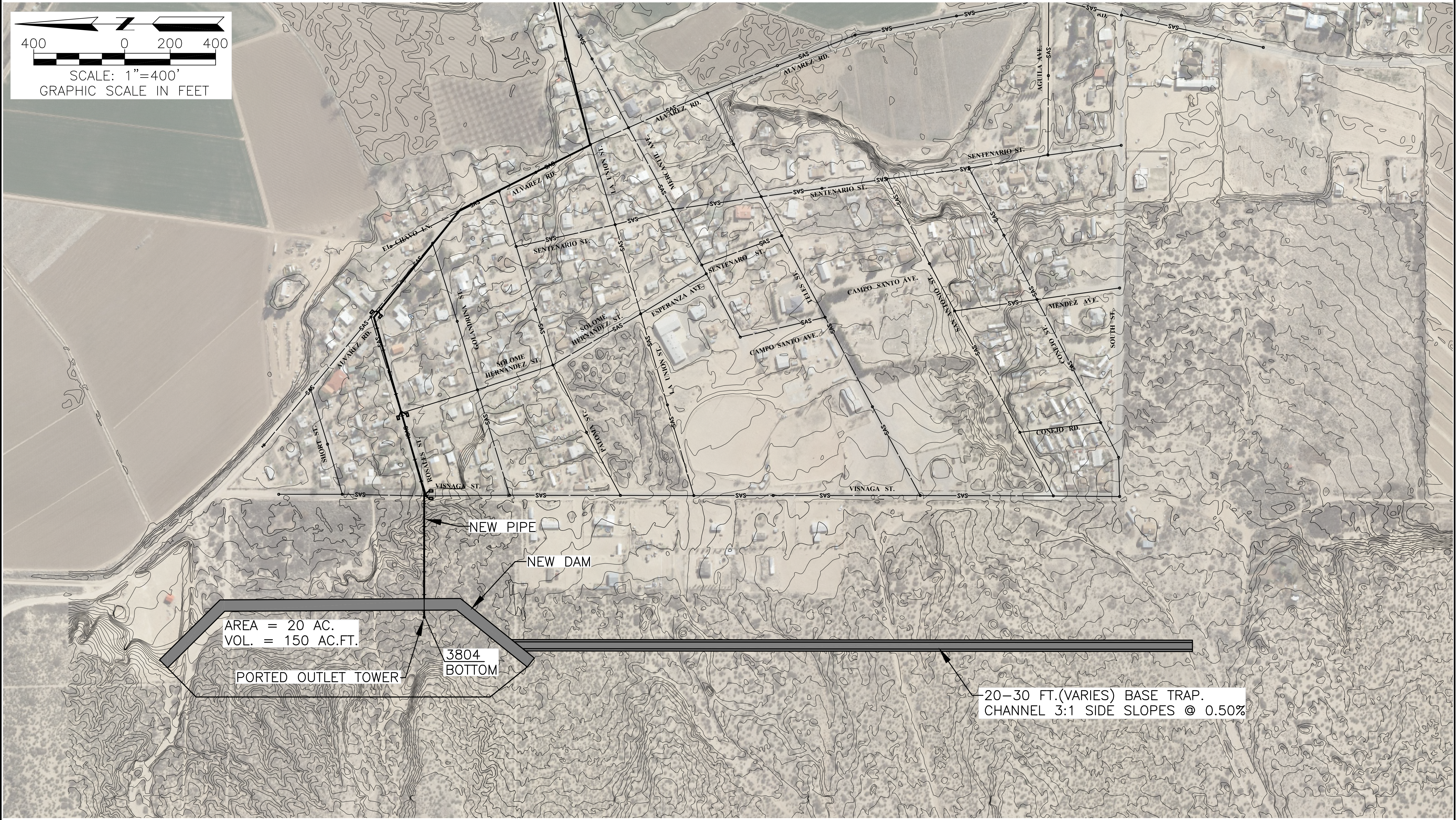

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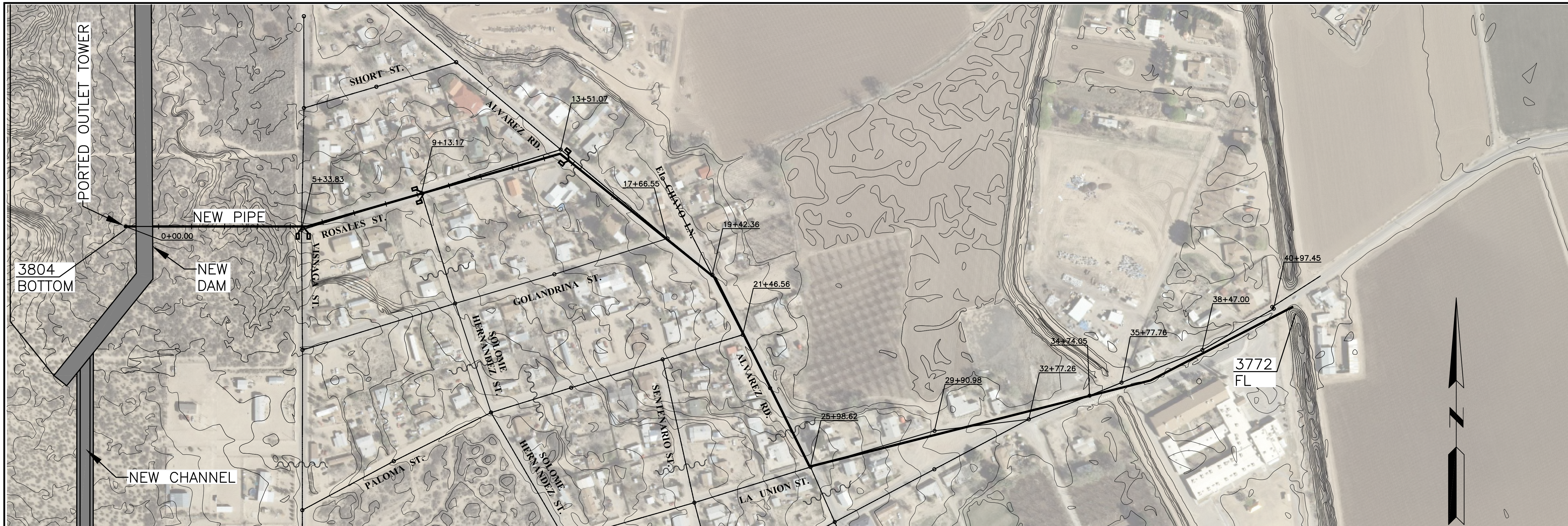
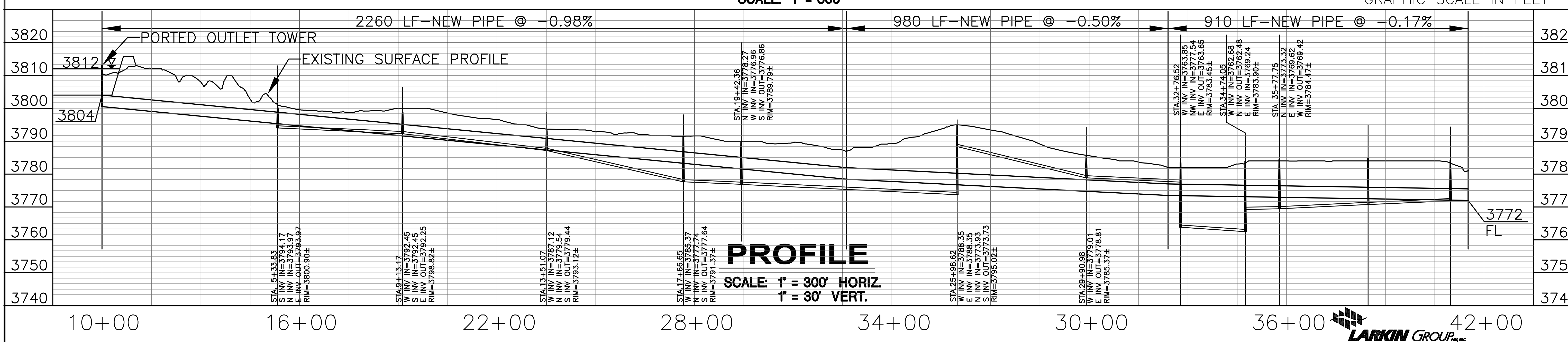
Figure 9 SINGLE DAM PRELIMINARY CHANNEL & DAM OPTION 2



PLAN

SCALE: 1" = 300'



PROFILE

SCALE: 1" = 300' HORIZ.
1" = 30' VERT.

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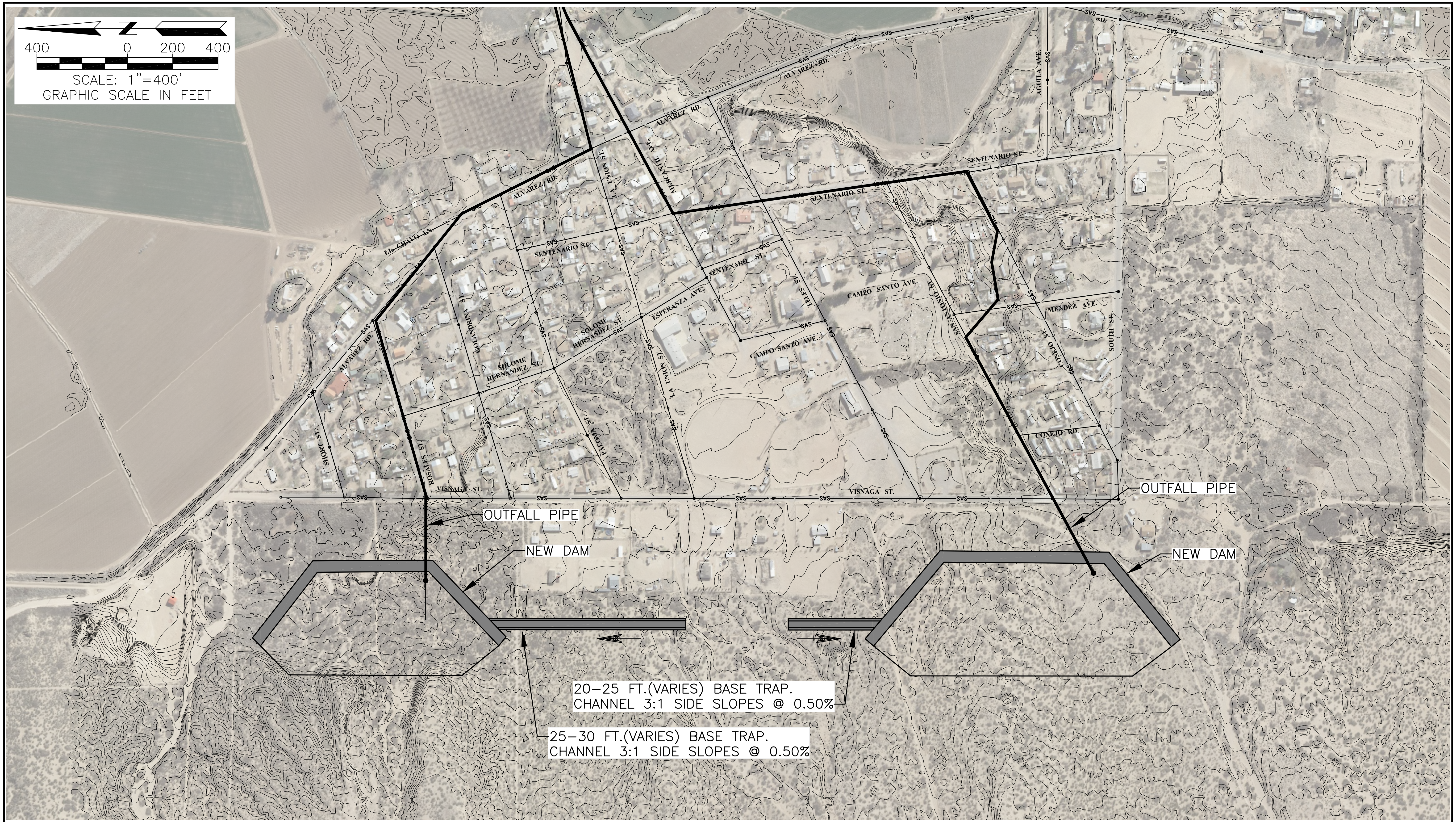
Figure 10 SINGLE DAM PRELIMINARY PLAN & PROFILE
OPTION 2



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REVISIONS		DOÑA ANA COUNTY FLOOD COMMISSION	Figure 11 ALTERNATIVE DAMS LAYOUT	PAGE
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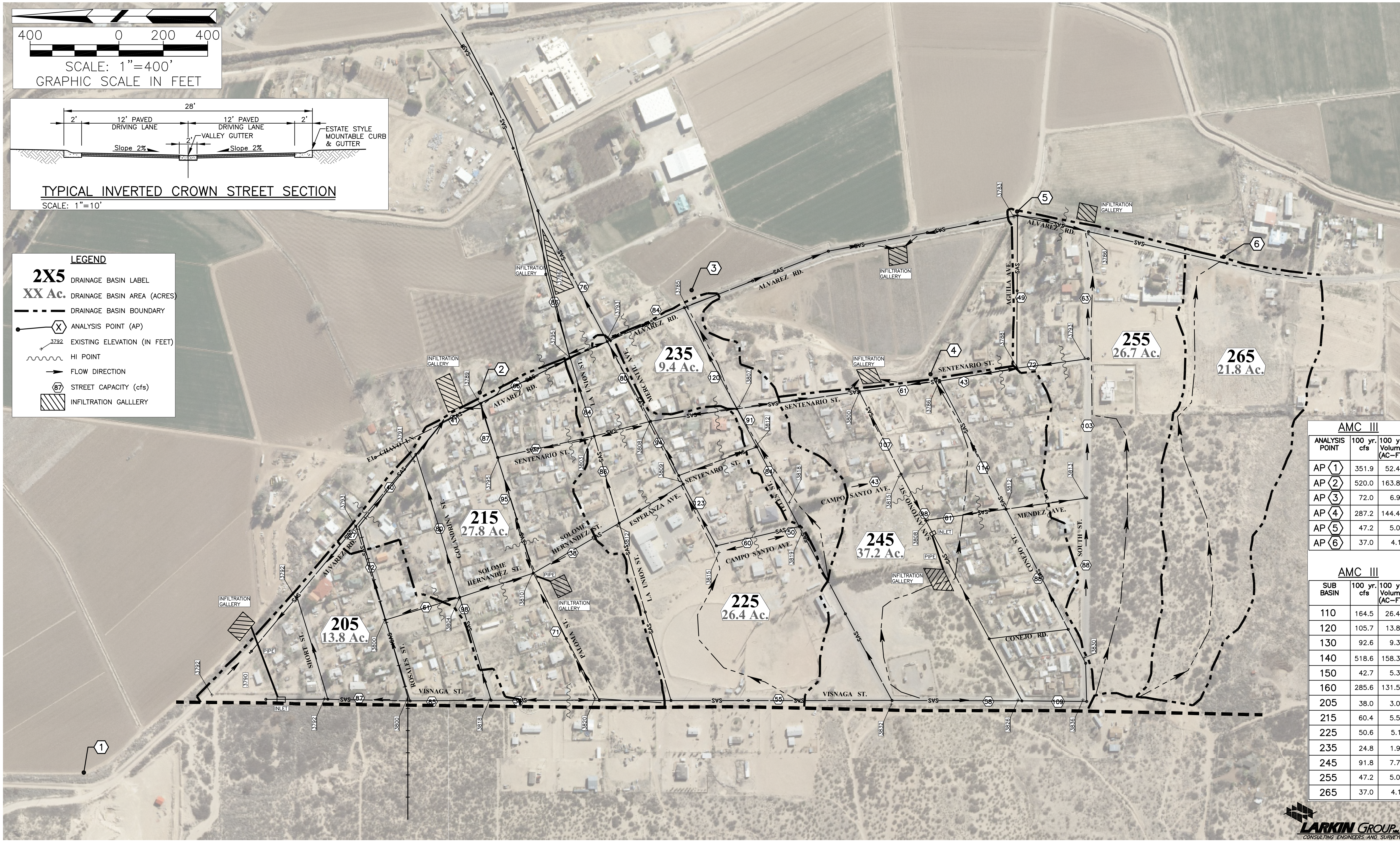

AMC III

ANALYSIS POINT	100 yr. cfs	100 yr. Volume (AC–FT)
AP 1	351.9	52.4
AP 2	520.0	163.8
AP 3	72.0	6.9
AP 4	287.2	144.4
AP 5	47.2	5.0
AP 6	37.0	4.1

AMC III

SUB BASIN	100 yr. cfs	100 yr. Volume (AC–FT)
110	164.5	26.4
120	105.7	13.8
130	92.6	9.3
140	518.6	158.3
150	42.7	5.3
160	285.6	131.5
205	38.0	3.0
215	60.4	5.5
225	50.6	5.1
235	24.8	1.9
245	91.8	7.7
255	47.2	5.0
265	37.0	4.1

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DATE ____ DRAWN GTM
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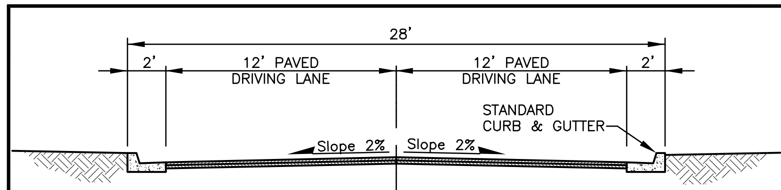
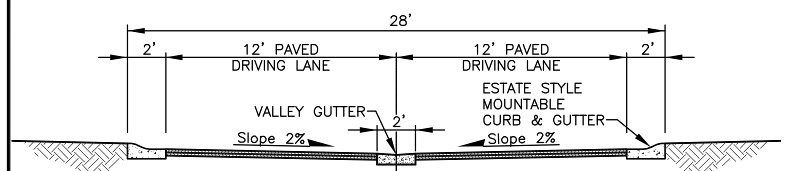
LA UNION MASTER DRAINAGE PLAN

Figure 12 PRELIMINARY STREET FLOW CAPACITIES



TYPICAL STREET SECTION

SCALE: 1"=10'

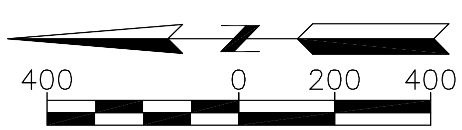


TYPICAL INVERTED CROWN STREET SECTION

SCALE: 1"=10'

LEGEND

- HI POINT
- FLOW DIRECTION
- TYPICAL CROWNED STREET
- INVERTED CROWN STREET
- CATTLE GUARD INLET
- DROP INLET W/PIPE
- INFILTRATION GALLERY
- FLOATABLE SEPARATION GALLERY



SCALE: 1"=400'

GRAPHIC SCALE IN FEET

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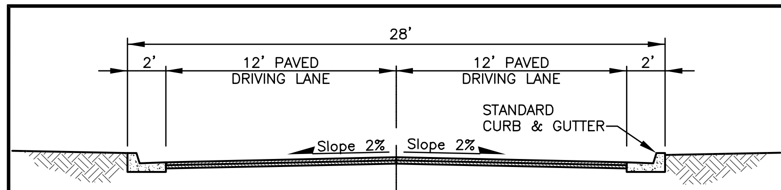
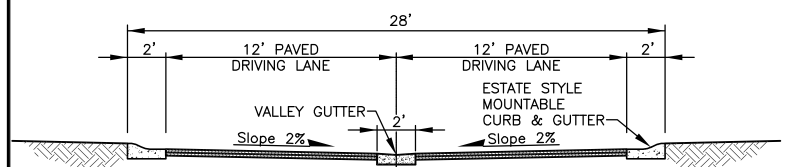
Figure 13 PROPOSED STREET IMPROVEMENTS ONE DAM OPTION



TYPICAL STREET SECTION

SCALE: 1"=10'

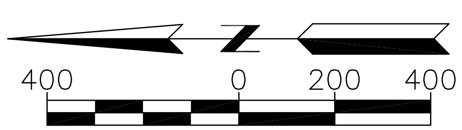


TYPICAL INVERTED CROWN STREET SECTION

SCALE: 1"=10'

LEGEND

- HI POINT
- FLOW DIRECTION
- TYPICAL CROWNED STREET
- INVERTED CROWN STREET
- CATTLE GUARD INLET
- DROP INLET W/PIPE
- INFILTRATION GALLERY
- FLOATABLE SEPARATION GALLERY



SCALE: 1"=400'

GRAPHIC SCALE IN FEET

LARKIN GROUP NM, INC

CONSULTING ENGINEERS AND SURVEYORS

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SCALE	APPROVED	DVO

DOÑA ANA COUNTY FLOOD COMMISSION

LA UNION MASTER DRAINAGE PLAN

Figure 14 PROPOSED STREET IMPROVEMENTS
TWO DAM OPTION

XII. Bibliography, References & Special Thanks

- Doña Ana County, Design and Construction Standards, Chapter 157, http://ecode360.com/print/DO2860
- FEMA Map Service Center, Effective FIRMs/FHBMs, Flood Insurance Studies (FIS), Effective Flood Insurance Studies (FIS), https://msc.fema.gov/webapp/wcs/stores/
- National Engineering Handbook, Part 360 Hydrology, Chapter 7 Hydrologic Soil Groups, January 2009, http://directives.sc.egov.usda.gov/
- New Mexico State Highway and Transportation Department (NMDOT), Drainage Manual, Volume I, Hydrology, 1995
- Sperlings Best Places, Population Data, Best Places to Live in La Union, New Mexico, http://www.bestplaces.net/city/new_mexico/la_union
- U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Soil Data Mart Website, Doña Ana County, New Mexico, http://soildatamart.nrcs.usda.gov/Survey.aspx?County=NM013
- U.S. Department of Agriculture, Soil Conservation Service, Soil Survey of Doña Ana County Area New Mexico, 1977
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), Average Annual Climatic Data, National Climatic Data Center, by Zipcode, http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=annual&layers=1&node=gis
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service, Office of Hydrologic Development, Hydrometeorological Design Studies Center, Precipitation Frequency Data Server (PFDS), http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

Special Thanks To
The citizens of the Townsite of La Union and Parish Hall